December 15, 2014

National Shipbuilder Research Program, Electric Technologies Panel: Low Voltage Quick Connector Evaluation

Prepared By

Gregory D. Stevens – General Dynamics Bath Iron Works

Contributions From

Mark Boucher – General Dynamics Bath Iron Works
Brent Dube – General Dynamics Bath Iron Works
John Poulin – General Dynamics Bath Iron Works
Gary Snell – General Dynamics Bath Iron Works
Dennis Fanguy – Bollinger Shipbuilding
Michael Fitzmaurice – Raytheon Company
Dayton T. Brown Laboratory Services

Contract Number:
2005-339 TO 29

Prepared For
SCRA Applied Research

National Shipbuilder Research Program
Electrical Technologies Panel

This Page Intentionally Blank

National Shipbuilder Research Program, Electric Technologies Panel: Low Voltage Quick Connector Evaluation

Prepared By

Gregory D. Stevens – General Dynamics Bath Iron Works

Contributions From

Mark Boucher – General Dynamics Bath Iron Works
Brent Dube – General Dynamics Bath Iron Works
John Poulin – General Dynamics Bath Iron Works
Gary Snell – General Dynamics Bath Iron Works
Dennis Fanguy – Bollinger Shipbuilding
Michael Fitzmaurice – Raytheon Company
Dayton T. Brown Laboratory Services

Project Technical Representative

Jason Farmer – Huntington Ingalls Inc. – Pascagoula

Special Thanks to

Newark element14	Weidmüller North America
Wago Corporation	Phoenix Corporation
Tyco Corporation	Cooper Industries/Eaton Bussmann
Eaton Corporation	3M Corporation

Date: December 15, 2014

Contract: 2005-339 TO 29

Prepared For

SCRA Applied Research
NSRP ETP

This Page Intentionally Blank

Change Record

Date	Revision	Reason for Change
12/15/14	-	Initial Release

This Page Intentionally Blank

Table of Contents

Figures

Tables

Executive Summary

Under the National Shipbuilder Research Program Electric Technologies Panel, a project was conducted to evaluate the performance of electrical connector units used to connect electrical circuit elements. The basic idea behind the use of such connectors is to expedite installation while maintaining the high level of reliability and performance generally associated with military programs. In so doing, validation testing was performed to add validity to investigative research and general recommendations.

Product data was researched and twenty-nine products were selected for detailed inspection and evaluation, electrical characterization, and performance testing. Specifications and standards were researched to gain familiarity with what would likely form baseline requirements for a particular program. A conservative approach was taken throughout, including the level of technical requirements that might be levied on a program. Stringent requirements were referenced. Other, less stringent requirements for other programs, by default, would meet those requirements deemed more stringent. The companies whose products were being evaluated supplied product needed to manufacture a demonstration unit that would form the foundation of this evaluation project.

Demonstrator designs were generated and reviewed by project members. The demonstrator designs were created so that minimal influence would be generated between test articles. This enabled several test articles to be tested simultaneously, generally expediting test schedules and lowering testing expenses. Demonstrator units were constructed to maximize the similarity one might find on ship programs with respect to materials and construction practices.

An independent lab conducted performance testing in accordance with testing procedures generated by the project team, referencing Navy protocols. Although this has not been considered a product qualification process, it is considered a first step in that process or considered a strong reference when entering an official qualification program. However, such qualification testing has been part of a first article testing and left to the manufacturer to conduct. The design could be leveraged for this purpose though, once it is determined that the design can support such activities.

Recommendations include future work in further validating results of this report, including estimated benefits and savings, extending certain validation testing through qualification testing, and optimizing existing products to better serve the marine shipbuilding industry. An implementation plan is offered to aid the user in establishing a program to incorporate certain connectors into designs, either as a new design or modification to an existing design. The report, overall, serves as a reference point as one moves through the process of quick connector integration.

Symbols, Abbreviations, and Acronyms

ABS American Bureau of Shipping

ANSI American National Standards Institute

ASME American Society of Mechanical Engineers

ASTM American Society for Testing and Materials

AWG American Wire Gauge

BIW Bath Iron Works

BTU British Thermal Unit

°C Centigrade

CBA Cost Benefit Analysis

cm Centimeters

COTS Commercial Off The Shelf

DIN Deutsches Institut für Normung (German Institute of Standardization)

DOD Department of Defense

ECB Executive Control Board

ETP Electrical Technologies Panel

EXCEL Computer Spreadsheet Software Program, supplied by Microsoft

°F Fahrenheit

g Grams

Hi Pot High Potential

Hrs Hours

Hz Hertz

IEEE Institute of Electrical and Electronics Engineers

kV Kilovolts

MIL Military

Mil-Dtl-xxx Military Detailed Specification

Mil-Prf-xxx Military Performance Specification

Mil-P-xxx Military Specification

Mil-S-xxx Military Specification

Mil-Std-xxx Military Standard

N/A Not Applicable

N Newtons (force)

NES Naval Engineering Standards

NAVSEA Naval Sea Systems Command

NEMA National Electrical Manufacturers Association

NRE Non-recurring Expenses

NSRP National Shipbuilding Research Program

NTA Navy Technical Authority

NVR Navy Vessel Rules

Ω Ohms

ROI Return on Investment

ROM Rough Order of Magnitude

PTR Project Technical Representative

PU Per Unit

RTD Resistance Temperature Detector

SPEC Specification (used to denote a specification, such as MIL-SPEC-xxx)

SME Subject Matter Expert

STD Standard

UL Underwriters Laboratories

UOM Unit of Measure

VFI Vendor Furnished Information

This Page Intentionally Blank

1 Introduction

The National Shipbuilder Research Program (NSRP) Electric Technology Panel (ETP) received funding, as directed by the Executive Control Board (ECB), for a project that focuses on the operating performance and electrical characteristics of low voltage connectors of various forms. This type of project is meant to identify what products are available in the marketplace for use in a marine environment, and in particular, in a military ship environment. It is expected, comparing to current hardware and methods, savings might be available when using other types of devices. However, the performance and characteristics of devices investigated must comply with established standards and specifications in order for those products, in current form or future revised form, to be considered suitable for such use. This project seeks to quantify and qualify product capability, and determine how products either meet existing standards, how they must change in order to meet such standards, or whether standards must change to accommodate an already capable product list.

Product designs that allow for fast installation, repeatable and reliable service, and can support commonality across multiple applications and platforms are desirable. This is a primary consideration for this project.

This report is organized into several sections, each of which will be briefly described below.

The scope of work is briefly discussed in Section 2. The basis for work and target audience are described at a high level. There are other considerations that will be outlined in later sections.

Section 3, Goals and Objectives, briefly describes why the project has been proposed and completed, and what the primary purpose for such a project is. The reader should gain an high level understanding of project intentions and underlying expectations.

General approaches are described in Section 4 that enables the project team to meet the goals and objectives described in Section 3. These methods are fairly standard, utilizing investigation, product inspection and testing, and data evaluation to make feasibility determinations.

Section 5 lays out technical evaluation that has enabled the project team to make these determinations. A mix of experience, creativity and data based assessment forms the basis of technical review.

The last section, Section 6, Conclusions and Recommendations, reflects on findings and provides the audience an insight gained by the project team that, hopefully, will enable others to make their own determinations as to whether products investigated fit their needs in relative contexts. Part of this section is a recommended course of future action in the form of an implementation plan. It is the hope of the project team to offer these ideas in a way that minimizes the need to perform investigations from scratch, but rather to use the content of this report to further understand and position groups for decision making and implementation if so warranted.

The report is the culmination of research, testing and validation. It is up to end users to determine whether the product offerings will meet their needs or if variants will need to be assembled and what it will take to diversify the marketplace. The project team has presented one data point or reference in what would otherwise be considered an environment of several options. End users are encouraged to use the results of this report, but will likely be required to perform their own investigations on what might meet individual needs.

2 Scope of Study

This project identifies prospective products and applications that tend to expedite electrical hook up while maintaining resilient and reliable system integration. The process of identifying such products and applications starts with researching product characteristics, identifying applications and determining what the associated requirements are for various applications. Demonstrating the performance characteristics of various products enables the audience to gain insight into product capability and make determinations on what combinations of products might best meet certain needs. Finally, compiling the data and presenting the data in tangible formats supports this process for the audience and lends insight to all those involved in general industry trends and innovations.

2.1 Target Audience

A primary target audience is the Navy and its agencies. It is their end use applications that will likely incorporate the items of interest targeted in this project. Since the products that are evaluated in this project are considered integration components, linking equipment to equipment via infrastructure components such as cable, those groups using such products to support applications for the Navy will also be the recipient of the output of this project. Even today, some manufacturers use similar products in their equipment to that researched and tested here. This is not to say that other markets cannot benefit from the findings of this report. However, the project has been structured to meet expectations generally recognized in Department of Defense (DoD) environments.

The direct customer is a contractor administering the National Shipbuilder Research Program Electric Technologies Panel (NSRP ETP) program contract, SCRA Applied Research. The benefactors of this work will include NSRP ETP membership and panel affiliates. It is expected the information could be used in commercial as well as government programs. In fact, it may well be that this project segues into another similar project or is used in a form of reference for extending other similar technologies, as described previously.

3 Goals and Objectives

Goals and objectives for this project include the following:

- Gain understanding of the types of designs used on ship programs with respect to low voltage connections for applications such as control panel termination boxes
- Become familiar with the specifications and requirements that drive the designs used
- Investigate what is used in the commercial shipbuilding industry and determine what products could be tested for a cursory performance evaluation
- Consider how current programs could benefit by using other types of products that serve similar functions

The following are considered primary tasks to meet the objectives.

- Identify and describe existing specifications and requirements used to procure low voltage termination and connection hardware for Navy programs
- Identify and describe existing specifications and requirements used to procure low voltage termination and connection units for commercial ship programs
- Investigate what products exist that could be tested for use on Navy ship programs; testing includes
    - Shock
    - Vibration
    - Some form of accelerated wear testing or cycle testing (although connections and terminations are generally pretty well protected from environmental issues)
- Conduct testing using a typical military qualified termination unit (as a baseline) and selected other units under investigation
- Perform a performance evaluation and comparison to the baseline
- Generate recommendations based on the evaluation targeting requirements, specifications and qualification programs

Actual tasking utilized throughout the project will be discussed in more detail in Section 4.

4 Approaches and Methods

The approach used for this project is broken down into the following primary areas.

- Historically reference what has been considered traditional hardware and technique
- Present typical standards and requirements used to apply products to applications
- Determine what other products and techniques can be considered that may meet certain performance criteria
- Characterize product attributes and demonstrate product capability
- Analyze, compile and correlate data and results to offer recommendations

In order to address these areas, the following methods and tasks were employed. Participants involved in these tasks are identified in parentheses (much of the contribution from participants will come in the form of product review). These will be described in more detail in Section 5.

1. Research Products: Compile a listing of products to consider for evaluation. This includes products that are currently used in programs today. (All Participants)
2. Evaluate Requirements: Generate a list of requirements used for the application of connectors and lugs for various types of interfaces. (All Participants)
3. Generate Evaluation Guide and Evaluate Products: Generate an evaluation guide to be used to evaluate various product characteristics and attributes. Conduct the evaluation of several product types and manufacturers. These guides will be used to select products that represent the closest match to applications and the greatest prospect for meeting various requirements. (All Participants)
4. Test Procedure: Generate a test procedure to test products using a certain battery of tests, to include at a minimum (All Participants):

    - Vibration testing
    - Shock testing
    - ESS thermal testing

5. Generate Testing Services SOW: Generate an SOW for the testing service which describes relative terms and references the details called out in the testing procedure. (BIW)
6. Design the Demonstrator: Design a test demonstrator that is capable of being tested for shock and vibration testing at a minimum, and a form of cycle testing. The demonstrator shall be the testing fixture assembly that holds all the individual testing articles in their various configurations. (BIW)
7. Build the Demonstrator: Build the demonstrator in accordance with the design and with those products that have been selected and provided by various manufacturers and distributors. (BIW)
8. Conduct Testing: Conduct testing at a laboratory. Document each test thoroughly so the results can be reviewed by all participants and the data assessed. (Lab)

9. Evaluate Results: Conduct an evaluation of the results. Establish trends and relationships between performance and test article attributes and characteristics. (All Participants)
10. Generate (and review) Report: Generate a report of findings and recommendations. A final outbrief will support the report of findings. Included in the report will be a basic implementation plan to addresses how the findings could be leveraged to gain particular benefits. (All Participants)

This approach and these methods represent one means of determining how existing products may meet certain requirements and criteria. The data, as presented in this report, and recommendations offered represent an interpretation by this project team. Through employing other methods and under different circumstances, the findings and recommendations might differ. The reader is encouraged to use this information in relative terms, seeking opportunity where one might interpret the best opportunities, not necessarily where and how opportunities are presented here. However, this set of findings and recommendations could form a basis for future work and follow on qualification activities and application for specific programs if the approach and methods are found to be suitable and applicable for their interests.

5 Technical Assessment

A primary element of this study is assessing the performance of connectors subjected to a battery of tests, as will be detailed in Section 5.6. The process starts, however, with the research of products that may meet certain criteria that are typically imposed on marine, and specifically, Navy programs. Although the intent of the project is not to endorse certain products, product lines or companies, a means to determine the most suitable products and those representing the greatest possibility of meeting certain demands (such as shock testing) is needed. Evaluation guides that offer the team a reference and comparison baseline were generated, allowing for down selecting. Although many of the products researched meet certain standards and specifications, such as IEC 60947-7-1 and UL486C, many do not list key military specifications as certifications or references of compliance. The tests chosen for this project demonstration utilize these key military standards as a means of identifying the most capable of products chosen for evaluation, such as MIL-C-55243 or MIL-DTL-26482H.

A particular product or product line may not be intended to meet a certain market requirement, such as that typically imposed on products for military applications. However, the project team, after discussing project scope and expectations with product vendors, concluded that the products that were chosen to be test articles represent a good cross section of products that could meet many applications shipboard in military applications as is or with minimal modification. As well, it was thought that if these products meet the rigorous demands of those requirements, it is likely they will meet less stringent requirements in commercial or private sector industries as discussed previously.

Finally, product performance was evaluated on a couple fronts. First, a validation of data sheet information was conducted through electrical and mechanical capability testing, as shown in Table 5.6-2, steps 1-4, and 8. Secondly, performance testing was then conducted along the lines of those specifications listed in Table 5.6-1 and the steps shown in Table 5.6-2 (more on this table in Section 5.6.1 and Section 5.6.2). Table 5.6-2, steps 5-7, represent the performance testing. These test are representative of military qualification tests, but are not necessarily applied in the most strict manner that would be indicative of qualification testing. The tests are chosen and applied in this way to determine relative reliance of products considered Commercial Off-The-Shelf (COTS) products that have not necessarily entered a fully engaged military testing program.

Table 5.6-1 indicates the specifications and standards that were referenced when conducting the respective tests. Relevancy and testing standards overlap were reviewed and a specific test table was generated indicating general sequence of the tests, which is shown in Table 5.6-2. The order of the test was chosen as shown to minimize influence of the outcome for a particular test negatively influencing another test. For instance, all electrical characterization tests were chosen to be done before the performance tests due to their low incidence of damage (except for the dielectric withstand test since this test represents one of higher risk of damage). In this way, it was hoped that data could be generated and testing could move to the next, increasing risk test. Such is the case with the shock and vibration testing. After conversing with the laboratory, feedback suggested the shock test represents a riskier type of performance test than the vibration test, since certain characteristics are not yet known going into the test, such as resonant frequency. Should the resonant frequency be at a value corresponding to the frequency range that is chosen for testing, it is possible, even for the lower mass items, the units will destroy themselves. Obviously, this is a high focus item of prevention.

5.1 Research Products

Many products exist that serve to add functionality to the process of conductor termination, in all forms and configurations. There are products that serve as quick connection means without the need to strip insulation just by placing a conductor into a device and closing a serrated contact assembly, and those that use innovative techniques to join large cable conductors to power studs using a pin and socket assembly technique. One common goal of all these units is to utilize hardware and techniques that tend to expedite the process of interface (in this case, terminating to a device) while maintaining a highly reliable, long term connection that may be subject to various dynamic forces. One of the goals of this project is to research and demonstrate capability of hardware and techniques that simplify the process of termination. Often in design, a piece of equipment will be designed and manufactured as an assembly that requires interfacing at the system component level, acting as a sort of black box that interfaces at a system distribution point (whether that distribution represents data, power, control or instrumentation in various forms of media). This enables the manufacturer to create the boundary on their equipment, test it and rely on common methods for system integration. Often, these points of integration rely on terminal blocks and connectors for system assembly. One side is already done by the manufacturer or one part of a production process, often times tested, and the other points integrate directly to system components or another piece of equipment directly, possibly supplied by another manufacturer. The hook up at these points of integration can often times be time consuming and tedious, requiring crimped lugs and connectors that work with the supplied terminal blocks. An example of a typical stud type of terminal block used for low voltage power, control and instrumentation for military programs is shown in Figure 5.1-1.

Figure 5.1-1 Military Style Terminal Block per A-A-59125/24

As seen, the process for interfacing to the terminal block requires crimped lugs be installed, the lug installed over the stud, and the stud torqued to a predetermined value. The process involves several steps, representing installation time and components. When this is considered across an entire program, it becomes obvious that the total time required for this effort is large. As seen in Figure 5.1-2, there are 16 terminal blocks with 12 connections each. There are a number of these types of boxes in designs for different programs, thus indicating the high labor involved in installing these types of systems, even though they are considered a rugged design. This style of terminal block will be one of the tested items used as a baseline, as will be seen and discussed in Sect. 5.5.1.

A goal, as stated before, is to make the job of installing these types of units easier while maintaining the same reliability, performance and precision. Another important aspect is to make the design readily available for disconnection and reconnection during activation sequences and troubleshooting. Often times, it is necessary to isolate the equipment to perform open loop testing, for either the equipment hardware or for the cable. Incorporating a quick connector helps facilitate this need.

Nominal electrical characteristics are used to find and select products for evaluation, such as operating voltage, operating current, surge voltage, conductor interface, etc. (see Sect. 8.2). Once the primary characteristics are evaluated and it determined that the characteristics fit the following primary criteria (Table 5.1-1), the products are put on a list for later comparison, ultimately leading to procurement and testing.

Table 5.1-1 Evaluation Criteria

Criteria	Characteristic	Comment
Voltage	<600 V	Considered low voltage
Surge Voltage	<10,000 V	Considered non specialty
Current	<500 A	Want a unit that is applied to lower power applications
SSC	⩾10 kA	Considered non specialty
Mounting Arrangement	Standard DIN or foot	A few units are tested that are not mounted traditionally
Strong Conductor Retention	⩾10 lbs (general)	Based on military specifications, and if the test article value is known
Possible widespread application		As products were researched, opportunities for use were drivers
Quick connection	Any mechanism that expedites termination	Units include anything that requires fewer steps than those used today for naval applications
Ease of procurement	Minimal expense and quick procurement	Because of the nature of NSRP projects of this sort, this criteria is typical; however, this does not preclude other units exhibiting similar characteristics
Size of test plate design	A goal was to keep it within the typical 2' X 2' test fixture	This allows for a more cost effective testing arrangement for a project of this sort

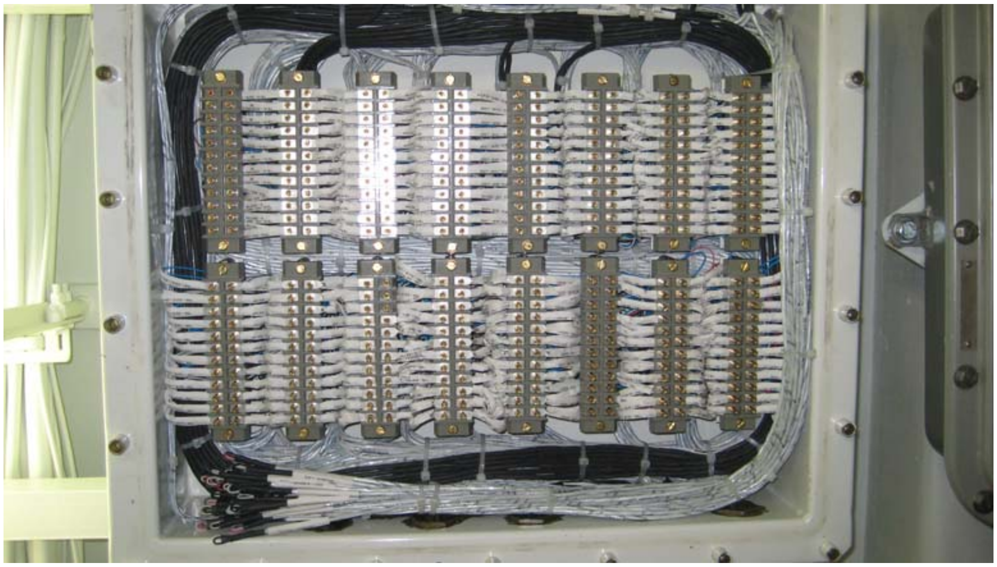


Figure 5.1-2 Typical Connector Box Layout

General types of connections investigated include the following:

- Screw and plate compression
- Spring clamp that is self-clamping and defeatable
- Spring clamp that is self-clamping and non-defeatable
- Lever lock

A style that was not investigated specifically is the type that cuts through insulation to make contact with the conductor, except for the inline splice connectors and one DIN (Deutsches Institut für Normung [German Institute of Standardization]) rail mounted unit. It was determined that this style of connector, although prevalent in other industries such as the automotive industry, would be more susceptible to the rigors of shock and vibration testing, and would not serve as a good test specimen for those applications where large numbers of connectors would be used in a terminal box design. Since stranded conductors were chosen as the conductor of choice, based on current electric plant configurations for naval vessels, these types of connectors might tend to damage the strands (typically strands are on the order of #26 - #34 AWG depending on the type of conductor and conductor design). However, the one in line splice connector unit that was tested was used to at least verify where the constraints for use lie, and how this technology might be deployed, if elected.

After conducting an informed search for different styles of conductors that generated about five different styles, representing a good spectrum for evaluation, vendors and manufacturers were solicited to provide products for evaluation, recognizing that this series of tests and evaluations is not meant to endorse a specific design or technology. Rather, it is meant to distinguish what technologies might hold promise for further program qualification and application. A large list of candidates was generated, whereby a down selection was conducted, representing the test base that will be discussed in Section 5.3.2.

5.2 Evaluate Requirements

Existing requirements, mainly those called out in military documents, were used as reference to create evaluation guides to evaluate products and determine testing procedures. It was thought that starting in this way with stringent guidelines will quickly identify those products that tend to have the greatest direct opportunity for merchant and naval marine applications. However, one must be cautious in this assessment. If a product does not meet a certain stringent requirement, it is not necessarily the case that the product is not the most effective product for an application in another industrial, commercial or residential setting. This process of evaluation does enable one to detect the most suitable products for military and non-military applications quickly, though.

The following are the requirements that were reviewed.

Table 5.2-1 Requirements Reviewed

References and Standards for Cable Terminations and Connectors

Item	Reference	Distribution	Section	Section Language	Remarks
1	MIL-C-55243: Connectors, Plugs, and Receptacles, Electrical, Quick Connect and Disconnect, 12 Contacts, Medium Power (NOTE - Listed	Not listed (A - Public Release)	3.8	**Contact retention.** Individual contacts shall be capable of withstanding an axial load of 10 pounds minimum uniformly applied at a rate of 1 pound per second. (see 4.7)	Each Contact shall withstand a load of 10 pounds
			3.1	**Contact resistance.** The voltage drop across mating contact terminals shall not	Resistance between two connected

References and Standards for Cable Terminations and Connectors					
Item	**Reference**	**Distribution**	**Section**	**Section Language**	**Remarks**
	as not for new design)			exceed 20 millivolts when a current of 7.5 amperes is applied (see 4.9).	terminals will be 2.67mΩ or less
			3.11	**Dielectric strength.** The connectors shall show no evidence of breakdown when subjected to a potential of 1500 volts rms, 60 cycles per second, for a minimum of one minute (see 4.10).	Adjacent terminals will be able to handle a 1500V difference without arcing
			3.12	**Insulation resistance.** The insulation resistance shall be not less than 1000 megohms except for unmated connectors following the immersion test when it shall be not less than 100 megohms (see 4.11).	1000MΩ minimum insulation resistance between separate terminals.
			3.19	**Pull.** Mated connectors shall withstand an axial pull of not less than 40 pounds applied to the shell and 25 pounds applied to the cable. The force shall be applied abruptly (see 4.18)	Mated connectors shall withstand 25lbs applied to the cable.
			3.21	**Temperature cycling.** At the extreme temperatures during the test specified in paragraph 4.20, the connectors shall be capable of being mated and unmated.	Connectors shall function during Method 102A test condition D of MIL-STD-202
			4.21	**Vibration (see 3.22).** Mated connectors shall be tested in accordance with Method 201 of Standard MIL-STD-202.	Connectors shall function during vibration test.
2	MIL-DTL-22992: Connectors, Plugs, and Receptacles, Electrical, Waterproof, Quick Disconnect, Heavy Duty Type, General Specification for	Not listed (A - Public Release)	3.7	**Contact resistance.** When connectors are tested as specified in 4.6.4, the resistance of mated pin and socket contacts shall be such that the potential drop at the test current specified in table I shall not be greater than the values specified.	Contact resistance depends on Contact size. (EX: Size 16, 20A current, 25mV maximum drop, 1.25mΩ. Increases as Contact size increases)

References and Standards for Cable Terminations and Connectors

Item	Reference	Distribution	Section	Section Language	Remarks
			3.8	**Dielectric withstanding voltage.** When connectors are tested as specified in 4.6.5, connectors shall be capable of withstanding the applicable voltages shown in table II without flashover or breakdown.	Maximum voltages at sea level range from 1000VAC to 7000VAC based on rating.
			3.11	**Contact retention.** When contacts are tested as specified in 4.6.8, they shall be capable of withstanding the axial loads shown in table III.	Contact retention depends on size. Withstand axial loads ranging from 10lbs to 35lbs between size 16 and 4/0
			3.13	**Insulation resistance.** When connectors are tested as specified in 4.6.10, the insulation resistance (prior to conditioning) shall not be less than 5,000 megohms	Insulation resistance minimum of 5000MΩ
			3.17	**Cable pull-out.** When connectors are tested as specified in 4.6.14, test cables (see 4.4.3) shall not pull-out when the loads given in table V are applied, nor shall slippage exceed .125 inches (3.18 mm)	Cables shall withstand loads from 50-125lbs of fource (based on weight of cable) without slipping more than 0.125"
			4.6.6	**Thermal shock (temperature cycling).** Unmated connectors shall be tested in accordance with test procedure EIA-364-32, condition I, 5 cycles, except that the high temperature shall be 125°C, +3°C - 0°C (see 3.9).	Connectors shall withstand temperatures detailed in EIA-364-33

References and Standards for Cable Terminations and Connectors

Item	Reference	Distribution	Section	Section Language	Remarks
			4.6.15	**Vibration (see 3.18).** Connectors with suitable adapters shall be tested in accordance with test procedure of EIA-364-28.The following details and exceptions shall apply: a. Test condition number: **III**. b. Counter part plugs shall be engaged with the mounted receptacles and held by normal locking means only. No safety wire shall be used. c. The vibration of the receptacle and fixture shall be monitored by a suitable sensor at a point or on the fixture near a receptacle support point or on the receptacle itself. d. All contacts shall be wired in a series circuit with at least 100 milliamperes of current flowing through the series circuit during vibration. e. The cable or wire bundle shall be clamped to non-vibrating points at least 8 inches from the rear of the connectors. The clamping length may be selected or changed to avoid resonance of the cable or wire. f. The grounding contacts of class L grounding connectors shall not be wired into the series monitoring circuit.	Connectors shall withstand vibration detailed in EIA-364-28, Test condition **III**, with exemptions as listed

References and Standards for Cable Terminations and Connectors

Item	Reference	Distribution	Section	Section Language	Remarks
			4.6.17	**High-impact shock (see 3.20).** Complete mated connectors with suitable adapters shall be tested in accordance with method 207 of MIL-STD-202. The following details and exceptions shall apply: a. Mounting fixtures - In accordance with MIL-STD-202, method 207, standard mounting fixtures for electrical-indicating switchboard meters and other panel-mounted parts. b. Electrical load and operating conditions - All contacts shall be wired in a series circuit with at least 100 milliamperes of dc current flowing through the series circuit during high-impact shock. c. Monitoring during test - A suitable device shall be used to monitor the current flow and indicate any discontinuity which exceeds 10 micro-seconds interruption of current flow. The grounding contacts of class L grounding connectors shall not be wired into the series monitoring circuit. d. The mated connectors shall be held together only by the normal locking device cable or wires shall be supported on a stationary frame not closer than 12 inches (305 mm) from the connector assembly.	Connectors shall withstand shock as detailed in MIL-STD-202, method 207, with exemptions as listed
			3.22	**Heat rise (class L).** When connectors are tested as specified in 4.6.19, the temperature rise of the individual contact terminals shall be not more than 30 Deg C (54 Deg F) above ambient temperature. There	No more than 30 Deg C above ambient temperature during 4 hours at full load

References and Standards for Cable Terminations and Connectors

Item	Reference	Distribution	Section	Section Language	Remarks
				shall be no evidence of physical damage.	
3	MIL-DTL-24558: Terminal boxes, Connection, for Electrical and Electronic Systems, General Specifications For	Not listed (A - Public Release)	3.4.4	**Terminals.** Terminal boards shall be in accordance with A-A-59125 and of the type specified in the applicable specification sheet. Terminal lug assemblies and terminal lug bases shall be as specified in the applicable specification sheet.	Specification for terminal boards
			3.4.4.1	**Mounting brackets.** Unless otherwise specified (see 6.2), the terminal board mounting brackets and pads shall be of brass and shall be as shown on figures 1 through 5. Mounting bracket and pad installation shall be as specified in the applicable specification sheet.	Standard mounting for Terminal boards. (For alternate, see 3.4.4.2)
			3.4.5	**Threaded parts.** Threads for all threaded fastening devices shall conform to FED-STD-H28 and FED-STD-H28/2. The threads shall be right hand, coarse thread series, unified thread form, class 2A or 2B, or American National thread form, class 2. Other thread series and classes, such as fine thread, may be used where it is necessary to assure functional operation of the equipment. Threads shall be checked during production with go-no go gages to insure conformance to FED-STD-H28 and FED-STD-H28/2.	Threaded fastning devices shall meet FED-STD-H28
4	MIL-T-16366F: Terminals, Electrical Lug and Conductor	Not listed (A - Public Release)	3.3.2	**Method of Crimping:** The lug terminals and conductor splices shall be capable of being attached	Lugs are crimped togeather

References and Standards for Cable Terminations and Connectors

Item	Reference	Distribution	Section	Section Language	Remarks
	Splices, Crimp-Style			to cables and wires by crimping. The method of crimping shall result in an attachment that will meet the performance requirements specified herein.	
			3.4.1	**Temperature Rise:** Lug terminals and conductor splices shall be designed to carry the rated load continuously with a temperature rise of not more than 5 degrees Celsius above that of the cables to which they are connected (see 4.7.2)	Lug temperature cannot exceed cable temperature by more than 5 deg. C at full load.
			3.4.2	**Pull-out Strength.** Lug Terminals and conductor splices shall be attached so that the cable or wire will not pull out nor will they break or become distorted to the extent that they are unfit for further use before the minimum pull-out force specified in tables **I**, **II**, **III**, and V is attained (see 4.7.3)	Pull-out force varies based on cable size. (190Lbs-3000lbs, from 14-1600 size, 14340-1662000cmil)
			3.4.4	**Voltage Drop:** The average voltage drop through the lug terminals and conductor splices at rated loads shall not exfeed the values shown in the applicable tables specified herin (see 4.7.5)	Voltage drop varies based on cable size. Measured after temperature is stabilized.
			4.7.4	**Vibration:** The terminals or splices shall be attached to a length of cable or wire. The lug terminal under test shall be rigidly mounted to the vibration table with wire of the conductor splice under test shall be rigidly mounted to the vibration table and the opposite end of the cable or wire secured to a stable support. One end of the cable or be approximately midway between the support and table. The	Vibration Testing: Vibrate for 2 hours in two orientations, frequency 10 to 55 to 10 Hz (cycling through these frequencies each minute). Cable shall not come loose.

References and Standards for Cable Terminations and Connectors

Item	Reference	Distribution	Section	Section Language	Remarks
				sample units shall be vibrated the opposite end of the cable or wire shall be secured to a stable support. The splice shall of 1/16 inch (total excursion of 1/8 inch), at a cycling frequency of 10 to 55 to 10 Hertz for 2 hours on each of the perpendiculars to the axis of the cable wires at an amplitude (Hz). The cycling frequency shall be accomplished in 1 minute. There shall be no evidence of the cable or wire becoming loose or signs of distortion.	
5	A-A-59125: Commercial Item Description - Terminal Boards, molded, Barrier Screw and Stud Types and associated accessories	A - Public Release		**	Each has its own CID. Ex: A-A-59125/1 s300 V rating, 3000VRMS Dielectric withstanding, 15A current rating.
6	SAE AS7928: Terminals, Lug: Splices, Conductor: Crimp Style, Copper, General Specification For	Not listed (A - Public Release)	3.5.1	**Voltage Drop:** When tested as specified in 4.7.2, the millivolt drop of the lug terminal or conductor splice shall not exceed the millivolt drop of an equivalent length of wire by more than the value specified in Table 2.	Based on material and size, for a given test current. Ranging from 1.6mΩ to 13μΩ for wire guages ranging from 26 to 0000 AWG.
			3.5.3	**Dielectric Withstanding Voltage (type II)** When tested as specified in 4.7.4, insulated lug terminals and conductor splices shall show no evidence of damage, arcing, or breakdown.	Method 301 of MIL-STD-202 Dielectric Withstanding testing
			3.5.5.1	**Axial Load (type I, multiple piece construction, crimped and uncrimped specimens)** On multiple piece construction, the metal sleeve on uncrimped lug terminals shall withstand a minimum axial	Multiple Piece Construction: Uncrimped lug shall withstand 8lbs of force, shall not more more than 1/32" (Type II has similar

References and Standards for Cable Terminations and Connectors

Item	Reference	Distribution	Section	Section Language	Remarks
				force of 8 pounds and shall not move more than 1/32 inch on the barrel of the lug terminal. The metal sleeve on a crimped lug terminal shall withstand a minimum axial force of 8 pounds (see 4.7.6.1 and 4.7.6.2).	requirements)
			3.5.6	**Vibration** When tested as specified in 4.7.7.1 or 4.7.7.2, there shall be no evidence of cracking, breaking, or loosening of parts. After vibration, the voltage drop shall not exceed the “after test” values specified in Table 2, and tensile strength shall be not less than the values specified in Table 2 or Table 3, as applicable.	Method 201 of MIL-STD-202 for 18 hours on each of two axes mutually perpendicular to each other (for units with insulation support and sizes 12 and larger without). Units size 14 and smaller without insulation support only test for 2 hours.
			3.5.7	**Tensile Strength** When tested as specified in 4.7.8, lug terminals and conductor splices shall not break or separate from the wire to which it is terminated before the minimum tensile strength specified in Table 2 or Table 3, as applicable, is reached.	Ranges from 5lbs to 875lbs for sizes from 26 to 0000 AWG
			3.5.9	**Heat Aging (type II)** After testing as specified in 4.7.10.1 or 4.7.10.2, lug terminals and conductor splices shall meet the dielectric withstanding voltage requirements specified in 3.5.3. Discoloration of the insulation material during this test shall not be cause for rejection.	Based on rating: contained in heated chamber at 105 or 150 deg C for 120 hours, then cooled to 23 deg C within 1 hour.

Notes: pins - SAE-AS39029
Connector - SAE-AS85049C

References and Standards for Cable Terminations and Connectors

Item	Reference	Distribution	Section	Section Language	Remarks
	Connector - NEMA 119-4 terminal board - mil-t-55164 (superseded by A-A-59125)				

As can be seen from Table 5.2-1, there are many overlapping requirements from various sources that may target specific segments of the military or private sectors. As shown in Section 5.3, these were narrowed down to those specifications that have the most applicability at this stage of feasibility assessment, motivated from cost and time perspectives.

Although it can be considered a subset of Table 5.2-1, Table 5.6-1 indicates the specifications and standards that were referenced when conducting the respective tests. Relevancy and testing standards overlap were reviewed and a specific test table was generated indicating general sequence of the tests, which is shown in Table 5.6-2. The order of the test was chosen as shown to minimize influence of the outcome of a particular test negatively influencing another test. For instance, all electrical characterization tests were chosen to be done before the performance tests due to their low incident of damage (except for the dielectric withstand test since this test represents one of higher risk of damage). In this way, it was hoped that data could be generated and testing could move to the next, increasing risk test. Such is the case with the shock and vibration testing. After conversing with the laboratory, feedback suggested the vibration test represents a higher risk type of performance test than the shock test, since certain characteristics were not yet known going into the test, such as resonant frequency. Should the resonant frequency be at a value corresponding to the frequency range that is chosen for testing, it is possible, even for the lower mass items, the units will destroy themselves. Obviously, this is a high focus item of prevention.

Table 5.6-2 covers the majority of items that one can use to form an evaluation of product capability.

5.3 Generate Evaluation Guide and Preliminary Product Evaluation

An evaluation guide was created to capture data that would later be used for comparison purposes across products. See Section 8.2 for a depiction of the table used. The Excel worksheets are also available upon request. Data was compiled as a means of product evaluation, using information in Section 5.2 as a reference for creating the guidelines shown in the table. One of the worksheets, as will be discussed in Section 5.6.3, ranks and scores the characteristics and performance data as compared to the evaluation guideline. This effectively lends insight into the likelihood that a particular product in the tested configuration will pass certain testing requirements similar to those called out in this study.

5.3.1 Generate Evaluation Guide

Certain standard characteristics are included in the evaluation guide, such as electrical characteristics previously referenced in thermal ratings, body materials, dimensional and weight data, and conductor retaining mechanism type and features. These areas form the basis for the evaluation guide and allow the user to compare the static characteristics even before performance testing and resulting data. This has effectively allowed the team to choose those products of highest interest, as described in Section 5.1. This approach could be applied to a much larger population of connectors, but due to overall project scope, this particular population of test articles seemed sufficient.

These units seem pretty small, but that is perspective. Dimensional data, weight data, short circuit capacity, and other seemingly unnecessary characteristics are still important. When one considers using many units of a particular product in a control box or power panel or drive, it becomes quickly apparent that this type of data is useful (refer to Figure 5.1-2). Having this information in a format where one can easily compare product attributes to product attributes allows the designer to best match the product to the application or design, whether primary drivers include space constraints, budget constraints or interface.

5.3.2 Preliminary Product Evaluation

Data sheets were compiled and used to populate the tables shown in Section 8.2. Most data was obtained either directly from the vendor, supplier or manufacturer, or from a catalog, either listed on the company website or in print form. Figure 5.5-2 and Figure 5.5-14 are representations of the products tested, and how they interfaced the test plate (i.e., DIN [Deutsches Institut für Normung] rail mounted, foot mounted or otherwise). The test plate or fixture arrangement will be discussed in more detail in Section 5.5.1 and more descriptive visual representations will be shown in Section 5.5.2. (where each test article is presented with short descriptions).

5.4 Develop Test Procedure and Generate Testing Scope of Work

5.4.1 Develop Test Procedure

The development of the test procedure was driven in part by the following:

- Project budget
- Project goals and objectives (i.e., feasibility assessment rather than qualification testing program)
- Relevance to programs of interest, such as military applications and certain merchant marine applications
- Current state of product qualification
- Types of tests that would likely be part of the testing and qualification requirements on a program of interest
- Type of data obtained from a testing program, that could be directly used on programs of interest

Certain testing requirements, such as those outlined in MIL-STD-901, were used to design the testing fixtures, so that minimal interface design would be necessary at the laboratory. Their testing stations are designed and operated in strict accordance with such standards, and deviation from requirements outlined requires changes on their part, either by interfacing with other hardware or requiring unique structures to support the testing in general. This generally adds cost and scope. As shown in the testing procedure, two primary areas of testing have been generated: Tests determining primary electrical characteristics and test that determine operational capability. The tests are shown in Table 5.6-2 with the corresponding reference and order of the test. Also, all of the electrical testing was completed at BIW, as well as the mechanical conductor retention test after initial installation. The conductor retention test was also conducted at the lab, to inspect whether the device had failed after the performance tests. The order of the tests is primarily due to when the testing fixture is available for testing, and the impact a failure might have on the remaining test sequences. Although each test has importance in its own right, the shock test is a test that requires attention and is therefore first in the test sequence. If a unit fails this test, then the rest of the tests are not critical in this type of demonstration for this particular test article, although efforts were made to rectify any failures before proceeding with other testing. During qualification and first article testing, that will not be the case, however. The test procedure for official qualification testing may require a second or third test article, exhibiting the same features and attributes, to be tested as a means of test validation and repeatability.

Inspection of the test fixture and individual test articles is done throughout the process for any evidence of failures, failure modes, impending failures or stable response. This is done to identify any issues that may reside with a particular test or the way a test is administered.

Due to budget constraints, it was determined that during performance testing, the tests will be done de-energized, and contact resistance measured during the test, indicating whether the connector failed to maintain a tight connection. This is a deviation from the standards, but during a qualification program, it would be budgeted directly to do the testing in the sequence indicated in the test procedures, while the unit is energized. Using sensitive and fast response data acquisition equipment, contact resistance will indicate whether the test subject will maintain a proper continuity. Voltage drop will be calculated from the value obtained during this test, which will indicate whether the test article will meet certain power quality standards for the interfaced application (i.e., DoD 1399-300B Sect. 5.1.1). The testing completed for this project is more in line with pass/fail testing, whereas a qualification testing might be more in line with profile testing.

Only certain sections of the testing references are used to generate the testing procedure. Those are sections that sufficiently test a certain attribute or capability such that one can determine whether the test article has met a certain requirement or has the possibility of meeting a particular requirement with minimal revision and modification.

Due to the type of contract arrangement that was used for this project, a testing scope of work was developed and delivered to SCRA for administration. The scope of work outlines terms of testing and references the testing procedure.

The test procedure used for this project is included in Section 8.4.

5.5 Demonstrators

5.5.1 Design the Demonstrators

Section 8.3.1 describes the demonstrator test plate design visually with the drawing information. It was decided, due to the number of test articles spanning the spectrum of configurations, two plates would be sufficient, in order to conform to standard test plate dimensions. The layout of the test plates was done to best accommodate type of mounting arrangements (i.e., DIN rail versus foot mounted or other).

The test plate material and thickness was chosen to replicate certain types of materials typically seen on naval vessels. Reinforcement has been added along the longitudinal and cross member center lines. In this arrangement, any response frequencies that are set up due to shock or vibration loading might be similar in nature to those types of plates and boxes used on various programs. This design is based much on experience. An end flange is created for two edges, while rolled crimps are used on the other two edges to offer rigidity in the corresponding direction. It was decided, after the design was complete and the plates manufactured, to fasten the plates to the test fixture through the plating rather than the flange. Originally, the flange was going to be the point of fixture. This method of attachment was chosen so that unnecessary flexure and amplified resonances will be avoided. However, the opportunity to test such an arrangement presents itself in two primary ways:

1. Test article testing: Testing of the chosen products is of foremost concern. Hindering this process puts the project testing at risk, since it is the capability and response of the test articles that the team is most interested in.

2. Application testing: These test articles are configured and laid out in a certain way that presents an opportunity to determine how they fare under a typical layout, interface and configuration. It is likely that the entire test module would be tested as a unit, not each individual component of this size. Therefore, the unit as a whole might well replicate what one would design or encounter on a program incorporating such devices.

A key aspect is to perform the testing so that both parts of the testing are performed without compromising the first point since this project is a focus primarily on the feasibility of the use of quick connector technologies in marine environments, primarily in military applications. This is a more stringent approach and could be considered conservative from a system standpoint, since it is likely that if an individual test article passes all tests, it is likely that is will pass in a more systems oriented environment, such as a box or plate family of products where the box or plate itself is shock mounted. If the box or plate is hard mounted, then, aside from the mounting arrangement being possibly of different response modes, the response to testing individually versus in the total mounting arrangement would likely be similar. Testing multiple articles at once on similar substrates and mounting arrangements is generally more cost effective and time effective as well.

Not all varieties of possible mounting arrangements have been included in the demonstrator designed (i.e., for any given test article, not all possible arrangements are tested, primarily due to volume of configurations). It was decided that various configurations can be spread out over available manufacturer mounting arrangements and the results assessed and the field of configurations sufficient to draw conclusions. Applicability would be similar for one manufacture to another, even for somewhat different configurations. For instance, if one manufacturer product is mounted on DIN rail, and another via a foot arrangement, the interfacing structures can be assessed to determine relative response and failure mechanisms (if they exist) and compared on a somewhat similar basis without having to install all of each manufacturer configurations (i.e., 2 units total versus 4 units). Generally, the mounting arrangements tested are either a DIN rail type of mount or direct foot mount. Other types of mounting arrangements exist, such as direct interface to other equipment for terminals interfacing to limit switches on breakers, but the primary mounting arrangements investigated in this study represent the majority of what is expected to be considered for a particular design.

Intermediate partitions and end plates are used between the individual manufacturer products for the DIN rail mounted equipment since it is likely that a DIN rail mounting system would be designed in similar fashion even if there are different manufactured products along the same DIN rail interface. Even though this represents a scenario where each product is not isolated, it is not expected to cause negative effects due to the similarity in products being tested (i.e., no unique stresses are placed on adjacent units and response is expected to be similar across products during all dynamic testing).

Splicing units, those shown as items 27, 11, 13, and 14 in Figure 8.3-6, have been designed to be both secured and unsecured. These units are typically housed in enclosures where securing them is not an absolute necessity, so provisions for securing the units are generally not provided other than available slots to pass devices such as tie wraps through. No feet or other mounting arrangement exist. A reason for securing them is to compare to the performance of the unsecured units and if the unsecured units fail (i.e., the housing fails due to impact to the test plate), then the contact retention devices will have been tested and performance of these components can be assessed. It is likely that if this type of device were to be pursued as a candidate for designs, a holding or securing mechanism would need to be designed into the device. These types of devices are essentially a wire nut that holds the conductor in its own interface space; instead of holding conductors in immediate contact with each other, the contact is done via a contacting interface in the device. This tends to minimize damage to the conductors, especially if the conductor comprises high stranding where twisting of the strands tends to damage or break the strands of a particular conductor.

Each device is described in the tables in Sect. 8.2. As a note, however, item 2, as shown on Figure 8.3-6, is considered the baseline unit that has been approved for military use in Grade A shock conditions. Item 36 in Figure 8.3-6 is considered a prototype that is not currently available in the configuration that is being tested. It was deemed a candidate since this type of connection might be used on power systems that may employ low voltage and high current (less than 600 V) and may prove to be useful in a similar manner as other units that are more suitable for instrumentation or controls applications.

Figure 8.3-1 depicts the front view of the test plate and all associated dimensional data while Figure 8.3-2 depicts the top view. The size and mounting arrangements of the test plates are in accordance with Mil-S-901D and Mil-Std-167-1A. As shown on Figure 8.3-2, a safety barrier is designed as a provision. Originally when the project testing sequences were being generated, it was not known whether a full load test would be conducted during dynamic testing. Since that time, it was decided that only a contact resistance test would be used as a determinant for product performance and full load testing would not be a test condition during dynamic testing. Therefore, it is unlikely that the phenolic standoffs and plate will be needed during these tests; however, they are provisions in the event these tests are completed at a future time.

As mentioned previously, flanges and crimps have been provided for reinforcement, as shown on Figure 8.3-3. The bars that have been riveted to the back of the test plates are shown on the drawing, and are made of aluminum and are 1” wide by ¼ ” thick. All mounting arrangements with dimensions for foot mounts and DIN rail mounting are shown on Figure 8.3-3 and Figure 8.3-4. All parts used for these test plates and test articles are shown on Figure 8.3-5 with the exception of miscellaneous hardware such as partition plates and end plates in some circumstances for DIN rail mounted connectors. Certain end clamps are shown for the DIN rails. These effectively hold the mounted terminal blocks in place and keep the whole column of connectors from shifting out of the DIN rail mount. The end plates are specifically designed to conform to the corresponding part to cover the energized parts of the terminal block, while partition plates allow the user to install multiple types of terminal blocks (different manufacturers or models) on the same DIN rail with spacing between units.

Figure 8.3-7 shows the cables that will interface to the test articles. The design uses the following sizes called out by the unit manufacturer: maximum, the minimum, and average of the two sizes. Pull retention will be done on all of the cables. Only the average sized conductor will be instrumented during the dynamic testing since this requires a large number of channels to accommodate (instrumenting all conductors would be prohibitively expensive). An actual qualification testing program would likely call for instrumenting maximum and minimum sized conductors, but this is a test to determine overall performance, and the average sized conductor was chosen as a good remedial indicator of performance. All conductors are standard stranded conductors, 600 V conductor, ranging in size from #10 AWG to #24 AWG, and typical stranding of counts ranging from 16 to 26. This is typical conductor design for these types of connectors following design criteria set forth in MIL-DTL-24643 (except the unit 36 on Figure 8.3-6 is a different stranding, larger sizing, as it is a prototype that was offered for the testing).

5.5.2 Build the Demonstrators

Construction of the demonstrator units commenced without issue in accordance with the design. The manufacturing and shock and vibration groups have been involved in the process throughout which greatly helped in determining whether any design issues would prevent sound construction or rigorous testing. A few minor items were addressed, but nothing that compromised the design or products.

Following are pictures detailing the product arrangement and each product representing the test articles. Refer to the tables in Sect. 8.2 for more detail for a particular test article. Some unique descriptions will be provided below as necessary.

Figure 5.5-1 shows the test plates with all 27 test articles mounted. The four columns of bars with rubber mounted underneath will be used to secure the cables once installed. The bottom plate is the first plate shown on the drawing shown in Figure 8.3-6 and the top plate is the one shown second on the drawing in Figure 8.3-6. (The first plate is lying down since there are parts that are not secured yet due to cables not being installed at this time [items 27, 11, 13, and 14 as shown in Sect. 8.2.]).

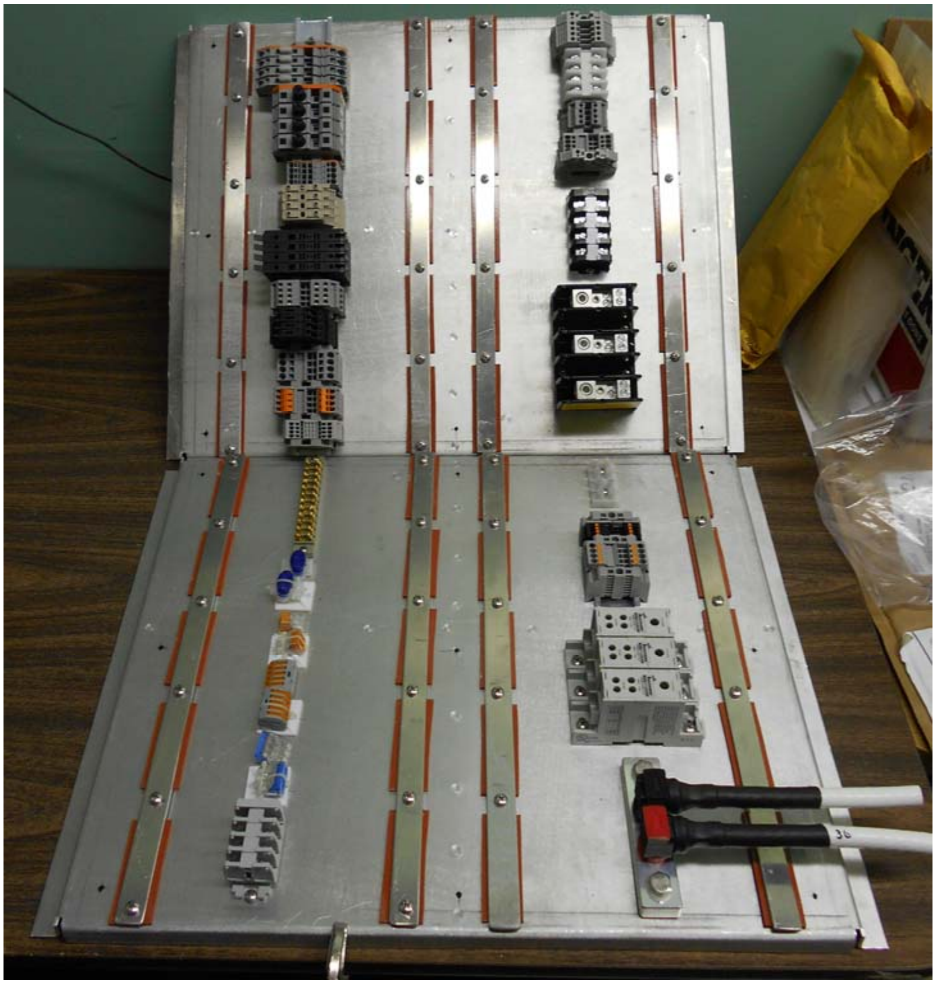


Figure 5.5-1 Test Panels with Test Articles Installed - Before Cable Installation

The lower right unit in Figure 5.1-2, item 36, is the prototype from Tyco Electronics and is considered a power connector. However, since the unit is in a prototype stage, it was decided that it would be appropriate to include the design in this testing sequence.

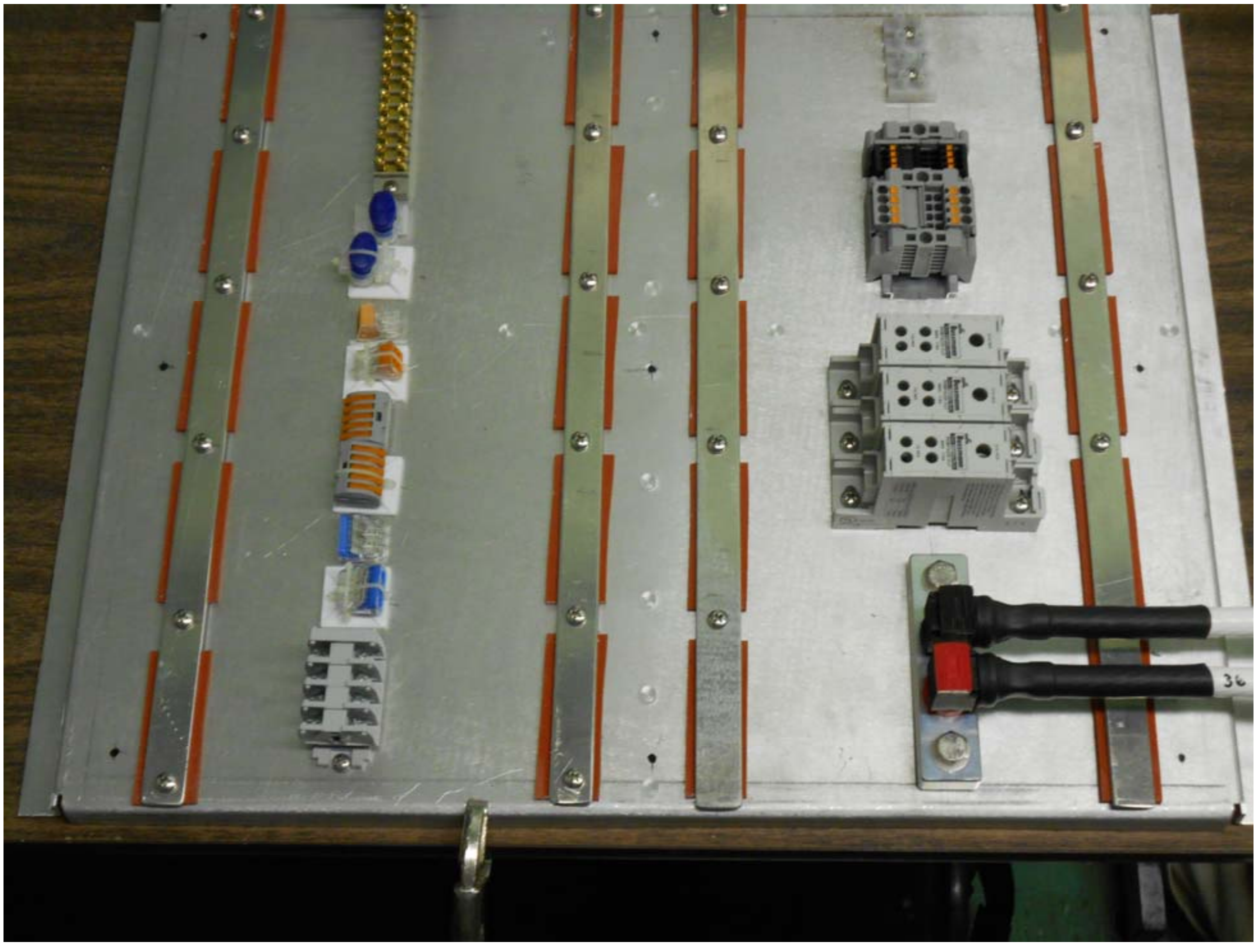


Figure 5.5-2 Test Plate No. 1

Figure 5.5-3 represents one configuration and size for the currently used, and military approved, terminal block assembly. As can be seen, it is quite rugged in its design and requires individual post caps to be tightened in accordance with prescribed torque values, adding time and effort to the overall termination process. Each conductor needs to utilize military approved lugs (crimped, swaged or soldered) to interface to the terminal block. They interface the stud, then the threaded end cap is installed over the top, and torqued to provide the retaining mechanism for the terminal block.

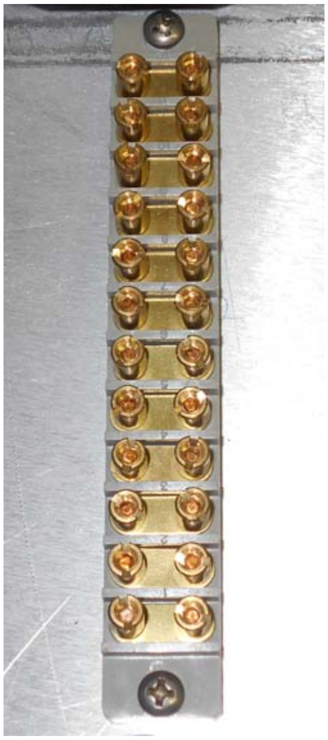


Figure 5.5-3 Item 2: A-A-59125/24

The remaining figures represent products that are not currently approved for Navy military use as stand-alone units that must meet shock and vibration requirements, and various ESS requirements. They each have certain features that may make them desirable for certain applications. Figure 5.5-4 through Figure 5.5-7 show splice units that work similarly to a wire nut. Most are 3 or 4 conductor units. One of the units for each set is secured using a tie wrap and an adhesive backed interface connection, while the other, as will be seen later, is secured only via the conductors interfaced to the unit. The unit in Figure 5.5-4 uses a gel material and cuts into the insulation to make the interfacing contact between the conductor and the internal contact strip. This is the only test article that does not require the conductor insulation to be stripped back in the traditional sense. This is a very quick process, but relies greatly on the way in which it is interfaced, the consistency of the cutting components and conductor insulation (material and thickness consistency) and offers a small interface along an edge that requires some derating. This method of attachment is being used and assessed for ease of attachment, and the possibility of using something comparable in the future in a military application (these pads are currently allowed in commercial applications), but this is not considered the only way to secure the units for operation or testing. In fact, it is likely, after reviewing the performance testing results and inspecting the test articles, other mounting arrangements may be recommended if this proves to be a viable type of connector.

Figure 5.5-4 Item 27: 3M 314-BOX

Figure 5.5-5 depicts a unit that requires conductor insulation stripped back, and uses a spring retention mechanism to hold the conductor. Many of the units use a spring retention method, of various configurations (some more complicated than others) to retain the conductor, that can be defeated or not (without damage).

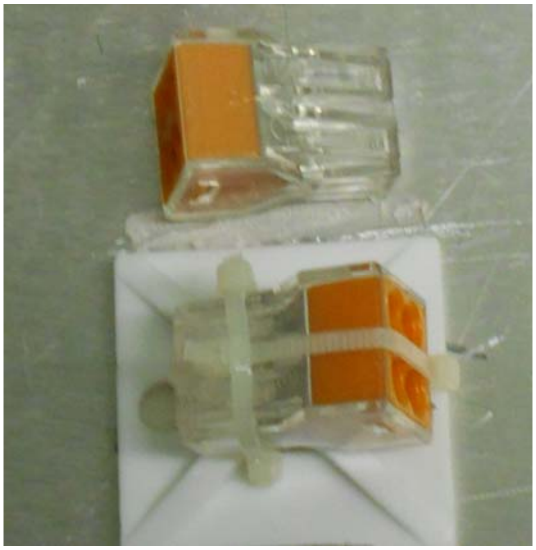


Figure 5.5-5 Item 11: Wago 773-164

Figure 5.5-6 shows a Wago unit that uses lever mechanisms to compress the conductor onto the interfacing plates of the connector. These types of units tend to have wider surfaces that either contact the conductor directly or push on floating contact plates that interface the conductor. The type that use wider surfaces are more compatible with fine stranded conductors. They do require a fair amount of force when using a solid conductor, and have limitations with respect to component damage or contact face deformation.

Figure 5.5-6 Item 13: Wago 222-415

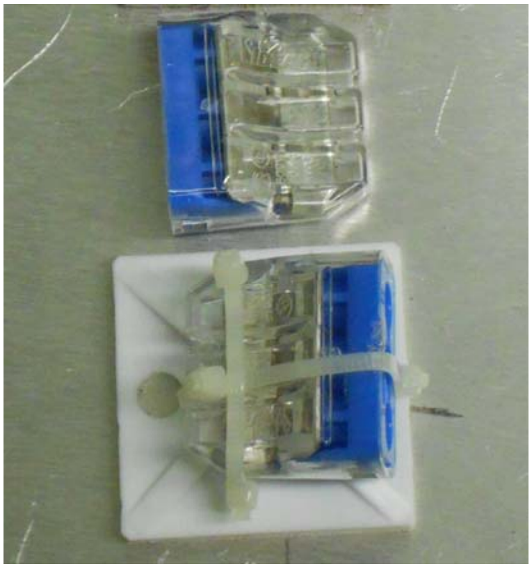


Figure 5.5-7 Item 14: Ideal Model 39/30-1039J

Figure 5.5-8 and Figure 5.5-9 use compression to hold the conductor via a screw pushing on the compression plate. One is enclosed in an integral sleeve (Figure 5.5-9), while the other is isolated by a partition integral to the frame. The unit in Figure 5.5-9 may provide greater conductor isolation. Each is suitable for the same NEMA 1 style application. The item shown in Figure 5.5-9 does not expose the conductor from the top, only at the entrance point where the conductor engages the contacts. This is an inherent safety feature of this device.

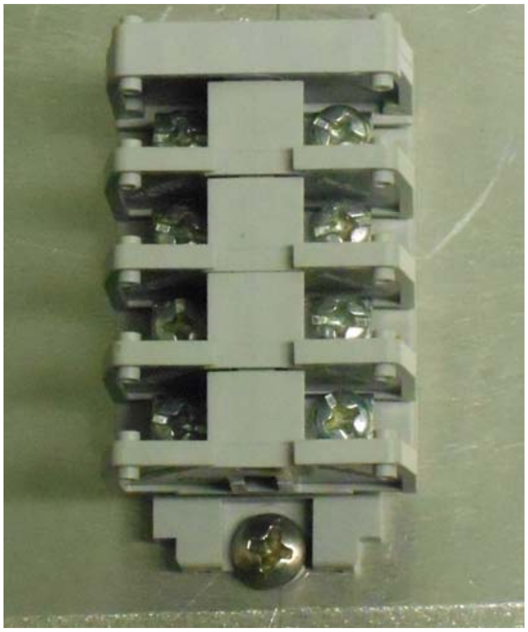


Figure 5.5-8 Item 35: Tyco 925

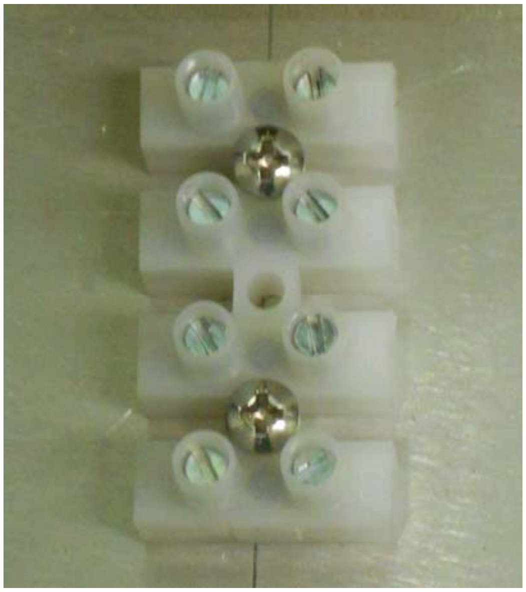


Figure 5.5-9 Item 6: Tyco 1-776302-4

The Phoenix Contact units shown in Figure 5.5-10 and Figure 5.5-11 use similar style of entry and retention, and have defeat mechanisms to release the conductor without damage (but with minor conductor deformation). The end plates holding the DIN rail mounted units are similar adding to common parts and dimensions.

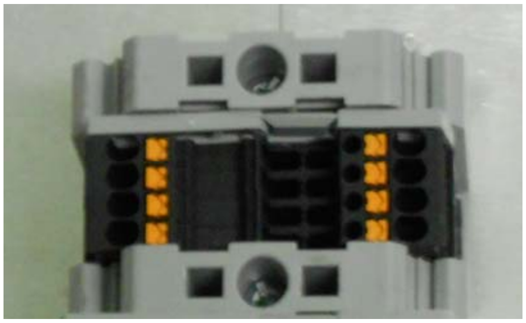


Figure 5.5-10 Item 15: Phoenix Contact PT 1,5/S

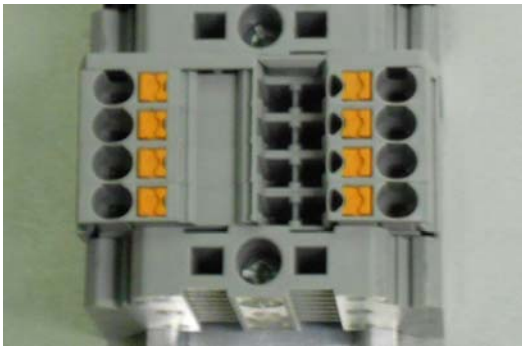


Figure 5.5-11 Item 16: Phoenix Contact PT 2,5

A more unique feature of the unit in Figure 5.5-12 is the fact different sized and numbers of conductor can be used for each side of the connector. The connectors are individually mounted and can be stacked. Conductors are retained through clamps and screws. These units appear to be quite rugged. The internal mechanisms were not inspected before installation onto the test plate. The unit uses compression plates for retention.

Figure 5.5-12 Item 20: Cooper Bussmann PDBFS 220

As mentioned previously, Figure 5.5-13 represents a prototype. The units are not available and the components were manufactured specifically for this project testing sequence. Large posts with grooves accept the connector which has protruding half rings that interface to the groove, allowing for 360 degree rotation as necessary. This occurs on the top and bottom of the post to maximize interface strength. The bus bar, for the purposes of this project, is mounted to phenolic standoffs. The bar provides a surface to mount the studs. Different arrangements might be considered for specific applications, where such bars are not exposed directly. However, this is something the manufacturer must come through as the product moves through development stages.

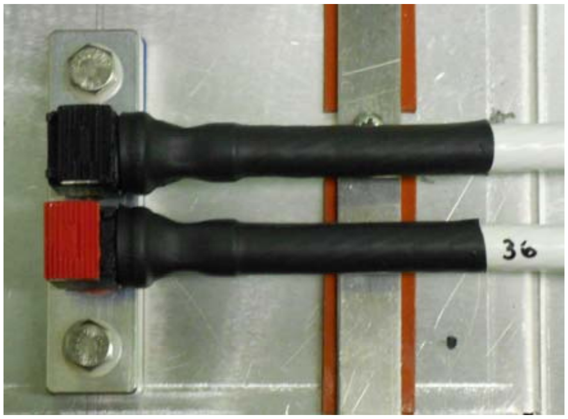


Figure 5.5-13 Item 36: Tyco prototype

Figure 5.5-14 represents the second test plate, similar to the first test plate except with more DIN rail mounted test articles. The plate configuration and design is identical to the first test plate, incorporating crimps and flanges for added strength, and conductor straps to secure the conductors. Figure 5.5-15 shows a Wago test unit with a set of automotive style fuses. They interface the unit by pushing into slots housing copper sprung contacts. Various electrically sized fuses will fit into the receiving slots so the designer has flexibility when designing the circuit components (interfacing devices, cables and conductors, etc.). Other units use different style fuse holders and interfaces, as will be seen later. If the fuse device, or the fuse itself fails, it will be noted and the fuse contacts will be jumpered, effectively taking the fuses out of the circuit, so further testing will not be hindered.

DIN rail mounted units have endplates, shown as the orange plate on the upper end of the terminal block in Figure 5.5-15, as well as end plate stops, shown as the gray colored, smaller fixture on the upper side, or end, of the endplate. The stops interface to the rail with a strong springing action of a metal component contained in the end stop unit. They are generally meant to be installed and left as a permanent fixture. One was installed, and then removed by force, but the molded foot holding the metal component failed upon removal, and created a substantial groove in the rail (this section was not used in the construction of this test plate). It was a good test for the retaining power of the end stops. End stops are generally generic, but the end plates for a particular manufacturer and model are unique, since they must interface the cross section exactly in their dimension to provide the coverage of internal working components (i.e., contact springs, conductor interfacing points). They are molded similarly, with integrated stiffening agents in the molded part. Manufacturers recommend end stops be used for a certain number of connectors forming a terminal strip or block of connectors, to keep pressure on the block itself, and minimize the chance of the whole series from becoming loose on the rail (preventing any movement like twisting from occurring).

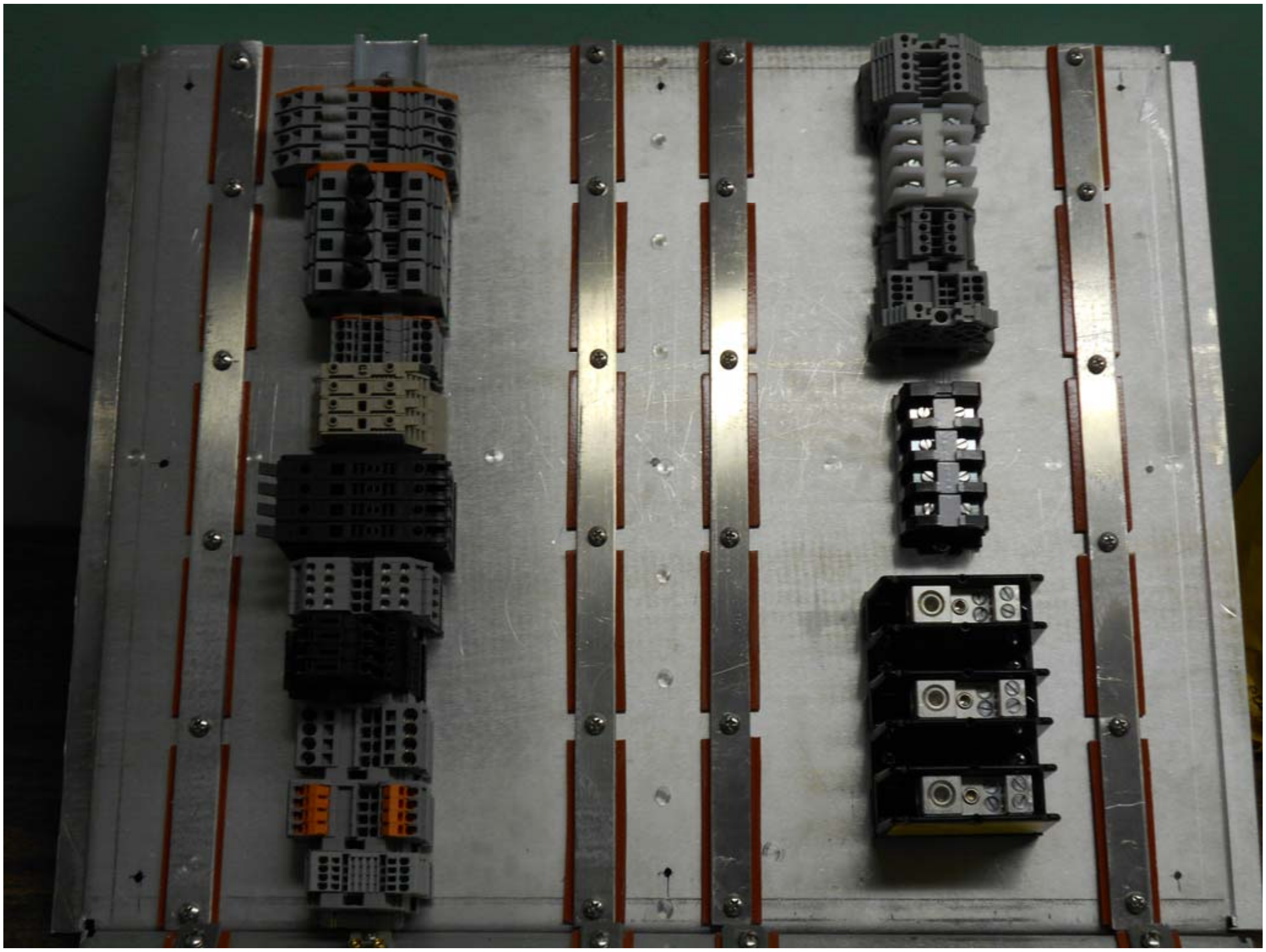


Figure 5.5-14 Test Plate No. 2

Figure 5.5-15 Item 9: Wago 282-696

Shown in Figure 5.5-16 and Figure 5.5-17 is a Wago unit that incorporates a different fuse design. These are screw in, glass style fuses that come in a variety of sizes. Each of the units shown in Figure 5.5-15 through Figure 5.5-17 have defeating mechanisms to allow the conductor to be removed from the termination without damaging the conductor or the terminal block. Defeating mechanisms come in handy during testing and troubleshooting, when isolating circuits is necessary to find issues.

Figure 5.5-16 Item 10: Wago 282-128

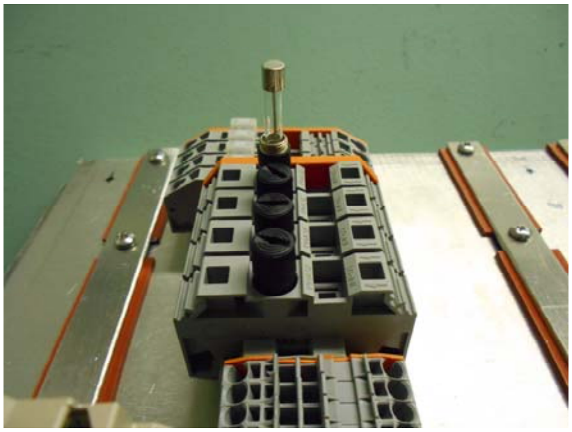


Figure 5.5-17 Wago 282-128 Fuse Component

Levers are used on the Wago unit in Figure 5.5-18 to act as keepers for the contacts that apply pressure to the conductor surface.

Figure 5.5-18 Item 12: Wago 2002-1201

The Weidmuller unit shown in Figure 5.5-19 uses levers as well, but these are on the end of the units. The fuse is housed in a rotating holder that rotates up and away from the connector. This may provide increased isolation from a neighboring fuse since there is a specific connector barrier between them. It may be somewhat important to have this feature should one elect to rotate the fuse upward during operation, isolating the connector, and a neighboring connector block already has a fuse rotated in the upward position.

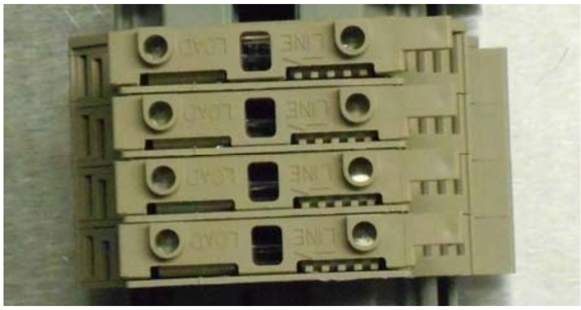


Figure 5.5-19 Item 21: Weidmuller 1011000000

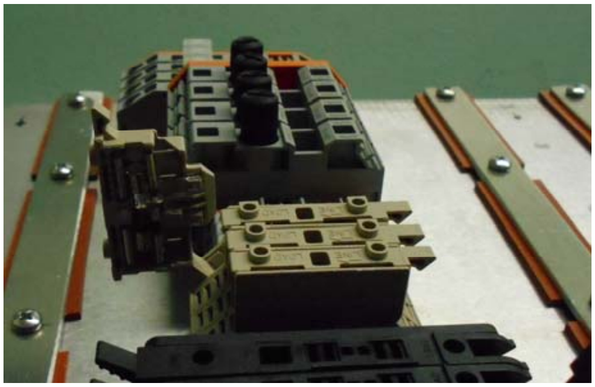


Figure 5.5-20 Weidmuller 1011000000 Fuse Component

Both Weidmuller designs tested have fuses, but in different configurations, as shown in Figure 5.5-20 and Figure 5.5-22. They both incorporate glass fuses, but the unit in Figure 5.5-21 is of a larger size, with a larger fuse component. They each have mechanisms to hold the holder in position and maintain contacts either open or closed.

Figure 5.5-21 Item 22: Weidmuller 1880430000

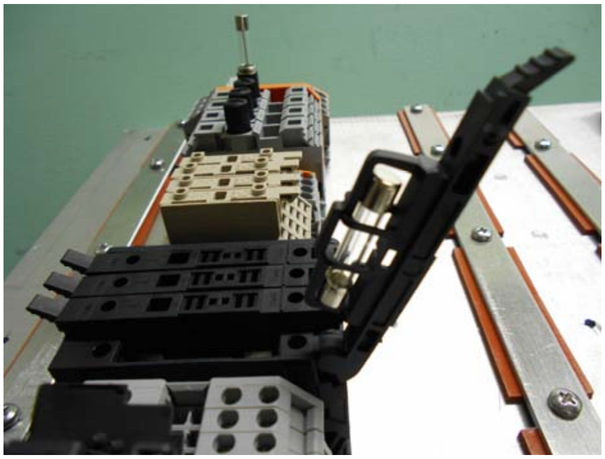


Figure 5.5-22 Weidmuller 1880430000 Fuse Component

The Eaton products, shown in Figure 5.5-23 through Figure 5.5-27, incorporate fuses and don’t incorporate fuses, as a comparison. They use screws and compression to maintain conductor interface. They are both DIN rail mounted and offer top access.

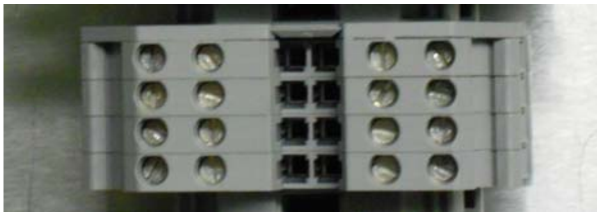


Figure 5.5-23 Item 23: Eaton XBUT25D22

Figure 5.5-24 Item 24: Eaton XBUT4FBE

The fuse holder mechanism for the XBUT4FBE appears robust, interfacing directly with the conductor components in the body of the unit. Testing will tend to prove this out. Latching mechanisms for the fuse holders appear tight, but may prove to be susceptible to high shock loading. Fuse holding mechanisms are generally metal, but the units that have holders that can rotate away from the unit generally employ plastic or nylon hinges. Testing will determine whether these mechanisms are capable of withstanding high shock loading without breakage.

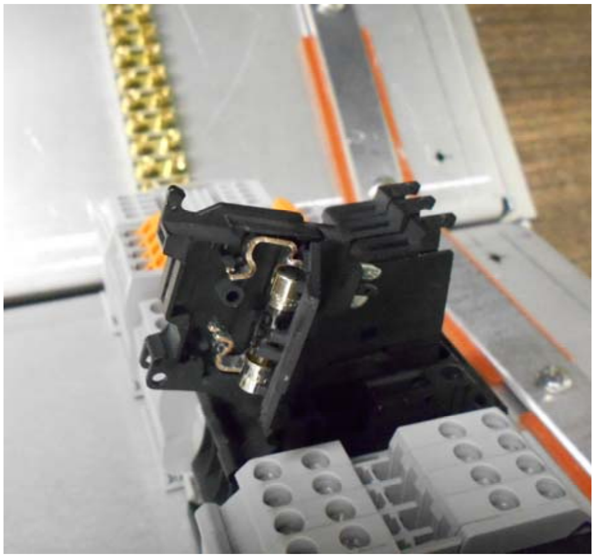


Figure 5.5-25 Eaton XBUT4FBE Fuse Component

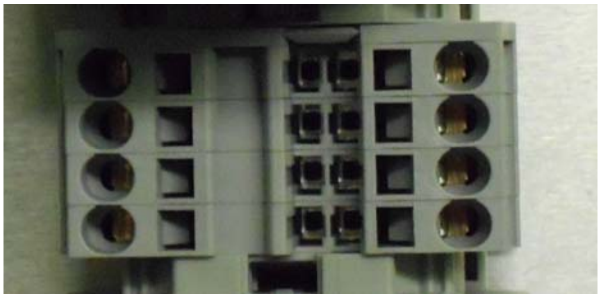


Figure 5.5-26 Item 25: Eaton XBPT4

The XBQT15 model, shown in Figure 5.5-27, uses members pushed in to hold the conductor and does not incorporate fuses. It is a compact design and is DIN rail mounted. The holding mechanisms, integral to the entry for the conductor, shown in orange, are a little tough to push in, but they may represent a sound and strong holding design. This is the only DIN rail mounted unit that cuts into the conductor insulation to establish continuity.

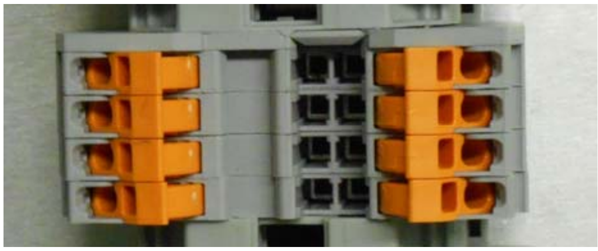


Figure 5.5-27 Item 26: Eaton XBQT15

Figure 5.5-28 through Figure 5.5-30 are Allen Bradley units of various configurations. They use screw-compression retention as well as spring retention (Figure 5.5-30 and Figure 5.5-31, respectively). These two are DIN rail mounted and stackable. They both accept a fairly wide range of conductor sizes.

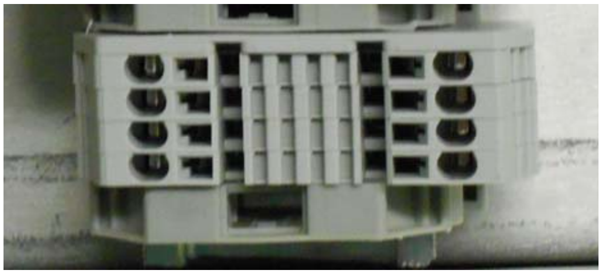


Figure 5.5-28 Item 28: Rockwell Allen Bradley 1492-L2

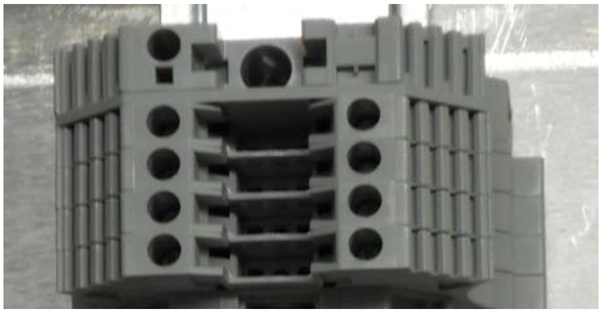


Figure 5.5-29 Item 29: Rockwell Allen Bradley 1492-J3

The Allen Bradley model 1492-CAM1, shown in Figure 5.5-30, is a traditional terminal block unit, very similar in nature to the baseline shown in Figure 5.5-3. It is direct mounted on the plate. This type of device was chosen for a couple reasons: (1) to test the manufacturer's various designs and compare performance within the manufacturer line, and (2) to compare directly with the baseline. It is expected this type of design will offer a stable component platform, over a wide range of conductors due to the nature of the design. The unit shown is one piece.

Figure 5.5-30 Item 30: Rockwell Allen Bradley 1492-CAM1

Figure 5.5-31 and Figure 5.5-32 present Phoenix Contact connectors, which incorporate screw and spring cage retention mechanisms, respectively. They are stackable, compact designs mounted on DIN rail. The designs are considered traditional DIN rail mounted designs.

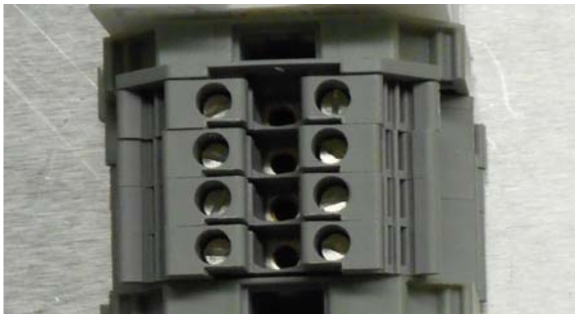


Figure 5.5-31 Item 31: Phoenix Contact UK 2,5 N

Figure 5.5-32 Item 32: Phoenix Contact ST 1,5

The Tyco 212 model shown in Figure 5.5-33, is a tubular screw, direct mounted unit. The conductor fits between compression plates and is retained by the screw applying pressure to the plate. This unit is similar to the baseline as well. Multiple units can be stacked between mounting points.

Figure 5.5-33 Item 34: Tyco 212

The Cooper Bussmann unit shown in Figure 5.5-34 is a larger design, primarily for power conductors, but offers the feature of terminating several conductors to one side, where one conductor is terminated to the other side. This particular model is designed to accommodate a standard three phase system. It is direct mounted, uses heavier terminal blocks as conductor interface, and accepts a large range of conductors (in this case, the range for the multiple termination side is #4 AWG to #14 AWG). The conductors would generally need a ferule or some means of creating compression without strand breakage, but this would depend on the size of the stranding and throw of the retaining block.

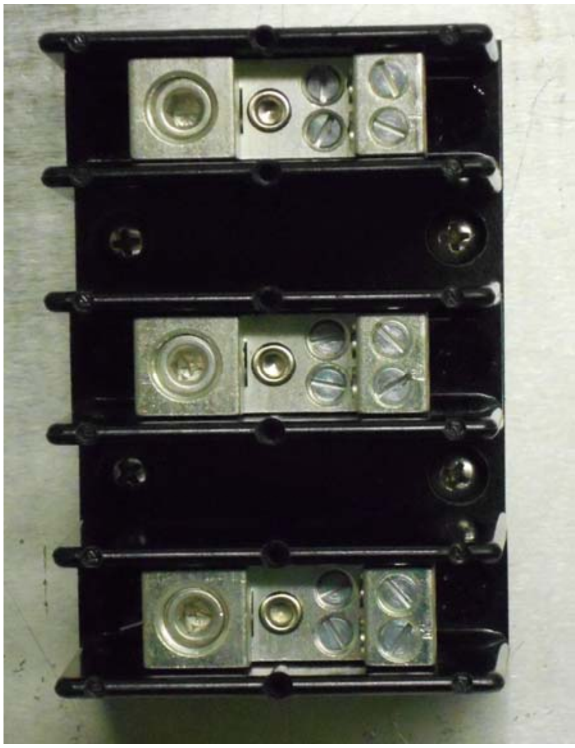


Figure 5.5-34 Item 18: Cooper Bussmann PDB-220-3

Figure 5.5-35 is an example of one of the test plates that has been wired. As can be seen in the figure, the metal strapping with rubber protection offers the conductors a retaining mechanism similar to a cable tie or strapping that may be tied to a piece of structure in an enclosure. The cable, wherever possible, is coiled with one coil or one turn used to accommodate plate deflection and component movement during shock and vibration testing. Most test articles are terminated with the largest conductor it can accept, the smallest it can accept and one of a size in the middle of the range, which is 15 feet long for instrumenting away from the test fixture, away from the testing machine or chamber. Most of the models are represented by four units so that three of the connectors can interface to their correspondingly sized conductor and one can be left blank. This will allow for a comparison of performance when the engaging mechanism is at various mechanical loads and interfacing configurations (which depends on how the stranded conductor is deformed to engage the retention mechanism). Other units that have only three connecting points use only two conductors, again leaving one blank for testing. The blank connector point is in a closed, or screw engaged position, similar to what would be done in a shipboard application.

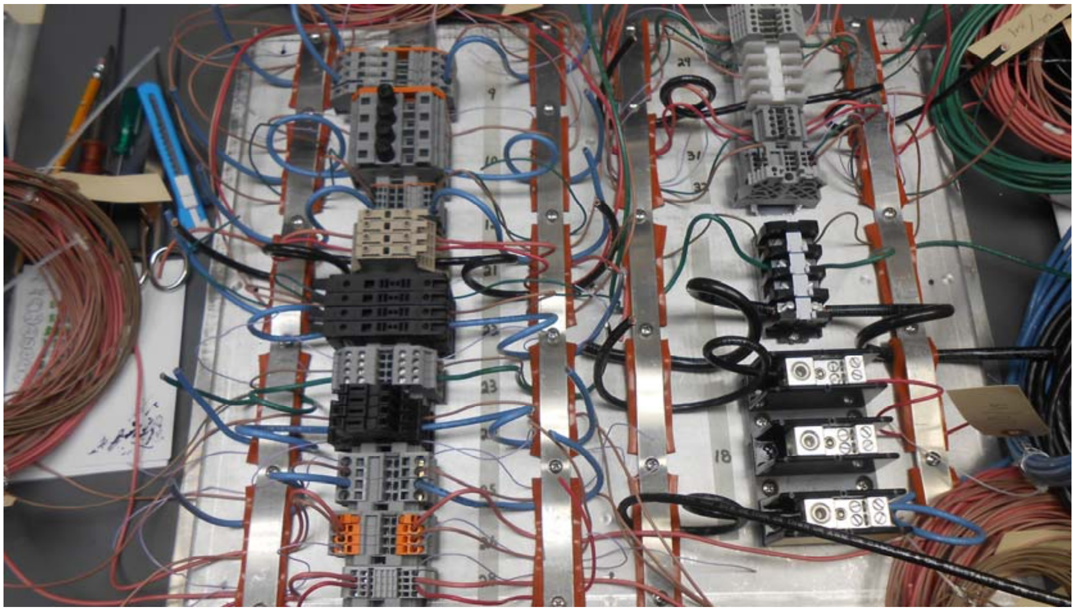


Figure 5.5-35 Test Plate #2 after Wiring

As shown in Figure 5.5-36, the coils are tagged with the unit number as depicted on the drawing, and indicating the size of conductor used for instrumentation. Some of the conductors are very small, as seen in Figure 5.5-36 with the use of the purple colored conductor.

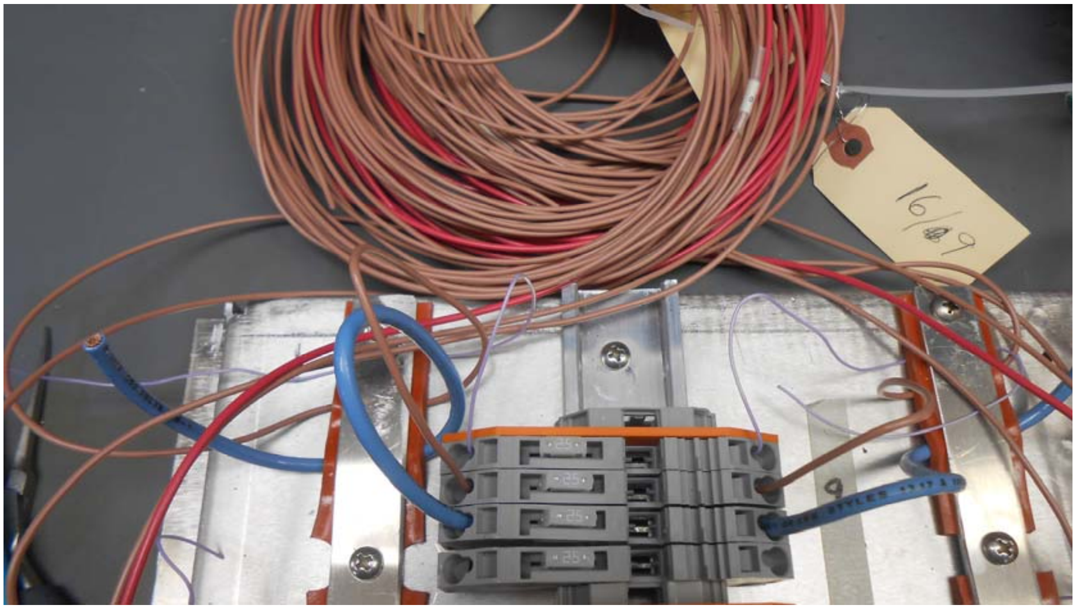


Figure 5.5-36 Conductors Coiled for Instrumenting Test Article

As mentioned previously, for those units that comprise less than four termination points, two conductors within the range of conductor sizes accepted are used and the larger one used for instrumentation, as shown in Figure 5.5-37 (indicated by the blue insulation and the corresponding black conductor on the other side).

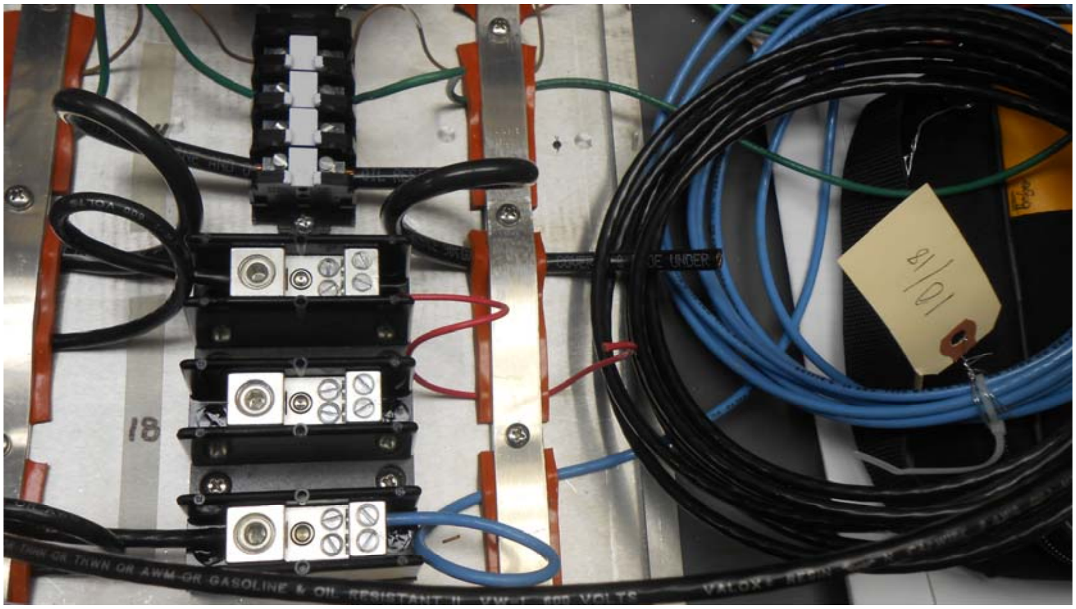


Figure 5.5-37 Closer View of Cable Interface

As seen on Test Plate #1 in Figure 5.5-38, two of the more unique style test articles are the Tyco prototype ring power connector on the lower right of the plate, and the free floating splicing connectors along the left side of the plate. The prototype connector was delivered as is, and the lab will interface to the large conductors to instrument the test article for voltage drop testing. The conductors are only about 12 inches long and are strapped down to prevent rotation during testing (they are pretty free floating in a circle in the plane of interface). It is likely, due to the design of the unit (clamping ring interfacing a recess in the large stud near the top), the tests will have little influence on the performance of the article.

The free floating splice units, of various styles (some are retained with a lever springing mechanism such as the Wago 222-415, which has four interfacing conductors, or the Ideal 39/30-1039J, which has two interfacing conductors) are shown wired in Figure 5.5-38. These can be seen in a close up view in Figure 5.5-39. The units are typically used to splice wires in boxes and enclosures and do not require mounting arrangements, since the wire itself acts as the supporting mechanism, along with how the units reside in the environment (i.e., resting on the surface of an enclosure or resting on a cable or conductor). These units are being tested in a free floating mode as well as a supported position. Testing in a free floating mode will give the inspection group an idea of whether these types of units, with their plastic and nylon construction, can survive shock and vibration testing, being slammed into the test panel. The blue 3M 314-BOX model, shown in Figure 5.5-40, also has a gel integral to the connector. The performance of this gel and the unit itself may be negatively influenced by the thermal cycle testing.

These units were also held down to determine whether they could withstand shock and vibration testing as conveyed directly by the test plate. Although there is no designed mechanism to facilitate this type of mounting arrangement, we used adhesive square 3M connectors to interface with the test article by way of wire ties. Most items on the ship, due to the nature of ship movement, and the fact that most items have enough mass to create acceleration and deceleration issues that will damage or adversely affect performance, need to be tied down in some fashion. Typically, adhesive holding mechanisms like those used here, do not meet requirements and are not present on shock qualified ships. These adhesive squares were used for ease of use, and relatively low costs. It will be interesting to compare the performance of the units that are considered tied down and those that are only supported by the cable terminating to the housing itself.

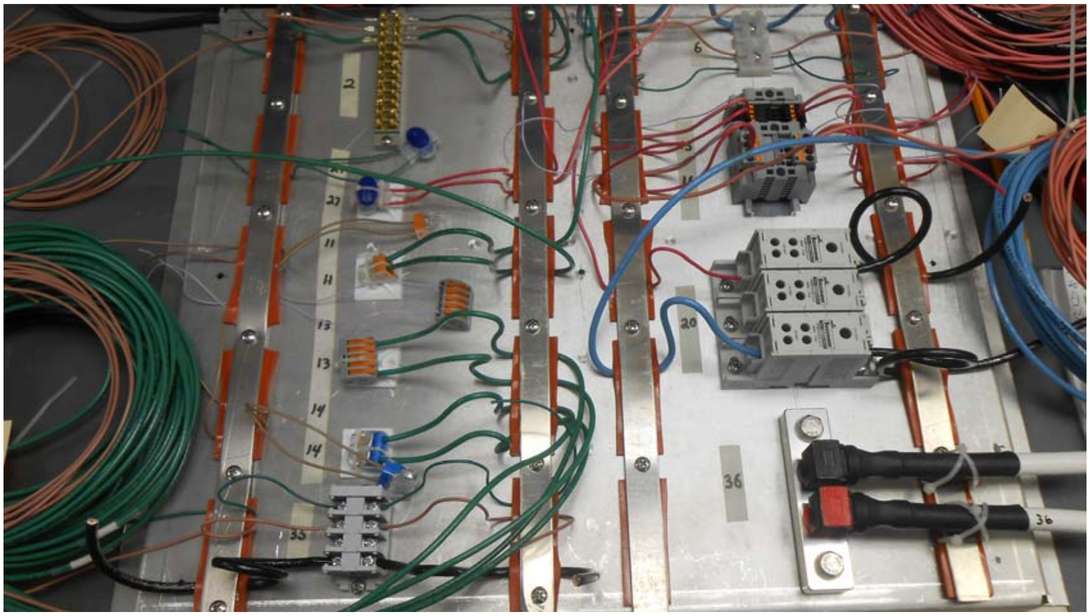


Figure 5.5-38 Test Plate #1 after Wiring

Because most of the conductors are small, and are not stiff enough to maintain a shape, these units may interact with one another, causing unwanted affects. This will be identified, where possible, when inspecting the products after testing.

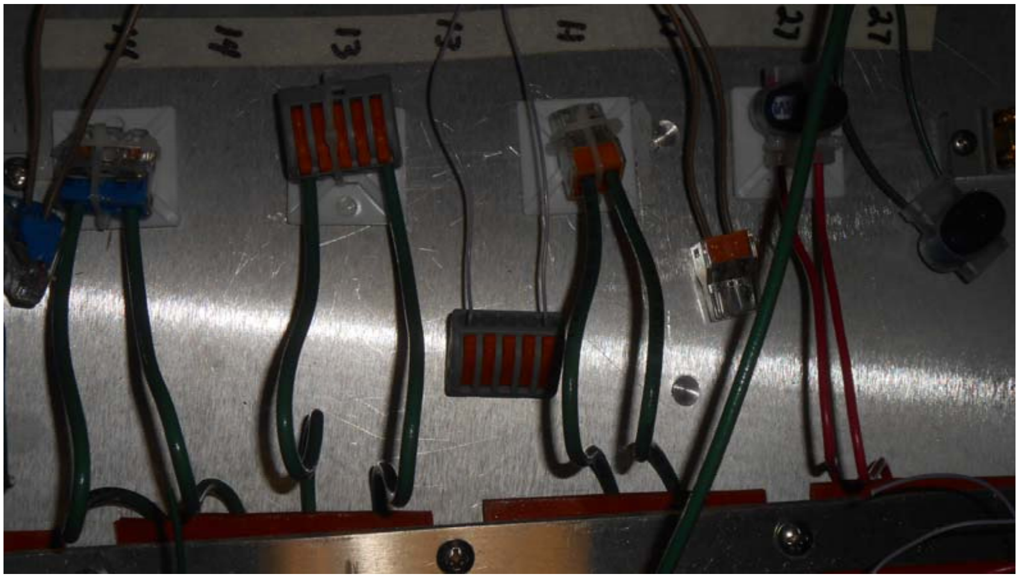


Figure 5.5-39 Free Floating Splicing Connectors

Figure 5.5-40 represents the baseline terminal block, with individual studs, requiring lug connectors for interface. This will form a comparison baseline when determining relative performance.

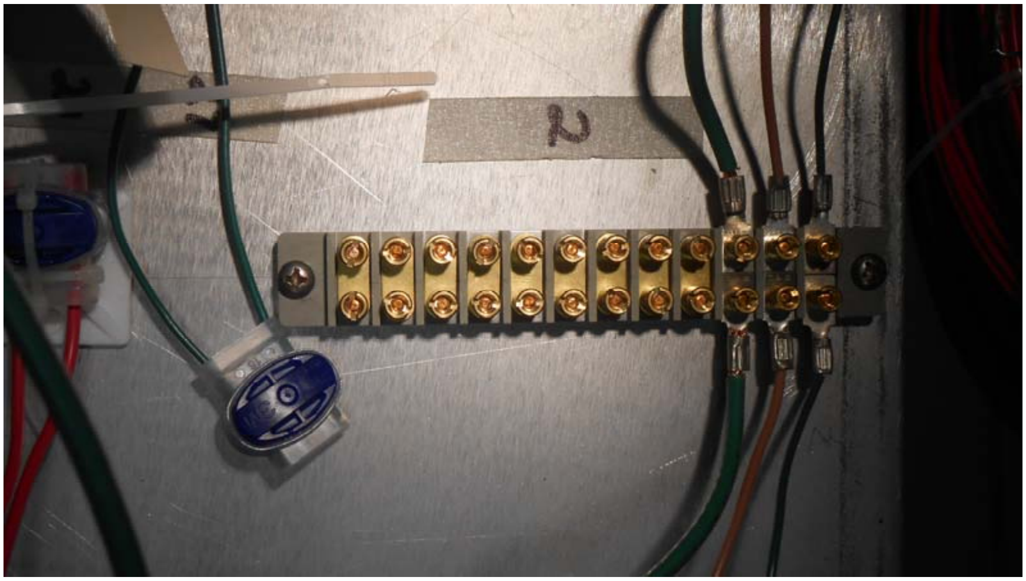


Figure 5.5-40 Baseline Terminal Block Assembly

Figure 5.5-41 shows the entire test plate ready to be packaged. Each unit, conductors and interfacing components were carefully handled so the test set up was not compromised. Wrapping materials were used to maintain the position of the cable with respect to the test articles and plates, so that no conductor stranding was compromised and undue pressure was not present on surfaces.

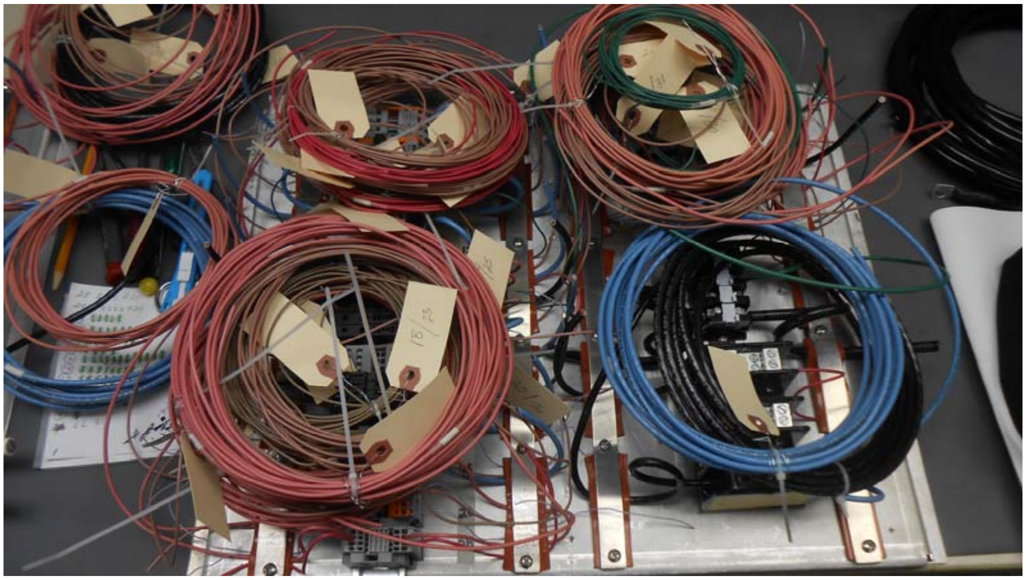


Figure 5.5-41 Entire Test Plate #2 Assembly Before Packaging

The test units were in fact received undamaged and the laboratory conducting the test was confident, if non catastrophic events occur during testing, that the units can be packaged in a similar method so that BIW may receive the tested units for further inspection, and testing if necessary.

5.6 Conduct Testing

The demonstrator units were sent to a laboratory for testing, in accordance with the testing procedure, as shown in Appendix 8.4. Each of the following sections will briefly describe the primary basis of the test, and high level results. The reader is advised to refer to the attached laboratory report for more details on the tests. Pictures are available for viewing, to gain appreciation for the test response and to view just how the demonstrator units responded. Some of the electrical testing was performed by BIW, primarily before the test units were shipped to the laboratory.

Table 5.6-1 shows the types of tests that the project team considered would be good indicators of electrical and functional performance. Some of the tests, such as the contact retention pull test, insulation resistance and voltage drop test were completed before shipment to the lab, and the pull retention test tested again after dynamic testing.

Table 5.6-1 Testing Standards Comparison

		Plug Conectors		**Lugs and Splices, Crimp**		**Terminal Boards**
		MIL-C-55243	*MIL-DTL-22992*	*MIL-T-16366F*	*SAE AS7928*	*A-A-59125*
Tests	*Shock*	N/A - Drop and Bounce tests Only	MIL-STD-202, method 207, modified	Not Defined	Not Defined	Slash Sheets Inconsistent. No Testing requirements were found.
	Vibration	Standard MIL-STD-202, method 201	EIA-364-28, Test condition III, modified	2hrs, 2 orientations, freq. 10->55->10 Hz, Ea. minute	MIL-STD-202, Method 201, modified	
	Temperature	MIL-STD-202, Method 102A, test condition D	EIA-364-33	Not Defined	Heated to 105/150 deg C for 120 hrs, then cooled to 23 deg C within 1 hour.	
Elect	*Contact Resistance*	≤ 2.67mΩ	Size 16-4/0, ≤ 1.25-0.055mΩ	V drop ranges from 6-22mV at rated Amperage	Varies per material/size/test current. Range from 1.6-0.013mΩ for 26-4/0 AWG.	
	Insulation Resistance	≥1000MΩ	≥5000MΩ	Not Defined	Not Defined	
	Dielectric Strength	Adj. Terminals: 1500V, without arcing	Range from 1000-7000VAC, 60Hz	Not Defined	MIL-STD-202, Method 301	
	Temperature Rise	Not Defined	Ambient temp +30 deg C Max at full load (for 4 hrs)	Cable Temp. +5 deg. C Max Temp at full load	Not Defined	
Mech	*Contact Retention*	Ea. Contact: Axial Load 10Lbs, applied 1Lb/sec	Ea. Contact: Size 16-4/0, Range 10-35Lbs Axial Load	Not Defined	Insulation/metal sleeve (uncrimped/crimped) withstand minimum axial force 8Lbs, move ≤1/32"	
	Cable Pull	Mated Connectors: 40Lbs to shell, 25Lbs to Cable	Range from 50-125Lbs w/o cable grip, 75-250Lbs with, for cables ranging from ≤350- ≥1000lbs per 1K ft.	Range from 190-3000Lbs, from 14-1600 size (14340-1662000cmil)	Ranges from 5-875Lbs from 26-4/0 AWG, depends on material	

Table 5.6-1 indicates the specifications and standards that were referenced when conducting the respective tests. Relevancy and testing standards overlap were reviewed and a specific test table was generated indicating general sequence of the tests, which is shown in Table 5.6-2. The order of the test was chosen as shown to minimize influence of the outcome of a particular test negatively influencing another test within the sequence. For instance, all electrical characterization tests were chosen to be done before the performance tests due to their low risk of incidence of damage (except for the dielectric withstand test since this test represents one of higher risk of damage). In this way, it was estimated that data could be generated and testing could move to the next, increasing risk test, with minimal disruption. Such is the case with the shock and vibration testing. After conversing with the laboratory, feedback suggested the vibration test represents a riskier type of performance test than the shock test, since certain characteristics are not yet known going into the test, such as resonant frequency. Should the resonant frequency be at a value corresponding to the frequency range that is chosen for testing, it is possible, even for the lower mass items, the units will destroy themselves. Obviously, this will be a high focus item of prevention.

Table 5.6-2 Testing Requirements Base Set

Demonstrator Unit Testing

Order of Test	Test	Standard	Called Out By	Section or Method	Reference	Test Values	Remarks
3	Voltage Drop	Mil-T-16366F		3.4.4		6 - 25mV at rated voltage	- used for 4-30 A units operating at rated current
4	Dielectric Withstand	Mil-Std-202G		301		-2x rated voltage +1000 V for 60 sec -leakage current less than 0.1% rated load	- raise voltage 500 V/sec - Mil-C-55243 uses 1500 V for 60 sec
5	Shock	Mil-Std-202G	Mil-C-55243	207	Mil-Std-901D	- continuity maintained better than 10% of contact resistance value (drop no less than 0.267 mΩ	- inspect for damage to mounts, contacts, springs, etc.
6	Vibration	Mil-Std-167-1A	Mil-C-55243			- ±0.03 in, 0-34 Hz in approx. 6 hrs	- inspect for damage to mounts, contacts, springs, etc.
7	Temperature Cycling	Mil-Std-202G	Mil-C-55243	107 Cond D		- -65 to -5 C 15 min 25 to -5 C 5 min 350 to 0 C 15 min 25 to -5 C 5 min	- inspect for damage, maybe conduct pull test
1, 8	Contact Retention/Pull Resistance	Mil-C-55243		3.8, 3.19		- 10 lbs @ 1lb/min	- 3.19 is for mated connectors (40 lbs)
2	Insulation Resistance	Mil-C-55243		3.12		1000 MΩ	
	Contact Resistance (TDR)	Mil-C-55243		3.10		≤20 mV @ 7.5 A ⇨2.67 mΩ	This will be done during shock and vib testing, instrumenting the demonstrator

5.6.1 Electrical Characteristics and Capability Testing

Generally, the tests chosen for this type of electrical testing are done to ensure positive electrical characteristics. This is considered a minimum number and types of testing sequence, and if a certain certification or qualification is sought for a particular device, more types of tests would likely be conducted, including full load current testing for a period of time, cyclical current loading, and current loading under shock and vibration.

Table 5.6-2 items 3, 4, 1, and 2, as indicated in the “Order of Test” column, are the tests that were chosen to represent an electrical characteristic of interest (except for the contact retention test, being a mechanical capability test). The retention test was used as a primary test to determine looseness and any movement of the conductor in the contact region. A close look at the surfaces of the conductor, where it contacts the connector interface points, was used as a referencing indicator of whether the conductor did in fact move while in the connector point of interface during all tests performed.

All units successful met the expectations for electrical testing, as shown in Table 5.6-3 However, two units did not meet the pull retention testing, which is a performance test and will be discussed in more detail in Section 5.6.3 and Section 5.7.1. In fact, the units tested well with respect to insulation and voltage drop testing. It was clear, even though some units, such as the Wago 282-696 unit (unit No. 9 on the demonstration test plate), had a wide range of conductor size capability, the units were still able to maintain sufficient pull retention and acceptable voltage drop. The interface was established and maintained.

Table 5.6-3 Electrical Characteristics Testing

NSRP ETP Project: Low Voltage Quick Connectors, Testing Results

Worksheet Number	Unit Number per Dwg	Name	Model/PN	Tensile Pull Resistance Pass/Fail[1]	Insulation Resistance (ohms)[2]	Voltage Drop Test Pass/Fail[3]	Post-Test Contact/Pull Resistance Test
1	2	Term Block Baseline	A-A-59125/24 16TB-12	Pass	10 G	Pass	Pass
2	27	3M	314-BOX	Pass/Pass	∞ / ∞	Pass/Pass	Pass
3	11	Wago	773-164	Pass/Pass	∞ / ∞	Pass/Pass	Pass
4	13	Wago	222-415	Pass/Pass	∞ / ∞	Pass/Pass	Pass
5	14	Ideal	Model 39/30-1039J	Pass	∞ / ∞	Pass/Pass	Fail
6	35	Tyco	925	Pass	6 G	Pass	Pass
7	6	Tyco	1-776302-4	Pass	4 G	Pass	Pass
8	15	Phoenix Contact	PT 1,5/S	Pass	4 G	Pass	Pass
9	16	Phoenix Contact	PT 2,5	Pass	5 G	Pass	Pass
10	20	Cooper Bussman	PDBFS 220	Pass	3 G	Pass	Pass
11	36	Tyco	N/A	Pass/Pass	4 G	Pass	Pass
12	9	Wago	282-696	Pass/Pass	5 G	Pass	Pass
13	10	Wago	282-128	Pass/Pass	10 G	Pass	Pass
14	12	Wago	2002-1201	Pass/Pass	2.6 G	Pass	Pass
15	21	WEIDMULLER	1011000000	Pass	2 G	Pass	Pass
16	22	WEIDMULLER	1880430000	Pass	5 G	Pass	Pass
17	23	Eaton	XBUT25D22	Pass	2.4 G	Pass	Pass
18	24	Eaton	XBUT4FBE	Pass	6 G	Pass	Pass
19	25	Eaton	XBPT4	Pass	4 G	Pass	Pass
20	26	Eaton	XBQT15	Pass	10 G	Pass	Pass
21	28	Rockwell Automation (Alan Bradley)	1492-L2	Fail	3 G	Pass	Pass
22	29	Rockwell Automation (Alan Bradley)	1492-J3	Pass	3 G	Pass	Pass
23	30	Rockwell Automation (Alan Bradley)	1492-CAM1	Pass	5 G	Pass	Pass
24	31	Phoenix Contact	UK 2,5 N	Pass	7 G	Pass	Pass
25	32	Phoenix Contact	ST 1,5	Fail	7 G	Pass	Pass
26	34	Tyco	212	Pass	4.5 G	Pass	Pass
27	18	Cooper Bussman	PDB-220-3	Pass	3 G	Pass	Pass

Notes:

[1] For those cells showing Pass/Pass, 2 conductors for the connector were tested

[2] For those cells showing Pass/Pass, voltage drop was measured across connector terminated port and unterminated port, for each conductor

[3] For those cells showing ∞ / ∞, measurement was made from conductor to ground, for each conductor; for the other units, worst case was across terminal points, all other measurements to ground were recorded as infinity

For those units that did fail, it was the smallest of the conductors used for the unit that came loose. This indicates that the holding mechanism cannot engage this size conductor such that 10 pounds of force can be applied without the conductor moving. However, the conductor/connector interfaces were able to resist up to 8 pounds. This was tested 3 times for verification. All other tests met and exceeded the expectations. The voltage drop test was done at rated current, and there were no issues encountered (voltage drop was below that indicated in the testing requirements of 25 mV). Insulation resistance drop exceeded requirement values of 1 GΩ. The units that are considered splice units were tested between conductors and ground for each termination point. The other units were measured between each conductor termination point and ground, as well as between conductor termination points. The highest value, generally registering infinity on the measuring device, was between each conductor and ground. The values recorded in Table 5.6-4 indicate the values between conductor termination point and conductor termination point. This is considered the worst case scenario and indicative of the integrity of the unit internal component structures. This testing was done with a standard ohmmeter. No other anomalies or unsuspected circumstances resulted from the electrical and conductor retention testing, nor during the construction of the units.

5.6.2 Performance Testing

The performance testing chosen is a series of dynamic tests, including shock tests, vibration tests, and thermal cycling tests. Shock testing follows the requirements for Grade A, Class I, Type B shock testing outlined in Mil-S-901D. Vibration testing follows the requirements for Type I testing outlined in Mil-Std-167-1A. Thermal testing follows requirements for Type A testing outlined in Mil-Std-202G-107, for items of 3 pounds or less. These tests were chosen to be conducted as close to the respective military standard tests as possible, so the data generated can be applied immediately to a military application as a reference or data point. This does not necessarily mean that the test articles that successfully passed the tests are considered qualified for use in those applications where Grade A shock, Type I vibration, and Type A thermal test conditions are required. The data set generated can be used as a reference or starting point when entering a comprehensive test program, either at the stage of first article testing or factory acceptance testing, depending on the requirements invoked on the programs utilizing the hardware. See Appendix 8.4 for more detail on the performance testing requirements. Ultimately, it is up to the end user of such information to apply it in a way that meets individual applications.

The test articles were instrumented during performance testing. A cable pull/retention test, following the requirements of Mil-C-55243, was conducted before and after all testing, and between tests for the instrumented conductors as shown in Figure 5.5-38 and Figure 5.5-35 (long lengths to get from the test fixture to the instruments recording test data). An instrument recording events associated with discontinuity, whether initiated in the connector internal components, or between the conductor and the clamping mechanism at the point of interface, was used to record points where an opened circuit resulted from the testing event. The test instrument used is a chatter box unit, Trig-Tek™ 850B (408303-001), ten channel unit with the following specifications and chosen settings shown in Table 5.6-4.

Table 5.6-4 Chatter Box Test Instrument, Trig-Tek™ 850B

Characteristic	Range	Accuracy	Setting	Remarks
Input	10 channel			Terminal inputs
Voltage	3 V	±3%		Adjust to receive 11 mA
Current level	0.1 – 11 mA	±3%	11 mA	Settable over 2 ranges
Monitoring	NO or NC contact		NC	

The highest current and lowest time interval were chosen, as shown in Table 5.6-4. The time interval corresponds to some types of requirements on sensitive ship systems. Although some may find this somewhat stringent, it is a starting point that can lend insight into response mechanisms of the individual test articles. The time interval indicates how long the discontinuity must last in order for the test unit to trigger as a fault or event. Once triggered, the test unit latches in this state until manual reset occurs. The laboratory was instructed to reset all channels after each shock blow during the shock testing activity, after moving from one frequency to another during the vibration testing activity, and after each thermal cycle during the thermal cycle testing activity. This allows for the dissemination of data points, and relative association with the type of event that influenced the results (i.e., orientation during the shock testing, a specific frequency during the vibration testing, a certain temperature or rate of rise during the thermal cycle testing). Once a channel is reset, all the channels are reset. With this type of testing and sequencing, it will only be possible to detect a momentary discontinuity within the bounds of the settings chosen. Response such as bounce and rebounding will not be captured in this method. However, this is secondary in importance to finding out how the test article will respond to the event since the activation of a channel trigger represents a host of possible outcomes, all considered undesirable. Another item to point out is the actual response profile is not exactly known. For instance, it will not be known whether the interfacing mechanism and internal components barely moved enough for a triggering event or if there was large departure creating the discontinuity. Nevertheless, any discontinuity will be an unwanted result that will be fed back to the manufacturer, suggesting more research into cause and effect. Keep in mind, this design, as outlined in Sect. 5.5.1, is a direct mounted assembly, with typical COTS (Commercial Off The Shelf) test articles, except for the baseline. Generally, it is not expected that certain performance characteristics typically met by hardened equipment be satisfied by non-hardened equipment. However, this type of testing on these types of test articles in the referenced configuration will indicate what more needs to be done to ensure hardened equipment performance, if that is what is desired.

For more information regarding any aspect or detail of the performance tests conducted, please see Attachment 9.1.

5.6.2.1 Shock Testing

Shock testing was conducted in accordance with Mil-S-901D Grade A, Class I, Type B requirements. A light weight machine was used to perform the shock tests. As such, the orientation was done in reference to the striking plane defined by the plane perpendicular to the trajectory of the hammer swing.

A pre-test visual inspection of the tested articles showed no damage or displacements on the demonstrator. The demonstrator unit was then mounted to a 305.5 lb mounting fixture to perform shock testing. The demonstrator was struck multiple times with various force from all three axes, back, top, and side, from three different heights. Throughout the test, chatter was monitored for an instance of loss of continuity through the connector.

Figure 5.6-1 shows the demonstrator in its pre-test mounted position for shock testing. One can see the presence of the Trig-Tek™ 850B chatter box that was used to monitor electrical continuity through the connectors. The demonstrator plates, in the mounting orientation, place the test articles in a horizontal direction. Although some pre load exists in this orientation, due to their mass, the pre load does not introduce skewed results or results that would be considered contingent upon orientation.

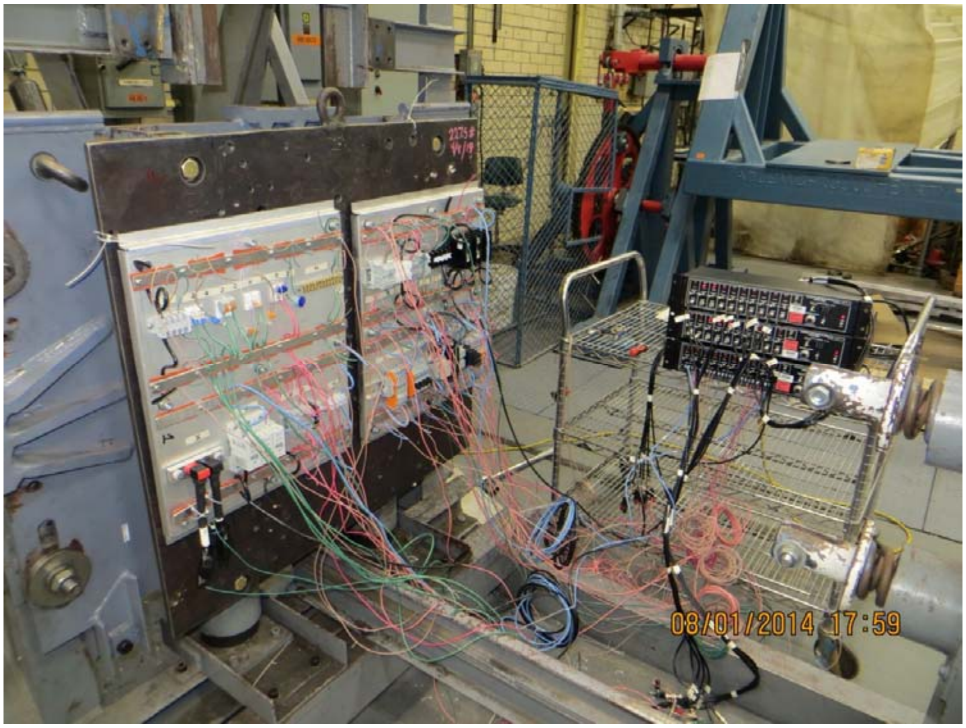


Figure 5.6-1 Pre Shock Test Set-up

Testing began with strikes to the back plane of the demonstrator. The first test strike took place with the hammer dropped from a distance of 1 foot. This strike created chatter, or loss of electrical continuity in connector #24. Along with the chatter present in connector #24, parts of certain connectors and end stops fell off of the demonstrator, disconnecting from their DIN rail. Continuing to a hammer drop distance of 3 and 5 feet striking the back plane resulted in more pieces falling off of the demonstrator. The strike at a distance of 5 feet created chatter in connector #21. Test articles secured with tie wraps also incurred failure of the tie wraps. Although not all had tie wraps fail, this indicates sufficient forces to break the holding mechanism, but not enough to dislodge the conductor from the connector.

Test strikes to the top surface of the demonstrator platform were performed without any chatter observed. Also, there was no further damage to any of the connectors or end pieces resulting from these top surface strikes, regardless of the drop distance. Testing continued with strikes to the side surface of the demonstrator platform. The first two strikes from drop heights of 1 foot and 3 feet resulted in no chatter or damage to any connectors or end pieces. However, a strike from a hammer drop height of 5 feet resulted in damage to the zip tie securing connector #27 and a partial separation of connector #30 to the demonstrator panel.

A post-test visual inspection showed several connectors that had come loose or completely disconnected from the demonstrator panel during testing. Damage was found to the connecting tabs on connector #34 while connector #35 had a portion of its base material broken. Zip-ties used to attach various connector types to the demonstrator had also broken, although not representing a failure of the connector itself. A complete summary of tests can be found in Table 5.6-5 and described further in Section 5.7.1.

5.6.2.2 Vibration Testing

Vibration testing was conducted in accordance with Mil-Std-167-1A Type I requirements.

A pre-test visual inspection of the tested articles shows that all previously damaged or misplaced equipment due to shock testing was repaired or replaced to their original state on the demonstrator, as indicated in Figure 5.6-2 and Table 5.6-5. Each unit was then exposed to three directional vibration testing sequences; front to back, up and down, and side to side. The vibration test incorporated varying vibrating frequencies ranging from 4 to 33 Hz. Chatter was monitored through the entirety of the vibration testing.

Figure 5.6-2 shows the demonstrator in its pre-test mounted position for vibration testing. You can also see the presence of the Trig-Tek™ 850B chatter box used for chatter monitoring.

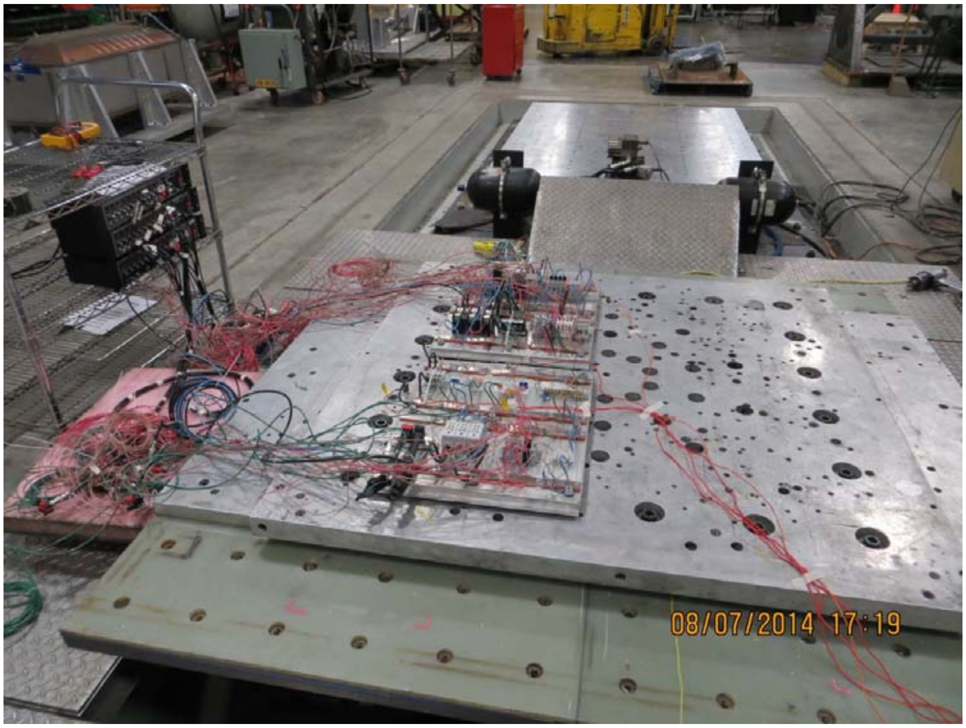


Figure 5.6-2 Pre Vibration Test Set-up

No electrical discontinuities were found in any test article through the entirety of the vibration testing. Furthermore, a post-test visual inspection showed no physical damage or article movement due to testing.

5.6.2.3 Thermal Testing

Thermal testing was conducted in accordance with Mil-Std-202G-107 Type A requirements for items of 3 pounds or less with the exception that the test items were not energized during the last two cycles.

A pre-test visual inspection of the tested articles showed no damage or displacements on the demonstrator. Each unit was then exposed to multiple temperature cycles ranging from -55ºC to 85ºC as shown in Figure 5.6-3.

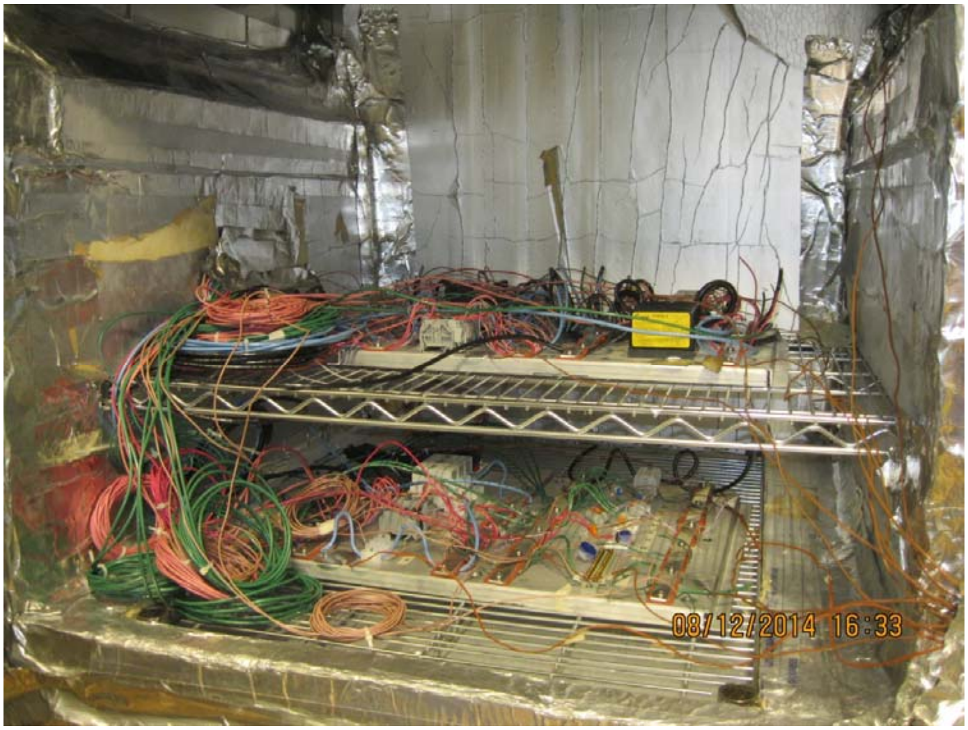


Figure 5.6-3 Pre Thermal Test Set-up

No electrical discontinuities were found in any test article through the entirety of the thermal testing. The attached cables did not become loose due to any expansion or contraction of either cable end or connector material resulting from a change in temperature. A post-test visual inspection showed no physical alterations to the connectors due to thermal testing. Conductor and connector poly materials did not indicate brittleness through indication of fracture lines, spidering, or chips. No internal components became loose as a result of cycling.

5.6.3 Testing Results Summary

The following table, Table 5.6-5, represents a summary of results for each test article. As shown, several units failed to meet the expectations.

Table 5.6-5 Testing Results Table

NSRP ETP Project: Low Voltage Quick Connectors, Testing Results

Worksheet Number	Unit Number per Dwg	Tensile Pull Resistance Pass/Fail[1]	Insulation Resistance (ohms)[2]	Voltage Drop Test Pass/Fail[3]	Shock Test Pass/Fail	Vibration Test Pass/Fail	Thermal Cycling Pass/Fail	Post-Test Contact/Pull Resistance Test	Ease of Use (conductor and unit installation)	Holding Mechanism Durability
1	2	Pass	10 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
2	27	Pass/Pass	∞ / ∞	Pass/Pass	Pass[4]	Pass	Pass	Pass	Satisfactory	Satisfactory
3	11	Pass/Pass	∞ / ∞	Pass/Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
4	13	Pass/Pass	∞ / ∞	Pass/Pass	Pass[4]	Pass	Pass	Pass	Satisfactory	Satisfactory
5	14	Pass	∞ / ∞	Pass/Pass	Pass[4]	Pass	Pass	Fail	Satisfactory	Satisfactory
6	35	Pass	6 G	Pass	Fail[7]	Pass	Pass	Pass	Satisfactory	Satisfactory
7	6	Pass	4 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
8	15	Pass	4 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
9	16	Pass	5 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
10	20	Pass	3 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
11	36	Pass/Pass	4 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
12	9	Pass/Pass	5 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
13	10	Pass/Pass	10 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
14	12	Pass/Pass	2.6 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
15	21	Pass	2 G	Pass	Fail[5,6]	Pass	Pass	Pass	Satisfactory	Satisfactory
16	22	Pass	5 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
17	23	Pass	2.4 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
18	24	Pass	6 G	Pass	Fail[6]	Pass	Pass	Pass	Satisfactory	Satisfactory
19	25	Pass	4 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
20	26	Pass	10 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
21	28	Fail	3 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Unsatisfactory
22	29	Pass	3 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
23	30	Pass	5 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
24	31	Pass	7 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
25	32	Fail	7 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Unsatisfactory
26	34	Pass	4.5 G	Pass	Fail[7]	Pass	Pass	Pass	Satisfactory	Satisfactory
27	18	Pass	3 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory

Notes:

[1] For those cells showing Pass/Pass, 2 conductors for the connector were tested

[2] For those cells showing Pass/Pass, voltage drop was measured across connector terminated port and unterminated port, for each conductor

[3] For those cells showing ∞ / ∞, measurement was made from conductor to ground, for each conductor; for the other units, worst case was across

[4] No connector test failure or damage. Fastening zip tie broke while testing.

[5] Disconnected from DIN rail

[6] Chatter present

[7] Connector Damage

Expectations were the following:

- The unit maintained sufficient holding strength so that voltage drop and pull retention was not compromised
- The unit stayed in place with no physical damage (i.e., stress fracturing, deformation)
- Features inherent to the unit, such as fuse holders, stayed in the operational position (generally in a closed position) [some of the fuse holders did open when

the shock load initiated from the back (first shock cycles), but otherwise remained intact and closed during the other shock sequences]
- No features failed (although damage was incurred on some of the unit base components)

This set of expectations does not imply a unit cannot operate in a state that did not meet expectations. Several of the units broke temporary holding mechanisms, such as the splice units held down with tie wraps, or units interfacing to DIN rails. The splice unit design did not incorporate a tie wrap holding mechanism. It was chosen to determine whether forces would be translated across the holding mechanism and impart damaging forces to the splice unit itself. These units were tested with holding tie wraps and without, and there was not apparent difference in holding strength or body withstand between the two test article configurations. As such, the manufacturer may consider a holding mechanism be designed into the splice unit if such mounting arrangements are to be targeted.

Other events, such as units disengaging from DIN rails, did so, after careful inspection, with interfacing member deformation, since the engaging tabs and features were not damaged during such events. It is assumed the engaging tabs and feet twisted and sufficiently deformed to release from the DIN rail. These features are designed to snap onto the DIN rail with a certain pressure across the engaging surface to create a retaining posture whereby features and the housing is not compromised during vibration normally encountered in industrial settings. Where shock is concerned, the manufacturer could investigate an engagement that provides sufficient shock absorption and tolerance so that other aspects of the unit design does not sustain unusually high stress. It is promising to have seen minimal or no damage to surfaces and edges of otherwise susceptible features.

5.7 Evaluate Results

The electrical characteristic and performance testing lead to satisfactory data to analyze the demonstrator connectors and terminal strips. In many cases the commercially available connectors performed well, even without the emphasis of qualification testing when being designed. In other cases, more development would be needed in order to pursue shipboard qualification of the sort referenced for this project. However, many of these connectors could successfully complete qualification with minimal redesigning of their current configuration.

5.7.1 Success and Failure Modes

As summarized in Table 5.6-5, there were several tests in which all connectors passed; the voltage drop test, vibration testing, thermal cycling testing, and ease of use analysis. Other tests, such as the tensile pull resistance test and the holding mechanism durability analysis had only a few failures. Shock test, however, revealed some reoccurring failure modes.

Shock testing resulted in some common failures across several connectors, two of which would be considered test object failures. Many DIN rail engaged connectors were dislodged from their associated rail. Also, some connectors, which are bolt mounted from each end of a stacked terminal block, were jarred out of place and came apart. Each of these failure modes will be analyzed below. Some mounting interfaces broke as well.

As previously highlighted, Table 5.6-5 lists several connectors that were dislodged from their mating DIN rail. The following figures depict these examples of this failure category. The connectors themselves were not damaged, however the connector to DIN rail interface allowed enough flexion during a shock event to dislodge the connection.

The following figures, Figure 5.7-1 through Figure 5.7-3, show DIN rail mounted demonstrator items, and how the connectors were separated from the DIN rail mounting structure. The left pains show the original installed state of the connectors. The right side pain shows the detached connectors due to shock testing.

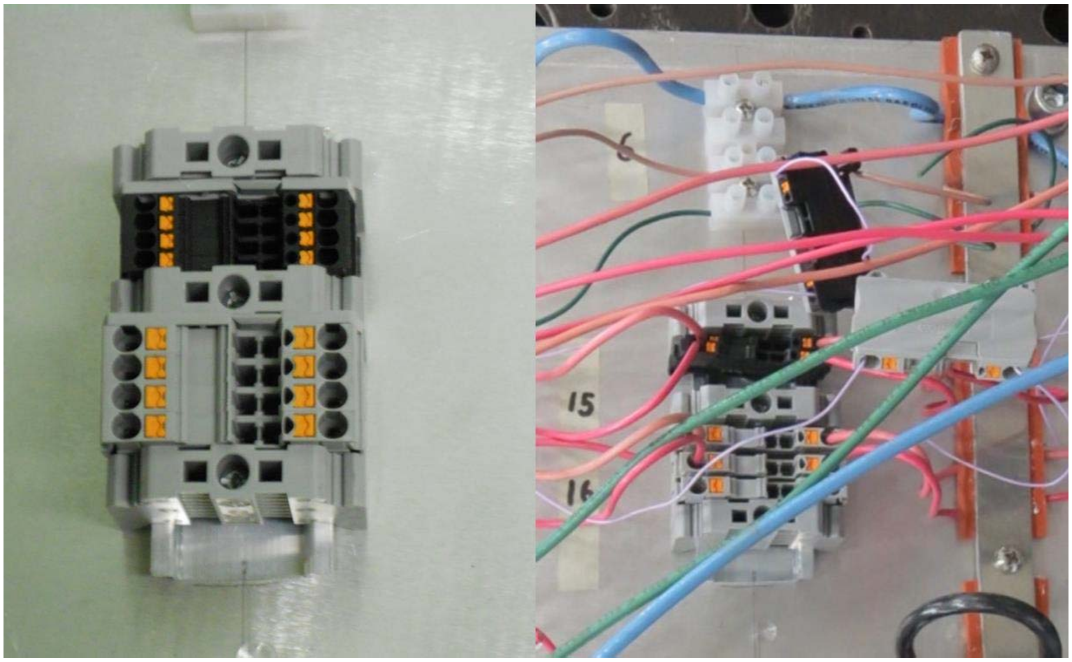


Figure 5.7-1 Connectors 15 and 16

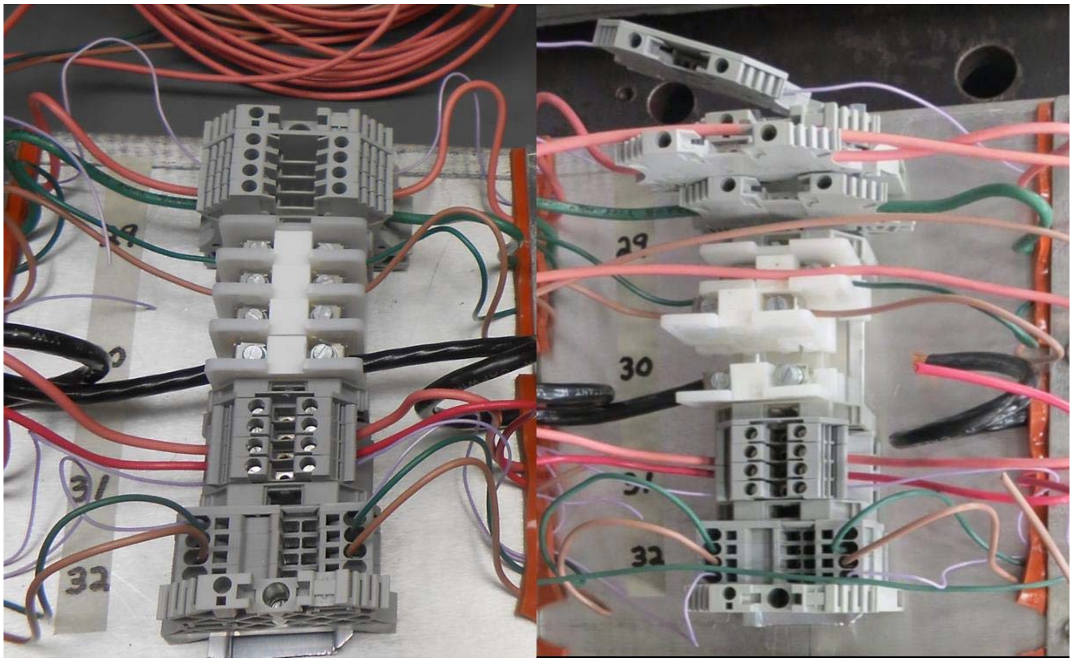


Figure 5.7-2 Connectors 29, 30, 31, and 32

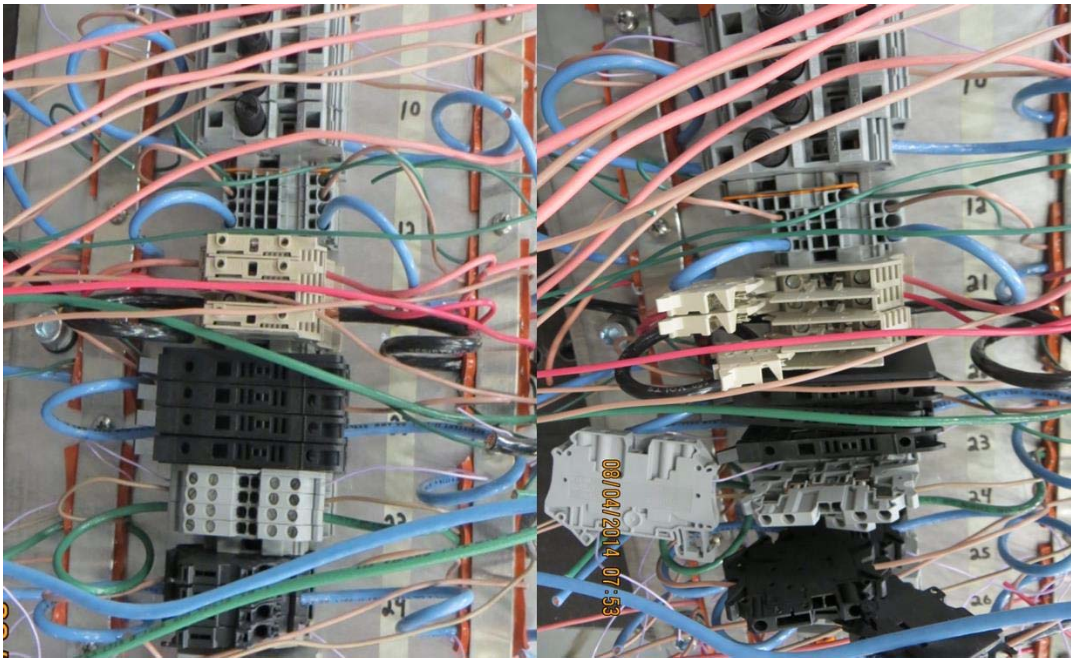


Figure 5.7-3 Connectors 10, 12, 21, 22, 23, and 24

DIN rail separation occurred exclusively during shock test strikes to the back plane of the demonstrator. The strike to the back plane of the demonstrator created enough flexion in the DIN rail and/or connector material to dislodge the connector from the rail. However, the strikes to the top and side surfaces of the demonstrator did not create the directional force needed to create a detachment. This is probably due to the way in which the shock load presents itself to the mounting surfaces. Back shock blows is a perpendicular force to the mounting plane, tending to push test articles outward and placing forces directly on the mounting interface. The side and top shock blows are parallel forces to the mounting interfaces. As long as sufficient stiction exists for DIN rail mounted connectors, and sufficient holding torque exists for foot mounted devices, unless sufficient torsional stress along a particular moment is exhibited at a particular point across the interface, it is not presumed such shock forces would disturb or dislodge such interfaces. For this reason, future shock qualification design efforts could be focused on the rear surface strike for the DIN rail mounted connectors.

The second common failure mode was found in demonstrator units 34 and 35 shown in Figure 5.7-4 and Figure 5.7-5 respectively. These connectors use mounting screws that secure end pieces of termination strips. Figure 5.7-4 points to an end piece used for demonstrator item #34. The connection points are then installed between these secured end pieces and use the compression force of the two end pieces as its sole means of stability and holding force.

Demonstrator unit #34 experienced a failure from shock test blow #2 to the rear plane of the demonstrator. The securing end piece tabs snapped off, causing the embedded terminal strip to separate from the demonstrator plate. It is assumed sufficient torsional stress was placed at the point of mounting interface to physically break this area of the component. As shown on each unit, there are points of minimal material that form the design and geometry of the integrated segments. These appear to be points of vulnerability to this type of torsional loading.

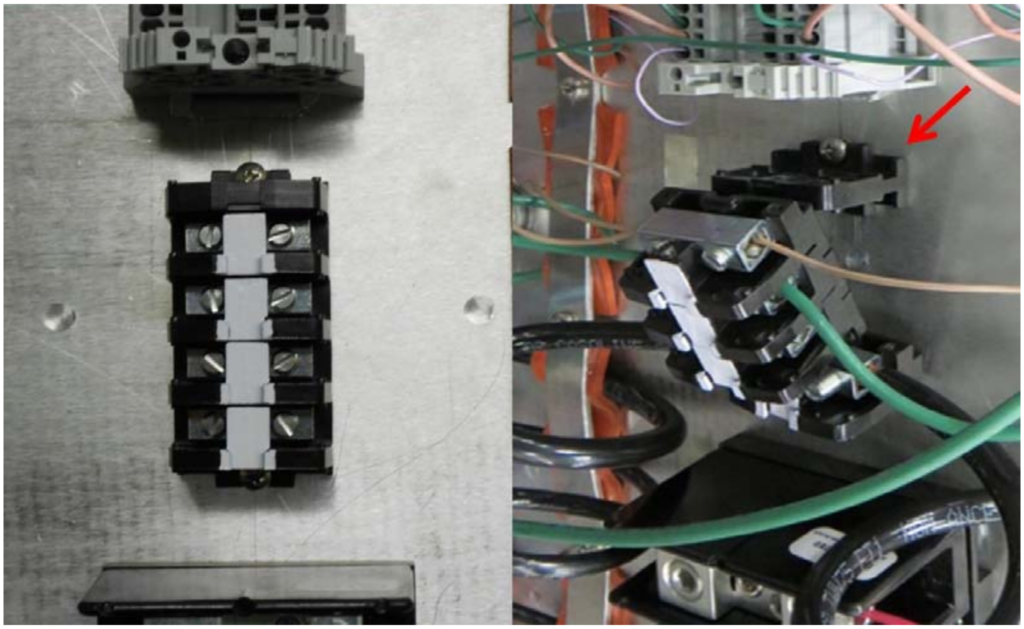


Figure 5.7-4 Demonstrator Connector # 34

Similarly, demonstrator unit #35 experienced an end piece securing tab failure, shown in Figure 5.7-5. This connector is even less stable than unit #34, due to the fact each terminal point is its own stackable unit. This gives the advantage of easily installing several sizes of terminal strips given identical parts, but severely sacrifices terminal strip stability. This unit tested experienced a shock test failure due to a strike in the rear plane.

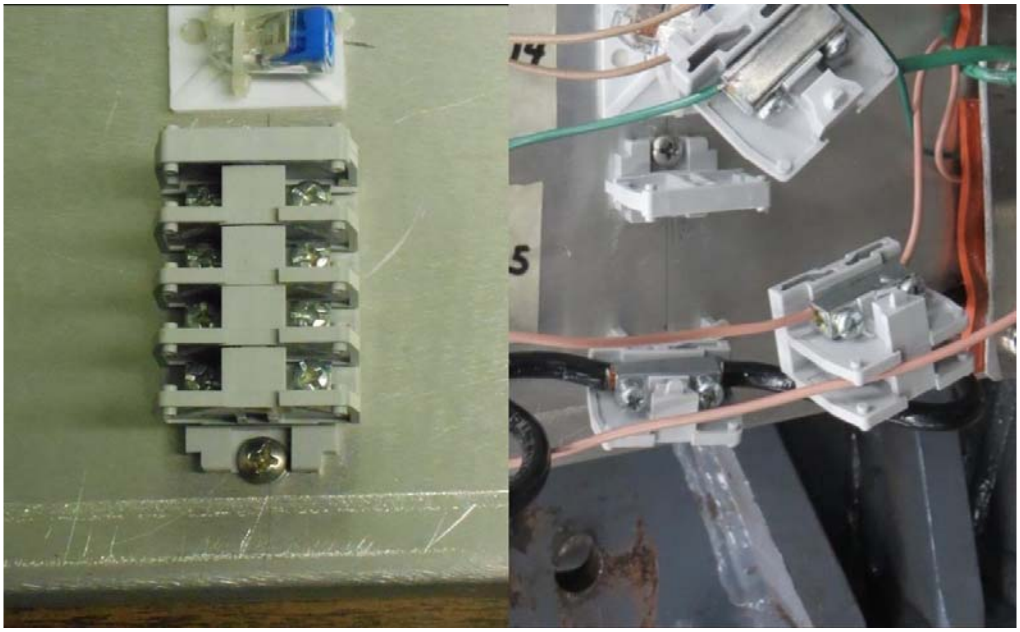


Figure 5.7-5 Demonstrator Connector # 35

5.7.2 Meeting Requirements

Not all test articles met all requirements exactly, although most of the units met the requirements in their entirety. Generally, requirements levied on a particular design need to be coordinated with the application. However, meeting stringent requirements often times, by default, enables a product to perform and meet less stringent requirements. The user can use this information to determine if the requirements that were used as points of testing compliance are suitable for their applications, or if a premium is associated with the design that is capable of meeting stringent requirements. A manufacturer, if the retail value fo a product, is not sufficiently large between those products that meet stringent requirements and those that do not, may choose to standardize on products that are more suited to stringent requirements to minimize the cost of holding multiple lines of products. It is determined through this testing that the test articles, in general, need minimal re-design to meet stringent requirements that have been explored in this study.

5.7.3 Specific Equipment Recommendations

If manufacturers so choose to engage markets with strict performance requirements, assuming demand exist in such markets, the following are offered.

Connectors 27, 11, 13, 14: Create versions of these products that can be integrally mounted to the a surface that does not compromise electrical interface characteristics.
Connectors 34, 35: Improve the capability of the foot mount to minimize the torsional stress that appears to have damaged the foot mount, and separated the stacked sections held together by mortised interfaced. The structural elements may need to be changed to allow for absorption or resisting of forces that propagate and tend to separate parts.
DIN rail mounted devices: These devices must have sufficient holding power to resist separation and flexure that will tend to break or dislodge components. A compromise in ability to flex and snap onto a rail, and withstand the forces that break or dislodge the tab holding device, should be sought.

Types of materials might also have an influence on product capability and performance. Electrical components performed well in their current configurations. S-shaped holding springs appear to be satisfactory designs, capable of holding a wide range of conductors. This might change should the conductor be a solid conductor, but for stranded conductors, performance was quite good.

5.8 Costs and Benefits

Costs and benefits have been assessed fundamentally as a baseline. The components of this assessment are presented here. It is important to note that this is only a cursory evaluation and more detail is required to better assess the expected return or benefit received from using such devices in place of more expensive devices.

5.8.1 Quantitative Assessment

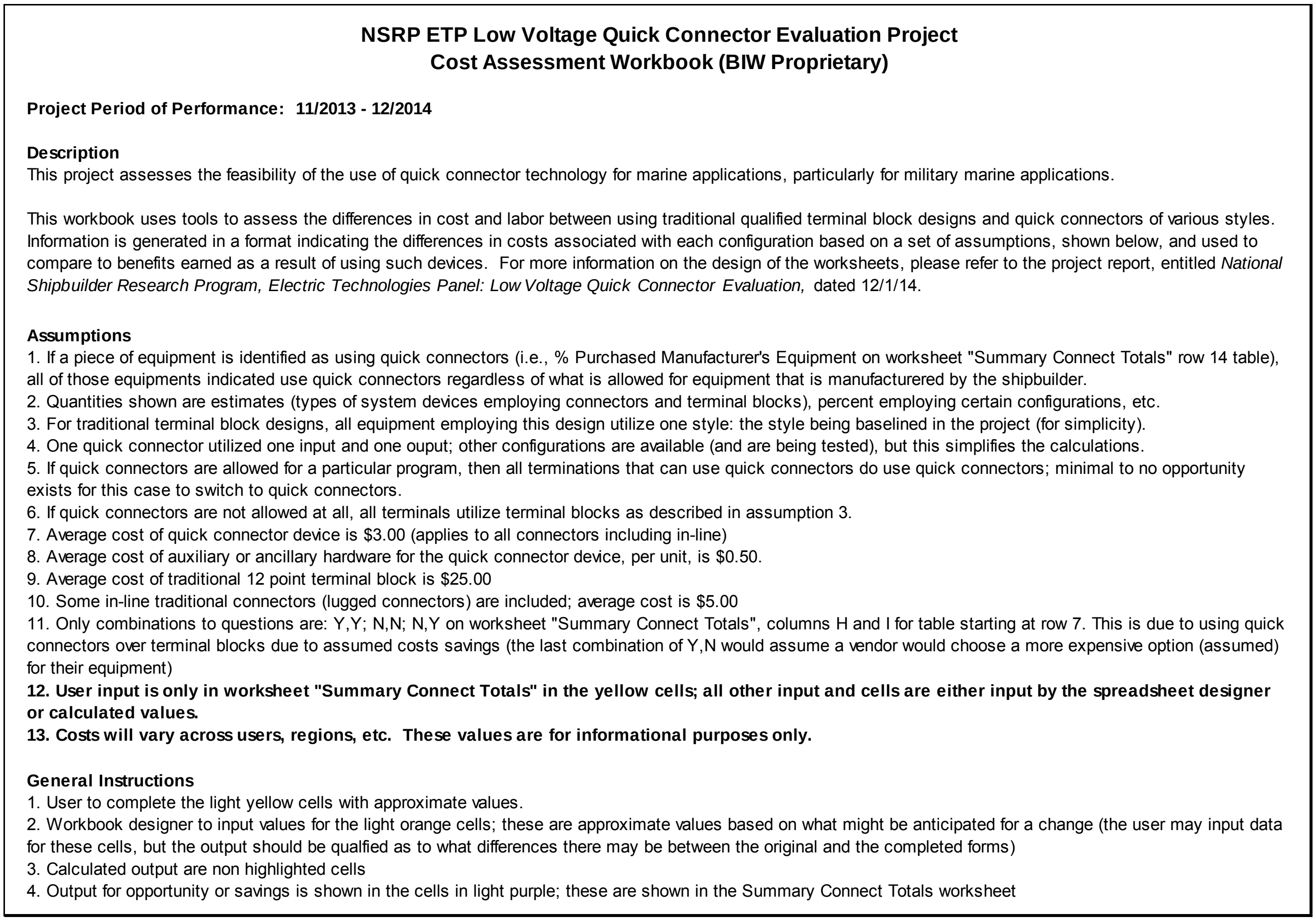
Figure 5.8-1 represents the instructions for the use of the tools used to calculate general cost benefit information, as well as the assumptions used to make the tool and interpret the results. These assessments are based on assumed values of labor rates and materials costs, and are shown in a rolled up, averaged fashion, to communicate the extent of possible savings that may be available for a particular type of program.

Because existing programs were evaluated, the following items were used in determining number of opportunities for quick connector use:

- Number of control panels on the ship
- Number of termination boxes on the ship
- Number of drives on the ship
- Number of power panels on the ship
- Amount of general electrical equipment on the ship that might deploy connectors and terminal blocks

These categories and the uses and applications of these categories described next, can be seen in the top of Figure 5.8-2. For each of the types of equipment that may employ terminal blocks and connectors, the total number of connection points are assigned. This is done since certain connectors can be purchased and installed individually, and per unit values used in the calculation are applied individually (to be discussed later). Therefore, the number of opportunities for quick connector installation needs to be used. The user, however, can input the actual values of estimated numbers of terminal blocks currently used and in want of replacement, under the “Estimated Number per Ship/Program” table, located near the middle of the page. The tables will accept up to 4 programs if an average across programs is needed. Otherwise, average values are calculated for only those cells and rows that are populated.

Another factor that is used for the calculation is the distinction between what is purchased as part of a manufacturer’s piece of equipment (i.e., whether the manufacturer includes terminal boxes and terminal strips in the equipment). If a piece of equipment comes with quick connectors already installed, there is no opportunity to switch to this technology, and the benefits are zero. The user can change this disposition at any time in the process. The overall percent of manufacturer’s equipment that is installed on the ship (purchased as a whole form the manufacturer, including all termination hardware) is entered by the user. With the previous three items of information, the workbook calculates total amount of equipment connections that are considered purchased and what is manufactured by the shipbuilder. Some shipbuilders manufacture their own panels and termination boxes, and therefore have total control on what to install in the box. When the manufacturer’s piece of equipment is specified, certain types of connectors and termination hardware can be specified, but otherwise, the manufacturer will provide whatever meets the requirements at the least cost with the quickest and most reliable delivery. These options allow the user certain flexible options to create scenarios that better match what designs call for, aligning with what equipment procurement groups and production groups actually do. The estimated percent of manufactured products purchased for a given category (as shown above) is an input by the user.



NSRP ETP Low Voltage Quick Connector Evaluation Project
Cost Assessment Workbook (BIW Proprietary)

Project Period of Performance: 11/2013 - 12/2014

Description
This project assesses the feasibility of the use of quick connector technology for marine applications, particularly for military marine applications.

This workbook uses tools to assess the differences in cost and labor between using traditional qualified terminal block designs and quick connectors of various styles. Information is generated in a format indicating the differences in costs associated with each configuration based on a set of assumptions, shown below, and used to compare to benefits earned as a result of using such devices. For more information on the design of the worksheets, please refer to the project report, entitled *National Shipbuilder Research Program, Electric Technologies Panel: Low Voltage Quick Connector Evaluation,* dated 12/1/14.

Assumptions
1. If a piece of equipment is identified as using quick connectors (i.e., % Purchased Manufacturer's Equipment on worksheet "Summary Connect Totals" row 14 table), all of those equipments indicated use quick connectors regardless of what is allowed for equipment that is manufacturered by the shipbuilder.
2. Quantities shown are estimates (types of system devices employing connectors and terminal blocks), percent employing certain configurations, etc.
3. For traditional terminal block designs, all equipment employing this design utilize one style: the style being baselined in the project (for simplicity).
4. One quick connector utilized one input and one ouput; other configurations are available (and are being tested), but this simplifies the calculations.
5. If quick connectors are allowed for a particular program, then all terminations that can use quick connectors do use quick connectors; minimal to no opportunity exists for this case to switch to quick connectors.
6. If quick connectors are not allowed at all, all terminals utilize terminal blocks as described in assumption 3.
7. Average cost of quick connector device is $3.00 (applies to all connectors including in-line)
8. Average cost of auxiliary or ancillary hardware for the quick connector device, per unit, is $0.50.
9. Average cost of traditional 12 point terminal block is $25.00
10. Some in-line traditional connectors (lugged connectors) are included; average cost is $5.00
11. Only combinations to questions are: Y,Y; N,N; N,Y on worksheet "Summary Connect Totals", columns H and I for table starting at row 7. This is due to using quick connectors over terminal blocks due to assumed costs savings (the last combination of Y,N would assume a vendor would choose a more expensive option (assumed) for their equipment)
12. User input is only in worksheet "Summary Connect Totals" in the yellow cells; all other input and cells are either input by the spreadsheet designer or calculated values.
13. Costs will vary across users, regions, etc. These values are for informational purposes only.

General Instructions
1. User to complete the light yellow cells with approximate values.
2. Workbook designer to input values for the light orange cells; these are approximate values based on what might be anticipated for a change (the user may input data for these cells, but the output should be qualfied as to what differences there may be between the original and the completed forms)
3. Calculated output are non highlighted cells
4. Output for opportunity or savings is shown in the cells in light purple; these are shown in the Summary Connect Totals worksheet

Figure 5.8-1 Instructions and Assumptions for CBA Workbook (cover page for workbook)

The last item of direct input is the answer to the question of whether quick connectors are currently used and allowed to be used on the program of interest. Given a per unit cost savings to install quick connectors over traditional terminal blocks (which is what has been shown and will be described next, and shown in Table 5.8-1), the greatest opportunity for cost savings occurs when the use of such connectors is not currently part of the program, and is being considered for future programs. The smallest opportunity for cost savings is if all connections use quick connectors currently, and there is little incentive to change to a different style of connector that may represent a per unit cost savings.

Figure 5.8-2 represents the tables that are used to calculate what is considered intermediate values that roll up to the total summarized opportunity cost savings once per unit costs are applied (for labor and materials, which the user must input). Four worksheets are used to calculate individual program costs and savings, then fed to the tables in Figure 5.8-2. These tables depict each program and then average the programs costs and savings. The template in the tool is shown here as an example. The actual averaged values will be discussed later, for the data that has been assessed. Three categories are used:

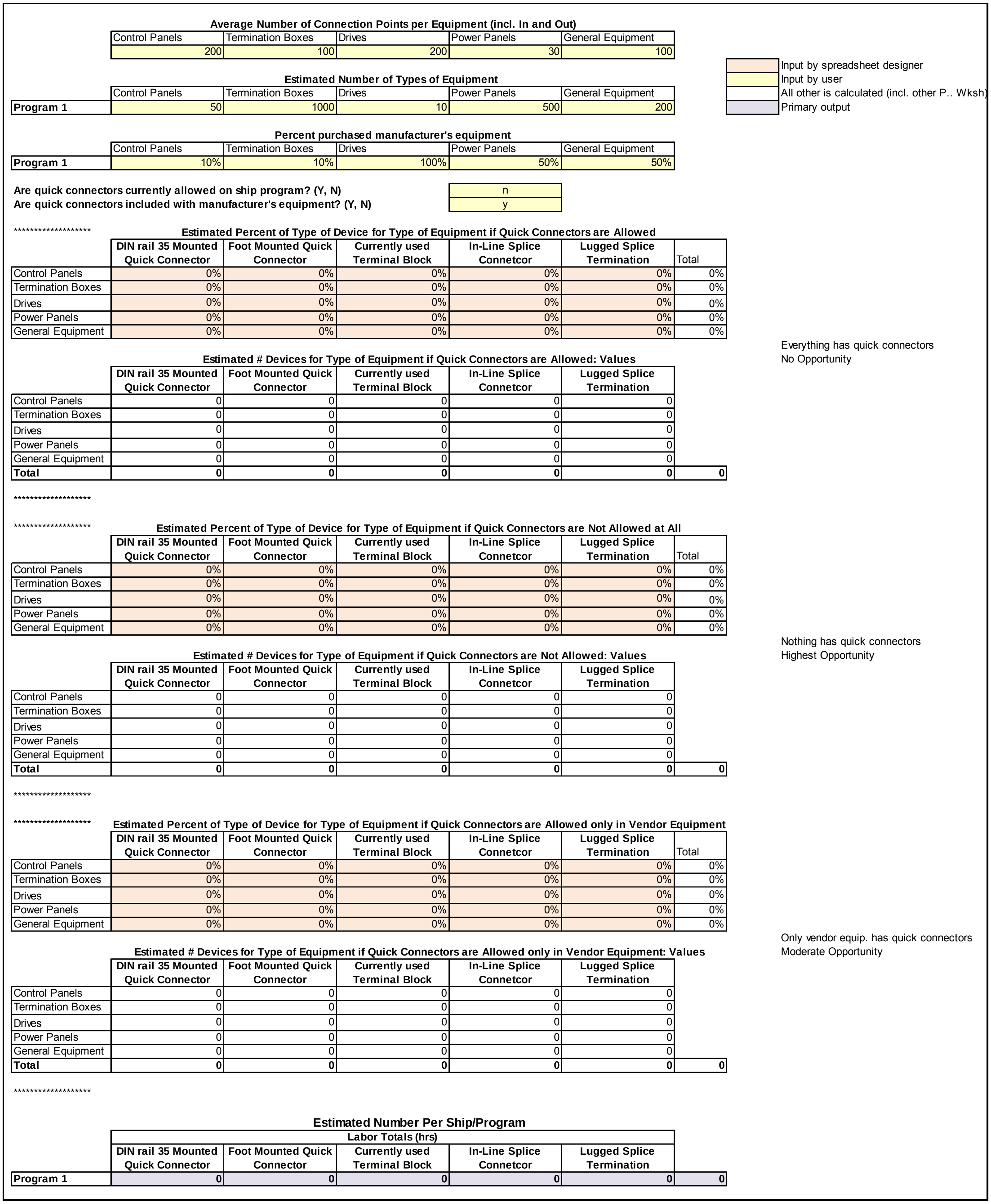
- Estimated Percent of Type of Device for Type of Equipment if Quick Connectors are Allowed

- Estimated Percent of Type of Device for Type of Equipment if Quick Connectors are Not Allowed at All
- Estimated Percent of Type of Device for Type of Equipment if Quick Connectors are Allowed only in Vendor Equipment

The output for this intermediate step is a conditional output based on the selections made by the user regarding percent manufacturer connections and allowances for use of connectors. This worksheet, entitled “Worksheet P1 to Estimate Totals”, coupled with the per unit worksheet, entitled “PU Cost Differences”, drive the values in the summary worksheet, entitled “Summary Connect Totals”. As seen there are a number of assumptions built into the tables and the information entered by the user and designer. It is important to qualify where assumptions are made and the relative importance of the assumption, in order to apply the information to a program opportunity. Qualitative assessment, coupled to the qualifiers for quantitative assessment, as indicated in Section 5.8.2 for this particular report, form the basis for an evaluation of this sort.

Per unit costs and savings, shown in Table 5.8-1, are estimates of what costs might be attributed to various materials (some are estimates and do not reflect any particular price point offered to any particular company), and estimated per unit labor differences as a result of some experimenting and the experiences of those working with such components in applications similar to those represented by the programs investigated. Certainly, these numbers will differ for different programs, companies and work site locations, based on a host of influences. However, these numbers serve to illustrate what might be available for savings and how the user might both use the worksheet tools described, and interpret the results. The user can also enter the hourly value used for labor calculations. In the table shown, $100/hr is used, but this is a notional value. It will be up to the user to determine what value best fits the application being estimated.

As can be seen, small values of difference are estimated since the worksheet defines a per unit item as one termination point, regardless of how the termination is made. If the termination is done through the use of terminal blocks, then if there are 12 terminations for each termination block, the time is linearly split over 12 terminations, to mount the terminal block, for instance. There are other tasks needed to install terminal blocks and connectors, but they are considered similar and therefore are not distinguishing tasks across types of terminations.



Average Number of Connection Points per Equipment (incl. In and Out)

Control Panels	Termination Boxes	Drives	Power Panels	General Equipment
200	100	200	30	100

🟧	Input by spreadsheet designer
🟨	Input by user
⬜	All other is calculated (incl. other P.. Wksh)
🟪	Primary output

Estimated Number of Types of Equipment

	Control Panels	Termination Boxes	Drives	Power Panels	General Equipment
Program 1	50	1000	10	500	200

Percent purchased manufacturer's equipment

	Control Panels	Termination Boxes	Drives	Power Panels	General Equipment
Program 1	10%	10%	100%	50%	50%

Are quick connectors currently allowed on ship program? (Y, N)	n
Are quick connectors included with manufacturer's equipment? (Y, N)	y

****

Estimated Percent of Type of Device for Type of Equipment if Quick Connectors are Allowed

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block	In-Line Splice Connetcor	Lugged Splice Termination	Total
Control Panels	0%	0%	0%	0%	0%	0%
Termination Boxes	0%	0%	0%	0%	0%	0%
Drives	0%	0%	0%	0%	0%	0%
Power Panels	0%	0%	0%	0%	0%	0%
General Equipment	0%	0%	0%	0%	0%	0%

Everything has quick connectors
No Opportunity

Estimated # Devices for Type of Equipment if Quick Connectors are Allowed: Values

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block	In-Line Splice Connetcor	Lugged Splice Termination	
Control Panels	0	0	0	0	0	
Termination Boxes	0	0	0	0	0	
Drives	0	0	0	0	0	
Power Panels	0	0	0	0	0	
General Equipment	0	0	0	0	0	
Total	**0**	**0**	**0**	**0**	**0**	**0**

****

****

Estimated Percent of Type of Device for Type of Equipment if Quick Connectors are Not Allowed at All

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block	In-Line Splice Connetcor	Lugged Splice Termination	Total
Control Panels	0%	0%	0%	0%	0%	0%
Termination Boxes	0%	0%	0%	0%	0%	0%
Drives	0%	0%	0%	0%	0%	0%
Power Panels	0%	0%	0%	0%	0%	0%
General Equipment	0%	0%	0%	0%	0%	0%

Nothing has quick connectors
Highest Opportunity

Estimated # Devices for Type of Equipment if Quick Connectors are Not Allowed: Values

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block	In-Line Splice Connetcor	Lugged Splice Termination	
Control Panels	0	0	0	0	0	
Termination Boxes	0	0	0	0	0	
Drives	0	0	0	0	0	
Power Panels	0	0	0	0	0	
General Equipment	0	0	0	0	0	
Total	**0**	**0**	**0**	**0**	**0**	**0**

****

****

Estimated Percent of Type of Device for Type of Equipment if Quick Connectors are Allowed only in Vendor Equipment

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block	In-Line Splice Connetcor	Lugged Splice Termination	Total
Control Panels	0%	0%	0%	0%	0%	0%
Termination Boxes	0%	0%	0%	0%	0%	0%
Drives	0%	0%	0%	0%	0%	0%
Power Panels	0%	0%	0%	0%	0%	0%
General Equipment	0%	0%	0%	0%	0%	0%

Only vendor equip. has quick connectors
Moderate Opportunity

Estimated # Devices for Type of Equipment if Quick Connectors are Allowed only in Vendor Equipment: Values

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block	In-Line Splice Connetcor	Lugged Splice Termination	
Control Panels	0	0	0	0	0	
Termination Boxes	0	0	0	0	0	
Drives	0	0	0	0	0	
Power Panels	0	0	0	0	0	
General Equipment	0	0	0	0	0	
Total	**0**	**0**	**0**	**0**	**0**	**0**

****

Estimated Number Per Ship/Program

	Labor Totals (hrs)					
	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block	In-Line Splice Connetcor	Lugged Splice Termination	
Program 1	0	0	0	0	0	0

Figure 5.8-2 CBA Intermediate Calculation Tables

Table 5.8-1 Per Unit Cost Savings

Cost Differences in Traditional Connectors and Quick Connectors

		Labor (min)					**Materials ($)**			**Totals**		**Difference from Traditional Methods**			
Item	**Description**	**Base Mounting**	**Device Mounting**	**Wire Preparation**	**Wire Installation**	**Torquing**	**Device**	**Associated Hardware**	**Base Mount**	**Labor (hrs)**	**Materials ($)**	**Labor (hrs)**	**Materials ($)**	**Total ($)**	**Simple ROI**
1	DIN rail 35 Mounted Quick Connector	0.75	0.17	1.00	0.33		$1.00	$0.20	$0.04	0.04	$1	(0.16)	($1)	($17)	22.7%
2	Foot Mounted Quick Connector		2.50	1.00	0.33		$3.00	$0.20	$0.00	0.06	$3	(0.13)	$1	($12)	43.5%
3	Currently used Terminal Block		0.83	5.00	5.00	1.00	$2.08	$0.20		0.20	$2				
4	In-Line Splice Connetcor		0.50	1.00	0.17		$0.40	$0.50	$0.00	0.03	$1	(0.24)	($2)	($26)	12.3%
5	Lugged Splice Termination		5.00	5.00	5.00	1.00	$3.00	$0.20		0.27	$3				

Notes: 1. The above information is an average of several inputs
2. The above information represents a per unit basis
3. DIN rail mounting estimates is for a strip 24" long, able to hold 40 quick connectors (and end hardware and spacers): takes 30 min. to install 40 units, or 30 sec. pu
4. Wire installation is for input and output sides of respective units
5. Existing terminal strip is divided by the number of terminal pairs (12)
6. Costs are averages across the cross section of units investigated (there is considerable difference, but value can be adjusted easily)
7. Associated hardware includes mounting screws, endplates and spacers (where applicable)
8. Differences is the quick connector method minus the traditional method
9. A positive ROI indicates a savings
10. 🟧 Spreadsheet designer entry
11. Labor Hourly cost $ 100

The following table, Table 5.8-2, shows what expected savings are possible from using a representative device versus the military specified terminal blocks that are used today (which are represented as the baseline for this study, and part of the testing as items number one in the upper left of demonstrator plate one) across programs investigated for this report, and estimating the number of opportunities based on control boxes, drives, termination boxes, etc. The information in Table 5.8-2 represents averaged savings across the program investigated. Other scenarios will be shown later. The worksheets that have been utilized for this assessment, which are shown in Attachment 9.3 and described previously, use the militarized 12 point terminal block, model A-A-59125/24 16TB-12, as a baseline for comparison (and other similar units are shown to exist on the programs of investigation). This is a stud terminal block with holding nuts, and requiring lugs for wire interface. The majority of the savings comes from labor savings, although a percentage of the savings, anywhere from 50-150% of the savings, comes in the form of materials savings, as shown in Figure 5.8-1 which describes the values used to assess per unit savings. Quantities of the terminations were assumed per programs based on calculations. Per unit returns are shown in Table 5.8-1 as well.

Table 5.8-2 Quantitative Cost Savings Scenario 1

Opportunity to Switch to Quick Connectors: From Terminal Blocks and Lugged Splice Connectors to Quick Connectors

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block	In-Line Splice Connector	Lugged Splice Termination	Total
Program Average	96,188	32,063		4,050		132,300

Opportunity Costs to Switch to Quick Connectors from Terminal Blocks and Lugged Splice Connectors: Labor Savings (mhrs)

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block	In-Line Splice Connector	Lugged Splice Termination	Total
Program Average	($1,737)	$265		($394)		($1,865)

Opportunity Costs to Switch to Quick Connectors from Terminal Blocks and Lugged Splice Connectors: Hardware Savings ($)

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block	In-Line Splice Connector	Lugged Splice Termination	Total
Program Average	($100,119)	$29,391		($9,315)		($80,044)

Opportunity Costs to Switch to Quick Connectors from Terminal Blocks and Lugged Splice Connectors: Total ($)

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block	In-Line Splice Connector	Lugged Splice Termination	Total
Program Average	($101,856)	$29,656		($9,709)		($81,908)

Note: Negative values indicate a savings

In this case, there are savings indicated, on average across programs investigated, and along the lines of assumptions used.

Another set of scenarios was run that depicts much less opportunity, but opportunity nevertheless.

Table 5.8-3 Quantitative Cost Savings Scenario 2

Opportunity to Switch to Quick Connectors: From Terminal Blocks and Lugged Splice Connectors to Quick Connectors

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block	In-Line Splice Connector	Lugged Splice Termination	Total
Average	3,059	532		452		3,741

Opportunity Costs to Switch to Quick Connectors from Terminal Blocks and Lugged Splice Connectors: Labor Savings (mhrs)

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block	In-Line Splice Connector	Lugged Splice Termination	Total
Average	(489)	(71)		(108)		(595)

Opportunity Costs to Switch to Quick Connectors from Terminal Blocks and Lugged Splice Connectors: Hardware Savings ($)

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block	In-Line Splice Connector	Lugged Splice Termination	Total
Average	(3,184)	487		(1,040)		(3,043)

Opportunity Costs to Switch to Quick Connectors from Terminal Blocks and Lugged Splice Connectors: Total ($)

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block	In-Line Splice Connector	Lugged Splice Termination	Total
Average	(3,672)	417		(1,148)		(3,638)

Note: Negative values indicate a savings

Opportunities are much less due to the number of terminal blocks estimated on the programs. Since the per unit savings are small, relatively speaking, and considered quite conservative for this assessment, the savings values translate to small savings for small numbers of opportunities. The user can appreciate the scope of opportunity quickly in these instances, and hopefully will be able to quickly determine whether conducting an assessment is worthwhile. Sources and details of data are purposely generalized to protect the source of the data. For more information about the data described here, one must contact the author or entity supplying the data.

Looking at all the savings tables, there is generally an opportunity for savings, even though there may be modest savings available for certain programs. The Non-Recurring Expenses (NRE) associated with the change, such as technical drawing and other documentation changes, procurement documentation change, and training, may indicate little or no opportunity for savings. Such expenses were not investigated in this study since the expense could vary widely, and the change is closely related to the type of program investigated, varying widely. For instance, for programs that require detailed documentation that cover many applications, the NRE associated with change may be quite high. For programs that do not require high levels of detail in documentation (i.e., termination devices are not specifically detailed and called out within documentation), leaning more toward performance oriented requirements, the NRE may be modest or low. If such programs hold many opportunities for change, the return would be much higher than those programs that are very detailed and have lower numbers of opportunities or applications. It will be up to the user to determine where their program lies with respect to opportunities and NRE, thus driving the overall expected savings.

5.8.2 Qualitative Assessment

Some items that are considered value added, but not necessarily quantified in this report, include the following:

1. Troubleshooting, testing and commissioning: During such events, the wires can easily be pulled out of the connectors if the connector allows for such removal, either with or without tools. Each time the wire is disconnected and reconnected, using current hardware and methods, two more steps are added to the process: installation of lugs if the wire needs to be shortened or lug removed, and the terminal block stud torqued to the proper torque value.
2. Flexible configuration and minimal impact to adjacent circuits: Each terminal point is a separate terminal point for the DIN (Deutsches Institut für Normung) rail mounted units. If a terminal point is damaged or needs to be replaced, it can be done so without disturbing the other units. Existing designs require all the circuits to be removed and re-installed, since the whole terminal block must be replaced. As the number of circuits changes (either increasing or decreasing in number), a DIN rail mounted arrangement can evolve to meet the needs, thus minimizing congestion when termination points are not needed. Lastly, the use of a DIN rail system can utilize a universal mounting arrangement and will support those devices and components that can mount universally, which tends to improve arrangement flexibility.

3. Reduced installation steps: Lugs are not needed for interface, therefore the steps of lug installation (a. install lug, b. compress lug, c. torque stud cap) and torque testing the applied nut on the stud are not needed. This tends to improve system installation QA due just to the elimination of steps in the process. The replacing installation tasks are not overly complicated in comparison to existing methods, and so it would be reasonable to assume the end product would reflect higher quality assurance. If ferruled conductors are required, which may be the case on many programs, testing procedures may include this step. Since they may already be required, the net difference in steps is zero. However, due to the ferrule interface, performance may be influenced. It is possible the ferrule may not be necessary due to the type of engagement offered by the type of connector used. In this case, a reduction in steps would be the outcome.
4. Fewer parts to manage: Each time a part is not available at the work site, the worker must go to the point of part distribution and retrieve the part to continue the task. This takes time, and although an individual event does not appear substantial, over the course of a longer period of time and over an entire group, this could add up to significant values. This is generally considered a disruption as well, preventing one from completing the job sooner and allowing for others to work in the same or adjacent spaces. As well, each occurrence represents an unplanned event that can have negative roll down impact to other schedules and tasks.
5. COTS (Commercial Off the Shelf) equipment: A larger market, such as the commercial or industrial segments, allows the user greater opportunity to find competitive solutions, assuming the components meet the requirements (in this case, it was demonstrated that substantial potential exists to meet requirements). Over the course of a particular program, several technology shifts usually occur and obsolescence could become a consideration. Components that serve other, possibly larger markets, tend to evolve with the market and are backward compatible in many instances. Of course, this could work in the opposite way as well. If the designs cannot support an evolving technology that is following a different, larger market, then obsolescence could come in the form of outdated designs, not matching where a particular market has moved.

Other considerations may influence the value added in a qualitative fashion as well. One of the largest benefits to using what is used today is the simplicity of the unit. There are no real moving parts (except the holding nut on the stud), whereas the units tested have a variety of moving parts, depending on the configuration. This aspect tends to support the idea that fewer moving parts are less susceptible to failure over the life cycle of the component. As described in the testing section, Section 5.7, various elements of the connectors, such as fuse holders that hinge, showed vulnerability to shock. However, some units that do not contain moving parts of this sort, performed well.

Having flexibility to install units in various configurations, and adding on to existing configurations without re-arrangement, are positive attributes of DIN rail mounted systems, assuming the DIN rail doesn’t have to be extended and there is sufficient space in the surrounding space to accommodate expanded configurations. Most of the units tested do not have exposed energized electrical surfaces, which is a key safety attribute. One can open an enclosure to inspect the contents without de-energizing circuits, provided all other safety precautions are followed for the voltage class of operation utilized.

With the use of retaining devices that can be defeated, changing a wire is as simple as defeating the mechanism, usually with a small screwdriver, removing the wire, and either re-installing elsewhere or securing. As long as sufficient wire length is available, the wire can serve another location or be bundled with others away from the termination area and secured.

Variously sized connectors can generally be installed on the same DIN 35 rail system, as shown in the testing demonstrator unit. This might be useful when one termination box or enclosure serves multiple purposes and circuits. Instead of consuming multiple zones of space, power, instrumentation and control can all be installed using a common rail system, as long as other requirements are met, such as shielding and proximity.

In general, the connectors tested are versatile, take up less space and weight on average, and perform well even at this stage of development. It is not known how the connectors might perform in other types of ESS testing, but certainly there is a baseline that indicates their performance might warrant future test sequences and minor product updates to enter full qualification testing.

6 Conclusions and Recommendations

6.1 Summary of Project Results and Conclusions

This project has culminated in an increased understanding of what exists in the form of quick wire connection units and their capabilities to interface across ranges of interface types, withstand environmental testing, and perform in applications that exist on Navy platforms. A fairly wide range of connector types, from splicing connectors, to large stud connectors, and those that require minimal effort for installation to those requiring a little more effort but less than current options, were selected for detailed evaluation. Electrical characteristics were measured and compared to manufacturer specification sheets, and tests were performed to determine operational capabilities under varying conditions, comparing to stringent standards, specifications and requirements.

Some test articles performed more favorably than others. Some units, due to their construction, physically failed during shock testing. Others failed to meet operational expectations, having disconnected from their mount (generally those mounted via DIN rail) and flew off the mounting surface, but did not sustain damage, and could be immediately re-installed and tested again. It is likely the units chosen were not originally designed to withstand certain shock and vibration tests, but nearly all of the units seem to hold promise for future ability to pass all such tests. Small modifications in design, either to the housing and mounting arrangements, or other features such as fuse holders and foot mounts, would be necessary in order for the units to pass these tests. It was understood during the test article selection process that there were likely no units tested to the same requirements that were invoked during this project (each manufacturer probably used slightly different testing criteria to identify failure modes). It was the intent of the project team to replicate certain environmental testing requirements that are likely to be used for military programs, so that the necessary performance characteristics could be measured and conclusions drawn regarding the capability of an individual component. Once this is known, further recommendations can be offered regarding extending product performance if such products were selected to serve the military industry.

Units that employed foot mounting on end sections and intermediate sections that interfaced end sections (and other intermediate sections) using tabs seemed to be more vulnerable to the shock testing, particularly the perpendicular blow (hammer striking the back of the plate perpendicular to the mounting surface). The tabs failed and dislodged, and mounting feet failed and were damaged. It is possible that the units experienced torsional stress loads that were greater than the withstand capability of the interfacing components. Even though the body components failed, the wire interfacing components did not fail, maintaining wire retention.

The units that failed pull retention testing initially, also failed pull retention testing after environmental testing. This was expected. However, no other units failed pull retention testing after environmental testing, indicating the mechanisms holding the wire in place were not degraded from this series of performance tests. This may change if there are more cycles of tests executed, but as a preliminary series of tests, units proved well.

As indicated in Table 5.6-5 and on Figure 5.7-2, many of the DIN rail mounted units physically came off the mount, but after close inspection, the interfacing features of the mount did not fail. For instance, the tab that fits under the horizontal rail section (that which is parallel to the mounting plate) did not break. It appears that the natural springing action of the foot mounting interface sprung in such a way that it was released from the rail. This occurred for the connector, as well as end plates (those plates that cover the internals of the last mounted connector of the series), and a few end holding plates (those plates that are designed to hold the series of connectors in place from moving along the DIN rail itself). This was surprising since many of these plates were quite rigid and interfaced tightly to the DIN rail. To be released from the DIN rail in this fashion suggests the plate might have undergone torsional stress, enabling one side to release to a certain degree before the other, effectively decreasing holding strength, and cascading to a full release. Nevertheless, the units were able to be re-mounted and testing commenced. This generally occurred during the shock blow from the back of the demonstrator plate, perpendicular to the mounting plane.

Some DIN rail mounted units were able to withstand the shock blows, staying in place without any percentage of release or apparent damage. Highly detailed level of inspection, such as inspection for fractures at magnification, was not conducted. This might be something that should be considered for future testing and evaluation events, or a full qualification program. Such inspection might include ultrasonic testing (UT Testing) and Linear-Elastic Plane-Strain Fracture Toughness.

Fuse holders were susceptible to opening, but not necessarily to damage. The opening of a fuse holder was considered a failure (not meeting operational or functional expectations). Retaining devices for the fuse holding mechanisms need to be assessed for their ability to maintain position. There was one unit, item number 10 that utilizes a fuse holder that requires more than one simple trigger for opening (or a force to overcome stiction in essentially one plane). Item 10 uses screw in fuse holders, where the fuse is held in a molded housing and conducts through a bus. Other fuse holders rely on tab holders to keep a rotating component from releasing (which some did), or rely on stiction to keep the fuse in place (such as that for item 9, where automotive style fuses are pushed into a pre sprung connection).

Most components used "S" style spring arrangements to either hold the conductor directly or push a flat surface against the conductor. The greatest amount of surface area that can be applied at the highest surface pressure will likely result in the highest reliability. Table 6.1-1 indicates those attributes, coupled to inspections and testing results, that offer the greatest performance. Average estimated per unit costs for the connectors investigated ranged from $1.20 (for the in line splice connector with a very roughly estimated cost for retaining hardware) to about $3.20. These are comparable to the costs for currently qualified stud terminal blocks. Therefore, the typical greatest value comes from those units that offer the greatest performance. More will be discussed in Section 6.2.

Table 6.1-1 Connector Type Ranking

	Rank of Preference in Quick Connectors	
	Rank (1-7)	**Comment**
DIN Rail Mounted Push In Retaining	4	
DIN Rail Mounted Push In Retaining with Defeat	3	
DIN Rail Mounted Push In Retaining with Lever	2	A defeating mechanism that doesn't use tools is preferred
Quick Lock Stud	1	Quick to install to plate and install connector when pre-lugged
Screw Down	5	
In Line Splice	2	These are separate units that are not directly comparable to the first five
In Line Splice with Defeat	1	

The demonstrator plate performed well, but there could have been slight deformation during shock testing that could have influenced the performance of the test articles. However, the way in which the test articles responded to the shock testing, was consistent with what is expected. Even though the demonstrator plate was mounted in a way where the DIN rails were horizontal to the floor, thus preloading one side of the DIN rail mounted units and unloading the other side, it is asserted that due to their small mass, this difference is negligible from having the demonstrator plates mounted so there is equal loading to both sides of the mounting interfaces (where the DIN rail is perpendicular to the floor). The demonstrator plates are reflective, at some level, to those surfaces that are likely to hold such devices in a ship design. Therefore, confidence is placed in the results and it is assumed, if the test articles are mounted in an actual termination box to be used on a ship program, the results would be very similar, if not identical.

All considered, the test articles performed well, with the exception of a couple that were damaged during one orientation of shock testing. Although there were not more environmental tests done to validate product effectiveness and robustness, these series of tests lend insight into what might be considered a positive option for the pursuit of product qualification and integration. Section 5.8 indicates there is saving potential on several programs and represents a conservative picture. These types of connectors are widely used in commercial and industrial applications, and on some marine applications. With some further testing and product modification, it is likely the products tested can meet qualification requirements on Navy programs. Part of this testing would be life cycle testing, since there may not be a lot of data to reference over the years of product integration that would be considered similar applications as those encountered on Navy platforms. Although there are some units used on Navy programs, which reside in shock mounted equipment, there are none that are used requiring shock qualification per connector or connector application. It is likely that if a manufacturer of such products would like to support the Navy programs invoking more rigorous requirements, similar or the same products as those researched appear to be good candidates for such application.

6.2 Future Work: Cost Data Estimates

The cost benefit assessment presented in Section 5.8 is a start to forming more definitive evaluation of where savings are possible for a particular program. The next steps would be the following:

- Request and receive more accurate materials and labor costs for certain, preferred units
    - Prototype work assignments could be used to estimate more accurately the costs associated with installation and certain testing sequences
- Determine a more accurate number of applications per program; this may require detailed investigation, but the assumptions built into the calculations would be effectively eliminated as a result
- Determine developmental costs associated with qualification programs, and whether those costs would be levied on the consumer

Although the estimates do offer insight into applications representing opportunities for savings, due to the assumptions made, more detailed assessment should be considered before committing to certain savings programs. This might include

- Costs of re tooling workstations where termination boxes, power panels and other enclosures use connectors and terminal blocks
- Use of current inventory and points of product insertion; this may drive certain planning and scheduling changes during transition and beyond, that represent a cost of change to the company
- Generation of installation and testing procedures needed to incorporate the products into the design
- Design costs of change to incorporate the new products into the design (incorporation into drawings, parts lists, etc.)

The user is encouraged to use the information contained within this report and apply it to their programs. The tools allow the user to input data drivers specific to their own programs quickly and easily, offering a quick insight of whether savings potential exists or whether other options should be explored.

6.3 Future Work: Universal Requirements

This project primarily assessed the capabilities and availabilities of quick connectors that are considered low voltage, fairly low power (generally less than 50 A). However, classifications for these types of connectors, whether captured in existing specifications, should be generalized as much as possible and captured with a simple matrix if possible. The most reliable, easiest to use and repeatable units should be baselined to form a set of requirements for a particular hull design and set of applications, in conjunction with the requirements set forth for the interfacing units. Three primary areas of focus would be power, control and communications, and instrumentation and monitoring. Areas of classification include:

- Voltage
- Power/current
- Conductor size/range
- Fusible or non-fusible
- Mounting arrangement
- Unit material

Using DIN rail or similar mounting arrangement allows for standard practices and methods. Shock and vibration qualified, as well as several other qualifications (see Section 6.4) would need to be part of requirements for given applications. There would be benefit to standardizing as much as possible, the type of connectors that would be used for a given program or set of applications. A good reference for instituting such standardization would be the commercial shipbuilding industry, where such connectors and associated standards are used in common practice.

6.4 Future Work: Qualification Program

The work done during this project is meant to be a first screen of those products considered likely candidates for application in demanding environments. The performance tests conducted during this project closely replicate those types of ESS tests that would likely be invoked during a qualification process. Other tests would probably be invoked as well, including

- Corrosion resistance testing
- Full Load testing during shock and vibration testing
- Pull retention testing during shock and vibration testing
- Physical cycle testing for those components capable of moving (such as fuse holders)
- Dielectric withstand testing
- Toxicity and flammability testing

Corrosion resistance testing may be more important in some applications than others, but most marine environments, even those considered deep inside the hull structure, are subject to salt air or other corrosive environmental effects to some degree. Interfacing parts, such as wire to metal connector surfaces, may experience certain degradation in such environments over time. The interface is considered a primary aspect of connectors of this sort and must be proven to resist corrosive effects in such environments. For connectors with other attributes, such as fuse holders, there are other interfaces to be considered.

Full load testing was not done during shock and vibration testing, only the monitoring of continuity with the use of chatter box channels. However, profiles could be generated to more descriptively account for the performance of a particular test article during such events. The connector is expected to perform at full load during shock and vibration events without abnormal response, maintaining circuit integrity and functionality. The continuity testing was done as a cursory look into the performance of test articles to indicate whether immediate performance concerns exist, as shown in unit numbers 21 and 24. The team gained insight into what might be considered major issues, but it is not necessarily known whether other items operated near a threshold that could be considered disruptive to the load served (high impedance condition where contacts do not totally open). It is recommended that future qualification programs include more descriptive monitoring during such tests, and be done in a full load scenario, which is considered a worst case scenario.

Retention testing was not done *during* shock and vibration testing for this project. This type of testing was done as a static test, first validating proper installation of the unit – conductor interface, and then as a measured test of performance after tests were completed. However, if there is a pre-load on a wire that is interfacing a connector, or if that loading changes dynamically during a shock or vibration event, there may be effects (essentially discontinuity) that would exist and be disruptive to sensitive circuit loads. An example might be the way in which a bundle of cables is tied together in a termination box. If, during a shock event, the whole bundle of wires moves, this may place tensile loads on the retaining mechanisms, causing the wires to physically move within the interface. If the movement is substantial, it may in fact cause discontinuity of some form to occur at the point of interface. This would probably be sensed during the previous type of full load testing, but only if there is total discontinuity or if the current profile indicates noise due to sparking or the introduction of artificial impedance due to something like a corona effect across the conductor and connector.

Any moving parts, such as fuse holders or levers required to utilize holding friction between conductor surface and connector surface, might be exercised for a certain number of repetitive cycles, as a test of endurance withstand. Although it is unlikely certain features would be operated a large number of cycles, breakdown testing is valuable to understand not only when a component has failed, but what the underlying mechanisms are, and whether such testing had an effect on other features or components. Although the fuses did not fail in this sequence of tests, it is likely a set of fuses of varying and expected sizes would be used during testing (if fuses were to be considered for such applications). This sequence of tests did not reveal susceptibility of any particular type of fuse. Even the glass fuses of smaller current rating, such as those used in item 21 or item 22 (fuse elements are small) did not sustain apparent damage. However, this testing procedure was ultimately a test of the connector itself, and not featured components. For future testing, all features and attributes would need to receive full attention and be tested to uncover any possible vulnerabilities.

Depending on the applications, whether they are control, instrumentation, communications or power, different standards and requirements will likely be invoked. One such specification that talks to several different fronts is MIL-C-55243. In this specification, it calls out several different requirements, including dielectric testing. Generally, these units will be used in low voltage, maybe isolated applications (such as dry contact applications). However, the materials comprising the unit must have sufficient dielectric strength to be included as safe during troubleshooting, even when the voltage is considered low. This is also important since some of the conductor will like be touching the unit housing in some way, due to the design of the unit.

Toxicity and flammability testing would be part of future testing, and would need to conform to such standards as the Naval Engineering Standards 713 (NES) and UL 1685 (Underwriters Laboratories). Do to the mass of individual units, and how one might consider these regarding system or equipment components, these types of tests might be invoked in different ways. It is likely to be important moving forward.

It is likely these are not the only other tests that will be required for qualification of this type. It will be increasingly important to keep focused in these areas, since it is possible a large number of these units could be incorporated on the ship.

6.5 Future Work: Product Resilience and Effectiveness

Those products that have a lower center point, whether mounted to a rail system or directly mounted, seemed to have greater resiliency and resistance to torsional stresses, but still had capability to withstand pull tests, pass voltage drop tests and had high insulation levels. Nylon products appeared to be stronger units, but may have had a little more brittleness (brittleness and hardness were not tested, but could be tested during future testing sequences). There needs to be sufficient energy absorbing characteristics so features such as holding tabs, feet, and retaining elements, do not break during shock events or other types of stress loading events. Flexibility should be high without sacrificing too much motion during forced movement such as shock testing. Product impact resistance should be high without creating brittleness. Engaging mechanisms, such as tabs and coupling components for stacking or mounting arrangements need to be capable of absorbing energy across the mechanism without damage or without sacrificing holding strength.

DIN rails need to be compatible with the materials that are used with which they will interface, for grounding purposes and corrosion prevention (such as oxidation). Manufacturers are encouraged to determine the most suitable attributes for given applications and use those designs for baselines from which to work. As seen during this project, there are a number of different types of configurations and product designs. Each generally caters to a different set of applications or markets.

The more intricate a component, such as hinged fuse holders, generally the more susceptible to damage during high impact tests and cycle tests. Some designs were quite simple and performed well, while others are more complex, some performing well and others failing. It appears the more simple designs are a little more favorable, but if more intricate designs become more resilient, then these designs might increase in preference.

6.6 Implementation Plan

The CBA indicates a savings of anywhere from $50k – $300k per ship program, depending on the program and the way in which the units are deployed. For instance, if all existing connectors represent an opportunity, then this reflects the largest possible savings if all applications are targeted for replacement and NRE costs are relatively low. However, if a percentage of current applications already deploy quick connectors, the opportunity decreases linearly. In order to implement a program to deploy such connectors, the following represents a possible approach. However, it is presented here at a high level since it is recognized various programs will treat change differently.

1. Identify opportunities: For a particular program, it is necessary to determine if existing opportunities exist and to what extent. This will be considered an opportunity or set of benefits that will be compared to the costs associated with invoking change.
2. Identify hardware and methodology availability: As seen in this project, not all units tested responded the same. And, some units are more readily available and some units are more suitable to various applications, from moderately important applications, to highly important and vital applications. This will tend to drive the type of unit to explore.

    a. Determine qualification status: Once a set of units is identified as possibly suitable, representing a low risk to design change and materials qualification processes, one should lay out the plan to fully qualify the products. This will likely be a collaboration between the vendor or manufacturer of the product, the consumer (shipyard probably) and the customer (probably the Navy or commercial customer).
    b. Determine qualification scope of work: An estimate of what it will take to get a product or series of products qualified will be necessary to determine how the products can be applied to certain applications.

3. Estimate costs and schedule associated with qualification: Even though not all parties or stakeholders will share in the costs of qualification, it is still necessary to understand the cost dynamic and where economic burden will be assessed. This could drive a model that proves infeasible to the manufacturer, customer, or both.
4. Determine overall cost of change: These costs include the cost of

    a. Design: revising drawings and other documentation to indicate the type of connectors that will be used and delete the existing references
    b. Procurement: revising lists and documents that may drive purchasing costs
    c. Materials Management: understanding current inventories and where the cut in for new technologies may exist (this will drive how NRE [Non-recurring Expenses] will be amortized)
    d. Production Planning: new designs generally need to be re-organized from a production perspective, how and when to assemble certain components in the process line
    e. General Logistics and Administrative Costs: typically, there are administrative costs associated with any change from that considered routine

5. Determine point of technology insertion: At some point, the decision is made to insert the proposed technology in process. This will drive the level of return accounting for any NRE that is amortized.

These steps are considered fundamental. In order to execute the change, different programs will institute different sets of requirements on how to invoke the change. It is likely that there will be several layers to the change process within these five steps, but the general idea is presented. One program, due to the way things are done, may be more suitable to change than another. Even though the per unit cost benefit analysis looks feasible, other areas of expense may drive the return down to a level where it no longer appears feasible. This will be up to the individual program invoking the change.

From a technical standpoint, regardless of how the economics of change are addressed, it appears there are several products that are ready to be implemented with minimal re-evaluation and re-design. Each product may be more suitable to certain applications (i.e., item 18 for moderate to high power applications). Some products, due to their compact size, and large range of operating capabilities, appear to be good candidates for multiple applications (i.e., item numbers 12 and 21). This offers the chance to standardize as much as possible, tending to improve overall CBA.

6.7 Concluding Remarks

Overall, this project proved successful in identifying various quick connector technologies that may prove capable of serving high demanding applications. It was learned where some vulnerabilities exist, such as DIN rail interface and stackable terminations, but it was also determined where improvements could be made to address such vulnerabilities. There is more work for manufacturers to do to meet a demanding market, such as that posed by the Department of Defense, but it is likely that multiple products would be able to do it in a fairly straight forward way, with minimal difficulty and re-design. Therefore, it is a recommendation that these products, and others, are investigated further, and determinations made as to the suitability of the insertion of such products on programs with demanding applications. Depending on the manufacturer’s confidence in products, coupled to the output of this and other similar reports, the manufacturer may elect to enter a qualification program without re-design in order to pursues immediate qualification or learn where modifications are needed to receive qualification.

.

This Page Intentionally Blank

7 References

American Society for Testing and Materials, ASTM D638-10 Standard Test Method for Tensile Properties of Plastics, May 15, 2010.

American Society for Testing and Materials, ASTM D695-10, Standard Test Method for Compressive Properties of Rigid Plastics, April 1, 2010.

American Society for Testing and Materials, ASTM D2990-09
Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics, September 1, 2009.

Department of Defense Interface Standard Section 300B Electric Power, Alternating Current Mil-Std-1399(Navy) Section 300b 24 April 2008.

Department of Defense Standard Practice Electric Plant Installation, Standard Methods for Surface Ships And Submarines (Cableways), MIL-STD-2003-4A, 3 September 2009, Superseding, DOD-STD-2003-4, 24 June 1987.

Detail Specification Cables And Cords, Electric, Low Smoke, For Shipboard Use General Specification For MIL-DTL-24643B, 22 August 2002, Superseding MIL-C-24643A, 14 March 1994.

IEC 60947-7-1, Low-Voltage Switchgear and Control Gear – Part 7-1: Ancillary Equipment – Terminal Blocks for Copper Conductors, Edition 3.0 2009-04.

Military Specification, MIL-C-29600 Military Specification Connectors, Electrical, Circular, Miniature, Composite,
High Density, Quick Coupling, Environment Resistant, Removable Crimp Contacts, Associated Hardware, General Specification for, 20 December 1989.

Military Specification, MIL-C-55243 Connectors, Plugs and Receptacles, Electrical, Quick Connect and Disconnect, 12 Contacts Medium Power, 25 October 1963.

Military Specification, MIL-C-81511F(AS) Military Specification Connectors, Electrical, Circular, High Density,
Quick Disconnect, Environment Resisting and Accessories, General Specification for,
30 September 1992.

Military Specification, MIL-DTL-22992G DETAIL Specification Connectors, Plugs and Receptacles, Electrical, Waterproof, Quick Disconnect, Heavy Duty Type, General Specification for, 2 February 2009.

Military Specification, MIL-DTL-26482H Detail Specification Connectors, Electrical, (Circular, Miniature, Quick Disconnect, Environment Resisting), Receptacles and Plugs, General Specification for, w/Amendment 2, 21 June 2013.

Military Specification, MIL-DTL-27599D Detail Specification Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect, Environment Resistant, Solder Contacts, General Specification For, 21 July 2008

Military Specification, MIL-DTL-38999l Detail Specification Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded, And Breech Coupling), Environment Resistant, Removable Crimp And Hermetic Solder Contacts, General Specification For, w/AMENDMENT 2, 10 May 2012.

Military Specification, MIL-STD-167-1A Test Method Standard: Mechanical Vibrations of Shipboard Equipment (Type I – Environmental and Type II – Internally Excited), November 2, 2005.

Military Specification, MIL-STD-721c Military Standard Definitions of Terms for Reliability and Maintainability, 12 June 1981.

Military Specification, MIL-STD-785B Military Standard Reliability Program For Systems and Equipment Development and Production, 15 September 1980.

Military Specification, Mil-S-901D Shock Tests, H.I. (High-Impact) Shipboard Machinery, Equipment, and Systems, 17 March 1989.

MIL-C-55243 (EL) Connectors, Plugs and Receptacles, Electrical, Quick Connect and Disconnect, Medium Power25 October, 1963.

UL 486C Splicing Wire Connectors, February 28, 2014 − UL 486C.

8 Appendices

The appendices are meant to offer extended information, and the content is placed here so as not to distract during the review of the main document content. In some cases, due to the sensitivity of data, the information has been range valued or estimated, but is close to actual data to indicate the nature of the argument or point. Some information has not been included since distribution would need to be more limited and specific authorizations granted to use the information in this format. However, the appendix is left in the document to indicate to the reader that the topic was explored along the lines described within the appendix.

8.1 Project White Paper

The following is the white paper that was generated for the ETP and Executive Control Board for their review and ultimately, their decision making regarding whether to submit for funding, and whether to allocate funding, respectively. (Shown is Rev. C of the white paper)

Low Voltage Quick Connector Evaluation

Proposer Identification: Lead – GD-BIW
Participants: Bollinger Shipyards

Concept Description: Currently, Navy ship programs use termination connection blocks in applications that are stud style blocks, rated for 150 V and greater, for applications that operate nominally less than 50 V. These applications are primarily associated with controls and instrumentation, for such equipments as operator interface units, central control termination boxes, and Input/Output control termination boxes. The purpose of this project is to determine if there is a more affordable component available that meets applicable requirements, and where the benefits reside by employing such components. This will require an investigation into component performance, materials cost, installation cost, and life cycle support features. Quick connectors and termination units have been used in a variety of applications, specifically a lot being used in land based industries. There may be similar connectors used in the marine industry that we can investigate and evaluate for possible use in Navy programs. If evaluations are favorable, specification and requirements changes may be recommended and thus set up the opportunity to levy such change on selected ship programs.

Project Goals and Objectives: The goals for the project include the following

- Gain understanding of the types of designs used on ship programs with respect to low voltage connections for such things as control panel termination boxes
- Become familiar with the specifications and requirements that drive the designs used
- Investigate what is used in the commercial shipbuilding industry and determine what products could be tested for a cursory performance evaluation
- Consider how current programs could benefit by using other types of products that serve similar functions

The following are considered primary tasks to meet the objectives, and may serve as a basis for a contract Scope of Work.

- Identify and describe existing specifications and requirements used to procure low voltage termination and connection units for Navy programs
- Identify and describe existing specifications and requirements used to procure low voltage termination and connection units for commercial ship programs
- Investigate what products exist that could be tested for use on Navy ship programs; likely testing will be
    - Shock
    - Vibration
    - Some form of accelerated wear testing (although connections and terminations are generally pretty well protected from environmental issues)
- Conduct testing using a typical military qualified termination unit (as a baseline) and selected other units under investigation
- Perform a performance evaluation and comparison to the baseline
- Generate recommendations based on the evaluation targeting requirements, specifications and qualification programs
- Submit a report of findings and recommendations, which would include implementation planning recommendations

Methods and Procedures Required for Accomplishing Goals and Objectives: Utilize guidance documents, such as MIL-T-55164, SAE AS39029C, SAE AS85049C, MIL-C-29600, and others as applicable.

Simple tools will be used, such as Excel or Access to build cost benefit models that indicate what the value added is regarding the use of a particular product type. Tables of preferences will be used in conjunction with the cost benefit assessment. The report will reflect those preferences and target some high level requirements. Preferences will order around features rather than specific products.

Previous and Current Related Work: No specific studies of this sort are known to have been conducted by the NSRP ETP. However, the team will leverage what vendors have done in this area of development.

Deliverables: The deliverable will be a report that compares available products, results of demonstration testing and recommendations regarding product selection and qualification. The report shall include the following items and be further detailed in the Scope of Work that will be defined.

1) Overview of basic qualified connectors and termination plugs available, and components regularly used in commercial applications, to include
    - Product descriptions and specifications
    - Application history
    - Performance testing (if directly applicable and available)
2) Evaluation methods and criteria
3) Demonstration designs
4) Testing criteria
5) Testing results
6) Cursory cost benefit assessment

7) Recommendations for qualification

Benefits and ROI: Benefits and ROI will be offered in relative terms. For example, targeted applications will be investigated for feasibility and approaches evaluated in terms of change for optimal performance. Per unit costs, number of applications for a particular ship design and installation labor will account for the basis for the assessment.

Technology Transfer Approach: Upon completion of the final report, it will become available to the shipbuilding community through presentation at an NSRP Electric Technologies Panel session or similar forum (such as an industry day) within specified limitations if applicable. Any demonstrator products will be made available for inspection and evaluation by others, subject to all legal liabilities, obligations and requirements.

Technology Implementation: During the course of the project, the project team shall evaluate how this technology could be implemented, share those strategies as appropriate among team participants, panel members and the Navy, and generate a technology transfer plan locally if such strategies coordinate with local business models and plans. It is quite possible the project determines there is not a feasible implementation plan to execute, and therefore, the outcome itself represents the findings and completion. Participants and panel members are encouraged to keep all information dissemination in the public domain so that the greatest number of recipients of such information can receive the greatest benefit. Implementation plan execution results shall be shared with the panel whenever practical and appropriate.

Expected Duration: Project duration shall not exceed 12 months from the time of contract or Technical Instruction execution.

Program Funds: Project cost shall not exceed $150,000. High level cost breakdown is attached.

Cost Share: none presented

Weighting Factor: xx%, according to white paper charting

Supporting Cost Data (ROM for budgetary purposes only)

Program Funds – Low Voltage Quick Connector Evaluation		
Type Description	***The below information is required to describe each proposed cost.***	**Amount**
Labor – Conduct research, Evaluate different testing units and provide recommendations based on an equipment down select, Develop report including recommendations based on findings and cost benefit analysis, consultant review for services	Shipyard A: GDBIW – $100,000	$100,000
	Shipyard B: HII-NNS – $15,000	$15,000
	Shipyard C: Bollinger – $15,000	$15,000
	Total:	$130,000
Materials – Various termination units and panels, mock up design and materials, shipping and handling, report materials, travel	Shipyard A: GDBIW	
	Termination units and panels	$1000
	Mock up design, construction, materials	$4000
	Misc. materials	$3000
	Travel	$3000
	Total:	$11,000
Consultants – Labor and Materials (i.e., equipment manufacturers)	Laboratory Services (part of BIW value above)	$0
Total		**$141,000**

8.2 Product Comparisons

The following table is information compiled from product data sheets that were used to compare products. Each product has certain characteristics that are better than others.

Table 8.2-1: Product Comparisons

NSRP ETP Project: Low Voltage Quick Connectors, Vendor and Product Information Evaluation: Final Listing

					Dimensions (in)									Mounting														
Worksheet Number	Unit Number per Dwg	Name	Model/PN	Product Description	Length	Width	Height	No. Connections	Conductor Size	Rated Voltage (V)	Rated Surge Voltage (V)	Rated Current (A)	Rated SCCR(UL) (A)	Metal	Plastic	DIN Rail	Tensile Pull Resistance (Nm)	Mechanism Type	Housing Material	Contact and Mechanism Material	Certification, Qualifications	Fire Rating	Temp Rating C	Interface Type	Passed Vibration Testing	Passed Shock Testing	Passed Thermal Stress Testing	Remarks
1	2	Term Block Baseline	A-A-59125/24 16TB-12	MIL qualified terminal block for lugged terminations, for Baseline	4.5	0.68	0.525	24	10-20	300	1600	20													Y	Y	Y	
2	27	3M	314-BOX	Insulation Displacement, 3-wire splicing connector, flame retardant and moisture resistant	0.95	0.92	0.47	3	14-22	600		15							Nylon	Tin plated brass	UL 486C, file No. E23438, CSE Std. 22.2 No. 0. 188-MI983, file No.		105	Insulation Displacement	Y	N^2	Y	
3	11	Wago	773-164	Push wire 4-conductor splicing connector	0.768	0.512	0.516	4	18-12	600	4k	20		n/a			meets UL	spring	see note	see note	E69654	V2	105 C	Push-wire	Y	Y	Y	Free floating splice
4	13	Wago	222-415	Splicing Connector	0.807	1.047	0.571	5	12-28	400	4000	32					meets UL	Lever	see note	see note	UL file: E696654	V0	85 C	Lever actuated CAGE CLAMP	Y	N^2	Y	Free floating splice
5	14	Ideal	Model 39/30-1039J	3 Port Push-In Connector	0.78	0.86	0.45	3	12-18	600	3000								Nylon/Polycarbonate	Copper	UL486C, 467, CSA C22.2 #188, RoHS	UL94V-2	105	Spring	Y	$N^{2,6}$	Y	
6	35	Tyco	925	Flat bottom Miniature Terminal Block, Tubular Screw Clamp	1.23	0.76+(.38 xN) [2.28 with 4 ckts]	1.25	2	8-22	600		30			x			Screw - Tubular Clamp	Polyester - GF	Zinc Plated Copper Alloy			150 Max	Tubular Screw Clamp	Y	N^5	Y	
7	6	Tyco	1-776302-4	1 Position Terminal Block	1.71	0.92	0.73	4	10-22	250	4500	40			x		125lbs	Screw down	Polyamide 6	Brass, tin plated		UL94V-2	-35 to +100		Y	Y	Y	Torque 10 in-lbs.
8	15	Phoenix Contact	PT 1,5/S	DIN Raol mounted, quick connecting terminal block; spring clamp	1.76	0.137	1.196	2	14-26 stranded	500	6000	17.5				x		Spring			IEC 60947-7-1	V0		Spring	Y	N^1	Y	IEC 60947-7-1
9	16	Phoenix Contact	PT 2,5	DIN Rail mounted, quick connecting terminal block; spring cage	1.91	0.204	1.38	2	12-26 stranded	800	6000	30	300			x	60 N	Spring Cage	PA		IEC 60947-7-1	V0	-60 - 125	Spring Cage	Y	N^1	Y	
10	20	Cooper Bussman	PDBFS 220	Gangable Connector Block Distribution Block (1 in to 4 out)	3.372	1.03	2.146	5	2/0-8 Source, 4-14 Load	600		175	200k							Tin Plated Aluminum	UL 1953, UL 94VO		75		Y	Y	Y	
11	36	Tyco	N/A	Bus Bar Assembled with 2 3/8" power Posts, connectors, cables supplied	4	1	>2	2	1/0-350cmil	<2000		300		x				Quick Plug	Composite Polymer	Silver Plated Copper Alloy			260 Max. Limited by cable to 150.	Quick Plug	Y	Y	Y	

					Dimensions (in)									Mounting														
Worksheet Number	Unit Number per Dwg	Name	Model/PN	Product Description	Length	Width	Height	No. Connections	Conductor Size	Rated Voltage (V)	Rated Surge Voltage (V)	Rated Current (A)	Rated SCCR(UL) (A)	Metal	Plastic	DIN Rail	Tensile Pull Resistance (Nm)	Mechanism Type	Housing Material	Contact and Mechanism Material	Certification, Qualifications	Fire Rating	Temp Rating C	Interface Type	Passed Vibration Testing	Passed Shock Testing	Passed Thermal Stress Testing	Remarks
12	9	Wago	282-696	Quick Connect Terminal Block with fuse	3.35	0.315	1.32	2	24 - 10	400	6k	25			x	Yes	meets UL	spring	see note	see note	UL file: E45172	V0	105 C	CAGE CLAMP	Y	Y	Y	
13	10	Wago	282-128	Fused Terminal Block	2.44	0.512	2.22	2	24 - 10	600	6k	10	10k		x	yes	meets UL	spring	see note	see note	UL E45172	V0	105 C	CAGE CLAMP	Y	N^{1}	Y	
14	12	Wago	2002-1201	2 conductor through terminal block	1.909	0.205	1.295	2	22 - 12	600	8k	20	100k			yes	meets UL	spring	see note	see note	E45172	V0	105 C	CAGE CLAMP S	Y	N^{1}	Y	
15	21	WEIDMULLER	1011000000	Quick connector, DIN Rail Mounted; 2 contacts	2.36	0.311	2.4	2	8-20	500	6000	6.3				Plastic DIN Rail		Screw	Wemid				-50-120	Screw	Y	$N^{1,3}$	Y	.8-1.6Nm tightening torque range
16	22	WEIDMULLER	1880430000	W-Series Fused Terminal Block	3.21	0.358	2.11	2	10-22	500	6000	6.3				x		Screw	Wemid				-50-120	Screw	Y	N^{1}	Y	.5-.8 Nm tightening torque range
17	23	Eaton	XBUT25D22	DIN Rail mounted quick connecting terminal block; screw connector, 4 conductors per block	2.52	0.2	1.87	4	12-26	500	6000	28				x		Screw	Polyamide 6.6	Tin Plated Copper			Up to 125C	Screw	Y	N^{1}	Y	5.3-7.1 in-lb tightening torque range (.6-.8Nm)
18	24	Eaton	XBUT4FBE	DIN Rail mounted quick connecting terminal block; screw connector	2.24	0.24	2.87	2	10-26	600	4000	6.3				x		Screw	Polyamide 6.6	Tin Plated Copper			Up to 125C	Screw	Y	N^{3}	Y	5.3-7.1 in-lb tightening torque range (.6-.8Nm)
19	25	Eaton	XBPT4	DIN Rail mounted quick connecting terminal block; spring connector	2.2	0.24	1.45	2	10-24	600	8000	40				x		Spring	Polyamide 6.6	Tin Plated Copper			Up to 125C	Spring	Y	Y	Y	
20	26	Eaton	XBQT15	DIN Rail mounted quick connecting terminal block; Insulation Displacement connector	2.31	0.2	1.55		16-24	600	8000	17.5				x		Insulation Displacement	Polyamide 6.6	Tin Plated Copper			Up to 125C	Insulation Displacement	Y	Y	Y	
21	28	Rockwell Automation (Alan Bradley)	1492-L2	DIN Rail Mounted quick connecting terminal block; spring clamp connector	2.03	0.138	1.16	2	14-26	300		20				x		Spring		Tin Plated Copper	UR, CSA, IEC		-58 to +248	Spring Clamp	Y	N^{1}	Y	
22	29	Rockwell Automation (Alan Bradley)	1492-J3	DIN Rail Mounted quick connecting terminal block; screw clamp connector	2.36	0.2	1.59	2	12-28	600		25				x		Screw		Tin Plated Copper	UR, CSA, IEC		-58 to +249	Screw	Y	N^{1}	Y	
23	30	Rockwell Automation (Alan Bradley)	1492-CAM1	DIN Rail Mounted quick connecting terminal block; screw clamp connector, Open Construction	1.5	0.41	1.44	2	8-22	600		55				x		Screw		Tin-Plated Copper Alloy	UR, CSA-UI		-40 to +221	Screw	Y	N^{1}	Y	
24	31	Phoenix Contact	UK 2,5 N	DIN Raol mounted, quick connecting terminal block; screw clamp	1.67	0.205	1.65	2	14-24 stranded	300	8000	24				x		Screw						Screw	Y	Y	Y	
25	32	Phoenix Contact	ST 1,5	DIN Rail mounted, quick connecting terminal block; spring cage	1.91	0.165	1.44	2	16-28 stranded	500	6000	17.5				x		Spring Cage						Spring Cage	Y	Y	Y	
26	34	Tyco	212	Flat Bottom NEMA terminal block, Tubular Screw	1.47	0.81+(.57 xN) [3.09 with 4 ckts]	1.3	2	4-18	600		85			x			Screw - Tubular Screw	Phenolic				150 Max	Tubular Screw	Y	N	Y	
27	18	Cooper Bussman	PDB-220-3	Gang Screw Termination Block	4.27	2.88	2.13	15	2/0 - 8 Source, 4-14 Load	600		175	200k							Tin Plated Aluminum	UL 1953, UL 94VO		75		Y	Y	Y	

8.3 Demonstrator Unit

8.3.1 Design and Construction

The following are the drawing sheets for the demonstrator unit, indicating two test plates and 27 test articles.

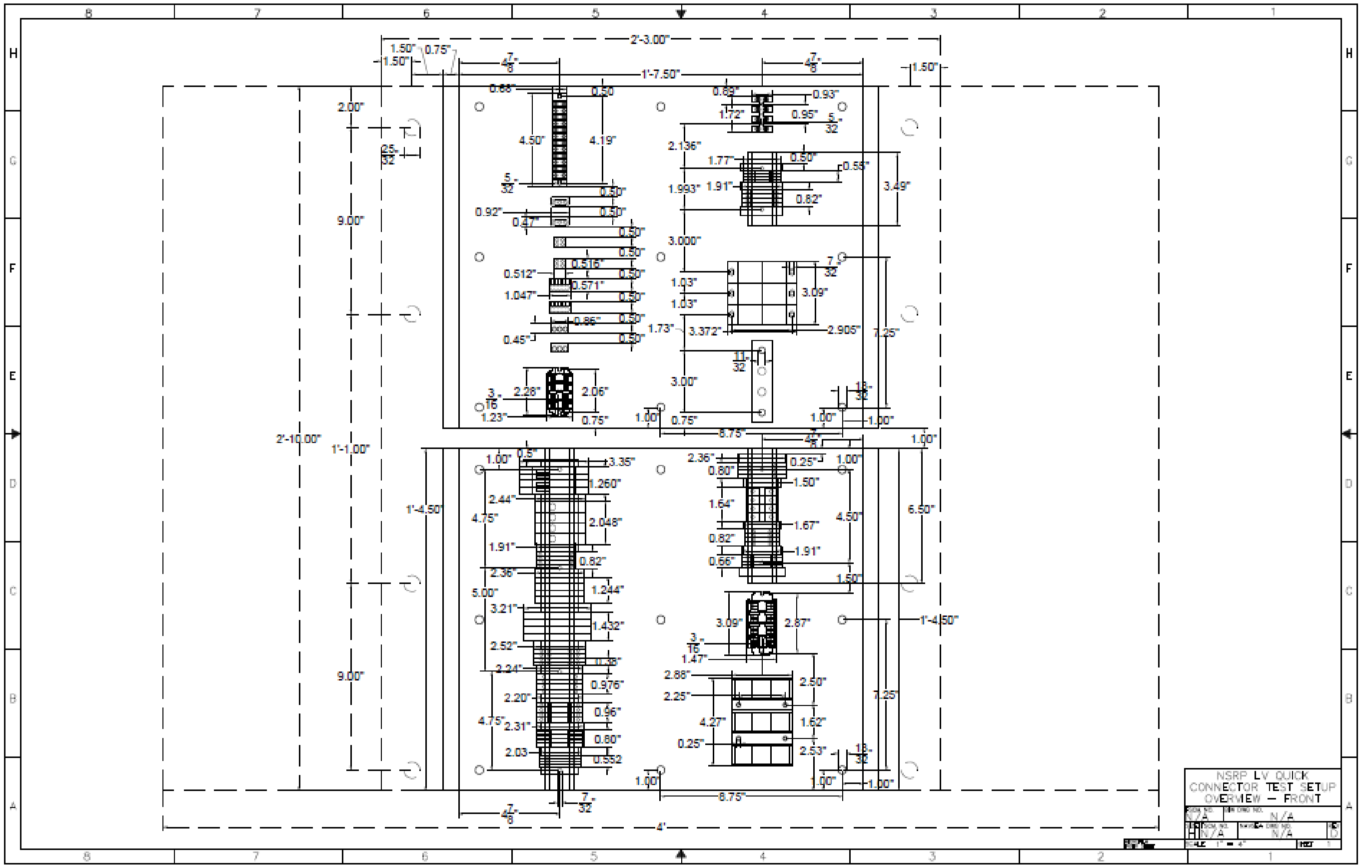


Figure 8.3-1 Test Set-up Overview Front, Sh. 1

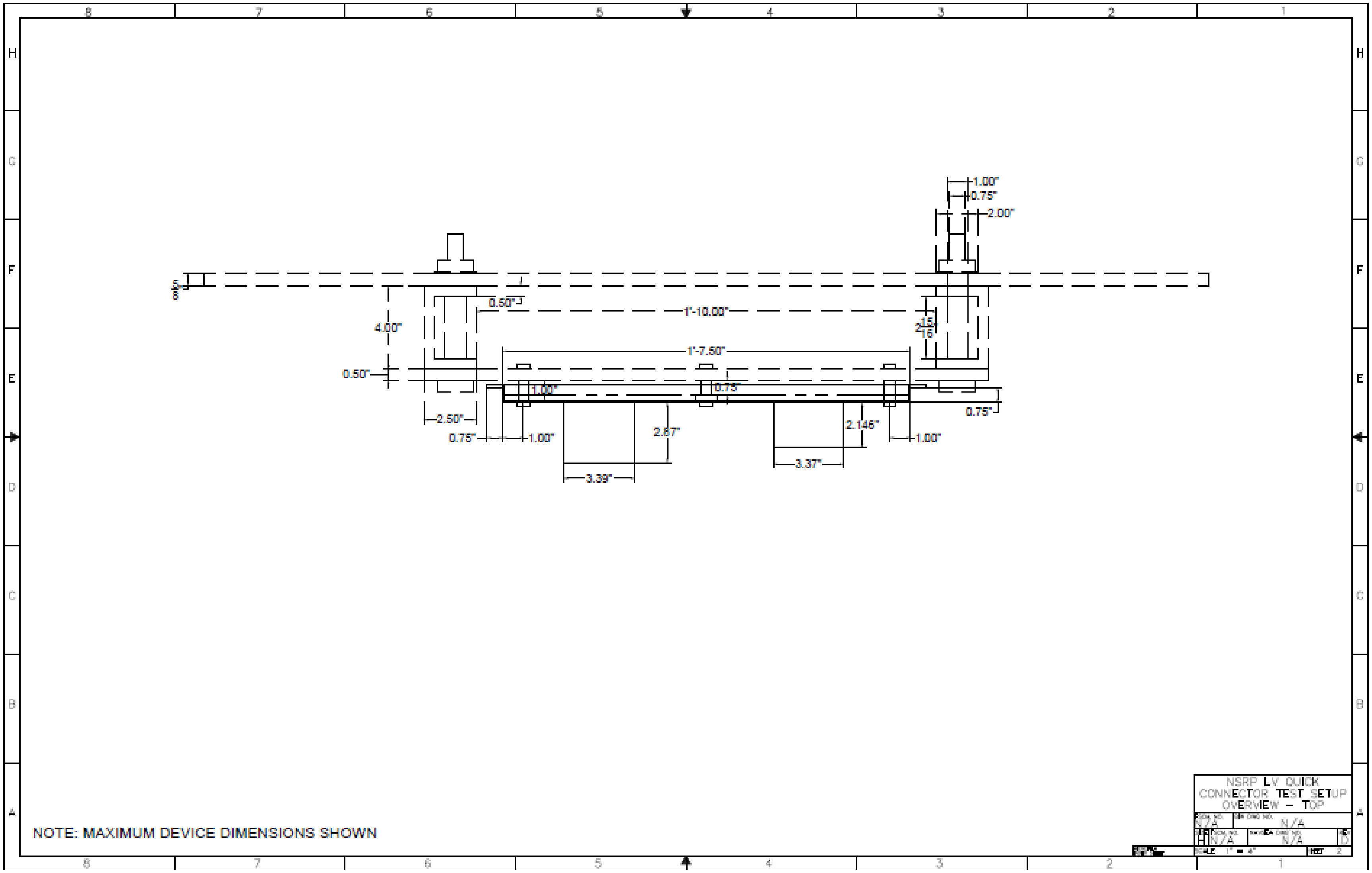


Figure 8.3-2 Test Set-up Overview Top, Sh. 2

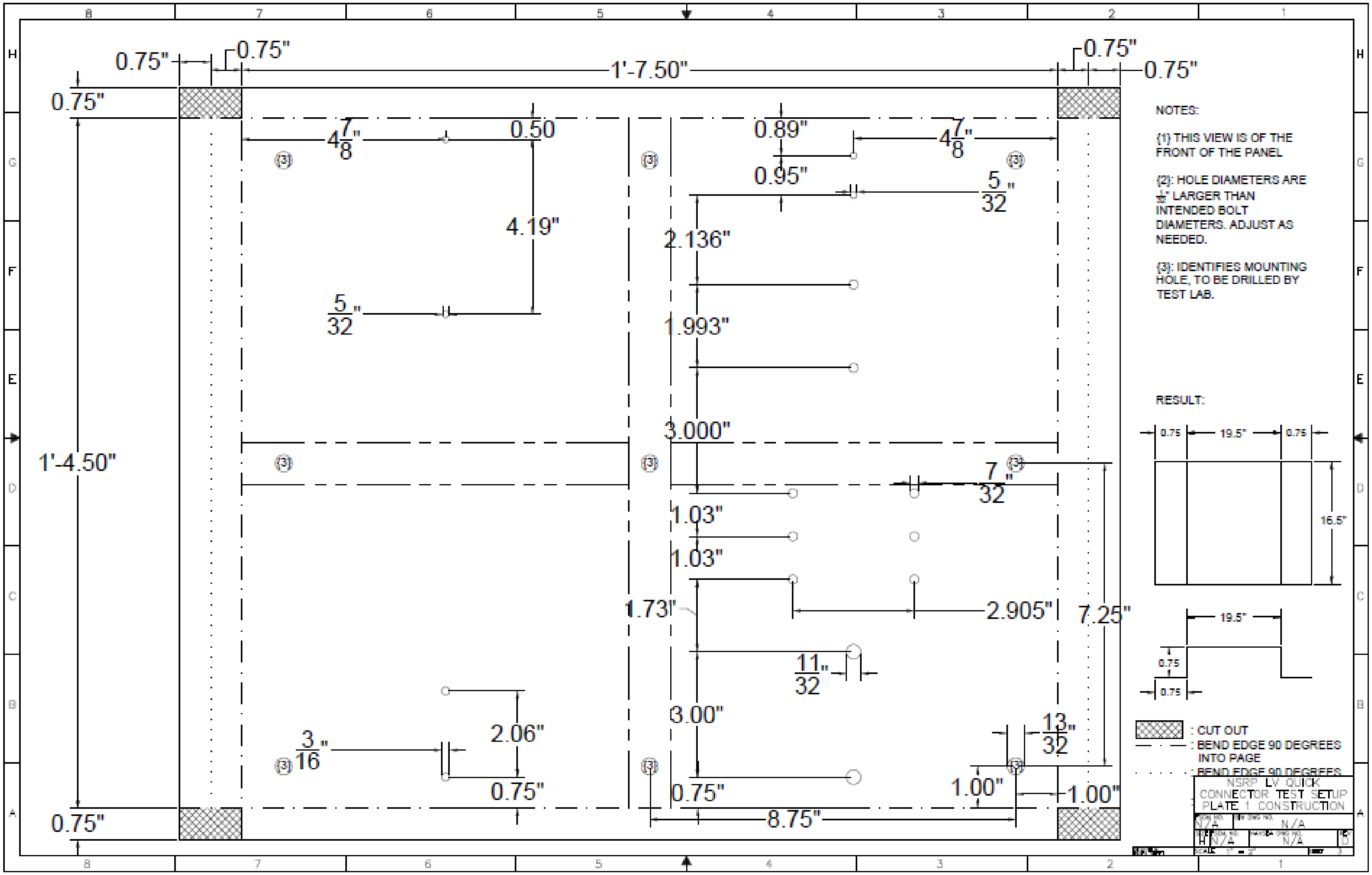


Figure 8.3-3 Test Set-up Overview Plate One Construction, Sh. 3

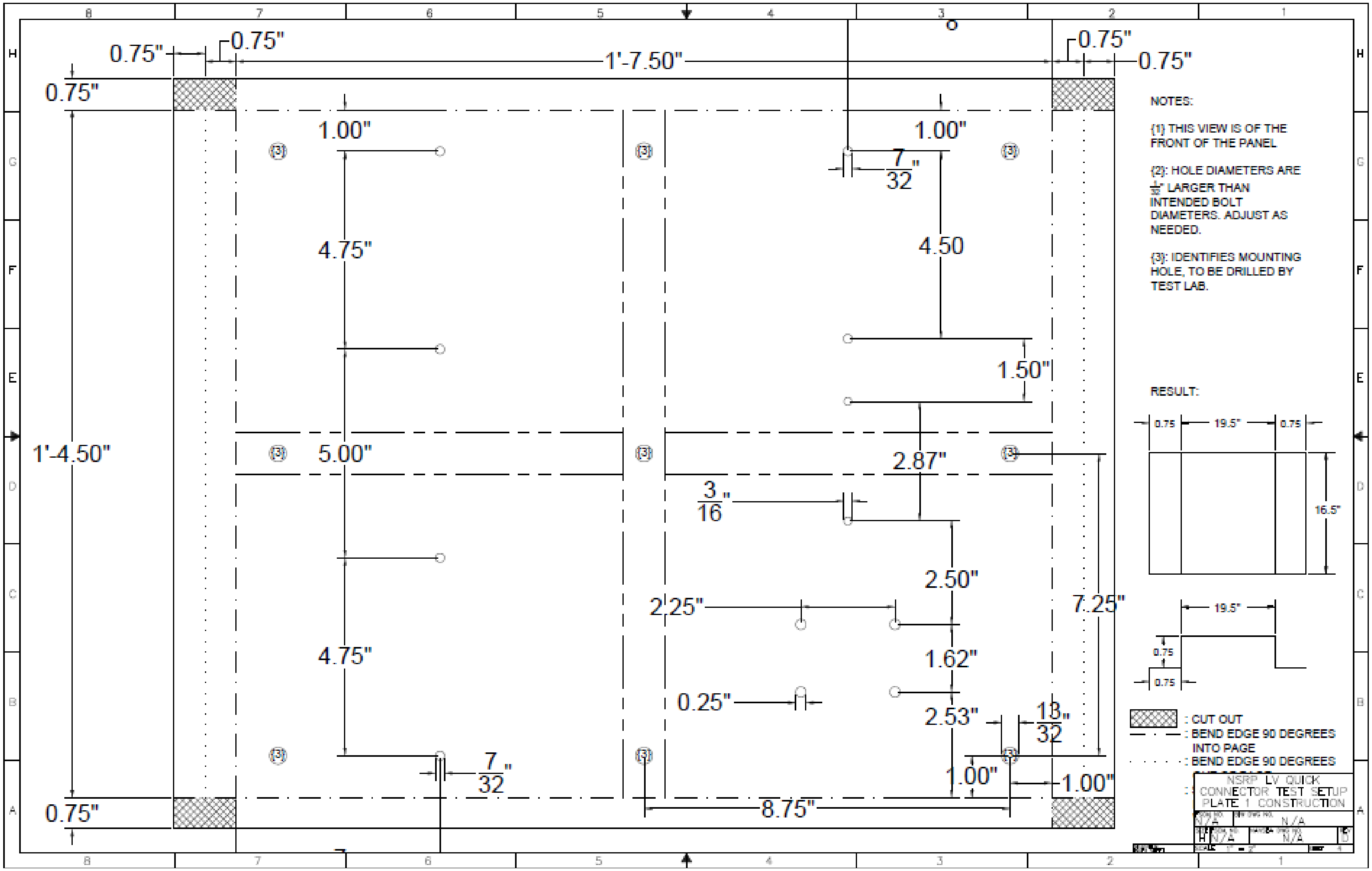
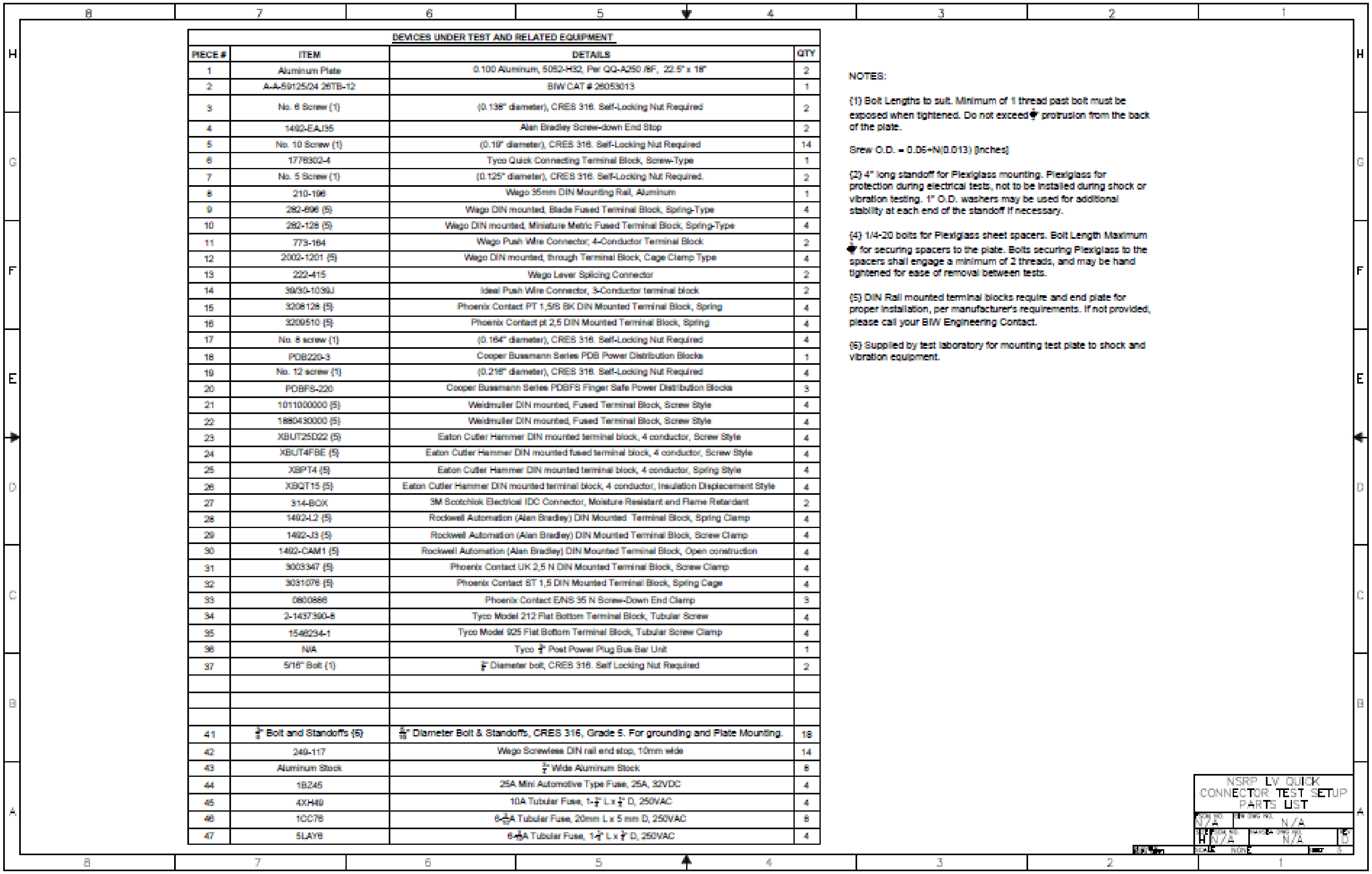


Figure 8.3-4 Test Set-up Overview Plate Two Construction, Sh. 4



DEVICES UNDER TEST AND RELATED EQUIPMENT

PIECE #	ITEM	DETAILS	QTY
1	Aluminum Plate	0.100 Aluminum, 5052-H32, Per QQ-A250 /8F, 22.5" x 18"	2
2	A-A-59125/24 26TB-12	BIW CAT # 26053013	1
3	No. 6 Screw (1)	(0.138" diameter), CRES 316. Self-Locking Nut Required	2
4	1492-EAJ35	Alan Bradley Screw-down End Stop	2
5	No. 10 Screw (1)	(0.19" diameter), CRES 316. Self-Locking Nut Required	14
6	1776302-4	Tyco Quick Connecting Terminal Block, Screw-Type	1
7	No. 5 Screw (1)	(0.125" diameter), CRES 316. Self-Locking Nut Required.	2
8	210-198	Wago 35mm DIN Mounting Rail, Aluminum	1
9	282-696 (5)	Wago DIN mounted, Blade Fused Terminal Block, Spring-Type	4
10	282-126 (5)	Wago DIN mounted, Miniature Metric Fused Terminal Block, Spring-Type	4
11	773-164	Wago Push Wire Connector, 4-Conductor Terminal Block	2
12	2002-1201 (5)	Wago DIN mounted, through Terminal Block, Cage Clamp Type	4
13	222-415	Wago Lever Splicing Connector	2
14	39/30-1039J	Ideal Push Wire Connector, 3-Conductor terminal block	2
15	3208128 (5)	Phoenix Contact PT 1,5/S BK DIN Mounted Terminal Block, Spring	4
16	3209510 (5)	Phoenix Contact pt 2,5 DIN Mounted Terminal Block, Spring	4
17	No. 8 screw (1)	(0.164" diameter), CRES 316. Self-Locking Nut Required	4
18	PDB220-3	Cooper Bussmann Series PDB Power Distribution Blocks	1
19	No. 12 screw (1)	(0.216" diameter), CRES 316. Self-Locking Nut Required	4
20	PDBFS-220	Cooper Bussmann Series PDBFS Finger Safe Power Distribution Blocks	3
21	1011000000 (5)	Weidmuller DIN mounted, Fused Terminal Block, Screw Style	4
22	1880430000 (5)	Weidmuller DIN mounted, Fused Terminal Block, Screw Style	4
23	XBUT25D22 (5)	Eaton Cutler Hammer DIN mounted terminal block, 4 conductor, Screw Style	4
24	XBUT4FBE (5)	Eaton Cutler Hammer DIN mounted fused terminal block, 4 conductor, Screw Style	4
25	XBPT4 (5)	Eaton Cutler Hammer DIN mounted terminal block, 4 conductor, Spring Style	4
26	XBQT15 (5)	Eaton Cutler Hammer DIN mounted terminal block, 4 conductor, Insulation Displacement Style	4
27	314-BOX	3M Scotchlok Electrical IDC Connector, Moisture Resistant and Flame Retardant	2
28	1492-L2 (5)	Rockwell Automation (Alan Bradley) DIN Mounted Terminal Block, Spring Clamp	4
29	1492-J3 (5)	Rockwell Automation (Alan Bradley) DIN Mounted Terminal Block, Screw Clamp	4
30	1492-CAM1 (5)	Rockwell Automation (Alan Bradley) DIN Mounted Terminal Block, Open construction	4
31	3003347 (5)	Phoenix Contact UK 2,5 N DIN Mounted Terminal Block, Screw Clamp	4
32	3031076 (5)	Phoenix Contact ST 1,5 DIN Mounted Terminal Block, Spring Cage	4
33	0800886	Phoenix Contact E/NS 35 N Screw-Down End Clamp	3
34	2-1437390-8	Tyco Model 212 Flat Bottom Terminal Block, Tubular Screw	4
35	1546234-1	Tyco Model 925 Flat Bottom Terminal Block, Tubular Screw Clamp	4
36	N/A	Tyco [illegible] Post Power Plug Bus Bar Unit	1
37	5/16" Bolt (1)	[illegible]" Diameter bolt, CRES 316. Self Locking Nut Required	2
41	[illegible]" Bolt and Standoffs (6)	$\frac{5}{16}$" Diameter Bolt & Standoffs, CRES 316, Grade 5. For grounding and Plate Mounting.	18
42	249-117	Wago Screwless DIN rail end stop, 10mm wide	14
43	Aluminum Stock	[illegible]" Wide Aluminum Stock	8
44	1B245	25A Mini Automotive Type Fuse, 25A, 32VDC	4
45	4XH49	10A Tubular Fuse, 1-[illegible]" L x [illegible]" D, 250VAC	4
46	1CC76	6-[illegible]A Tubular Fuse, 20mm L x 5 mm D, 250VAC	8
47	5LAY8	6-[illegible]A Tubular Fuse, 1-[illegible]" L x [illegible]" D, 250VAC	4

NOTES:

(1) Bolt Lengths to suit. Minimum of 1 thread past bolt must be exposed when tightened. Do not exceed [illegible]" protrusion from the back of the plate.

Srew O.D. = 0.06+N(0.013) [inches]

(2) 4" long standoff for Plexiglass mounting. Plexiglass for protection during electrical tests, not to be installed during shock or vibration testing. 1" O.D. washers may be used for additional stability at each end of the standoff if necessary.

(4) 1/4-20 bolts for Plexiglass sheet spacers. Bolt Length Maximum [illegible]" for securing spacers to the plate. Bolts securing Plexiglass to the spacers shall engage a minimum of 2 threads, and may be hand tightened for ease of removal between tests.

(5) DIN Rail mounted terminal blocks require and end plate for proper installation, per manufacturer's requirements. If not provided, please call your BIW Engineering Contact.

(6) Supplied by test laboratory for mounting test plate to shock and vibration equipment.

NSRP LV QUICK
CONNECTOR TEST SETUP
PARTS LIST

N/A
N/A
H N/A
N/A
D
SCALE NONE
5

Figure 8.3-5 Test Set-up Parts List, Sh. 5

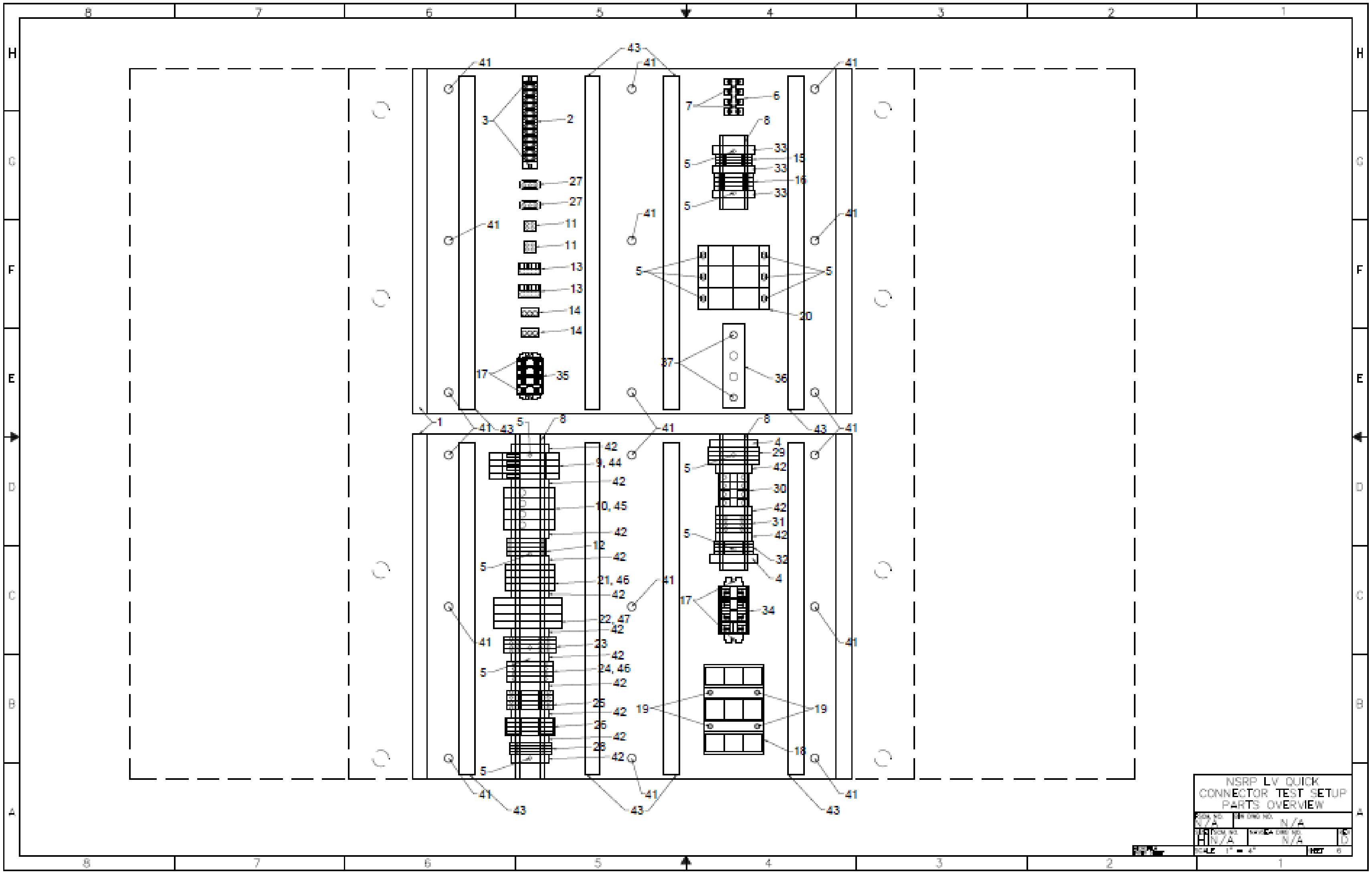
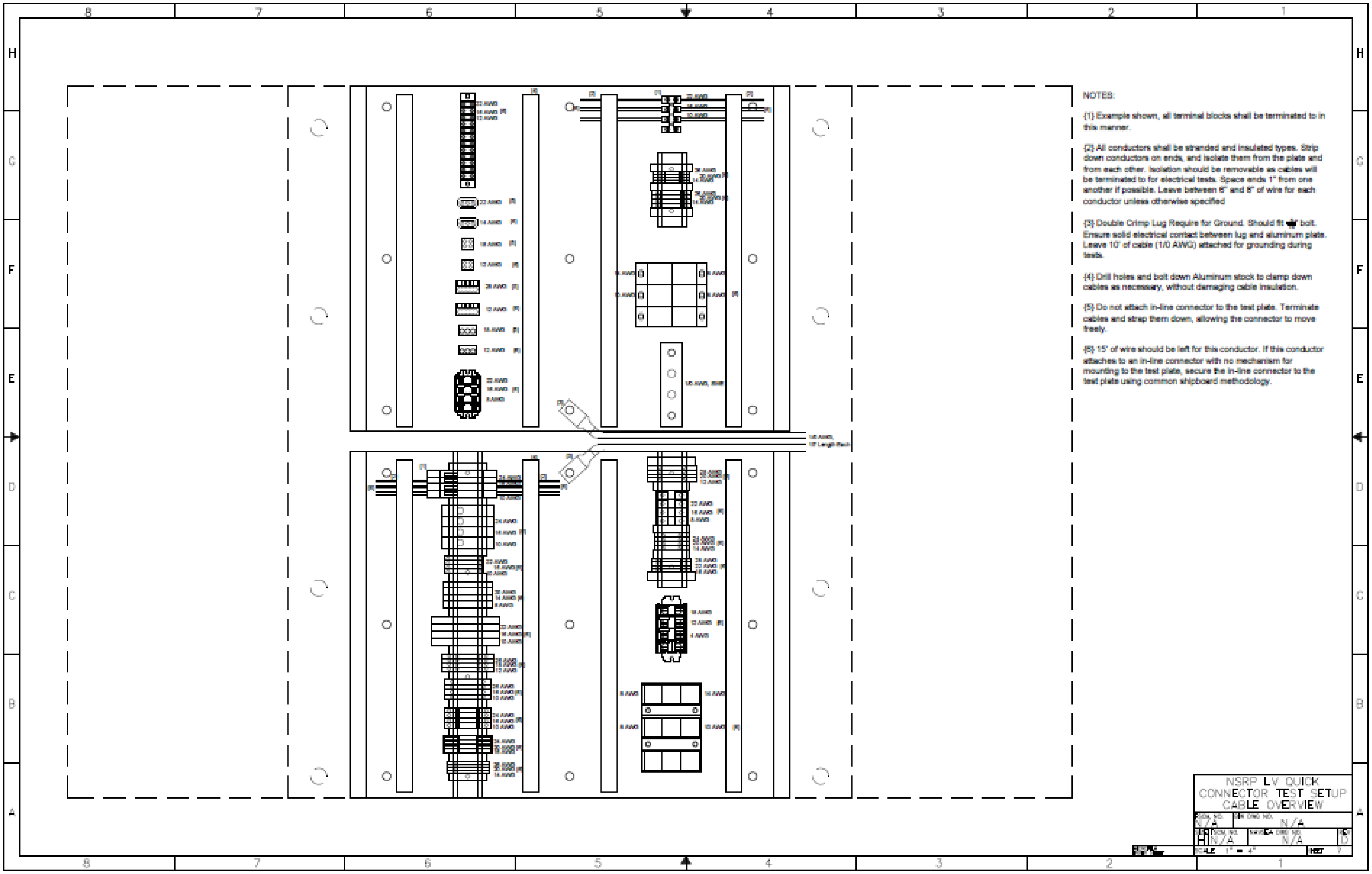


Figure 8.3-6 Test Set-up Overview Parts Overview, Sh. 6



NOTES:

{1} Example shown, all terminal blocks shall be terminated to in this manner.

{2} All conductors shall be stranded and insulated types. Strip down conductors on ends, and isolate them from the plate and from each other. Isolation should be removable as cables will be terminated to for electrical tests. Space ends 1" from one another if possible. Leave between 6" and 8" of wire for each conductor unless otherwise specified

{3} Double Crimp Lug Require for Ground. Should fit [illegible]" bolt. Ensure solid electrical contact between lug and aluminum plate. Leave 10' of cable (1/0 AWG) attached for grounding during tests.

{4} Drill holes and bolt down Aluminum stock to clamp down cables as necessary, without damaging cable insulation.

{5} Do not attach in-line connector to the test plate. Terminate cables and strap them down, allowing the connector to move freely.

{6} 15' of wire should be left for this conductor. If this conductor attaches to an in-line connector with no mechanism for mounting to the test plate, secure the in-line connector to the test plate using common shipboard methodology.

NSRP LV QUICK
CONNECTOR TEST SETUP
CABLE OVERVIEW

FSCM NO. N/A	DWG NO. N/A		
SIZE H	FSCM NO. N/A	DWG NO. N/A	REV D
SCALE 1" = 4"		SHEET 7	

Figure 8.3-7 Test Set-up Cable Overview, Sh. 7

8.4 Demonstrator Testing Procedure

The following is the testing procedure that was referenced for testing both at BIW and at the laboratory, for the electrical and conductor retention testing, and performance testing, respectively.

National Shipbuilder Research Program, Electric Technologies Panel
Low Voltage Quick Connector Project

Demonstrator Test Procedure

Submitted by: Greg Stevens, BIW
3/17/14

Revision	Date	Description	Pages
-	3/17/14	Initial Release	all

Contents

Figures

Tables

1 Overview

This is part of a National Shipbuilding Research Program project that investigates available quick connector and traditional connector units in various configurations, and tests these units on a demonstrator back panel to exhibit capability in relation to typical military requirements. The project team investigated a number of products and determined that the ones comprising the demonstrator unit are those of highest interest subject to various tests in order to determine resilience and overall performance. A primary purpose of this testing sequence is to determine the withstand capability of several different technologies and configurations of connectors in order to decide which units might be good candidates for formal qualification. Three standard performance tests will be used, and are described below: vibration testing, shock testing, and various stress testing. Once each test is completed, the individual product withstand is determined by measuring such items as capability to maintain conductivity across the interfacing points and tensile strength in holding a conductor in place (testing whether the performance test caused mechanisms to disengage). The test specimens shall be instrumented to test voltage drop during vibration and shock testing, which will be detailed below.

2 Performance Testing

Each product will be installed on a demonstrator unit backplane which will permit the sample to be performance tested for vibration, shock, and thermal cycling, in that order (considered a series test sequence). The demonstrator unit comprises several different products, cable engagements including cable supports, all mounted on a reinforced structural backplane such that all the products can be performance tested at the same time and inspected and tested individually for capability. The design utilizes manufacturer recommended installation and mounting arrangements. Cables have been restrained using bar stock for ease of installation; the functionality replicates a single conductor being restrained either individually or within a bundle of conductors, which, collectively, are strapped down inside a box. If a cable becomes loose from the backplane, the laboratory personnel performing inspections and tests will be responsible for restraining the cable such that they do not impart undue forces on the products being tested. Cables coming loose from the specimen being tested represents a failure, and must be re-engaged, if possible, before moving onto the next test sequence.

All testing shall be performed in compliance with all local, state and federal safety and environmental regulations.

3 Testing References

MIL-STD-167-1: Department of Defense Test Method Standard Mechanical Vibrations of Shipboard Equipment (Type I – Environmental and Type II – Internally Excited)

MIL-S-901D: Military Specification, Shock Tests, H.I. (High-Impact) Shipboard Machinery, Equipment, and Systems, Requirements for, March 17, 1989.

MIL-STD-202G: Department Of Defense, Test Method Standard, Electronic and Electrical Component Parts, 28 June 2013.

Mil-T-16366F: Military Specification, Terminals, Electrical Lug and Conductor Splices, Crimp Style, February 8, 1980.

Mil-C-55243: Military Specification, Connectors, Plugs and Receptacles, Electrical, Quick Connect And Disconnect, 12 Contacts? Medium Power, 25 October, 1963.

4 Attachments

Attachment A:	Demonstrator Design Plates: NSRP ETP Low Voltage Quick Connector Test Plate Design DWG.pdf
Attachment B:	Testing Worksheets (Performance and Electrical Testing): NSRP ETP Low Voltage Quick Connectors Testing Worksheet.xls

5 Testing Tools

The following are tools that will be required to perform the testing listed in this document.

1. Fluke 287 multimeter or similar (even though max. resistive value is 500 MΩ for the insulation resistance test)
2. Phenix PM6 Hi Pot tester or similar
3. Genesis GEN5i Data Acquisition Unit or similar (instrument 28 points for contact resistance test)
4. Lightweight Shock Testing Machine in accordance with Mil-S-901D
5. Vibration Testing Machine in accordance with Mil-Std-167
6. Thermal Stress Testing enclosure in accordance with Mil-Std-202G
7. Jonard GPP-15 pull tester or similar
8. Milwaukee TEMP GUN laser temperature gun or similar
9. 10 V power source, 500 W
10. 10 Ω rheostat, 500 W
11. Various miscellaneous tools as necessary

6 Demonstrator Configuration

The demonstrator unit comprises an aluminum structure representing the mounting fixture and the mounted test specimens, and protective Plexiglass used when the thermal cycling test is done and the specimens are energized to 450 V and during the dielectric test. This is shown in Figure 6-1, and in more detail in Attachments A through F.

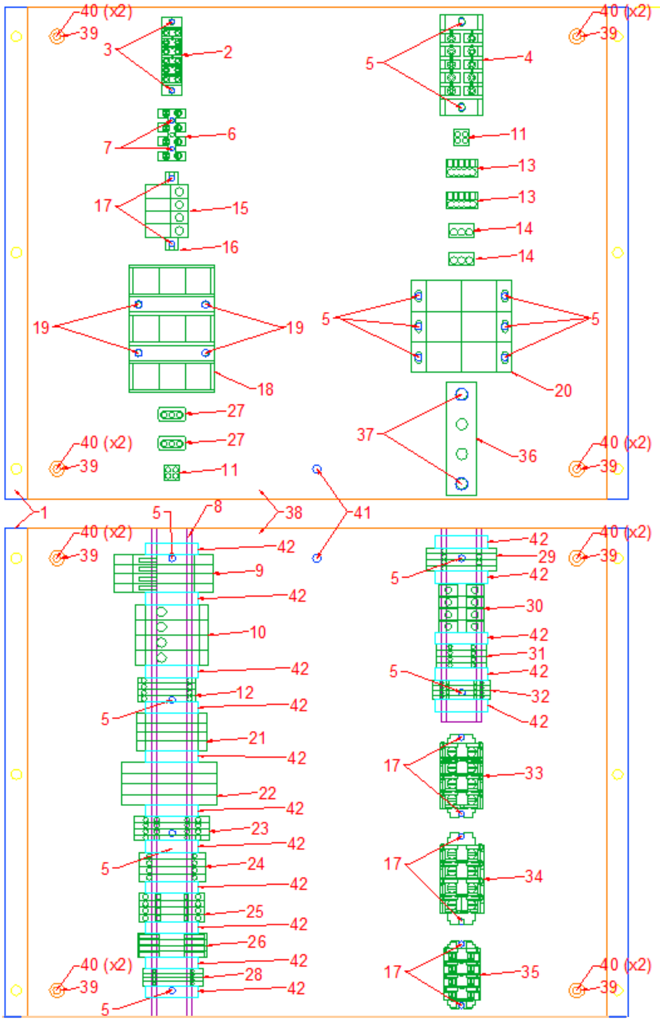


Figure 6-8.4-1: Example of Test Plates

The plate is not drilled to accept the anvil plate, but is shown as a template in yellow in Attachment A, in accordance with typical test plate parameters of Mil-S-901D, Fig. 7. This will allow the laboratory the flexibility to mount to their particular test stands, but it is noted that all mounting arrangements must be in compliance to both Mil-S-901D and Mil-Std-167. Each test specimen on the test plates is mounted in accordance with manufacturer's recommendations, and interfaced with conductors. These conductors have been installed per manufacturer's recommendations. Since the test specimens specify a range of conductors to interface to, it has been determined to use the largest conductor acceptable on one end, the smallest conductor acceptable on the other end and a conductor sized in the middle of the range for the middle connection point (see Table 8.3-1 for conductor ranges for specimens). The middle conductor will be used to instrument the test during performance testing (see Sect. 8.2). For those units that have a means of removing the conductors for inspection (conductors are not permanently held in place), this should be done with care so as not to damage or disturb the conductor surfaces. The conductors are held in place with a restraining mechanism as outlined in Attachment A and B. The inspection is meant to determine if there is movement of conductors between the conductor surface and the interfacing holding mechanisms, and is part of the responsibility of the laboratory operating technicians during the testing process.

Attachment E lists the test specimens that are being investigated. Each unit on the panel is labeled accordingly, with information for quick reference. When the tensile strength or pull test is done for the first time, the testing personnel shall use a spring scale to attach to the conductor outer perimeter and pull, slowly increasing tension, until the static friction interface relieves and allows the conductor to move away from the interface without damaging the conductor or the connector (complete removal is not necessary, only the evidence of movement when located in the holding mechanism area). Subsequent pull tests will be conducted in accordance with Sect. 8.1.1, up to 10 pounds. The order of testing shall be the following

1. General inspection and electrical testing (see Sect. 8.1)
2. Performance testing (see Sect. 8.2)
3. General inspection and electrical testing (see Sect. 8.1)

The Plexiglass safety panel and hardware must be removed before performing the shock and vibration testing. The safety panel shall be re-installed before the specimens are energized during the thermal testing sequence, and before the dielectric test.

All packaging materials should be retained and re-used when sending the unit back to BIW.

7 Receipt of Materials, General Handling and Inspection

Note: Care should be exercised when unpacking and handling the demonstrator units, as the test specimens are subject to damage should the panel fall onto a hard surface.

Upon receiving the demonstrator units, the units shall be carefully inspected for damage. If damage is noted, immediately contact BIW to notify of the damage; the damage shall be documented with pictures and any descriptions that will be included in the final report. It is expected the damage will be repaired by the lab, a representative of the manufacturing company that supplied the testing sample and accompanying components, or the specimen will be replaced. If the structure supporting the demonstration units has been compromised, send pictures of the damage to BIW for review and disposition.

Care for assemblies shall be afforded the demonstrator when moving the piece from station to station, and when re-packaging, so as not to disturb or otherwise damage demonstrator elements.

8 Testing

The following, Table 8-1, indicates the tests to perform on the demonstrator unit, and corresponding sequence to perform the test. If a unit fails a test, the unit shall remain on the test plate until the test is completed, unless the unit poses a hazard to personnel or to other test specimens, in which case, the test will be shut down, the unit secured, and the test resumed. A new unit shall be installed in the vacant space for the next test sequence (i.e., vibration failure, new unit, proceed to shock test). Each conductor and interfacing connector block shall be electrically tested. Only the middle sized conductor – connector unit will be instrumented for contact resistance testing during the Shock and Vibration tests as outlined in Sect. 8.2.1 and Sect. 8.2.2. After each test, the individual specimens shall be inspected for damage. (Refer to the testing scope of work forming the basis of your contract or work tasking to determine what tests will be required for you to perform). The following shall form guidelines for this inspection:

1. Before testing, in the general inspection section (see Sect. 7), measure the distance from the termination point (nearest point of engagement of the conductor), to the point at which the conductor insulation is stripped. This will form the baseline to determine if movement or slippage occurs during testing. This shall be done for each test specimen.
2. Inspect surfaces for scuffs, cracks or contamination. Note any issues.
3. Inspect the conductors for damage and looseness at the restraint. Tighten the restraining device if necessary.

Table 8-1: Tests to Perform on Demonstrator

Demonstrator Unit Testing							
Order of Test	**Test**	**Standard**	**Called Out By**	**Section or Method**	**Reference**	**Test Values**	**Remarks**
3	Voltage Drop	Mil-T-16366F		3.4.4		6 - 25mV at rated voltage	- used for 4-30 A units operating at rated current
4	Dielectric Withstand	Mil-Std-202G		301		-2x rated voltage +1000 V for 60 sec -leakage current less than 0.1% rated load	- raise voltage 500 V/sec - Mil-C-55243 uses 1500 V for 60 sec
5	Shock	Mil-Std-202G	Mil-C-55243	207	Mil-Std-901D	- continuity maintained better than 10% of contact resistance value (drop no less than 0.267 mΩ	- inspect for damage to mounts, contacts, springs, etc.
6	Vibration	Mil-Std-167-1A	Mil-C-55243			- ±0.03 in, 0-34 Hz in approx. 6 hrs	- inspect for damage to mounts, contacts, springs, etc.
7	Temperature Cycling	Mil-Std-202G	Mil-C-55243	107 Cond D		- -65 to -5 C 15 min 25 to -5 C 5 min 350 to 0 C 15 min 25 to -5 C 5 min	- inspect for damage, maybe conduct pull test
1, 8	Contact Retention/Pull Resistance	Mil-C-55243		3.8, 3.19		- 10 lbs @ 1lb/min	- 3.19 is for mated connectors (40 lbs)
2	Insulation Resistance	Mil-C-55243		3.12		1000 MΩ	
	Contact Resistance (TDR)	Mil-C-55243		3.10		≤20 mV @ 7.5 A ⇨2.67 mΩ	This will be done during shock and vib testing, instrumenting the demonstrator

Inspection of the units at any time before and after a particular performance test has been conducted will include the following attention to detail and recording of findings:

- Conductor restraint has failed and cable or conductor is loose
- Conductor has failed (broken or severely damaged)

- Cable engaging mechanism on the product has failed (loose parts, physical damage, separated from base unit)
- Cracks exist around perimeter of the product, at seams or corners junctions (note where these exist and take pictures, labeled accordingly)
- Discoloration of the product housing, components or the interfacing conductors
- Separation of the main unit from the mounting base
- Failure of the DIN rail if used
- Product specimen shows signs of thermal damage
- Chaffing, rubbing or smoothed surface of the conductor, or broken strands of wire

To inspect the cable after all testing is complete, release the conductor, if the unit allows, and inspect for signs of slippage. Record all observations. Re-install the conductor, noting the new distance from the stripped portion of the conductor to the connector engagement (if it changes).

Note: Perform all testing equipment calibration as applicable before the start of testing.

8.1 Electrical and Mechanical Testing

8.1.1 Contact, Pull Resistance Testing

A tension meter shall be used to clamp the unit to the conductor as close to the quick connecting point as possible. Per Mil-C-55243 Sect. 3.8 and 3.19, pull the conductor away, perpendicularly from the face of the conductor interface point of the quick connector. The pull force shall be 1 lb/sec up to a maximum of 10 lbs of tensile pulling force. Once 10 lbs of force as been attained, the tension shall be released in a controlled fashion and the tension meter shall be disconnected from the conductor. The conductor shall be inspected for signs of movement by measuring the distance from the engaging mechanism to the point where the insulation is stripped from the conductor, and compared to the value recorded from Sect. 8, item 1. All conductors will be initially tested and end tested, and only the middle (instrumented) conductor will be tested between testing sequences.

8.1.2 Insulation Resistance Testing

A standard ohm meter or hi pot meter shall be used to measure the insulation resistance of the contact – cable set up in accordance with Mil-C-55243 Sect. 3.12. Measure the value from one side of the quick connector to the other, measuring at the conductor on each side. Record the reading indicating the quick connector and conductor label. Measure all conductors for all quick connectors

8.1.3 Voltage Drop Testing

Table 8.1.3-1 indicates the rated voltage and current for the specimen. The test shall be conducted at rated current by applying 10 V_{ac} from the voltage source, on one side of the connector at the conductor interfacing the connector, and across the connector by connecting to the other side conductor, interfacing to a rheostat that will control the current, and then returning to the voltage source. The voltage source shall be properly grounded, with the test plate grounded to the same ground point, during the test. Measurement, therefore, is in accordance with Mil-T-16366, Sect. 3.4.4 and Sect. 4.5.7.1.d, from cable end to cable end.

Table 8.1.3-1: Voltage Drop Test Table

Item	Name	Model/PN	Product Description	Conductor Size	Rated Voltage (V)	Rated Current (A)	Resistance Required 10 V (ohms)
1	Term Block Baseline	A-A-59125/24 16TB-06	MIL qualified terminal block for lugged terminations, for Baseline	10-20	300	20	0.5
2	Term Block Baseline	A-A-59125/12 6TB-10	MIL qualified terminal block for lugged terminations, for Baseline	10-20	600	30	0.3
3	Tyco	1-776302-4	1 Position Fused Terminal Block	10-22	250	40	0.3
4	Wago	282-696	Quick Connect Terminal Block with fuse	24 - 10	400	25	0.4
5	Wago	282-128	Fused Terminal Block	24 - 10	600	10	1.0
6	Wago	773-164	Push wire 4-conductor splicing connector	18-12	600	20	0.5
7	Wago	2002-1201	2 conductor through terminal block	22 - 12	600	20	0.5
8	Wago	222-415	Splicing Connector	12-28	400	32	0.3
9	Ideal	Model 39/30-1039J	3 Port Push-In Connector	12-18	600	30	0.3
10	Cooper Bussman	BNQ21	Gangable Connector Block	8-22	600	40	0.3
11	Cooper Bussman	PDB-220-3	Gang Screw Termination Block	2/0 - 8 Source, 4-14 Load	600	175	0.1
12	Cooper Bussman	PDBFS 220	Gangable Connector Block Distribution Block (1 in to 4 out)	2/0-8 Source, 4-14 Load	600	175	0.1
13	WEIDMULLER	1011000000	Quick connector, DIN Rail Mounted; 2 contacts	8-20	500	6.3	1.6
14	WEIDMULLER	1880430000	W-Series Fused Terminal Block	10-22	500	6.3	1.6

Item	Name	Model/PN	Product Description	Conductor Size	Rated Voltage (V)	Rated Current (A)	Resistance Required 10 V (ohms)
15	Eaton	XBUT25D22	DIN Rail mounted quick connecting terminal block; screw connector, 4 conductors per block	12-26	500	28	0.4
16	Eaton	XBUT4FBE	DIN Rail mounted quick connecting terminal block; screw connector	10-26	600	6.3	1.6
17	Eaton	XBPT4	DIN Rail mounted quick connecting terminal block; spring connector	10-24	600	40	0.3
18	Eaton	XBQT15	DIN Rail mounted quick connecting terminal block; Insulation Displacement connector	16-24	600	17.5	0.6
19	3M	314-BOX	Insulation Displacement, 3-wire splicing connector, flame retardant and moisture resistant	14-22	600	15	0.7
20	Rockwell Automation (Alan Bradley)	1492-L2	DIN Rail Mounted quick connecting terminal block; spring clamp connector	14-26	300	20	0.5
21	Rockwell Automation (Alan Bradley)	1492-J3	DIN Rail Mounted quick connecting terminal block; screw clamp connector	12-28	600	25	0.4
22	Rockwell Automation (Alan Bradley)	1492-CAM1	DIN Rail Mounted quick connecting terminal block; screw clamp connector, Open Construction	8-22	600	55	0.2
23	Phoenix Contact	UK 2,5 N	DIN Raol mounted, quick connecting terminal block; screw clamp	14-24	300	24	0.4
23	Phoenix Contact	ST 1,5	DIN Rail mounted, quick connecting terminal block; spring cage	16-28	500	17.5	0.6
24	Tyco	241	Flat bottom Terminal Block, Strap Screw	10-22	600	35	0.3
25	Tyco	212	Flat Bottom NEMA terminal block, Tubular Screw	4-18	600	85	0.1
26	Tyco	925	Flat bottom Miniature Terminal Block, Tubular Screw Clamp	8-22	600	30	0.3
27	Tyco	N/A	Bus Bar Assembled with 2 3/8" power Posts, connectors, cables supplied	8-23	600	30	0.3

Note: Load current testing will be capped at a maximum load current of 40 A.

The voltage shall be applied long enough to stabilize maximum load current across the specimen and stabilize in temperature. An inferred heat gun shall be used to verify temperature stability.

A multimeter shall be used to measure the voltage drop across the terminals from conductor to conductor. Use caution when adjusting for the proper load current so as not to overload the connector. If this occurs, make note, disconnect the voltage source from the connector, and conduct the insulation resistance test (see Sect. 8.1.2, followed by Sect. 8.1.4). If the insulation test result is less than prescribed, and the hi pot test result is less than prescribed in this test procedure (see Sect. 8.1.4), make note that the test specimen has failed these tests. The Plexiglass barrier may be used during this test to provide for a safe test environment, although the test voltage is considered low voltage.

8.1.4 Dielectric Testing

Install a voltage source across the test specimen (a hi pot device can be used for this section of the test, but be cautious not to damage the unit). Per Mil-Std-202G, apply 2X rated voltage +1000 V and measure the leakage current (refer to Table 8.3.1-1). The Plexiglass barrier shall be installed before the test voltage is applied. (Note: the voltage ratings shown in Table 8.3.1-1 are peak voltages; RMS voltage should be used to determine voltage to apply for dielectric testing.)

8.2 Performance Tests

During the performance testing sequences, the demonstrator test specimens shall be instrumented to perform a contact resistance test. The data acquisition equipment shall be set to sufficiently capture momentary resistance changes in coordination with the frequency of the test (for vibration testing) and typical response to shock events. Only the middle sized conductor connector block will be used for instrumentation. This will be the conductor physically located between the outer conductors used for a given test specimen. Data shall be gathered that covers the events immediately surrounding the test (shock strike, vibration changes in frequency and amplitude). A sample at each vibration point during the vibration shall be data collected. Test leads shall be placed across the connector, connecting at the end of each corresponding conductor. Positive test lead connection will be required so as not to introduce a contact resistance reading in the data resulting from a poor contact between the specimen conductor and the test lead. Heavily sprung clamps on the test leads will be necessary for this test.

8.2.1 Vibration Performance Test

Each demonstrator unit shall be vibration tested in accordance with Type I vibration requirements of MIL-STD-167-1. Instrument the test plate as indicated in Sect. 8.2. Unless deemed unsafe, the Plexiglass cover shall not be used during vibration testing to avoid an unwanted failure. If deemed unsafe not using the Plexiglass panel, BIW shall be consulted before the vibration and shock tests are initiated.

The assembly shall not demonstrate loosening or failure of any component or a detectible change of state of materials that may affect performance (see above for items to consider when inspecting). Upon favorable testing results and or repair, the demonstrator shall be moved to the shock testing sequence. Record results and remarks on the worksheet provided and augment with any other recordings as necessary (i.e., other data sheets, pictures, videos).

8.2.2 Shock Performance Test

The demonstrator units shall be subjected to a Grade A, Class I, Type A shock test in accordance with MIL-S-901-D prior to conducting the thermal cycling tests. Instrument the test plate as indicated in Sect. 6. Unless deemed unsafe, the Plexiglass cover shall not be used during vibration testing to avoid an unwanted failure. This mounting arrangement is considered a worst case controlled scenario (unless one considers a backplane being sufficiently deflected and distorted so as to detrimentally effect the performance of the test specimen), and will cover the possibility of the test specimen being mounted in a box or other mounting device that does not utilize shock mounts as the mounting mechanism to ship structure. This type of testing is considered a simple testing type for this arrangement, without bringing into effect subsidiary components and other mounting plates that would tend to further complicate or affect the shock response.

The demonstrator units shall be inspected to verify the design is adequate to withstand shock testing. If major re-design is needed, BIW shall be notified immediately so that change may be authorized.

After each shock sequence for a particular orientation, each test specimen shall be tested for tensile strength pull withstand (See Sect. 8.1.1). Collected data shall be recorded on the data sheet.

The assembly shall be inspected after the shock test and shall not demonstrate loosening or failure of any component or a detectible change of state of materials that may affect performance (see above for items to consider when inspecting). Upon favorable testing results and or repair, the demonstrator shall be moved to the thermal cycling testing sequence. Record results and remarks on the worksheet provided (or similar) and augment with any other recordings as necessary (i.e., other data sheets, pictures, videos).

8.2.3 Thermal Cycling Test

To conduct the thermal cycle test, the demonstrator unit must start at room temperature. Instrument the test plate as indicated in Sect. 8.2, recording data at the lowest temperature and the highest temperature (several data points around each peak and low value). A chart indicating the thermal cycle temperatures will be part of the test facility’s final report. The method, in reference to the ANSI standard and Mil-Std-202G shall be Method A (107G), condition 1, A-1 (25 cycles), as shown below in (from ANSI/EIA-364-32F). The test will be a variant of the method chosen (see Table 8.2.3-1), and shall be conducted as a 10 cycle sequence. The laboratory shall use a heating and cooling mechanism that is capable of heating and cooling the demonstration unit at the rates and to the values per the chosen method. The duration of the testing is chosen to be 1 hour (based on a specimen of not more than 3 pounds, see Table 8.2.3-2).

Table 8.2.3-1: Thermal Shock Testing Table

Step	Test condition	Number of cycles
	A	5
	A-1	25
	A-2	50
	A-3	100
	Temperature	Time
	°C	
1	-55 +0, -3	See table 107-II
2	25 +10, -5	5 minutes maximum
3	85 +3, -0	See table 107-II
4	25 +10, -5	5 minutes maximum

Table 8.2.3-2: Thermal Shock Testing Table Weights

Weight of specimen	Minimum time (for steps 1 and 3)
	Hours
1 ounce (28 grams and below)	1/4 (or as specified)
Above 1 ounce (28 grams) to .3 pound (136 grams), inclusive	½
Above .3 pounds (136 grams) to 3 pounds (1.36 kilograms), inclusive	1
Above 3 pounds (1.36 kilograms) to 30 pounds (13.6 kilograms), inclusive	2
Above 30 pounds (13.6 kilograms) to 300 pounds (136 kilograms), inclusive	4
Above 300 pounds (136 kilograms)	8

The last 2 cycles shall be conducted with the electrical cables energized to 250 V. Connection will be done in a similar fashion as indicated in Sect. 8.1.3. If upon inspection at the 8th cycle any specimen indicates a failure or impending failure, the unit shall either be repaired (i.e., conductor placed back into the connection) or if non-repairable, the test specimen shall be secured and isolated and the remaining specimens tested accordingly. This shall also be done after the 9th cycle. Power shall then be removed and the entire specimen family inspected in accordance with the testing procedure for electrical and mechanical testing (see Sect. 8).

9 Test Report and Demonstrator Disposition

A test report shall be generated and submitted to the services procuring company and BIW, which identifies and describes the following:

- Date of receipt of demonstrator units
- Received condition and any repairs that were needed

- Condition of demonstrator units and samples immediately before and after each test (based on inspections and tests outlined in this procedure)
- Performance of each test, with all applicable data and observations outlined (use provided worksheets to record data, or sheets that are similar and account, at a minimum, the data requested)
- Pictures and videos of the demonstrator and samples immediately before and after a particular test, and during the testing if applicable
- Data sheet and description of all testing apparatus used for each test, including test instrument calibration where applicable
- Time and date each test was performed
- Any anomalies encountered during any of the tests

After the testing is completed, the testing company shall package each demonstrator for shipment such that the tested samples are stable and at minimal risk for damage during transport. The units shall be shipped to BIW, whereby further inspection and testing may be performed.

10 Appendix A: Test Work Sheet Example (see Attachment G)

NSRP ETP Low Voltage Quick Connector Project Test Datasheet: Electrical Testing

Test Performed By: ______________________________

Date: ______________________________

Unit Number	Name	Model	Conductor	Distance Between Conductor and Connector (Before Testing) mm	Distance Between Conductor and Connector After Vibration Testing) mm	Distance Between Conductor and Connector After Shock Testing) mm	Contact Pull Resistance (Pass/Fail, lbs)	Insulation Resistance Testing (MΩ)	Voltage Drop Testing (mV)	Dielectric Testing (Pass/Fail)	Remarks
1	Term Block Baseline		IN: A								
			B								
			C								
			D								
			OUT: A								
			B								
			C								
			D								
2	Term Block Baseline		IN: A								
			B								
			C								
			D								
			OUT: A								
			B								
			C								
			D								
3	Tyco	1-776302-4	IN: A								
			B								
			C								
			D								
			OUT: A								
			B								
			C								
			D								

NSRP ETP Low Voltage Quick Connector Project Test Datasheet: Performance Testing

Test Performed By: ______________________________

Date: ______________

				Vibration Testing					Shock Testing					Thermal Cycle Testing				
Unit Number	Name	Model	Conductor	Inspection Remarks	Conductivity (ohms)	Tensile Strength (pounds)	Conductor Moved?	Failure?	Inspection Remarks	Conductivity (Ave ohms)	Tensile Strength (pounds)	Conductor Moved?	Failure?	Inspection Remarks	Conductivity (ohms)	Tensile Strength (pounds)	Conductor Moved?	Failure?
1	Term Block Baseline		IN: A															
			B															
			C															
			D															
			OUT: A															
			B															
			C															
			D															
2	Term Block Baseline		IN: A															
			B															
			C															
			D															
			OUT: A															
			B															
			C															
			D															

9 Attachments

9.1 BIW Test Report

Attached are the Excel worksheets used by BIW to capture testing data.

Product Testing Results Rev. -.xlsx

9.2 Laboratory Test Report

Attached is the Dayton T. Brown test report. The report is considered comprehensive, and is augmented with video recording.

Dayton Testing Report 413980-00-04-R14-0853.pdf

9.3 Cost Benefit Analysis Workbook

Attached is a file comprising cost benefit assessment worksheets that calculate savings based on a specific baseline, and averaged across all units to be investigated and tested. These sheets are templates of what the user(s) and designer worked with during the project. Templates have been included here, but the data used for the project is not included in the detailed file attached here. Only summary pages are included in the report, to protect the data that was used for r the report. Averaged values across programs investigated are used and discussed.

Traditional versus Quick Connector CBA Tool.xls

NSRP ETP Project: Low Voltage Quick Connectors, Vendor and Product Information: Final Listing

					Manufacturer			Distributor					
Worksheet Number	**Unit Number per Dwg**	**Item Category**	**Product Name**	**Model/PN**	**Name**	**Website**	**Part #**	**Name**	**Website**	**Part #**	**Product Description**	**Catalog Info**	**Notes**
1	2	Terminal Block	Terminal Board, Molded, Barrier Stud Type, Class 26TB	A-A-59125/24 16TB-12	Term Block Baseline		16TB-06				MIL qualified terminal block for lugged terminations, for Baseline		Baseline
2	27	Splice Connector	Scotchlok electrical IDC	314-BOX	3M	http://solutions.3m.com/wps/portal/3M/en_US/EMDCI/Home/Products/Catalog/~/3M-Scotchlok-Electrical-IDC-314-BOX-Pigtail-Self-Stripping-Moisture-Resistant-and-Flame-Retardant-Blue-22-14-AWG-50-per-carton-500-per-case?N=4294937954+5427538&&Nr=AND%28hrcy_id%3AGS23CB751Cgs_FFFHJCVLPC_N2RL3FHWVK_GPD0K8BC31gv%29&rt=d	314-BOX	Newark	http://www.newark.com/3m/314-box/terminal-pigtail-splice-crimp/dp/90F2058?ost=314-BOX	90F2058	Insulation Displacement, 3-wire splicing connector, flame retardant and moisture resistant	http://multimedia.3m.com/mws/mediawebserver?mwsId=SSSSSufSevTsZxtU4xmB58_ZevUqevTSevTSevTSeSSSSSS--&fn=314_instrs.pdf	
3	11	Splice Connector	Splicing Connector	773-164	Wago	http://www.wago.us/					Push wire 4-conductor splicing connector	https://eshop.wago.com/JPBC/0_5StartPage.jsp?supplierAID=770-203&catalogID=WAGO01&zone=7	Push wire 4-cond splice
4	13	Splice Connector	Splicing Connector	222-415	Wago	http://www.wago.us/					Splicing Connector	https://eshop.wago.com/JPBC/0_5StartPage.jsp?zone=6	Lever Splice Connection
5	14	Push In Connector		Model 39/30-1039J	Ideal	http://www.idealindustries.com/prodDetail.do?prodId=in-sure&div=0&l1=push-in		Grainger	http://www.grainger.com/product/IDEAL	5EKN4	3 Port Push-In Connector	Cat. # 30-1639,	NOTE - Similar to a product recommended by Wago
6	35	Terminal Block	Feed-Through Terminal Block (Tubular Clamp, Screw)	925	Tyco	http://www.te.com/catalog/bin/TE.Connect?C=16697&M=PPROP&P=91099,91093,91096,91098,118843&BML=10576,10785&LG=1&PG=1&IDS=182720,182776,182818,182778,182765,182777,182798,182783&N=4	1546234-1				Flat bottom Miniature Terminal Block, Tubular Screw Clamp	http://www.te.com/commerce/DocumentDelivery/DDEController?Action=showdoc&DocId=Catalog+Section%7F1308389_NEMA_TERMINAL_BLOCKS%7F0607%7Fpdf%7FEnglish%7FENG_CS_1308389_NEMA_TERMINAL_BLOCKS_0607.pdf%7F1546234-1	
7	6	Screw Type Terminal Block	Screw Terminal Block	1-776302-4	Tyco						1 Position Terminal Block	BUCHANAN TERMINAL BLOCKS CATALOG - EUROPA TERMINAL B... (PDF, English)	

NSRP ETP Project: Low Voltage Quick Connectors, Vendor and Product Information: Final Listing

					Manufacturer			Distributor					
Worksheet Number	**Unit Number per Dwg**	**Item Category**	**Product Name**	**Model/PN**	**Name**	**Website**	**Part #**	**Name**	**Website**	**Part #**	**Product Description**	**Catalog Info**	**Notes**
8	15	Terminal Block	Standard Feed-Through Terminal Block Spring Clamp)	PT 1,5/S	Phoenix Contact	https://www.phoenixcontact.com/online/portal/us?uri=pxc-oc-itemdetail:pid=3208128&library=usen&pcck=P-15-02-02-01&tab=1	3208128				DIN Rail mounted, quick connecting terminal block; screw clamp		
9	16	Terminal Block	Standard Feed-Through Terminal Block (Spring Cage)	PT 2,5	Phoenix Contact	https://www.phoenixcontact.com/online/portal/us?uri=pxc-oc-itemdetail:pid=3209510&library=usen&pcck=P-15-02-02-01&tab=1	3209510				DIN Rail mounted, quick connecting terminal block; spring cage		
10	20	Connector Block	Gang Screw Termination Block	PDB-220-3	Cooper Bussman	http://www.cooperindustries.com/content/public/en/bussmann/electrical/products/power_distributionblocksterminalblocks/pdb_series_.html		Newark	http://www.newark.com/cooper-bussmann/pdb220-3/power-distribution-block/dp/15M9867?ost=pdb-220-3		Gang Screw Termination Block; Eaton units; standard terminal block as a baseline reference		Power Applications. However, these are TBs and could provide useful insight. Test if space is avaliable. We do not have to test both of these, unless we desire to.
11	36	Bus Bar	Tyco 3/8" Post Power Plug Bus Bar Assy	N/A	Tyco	n/a	n/a	n/a	n/a	n/a	Bus Bar Assembled with 2 3/8" power Posts, connectors, cables supplied	n/a	
12	9	Terminal Block	Fused Terminal Block	282-696	Wago	http://www.wago.us/		Newark	http://www.newark.com/wago/0282-0696/terminal-block-fused-24-10awg/dp/79K2106	79K2106	Quick Connect Terminal Block with fuse	https://eshop.wago.com/JPBC/0_5StartPage.jsp?TopNavi=0_6TopNavi.jsp&Zone=2&Hauptframe=%2FJPBC%2FCommonPageHandler.jsp&activatedPage=SEARCHPAGE	Fused (Blade Type), Spring Type QC TB
13	10	Terminal Block	Fused Terminal Block	282-128	Wago	http://www.wago.us/		Newark		98M5428	Fused Terminal Block	https://eshop.wago.com/JPBC/0_5StartPage.jsp?TopNavi=0_6TopNavi.jsp&Zone=2&Hauptframe=%2FJPBC%2FCommonPageHandler.jsp&activatedPage=SEARCHPAGE	Fused, Spring Type QC TB

NSRP ETP Project: Low Voltage Quick Connectors, Vendor and Product Information: Final Listing

					Manufacturer			Distributor					
Worksheet Number	**Unit Number per Dwg**	**Item Category**	**Product Name**	**Model/PN**	**Name**	**Website**	**Part #**	**Name**	**Website**	**Part #**	**Product Description**	**Catalog Info**	**Notes**
14	12	Terminal Block	Terminal Block	2002-1201	Wago	http://www.wago.us/					2 conductor through terminal block	https://eshop.wago.com/JPBC/0_5StartPage.jsp?TopNavi=0_6TopNavi.jsp&Zone=2&Hauptframe=%2FJPBC%2FCommonPageHandler.jsp&activatedPage=SEARCHPAGE	Push wire QC TB
15	21	Terminal Block	Fused Terminal Block	1011000000	WEIDMULLER			Newark	http://www.newark.com/weidmuller/1011000000/terminal-block-fused-5-x-20mm/dp/70M7829?MER=PPSO_N_P_Fused_None	70M7829	Quick connector, DIN Rail Mounted; 2 contacts	http://catalog.weidmueller.com/catalog/Start.do?localeId=en&ObjectID=1011000000	
16	22	Terminal Block	Fused Terminal Block	1880430000	WEIDMULLER			Newark	http://www.newark.com/weidmuller/1880430000/fused-terminal-block-6-3x32mm/dp/03M3058?ost=1880430000	03M3058	W-Series Fused Terminal Block	http://catalog.weidmueller.com/procat/Product.jsp;jsessionid=A7A354C0CA910318A7BF279CD708D92B?productId=(%5b1880430000%5d)&page=Product	
17	23	Terminal Block	Multi-conductor terminal block	XBUT25D22	Eaton		XBUT25D22	Omega	http://www.omega.com/pptst/XBUTD.html		DIN Rail mounted quick connecting terminal block; screw connector, 4 conductors per block		
18	24	Terminal Block	Fused Terminal Block	XBUT4FBE	Eaton		XBUT4FBE	Omega	http://www.omega.com/ppt/pptsc_print.asp?ref=XBUT-F		DIN Rail mounted quick connecting terminal block; screw connector		
19	25	Terminal Block	Spring Cage Terminal Block	XBPT4	Eaton		XBPT4	Omega	http://www.omega.com/pptst/XBPT.html		DIN Rail mounted quick connecting terminal block; spring connector		Or XBPT25D12
20	26	Terminal Block	Insulation Displacement Connection Terminal Block	XBQT15	Eaton		XBQT15	Omega	http://www.omega.com/pptst/XBQ.html		DIN Rail mounted quick connecting terminal block; Insulation Displacement connector		

NSRP ETP Project: Low Voltage Quick Connectors, Vendor and Product Information: Final Listing

					Manufacturer			Distributor					
Worksheet Number	Unit Number per Dwg	Item Category	Product Name	Model/PN	Name	Website	Part #	Name	Website	Part #	Product Description	Catalog Info	Notes
21	28	Terminal Block	Standard Feed-Through Terminal Block (Spring Clamp)	1492-L2	Rockwell Automation (Alan Bradley)	http://ab.rockwellautomation.com/Terminal-Blocks/IEC-Spring-Clamp/1492-L2#/tab3	Horizon Solutions				DIN Rail Mounted quick connecting terminal block; spring clamp connector	http://www.ab.com/en/epub/catalogs/12768/229240/229268/3170951/2333073/Standard-Feed-Through-Blocks.html	
22	29	Terminal Block	Standard Feed-Through Terminal Block (Screw Clamp)	1492-J3	Rockwell Automation (Alan Bradley)	http://ab.rockwellautomation.com/Terminal-Blocks/1492-J-Standard-Feed-Through#/tab3	Horizon Solutions				DIN Rail Mounted quick connecting terminal block; screw clamp connector	http://www.ab.com/en/epub/catalogs/12768/229240/229268/3170951/2297059/Standard-Feed-Through-Blocks.html	
23	30	Terminal Block	Standard Feed-Through Terminal Block (Screw Clamp, Open Construction)	1492-CAM1	Rockwell Automation (Alan Bradley)	http://ab.rockwellautomation.com/Terminal-Blocks/1492-F-Open-Construction-NEMA#/tab6	Horizon Solutions				DIN Rail Mounted quick connecting terminal block; screw clamp connector, Open Construction		
24	31	Terminal Block	Standard Feed-Through Terminal Block (Screw Clamp)	UK 2,5 N	Phoenix Contact	https://www.phoenixcontact.com/online/portal/us?uri=pxc-oc-itemdetail:pid=3003347&library=usen&pcck=P-15-01-02-01&tab=1	3003347				DIN Raol mounted, quick connecting terminal block; screw clamp		
25	32	Terminal Block	Standard Feed-Through Terminal Block (Spring Cage)	ST 1,5	Phoenix Contact	https://www.phoenixcontact.com/online/portal/us?uri=pxc-oc-itemdetail:pid=3031076&library=usen&pcck=P-15-03-02-01&tab=1	3031076				DIN Rail mounted, quick connecting terminal block; spring cage		

NSRP ETP Project: Low Voltage Quick Connectors, Vendor and Product Information: Final Listing

					Manufacturer			Distributor					
Worksheet Number	**Unit Number per Dwg**	**Item Category**	**Product Name**	**Model/PN**	**Name**	**Website**	**Part #**	**Name**	**Website**	**Part #**	**Product Description**	**Catalog Info**	**Notes**
26	34	Terminal Block	Feed-Through Terminal Block (Tubular, Screw)	212	Tyco	http://www.te.com/catalog/bin/TE.Connect?C=16697&M=PPROP&P=91099,91093,91096,91098,91085&BML=10576,10785&LG=1&PG=1&IDS=142767,142738,142747,142751,142761,142768,142804,142760,142803&N=6	2-1437390-8				Flat Bottom NEMA terminal block, Tubular Screw	http://www.te.com/commerce/DocumentDelivery/DDEController?Action=showdoc&DocId=Catalog+Section%7F1308389_NEMA_TERMINAL_BLOCKS%7F0607%7Fpdf%7FEnglish%7FENG_CS_1308389_NEMA_TERMINAL_BLOCKS_0607.pdf%7F2-1437390-8	
27	18	Connector Block	Gang Screw Termination Block	PDB-220-3	Cooper Bussman	http://www.cooperindustries.com/content/public/en/bussmann/electrical/products/power_distributionblocksterminalblocks/pdb_series_.html		Newark	http://www.newark.com/cooper-bussmann/pdb220-3/power-distribution-block/dp/15M9867?ost=pdb-220-3		Gang Screw Termination Block	Eaton units; standard terminal block as a baseline reference	Power Applications. However, these are TBs and could provide useful insight. Test if space is avaliable. We do not have to test both of these, unless we desire to.

Notes: 1. Distributors listed are one of possibly several who may represent these company products.

NSRP ETP Project: Low Voltage Quick Connectors, Vendor and Product Information Evaluation: Final Listing

					Dimensions (in)									Mounting														
Worksheet Number	**Unit Number per Dwg**	**Name**	**Model/PN**	**Product Description**	**Length**	**Width**	**Height**	**No. Connections**	**Conductor Size**	**Rated Voltage (V)**	**Rated Surge Voltage (V)**	**Rated Current (A)**	**Rated SCCR(UL) (A)**	**Metal**	**Plastic**	**DIN Rail**	**Tensile Pull Resistance (Nm)**	**Mechanism Type**	**Housing Material**	**Contact and Mechanism Material**	**Certification, Qualifications**	**Fire Rating**	**Temp Rating C**	**Interface Type**	**Passed Vibration Testing**	**Passed Shock Testing**	**Passed Thermal Stress Testing**	**Remarks**
1	2	Term Block Baseline	A-A-59125/24 16TB-12	MIL qualified terminal block for lugged terminations, for Baseline	4.5	0.68	0.525	24	10-20	300	1600	20													Y	Y	Y	
2	27	3M	314-BOX	Insulation Displacement, 3-wire splicing connector, flame retardant and moisture resistant	0.95	0.92	0.47	3	14-22	600		15							Nylon	Tin plated brass	UL 486C, file No. E23438, CSE Std. 22.2 No. 0. 188-MI983, file No.		105	Insulation Displacement	Y	N[2]	Y	
3	11	Wago	773-164	Push wire 4-conductor splicing connector	0.768	0.512	0.516	4	18-12	600	4k	20		n/a			meets UL	spring	see note	see note	E69654	V2	105 C	Push-wire	Y	Y	Y	Free floating splice
4	13	Wago	222-415	Splicing Connector	0.807	1.047	0.571	5	12-28	400	4000	32					meets UL	Lever	see note	see note	UL file: E696654	V0	85 C	Lever actuated CAGE CLAMP	Y	N[2]	Y	Free floating splice
5	14	Ideal	Model 39/30-1039J	3 Port Push-In Connector	0.78	0.86	0.45	3	12-18	600	3000								Nylon/Polycarbonate	Copper	UL486C, 467, CSA C22.2 #188, RoHS	UL94V-2	105	Spring	Y	N[2,6]	Y	
6	35	Tyco	925	Flat bottom Miniature Terminal Block, Tubular Screw Clamp	1.23	0.76+(.38x N) [2.28 with 4 ckts]	1.25	2	8-22	600		30			x			Screw - Tubular Clamp	Polyester - GF	Zinc Plated Copper Alloy			150 Max	Tubular Screw Clamp	Y	N[5]	Y	
7	6	Tyco	1-776302-4	1 Position Terminal Block	1.71	0.92	0.73	4	10-22	250	4500	40			x		125lbs	Screw down	Polyamide 6	Brass, tin plated		UL94V-2	-35 to +100		Y	Y	Y	Torque 10 in-lbs.
8	15	Phoenix Contact	PT 1,5/S	DIN Raol mounted, quick connecting terminal block; spring clamp	1.76	0.137	1.196	2	14-26 stranded	500	6000	17.5				x		Spring			IEC 60947-7-1	V0		Spring	Y	N[1]	Y	IEC 60947-7-1
9	16	Phoenix Contact	PT 2,5	DIN Rail mounted, quick connecting terminal block; spring cage	1.91	0.204	1.38	2	12-26 stranded	800	6000	30	300			x	60 N	Spring Cage	PA		IEC 60947-7-1	V0	-60 - 125	Spring Cage	Y	N[1]	Y	
10	20	Cooper Bussman	PDBFS 220	Gangable Connector Block Distribution Block (1 in to 4 out)	3.372	1.03	2.146	5	2/0-8 Source, 4-14 Load	600		175	200k							Tin Plated Aluminum	UL 1953, UL 94VO		75		Y	Y	Y	
11	36	Tyco	N/A	Bus Bar Assembled with 2 3/8" power Posts, connectors, cables supplied	4	1	>2	2	1/0-350cmil	<2000		300		x				Quick Plug	Composite Polymer	Silver Plated Copper Alloy			260 Max. Limited by cable to 150.	Quick Plug	Y	Y	Y	
12	9	Wago	282-696	Quick Connect Terminal Block with fuse	3.35	0.315	1.32	2	24 - 10	400	6k	25			x	Yes	meets UL	spring	see note	see note	UL file: E45172	V0	105 C	CAGE CLAMP	Y	Y	Y	
13	10	Wago	282-128	Fused Terminal Block	2.44	0.512	2.22	2	24 - 10	600	6k	10	10k		x	yes	meets UL	spring	see note	see note	UL E45172	V0	105 C	CAGE CLAMP	Y	N[1]	Y	
14	12	Wago	2002-1201	2 conductor through terminal block	1.909	0.205	1.295	2	22 - 12	600	8k	20	100k			yes	meets UL	spring	see note	see note	E45172	V0	105 C	CAGE CLAMP S	Y	N[1]	Y	
15	21	WEIDMULLER	1011000000	Quick connector, DIN Rail Mounted; 2 contacts	2.36	0.311	2.4	2	8-20	500	6000	6.3				Plastic DIN Rail		Screw	Wemid				-50-120	Screw	Y	N[1,3]	Y	.8-1.6Nm tightening torque range
16	22	WEIDMULLER	1880430000	W-Series Fused Terminal Block	3.21	0.358	2.11	2	10-22	500	6000	6.3				x		Screw	Wemid				-50-120	Screw	Y	N[1]	Y	.5-.8 Nm tightening torque range
17	23	Eaton	XBUT25D22	DIN Rail mounted quick connecting terminal block; screw connector, 4 conductors per block	2.52	0.2	1.87	4	12-26	500	6000	28				x		Screw	Polyamide 6.6	Tin Plated Copper			Up to 125C	Screw	Y	N[1]	Y	5.3-7.1 in-lb tightening torque range (.6-.8Nm)
18	24	Eaton	XBUT4FBE	DIN Rail mounted quick connecting terminal block; screw connector	2.24	0.24	2.87	2	10-26	600	4000	6.3				x		Screw	Polyamide 6.6	Tin Plated Copper			Up to 125C	Screw	Y	N[3]	Y	5.3-7.1 in-lb tightening torque range (.6-.8Nm)

NSRP ETP Project: Low Voltage Quick Connectors, Vendor and Product Information Evaluation: Final Listing

					Dimensions (in)									Mounting															
Worksheet Number	Unit Number per Dwg	Name	Model/PN	Product Description	Length	Width	Height	No. Connections	Conductor Size	Rated Voltage (V)	Rated Surge Voltage (V)	Rated Current (A)	Rated SCCR(UL) (A)	Metal	Plastic	DIN Rail	Tensile Pull Resistance (Nm)	Mechanism Type	Housing Material	Contact and Mechanism Material	Certification, Qualifications	Fire Rating	Temp Rating C	Interface Type	Passed Vibration Testing	Passed Shock Testing	Passed Thermal Stress Testing	Remarks
19	25	Eaton	XBPT4	DIN Rail mounted quick connecting terminal block; spring connector	2.2	0.24	1.45	2	10-24	600	8000	40				x		Spring	Polyamide 6.6	Tin Plated Copper			Up to 125C	Spring	Y	Y	Y	
20	26	Eaton	XBQT15	DIN Rail mounted quick connecting terminal block; Insulation Displacement connector	2.31	0.2	1.55		16-24	600	8000	17.5				x		Insulation Displacement	Polyamide 6.6	Tin Plated Copper			Up to 125C	Insulation Displacement	Y	Y	Y	
21	28	Rockwell Automation (Alan Bradley)	1492-L2	DIN Rail Mounted quick connecting terminal block; spring clamp connector	2.03	0.138	1.16	2	14-26	300		20				x		Spring		Tin Plated Copper	UR, CSA, IEC		-58 to +248	Spring Clamp	Y	N[1]	Y	
22	29	Rockwell Automation (Alan Bradley)	1492-J3	DIN Rail Mounted quick connecting terminal block; screw clamp connector	2.36	0.2	1.59	2	12-28	600		25				x		Screw		Tin Plated Copper	UR, CSA, IEC		-58 to +249	Screw	Y	N[1]	Y	
23	30	Rockwell Automation (Alan Bradley)	1492-CAM1	DIN Rail Mounted quick connecting terminal block; screw clamp connector, Open Construction	1.5	0.41	1.44	2	8-22	600		55				x		Screw		Tin-Plated Copper Alloy	UR, CSA-Ul		-40 to +221	Screw	Y	N[1]	Y	
24	31	Phoenix Contact	UK 2,5 N	DIN Raol mounted, quick connecting terminal block; screw clamp	1.67	0.205	1.65	2	14-24 stranded	300	8000	24				x		Screw						Screw	Y	Y	Y	
25	32	Phoenix Contact	ST 1,5	DIN Rail mounted, quick connecting terminal block; spring cage	1.91	0.165	1.44	2	16-28 stranded	500	6000	17.5				x		Spring Cage						Spring Cage	Y	Y	Y	
26	34	Tyco	212	Flat Bottom NEMA terminal block, Tubular Screw	1.47	0.81+(.57x N) [3.09 with 4 ckts]	1.3	2	4-18	600		85			x			Screw - Tubular Screw	Phenolic				150 Max	Tubular Screw	Y	N	Y	
27	18	Cooper Bussman	PDB-220-3	Gang Screw Termination Block	4.27	2.88	2.13	15	2/0 - 8 Source, 4-14 Load	600		175	200k							Tin Plated Aluminum	UL 1953, UL 94VO		75		Y	Y	Y	

NSRP ETP Project: Low Voltage Quick Connectors, Vendor and Product Information Evaluation: Final Listing

											Mechanism Type															
Worksheet Number	Unit Number per Dwg	Name	Model/PN	Product Description	Conductor Size	Rated Voltage (V)	Rated Current (A)	Power Capacity (kW)	Power Density (kW/cu in)	Tensile Pull Resistance Pass/Fail[1]	Durability	Repeatability	Any Failure Experienced	Dielectric Test Pass/Fail	Insulation Resistance (ohms)[2]	Voltage Drop Test Pass/Fail[3]	Shock Test Pass/Fail	Vibration Test Pass/Fail	Thermal Cycling Pass/Fail	Ease of Use (conductor and unit installation)	Ease of Inspection	Holding Mechanism Durability	Overall Applicability	Score	Rating	Remarks
1	2	Term Block Baseline	A-A-59125/24 16TB-12	MIL qualified terminal block for lugged terminations, for Baseline	10-20	300	20	6	3.73	Pass					10 G	Pass				Satisfactory		Satisfactory				
2	27	3M	314-BOX	Insulation Displacement, 3-wire splicing connector, flame retardant and moisture resistant	14-22	600	15	9	21.91	Pass/Pass					∞ / ∞	Pass/Pass				Satisfactory		Satisfactory				
3	11	Wago	773-164	Push wire 4-conductor splicing connector	18-12	600	20	12	59.14	Pass/Pass					∞ / ∞	Pass/Pass				Satisfactory		Satisfactory				
4	13	Wago	222-415	Splicing Connector	12-28	400	32	12.8	26.53	Pass/Pass					∞ / ∞	Pass/Pass				Satisfactory		Satisfactory				
5	14	Ideal	Model 39/30-1039J	3 Port Push-In Connector	12-18	600	30	18	59.63	Pass					∞ / ∞	Pass/Pass				Satisfactory		Satisfactory				
6	35	Tyco	925	Flat bottom Miniature Terminal Block, Tubular Screw Clamp	8-22	600	30	18	3.85	Pass					6 G	Pass				Satisfactory		Satisfactory				
7	6	Tyco	1-776302-4	1 Position Terminal Block	10-22	250	40	10	8.71	Pass					4 G	Pass				Satisfactory		Satisfactory				
8	15	Phoenix Contact	PT 1,5/S	DIN Raol mounted, quick connecting terminal block; spring	14-26	500	17.5	8.75	30.34	Pass					4 G	Pass				Satisfactory		Satisfactory				
9	16	Phoenix Contact	PT 2,5	DIN Rail mounted, quick connecting terminal block; spring cage	12-26	800	30	24	44.63	Pass					5 G	Pass				Satisfactory		Satisfactory				
10	20	Cooper Bussman	PDBFS 220	Gangable Connector Block Distribution Block (1 in to 4 out)	2/0-8 Source, 4-14 Load	600	175	105	14.09	Pass					3 G	Pass				Satisfactory		Satisfactory				
11	36	Tyco	N/A	Bus Bar Assembled with 2 3/8" power Posts, connectors, cables supplied	8-23	600	30	18	2.25	Pass/Pass					4 G	Pass				Satisfactory		Satisfactory				
12	9	Wago	282-696	Quick Connect Terminal Block with fuse	24 - 10	400	25	10	7.18	Pass/Pass					5 G	Pass				Satisfactory		Satisfactory				
13	10	Wago	282-128	Fused Terminal Block	24 - 10	600	10	6	2.16	Pass/Pass					10 G	Pass				Satisfactory		Satisfactory				
14	12	Wago	2002-1201	2 conductor through terminal block	22 - 12	600	20	12	23.68	Pass/Pass					2.6 G	Pass				Satisfactory		Satisfactory				
15	21	WEIDMULLER	1011000000	Quick connector, DIN Rail Mounted; 2 contacts	8-20	500	6.3	3.15	1.79	Pass					2 G	Pass				Satisfactory		Satisfactory				
16	22	WEIDMULLER	1880430000	W-Series Fused Terminal Block	10-22	500	6.3	3.15	1.30	Pass					5 G	Pass				Satisfactory		Satisfactory				
17	23	Eaton	XBUT25D22	DIN Rail mounted quick connecting terminal block; screw connector, 4 conductors per block	12-26	500	28	14	14.85	Pass					2.4 G	Pass				Satisfactory		Satisfactory				

NSRP ETP Project: Low Voltage Quick Connectors, Vendor and Product Information Evaluation: Final Listing

											Mechanism Type															
Worksheet Number	Unit Number per Dwg	Name	Model/PN	Product Description	Conductor Size	Rated Voltage (V)	Rated Current (A)	Power Capacity (kW)	Power Density (kW/cu in)	Tensile Pull Resistance Pass/Fail[1]	Durability	Repeatability	Any Failure Experienced	Dielectric Test Pass/Fail	Insulation Resistance (ohms)[2]	Voltage Drop Test Pass/Fail[3]	Shock Test Pass/Fail	Vibration Test Pass/Fail	Thermal Cycling Pass/Fail	Ease of Use (conductor and unit installation)	Ease of Inspection	Holding Mechanism Durability	Overall Applicability	Score	Rating	Remarks
18	24	Eaton	XBUT4FBE	DIN Rail mounted quick connecting terminal block; screw connector	10-26	600	6.3	3.78	2.45	Pass					6 G	Pass				Satisfactory		Satisfactory				
19	25	Eaton	XBPT4	DIN Rail mounted quick connecting terminal block; spring connector	10-24	600	40	24	31.35	Pass					4 G	Pass				Satisfactory		Satisfactory				
20	26	Eaton	XBQT15	DIN Rail mounted quick connecting terminal block; Insulation Displacement connector	16-24	600	17.5	10.5	14.66	Pass					10 G	Pass				Satisfactory		Satisfactory				
21	28	Rockwell Automation (Alan Bradley)	1492-L2	DIN Rail Mounted quick connecting terminal block; spring clamp connector	14-26	300	20	6	18.46	Fail			smallest conductor: 24 AWG		3 G	Pass				Satisfactory		Unsatisfactory				
22	29	Rockwell Automation (Alan Bradley)	1492-J3	DIN Rail Mounted quick connecting terminal block; screw clamp connector	12-28	600	25	15	19.99	Pass					3 G	Pass				Satisfactory		Satisfactory				
23	30	Rockwell Automation (Alan Bradley)	1492-CAM1	DIN Rail Mounted quick connecting terminal block; screw clamp connector, Open Construction	8-22	600	55	33	37.26	Pass					5 G	Pass				Satisfactory		Satisfactory				
24	31	Phoenix Contact	UK 2,5 N	DIN Raol mounted, quick connecting terminal block; screw clamp	14-24	300	24	7.2	12.75	Pass					7 G	Pass				Satisfactory		Satisfactory				
25	32	Phoenix Contact	ST 1,5	DIN Rail mounted, quick connecting terminal block; spring cage	16-28	500	17.5	8.75	19.28	Fail			smallest conductor: 24 AWG		7 G	Pass				Satisfactory		Unsatisfactory				
26	34	Tyco	212	Flat Bottom NEMA terminal block, Tubular Screw	4-18	600	85	51	6.84	Pass					4.5 G	Pass				Satisfactory		Satisfactory				
27	18	Cooper Bussman	PDB-220-3	Gang Screw Termination Block	2/0 - 8 Source, 4-14 Load	600	175	105	4.01	Pass					3 G	Pass				Satisfactory		Satisfactory				

Notes:

[1] For those cells showing Pass/Pass, 2 conductors for the connector were tested

[2] For those cells showing Pass/Pass, voltage drop was measured across connector terminated port and unterminated port, for each conductor

[3] For those cells showing ∞/∞, measurement was made from conductor to ground, for each conductor; for the other units, worst case was across terminal points, all other measurements to ground were recorded as infinity

NSRP ETP Project: Low Voltage Quick Connectors, Vendor and Product Information Evaluation: Product Testing Results

											Mechanism Type						
Worksheet Number	**Unit Number per Dwg**	**Name**	**Model/PN**	**Product Description**	**Conductor Size**	**Rated Voltage (V)**	**Rated Current (A)**	**Power Capacity (kW)**	**Power Density (kW/cu in)**	**Tensile Pull Resistance Pass/Fail[1]**	**Durability**	**Repeatability**	**Any Failure Experienced**	**Insulation Resistance (ohms)[2]**	**Voltage Drop Test Pass/Fail[3]**	**Ease of Use (conductor and unit installation)**	**Holding Mechanism Durability**
1	2	Term Block Baseline	A-A-59125/24 16TB-12	MIL qualified terminal block for lugged terminations, for Baseline	10-20	300	20	6	3.73	Pass				10 G	Pass	Satisfactory	Satisfactory
2	27	3M	314-BOX	Insulation Displacement, 3-wire splicing connector, flame retardant and moisture resistant	14-22	600	15	9	21.91	Pass/Pass				∞ / ∞	Pass/Pass	Satisfactory	Satisfactory
3	11	Wago	773-164	Push wire 4-conductor splicing connector	18-12	600	20	12	59.14	Pass/Pass				∞ / ∞	Pass/Pass	Satisfactory	Satisfactory
4	13	Wago	222-415	Splicing Connector	12-28	400	32	12.8	26.53	Pass/Pass				∞ / ∞	Pass/Pass	Satisfactory	Satisfactory
5	14	Ideal	Model 39/30-1039J	3 Port Push-In Connector	12-18	600	30	18	59.63	Pass				∞ / ∞	Pass/Pass	Satisfactory	Satisfactory
6	35	Tyco	925	Flat bottom Miniature Terminal Block, Tubular Screw Clamp	8-22	600	30	18	3.85	Pass				6 G	Pass	Satisfactory	Satisfactory
7	6	Tyco	1-776302-4	1 Position Terminal Block	10-22	250	40	10	8.71	Pass				4 G	Pass	Satisfactory	Satisfactory

NSRP ETP Project: Low Voltage Quick Connectors, Vendor and Product Information Evaluation: Product Testing Results

											Mechanism Type						
Worksheet Number	**Unit Number per Dwg**	**Name**	**Model/PN**	**Product Description**	**Conductor Size**	**Rated Voltage (V)**	**Rated Current (A)**	**Power Capacity (kW)**	**Power Density (kW/cu in)**	**Tensile Pull Resistance Pass/Fail[1]**	**Durability**	**Repeatability**	**Any Failure Experienced**	**Insulation Resistance (ohms)[2]**	**Voltage Drop Test Pass/Fail[3]**	**Ease of Use (conductor and unit installation)**	**Holding Mechanism Durability**
8	15	Phoenix Contact	PT 1,5/S	DIN Raol mounted, quick connecting terminal block; spring	14-26	500	17.5	8.75	30.34	Pass				4 G	Pass	Satisfactory	Satisfactory
9	16	Phoenix Contact	PT 2,5	DIN Rail mounted, quick connecting terminal block; spring cage	12-26	800	30	24	44.63	Pass				5 G	Pass	Satisfactory	Satisfactory
10	20	Cooper Bussman	PDBFS 220	Gangable Connector Block Distribution Block (1 in to 4 out)	2/0-8 Source, 4-14 Load	600	175	105	14.09	Pass				3 G	Pass	Satisfactory	Satisfactory
11	36	Tyco	N/A	Bus Bar Assembled with 2 3/8" power Posts, connectors, cables supplied	8-23	600	30	18	2.25	Pass/Pass				4 G	Pass	Satisfactory	Satisfactory

12	9	Wago	282-696	Quick Connect Terminal Block with fuse	24 - 10	400	25	10	7.18	Pass/Pass				5 G	Pass	Satisfactory	Satisfactory
13	10	Wago	282-128	Fused Terminal Block	24 - 10	600	10	6	2.16	Pass/Pass				10 G	Pass	Satisfactory	Satisfactory
14	12	Wago	2002-1201	2 conductor through terminal block	22 - 12	600	20	12	23.68	Pass/Pass				2.6 G	Pass	Satisfactory	Satisfactory
15	21	WEIDMULLER	1011000000	Quick connector, DIN Rail Mounted; 2 contacts	8-20	500	6.3	3.15	1.79	Pass				2 G	Pass	Satisfactory	Satisfactory
16	22	WEIDMULLER	1880430000	W-Series Fused Terminal Block	10-22	500	6.3	3.15	1.30	Pass				5 G	Pass	Satisfactory	Satisfactory

NSRP ETP Project: Low Voltage Quick Connectors, Vendor and Product Information Evaluation: Product Testing Results

											Mechanism Type						
Worksheet Number	**Unit Number per Dwg**	**Name**	**Model/PN**	**Product Description**	**Conductor Size**	**Rated Voltage (V)**	**Rated Current (A)**	**Power Capacity (kW)**	**Power Density (kW/cu in)**	**Tensile Pull Resistance Pass/Fail[1]**	**Durability**	**Repeatability**	**Any Failure Experienced**	**Insulation Resistance (ohms)[2]**	**Voltage Drop Test Pass/Fail[3]**	**Ease of Use (conductor and unit installation)**	**Holding Mechanism Durability**
17	23	Eaton	XBUT25D22	DIN Rail mounted quick connecting terminal block; screw connector, 4 conductors per block	12-26	500	28	14	14.85	Pass				2.4 G	Pass	Satisfactory	Satisfactory
18	24	Eaton	XBUT4FBE	DIN Rail mounted quick connecting terminal block; screw connector	10-26	600	6.3	3.78	2.45	Pass				6 G	Pass	Satisfactory	Satisfactory
19	25	Eaton	XBPT4	DIN Rail mounted quick connecting terminal block; spring connector	10-24	600	40	24	31.35	Pass				4 G	Pass	Satisfactory	Satisfactory
20	26	Eaton	XBQT15	DIN Rail mounted quick connecting terminal block; Insulation Displacement connector	16-24	600	17.5	10.5	14.66	Pass				10 G	Pass	Satisfactory	Satisfactory
21	28	Rockwell Automation (Alan Bradley)	1492-L2	DIN Rail Mounted quick connecting terminal block; spring clamp connector	14-26	300	20	6	18.46	Fail			smallest conductor: 24 AWG	3 G	Pass	Satisfactory	Unsatisfactory
22	29	Rockwell Automation (Alan Bradley)	1492-J3	DIN Rail Mounted quick connecting terminal block; screw clamp connector	12-28	600	25	15	19.99	Pass				3 G	Pass	Satisfactory	Satisfactory
23	30	Rockwell Automation (Alan Bradley)	1492-CAM1	DIN Rail Mounted quick connecting terminal block; screw clamp connector, Open Construction	8-22	600	55	33	37.26	Pass				5 G	Pass	Satisfactory	Satisfactory
24	31	Phoenix Contact	UK 2,5 N	DIN Raol mounted, quick connecting terminal block; screw clamp	14-24	300	24	7.2	12.75	Pass				7 G	Pass	Satisfactory	Satisfactory

25	32	Phoenix Contact	ST 1,5	DIN Rail mounted, quick connecting terminal block; spring cage	16-28	500	17.5	8.75	19.28	Fail			smallest conductor: 24 AWG	7 G	Pass	Satisfactory	Unsatisfactory

NSRP ETP Project: Low Voltage Quick Connectors, Vendor and Product Information Evaluation: Product Testing Results

											Mechanism Type						
Worksheet Number	**Unit Number per Dwg**	**Name**	**Model/PN**	**Product Description**	**Conductor Size**	**Rated Voltage (V)**	**Rated Current (A)**	**Power Capacity (kW)**	**Power Density (kW/cu in)**	**Tensile Pull Resistance Pass/Fail[1]**	**Durability**	**Repeatability**	**Any Failure Experienced**	**Insulation Resistance (ohms)[2]**	**Voltage Drop Test Pass/Fail[3]**	**Ease of Use (conductor and unit installation)**	**Holding Mechanism Durability**
26	34	Tyco	212	Flat Bottom NEMA terminal block, Tubular Screw	4-18	600	85	51	6.84	Pass				4.5 G	Pass	Satisfactory	Satisfactory
27	18	Cooper Bussman	PDB-220-3	Gang Screw Termination Block	2/0 - 8 Source, 4-14 Load	600	175	105	4.01	Pass				3 G	Pass	Satisfactory	Satisfactory

Notes:

[1] For those cells showing Pass/Pass, 2 conductors for the connector were tested

[2] For those cells showing Pass/Pass, voltage drop was measured across connector terminated port and unterminated port, for each conductor

[3] For those cells showing ∞/∞, measurement was made from conductor to ground, for each conductor; for the other units, worst case was across terminal points, all other measurements to ground were recorded as infinity

NSRP ETP Project: Low Voltage Quick Connectors, Testing R

Worksheet Number	Unit Number per Dwg	Name	Model/PN	Tensile Pull Resistance Pass/Fail[1]	Insulation Resistance (ohms)[2]
1	2	Term Block Baseline	A-A-59125/24 16TB-12	Pass	10 G
2	27	3M	314-BOX	Pass/Pass	∞ / ∞
3	11	Wago	773-164	Pass/Pass	∞ / ∞
4	13	Wago	222-415	Pass/Pass	∞ / ∞
5	14	Ideal	Model 39/30-1039J	Pass	∞ / ∞
6	35	Tyco	925	Pass	6 G
7	6	Tyco	1-776302-4	Pass	4 G
8	15	Phoenix Contact	PT 1,5/S	Pass	4 G
9	16	Phoenix Contact	PT 2,5	Pass	5 G
10	20	Cooper Bussman	PDBFS 220	Pass	3 G
11	36	Tyco	N/A	Pass/Pass	4 G
12	9	Wago	282-696	Pass/Pass	5 G
13	10	Wago	282-128	Pass/Pass	10 G
14	12	Wago	2002-1201	Pass/Pass	2.6 G
15	21	WEIDMULLER	1011000000	Pass	2 G
16	22	WEIDMULLER	1880430000	Pass	5 G
17	23	Eaton	XBUT25D22	Pass	2.4 G
18	24	Eaton	XBUT4FBE	Pass	6 G
19	25	Eaton	XBPT4	Pass	4 G
20	26	Eaton	XBQT15	Pass	10 G
21	28	Rockwell Automation (Alan Bradley)	1492-L2	Fail	3 G
22	29	Rockwell Automation (Alan Bradley)	1492-J3	Pass	3 G
23	30	Rockwell Automation (Alan Bradley)	1492-CAM1	Pass	5 G
24	31	Phoenix Contact	UK 2,5 N	Pass	7 G
25	32	Phoenix Contact	ST 1,5	Fail	7 G
26	34	Tyco	212	Pass	4.5 G
27	18	Cooper Bussman	PDB-220-3	Pass	3 G

Notes:

[1] For those cells showing Pass/Pass, 2 conductors for the connector were tested

[2] For those cells showing Pass/Pass, voltage drop was measured across connector ter
unterminated port, for each conductor

[3] For those cells showing ∞ / ∞, measurement was made from conductor to ground, fo
other units, worst case was across terminal points, all other measurements to ground

esults

Voltage Drop Test Pass/Fail[3]	Post-Test Contact/Pull Resistance Test
Pass	Pass
Pass/Pass	Pass
Pass/Pass	Pass
Pass/Pass	Pass
Pass/Pass	Fail
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass

rminated port and

r each conductor; for the
were recorded as infinity

NSRP ETP Project: Low Voltage Quick Connectors, Testing Results

Worksheet Number	Unit Number per Dwg	Tensile Pull Resistance Pass/Fail[1]	Insulation Resistance (ohms)[2]	Voltage Drop Test Pass/Fail[3]	Shock Test Pass/Fail	Vibration Test Pass/Fail	Thermal Cycling Pass/Fail	Post-Test Contact/Pull Resistance Test	Ease of Use (conductor and unit installation)	Holding Mechanism Durability
1	2	Pass	10 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
2	27	Pass/Pass	∞ / ∞	Pass/Pass	Pass[4]	Pass	Pass	Pass	Satisfactory	Satisfactory
3	11	Pass/Pass	∞ / ∞	Pass/Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
4	13	Pass/Pass	∞ / ∞	Pass/Pass	Pass[4]	Pass	Pass	Pass	Satisfactory	Satisfactory
5	14	Pass	∞ / ∞	Pass/Pass	Pass[4]	Pass	Pass	Fail	Satisfactory	Satisfactory
6	35	Pass	6 G	Pass	Fail[7]	Pass	Pass	Pass	Satisfactory	Satisfactory
7	6	Pass	4 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
8	15	Pass	4 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
9	16	Pass	5 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
10	20	Pass	3 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
11	36	Pass/Pass	4 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
12	9	Pass/Pass	5 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
13	10	Pass/Pass	10 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
14	12	Pass/Pass	2.6 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
15	21	Pass	2 G	Pass	Fail[5,6]	Pass	Pass	Pass	Satisfactory	Satisfactory
16	22	Pass	5 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
17	23	Pass	2.4 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
18	24	Pass	6 G	Pass	Fail[6]	Pass	Pass	Pass	Satisfactory	Satisfactory
19	25	Pass	4 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
20	26	Pass	10 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
21	28	Fail	3 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Unsatisfactory
22	29	Pass	3 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
23	30	Pass	5 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
24	31	Pass	7 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
25	32	Fail	7 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Unsatisfactory
26	34	Pass	4.5 G	Pass	Fail[7]	Pass	Pass	Pass	Satisfactory	Satisfactory
27	18	Pass	3 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory

Notes:

[1] For those cells showing Pass/Pass, 2 conductors for the connector were tested

[2] For those cells showing Pass/Pass, voltage drop was measured across connector terminated port and unterminated port, for each conductor

[3] For those cells showing ∞ / ∞, measurement was made from conductor to ground, for each conductor; for the other units, worst case was across

[4] No connector test failure or damage. Fastening zip tie broke while testing.

[5] Disconnected from DIN rail

[6] Chatter present

[7] Connector Damage

NSRP ETP Project: Low Voltage Quick Connectors, Testing Results

Worksheet Number	Unit Number per Dwg	Name	Model/PN	Tensile Pull Resistance Pass/Fail[1]	Insulation Resistance (ohms)[2]	Voltage Drop Test Pass/Fail[3]	Shock Test Pass/Fail	Vibration Test Pass/Fail	Thermal Cycling Pass/Fail	Post-Test Contact/Pull Resistance Test	Ease of Use (conductor and unit installation)	Holding Mechanism Durability
1	2	Term Block Baseline	A-A-59125/24 16TB-12	Pass	10 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
2	27	3M	314-BOX	Pass/Pass	∞ / ∞	Pass/Pass	Pass[4]	Pass	Pass	Pass	Satisfactory	Satisfactory
3	11	Wago	773-164	Pass/Pass	∞ / ∞	Pass/Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
4	13	Wago	222-415	Pass/Pass	∞ / ∞	Pass/Pass	Pass[4]	Pass	Pass	Pass	Satisfactory	Satisfactory
5	14	Ideal	Model 39/30-1039J	Pass	∞ / ∞	Pass/Pass	Pass[4]	Pass	Pass	Fail	Satisfactory	Satisfactory
6	35	Tyco	925	Pass	6 G	Pass	Fail[7]	Pass	Pass	Pass	Satisfactory	Satisfactory
7	6	Tyco	1-776302-4	Pass	4 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
8	15	Phoenix Contact	PT 1,5/S	Pass	4 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
9	16	Phoenix Contact	PT 2,5	Pass	5 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
10	20	Cooper Bussman	PDBFS 220	Pass	3 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
11	36	Tyco	N/A	Pass/Pass	4 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
12	9	Wago	282-696	Pass/Pass	5 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
13	10	Wago	282-128	Pass/Pass	10 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
14	12	Wago	2002-1201	Pass/Pass	2.6 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
15	21	WEIDMULLER	1011000000	Pass	2 G	Pass	Fail[5,6]	Pass	Pass	Pass	Satisfactory	Satisfactory
16	22	WEIDMULLER	1880430000	Pass	5 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
17	23	Eaton	XBUT25D22	Pass	2.4 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
18	24	Eaton	XBUT4FBE	Pass	6 G	Pass	Fail[6]	Pass	Pass	Pass	Satisfactory	Satisfactory
19	25	Eaton	XBPT4	Pass	4 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
20	26	Eaton	XBQT15	Pass	10 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
21	28	Rockwell Automation (Alan Bradley)	1492-L2	Fail	3 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Unsatisfactory
22	29	Rockwell Automation (Alan Bradley)	1492-J3	Pass	3 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
23	30	Rockwell Automation (Alan Bradley)	1492-CAM1	Pass	5 G	Pass	Fail[5]	Pass	Pass	Pass	Satisfactory	Satisfactory
24	31	Phoenix Contact	UK 2,5 N	Pass	7 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory
25	32	Phoenix Contact	ST 1,5	Fail	7 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Unsatisfactory
26	34	Tyco	212	Pass	4.5 G	Pass	Fail[7]	Pass	Pass	Pass	Satisfactory	Satisfactory
27	18	Cooper Bussman	PDB-220-3	Pass	3 G	Pass	Pass	Pass	Pass	Pass	Satisfactory	Satisfactory

Notes:

[1] For those cells showing Pass/Pass, 2 conductors for the connector were tested

[2] For those cells showing Pass/Pass, voltage drop was measured across connector terminated port and unterminated port, for each conductor

[3] For those cells showing ∞ / ∞, measurement was made from conductor to ground, for each conductor; for the other units, worst case was across terminal points, all other measurements to

[4] No connector test failure or damage. Fastening zip tie broke while testing.

[5] Disconnected from DIN rail

[6] Chatter present

[7] Connector Damage

NSRP ETP Low Voltage Quick Connector Evaluation Project
Cost Assessment Workbook

Project Period of Performance: 11/2013 - 12/2014

Description

This project assesses the feasibility of the use of quick connector technology for marine applications, particularly for military marine applications.

This workbook uses tools to assess the differences in cost and labor between using traditional qualified terminal block designs and quick connectors of various styles. Information is generated in a format indicating the differences in costs associated with each configuration based on a set of assumptions, shown below, and used to compare to benefits earned as a result of using such devices. For more information on the design of the worksheets, please refer to the project report, entitled *National Shipbuilder Research Program, Electric Technologies Panel: Low Voltage Quick Connector Evaluation,* dated 12/1/14.

Assumptions

1. If a piece of equipment is identified as using quick connectors (i.e., % Purchased Manufacturer's Equipment on worksheet "Summary Connect Totals" row 14 table), all of those equipments indicated use quick connectors regardless of what is allowed for equipment that is manufacturered by the shipbuilder.
2. Quantities shown are estimates (types of system devices employing connectors and terminal blocks), percent employing certain configurations, etc.
3. For traditional terminal block designs, all equipment employing this design utilize one style: the style being baselined in the project (for simplicity).
4. One quick connector utilized one input and one ouput; other configurations are available (and are being tested), but this simplifies the calculations.
5. If quick connectors are allowed for a particular program, then all terminations that can use quick connectors do use quick connectors; minimal to no opportunity exists for this case to switch to quick connectors.
6. If quick connectors are not allowed at all, all terminals utilize terminal blocks as described in assumption 3.
7. Average cost of quick connector device is $3.00 (applies to all connectors including in-line)
8. Average cost of auxiliary or ancillary hardware for the quick connector device, per unit, is $0.50.
9. Average cost of traditional 12 point terminal block is $25.00
10. Some in-line traditional connectors (lugged connectors) are included; average cost is $5.00
11. Only combinations to questions are: Y,Y; N,N; N,Y on worksheet "Summary Connect Totals", columns H and I for table starting at row 7. This is due to using quick connectors over terminal blocks due to assumed costs savings (the last combination of Y,N would assume a vendor would choose a more expensive option (assumed) for their equipment)
12. **User input is only in worksheet "Summary Connect Totals" in the yellow cells; all other input and cells are either input by the spreadsheet designer or calculated values.**

General Instructions

1. User to complete the light yellow cells with approximate values.
2. Workbook designer to input values for the light orange cells; these are approximate values based on what might be anticipated for a change (the user may input data for these cells, but the output should be qualfied as to what differences there may be between the original and the completed forms)
3. Calculated output are non highlighted cells
4. Output for opportunity or savings is shown in the cells in light purple; these are shown in the Summary Connect Totals worksheet

🟧	Input by spreadsheet designer
🟨	Input by user

□ All other is calculated (incl. other P.. Worksheets)
▨ Primary output
▩ Cell not used

Average Number of Connection Points per Equipment (incl. In and Out)

Control Panels	Termination Boxes	Drives	Power Panels	General Equipment
0	0	0	0	0

(program independent assumption)

Estimated Number of Types of Equipment Candidates

	Control Panels	Termination Boxes	Drives	Power Panels	General Equipment	Are quick connectors currently allowed on ship program? (Y, N)	Are quick connectors included with manufacturer's equipment? (Y, N)
Program 1	0	0	0	0	0	n	y
Program 2	0	0	0	0	0	y	n
Program 3							
Program 4							

Percent purchased manufacturer's equipment

	Control Panels	Termination Boxes	Drives	Power Panels	General Equipment
Program 1	0%	0%	0%	0%	0%
Program 2	0%	0%	0%	0%	0%
Program 3					
Program 4					

Estimated Number Per Ship/Program

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block	In-Line Splice Connetcor	Lugged Splice Termination
Program 1	0	0	0	0	0
Program 2	0	0	0	0	0
Program 3	0	0	0	0	0
Program 4	0	0	0	0	0
Average	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**

Table to distribute terminal blocks to quick connector styles

DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	In-Line Splice Connector
0%	0%	100% of in line lugged connector

This is used to estimate DIN rail opportunities
Affects Row 34 only

Opportunity to Switch to Quick Connectors: From Terminal Blocks and Lugged Splice Connectors to Quick Connectors

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block	In-Line Splice Connetcor	Lugged Splice Termination	Total
Program 1	0	0		0		**0**
Program 2	0	0		0		**0**
Program 3	0	0		0		**0**
Program 4	0	0		0		**0**
Average	**#DIV/0!**	**#DIV/0!**		**#DIV/0!**		**#DIV/0!**

Opportunity Costs to Switch to Quick Connectors from Terminal Blocks and Lugged Splice Connectors: Labor Savings (mhrs)

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block	In-Line Splice Connetcor	Lugged Splice Termination	Total
Program 1	$0	$0		$0		**$0**
Program 2	$0	$0		$0		**$0**
Program 3	$0	$0		$0		**$0**
Program 4	$0	$0		$0		**$0**
Average	**#DIV/0!**	**#DIV/0!**		**#DIV/0!**		**#DIV/0!**

Opportunity Costs to Switch to Quick Connectors from Terminal Blocks and Lugged Splice Connectors: Hardware Savings ($)

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block	In-Line Splice Connetcor	Lugged Splice Termination	Total
Program 1	$0.00	$0.00		$0		**$0**
Program 2	$0.00	$0.00		$0		**$0**
Program 3	$0.00	$0.00		$0		**$0**

Program 4	$0.00	$0.00		$0		**$0**
Average	**#DIV/0!**	**#DIV/0!**		**#DIV/0!**		**#DIV/0!**

Opportunity Costs to Switch to Quick Connectors from Terminal Blocks and Lugged Splice Connectors: Total ($)

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block	In-Line Splice Connetcor	Lugged Splice Termination	Total
Program 1	$0.00	$0.00		$0.00		$0.00
Program 2	$0.00	$0.00		$0.00		$0.00
Program 3	$0.00	$0.00		$0.00		$0.00
Program 4	$0.00	$0.00		$0.00		$0.00
Average	**#DIV/0!**	**#DIV/0!**		**#DIV/0!**		**#DIV/0!**

Note: Negative values indicate a savings

Rank of Preference in Quick Connectors

	Rank (1-7)	Comment
DIN Rail Mounted Push In Retaining		
DIN Rail Mounted Push In Retaining with Defeat		
DIN Rail Mounted Push In Retaining with Lever		
Quick Lock Stud		
Screw Down		
In Line Splice		
In Line Splice with Defeat		

Cost Differences in Traditional Connectors and Quick Connectors

		Labor (min)					Materials ($)			Totals		Difference from Traditional Methods			
Item	Description	Base Mounting	Device Mounting	Wire Preparation	Wire Installation	Torquing	Device	Associated Hardware	Base Mount	Labor (hrs)	Materials ($)	Labor (hrs)	Materials ($)	Total ($)	Simple ROI
1	DIN rail 35 Mounted Quick Connector	0.75	0.17	1.00	0.33		$1.00	$0.20	$0.04	0.04	$1	(0.02)	($1)	($3)	36.3%
2	Foot Mounted Quick Connector		2.50	1.00	0.33		$3.00	$0.20	$0.00	0.06	$3	0.01	$1	$2	-22.3%
3	Currently used Terminal Block		0.83	1.00	1.00	0.50	$2.08	$0.20		0.06	$2				
4	In-Line Splice Connetcor		0.50	1.00	0.17		$0.40	$0.50	$0.00	0.03	$1	(0.10)	($2)	($12)	76.5%
5	Lugged Splice Termination		5.00	1.00	1.00	0.50	$3.00	$0.20		0.13	$3				

Notes: 1. The above information is an average of several inputs
2. The above information represents a per unit basis
3. DIN rail mounting estimates is for a strip 24" long, able to hold 40 quick connectors (and end hardware and spacers): takes 30 min. to install 40 units, or 30 sec. pu
4. Wire installation is for input and output sides of respective units
5. Existing terminal strip is divided by the number of terminal pairs (12)
6. Costs are averages across the cross section of units investigated (there is considerable difference, but value can be adjusted easily)
7. Associated hardware includes mounting screws, endplates and spacers (where applicable)
8. Differences is the quick connector method minus the traditional method
9. A positive ROI indicates a savings
10. 🟧 Spreadsheet designer entry

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1			**Average Number of Connection Points per Equipment (incl. In and Out)**											
2			Control Panels	Termination Boxes	Drives	Power Panels	General Equipment							
3			0	0	0	0	0							
4									🟧	Input by spreadsheet designer				
5			**Estimated Number of Types of Equipment**						🟨	Input by user				
6			Control Panels	Termination Boxes	Drives	Power Panels	General Equipment		⬜	All other is calculated (incl. other P.. Worksheets)				
7		**Program 1**	0	0	0	0	0		🟪	Primary output				
8														
9			**Percent purchased manufacturer's equipment**											
10			Control Panels	Termination Boxes	Drives	Power Panels	General Equipment							
11		**Program 1**	0%	0%	0%	0%	0%							
12														
13		**Are quick connectors currently allowed on ship program? (Y, N)**				n								
14		**Are quick connectors included with manufacturer's equipment? (Y, N)**				y								
15														
16		*******************	**Estimated Percent of Type of Device for Type of Equipment if Quick Connectors are Allowed**											
17			**DIN rail 35 Mounted Quick Connector**	**Foot Mounted Quick Connector**	**Currently used Terminal Block**	**In-Line Splice Connetcor**	**Lugged Splice Termination**	Total						
18		Control Panels	0%	0%	0%	0%	0%	0%						
19		Termination Boxes	0%	0%	0%	0%	0%	0%						
20		Drives	0%	0%	0%	0%	0%	0%						
21		Power Panels	0%	0%	0%	0%	0%	0%						
22		General Equipment	0%	0%	0%	0%	0%	0%						
23										Everything has quick connectors				
24			**Estimated # Devices for Type of Equipment if Quick Connectors are Allowed: Values**							No Opportunity				
25			**DIN rail 35 Mounted Quick Connector**	**Foot Mounted Quick Connector**	**Currently used Terminal Block**	**In-Line Splice Connetcor**	**Lugged Splice Termination**							
26		Control Panels	0	0	0	0	0							
27		Termination Boxes	0	0	0	0	0							
28		Drives	0	0	0	0	0							
29		Power Panels	0	0	0	0	0							
30		General Equipment	0	0	0	0	0							
31		**Total**	**0**	**0**	**0**	**0**	**0**	**0**						
32														
33		*******************												
34														
35		*******************	**Estimated Percent of Type of Device for Type of Equipment if Quick Connectors are Not Allowed at All**											
36			**DIN rail 35 Mounted Quick Connector**	**Foot Mounted Quick Connector**	**Currently used Terminal Block**	**In-Line Splice Connetcor**	**Lugged Splice Termination**	Total						
37		Control Panels	0%	0%	0%	0%	0%	0%						
38		Termination Boxes	0%	0%	0%	0%	0%	0%						
39		Drives	0%	0%	0%	0%	0%	0%						
40		Power Panels	0%	0%	0%	0%	0%	0%						
41		General Equipment	0%	0%	0%	0%	0%	0%						
42										Nothing has quick connectors				
43			**Estimated # Devices for Type of Equipment if Quick Connectors are Not Allowed: Values**							Highest Opportunity				
44			**DIN rail 35 Mounted Quick Connector**	**Foot Mounted Quick Connector**	**Currently used Terminal Block**	**In-Line Splice Connetcor**	**Lugged Splice Termination**							
45		Control Panels	0	0	0	0	0							
46		Termination Boxes	0	0	0	0	0							
47		Drives	0	0	0	0	0							
48		Power Panels	0	0	0	0	0							
49		General Equipment	0	0	0	0	0							
50		**Total**	**0**	**0**	**0**	**0**	**0**	**0**						
51														
52		*******************												
53														
54		*******************	**Estimated Percent of Type of Device for Type of Equipment if Quick Connectors are Allowed only in Vendor Equipment**											
55			**DIN rail 35 Mounted Quick Connector**	**Foot Mounted Quick Connector**	**Currently used Terminal Block**	**In-Line Splice Connetcor**	**Lugged Splice Termination**	Total						
56		Control Panels	0%	0%	0%	0%	0%	0%						
57		Termination Boxes	0%	0%	0%	0%	0%	0%						
58		Drives	0%	0%	0%	0%	0%	0%						
59		Power Panels	0%	0%	0%	0%	0%	0%						
60		General Equipment	0%	0%	0%	0%	0%	0%						
61										Only vendor equip. has quick connectors				
62			**Estimated # Devices for Type of Equipment if Quick Connectors are Allowed only in Vendor Equipment: Values**							Moderate Opportunity				
63			**DIN rail 35 Mounted Quick Connector**	**Foot Mounted Quick Connector**	**Currently used Terminal Block**	**In-Line Splice Connetcor**	**Lugged Splice Termination**							
64		Control Panels	0	0	0	0	0							
65		Termination Boxes	0	0	0	0	0							
66		Drives	0	0	0	0	0							
67		Power Panels	0	0	0	0	0							
68		General Equipment	0	0	0	0	0							
69		**Total**	**0**	**0**	**0**	**0**	**0**	**0**						
70														
71		*******************												
72														
73			**Estimated Number Per Ship/Program**											
74			**Labor Totals (hrs)**											
75			**DIN rail 35 Mounted Quick Connector**	**Foot Mounted Quick Connector**	**Currently used Terminal Block**	**In-Line Splice Connetcor**	**Lugged Splice Termination**							
76		**Program 1**	**0**	**0**	**0**	**0**	**0**	**0**						

Average Number of Connection Points per Equ

Control Panels	Termination Boxes	Drives
0	0	0

Estimated Number of Types of E

	Control Panels	Termination Boxes	Drives
Program 2	0	0	0

Percent purchased manufacturer's

	Control Panels	Termination Boxes	Drives
Program 2	0%	0%	0%

Are quick connectors allowed on ship program? (Y, N)
Are quick connectors included with manufacturer's equipment? (Y, N)

****

Estimated Percent of Type of Device for Type of Equ

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block
Control Panels	0%	0%	0%
Termination Boxes	0%	0%	0%
Drives	0%	0%	0%
Power Panels	0%	0%	0%
General Equipment	0%	0%	0%

Estimated # Devices for Type of Equipment if Qu

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block
Control Panels	0	0	0
Termination Boxes	0	0	0
Drives	0	0	0
Power Panels	0	0	0
General Equipment	0	0	0
Total	**0**	**0**	**0**

****

****

Estimated Percent of Type of Device for Type of Equipme

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block
Control Panels	0%	0%	0%
Termination Boxes	0%	0%	0%
Drives	0%	0%	0%
Power Panels	0%	0%	0%
General Equipment	0%	0%	0%

Estimated # Devices for Type of Equipment if Quic

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block
Control Panels	0	0	0
Termination Boxes	0	0	0
Drives	0	0	0
Power Panels	0	0	0
General Equipment	0	0	0
Total	**0**	**0**	**0**

****

****

Estimated Percent of Type of Device for Type of Equipment if Qui

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block
Control Panels	0.00%	0.00%	90.00%
Termination Boxes	0.00%	0.00%	100.00%
Drives	0.00%	0.00%	100.00%
Power Panels	0.00%	0.00%	90.00%
General Equipment	0.00%	0.00%	90.00%

Estimated # Devices for Type of Equipment if Quick Connecto

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block
Control Panels	0	0	0
Termination Boxes	0	0	0
Drives	0	0	0
Power Panels	0	0	0
General Equipment	0	0	0
Total	**0**	**0**	**0**

****

Estimated Number Per S

			Labor Totals (hrs)
	DIN rail 35 Mounted Quick Connector	**Foot Mounted Quick Connector**	**Currently used Terminal Block**
Program 2	**0**	**0**	**0**

ipment (incl. In and Out)

Power Panels	General Equipment
0	0

quipment

Power Panels	General Equipment
0	0

equipment

Power Panels	General Equipment
0%	0%

y
n

ipment if Quick Connectors are Allowed

In-Line Splice Connetcor	**Lugged Splice Termination**	Total
0%	0%	0%
0%	0%	0%
0%	0%	0%
0%	0%	0%
0%	0%	0%

Everything has quick connectors
No Opportunity

iick Connectors are Allowed: Values

In-Line Splice Connetcor	**Lugged Splice Termination**	
0	0	
0	0	
0	0	
0	0	
0	0	
0	**0**	**0**

nt if Quick Connectors are Not Allowed at All

In-Line Splice Connetcor	**Lugged Splice Termination**	Total
0%	0%	0%
0%	0%	0%
0%	0%	0%
0%	0%	0%
0%	0%	0%

Nothing has quick connectors
Highest Opportunity

k Connectors are Not Allowed: Values

In-Line Splice Connetcor	**Lugged Splice Termination**	
0	0	
0	0	
0	0	
0	0	
0	0	
0	**0**	**0**

ck Connectors are Allowed only in Vendor Equipment

In-Line Splice Connetcor	Lugged Splice Termination	Total
0.00%	10.00%	100%
0.00%	0.00%	100%
0.00%	0.00%	100%
0.00%	10.00%	100%
0.00%	10.00%	100%

Only vendor equip. has quick conr
Moderate Opportunity

rs are Allowed only in Vendor Equipment: Values

In-Line Splice Connetcor	Lugged Splice Termination	
0	0	
0	0	
0	0	
0	0	
0	0	
0	**0**	**0**

hip/Program

In-Line Splice Connetcor	Lugged Splice Termination	
0	**0**	**0**

ectors

Average Number of Connection Points per Equ

Control Panels	Termination Boxes	Drives
0	0	0

Estimated Number of Types of E

	Control Panels	Termination Boxes	Drives
Program 3	0	0	0

Percent purchased manufacturer's

	Control Panels	Termination Boxes	Drives
Program 3	0%	0%	0%

Are quick connectors allowed on ship program? (Y, N)
Are quick connectors included with manufacturer's equipment? (Y, N)

****

Estimated Percent of Type of Device for Type of Equ

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block
Control Panels	0%	0%	0%
Termination Boxes	0%	0%	0%
Drives	0%	0%	0%
Power Panels	0%	0%	0%
General Equipment	0%	0%	0%

Estimated # Devices for Type of Equipment if Qu

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block
Control Panels	0	0	0
Termination Boxes	0	0	0
Drives	0	0	0
Power Panels	0	0	0
General Equipment	0	0	0
Total	**0**	**0**	**0**

****

****

Estimated Percent of Type of Device for Type of Equipme

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block
Control Panels	0%	0%	0%
Termination Boxes	0%	0%	0%
Drives	0%	0%	0%
Power Panels	0%	0%	0%
General Equipment	0%	0%	0%

Estimated # Devices for Type of Equipment if Quic

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block
Control Panels	0	0	0
Termination Boxes	0	0	0
Drives	0	0	0
Power Panels	0	0	0
General Equipment	0	0	0
Total	**0**	**0**	**0**

****

****

Estimated Percent of Type of Device for Type of Equipment if Qui

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block
Control Panels	0.00%	0.00%	90.00%
Termination Boxes	0.00%	0.00%	100.00%
Drives	0.00%	0.00%	100.00%
Power Panels	0.00%	0.00%	90.00%
General Equipment	0.00%	0.00%	90.00%

Estimated # Devices for Type of Equipment if Quick Connecto

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block
Control Panels	0	0	0
Termination Boxes	0	0	0
Drives	0	0	0
Power Panels	0	0	0
General Equipment	0	0	0
Total	**0**	**0**	**0**

****

Estimated Number Per S

			Labor Totals (hrs)
	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block
Program 3	**0**	**0**	**0**

ipment (incl. In and Out)

Power Panels	General Equipment
0	0

quipment

Power Panels	General Equipment
0	0

equipment

Power Panels	General Equipment
0%	0%

0
0

ipment if Quick Connectors are Allowed

In-Line Splice Connetcor	**Lugged Splice Termination**	Total
0%	0%	0%
0%	0%	0%
0%	0%	0%
0%	0%	0%
0%	0%	0%

Everything has quick connectors
No Opportunity

ick Connectors are Allowed: Values

In-Line Splice Connetcor	**Lugged Splice Termination**	
0	0	
0	0	
0	0	
0	0	
0	0	
0	**0**	**0**

nt if Quick Connectors are Not Allowed at All

In-Line Splice Connetcor	**Lugged Splice Termination**	Total
0%	0%	0%
0%	0%	0%
0%	0%	0%
0%	0%	0%
0%	0%	0%

Nothing has quick connectors
Highest Opportunity

k Connectors are Not Allowed: Values

In-Line Splice Connetcor	**Lugged Splice Termination**	
0	0	
0	0	
0	0	
0	0	
0	0	
0	**0**	**0**

ck Connectors are Allowed only in Vendor Equipment

In-Line Splice Connetcor	Lugged Splice Termination	Total
0.00%	10.00%	100%
0.00%	0.00%	100%
0.00%	0.00%	100%
0.00%	10.00%	100%
0.00%	10.00%	100%

Only vendor equip. has quick conr
Moderate Opportunity

rs are Allowed only in Vendor Equipment: Values

In-Line Splice Connetcor	Lugged Splice Termination	
0	0	
0	0	
0	0	
0	0	
0	0	
0	**0**	**0**

ship/Program

In-Line Splice Connetcor	Lugged Splice Termination	
0	**0**	**0**

ectors

Average Number of Connection Points per Equ

Control Panels	Termination Boxes	Drives
0	0	0

Estimated Number of Types of E

	Control Panels	Termination Boxes	Drives
Program 4	0	0	0

Percent purchased manufacturer's

	Control Panels	Termination Boxes	Drives
Program 4	0%	0%	0%

Are quick connectors allowed on ship program? (Y, N)

Are quick connectors included with manufacturer's equipment? (Y, N)

****

Estimated Percent of Type of Device for Type of Equ

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block
Control Panels	0%	0%	0%
Termination Boxes	0%	0%	0%
Drives	0%	0%	0%
Power Panels	0%	0%	0%
General Equipment	0%	0%	0%

Estimated # Devices for Type of Equipment if Qu

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block
Control Panels	0	0	0
Termination Boxes	0	0	0
Drives	0	0	0
Power Panels	0	0	0
General Equipment	0	0	0
Total	**0**	**0**	**0**

****

****

Estimated Percent of Type of Device for Type of Equipme

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block
Control Panels	0%	0%	0%
Termination Boxes	0%	0%	0%
Drives	0%	0%	0%
Power Panels	0%	0%	0%
General Equipment	0%	0%	0%

Estimated # Devices for Type of Equipment if Quic

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block
Control Panels	0	0	0
Termination Boxes	0	0	0
Drives	0	0	0
Power Panels	0	0	0
General Equipment	0	0	0
Total	**0**	**0**	**0**

****

****

Estimated Percent of Type of Device for Type of Equipment if Qui

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block
Control Panels	0.00%	0.00%	90.00%
Termination Boxes	0.00%	0.00%	100.00%
Drives	0.00%	0.00%	100.00%
Power Panels	0.00%	0.00%	90.00%
General Equipment	0.00%	0.00%	90.00%

Estimated # Devices for Type of Equipment if Quick Connecto

	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block
Control Panels	0	0	0
Termination Boxes	0	0	0
Drives	0	0	0
Power Panels	0	0	0
General Equipment	0	0	0
Total	**0**	**0**	**0**

****

Estimated Number Per S

	Labor Totals (hrs)		
	DIN rail 35 Mounted Quick Connector	Foot Mounted Quick Connector	Currently used Terminal Block
Program 4	**0**	**0**	**0**

ipment (incl. In and Out)

Power Panels	General Equipment
0	0

quipment

Power Panels	General Equipment
0	0

equipment

Power Panels	General Equipment
0%	0%

0
0

ipment if Quick Connectors are Allowed

In-Line Splice Connetcor	**Lugged Splice Termination**	Total
0%	0%	0%
0%	0%	0%
0%	0%	0%
0%	0%	0%
0%	0%	0%

Everything has quick connectors
No Opportunity

uick Connectors are Allowed: Values

In-Line Splice Connetcor	**Lugged Splice Termination**	
0	0	
0	0	
0	0	
0	0	
0	0	
0	**0**	**0**

nt if Quick Connectors are Not Allowed at All

In-Line Splice Connetcor	**Lugged Splice Termination**	Total
0%	0%	0%
0%	0%	0%
0%	0%	0%
0%	0%	0%
0%	0%	0%

Nothing has quick connectors
Highest Opportunity

k Connectors are Not Allowed: Values

In-Line Splice Connetcor	**Lugged Splice Termination**	
0	0	
0	0	
0	0	
0	0	
0	0	
0	**0**	**0**

ck Connectors are Allowed only in Vendor Equipment

In-Line Splice Connetcor	Lugged Splice Termination	Total
0.00%	10.00%	100%
0.00%	0.00%	100%
0.00%	0.00%	100%
0.00%	10.00%	100%
0.00%	10.00%	100%

Only vendor equip. has quick conr
Moderate Opportunity

ors are Allowed only in Vendor Equipment: Values

In-Line Splice Connetcor	Lugged Splice Termination	
0	0	
0	0	
0	0	
0	0	
0	0	
0	**0**	**0**

hip/Program

In-Line Splice Connetcor	Lugged Splice Termination	
0	**0**	**0**

nectors

DAYTON T. BROWN INC.
Founded 1950

ENGINEERING AND TEST DIVISION
1175 CHURCH STREET, BOHEMIA, LONG ISLAND, NEW YORK 11716 (631) 589-6300

TEST REPORT NO.: 413980-00-04-R14-0853

DAYTON T. BROWN, INC. JOB NO.: 413980-00-000

CUSTOMER:
ADVANCED TECHNOLOGY INTERNATIONAL
5300 INTERNATIONAL BOULEVARD
NORTH CHARLESTON, SC 29418

SUBJECT: LIGHTWEIGHT HAMMER SHOCK, VIBRATION AND THERMAL CYCLING TESTING PERFORMED ON 35 LOW VOLTAGE QUICK CONNECTORS MOUNTED ON TWO PANELS

PURCHASE ORDER NO.: 2014-447

ATTENTION: MS. LISA A. FISHER

THIS REPORT CONTAINS: THREE PAGES AND FOUR ENCLOSURES

PREPARED BY	L. Bailey L. BAILEY
TEST ENGINEER	J. SOOKHDEO
DEPARTMENT SUPERVISOR	T. ZIMOULIS
DATE	25 SEPTEMBER 2014

THE DATA CONTAINED IN THIS REPORT WAS OBTAINED BY TESTING IN COMPLIANCE WITH THE APPLICABLE TEST SPECIFICATION AS NOTED

TABLE OF CONTENTS

1.0 ABSTRACT

This test report details the results of the lightweight hammer shock, vibration and thermal cycling testing performed on 35 Low Voltage Quick Connectors Mounted on two Panels, under reference (a) to the requirements of references (c) and (d).

Results of the tests are detailed in the following text.

The test items were operated during specified portions of testing.

The operation of the test items was monitored by Dayton T. Brown, Inc. personnel.

Test data pertinent to this program will remain on file at Dayton T. Brown, Inc. for 90 days.

The test results recorded in this report relate only to those items tested.

This test report shall not be reproduced, except in full, without the written approval of Dayton T. Brown, Inc.

2.0 REFERENCES

(a)	Customer Purchase Order No.:	2014-447
(b)	Dayton T. Brown, Inc. Job No.:	413980-00-000
(c)	Test Specification:	National Shipbuilder Research Program, Electric Technologies Panel Low Voltage Quick Connector Project Demonstrator Test Procedure, Revision - dated 17 March 2014
(d)	Test Specification:	Dayton T. Brown, Inc. Quote No. 14-0655A

3.0 ADMINISTRATIVE INFORMATION

Customer	Advanced Technology International 5300 International Boulevard North Charleston, SC 29418
Test Item Description	Low Voltage Quick Connectors
Quantity Received	35
Part No.	N/A
Serial Nos.	DTB #1 through 35
Date Received	17 June 2014
Dates Tested	31 July through 15 August 2014
Date Shipped	9 September 2014

4.0 TEST PROGRAM OUTLINE

Test	Test Item Description	Results
Lightweight Hammer Shock	Low Voltage Quick Connectors, Serial Nos. DTB #1 through 35	See test results in Enclosure 1.
Vibration	Low Voltage Quick Connectors, Serial Nos. DTB #1 through 35	No anomalies noted.
Thermal Cycling	Low Voltage Quick Connectors, Serial Nos. DTB #1 through 35	No anomalies noted.
Contact/Pull Resistance	Low Voltage Quick Connectors, Serial Nos. DTB #1 through 35	See test results in Enclosure 4.

Enclosure 1

Lightweight Hammer Shock Test and Results

TEST REQUIREMENT

The lightweight hammer shock test shall be conducted in accordance with references (c) and (d).

TEST RESULTS

A pretest visual inspection of the test items revealed no anomalies.

All testing was performed in accordance with the referenced specification and as detailed in the Lightweight Hammer Shock Test Summary with the following exceptions:

- The lightweight hammer shock test was performed before vibration testing at the request of the customer in lieu of the test order specified in reference (c).
- As directed by the customer, tensile testing was not performed after the completion of shock testing.

The total weight on the shock machine was measured as indicated in the table below.

WEIGHT ON SHOCK MACHINE DURING THE LIGHTWEIGHT HAMMER SHOCK TEST

Item	Weight (lb)
Low Voltage Quick Connectors Mounted on two Panels, Serial Nos. DTB #1 through 35 and Test Fixture	33.5
Standard Mounting Fixture 4A	305.5
Total Weight	339

The test and test items were classified as follows:

Test Items	Low Voltage Quick Connectors Mounted on two Panels, Serial Nos. DTB #1 through 35
Shock Grade	A
Equipment Class	I
Shock Test Type	A
Mounting Location	Deck Mounted
Mounting Plane	Base
Mounting Orientation	Unrestricted

The test items were mounted to the test fixture with Grade 5 3/8-inch bolts.

Refer to the Lightweight Hammer Shock Test Summary for tabulated results.

LIGHTWEIGHT HAMMER SHOCK TEST SUMMARY

Shock Blow No.	Orientation	Drop Height (ft)	Comments
1 August 2014			
1	Back	1	Chatter was detected on #24. The chatter checker was not reset. Parts fell off and came loose.
2	Back	3	Parts fell off and came loose.
3	Back	5	Chatter was detected on #21. The chatter checker was not reset. Parts continued to fly off and come loose.
After Shock Blow No. 3, at the request of Advanced Technology International personnel, the loose connectors were reinstalled on the Low Voltage Quick Connector Panels and testing was continued.			
4 August 2014			
4	Top	1	No chatter detected. No additional parts came loose or were broken.
5	Top	3	No chatter detected. No additional parts came loose or were broken.
6	Top	5	No chatter detected. No additional parts came loose or were broken.
7	Side	1	No chatter detected. No additional parts came loose or were broken.
8	Side	3	No chatter detected. No additional parts came loose or were broken.
5 August 2014			
9	Side	5	No chatter was detected. The zip tie securing #27 broke, and #30 partially came off of the Panel.

The test items completed all phases of testing.

A post-test visual inspection of the test items revealed that a number of the connectors became loose or completely disconnected from the Panels during testing. The tabs on #34 snapped off and one side of the base of #35 was broken. The zip ties holding #13, #14 and #27 in place were also broken.

Test equipment utilized for the program reported herein was within its assigned interval of calibration.
Details are on file at Dayton T. Brown, Inc. and will be made available upon request.

Job Sub: **413980-04** **TEST: LIGHTWEIGHT HAMMER SHOCK**

ITEM	MANUFACTURER	MODEL	DTB NO.	ACCURACY	CAL DUE DATE
SHOCK MACHINE, HAMMER	NEW ENGLAND TRAWLER	LIGHT-WEIGHT	04V-022	N/A	N.C.R.
DETECTOR, CONTACT CHATTER	TRIG-TEK	850A	11-5	MFR	10/19/2014
DETECTOR, CONTACT CHATTER	EADS	850B	11-6	MFR	04/05/2015
DETECTOR, CONTACT CHATTER	TRANS-TEK	850A	11-7	MFR	04/19/2015
SCALE, HANGING 2K LBS	TRI-COASTAL	264BW	61-4	±0.15% OF F.S	09/07/2014

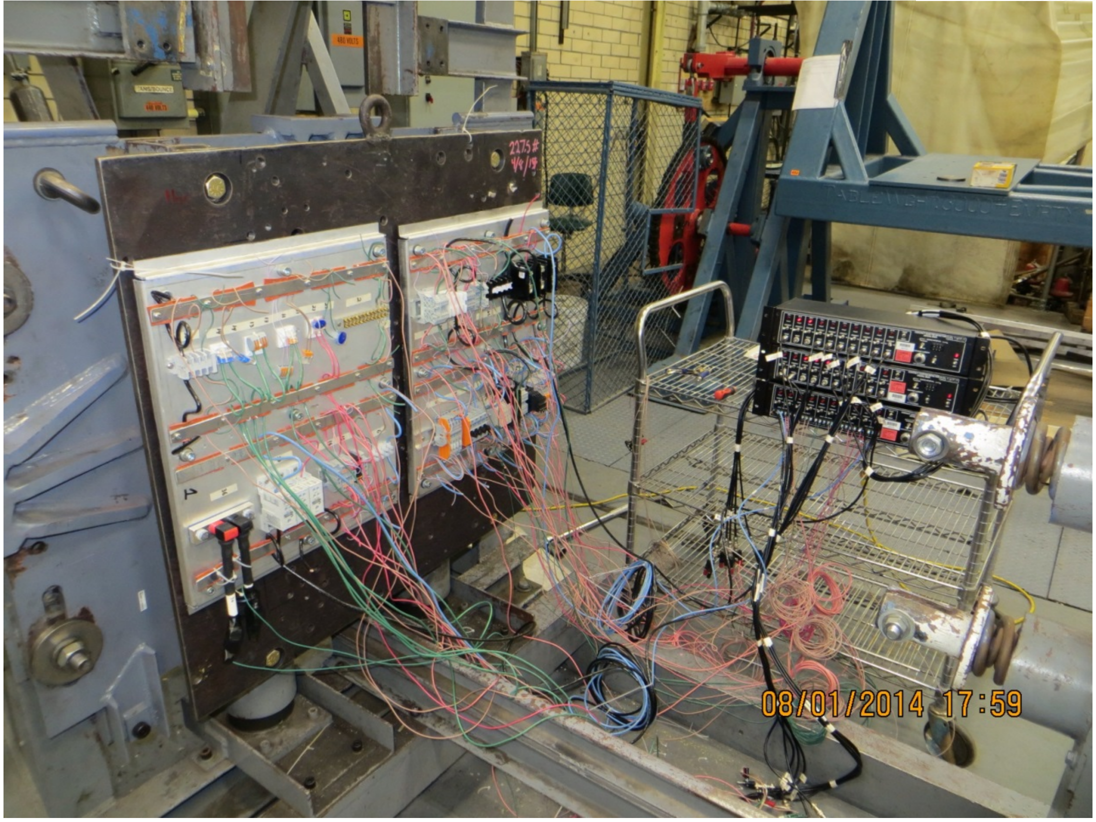


Photo 1 – File No. AG14-1032
Lightweight hammer shock test setup for testing in the back and top orientation

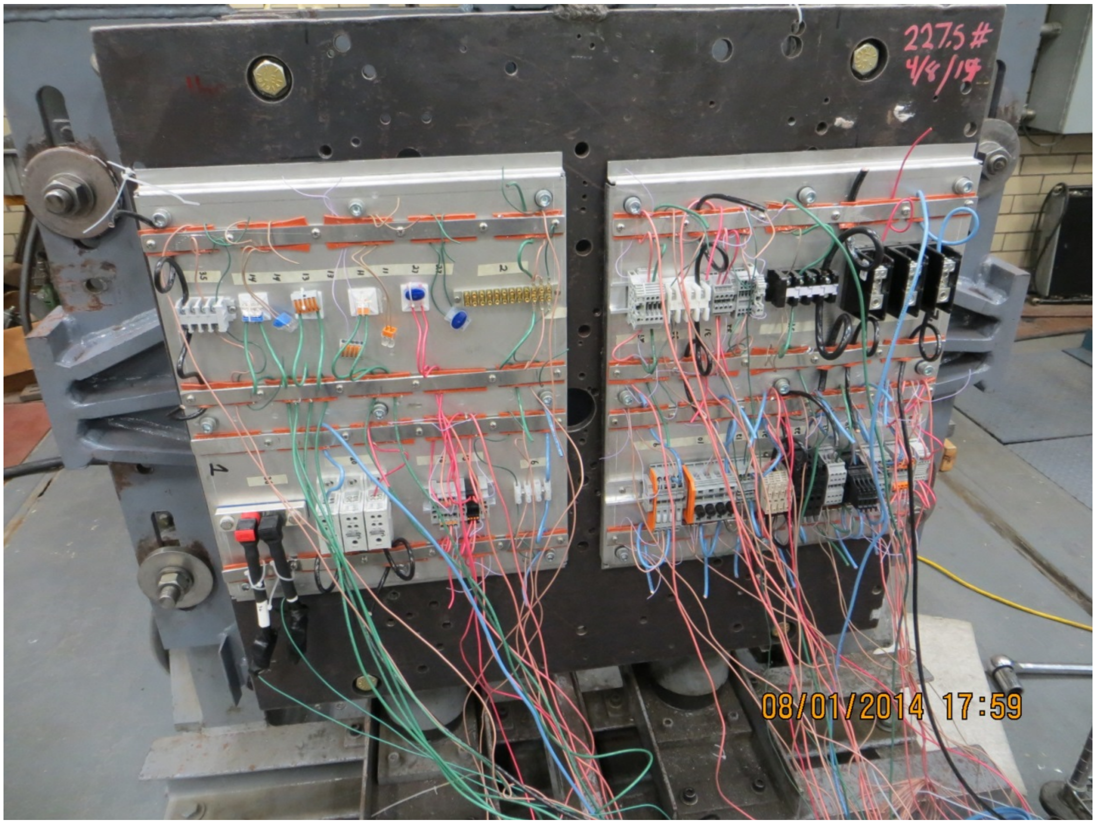


Photo 2 – File No. AG14-1033
Lightweight hammer shock test setup for testing in the back and top orientation

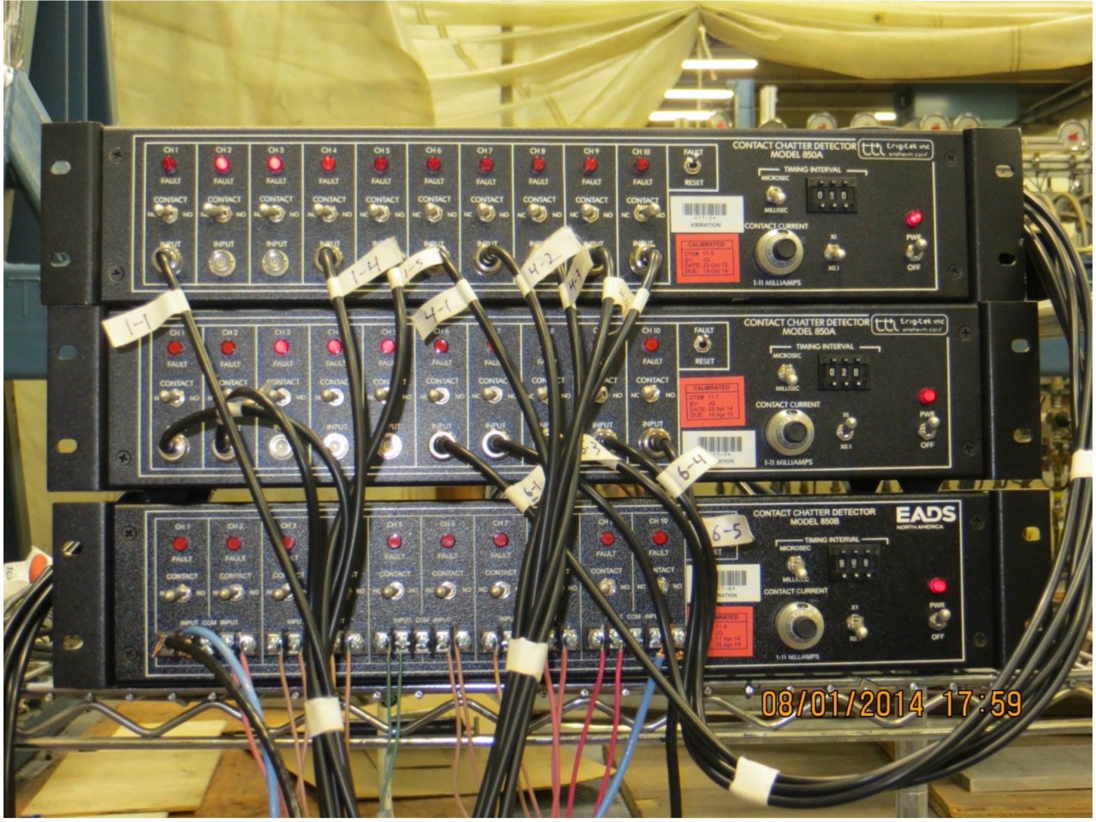


Photo 3 – File No. AG14-1034
Lightweight hammer shock test setup for testing in the back and top orientation

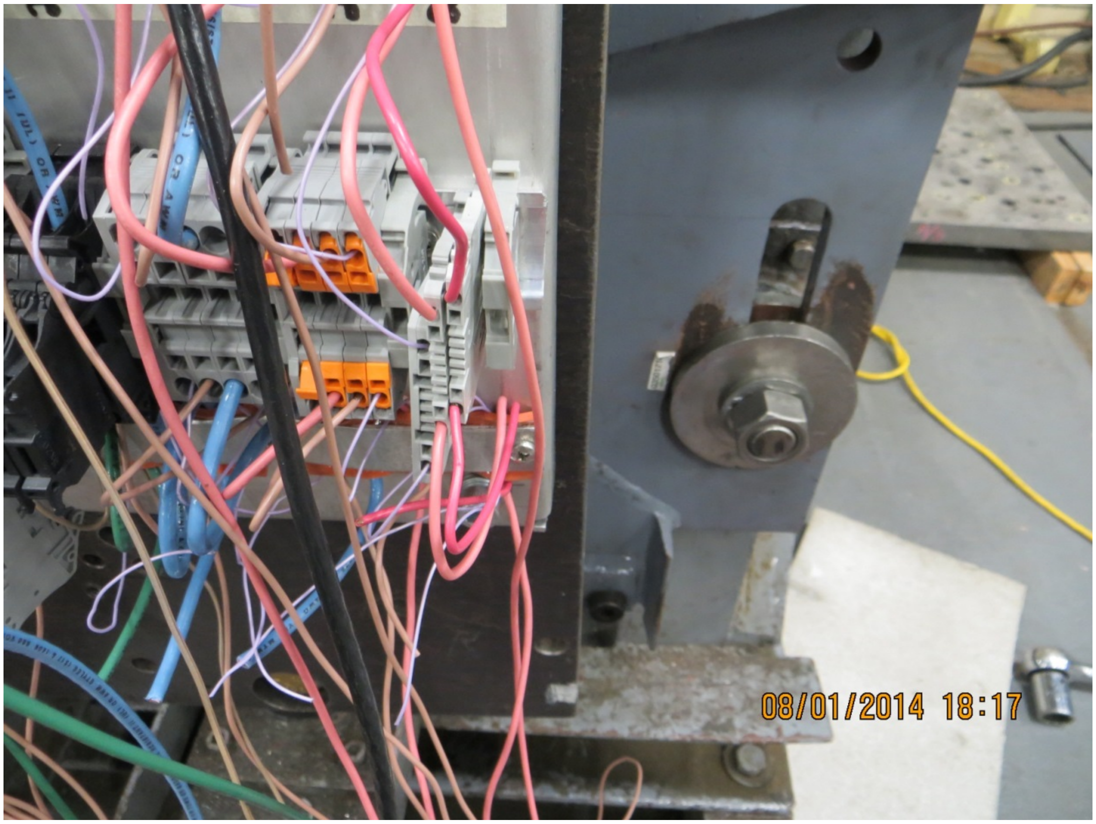


Photo 4 – File No. AG14-1035
View after Shock Blow No. 1 in the back direction, parts fell off and came loose

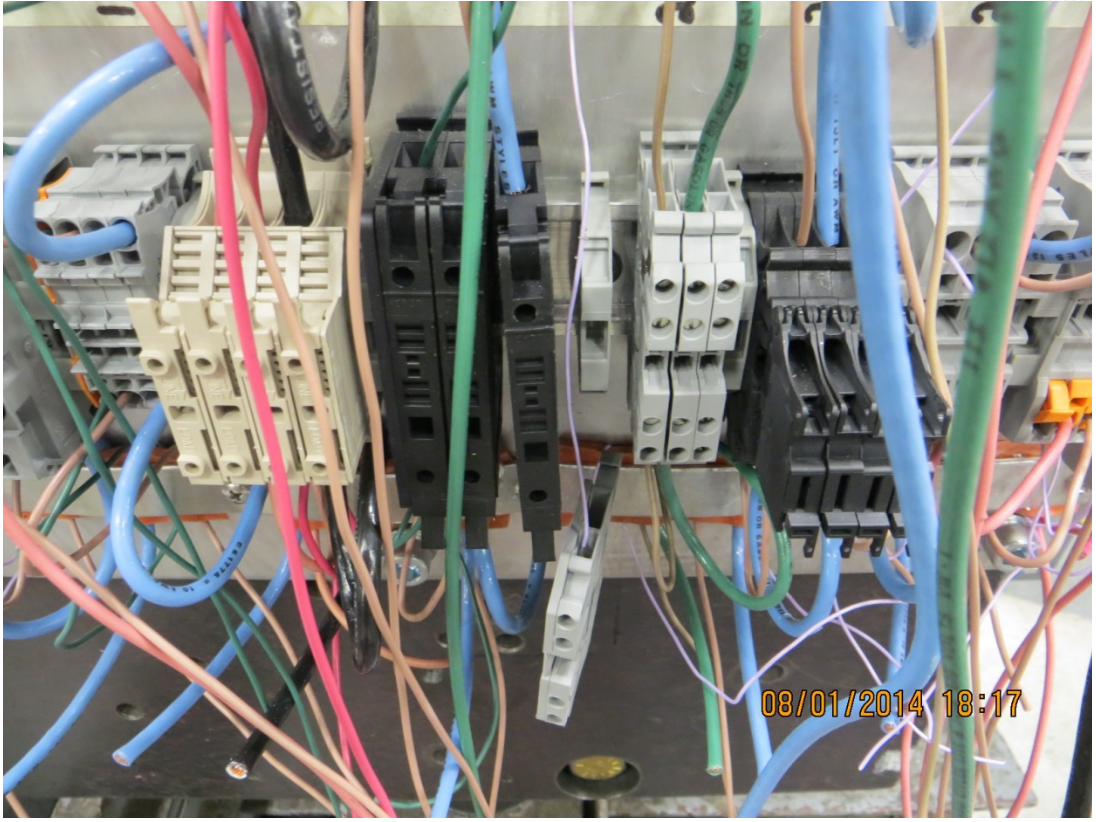


Photo 5 – File No. AG14-1036
View after Shock Blow No. 1 in the back direction, parts fell off and came loose

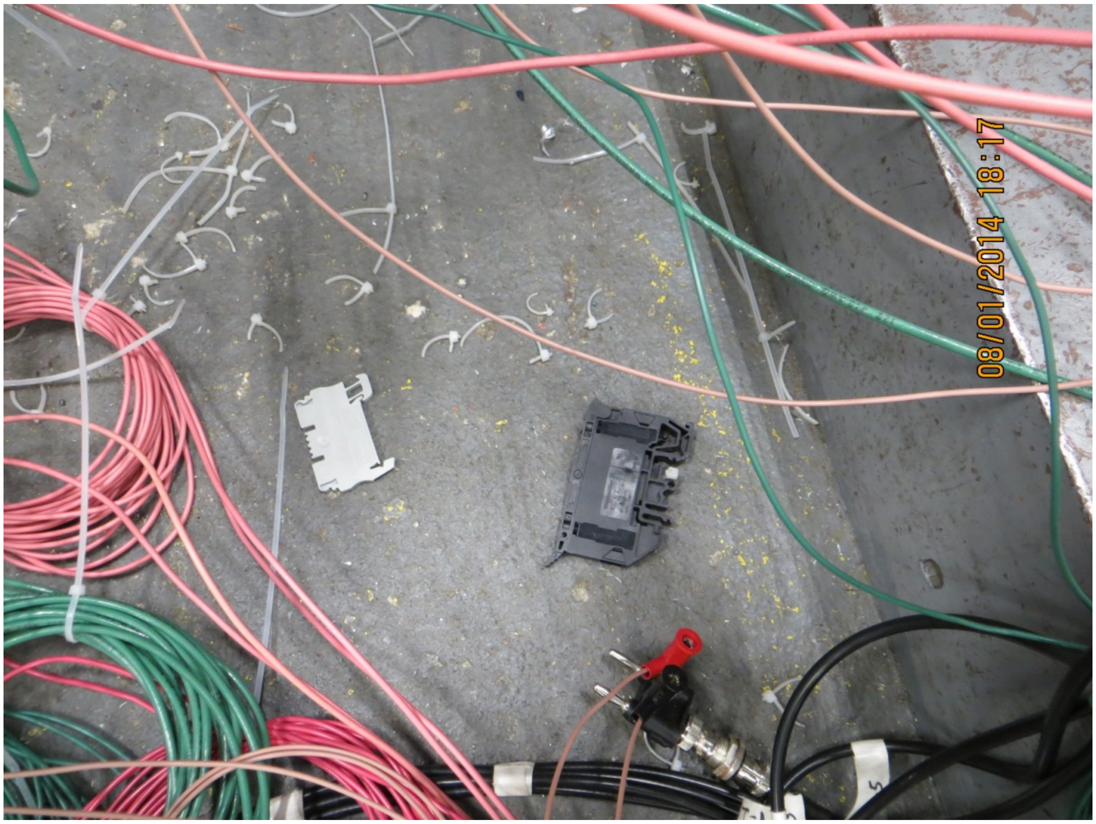


Photo 6 – File No. AG14-1037
View after Shock Blow No. 1 in the back direction, parts fell off and came loose

Photo 7 – File No. AG14-1038
View after Shock Blow No. 1 in the back direction, item #24 had chatter

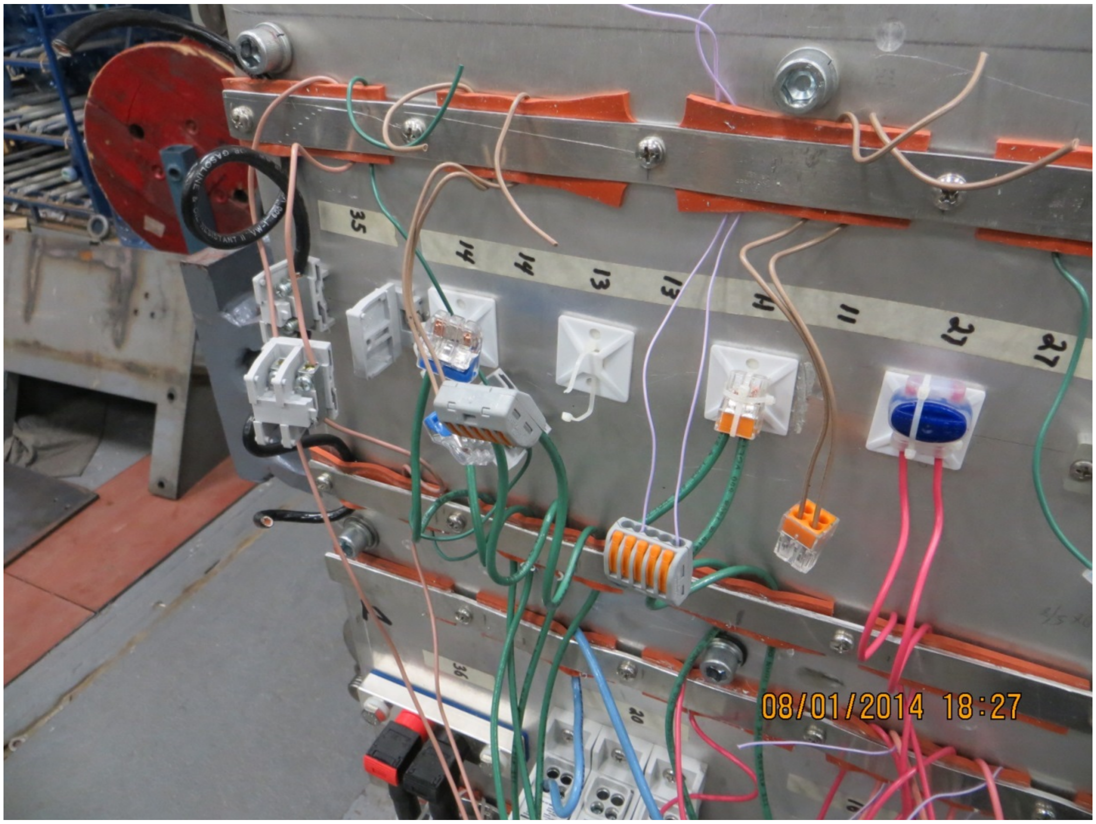


Photo 8 – File No. AG14-1039
View after Shock Blow No. 2 in the back direction, parts fell off and others were loose

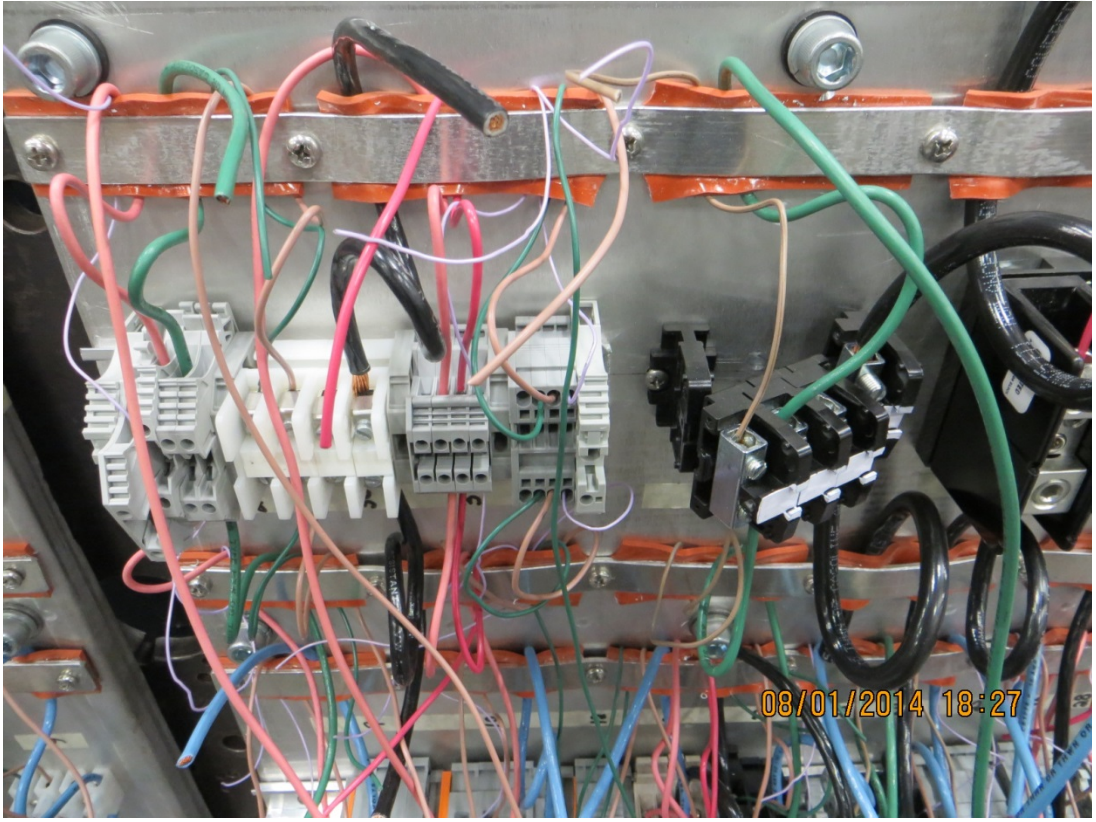


Photo 9 – File No. AG14-1040
View after Shock Blow No. 2 in the back direction, parts fell off and others were loose

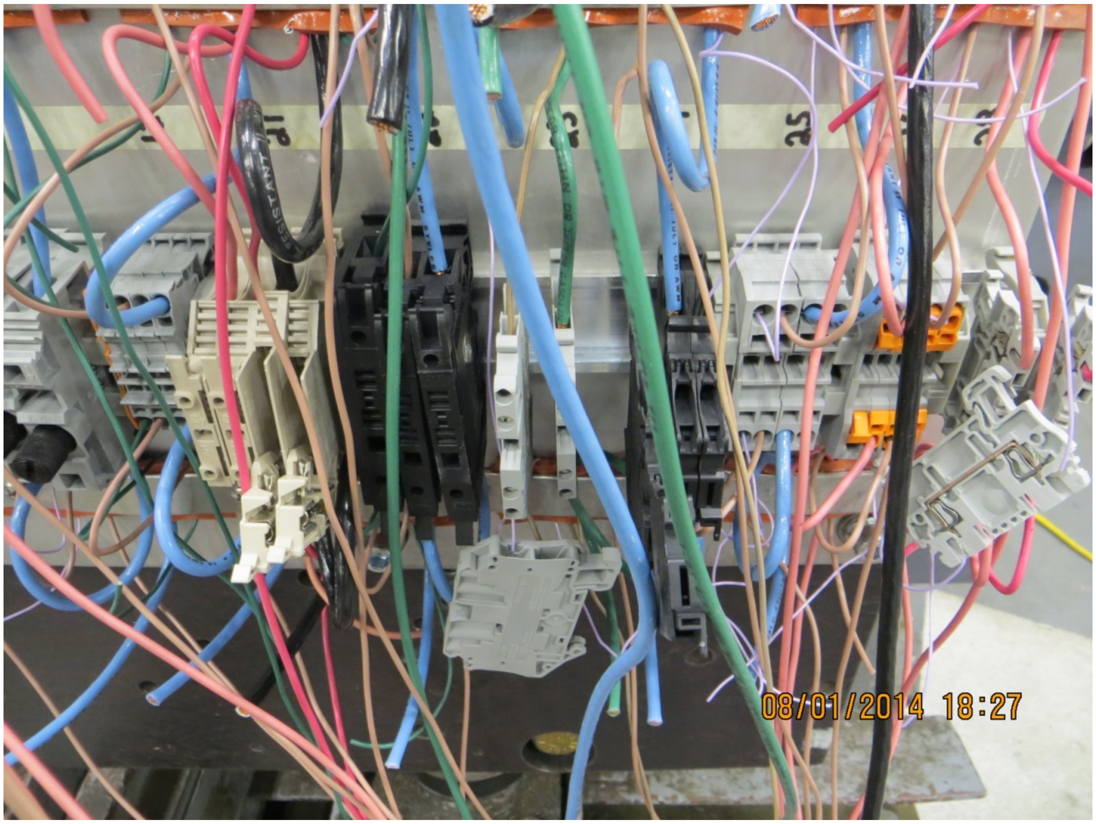


Photo 10 – File No. AG14-1041
View after Shock Blow No. 2 in the back direction, parts fell off and others were loose

Photo 11 – File No. AG14-1042
View after Shock Blow No. 2 in the back direction, parts fell off and others were loose

Photo 12 – File No. AG14-1043
View after Shock Blow No. 2 in the back direction, parts fell off and others were loose

Photo 13 – File No. AG14-1044
View after Shock Blow No. 2 in the back direction, parts fell off and others were loose

Photo 14 – File No. AG14-1045
View after Shock Blow No. 2 in the back direction, parts fell off and others were loose

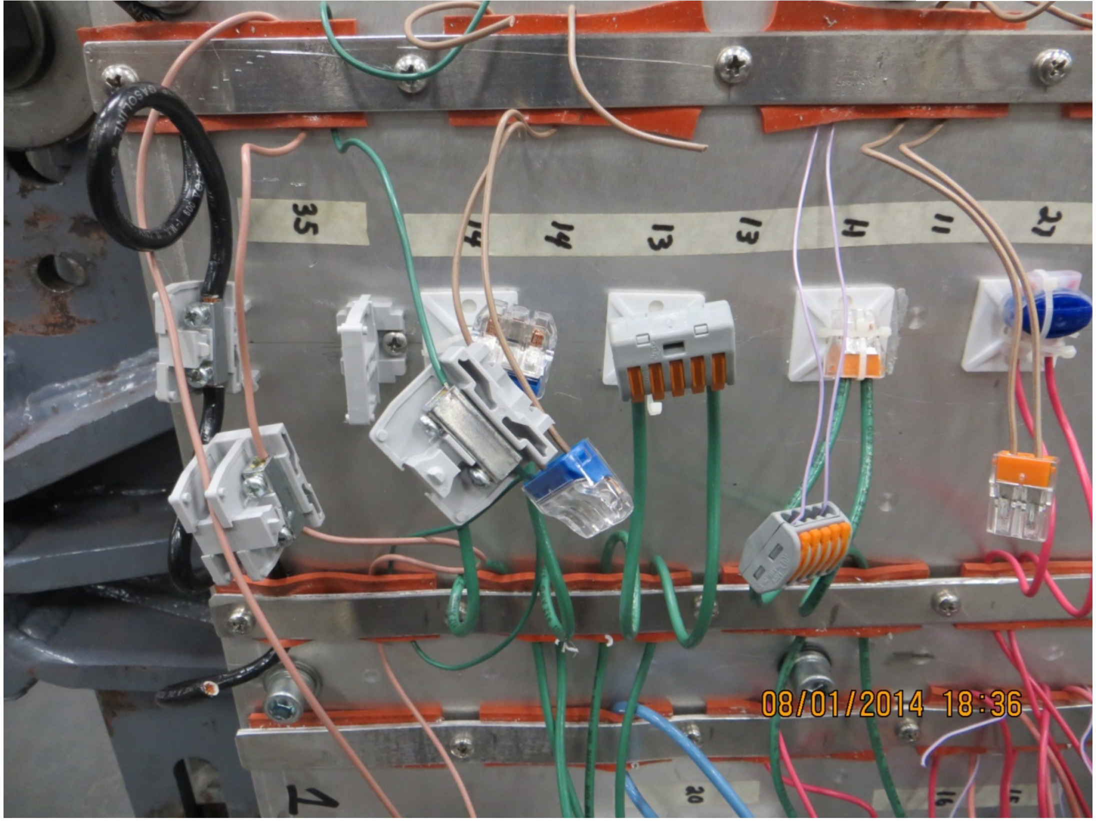


Photo 15 – File No. AG14-1046
View after Shock Blow No. 3 in the back direction, parts flew off and came loose

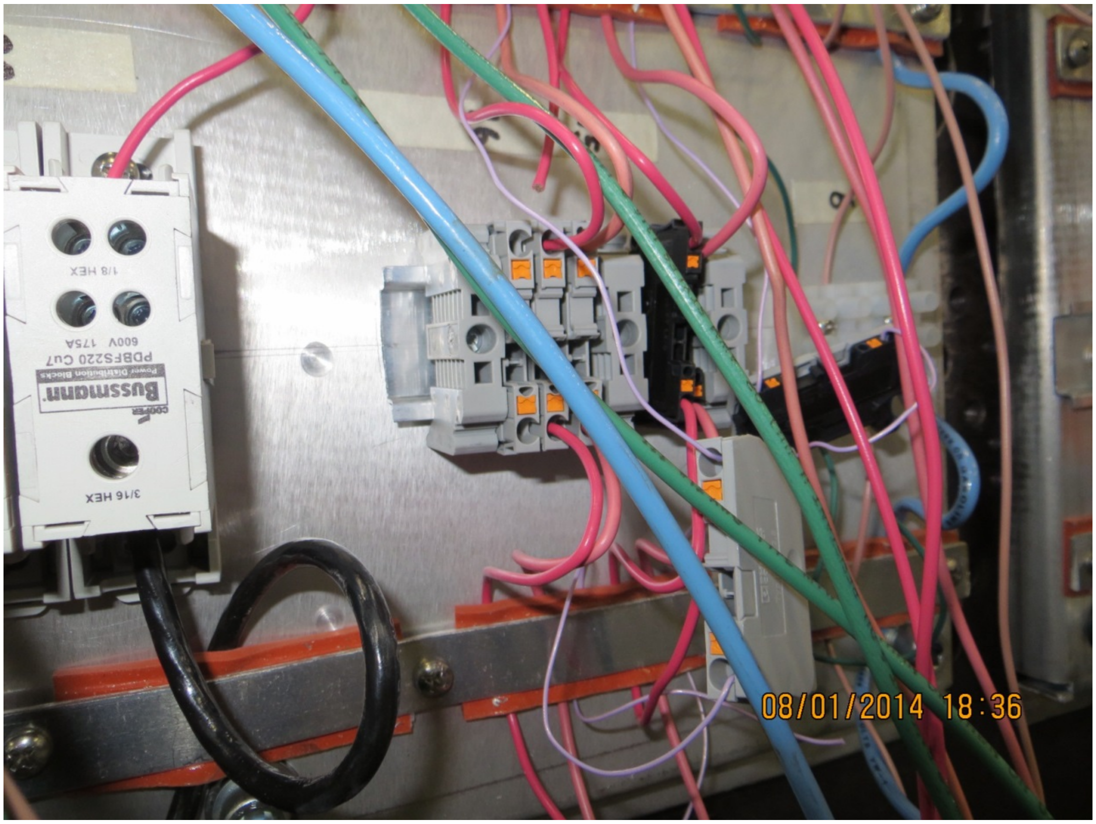


Photo 16 – File No. AG14-1047
View after Shock Blow No. 3 in the back direction, parts flew off and came loose

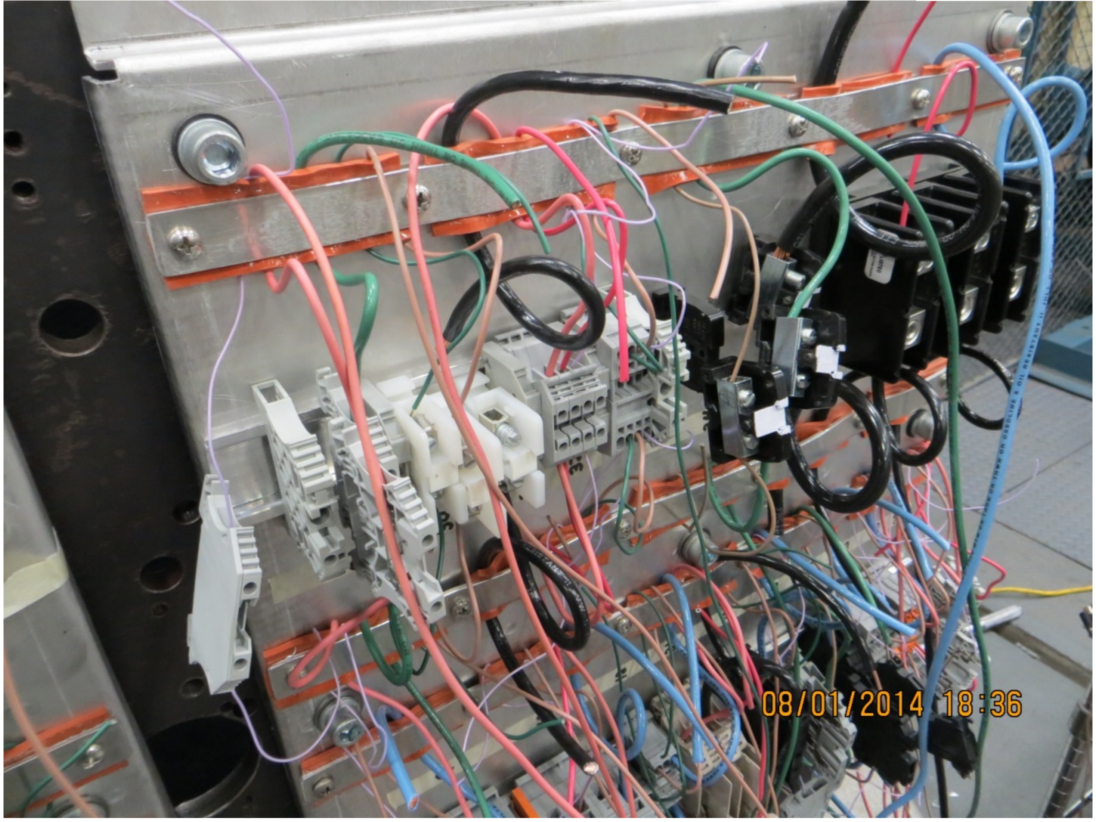


Photo 17 – File No. AG14-1048
View after Shock Blow No. 3 in the back direction, parts flew off and came loose

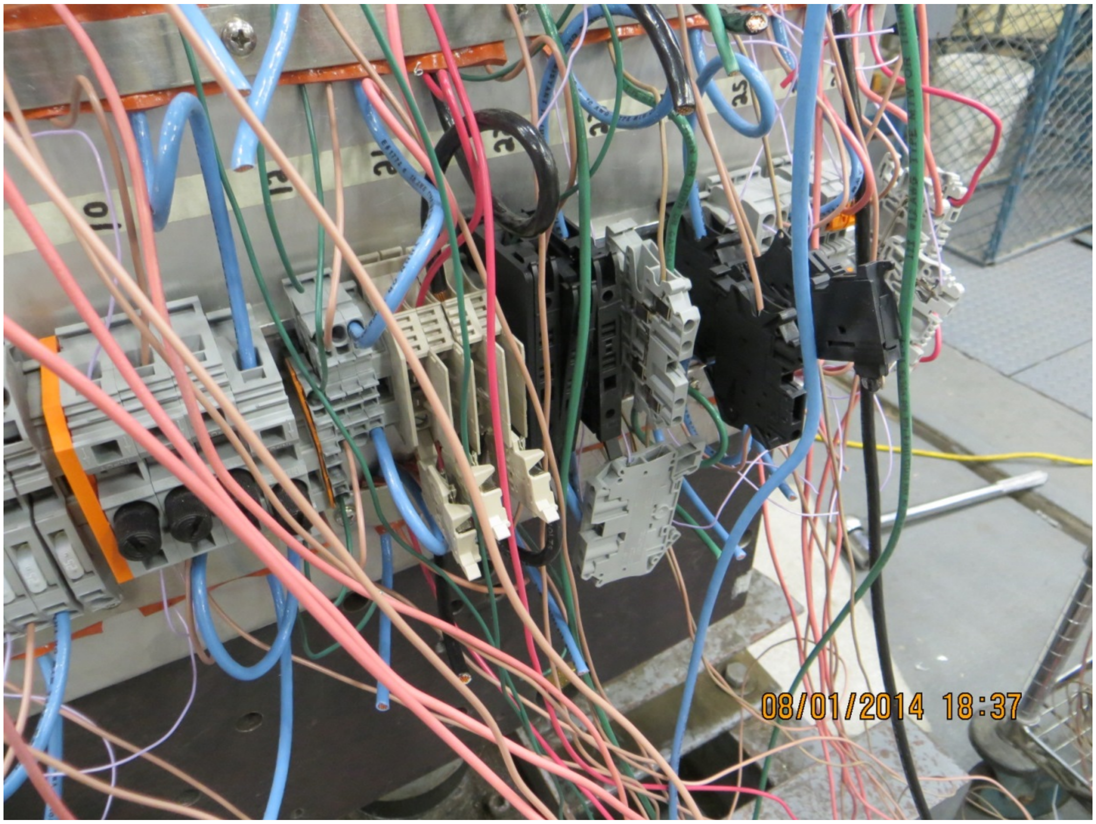


Photo 18 – File No. AG14-1049
View after Shock Blow No. 3 in the back direction, parts flew off and came loose

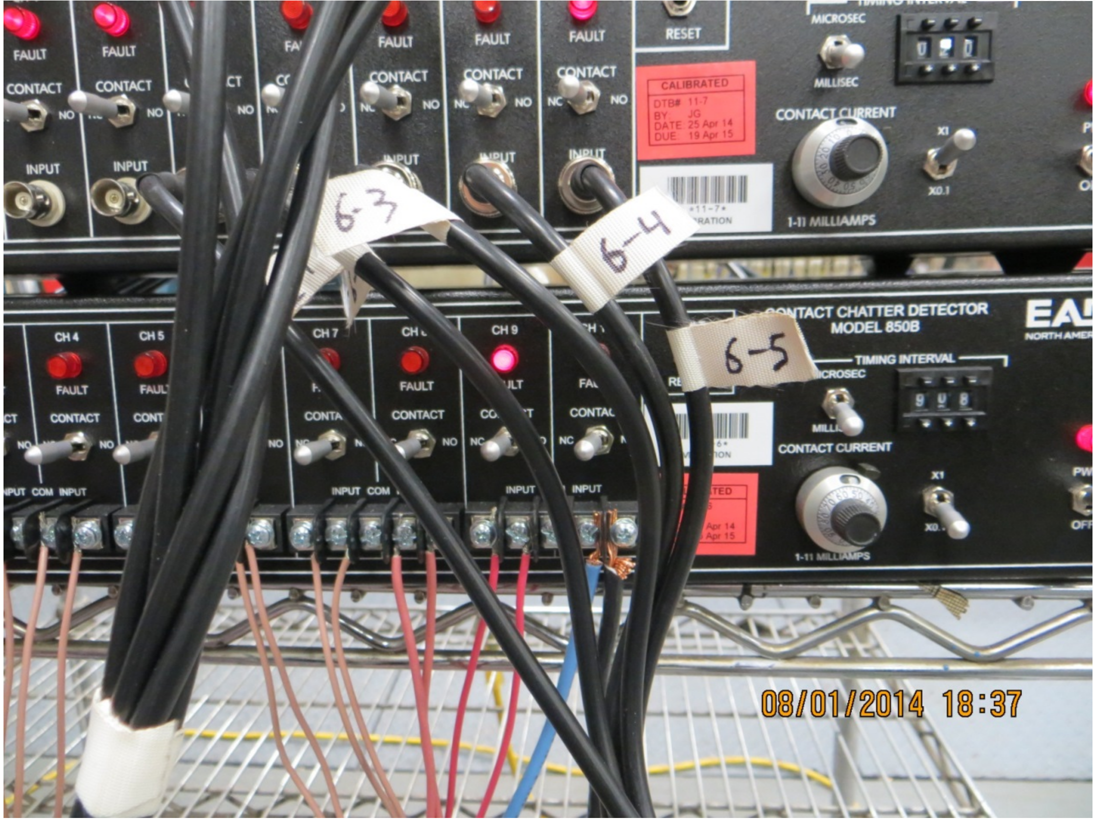


Photo 19 – File No. AG14-1050
View after Shock Blow No. 3 in the back direction, #21 had chatter

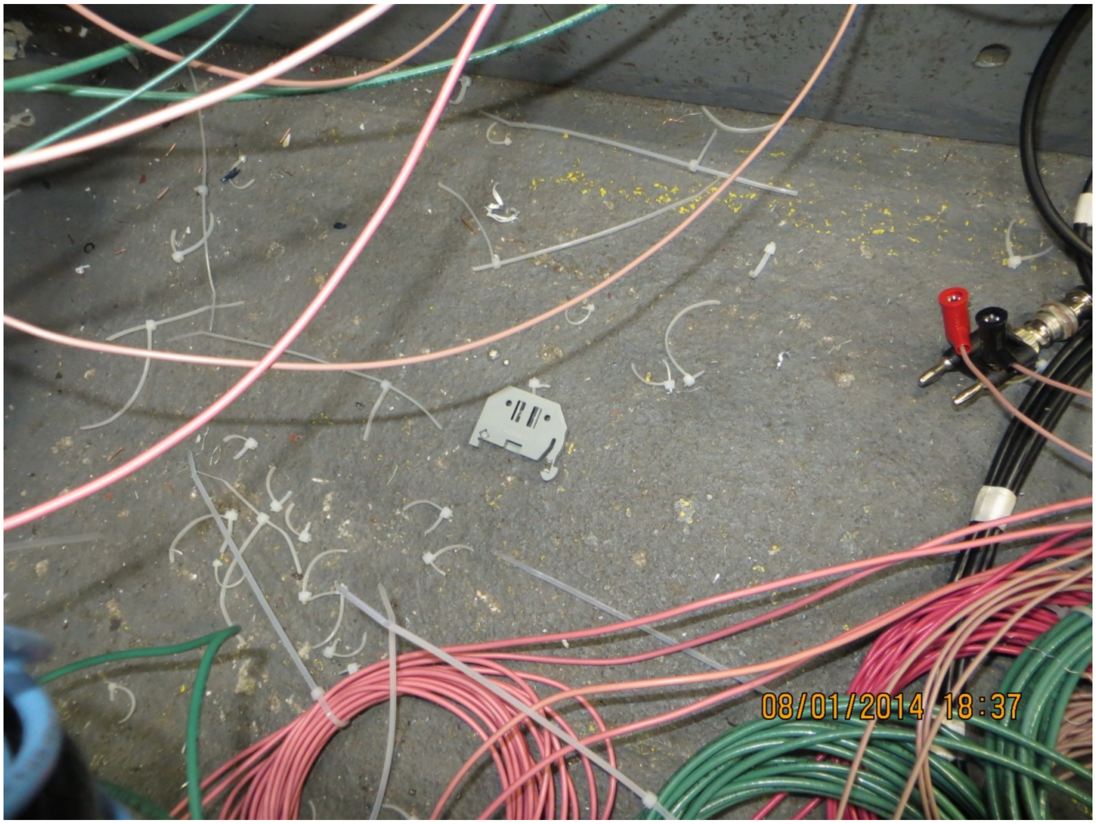


Photo 20 – File No. AG14-1051
View after Shock Blow No. 3 in the back direction, parts flew off and came loose

Photo 21 – File No. AG14-1052
View after Shock Blow No. 3 in the back direction, parts flew off and came loose

Photo 22 – File No. AG14-1053
View after Shock Blow No. 3 in the back direction, parts flew off and came loose

Photo 23 – File No. AG14-1054
View after Shock Blow No. 3 in the back direction, parts flew off and came loose

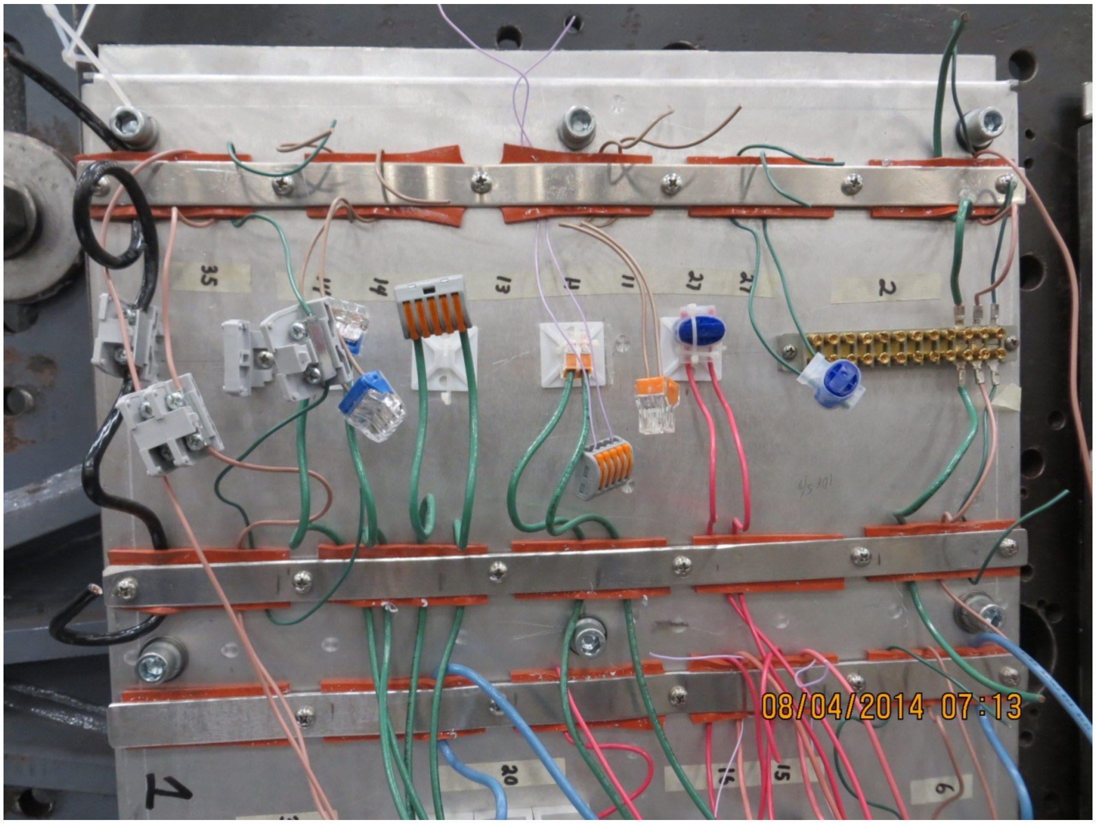


Photo 24 – File No. JP14-0163
View showing various loose connectors after Shock Blow No. 3

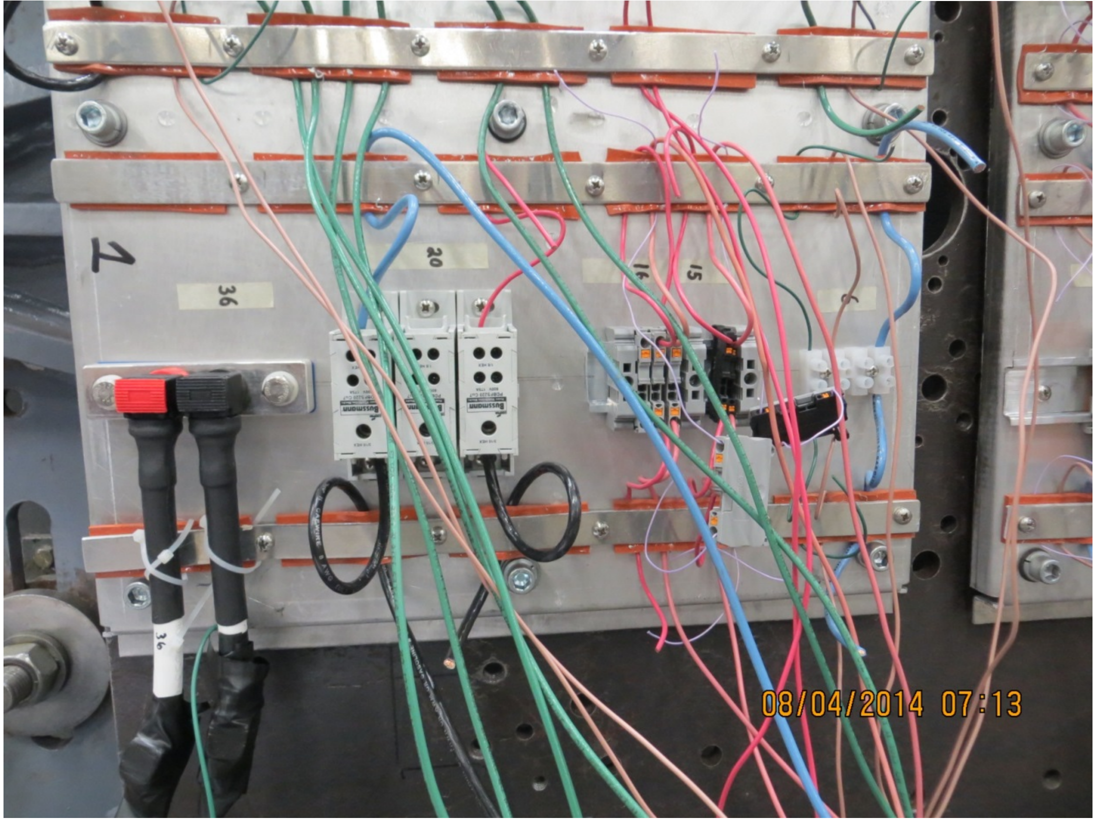


Photo 25 – File No. JP14-0164
View showing various loose connectors after Shock Blow No. 3

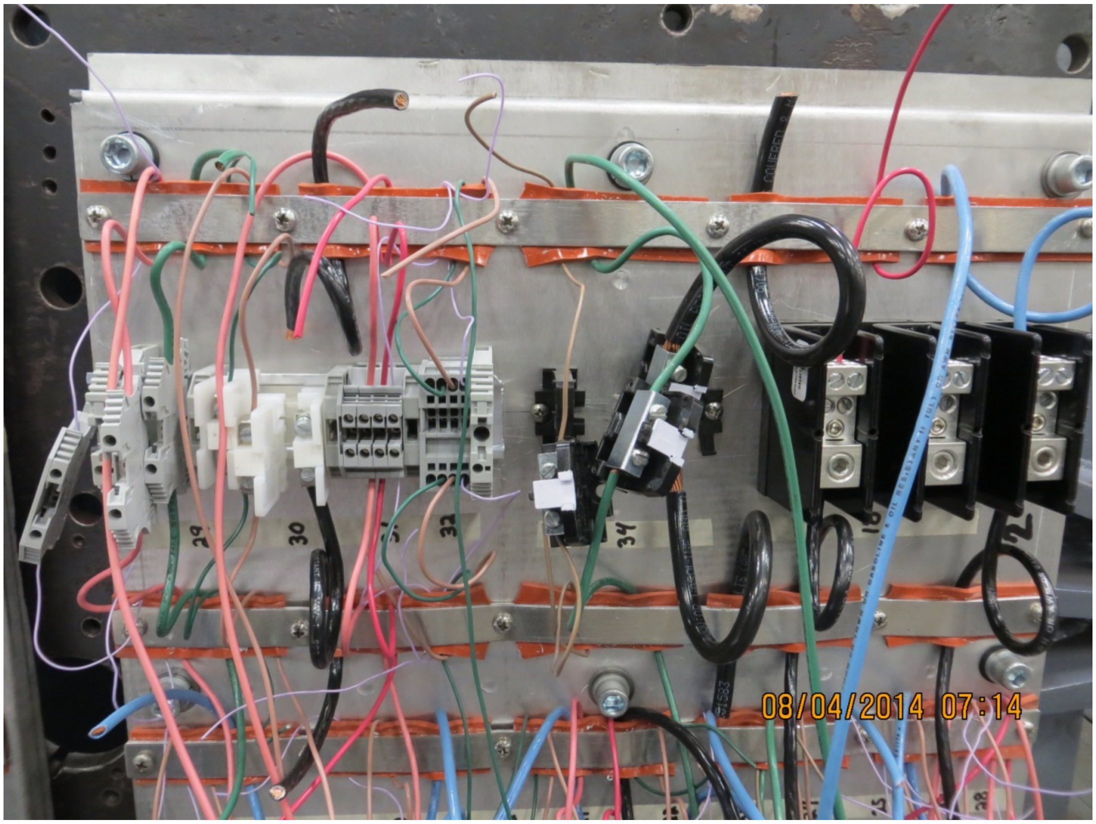


Photo 26 – File No. JP14-0165
View showing various connectors after Shock Blow No. 3

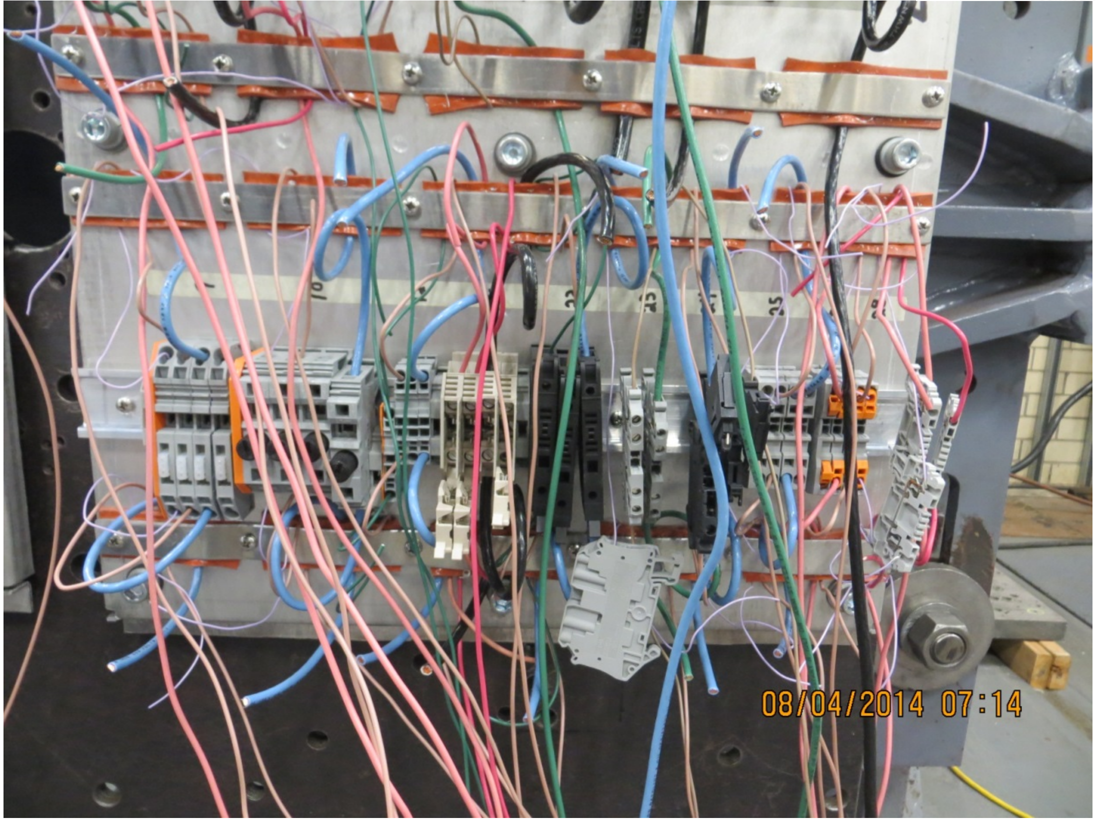


Photo 27 – File No. JP14-0166
View showing various loose connectors after Shock Blow No. 3

Photo 28 – File No. JP14-0167
View showing connector #35 broken at base after Shock Blow No. 3

Photo 29 – File No. JP14-0168
View showing connector #14 with broken ties after Shock Blow No. 3

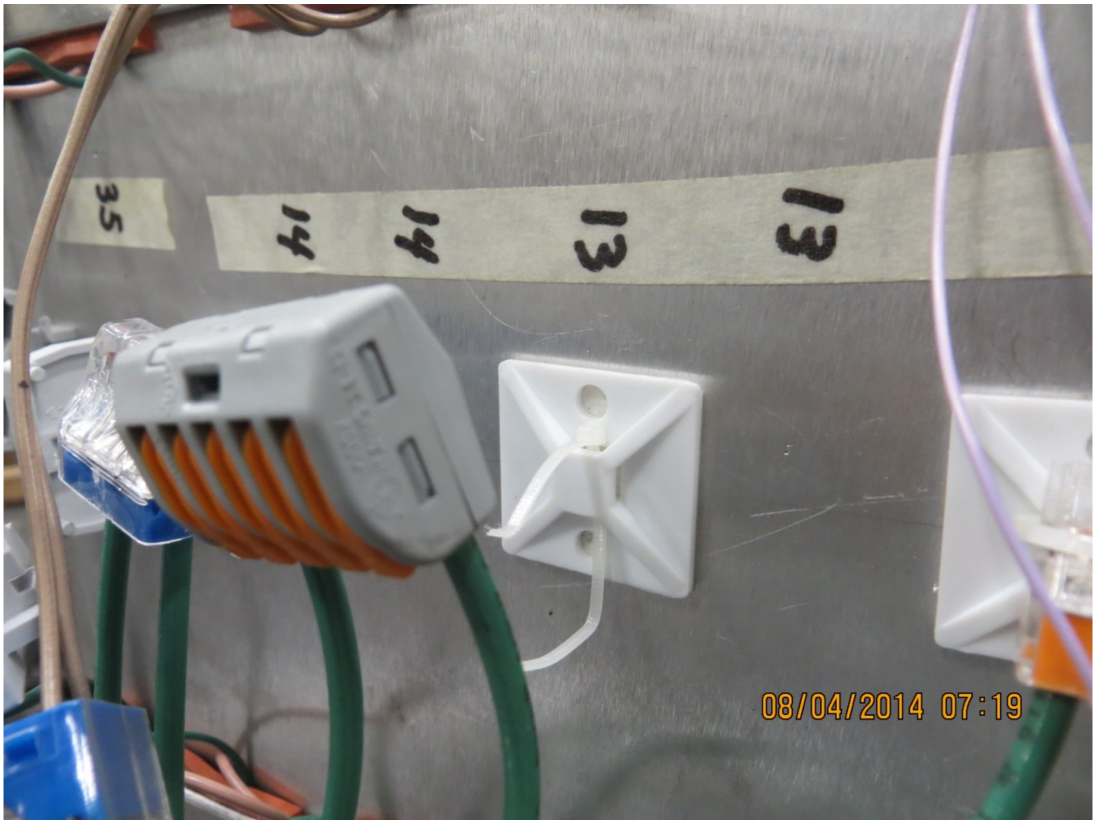


Photo 30 – File No. JP14-0169
View showing connector #13 with broken ties after Shock Blow No. 3

Photo 31 – File No. JP14-0170
View showing connectors #15 and #16 disconnected from DIN rails after Shock Blow No. 3

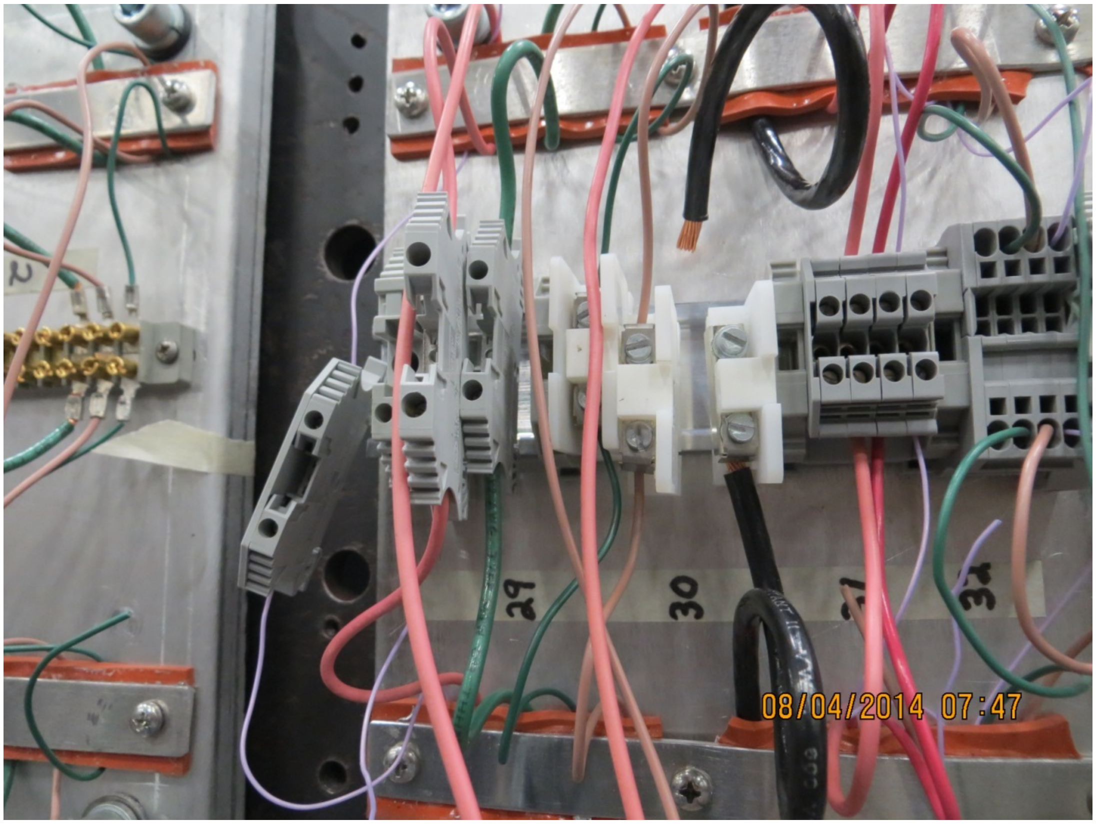


Photo 32 – File No. JP14-0171
View showing connectors #29 and #30 disconnected from DIN rails after Shock Blow No. 3

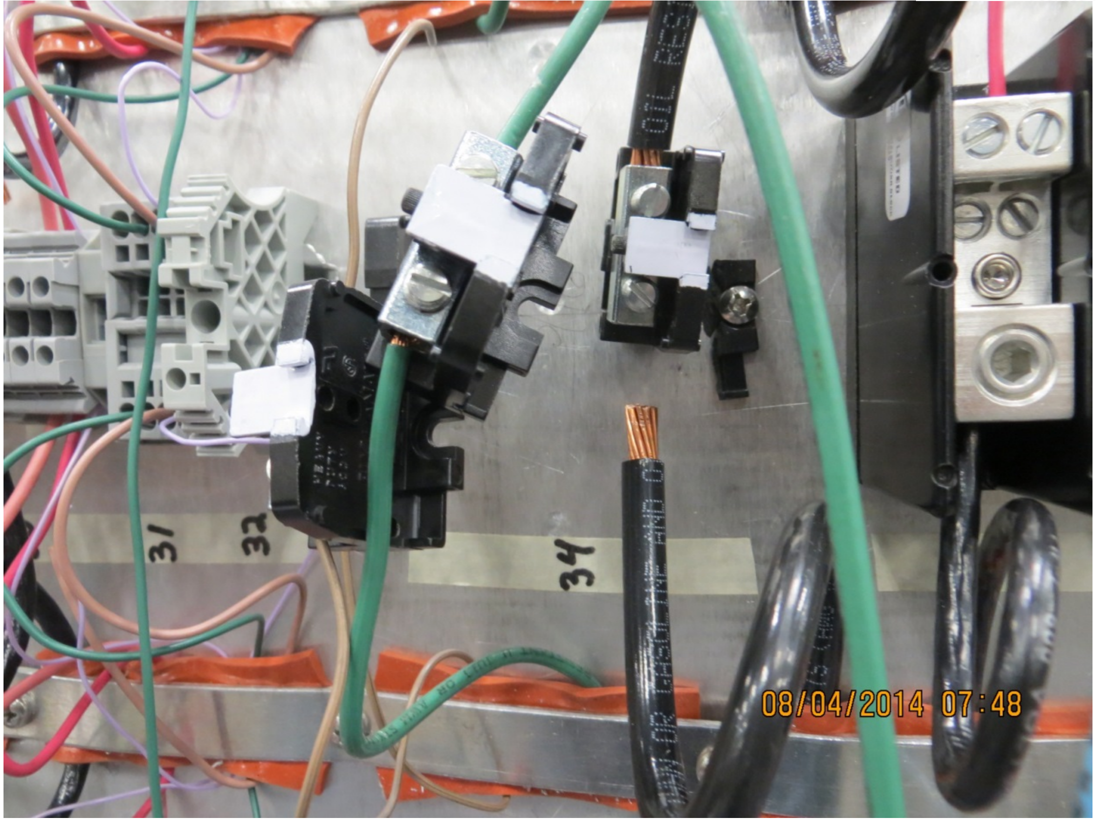


Photo 33 – File No. JP14-0172
View showing connector #34 with broken tabs after Shock Blow No. 3

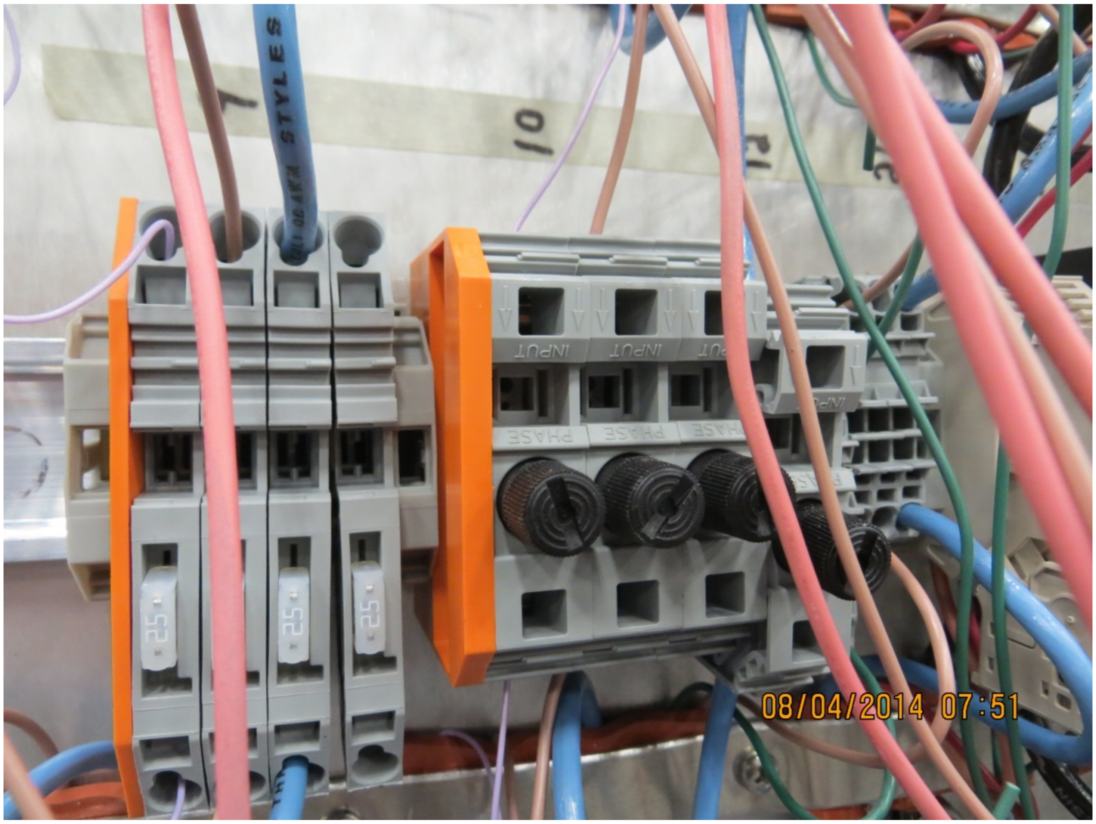


Photo 34 – File No. JP14-0173
View showing connector #10 disconnected from DIN rails after Shock Blow No. 3

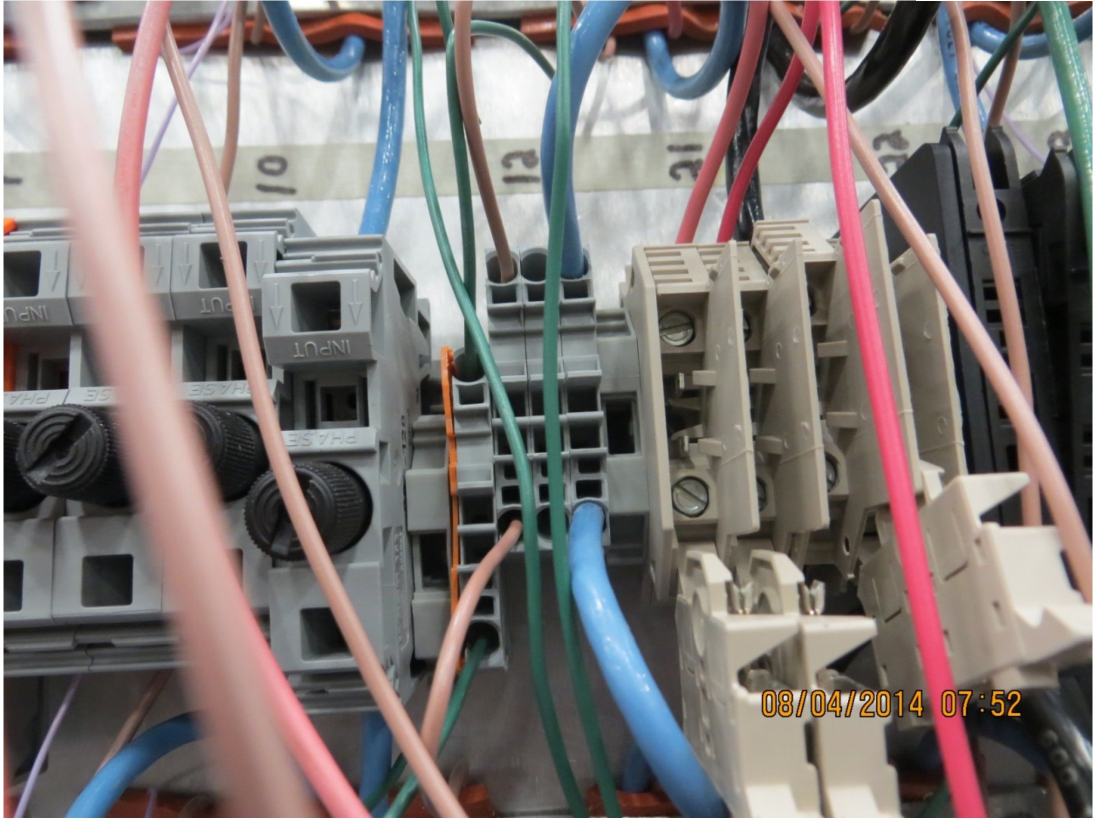


Photo 35 – File No. JP14-0174
View showing connector #12 disconnected from DIN rails after Shock Blow No. 3

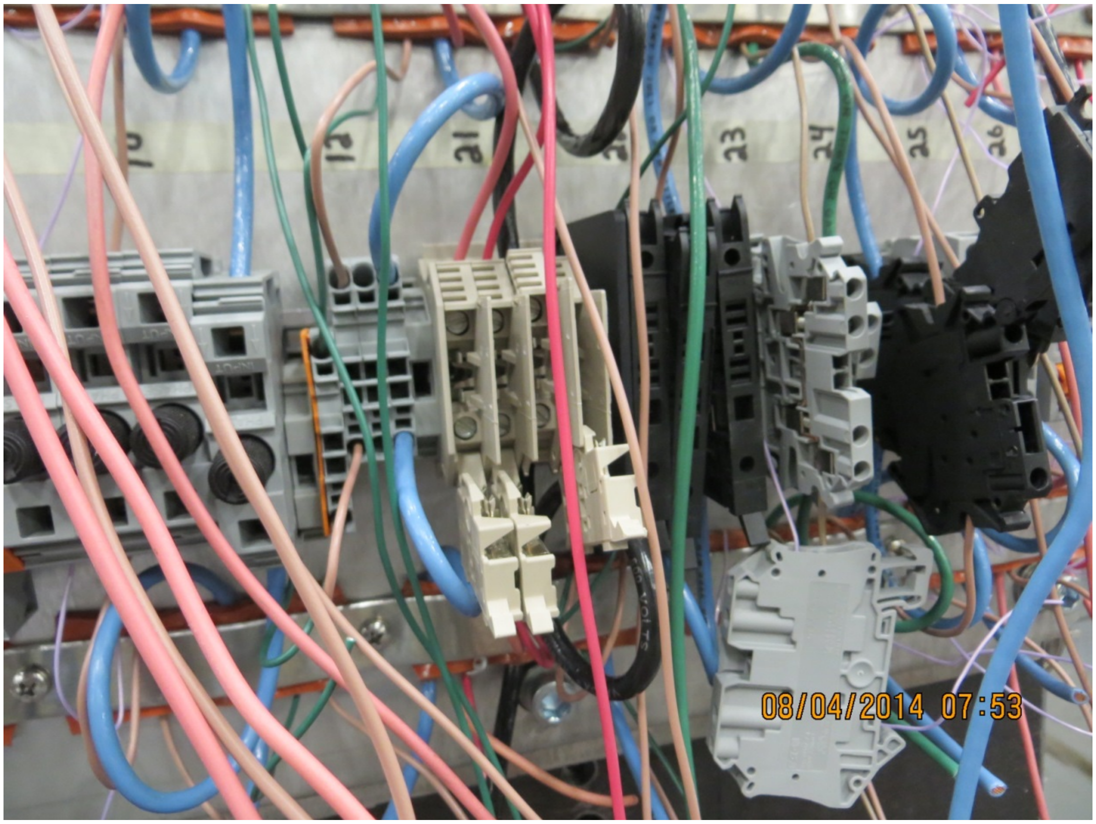


Photo 36 – File No. JP14-0175
View showing connector #21 disconnected and #22 partially disconnected from DIN rails

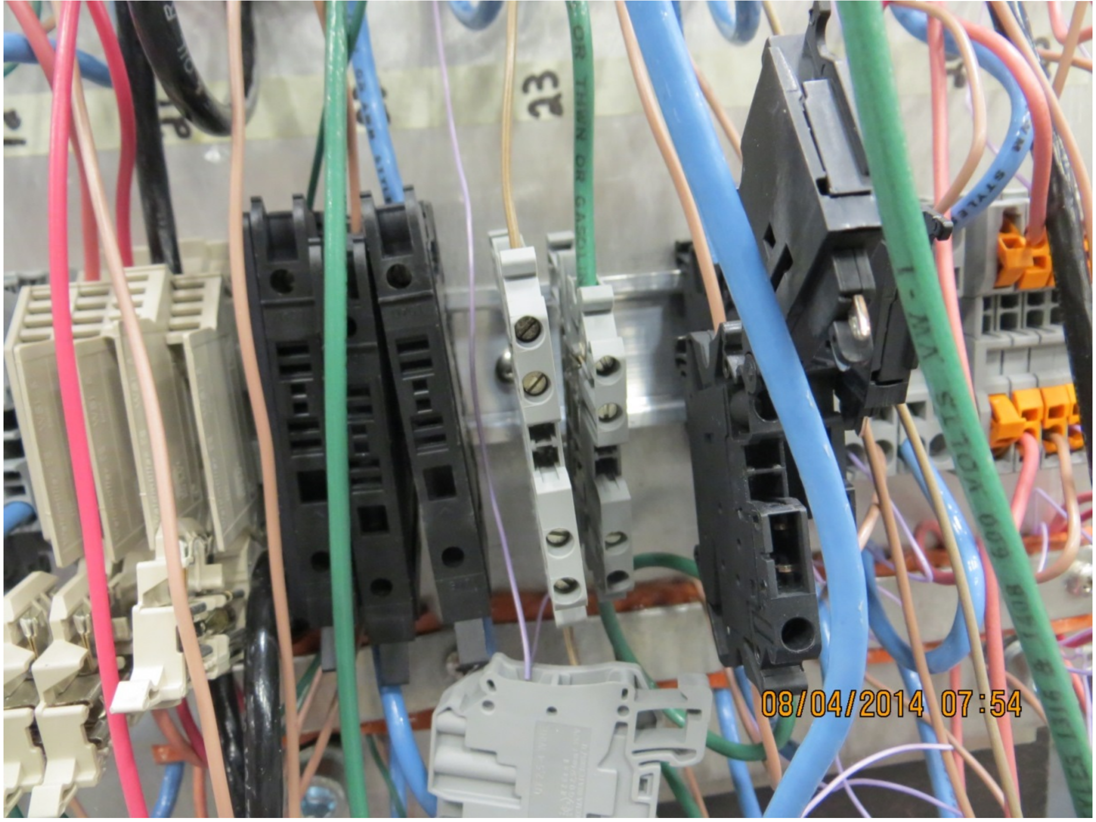


Photo 37 – File No. JP14-0176
View showing connector #23 disconnected from DIN rails after Shock Blow No. 3

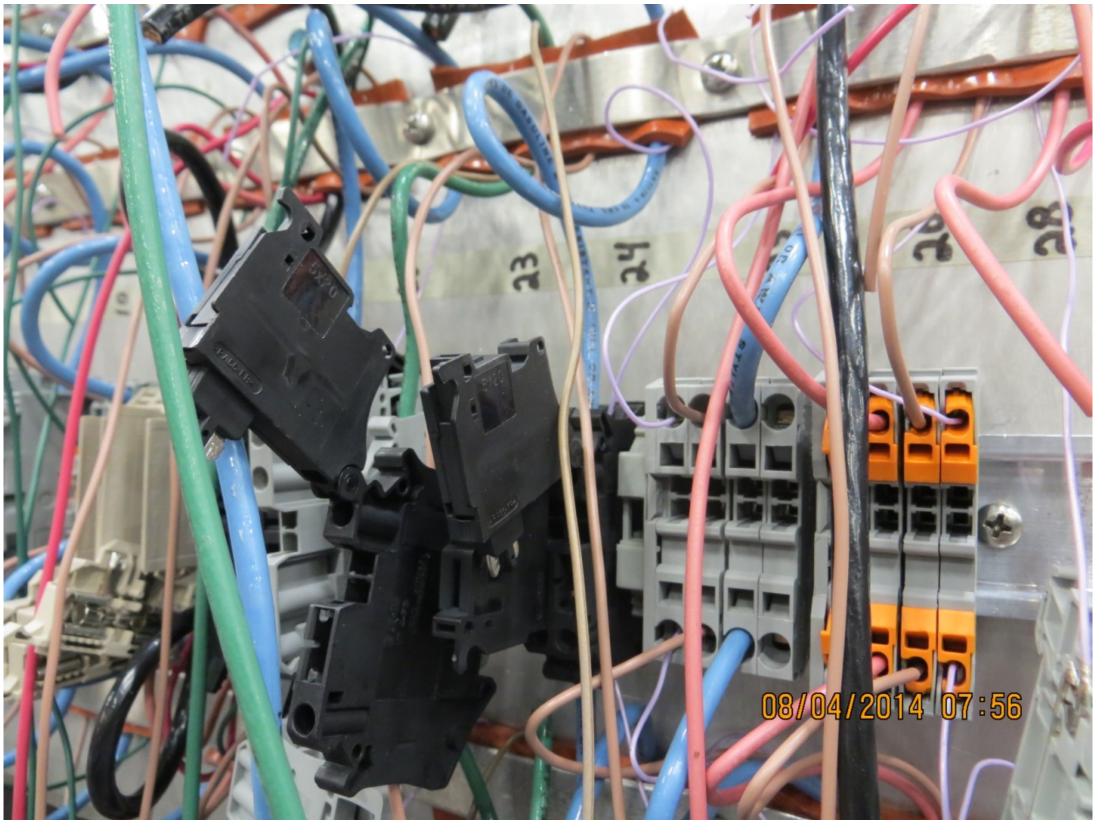


Photo 38 – File No. JP14-0177
View showing connector #24 disconnected from DIN rails after Shock Blow No. 3

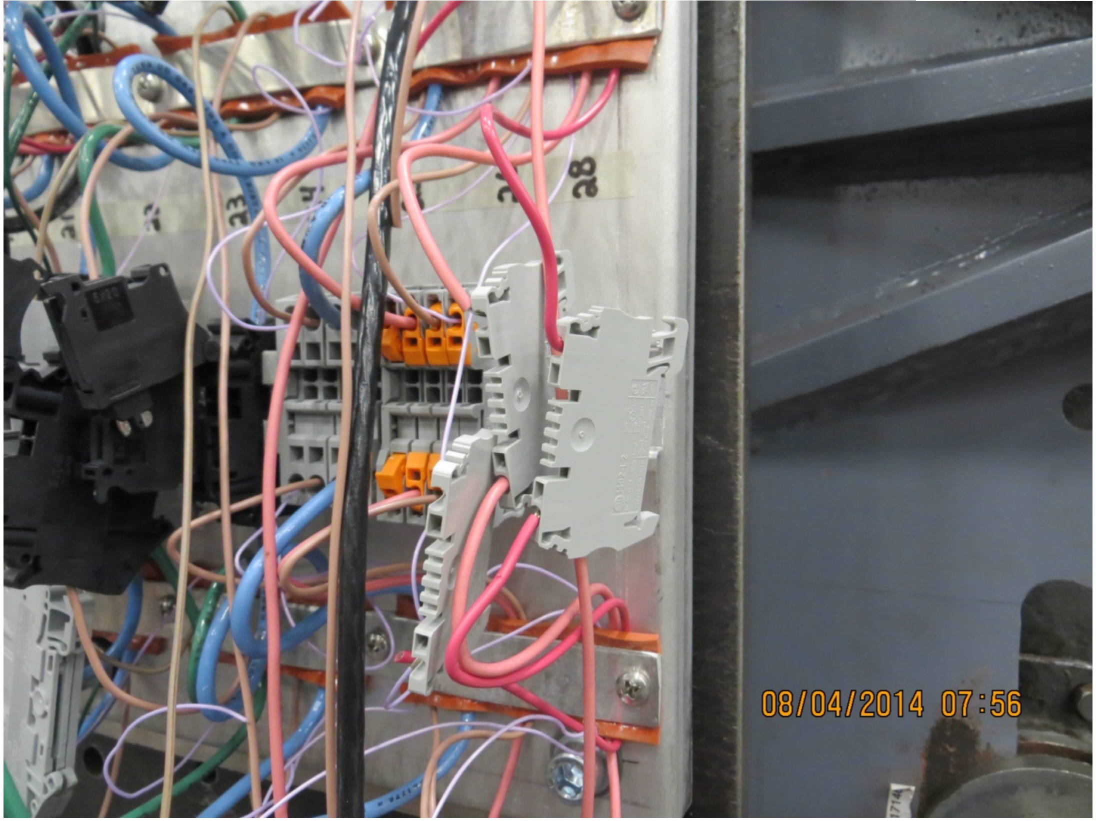


Photo 39 – File No. JP14-0178
View showing connector #28 disconnected from DIN rails after Shock Blow No. 3

Photo 40 – File No. JP14-0179
View showing dislodged connector pieces after Shock Blow No. 3

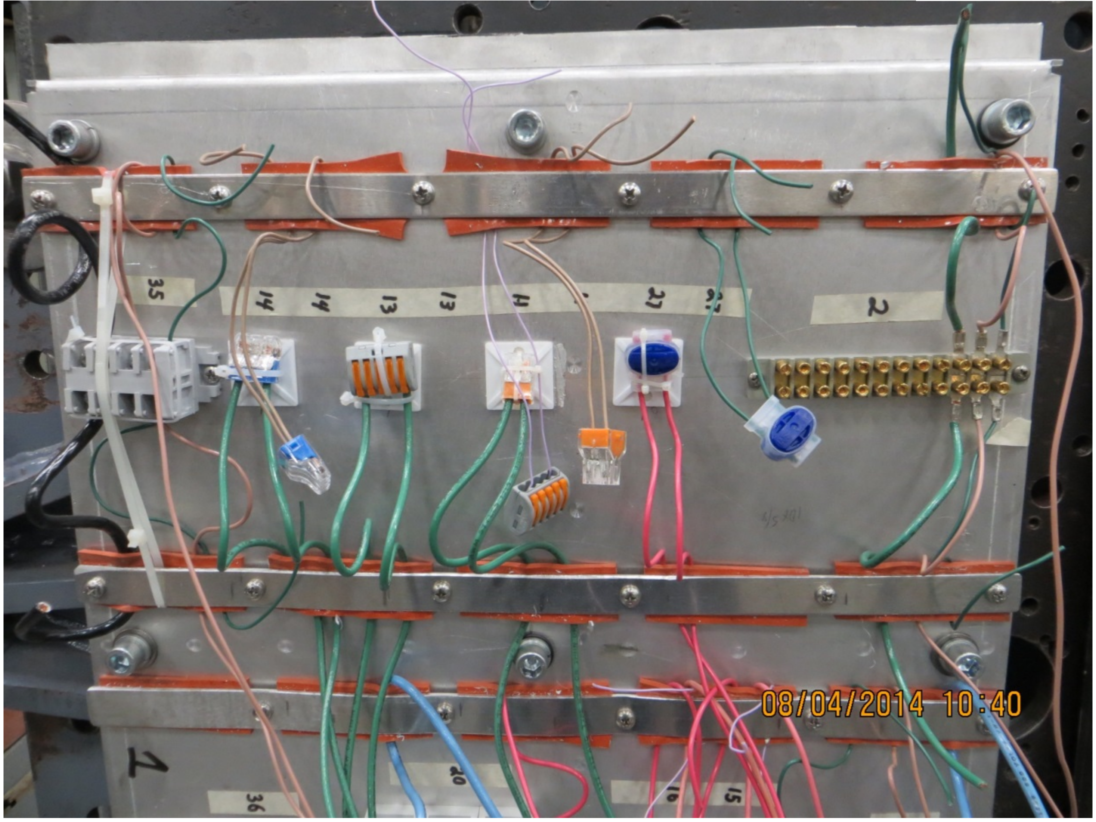


Photo 41 – File No. AG14-1055
View showing reassembled Low Voltage Quick Connector Panels

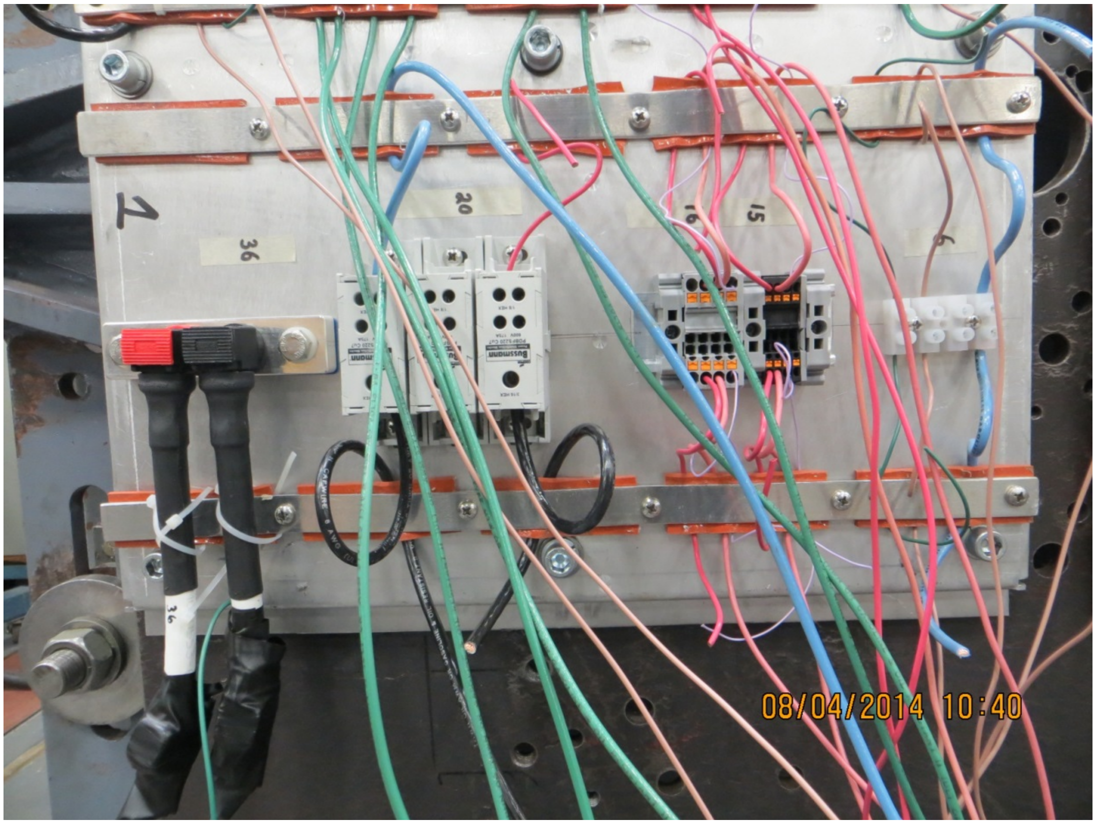


Photo 42 – File No. AG14-1056
View showing reassembled Low Voltage Quick Connector Panels

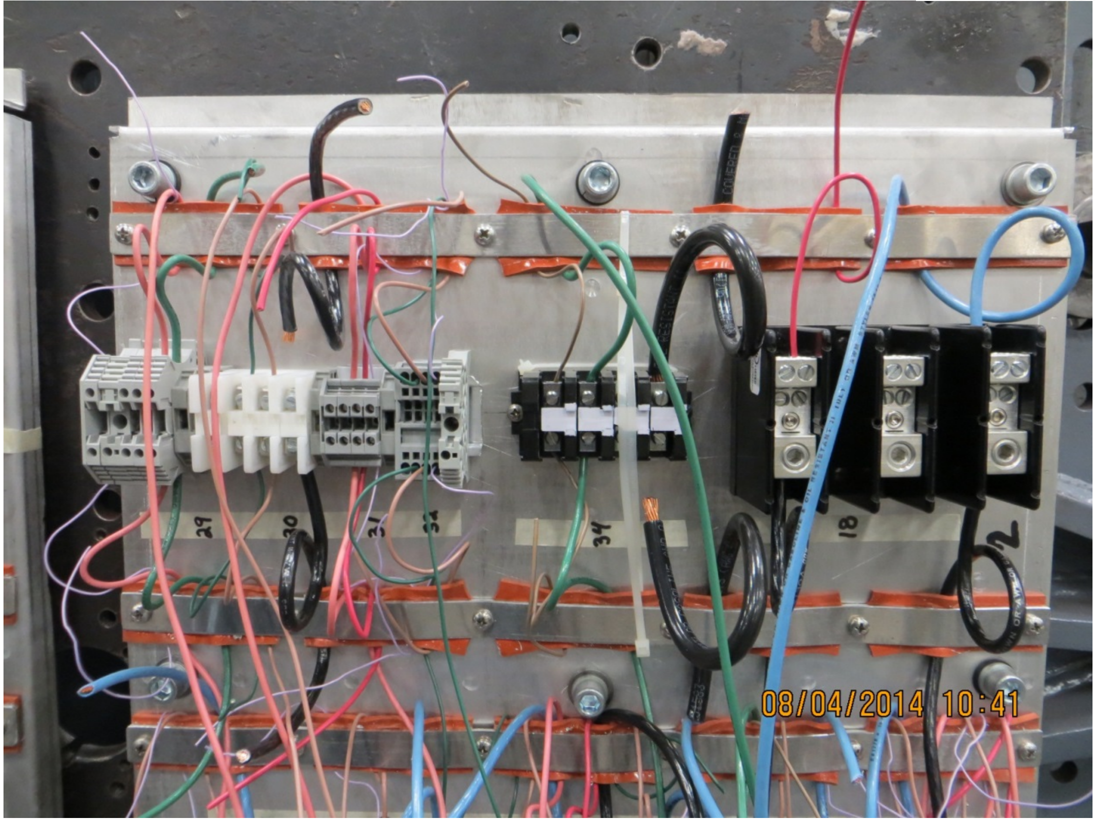


Photo 43 – File No. AG14-1057
View showing reassembled Low Voltage Quick Connector Panels

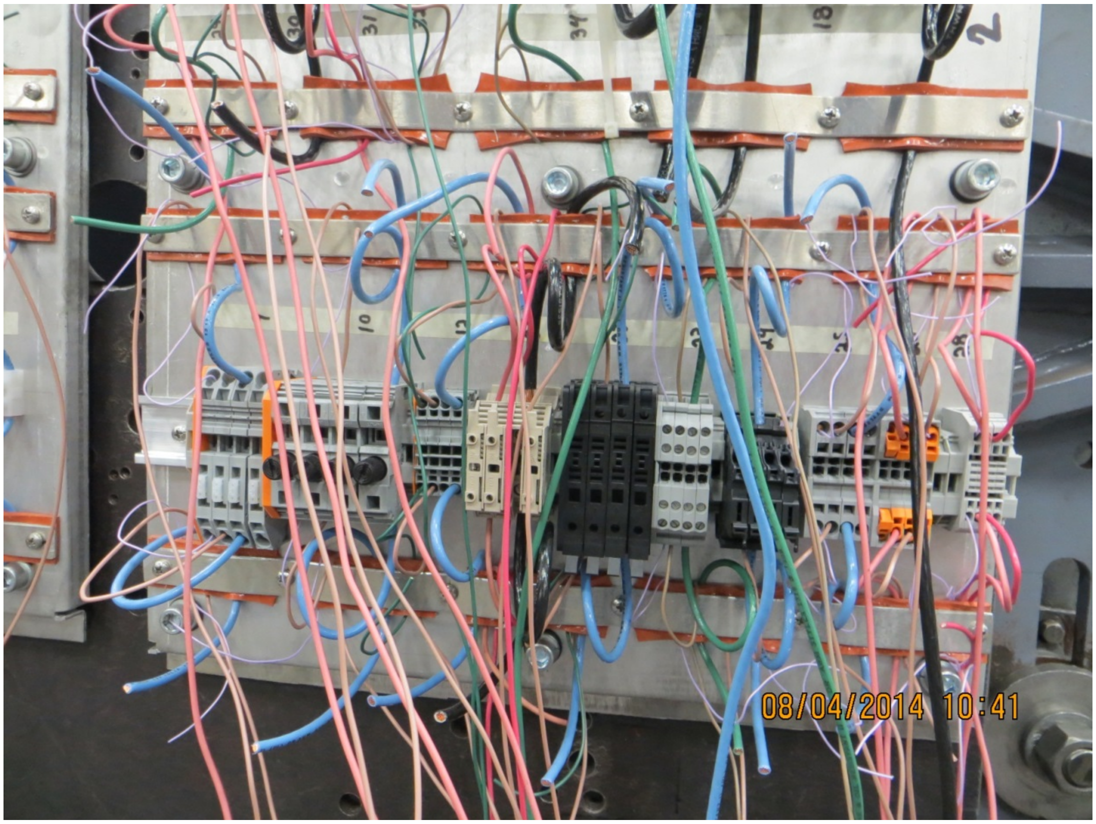


Photo 44 – File No. AG14-1058
View showing reassembled Low Voltage Quick Connector Panels

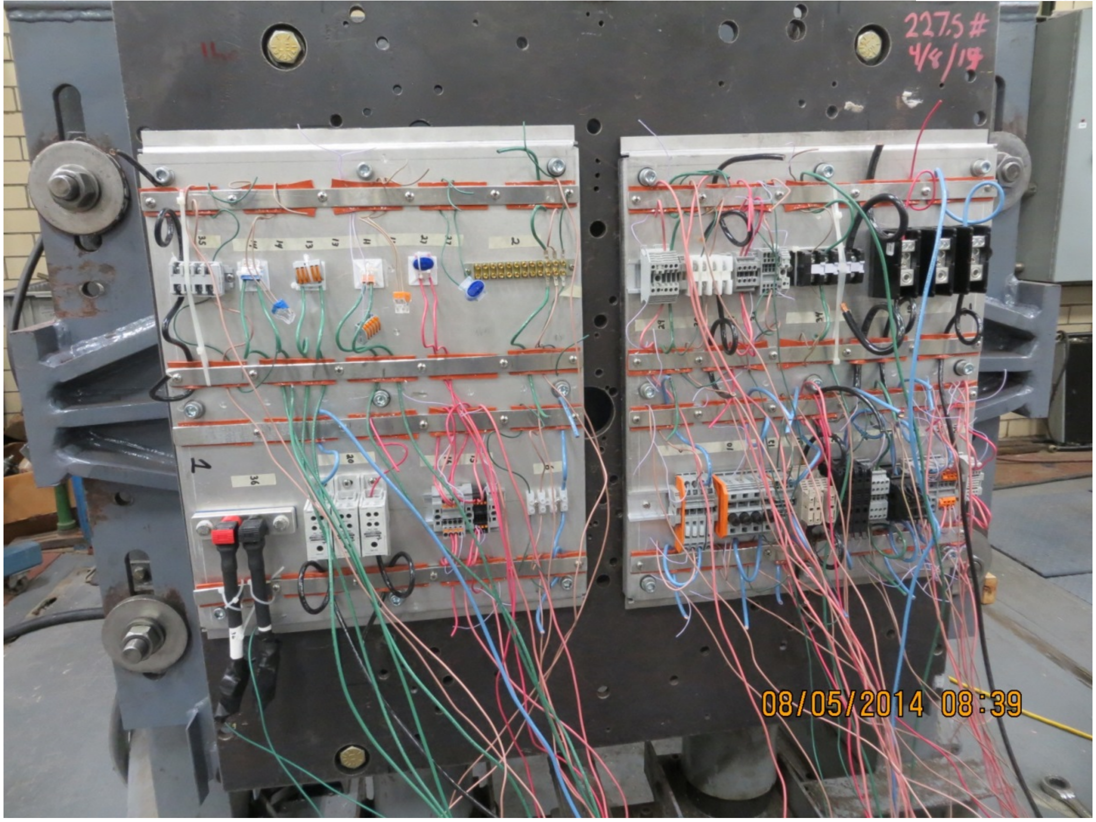


Photo 45 – File No. TE14-0578
View after testing in the top direction

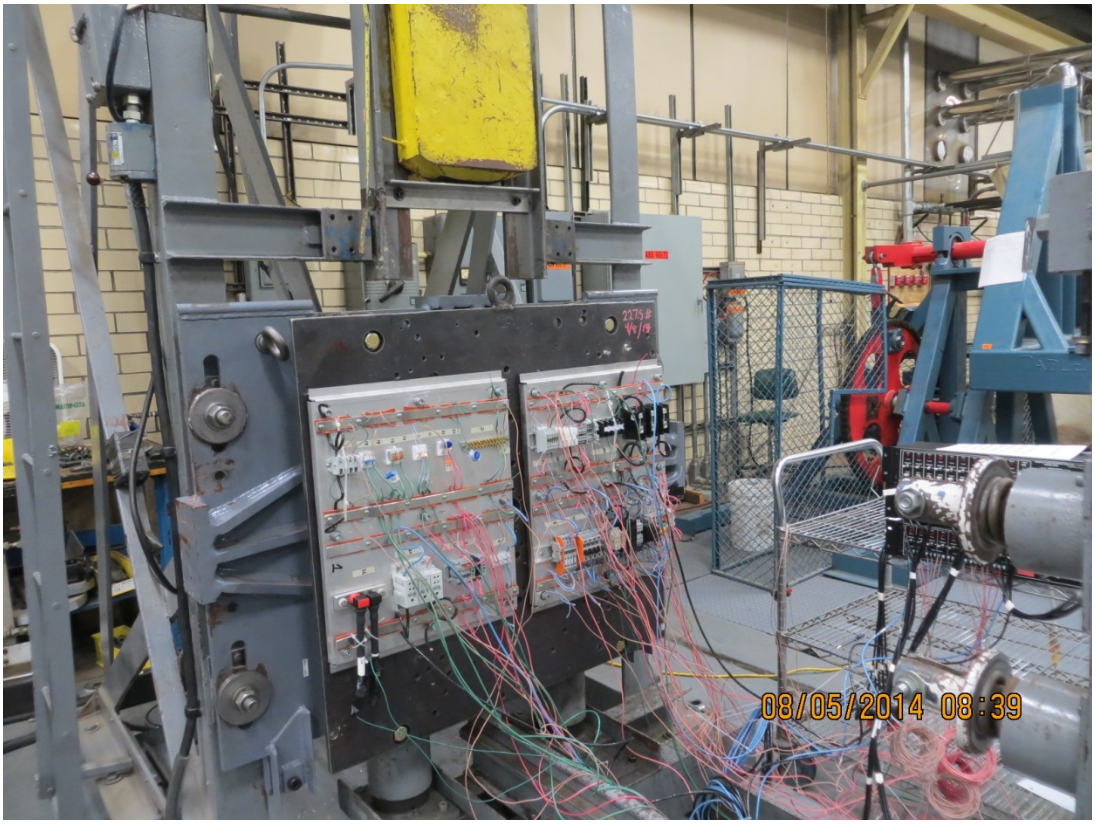


Photo 46 – File No. TE14-0579
View after testing in the top direction

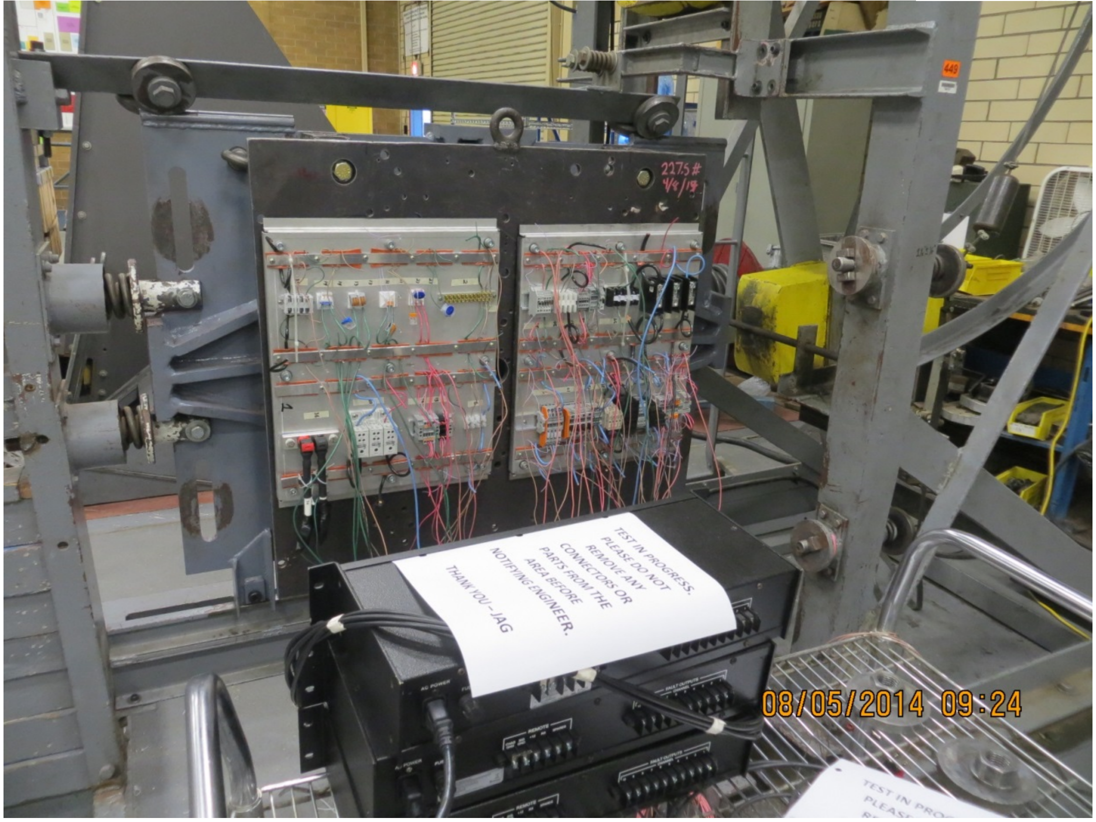


Photo 47 – File No. TE14-0580
Lightweight hammer shock test setup for testing in the side direction

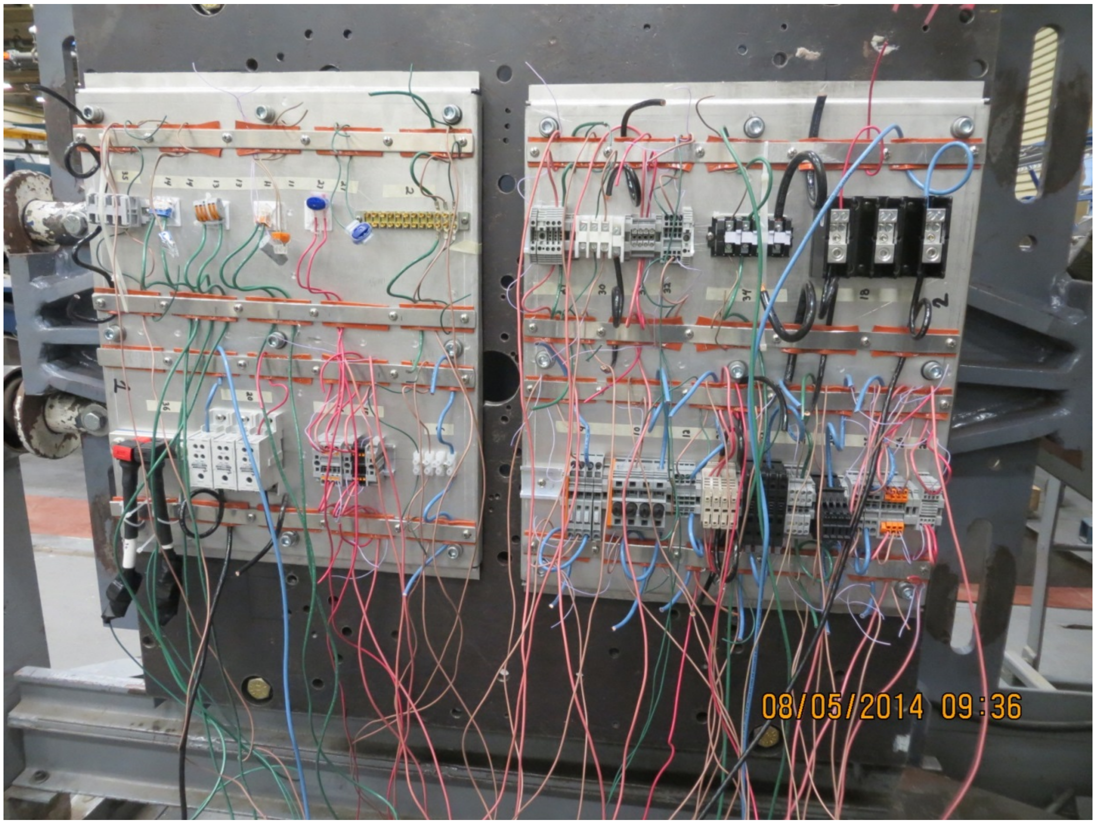


Photo 48 – File No. TE14-0581
View after testing in the side direction

Photo 49 – File No. TE14-0582
View showing connector #27 with broken zip tie

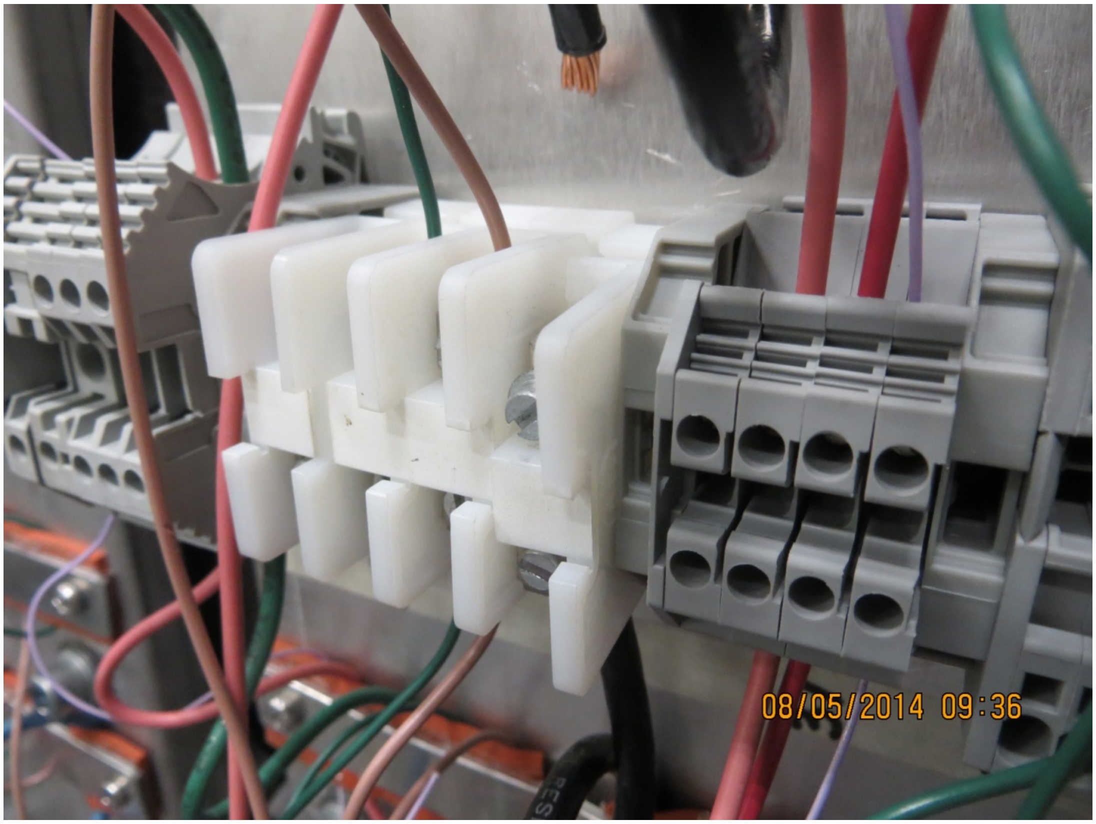


Photo 50 – File No. TE14-0583
View showing connector #30 partially disconnected from rail

Enclosure 2

Vibration Test and Results

TEST REQUIREMENT

The vibration test shall be conducted in accordance with references (c) and (d).

TEST RESULTS

A pretest visual inspection of the test items revealed that the zip ties holding #13, #14 and #27 in place were also replaced and the connectors were remounted.

All testing was performed in accordance with the referenced specification and as detailed in the Vibration Test Summary below and with the following exceptions:

- A fixture survey prior to the beginning of MIL-STD-167 vibration in the front/back axis was not performed as required by reference (d). Instead it was performed at the completion of that axis before the beginning testing in the up/down axis.

Note: The vibration plots in this enclosure inadvertently show DTB #1 as the test item but the actual items tested were the Low Voltage Quick Connectors, Serial Nos. DTB #1 through 35.

Refer to the Vibration Test Summary for tabulated results.

VIBRATION TEST SUMMARY

Sequence No.	Axis	Condition	Duration (min)	Page No. (Enc 2)
7 August 2014				
1	Front/Back	Exploratory Vibration, 4 – 33 Hz, 0.02 inch DA, 15 seconds at each discrete frequency	7 min 30 sec	3 – 11
2	Front/Back	Variable Vibration, 4 – 33 Hz, 5 minutes at each discrete frequency	2 hr 30 min	12 – 20
3	Front/Back	Endurance Dwell, 33 Hz, 0.02 inch DA	2 hr	21 – 29
8 August 2014				
4	Front/Back	Fixture Survey, 4 – 33 Hz, 0.25g, 1.0 oct/min	3 min 2 sec	30 – 38
5	Up/Down	Fixture Survey, 4 – 33 Hz, 0.25g, 1.0 oct/min	3 min 2 sec	39 – 47
6	Up/Down	Exploratory Vibration, 4 – 33 Hz, 0.02 inch DA, 15 seconds at each discrete frequency	7 min 30 sec	48 – 56
7	Up/Down	Variable Vibration, 4 – 33 Hz, 5 minutes at each discrete frequency	2 hr 30 min	57 – 65
8	Up/Down	Endurance Dwell, 33 Hz, 0.02 inch DA	2 hr	66 – 74
9	Side/Side	Fixture Survey, 4 – 33 Hz, 0.25g, 1.0 oct/min	3 min 2 sec	75 – 84
10	Side/Side	Exploratory Vibration, 4 – 33 Hz, 0.02 inch DA, 15 seconds at each discrete frequency	7 min 30 sec	85 – 93

Sequence No.	Axis	Condition	Duration (min)	Page No. (Enc 2)
9 August 2014				
11	Side/Side	Variable Vibration, 4 – 33 Hz, 5 minutes at each discrete frequency	2 hr 30 min	94 – 102
11 August 2014				
12	Side/Side	Endurance Dwell, 33 Hz, 0.02 inch DA	2 hr	103 – 111

Chatter was monitored throughout the vibration testing and no chatter was detected.

The test items completed all phases of testing.

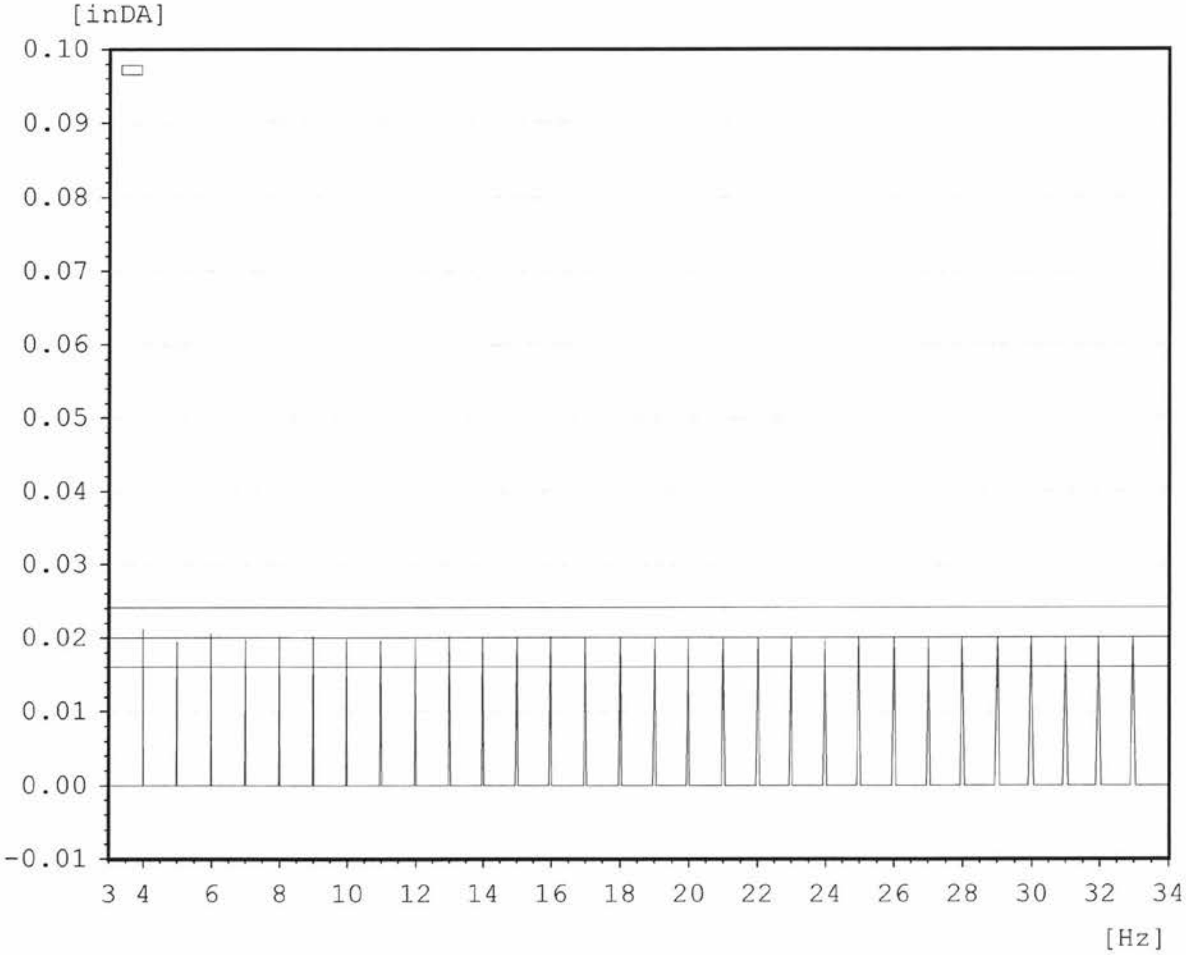
A post-test visual inspection of the test items revealed no anomalies due to testing.

Sine Dwell

Control channel (2xintegr)

Axis: Front/Back

Condition: Exploratory Frequency



Chan.type: X
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:07:30
remaining: 000:00:00

Date: 08-07-14
Time: 18:35:15
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech. : F. Baumbach

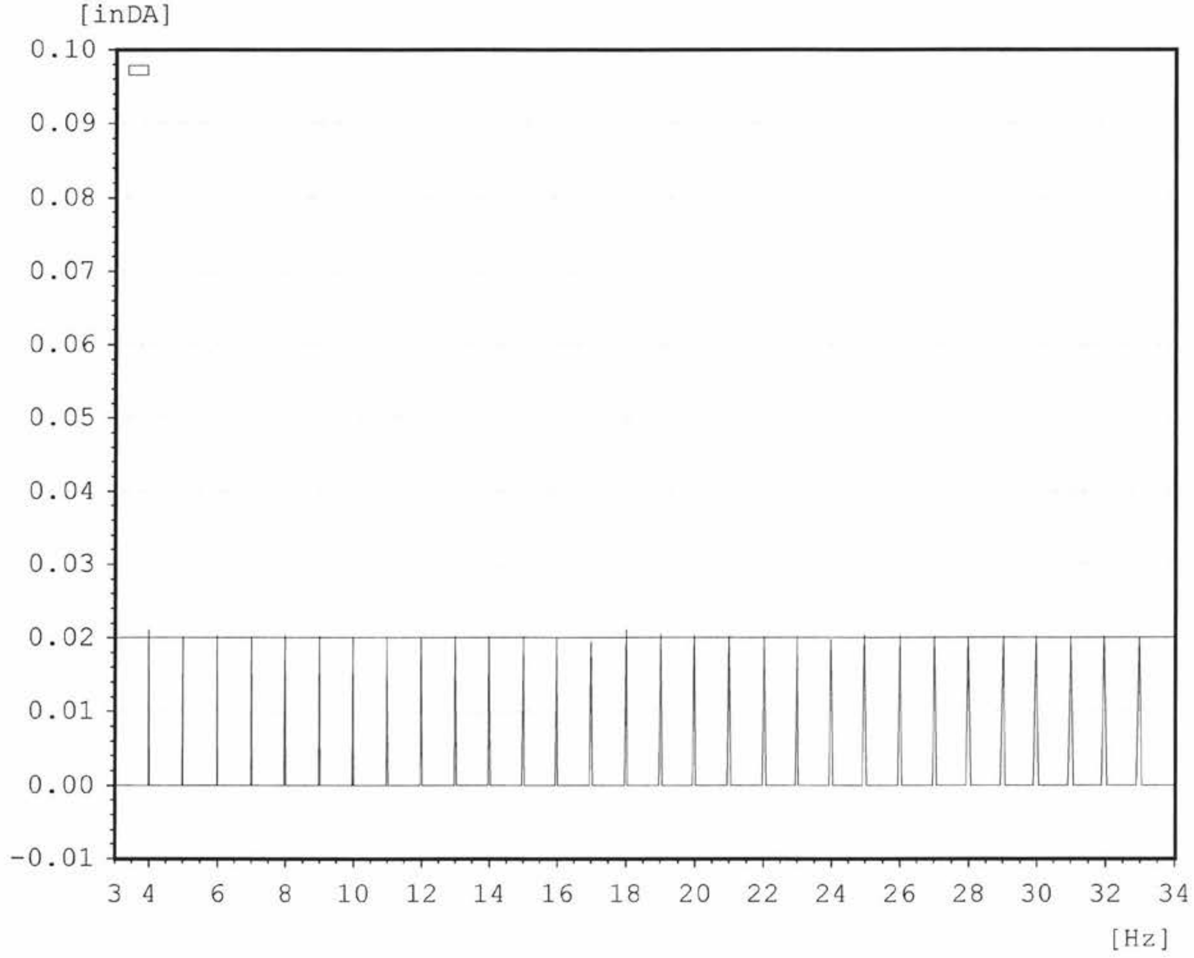
Eng.: J. Sookhdeo Plot: 1A

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_001.rsd

Sine Dwell

C1 Fixture top (2xintegr)

Axis: Front/Back
Condition: Exploratory Frequency



Chan.no: 1
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:07:30
remaining: 000:00:00

Date: 08-07-14
Time: 18:35:15
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

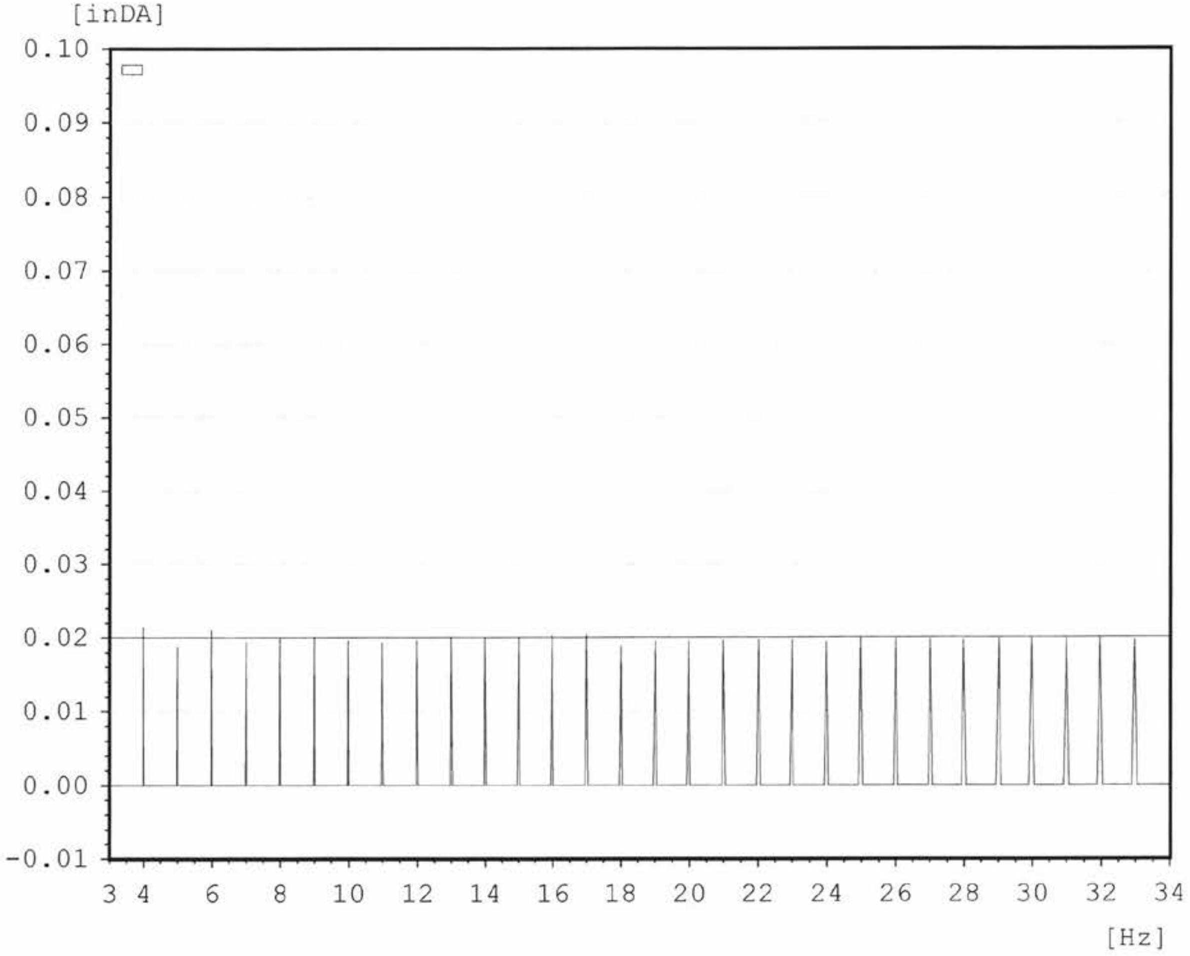
Tech. : F. Baumbach
Eng.: J. Sookhdeo Plot: 1A2

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_001.rsd

Sine Dwell

C2 Fixture Bottom (2xintegr)

Axis: Front/Back
Condition: Exploratory Frequency



Chan.no: 2
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:07:30
remaining: 000:00:00

Date: 08-07-14
Time: 18:35:15
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

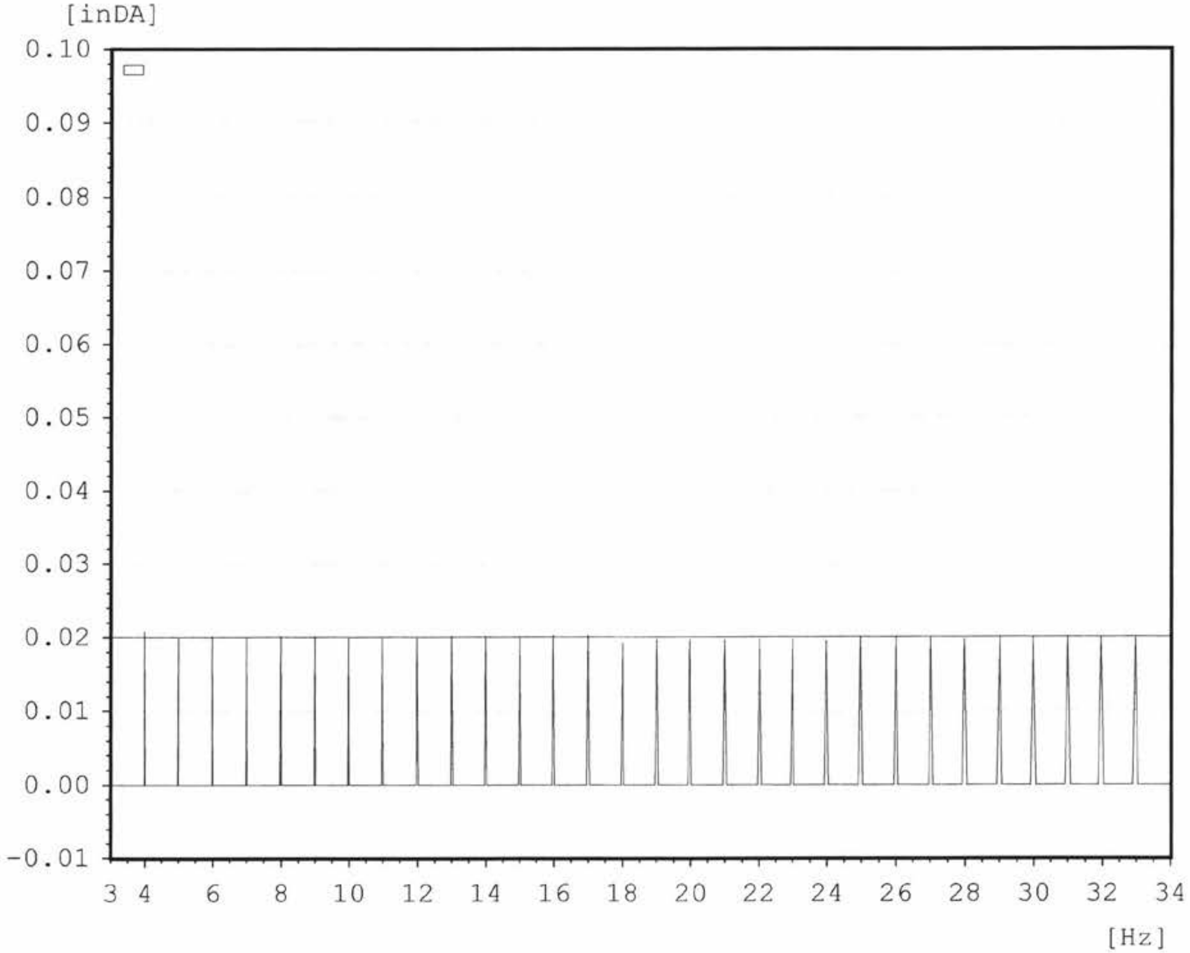
Tech. : F. Baumbach
Eng.: J. Sookhdeo Plot: 1A3

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_001.rsd

Sine Dwell

R1 Board 1 (2xintegr)

Axis: Front/Back
Condition: Exploratory Frequency



Chan.no: 3
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

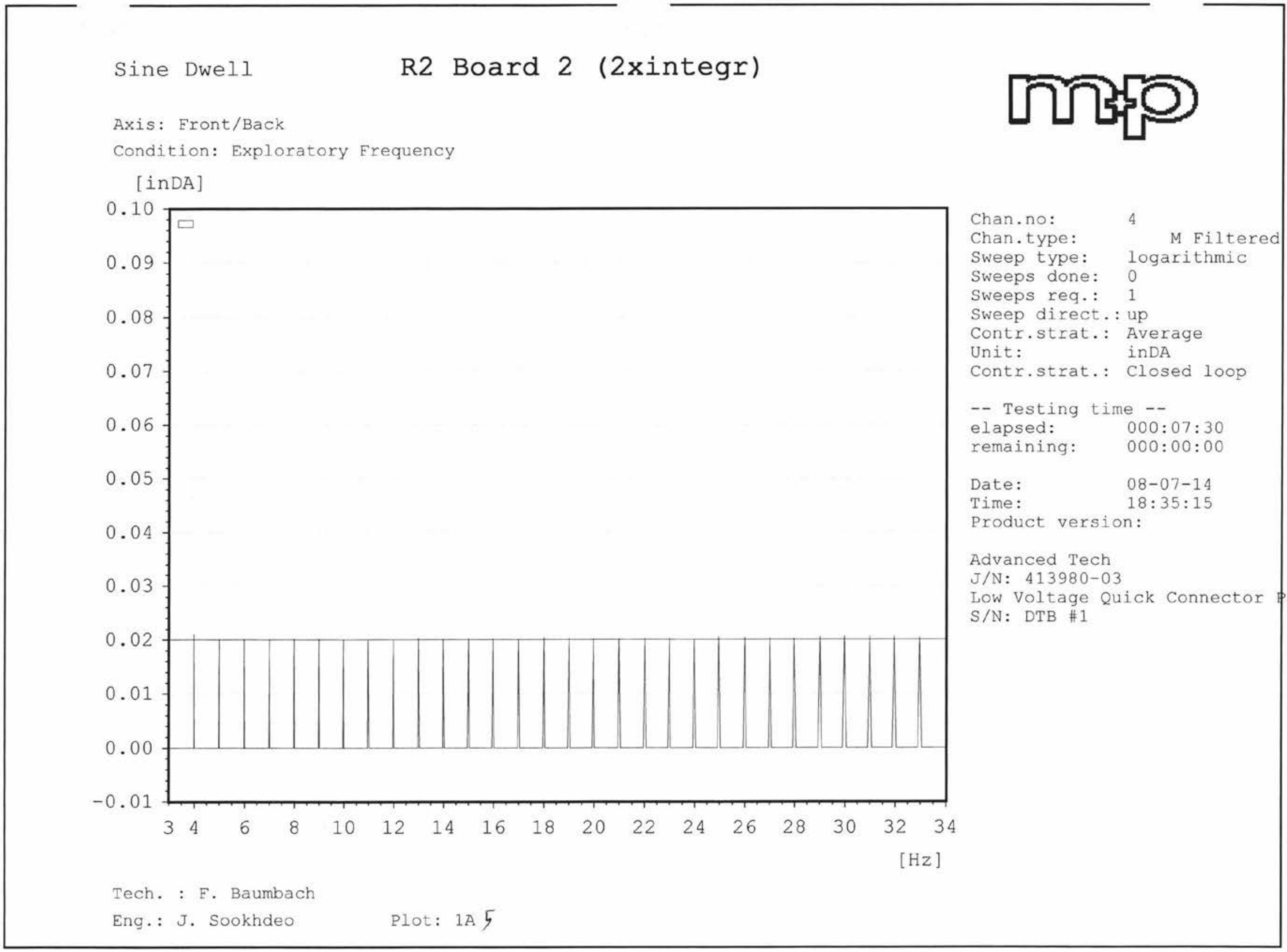
-- Testing time --
elapsed: 000:07:30
remaining: 000:00:00

Date: 08-07-14
Time: 18:35:15
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech. : F. Baumbach
Eng.: J. Sookhdeo
Plot: 1A4

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_001.rsd



Sine Dwell

R2 Board 2 (2xintegr)

Axis: Front/Back
Condition: Exploratory Frequency

```
Chan.no:         4
Chan.type:           M Filtered
Sweep type:      logarithmic
Sweeps done:     0
Sweeps req.:     1
Sweep direct.:   up
Contr.strat.:    Average
Unit:            inDA
Contr.strat.:    Closed loop

-- Testing time --
elapsed:         000:07:30
remaining:       000:00:00

Date:            08-07-14
Time:            18:35:15
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1
```

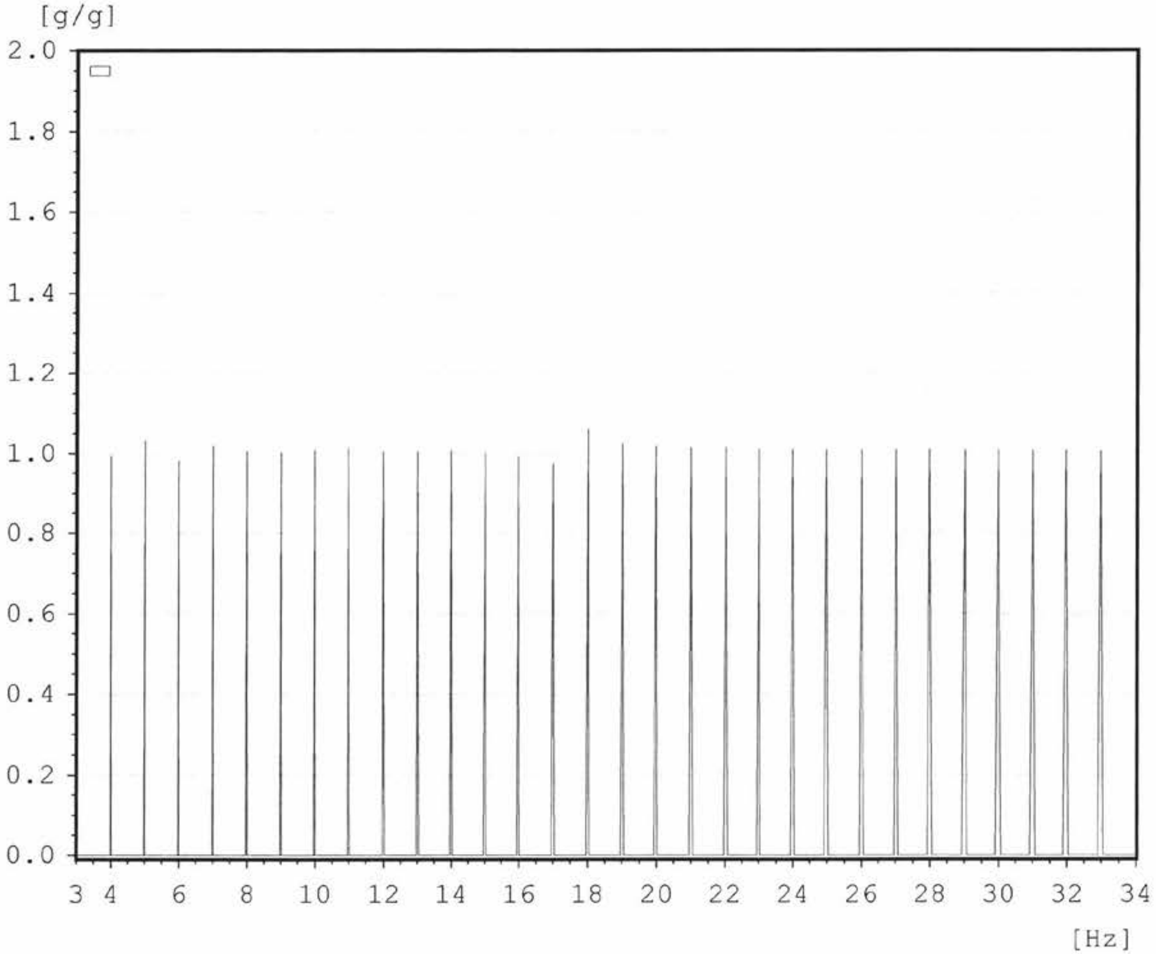
Tech. : F. Baumbach
Eng.: J. Sookhdeo   Plot: 1A 5

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_001.rsd

Sine Dwell **C1 Fixture top vs. Control channel**

Axis: Front/Back

Condition: Exploratory Frequency



Ref.Chan.type: X
Chan.no: 1
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:07:30
remaining: 000:00:00

Date: 08-07-14
Time: 18:35:15
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech. : F. Baumbach

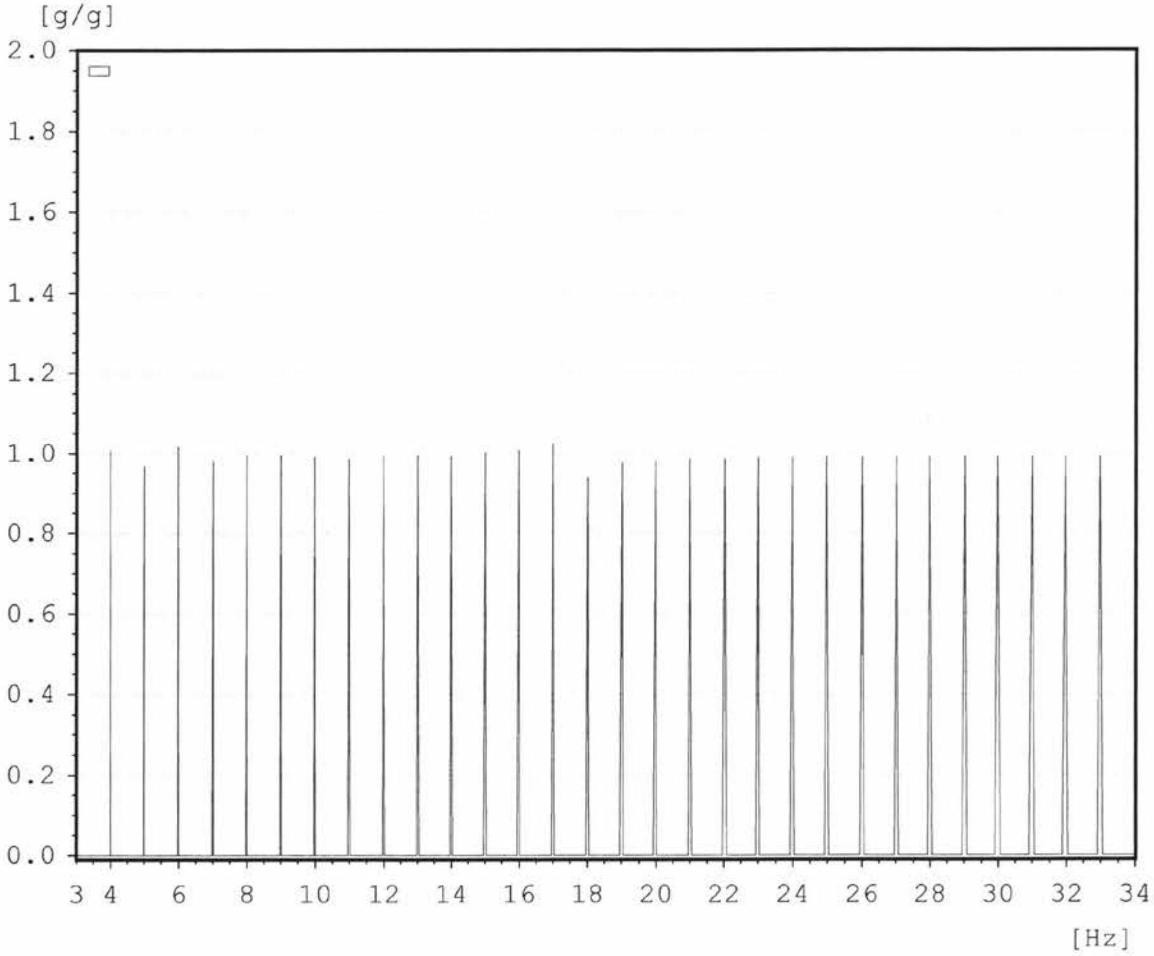
Eng.: J. Sookhdeo Plot: 1A6

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_001.rsd

Sine Dwell **C2 Fixture Bottom vs. Control channel**

Axis: Front/Back

Condition: Exploratory Frequency



Ref.Chan.type: X
Chan.no: 2
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:07:30
remaining: 000:00:00

Date: 08-07-14
Time: 18:35:15
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech. : F. Baumbach
Eng.: J. Sookhdeo   Plot: 1A 7

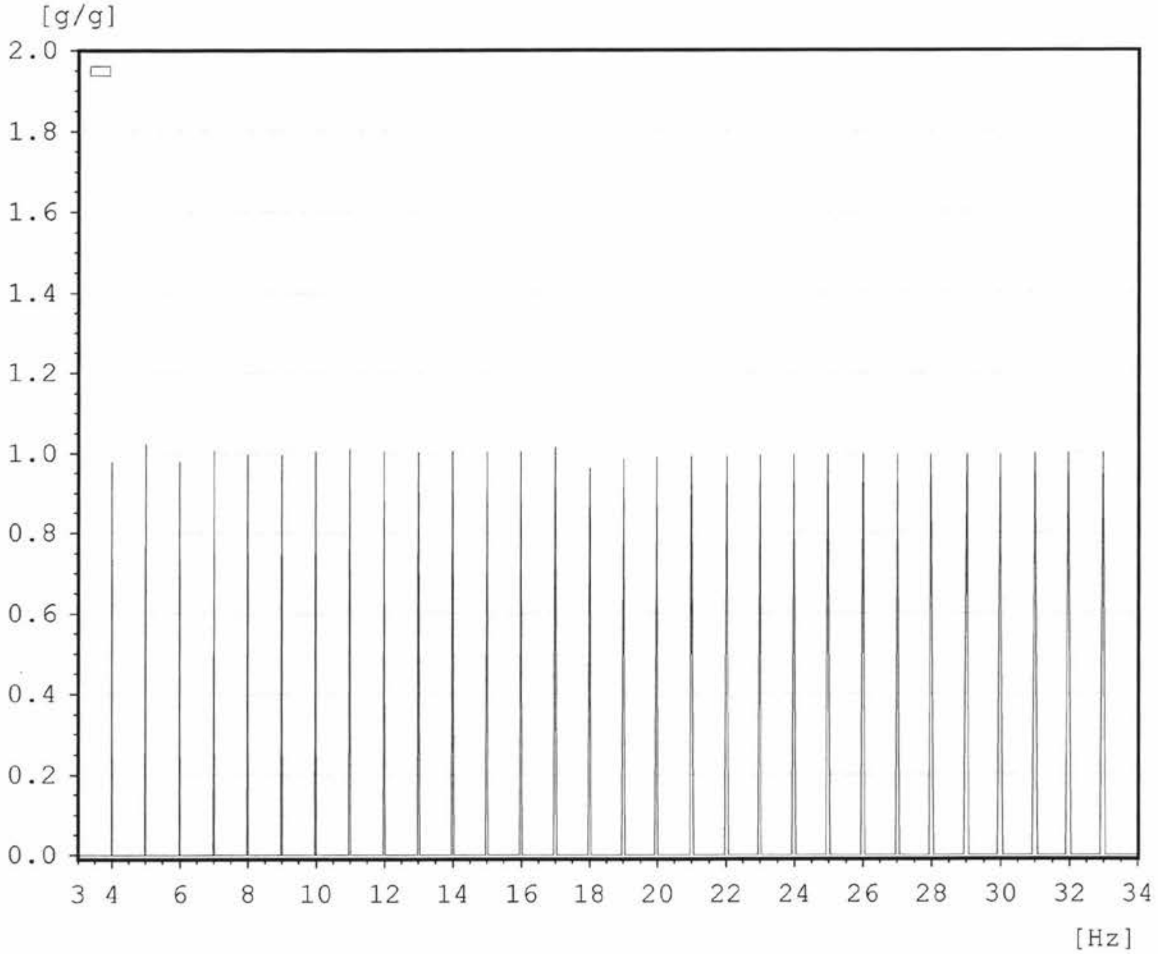
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_001.rsd

Sine Dwell

R1 Board 1 vs. Control channel

Axis: Front/Back

Condition: Exploratory Frequency



Ref.Chan.type: X
Chan.no: 3
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:07:30
remaining: 000:00:00

Date: 08-07-14
Time: 18:35:15
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech. : F. Baumbach
Eng.: J. Sookhdeo Plot: 1A8

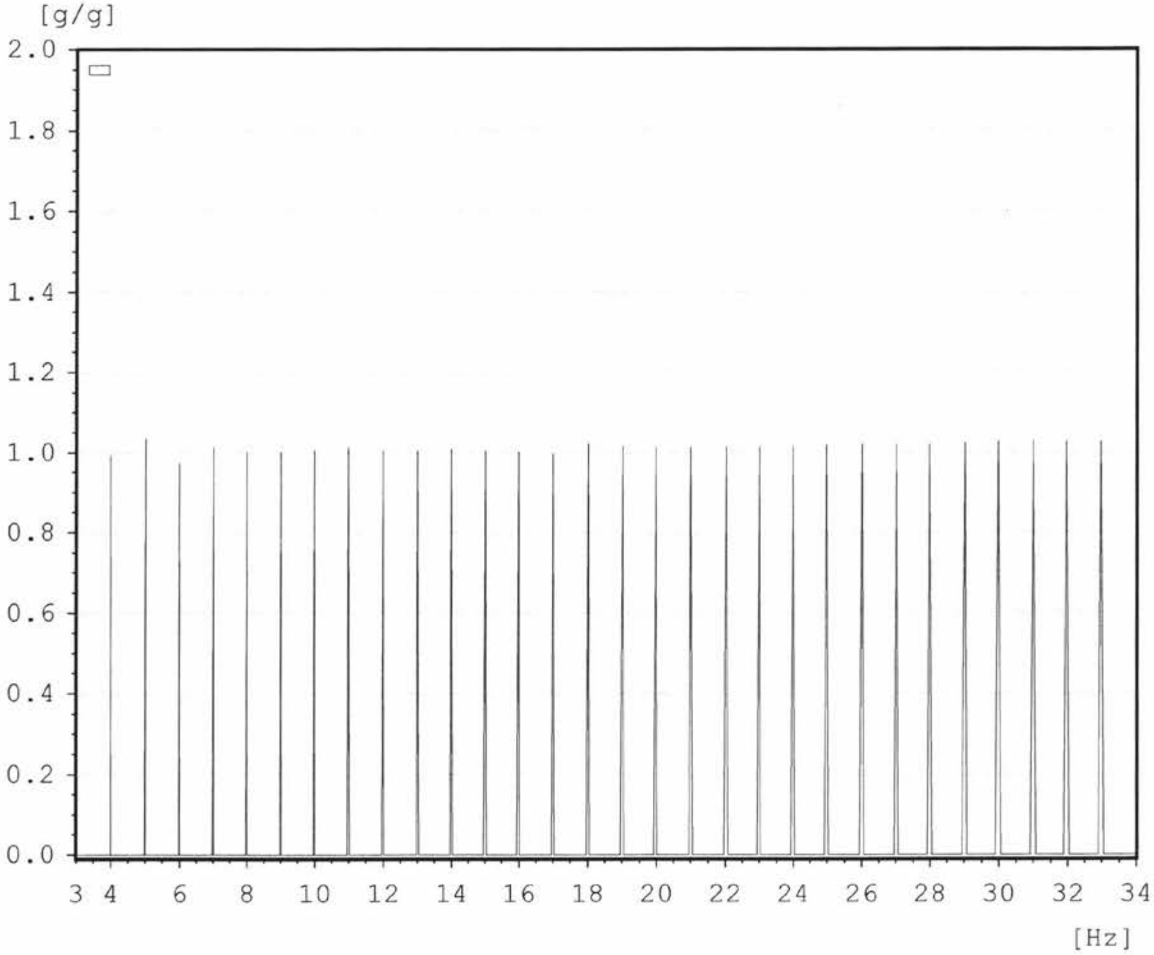
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_001.rsd

Sine Dwell

R2 Board 2 vs. Control channel

Axis: Front/Back

Condition: Exploratory Frequency



Ref.Chan.type: X
Chan.no: 4
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:07:30
remaining: 000:00:00

Date: 08-07-14
Time: 18:35:15
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech. : F. Baumbach
Eng.: J. Sookhdeo Plot: 1A 9

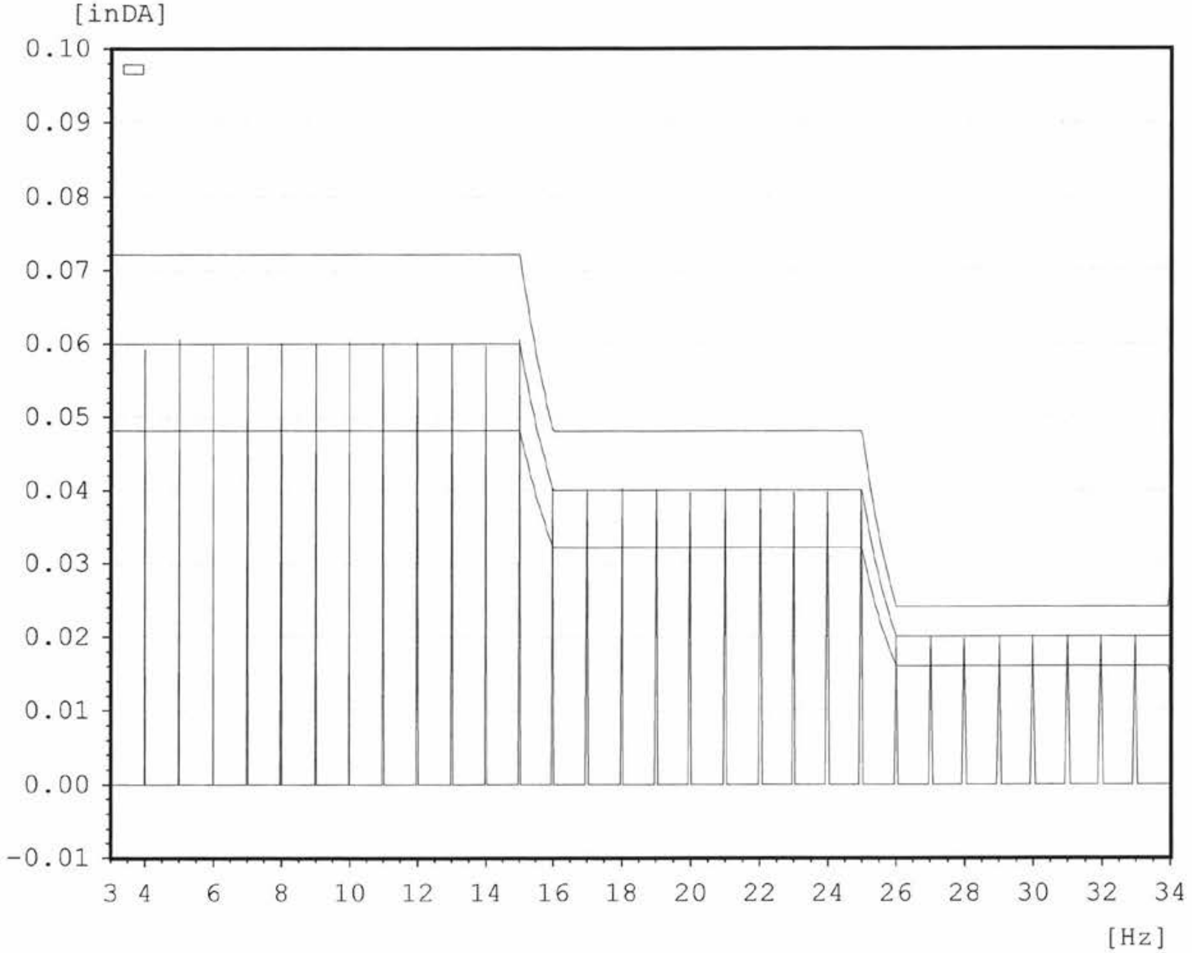
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_001.rsd

Sine Dwell

Control channel (2xintegr)

Axis: F. Baumbach

Condition: Variable Frequency



```
Chan.type:      X
Sweep type:     logarithmic
Sweeps done:    0
Sweeps req.:    1
Sweep direct.: up
Contr.strat.:  Average
Unit:           inDA
Contr.strat.:  Closed loop

-- Testing time --
elapsed:        002:30:00
remaining:      000:00:00

Date:           08-07-14
Time:           21:20:28
Product version:

 Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1
```

Tech.: F. Baumbach

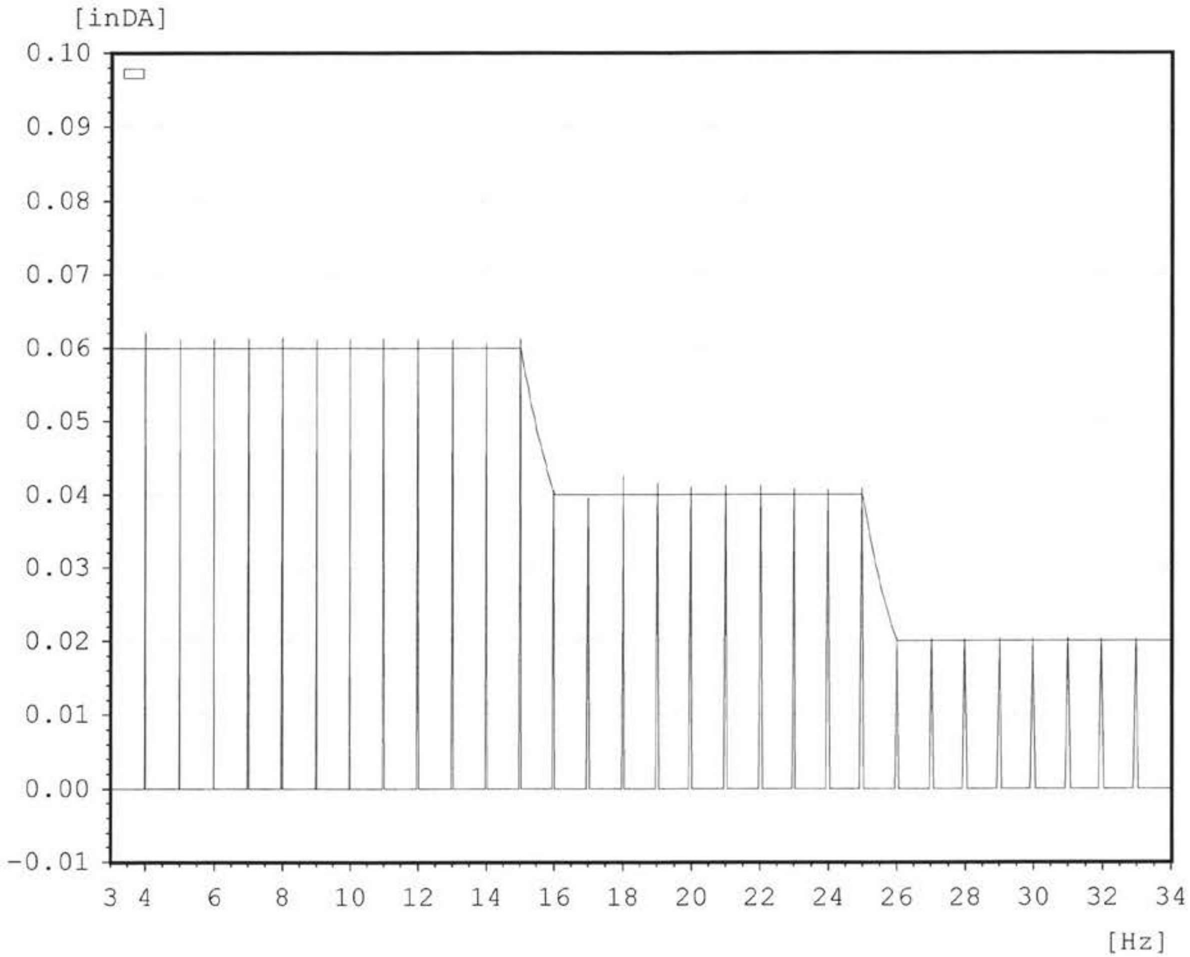
Engineer: J. Sookhdeo   Plot: 2A

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_002.rsd

Sine Dwell

C1_Fixture Top (2xintegr)

Axis: F. Baumbach
Condition: Variable Frequency



Chan.no: 1
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:30:00
remaining: 000:00:00

Date: 08-07-14
Time: 21:20:28
Product version:

Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

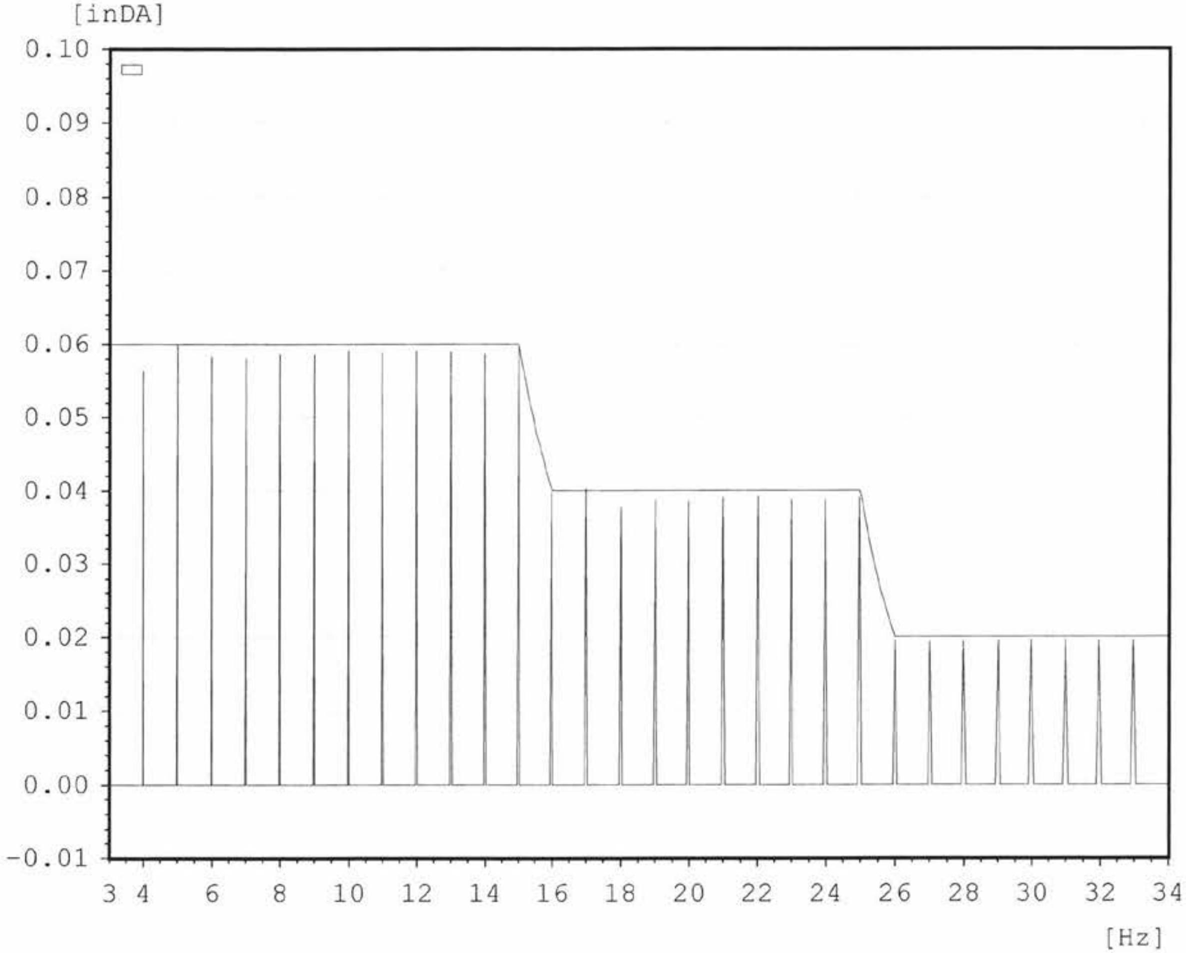
Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 2A2

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_002.rsd

Sine Dwell

C2 Fixture Bottom (2xintegr)

Axis: F. Baumbach
Condition: Variable Frequency



Chan.no: 2
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:30:00
remaining: 000:00:00

Date: 08-07-14
Time: 21:20:28
Product version:

Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

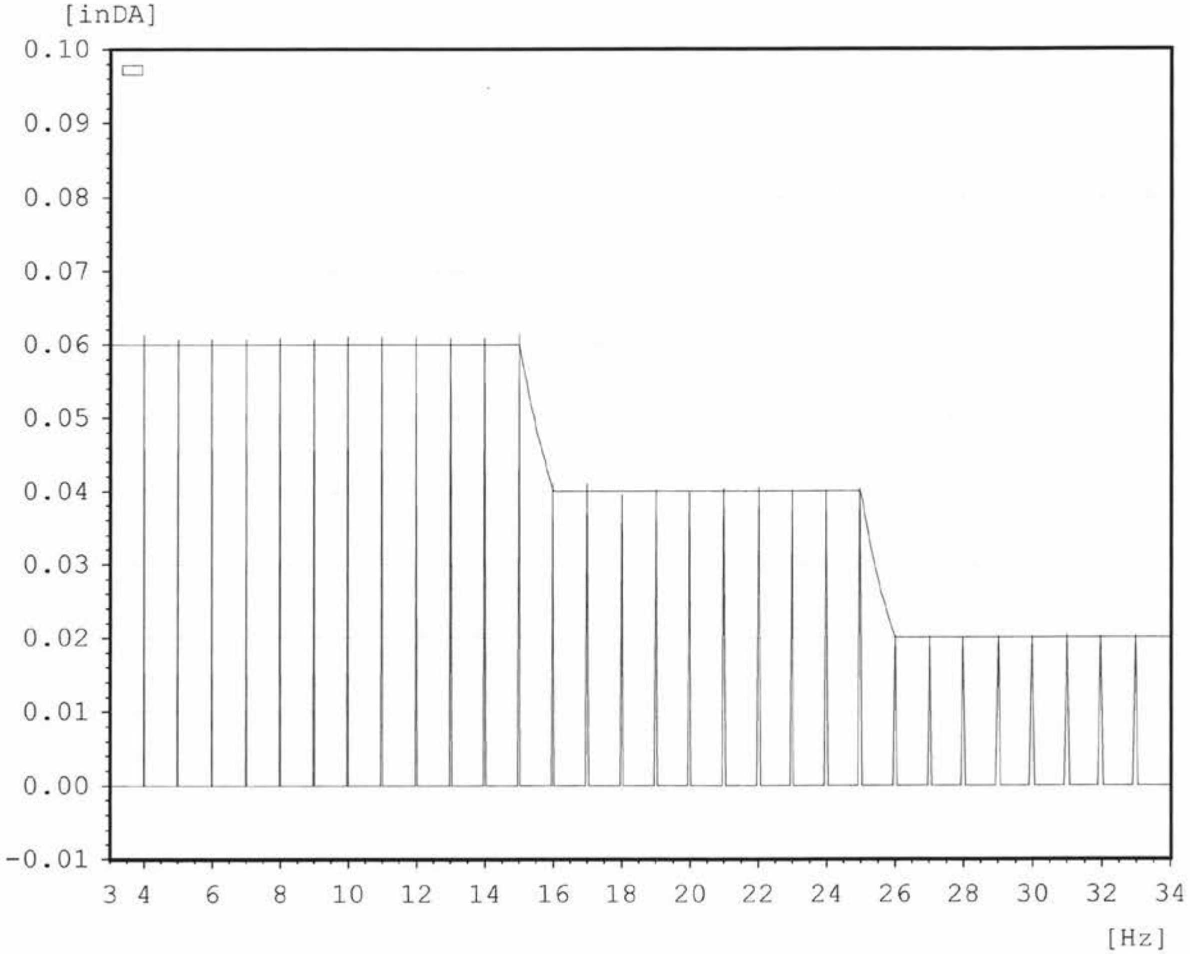
Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 2A3

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_002.rsd

Sine Dwell

R1 Board 1 (2xintegr)

Axis: F. Baumbach
Condition: Variable Frequency



Chan.no: 3
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:30:00
remaining: 000:00:00

Date: 08-07-14
Time: 21:20:28
Product version:

Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

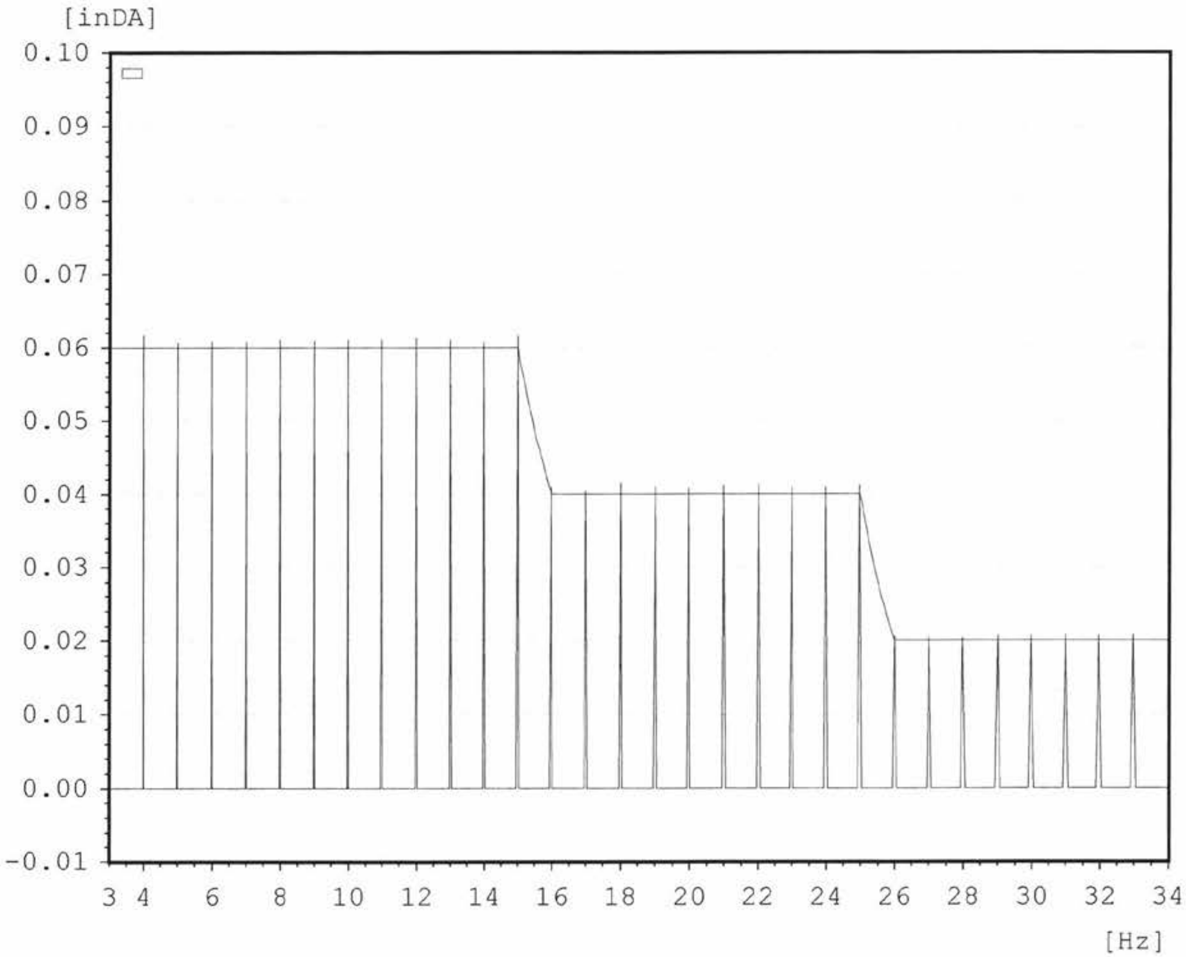
Tech.: F. Baumbach
Engineer: J. Sookhdeo
Plot: 2A4

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_002.rsd

Sine Dwell

R2 Board 2 (2xintegr)

Axis: F. Baumbach
Condition: Variable Frequency



Chan.no: 4
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:30:00
remaining: 000:00:00

Date: 08-07-14
Time: 21:20:28
Product version:

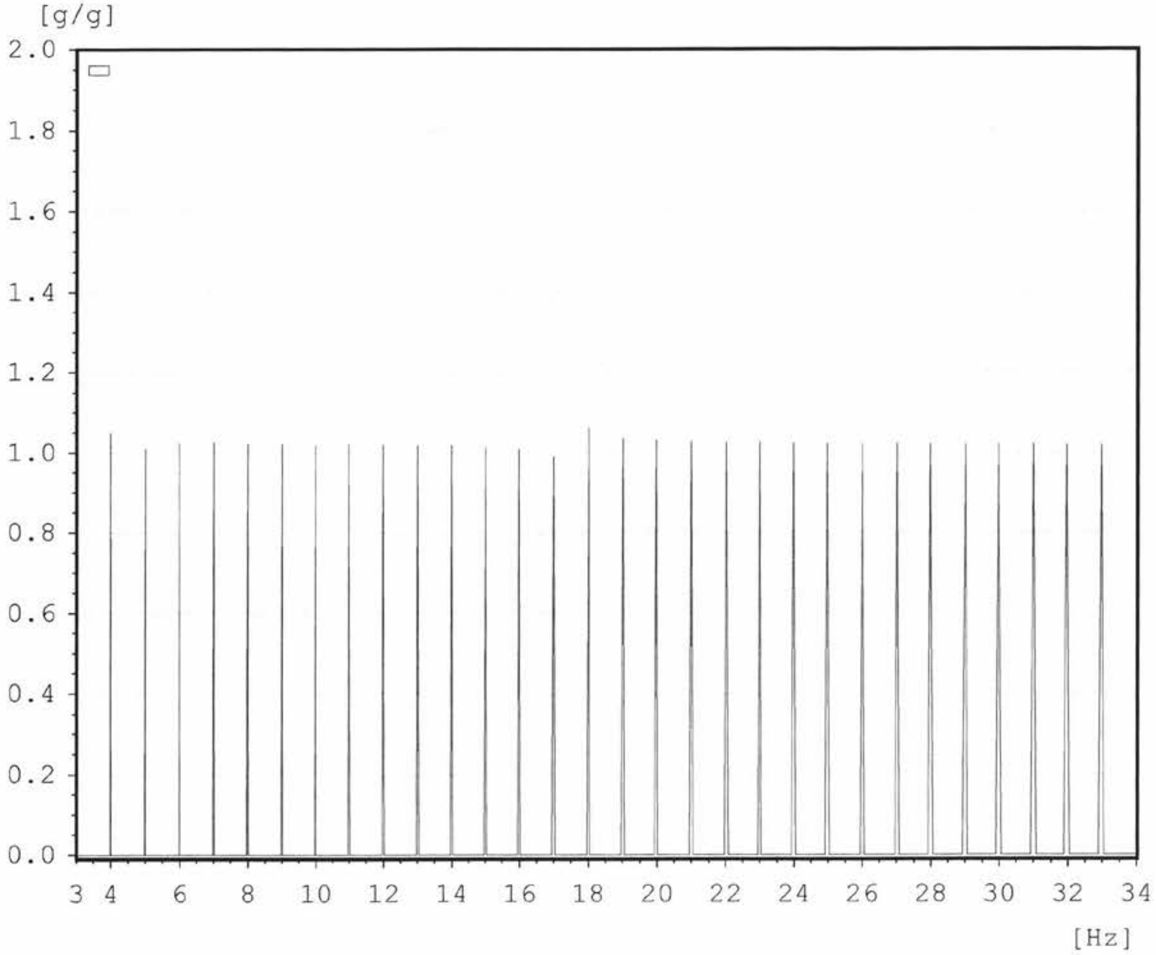
Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach
Engineer: J. Sookhdeo
Plot: 2A

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_002.rsd

Sine Dwell C1_Fixture Top vs. Control channel

Axis: F. Baumbach
Condition: Variable Frequency



Ref.Chan.type: X
Chan.no: 1
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:30:00
remaining: 000:00:00

Date: 08-07-14
Time: 21:20:28
Product version:

Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

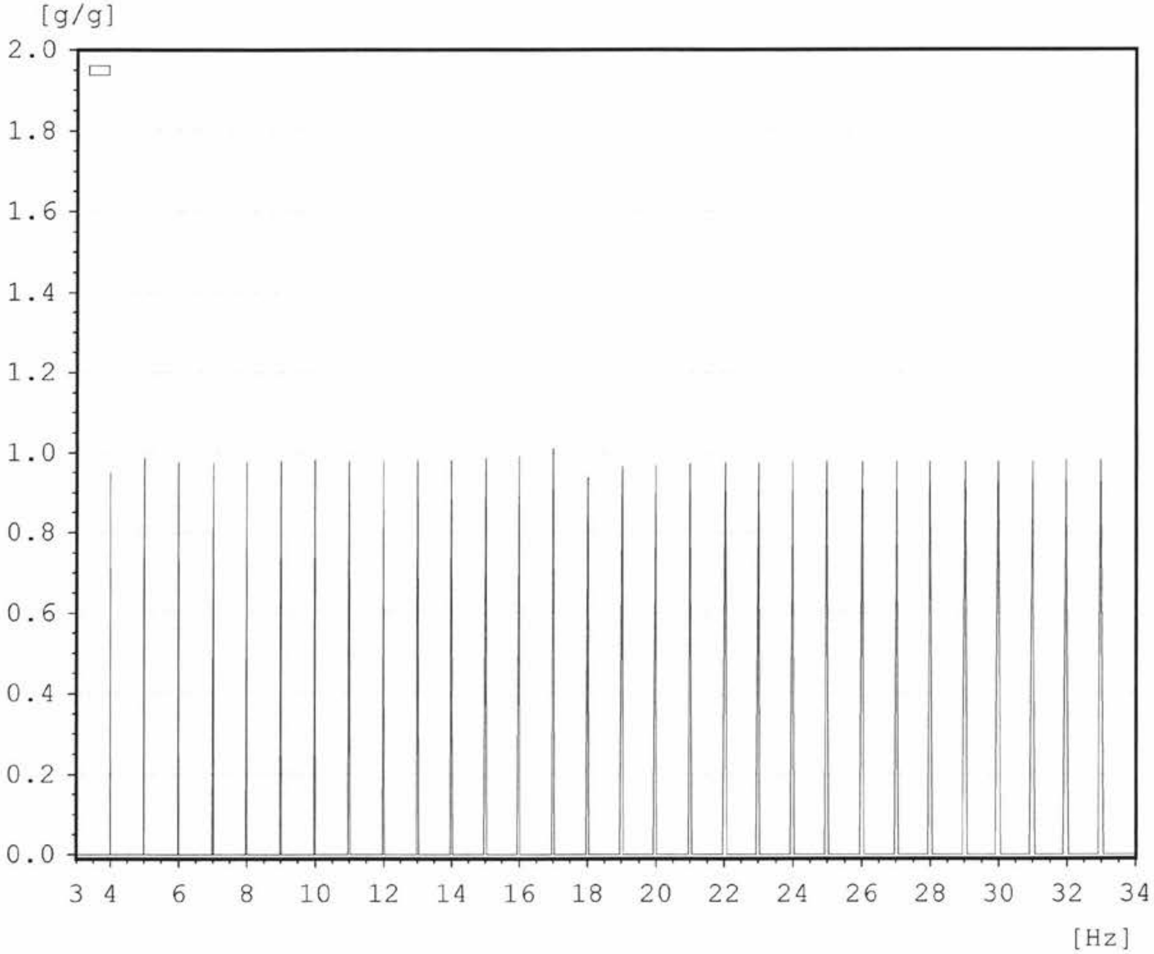
Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 2A 6

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_002.rsd

Sine DwellC2 **Fixture Bottom vs. Control channel**

Axis: F. Baumbach

Condition: Variable Frequency



Ref.Chan.type: X
Chan.no: 2
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:30:00
remaining: 000:00:00

Date: 08-07-14
Time: 21:20:28
Product version:

Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach

Engineer: J. Sookhdeo Plot: 2A 7

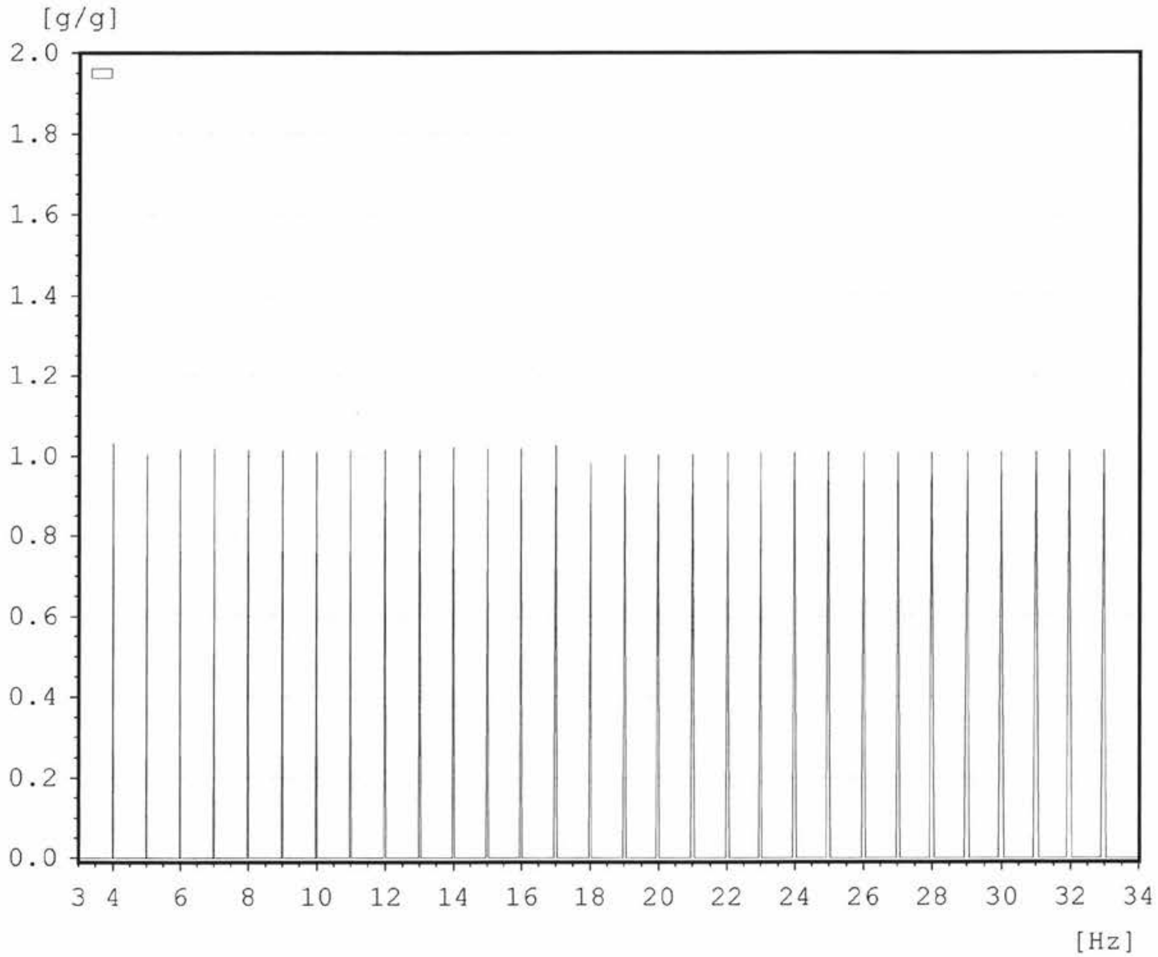
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_002.rsd

Sine Dwell

R1 Board 1 vs. Control channel

Axis: F. Baumbach

Condition: Variable Frequency



Ref.Chan.type: X
Chan.no: 3
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:30:00
remaining: 000:00:00

Date: 08-07-14
Time: 21:20:28
Product version:

Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach

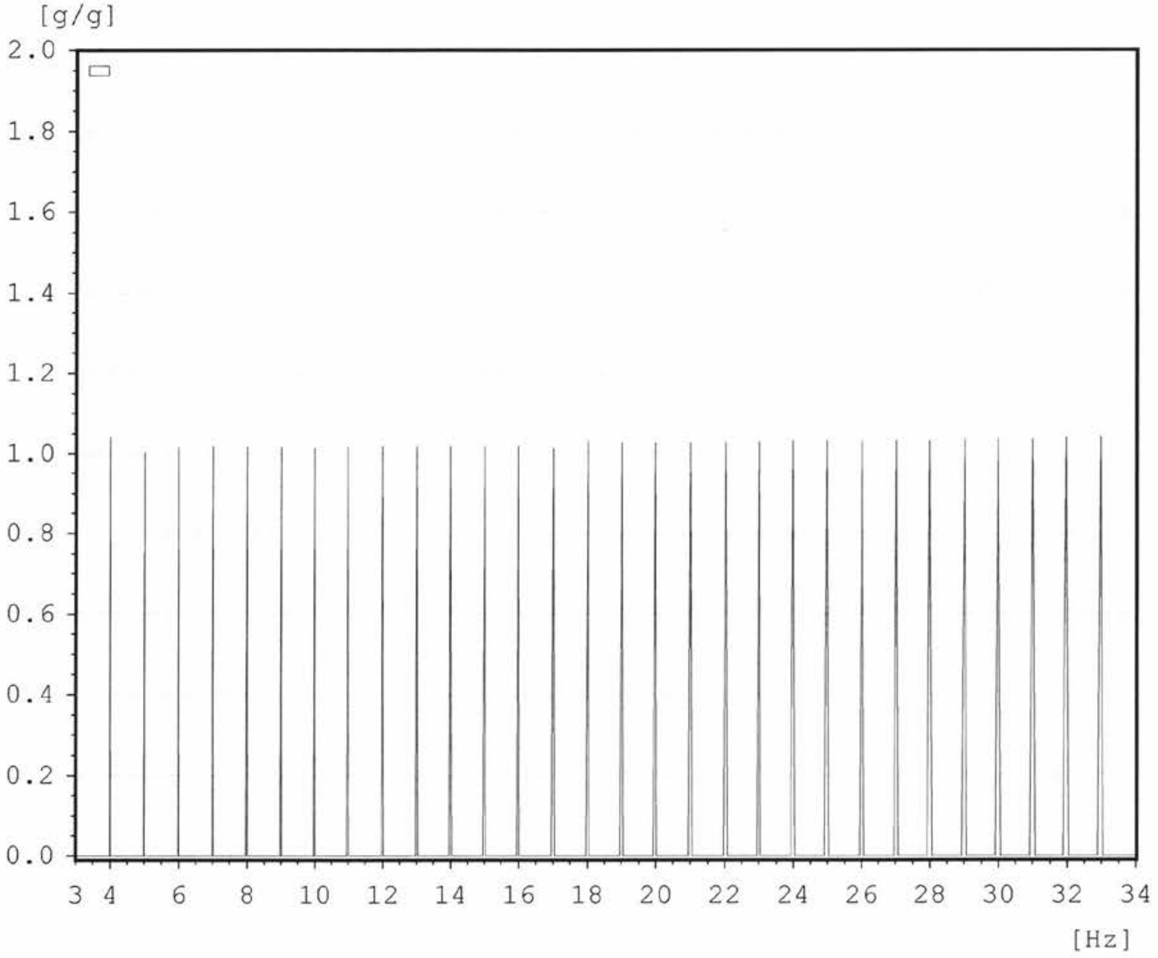
Engineer: J. Sookhdeo Plot: 2A

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_002.rsd

Sine Dwell

R2 Board 2 vs. Control channel

Axis: F. Baumbach
Condition: Variable Frequency



Ref.Chan.type:	X
Chan.no:	4
Chan.type:	M Filtered
Sweep type:	logarithmic
Sweeps done:	0
Sweeps req.:	1
Sweep direct.:	up
Contr.strat.:	Average
Unit:	g/g
Contr.strat.:	Closed loop

-- Testing time --

elapsed:	002:30:00
remaining:	000:00:00

Date:	08-07-14
Time:	21:20:28
Product version:	

Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

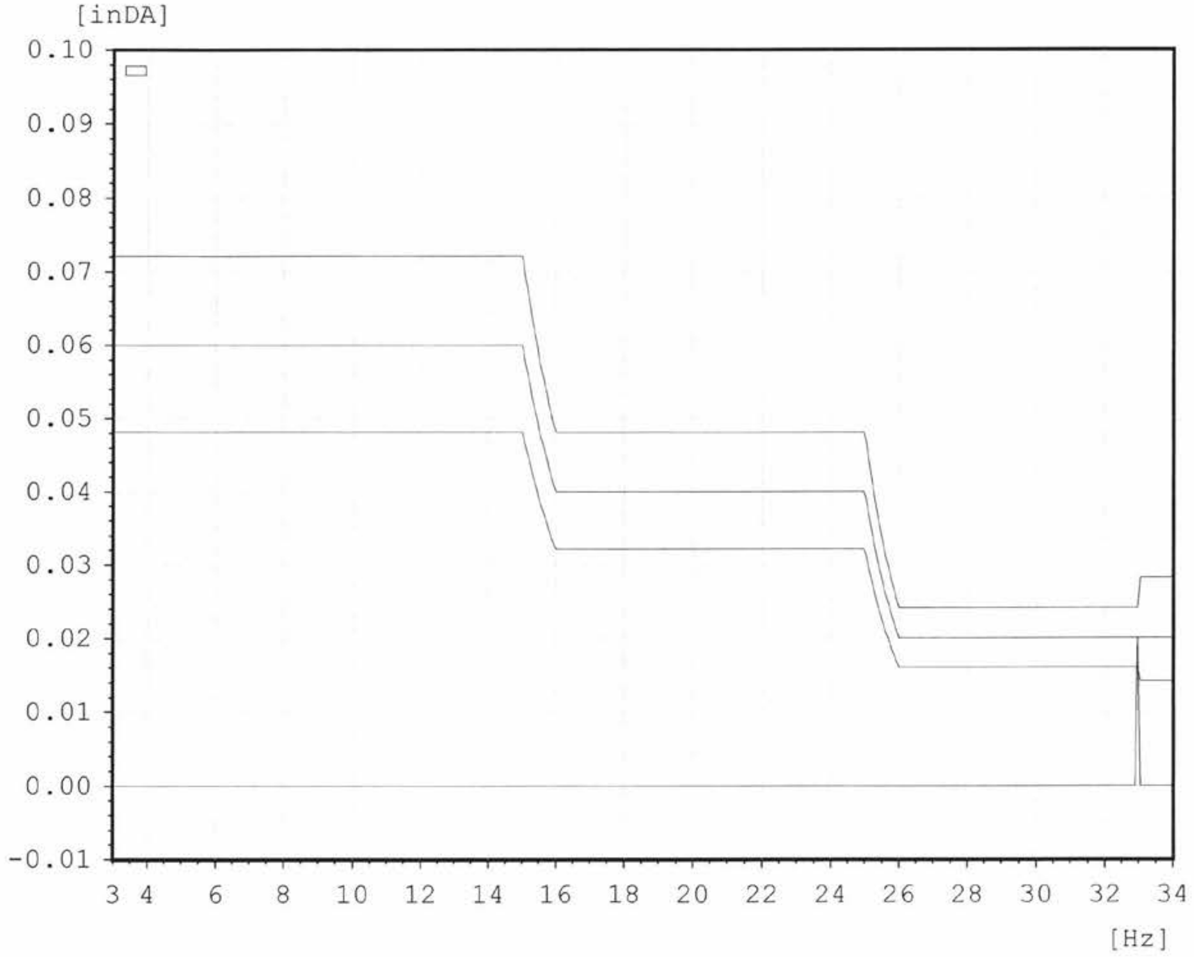
Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 2A 9

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_002.rsd

Sine Dwell

Control channel (2xintegr)

Axis: Front/Back
Condition: Endurance



Chan.type: X
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-07-14
Time: 23:30:12
Product version:

AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

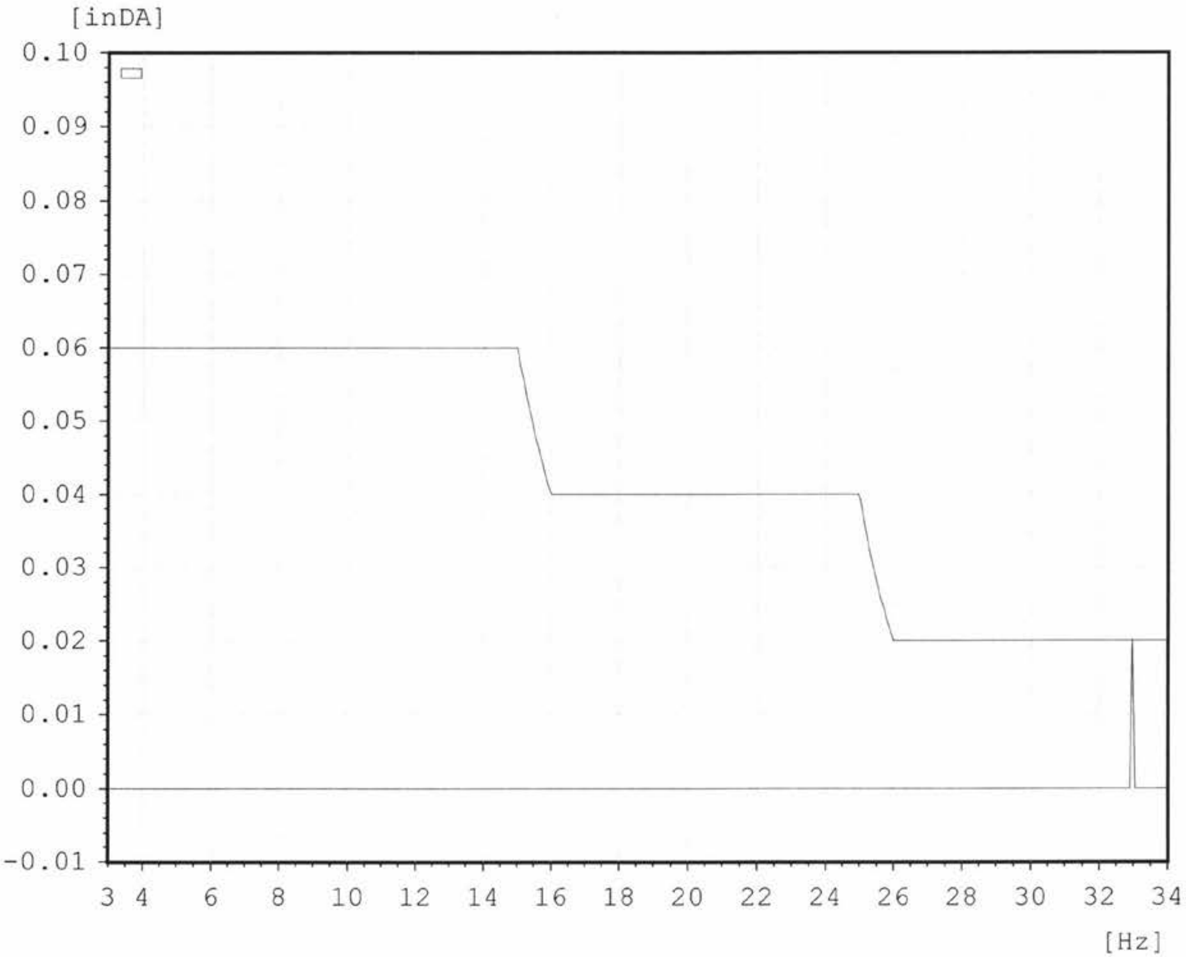
Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 3A 1

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_002.rsd

Sine Dwell

C1 Fixture Top (2xintegr)

Axis: Front/Back
Condition: Endurance



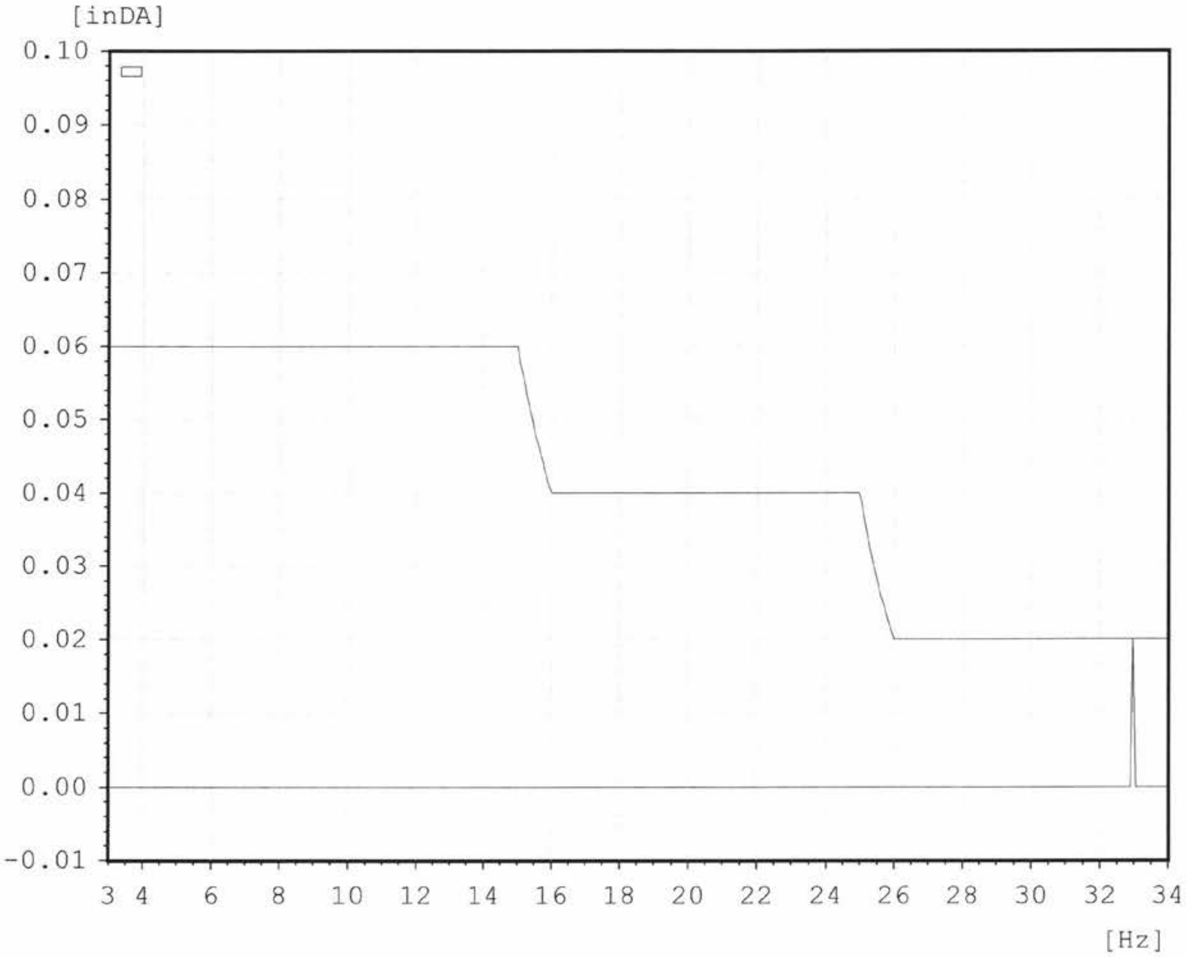
```
Chan.no:         1
Chan.type:       CW   Filtered
Sweep type:      logarithmic
Sweeps done:     0
Sweeps req.:     1
Sweep direct.:   up
Contr.strat.:    Average
Unit:            inDA
Contr.strat.:    Closed loop

-- Testing time --
elapsed:         002:00:00
remaining:       000:00:00

Date:            08-07-14
Time:            23:30:12
Product version:

AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1
```

Tech.: F. Baumbach
Engineer: J. Sookhdeo   Plot: 3A 2

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_002.rsd

Sine Dwell **C2 Fixture Bottom (2xintegr)**

Axis: Front/Back
Condition: Endurance



Chan.no: 2
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-07-14
Time: 23:30:12
Product version:

AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

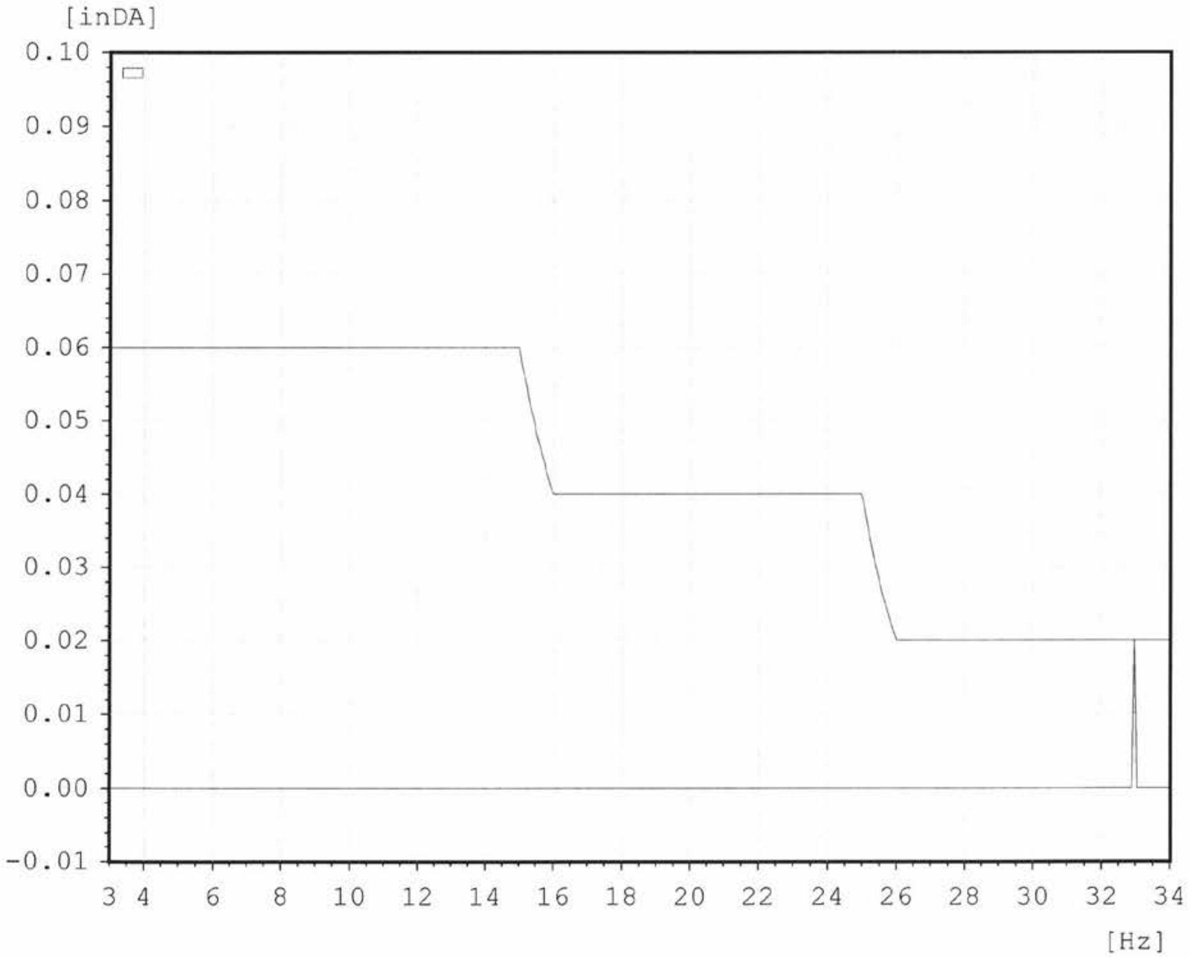
Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 3A3

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_002.rsd

Sine Dwell

R1 Board 1 (2xintegr)

Axis: Front/Back
Condition: Endurance



Chan.no: 3
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-07-14
Time: 23:30:12
Product version:

AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

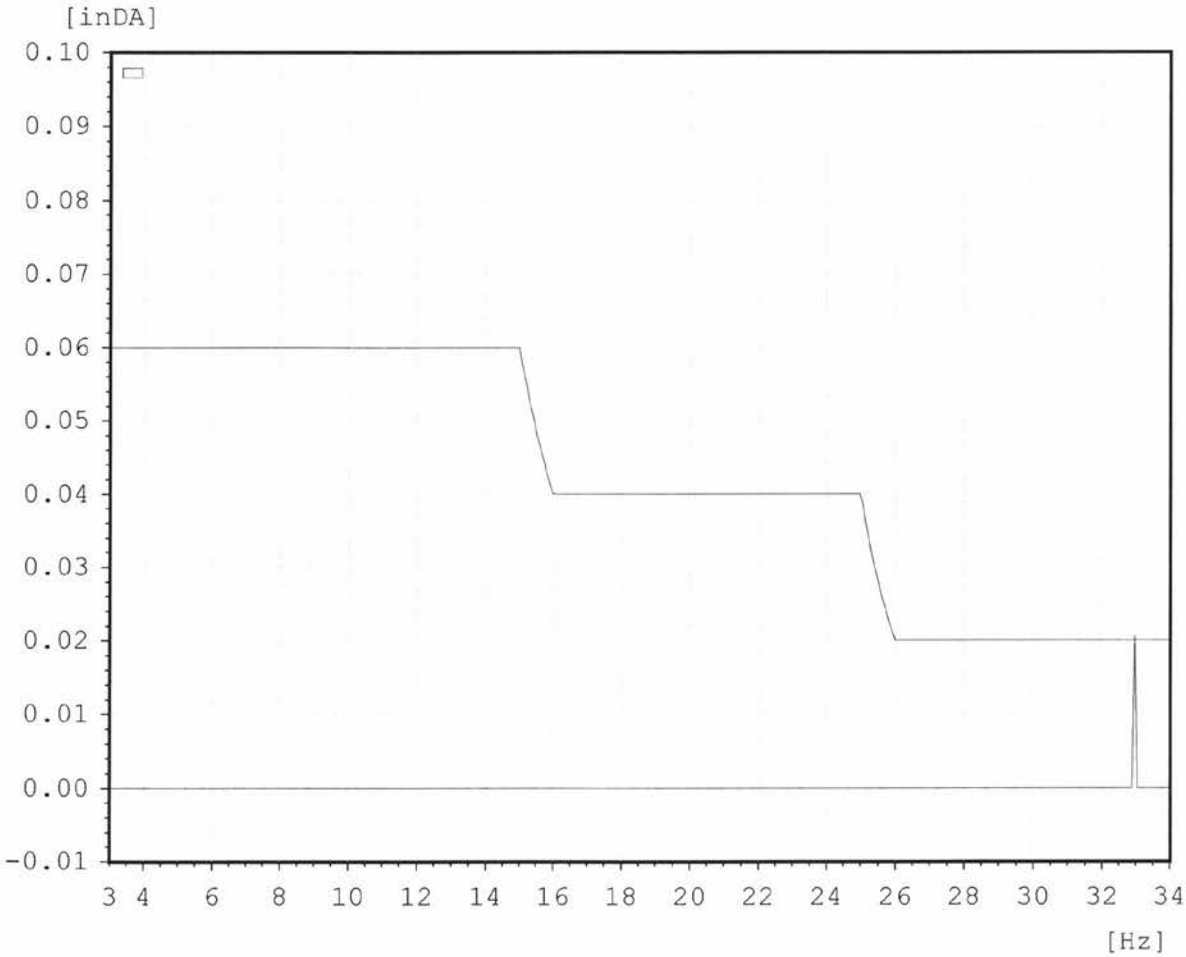
Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 3A 4

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_002.rsd

Sine Dwell

R2 Board 2 (2xintegr)

Axis: Front/Back
Condition: Endurance



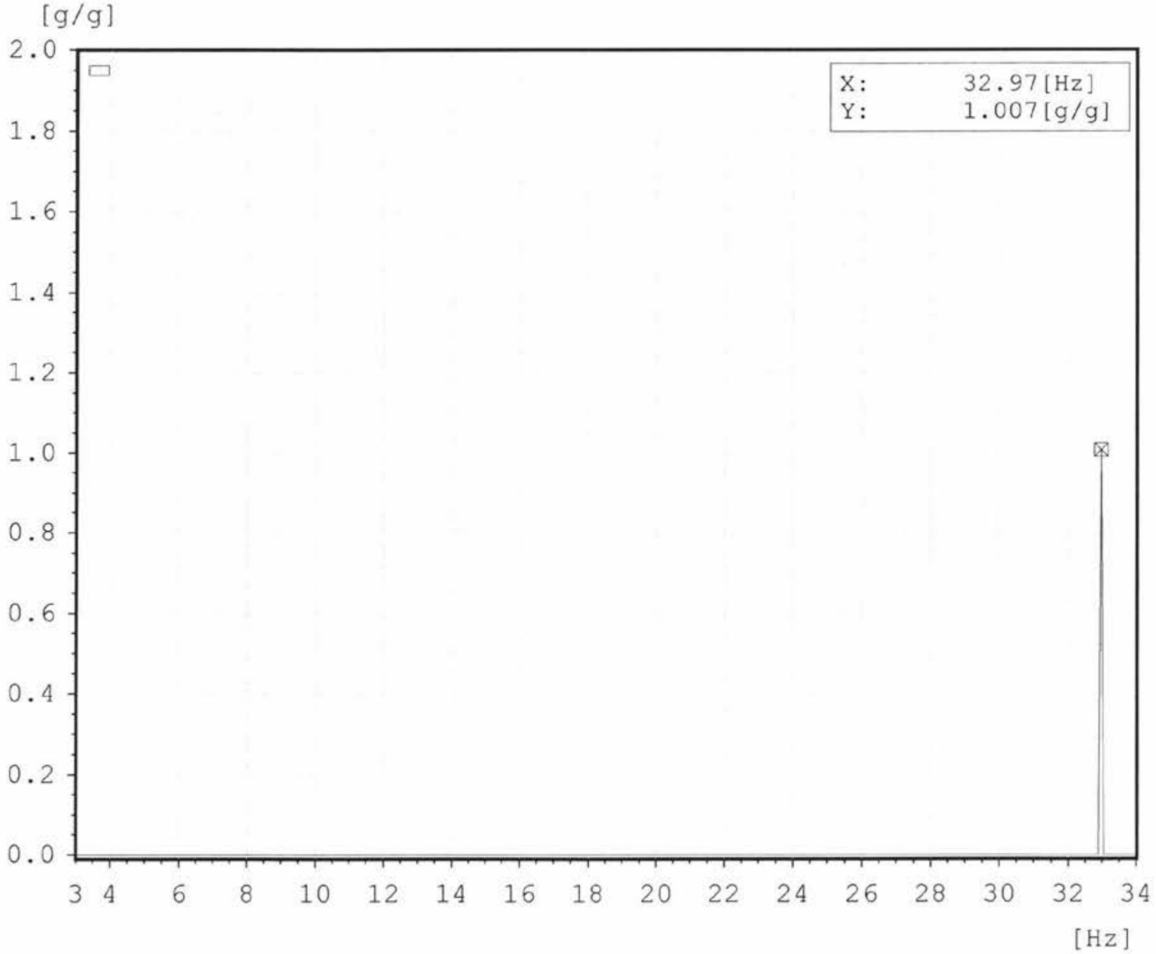
```
Chan.no:        4
Chan.type:          M Filtered
Sweep type:     logarithmic
Sweeps done:    0
Sweeps req.:    1
Sweep direct.:  up
Contr.strat.:   Average
Unit:           inDA
Contr.strat.:   Closed loop

-- Testing time --
elapsed:        002:00:00
remaining:      000:00:00

Date:           08-07-14
Time:           23:30:12
Product version:

AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1
```

Tech.: F. Baumbach
Engineer: J. Sookhdeo   Plot: 3A5

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_002.rsd

Sine Dwell **C1 Fixture Top vs. Control channel**

Axis: Front/Back
Condition: Endurance



Ref.Chan.type: X
Chan.no: 1
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-07-14
Time: 23:30:12
Product version:

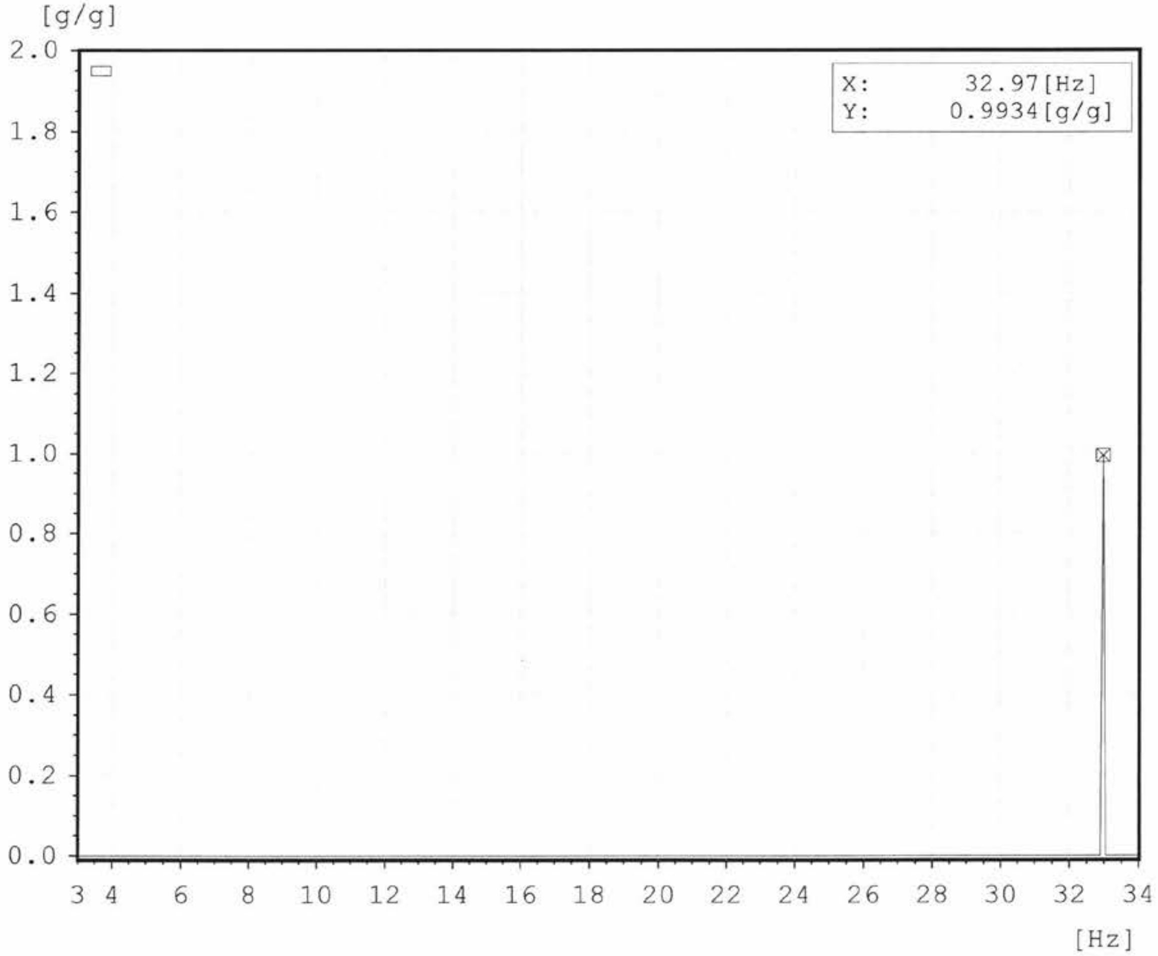
AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 3A6

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_002.rsd

Sine DwelC2 Fixture Bottom vs. Control channel

Axis: Front/Back
Condition: Endurance



Ref.Chan.type: X
Chan.no: 2
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-07-14
Time: 23:30:12
Product version:

AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

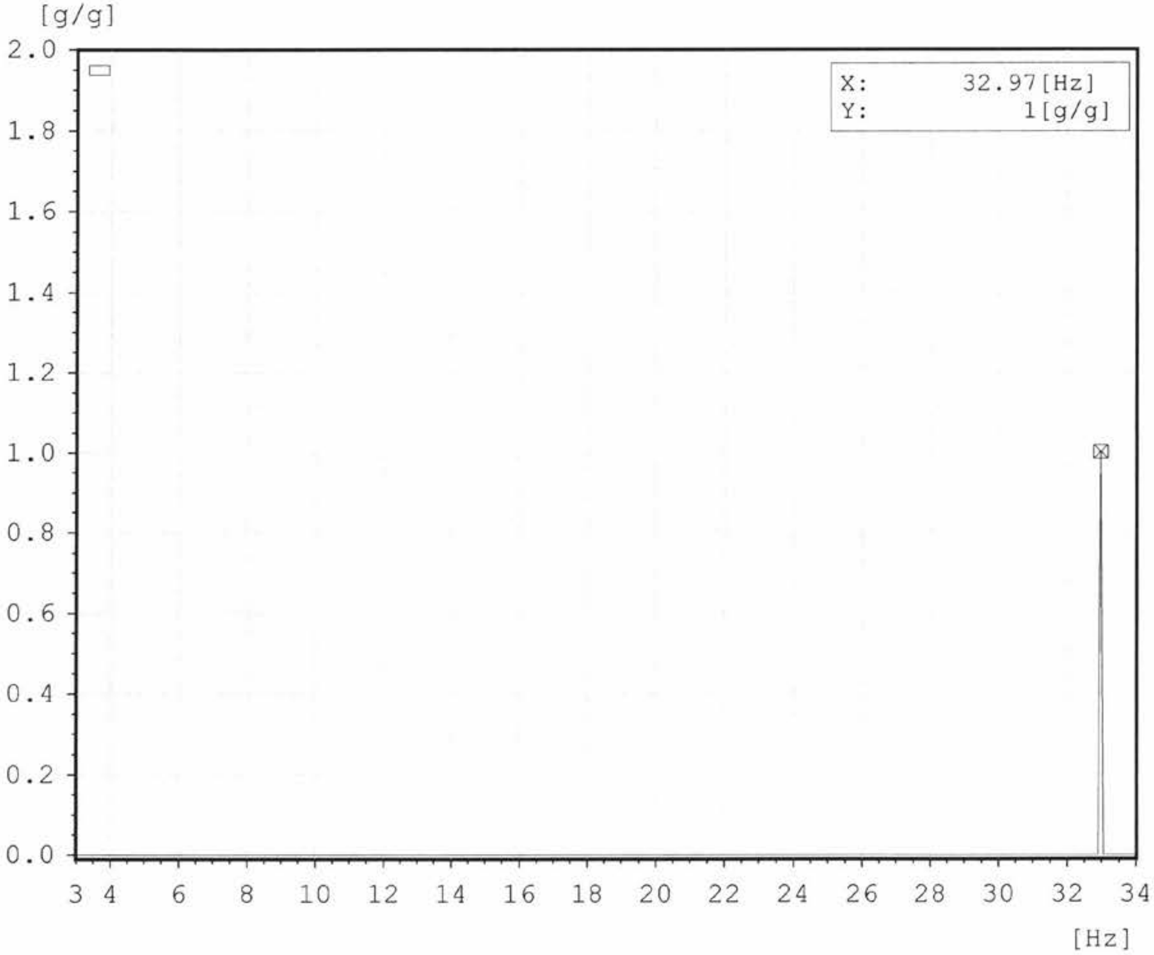
Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 3A7

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_002.rsd

Sine Dwell

R1 Board 1 vs. Control channel

Axis: Front/Back
Condition: Endurance



Ref.Chan.type:	X
Chan.no:	3
Chan.type:	M Filtered
Sweep type:	logarithmic
Sweeps done:	0
Sweeps req.:	1
Sweep direct.:	up
Contr.strat.:	Average
Unit:	g/g
Contr.strat.:	Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-07-14
Time: 23:30:12
Product version:

AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

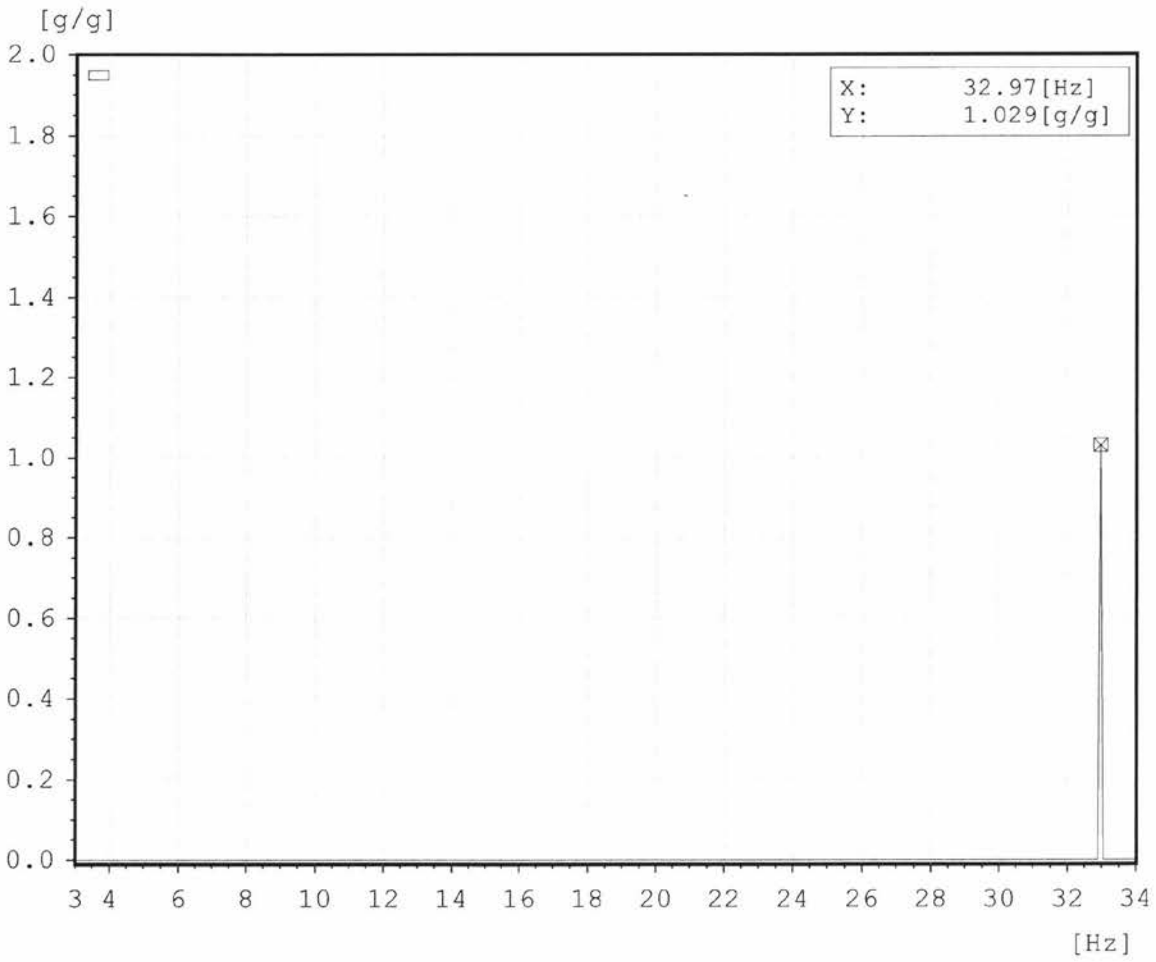
Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 3A8

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_002.rsd

Sine Dwell **R2 Board 2 vs. Control channel**

Axis: Front/Back

Condition: Endurance



Ref.Chan.type: X
Chan.no: 4
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-07-14
Time: 23:30:12
Product version:

AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach

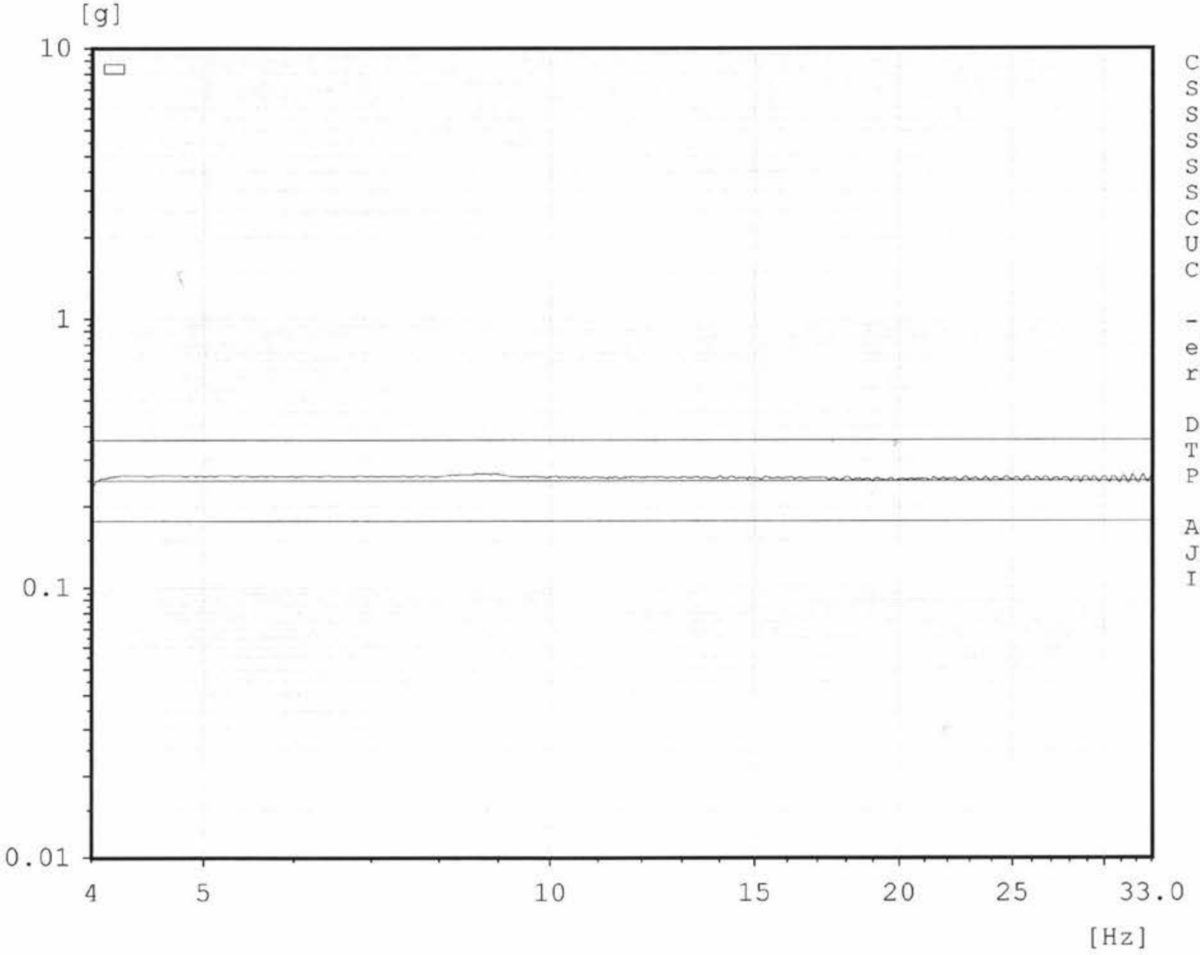
Engineer: J. Sookhdeo Plot: 3A9

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_002.rsd

Sine

Control channel

Axis: Front/Back
Condtion: Fixture Survey



Chan.type: X
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 09:05:10
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

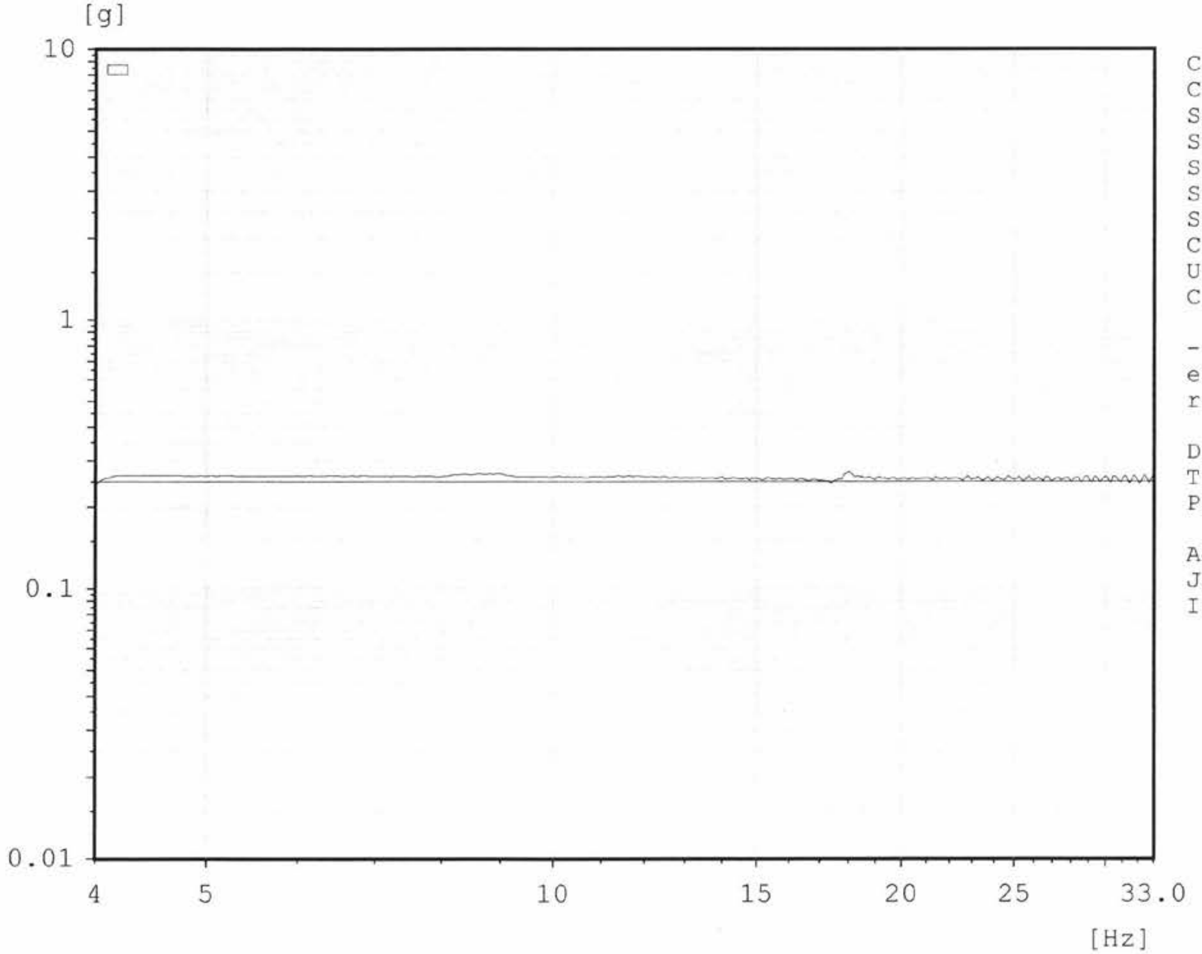
Tech: Steve Palmer
Eng.: J. Sookhdeo Plot: 4A

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_002.rsn

Sine

C1 Fixture top

Axis: Front/Back
Condtion: Fixture Survey



Chan.no: 1
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 09:05:10
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

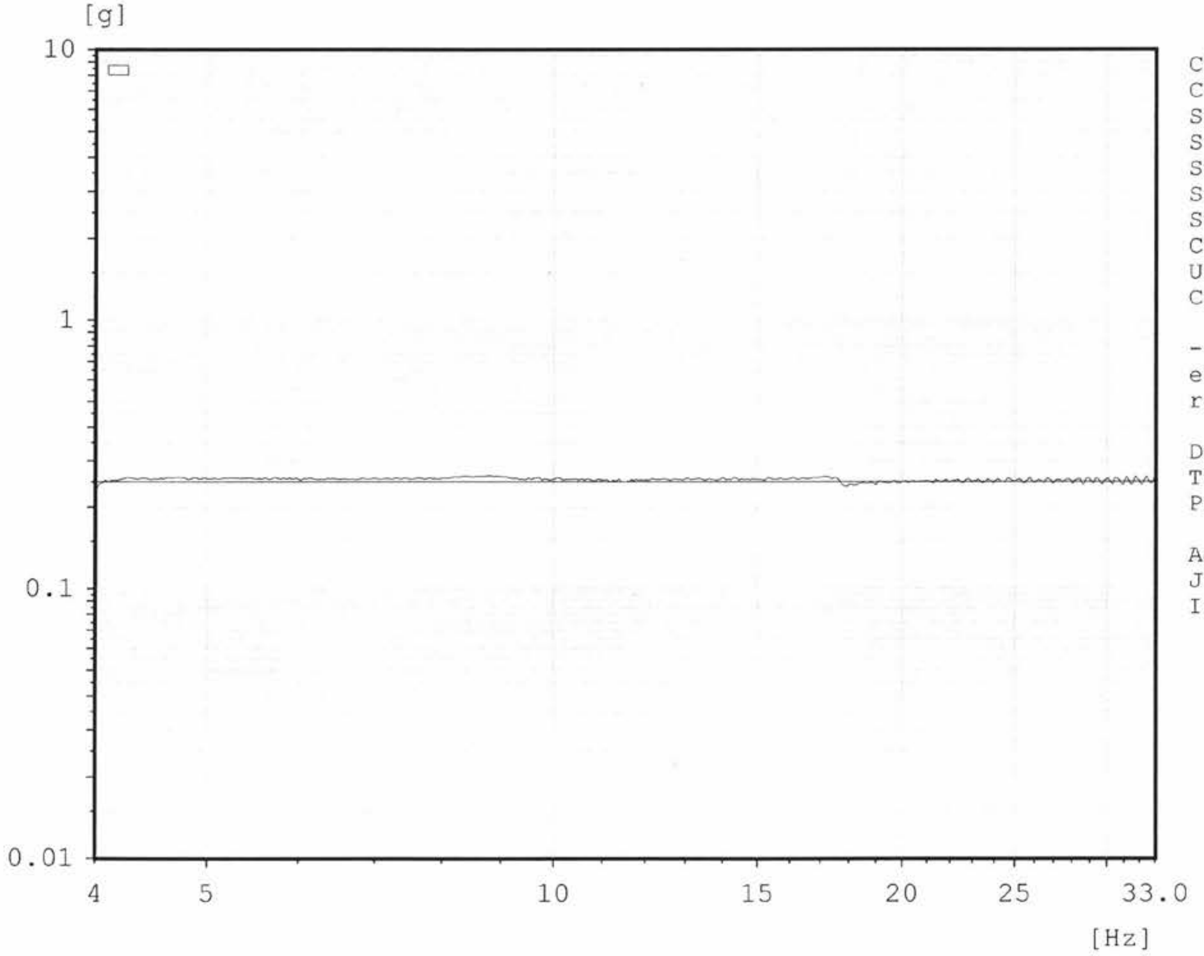
Tech: Steve Palmer
Eng.: J. Sookhdeo Plot: 4A

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_002.rsn

Sine

C2 Fixture Bottom

Axis: Front/Back
Condtion: Fixture Survey



Chan.no: 2
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 09:05:10
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

Tech: Steve Palmer
Eng.: J. Sookhdeo Plot: 4A 32

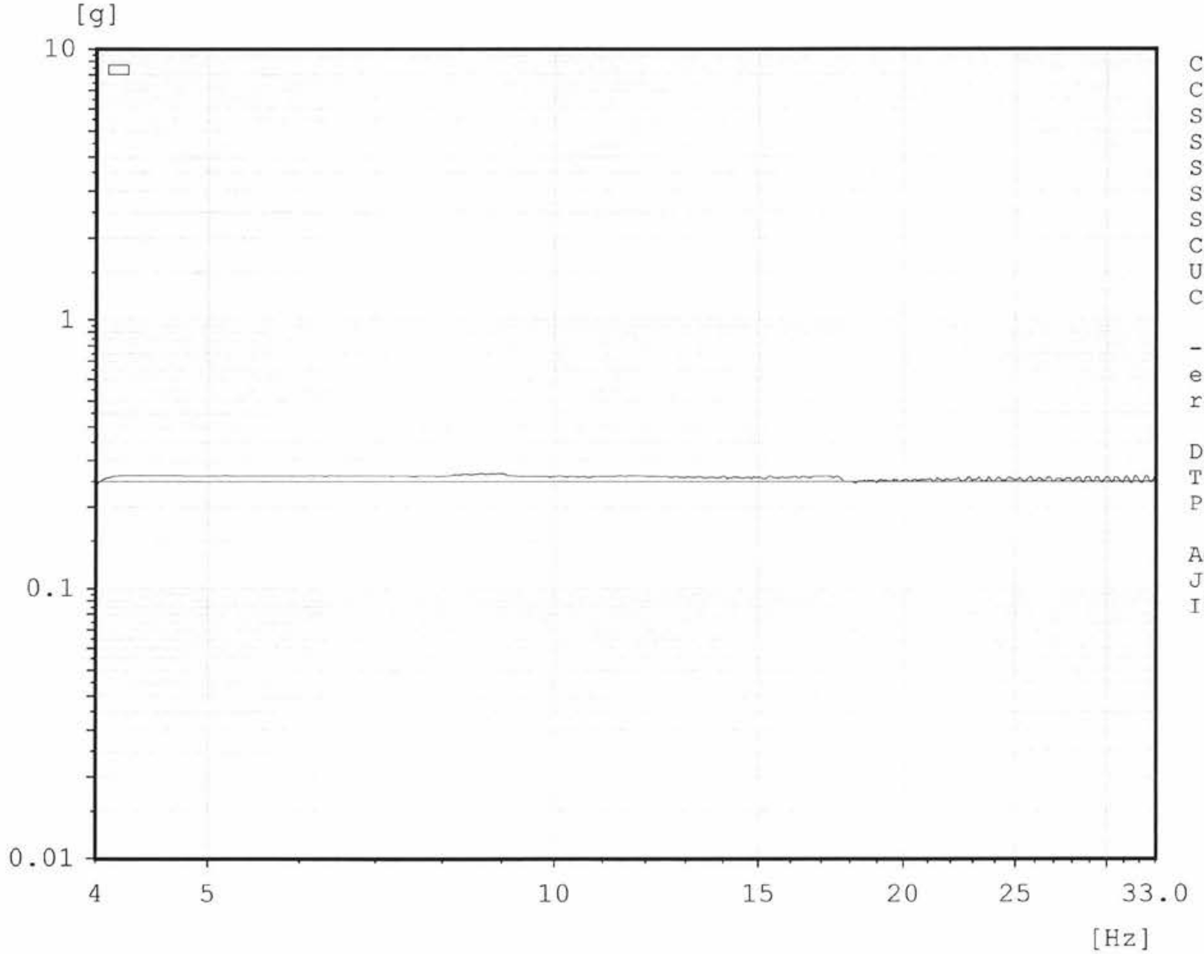
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_002.rsn

Sine

R1 Board 1 Fixture

Axis: Front/Back

Condtion: Fixture Survey



Chan.no: 3
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 09:05:10
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

Tech: Steve Palmer

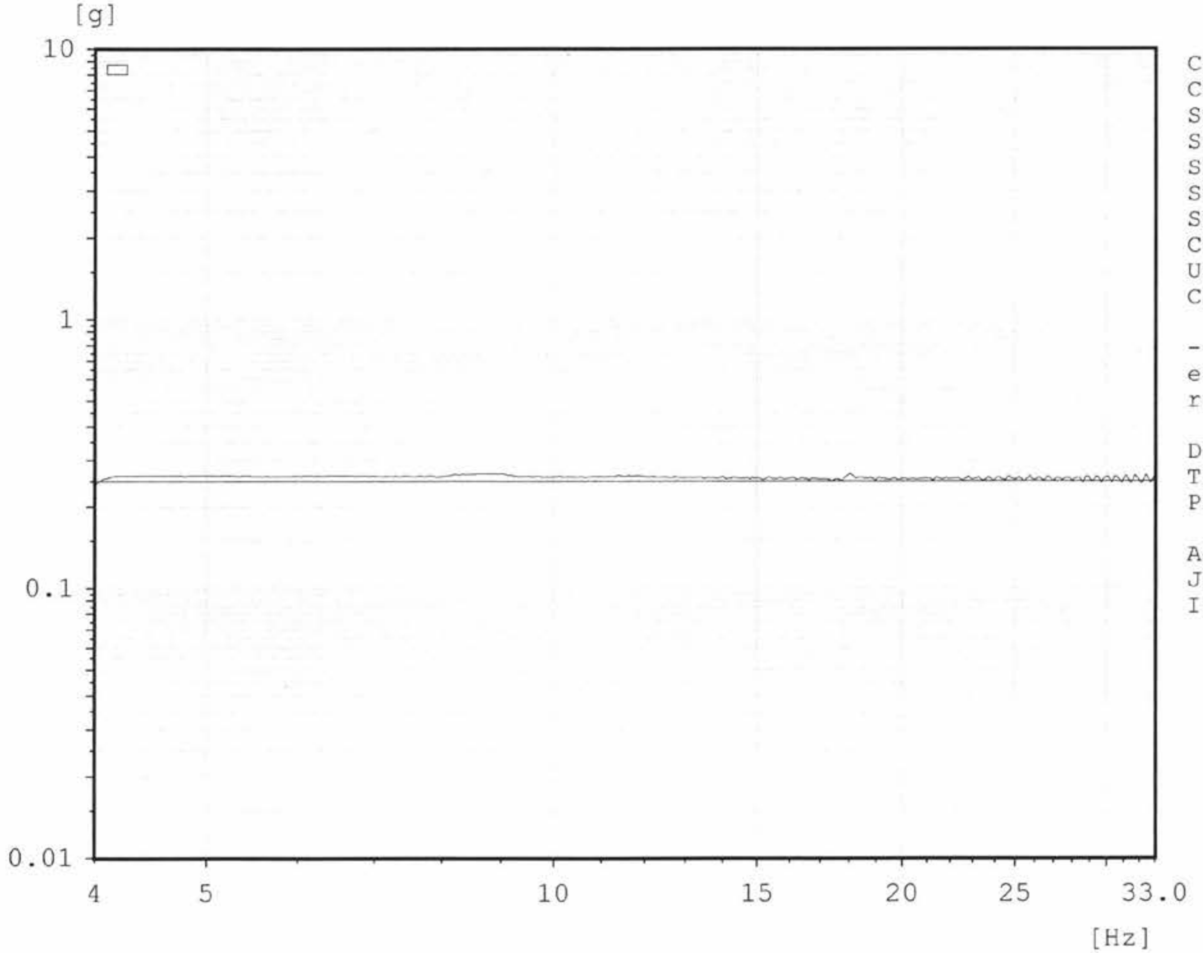
Eng.: J. Sookhdeo Plot: 4A

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_002.rsn

Sine

R2 Board 2 Fixture

Axis: Front/Back
Condtion: Fixture Survey



```
Chan.no:        4
Chan.type:         M Filtered
Sweep type:     logarithmic
Sweeps done:    1
Sweeps req.:    1
Sweep direct.:  up
Sweep rate:       1.00 Oct/min
Contr.strat.:   Average
Unit:           g
Contr.strat.:   Closed loop

-- Testing time --
elapsed:        000:03:02
remaining:      000:00:00

Date:           08-08-14
Time:           09:05:10
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick
```

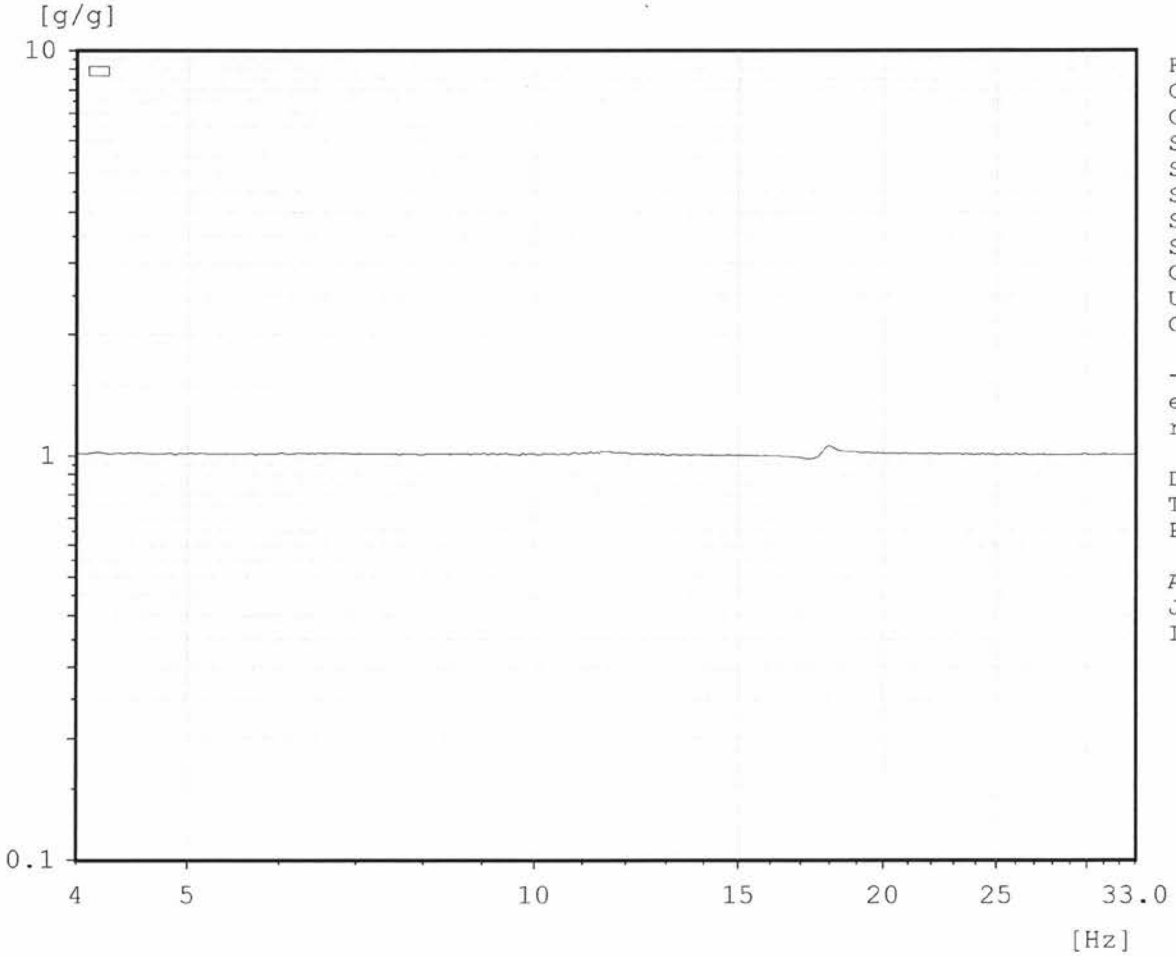
Tech: Steve Palmer
Eng.: J. Sookhdeo   Plot: 4A

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_002.rsn

Sine

C1 Fixture top vs. Control channel

Axis: Front/Back
Condtion: Fixture Survey



Ref.Chan.type: X
Chan.no: 1
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 09:05:10
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

Tech: Steve Palmer
Eng.: J. Sookhdeo Plot: 4A 6

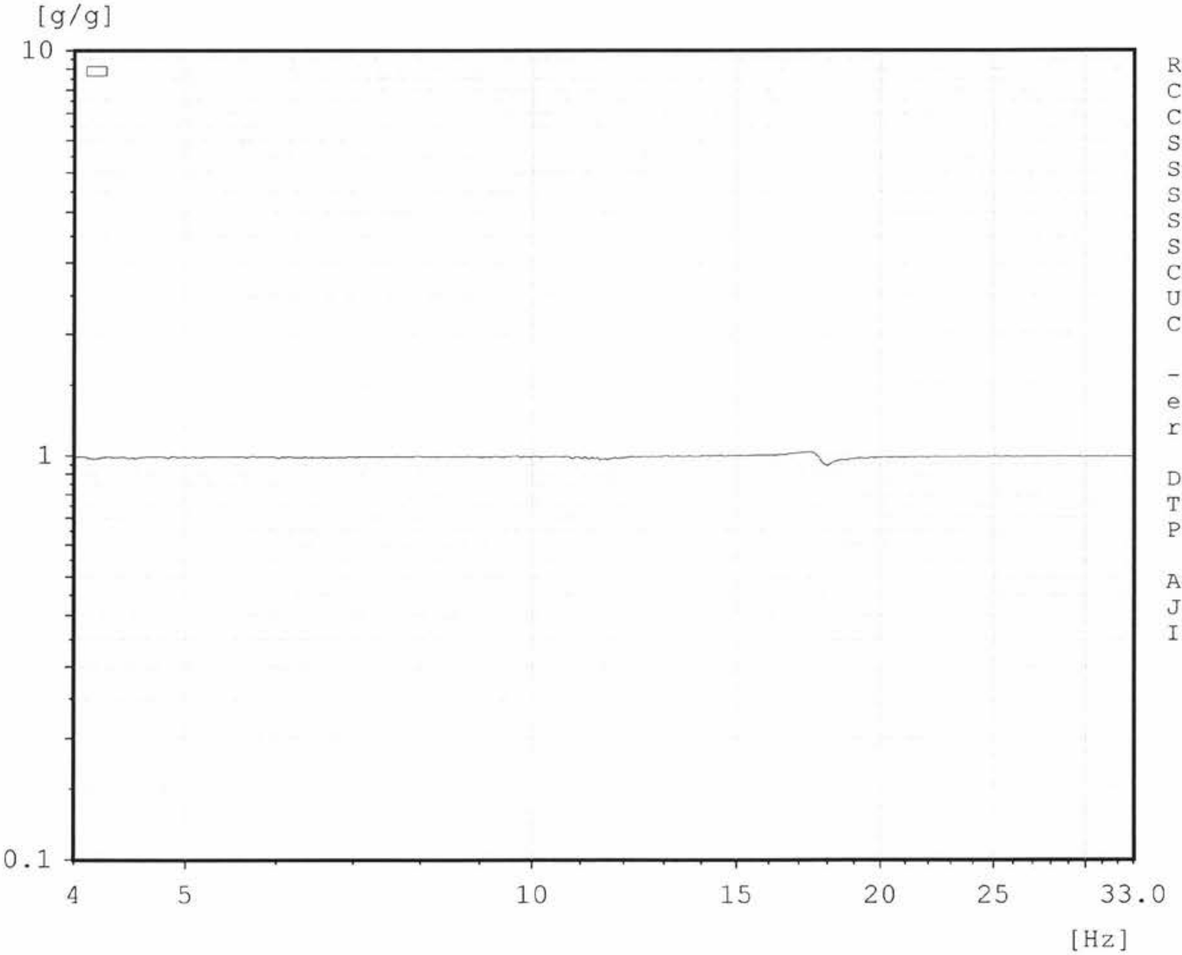
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_002.rsn

Sine

C2 Fixture Bottom vs. Control channel

Axis: Front/Back

Condtion: Fixture Survey



Ref.Chan.type: X
Chan.no: 2
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 09:05:10
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

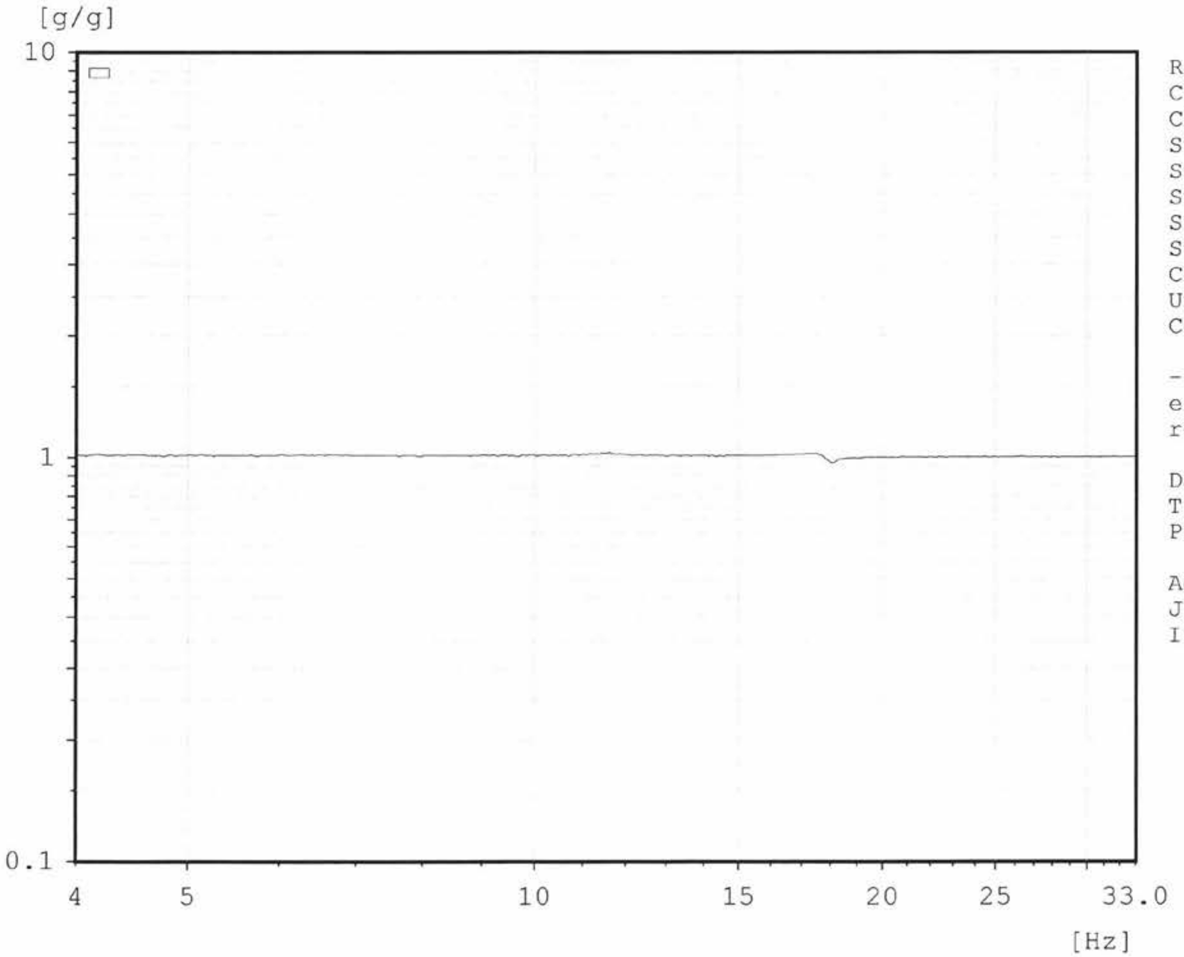
Tech: Steve Palmer
Eng.: J. Sookhdeo Plot: 4A 7

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_002.rsn

Sine **R1 Board 1 Fixture vs. Control channel**

m+p

Axis: Front/Back
Condtion: Fixture Survey



Ref.Chan.type: X
Chan.no: 3
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 09:05:10
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

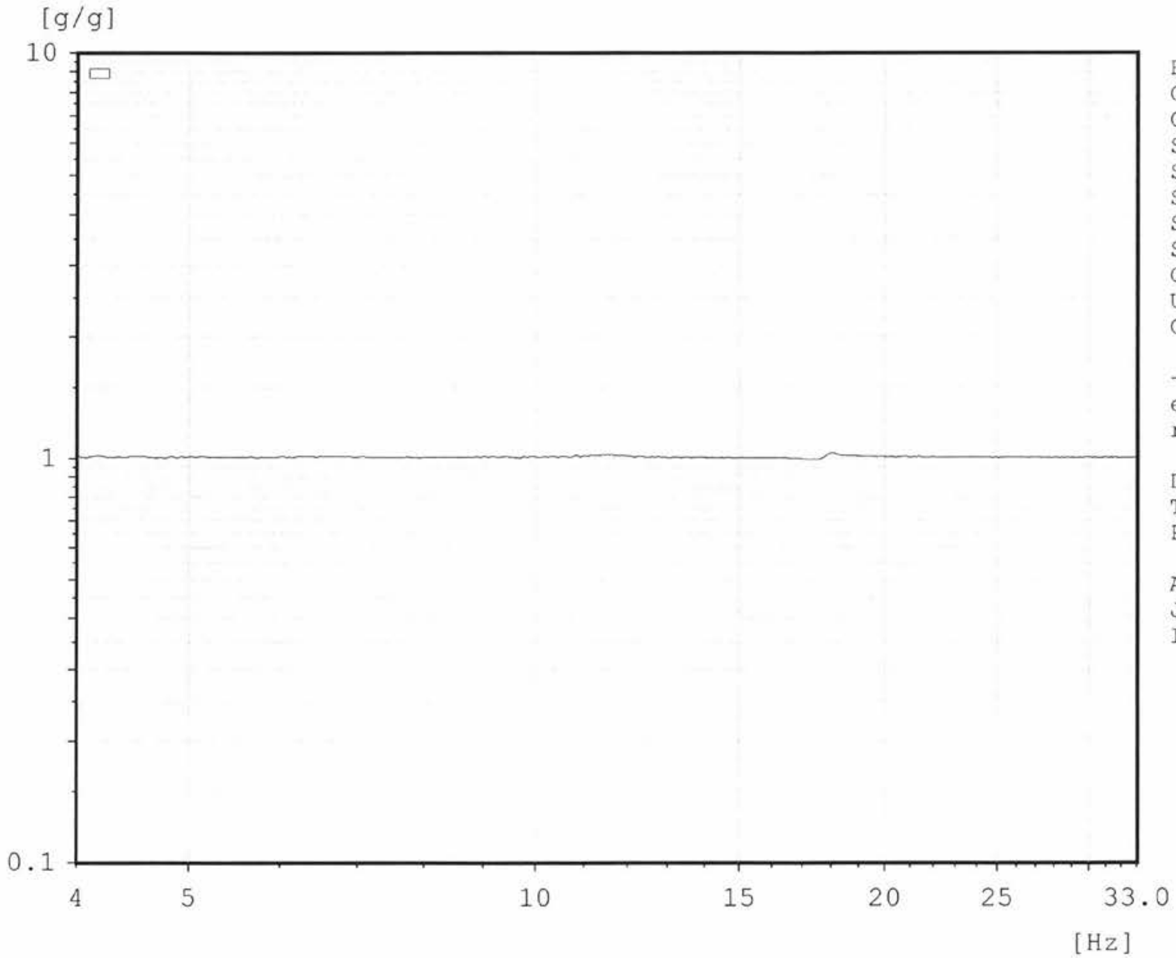
Tech: Steve Palmer
Eng.: J. Sookhdeo Plot: 4A

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_002.rsn

Sine

R2 Board 2 Fixture vs. Control channel

Axis: Front/Back
Condtion: Fixture Survey



Ref.Chan.type: X
Chan.no: 4
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 09:05:10
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

Tech: Steve Palmer
Eng.: J. Sookhdeo   Plot: 4A 9

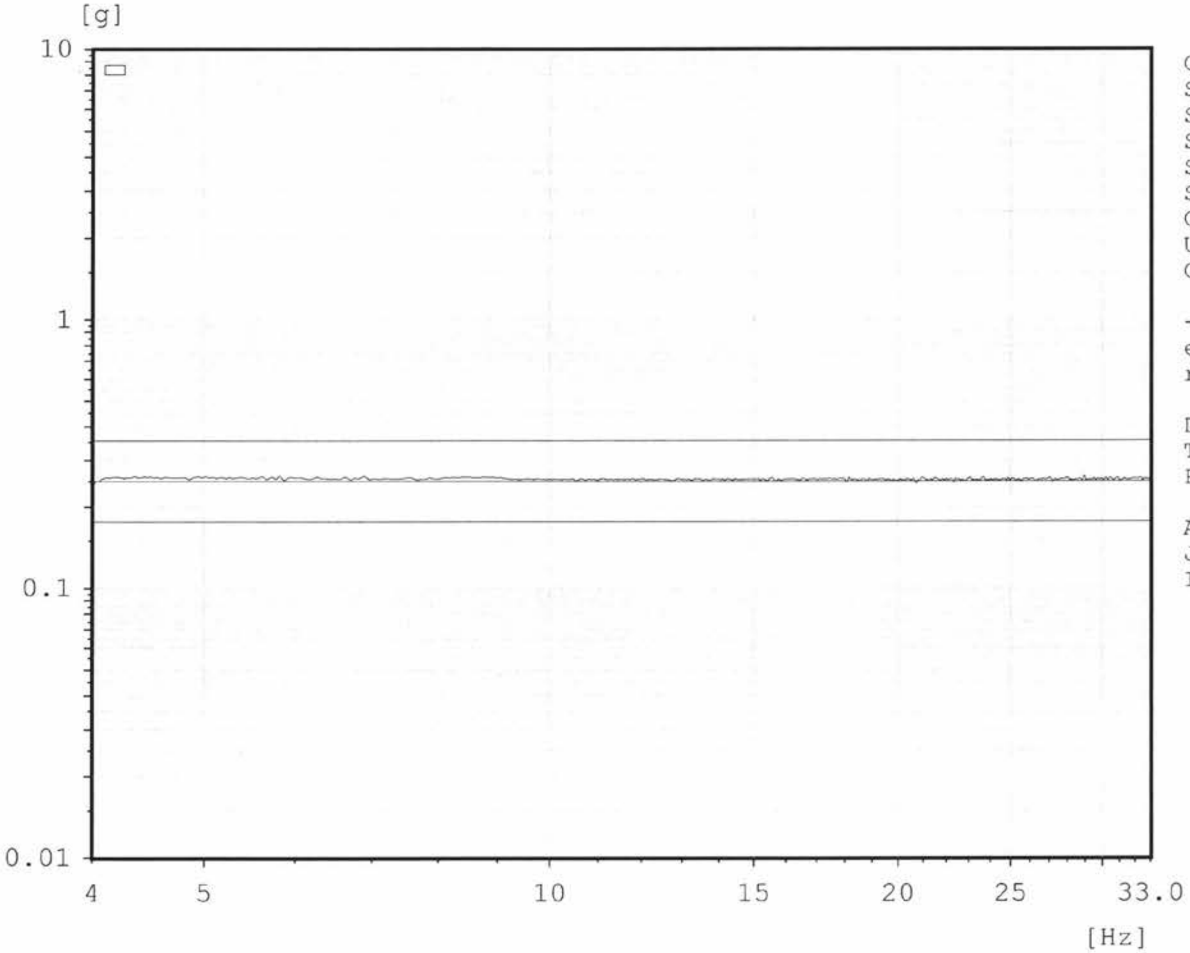
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_002.rsn

Sine

Control channel

Axis: Up/Down

Condtion: Fixture Survey



Chan.type: X
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 13:11:30
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

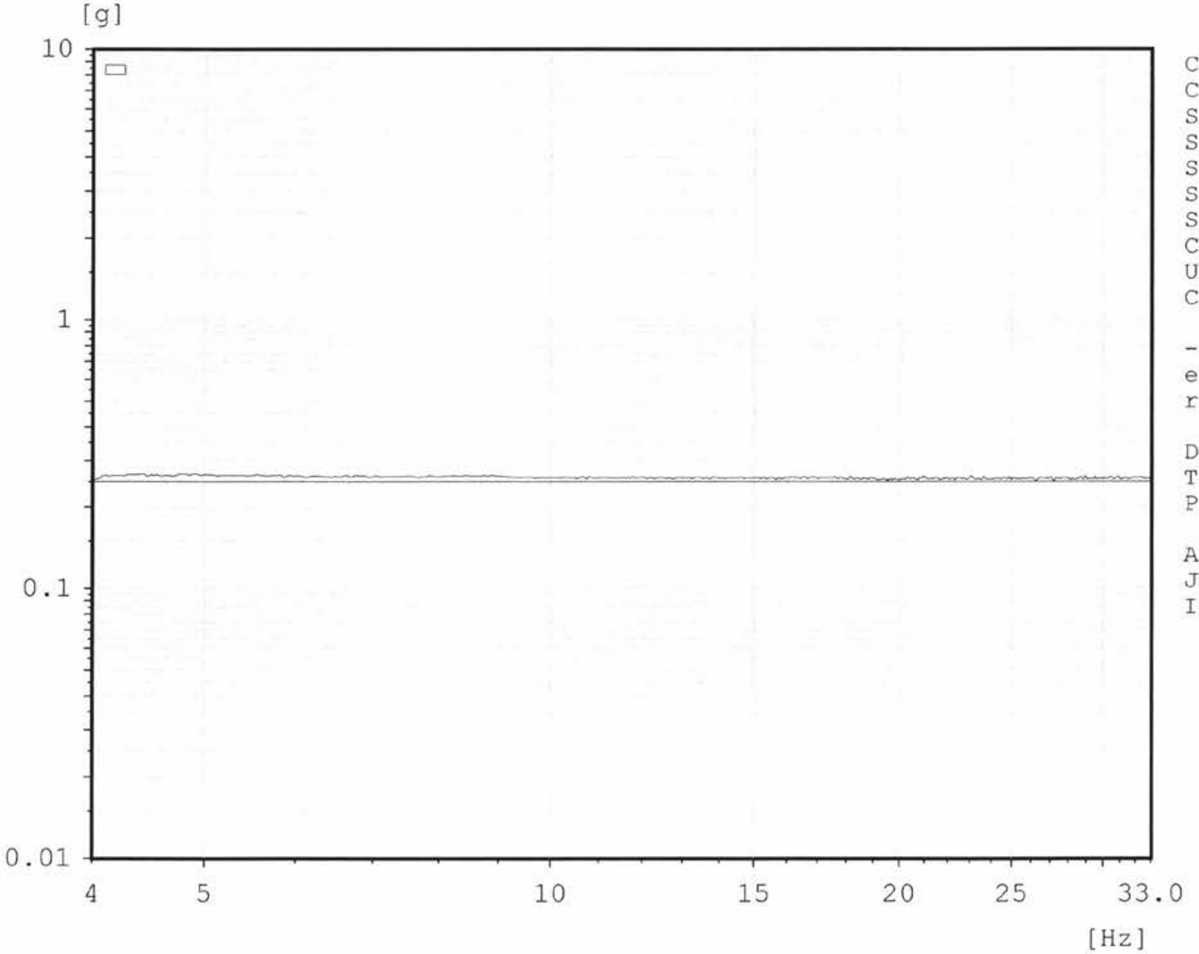
Tech: Steve Palmer
Eng.: J. Sookhdeo Plot: 5A

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_003.rsn

Sine

C1 Fixture top

Axis: Up/Down
Condtion: Fixture Survey



Chan.no: 1
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 13:11:30
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

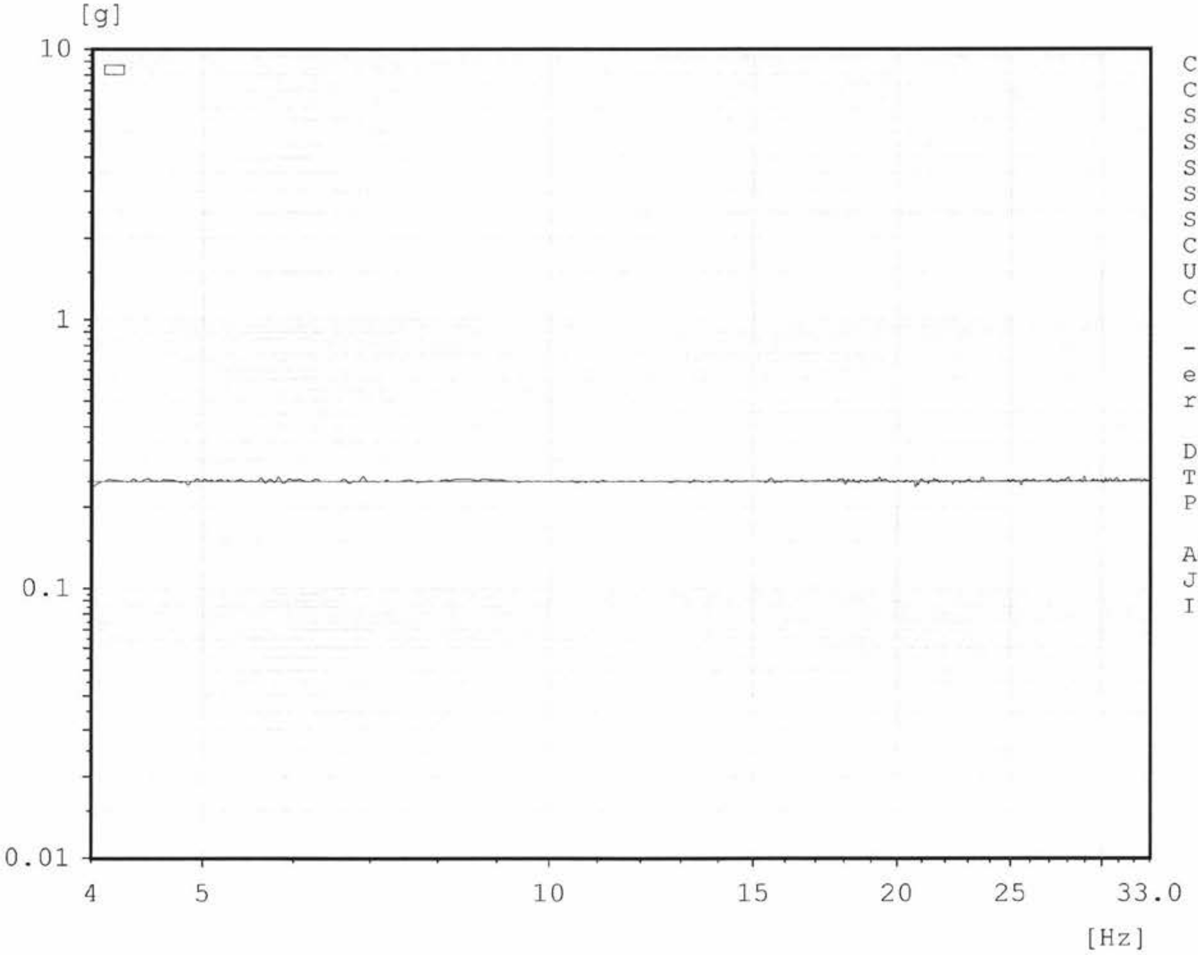
Tech: Steve Palmer
Eng.: J. Sookhdeo Plot: 5A 2

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_003.rsn

Sine

C2 Fixture Bottom

Axis: Up/Down
Condtion: Fixture Survey



Chan.no: 2
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 13:11:30
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

Tech: Steve Palmer
Eng.: J. Sookhdeo Plot: 5A 3

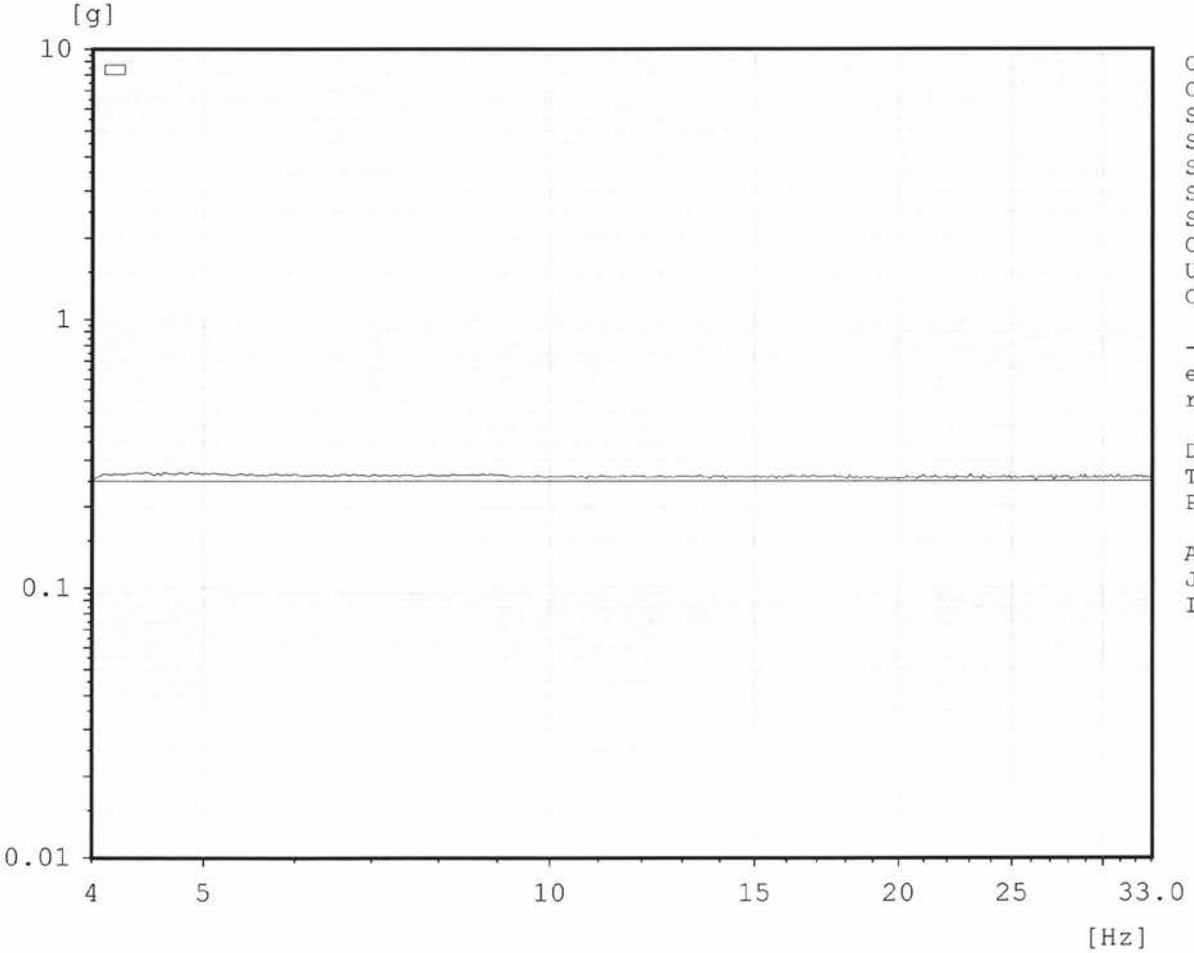
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_003.rsn

Sine

R1 Board 1 Fixture

Axis: Up/Down

Condtion: Fixture Survey



Chan.no: 3
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 13:11:30
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

Tech: Steve Palmer

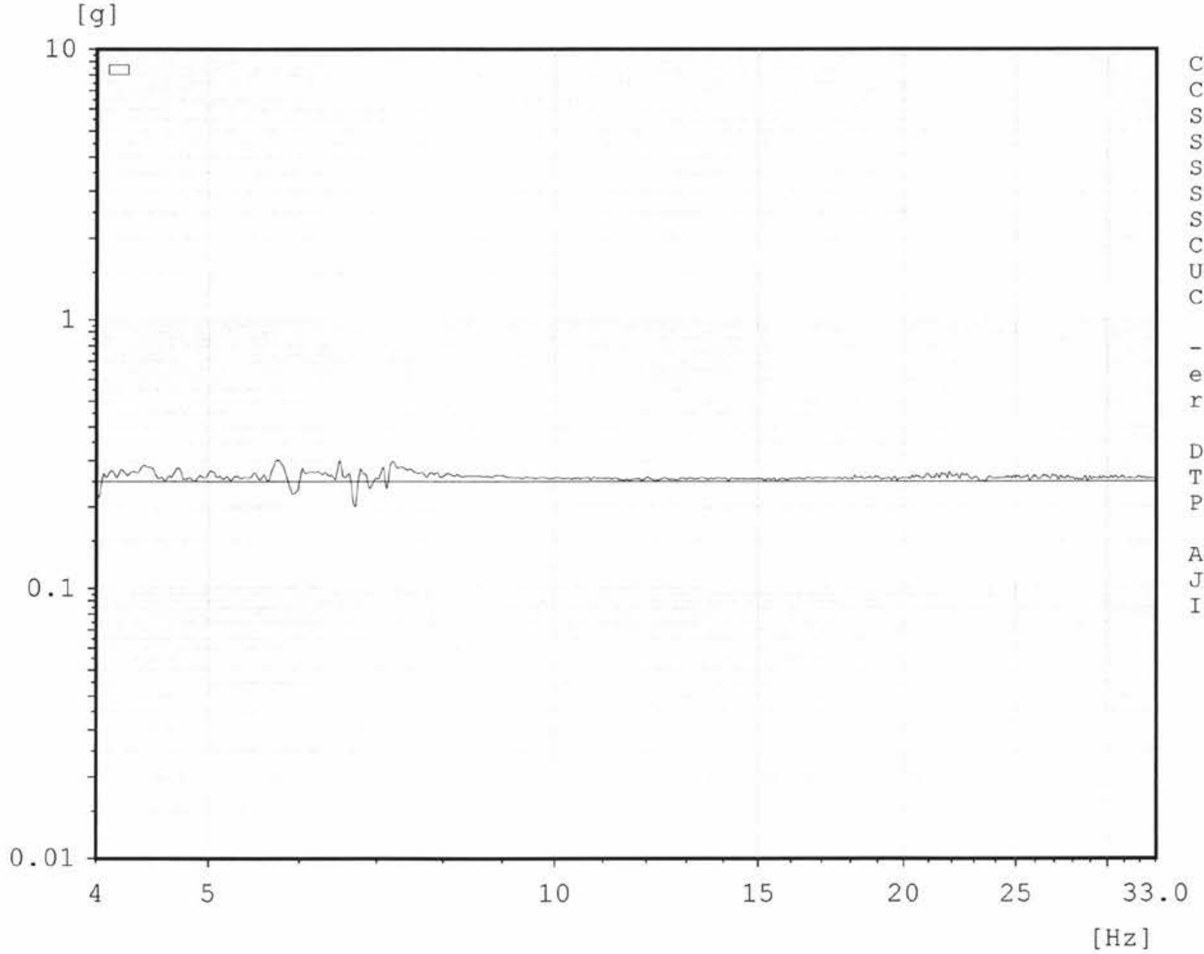
Eng.: J. Sookhdeo Plot: 5A 4

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_003.rsn

Sine

R2 Board 2 Fixture

Axis: Up/Down
Condtion: Fixture Survey



Chan.no: 4
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 13:11:30
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

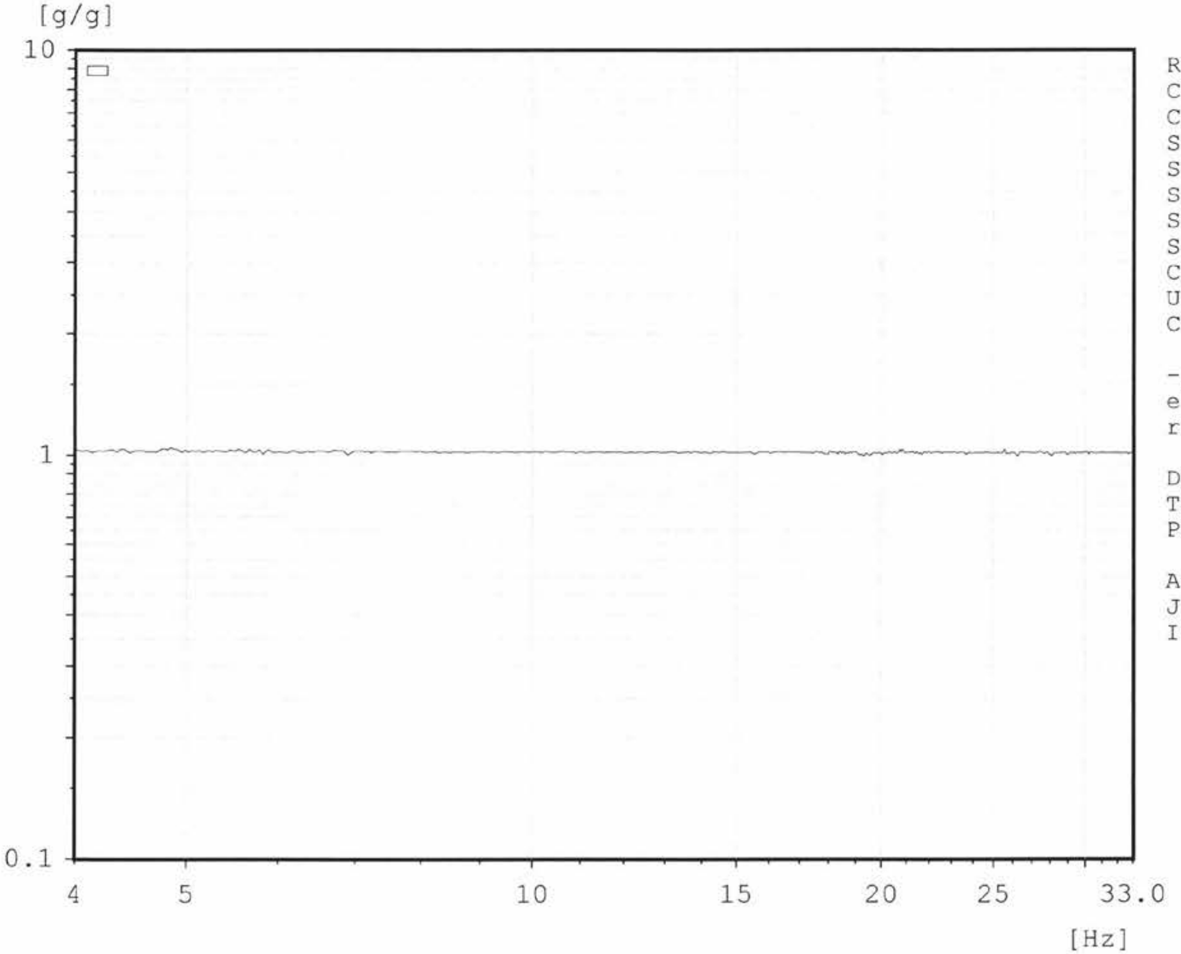
Tech: Steve Palmer
Eng.: J. Sookhdeo Plot: 5A 5

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_003.rsn

Sine

C1 Fixture top vs. Control channel

Axis: Up/Down
Condtion: Fixture Survey



Ref.Chan.type: X
Chan.no: 1
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 13:11:30
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

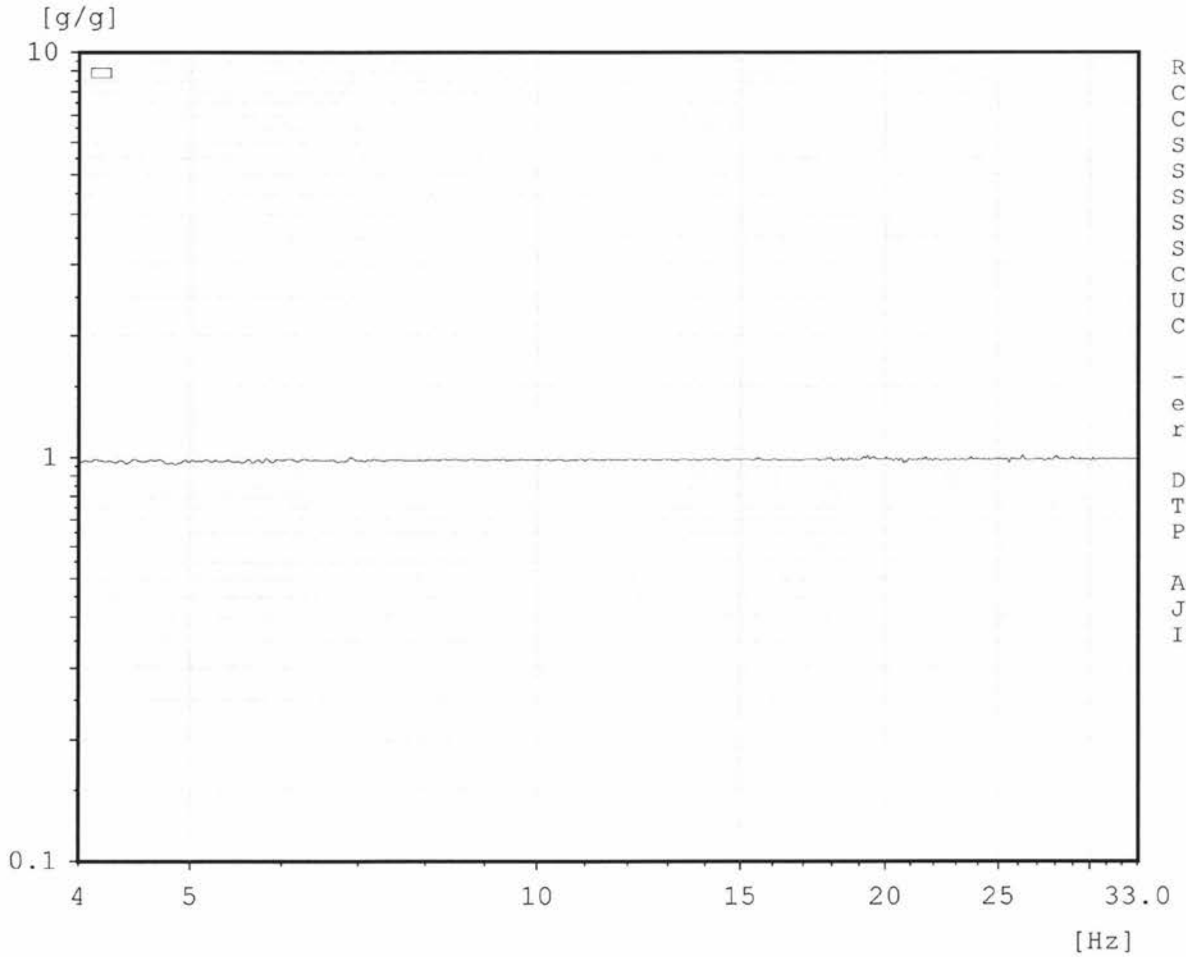
Tech: Steve Palmer
Eng.: J. Sookhdeo Plot: 5A 6

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_003.rsn

Sine

C2 Fixture Bottom vs. Control channel

Axis: Up/Down
Condtion: Fixture Survey



Ref.Chan.type: X
Chan.no: 2
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 13:11:30
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

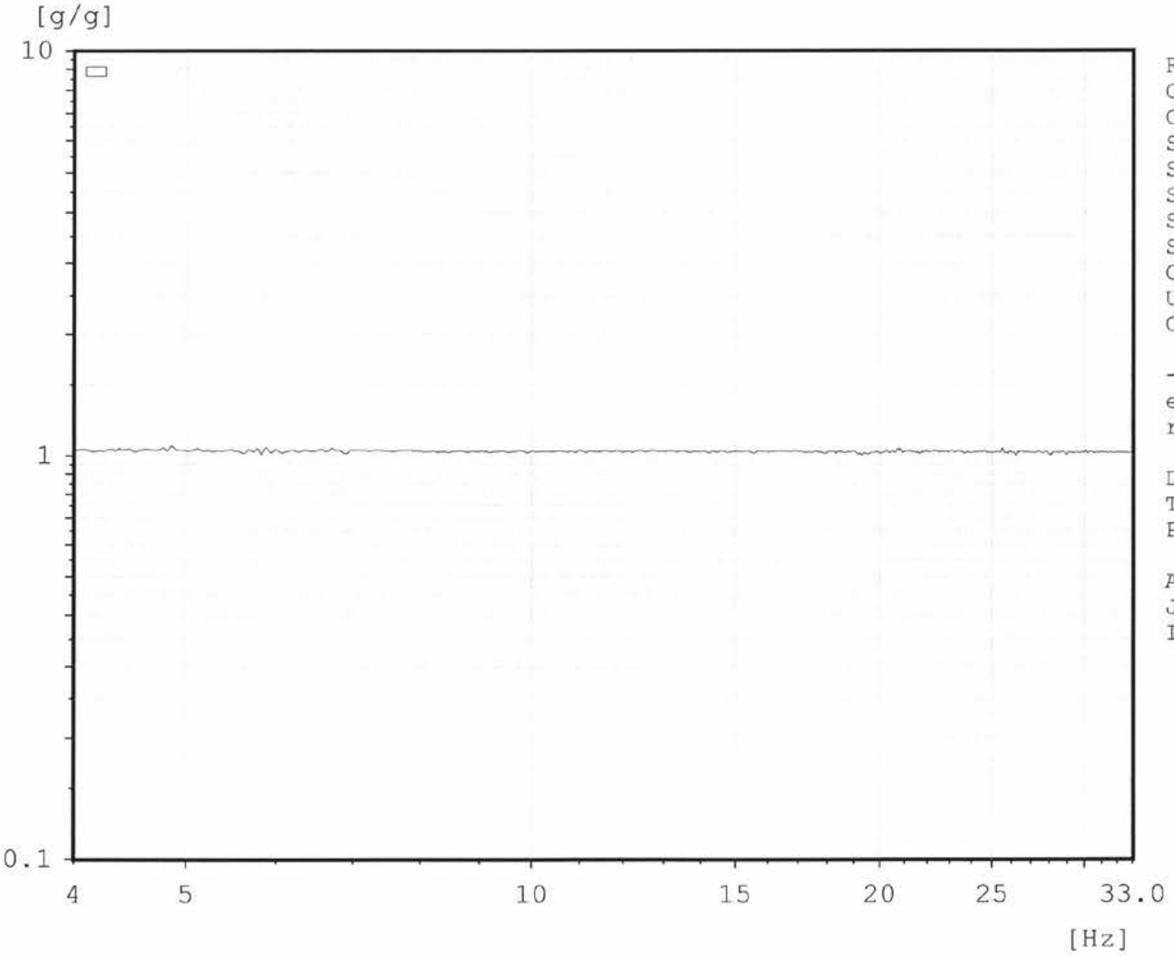
Tech: Steve Palmer
Eng.: J. Sookhdeo Plot: 5A 7

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_003.rsn

Sine

R1 Board 1 Fixture vs. Control channel

Axis: Up/Down
Condtion: Fixture Survey



Ref.Chan.type: X
Chan.no: 3
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 13:11:30
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

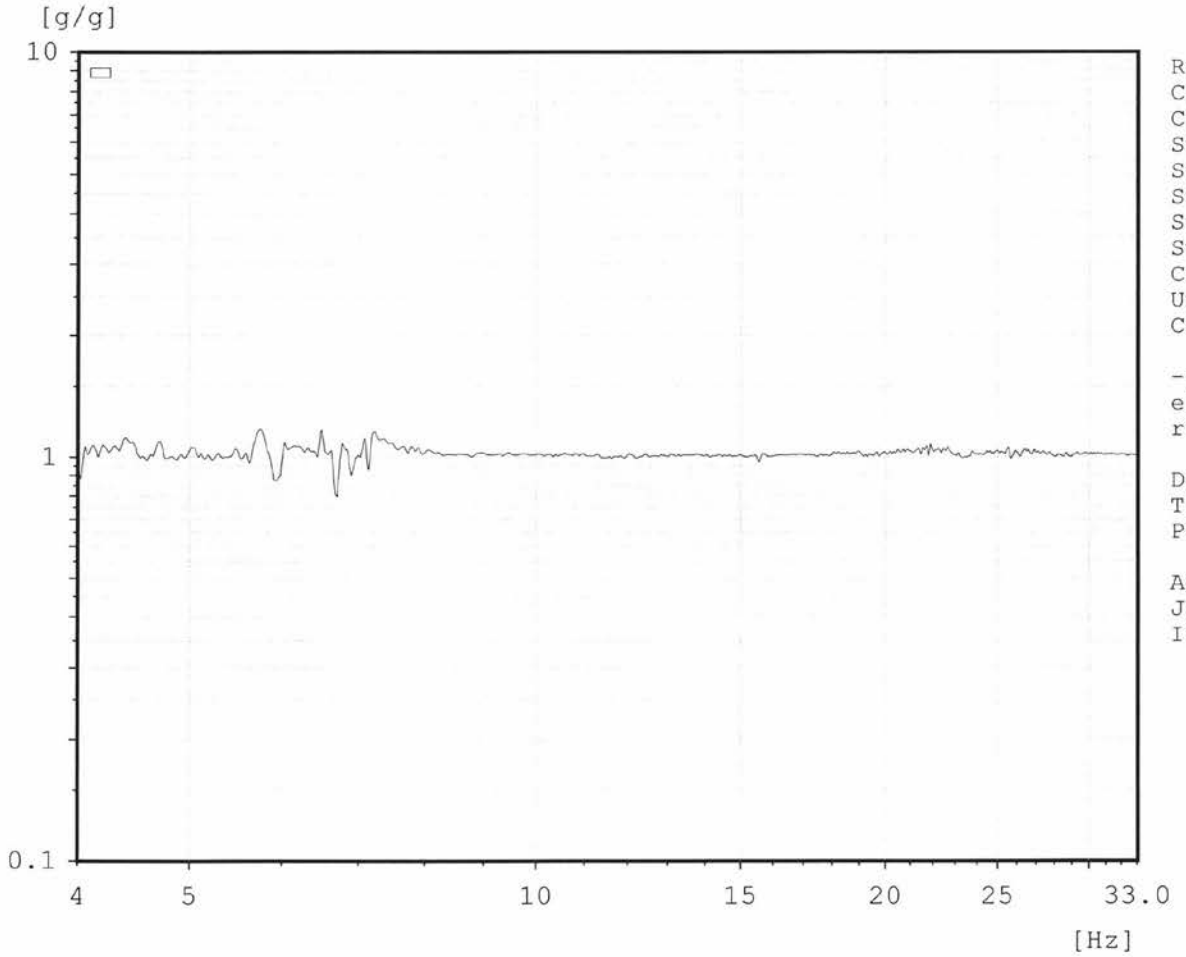
Tech: Steve Palmer
Eng.: J. Sookhdeo Plot: 5A 8

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_003.rsn

Sine

R2 Board 2 Fixture vs. Control channel

Axis: Up/Down
Condtion: Fixture Survey



Ref.Chan.type:	X
Chan.no:	4
Chan.type:	M Filtered
Sweep type:	logarithmic
Sweeps done:	1
Sweeps req.:	1
Sweep direct.:	up
Sweep rate:	1.00 Oct/min
Contr.strat.:	Average
Unit:	g/g
Contr.strat.:	Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 13:11:30
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

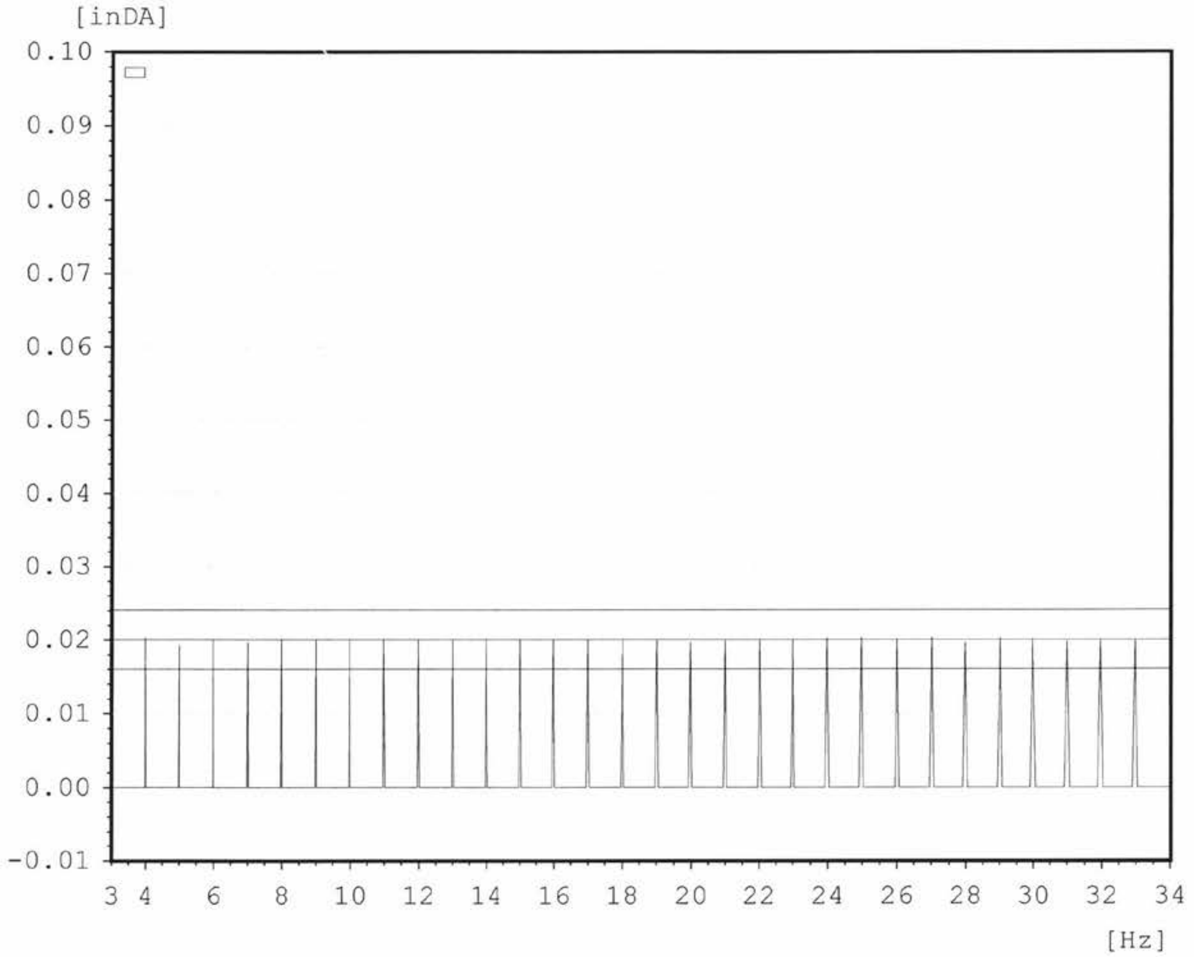
Tech: Steve Palmer
Eng.: J. Sookhdeo Plot: 5A 9

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_003.rsn

Sine Dwell

Control channel (2xintegr)

Axis: up/down
Condition: Exploratory Frequency



Chan.type: X
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:07:30
remaining: 000:00:00

Date: 08-08-14
Time: 15:00:59
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

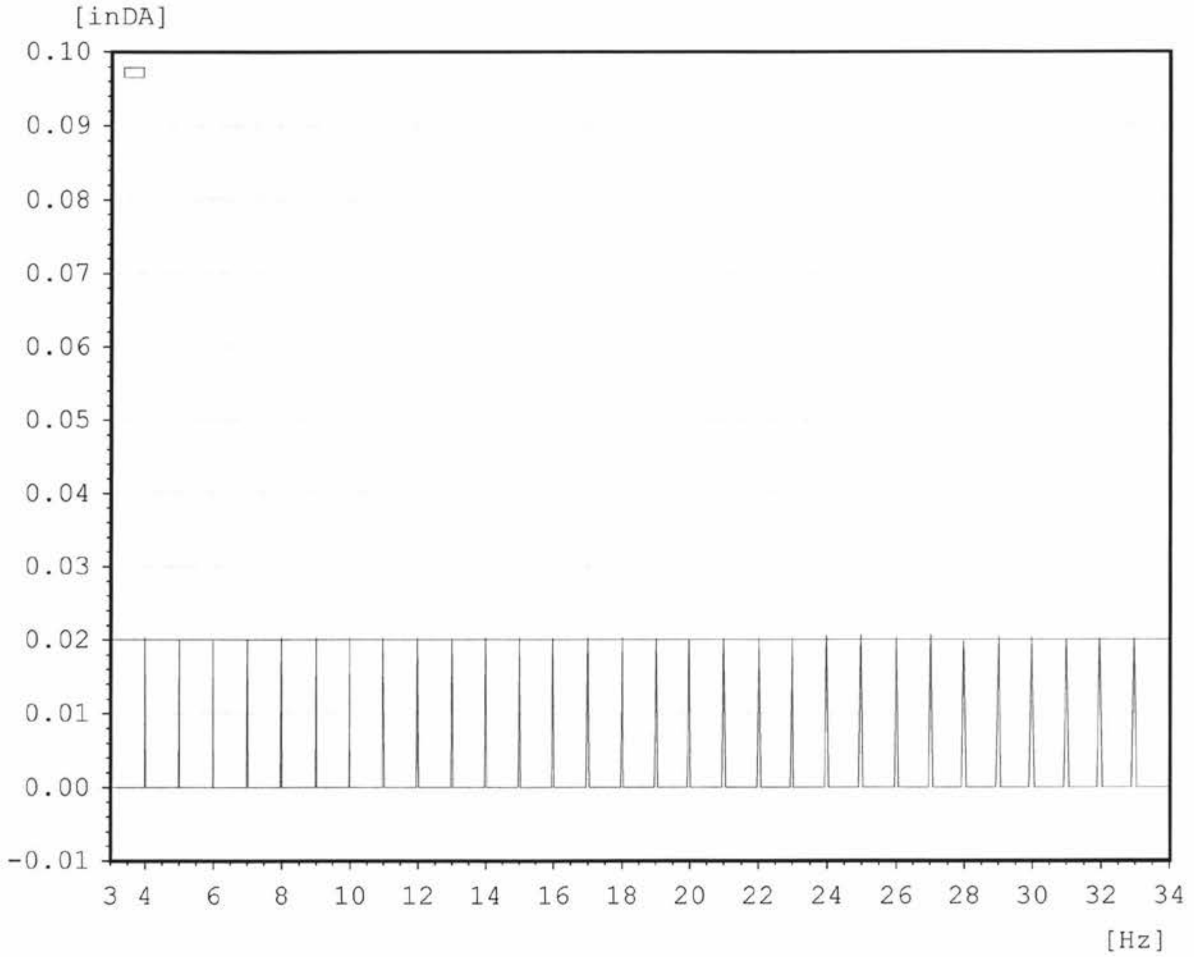
Tech. peter urso
Eng. j. Sookhdeo Plot: 6A

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_002.rsd

Sine Dwell

C1 Fixture top (2xintegr)

Axis: up/down
Condition: Exploratory Frequency



Chan.no: 1
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:07:30
remaining: 000:00:00

Date: 08-08-14
Time: 15:00:59
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

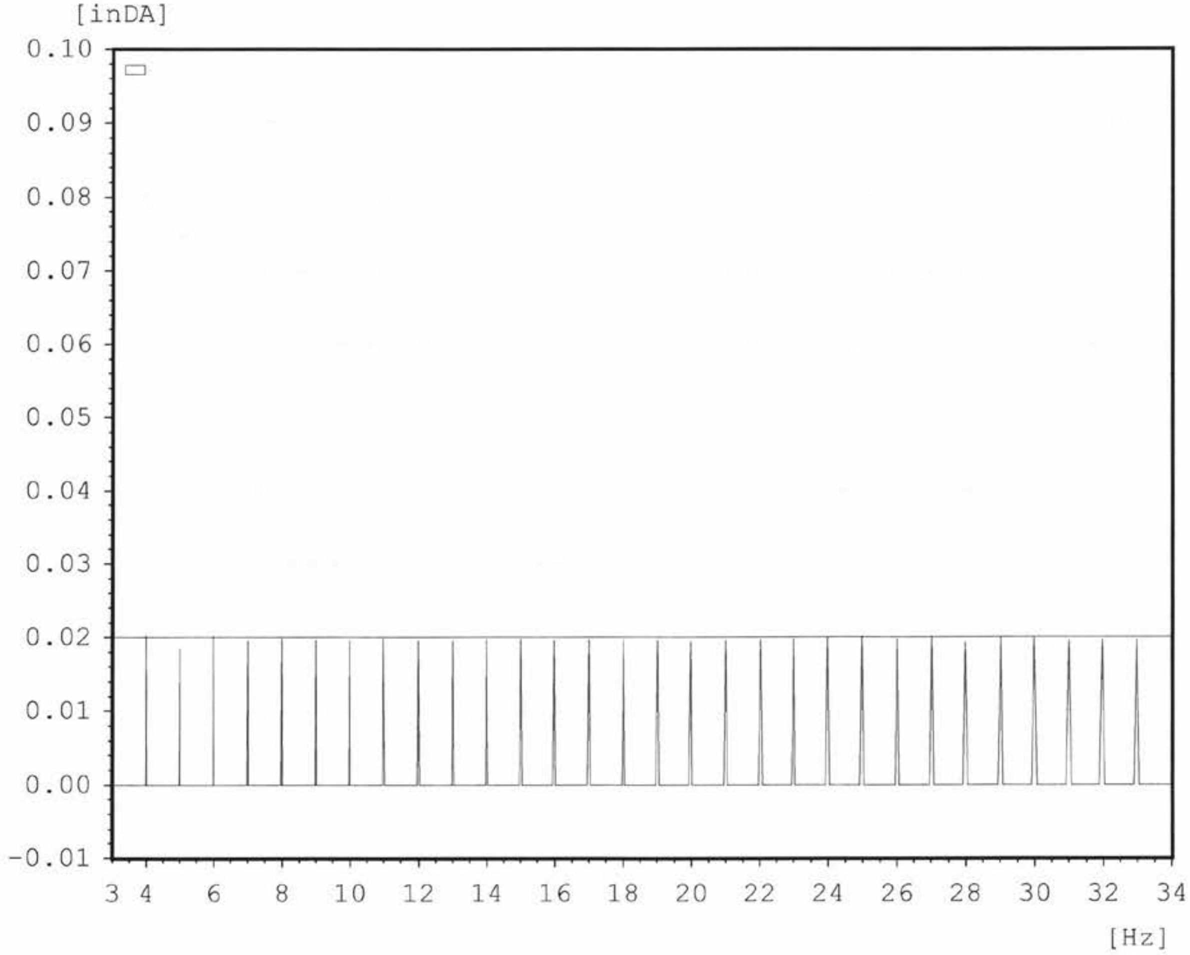
Tech. peter urso
Eng. j. Sookhdeo Plot: 6A 2

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_002.rsd

Sine Dwell

C2 Fixture Bottom (2xintegr)

Axis: up/down
Condition: Exploratory Frequency



Chan.no: 2
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

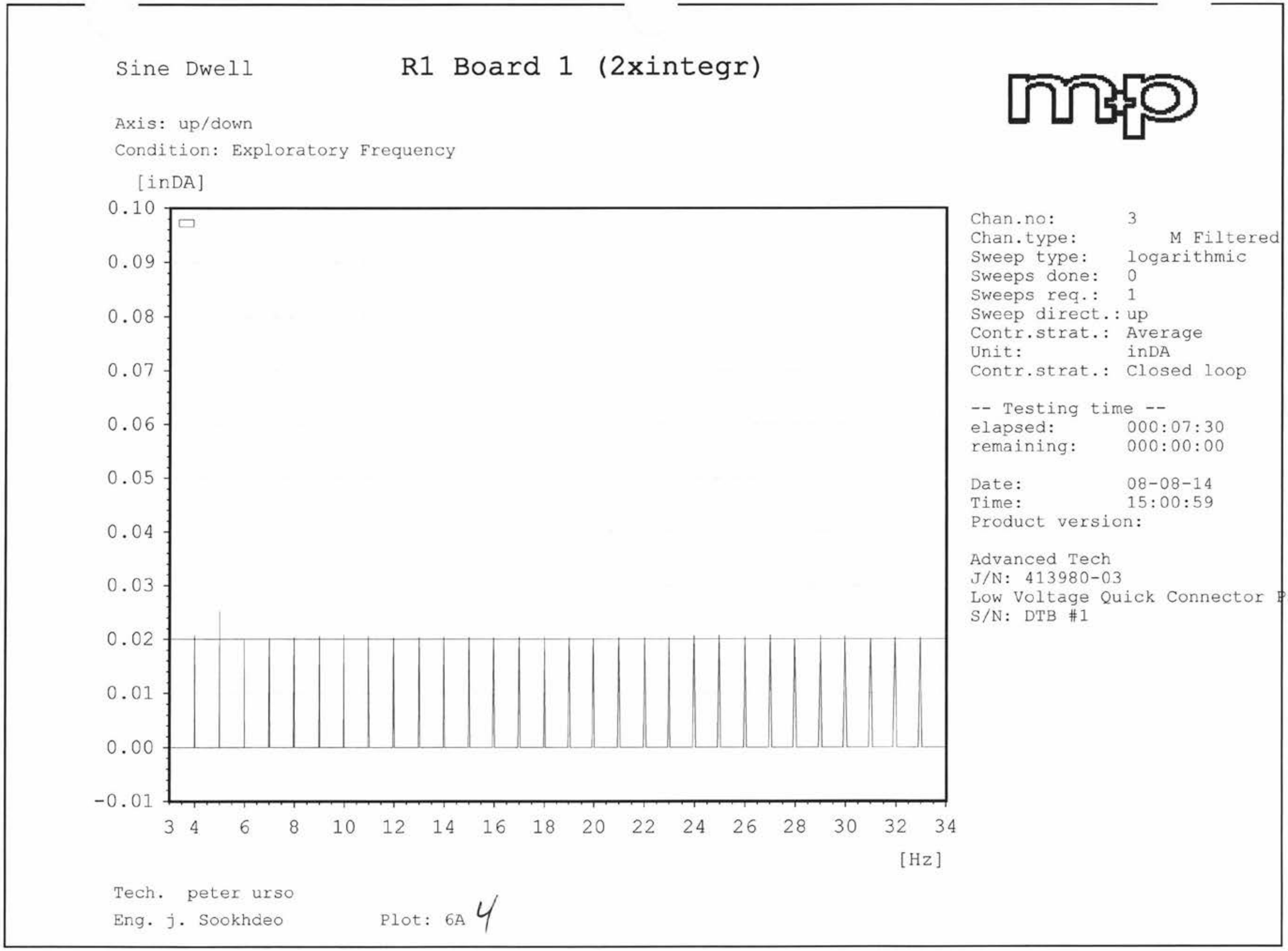
-- Testing time --
elapsed: 000:07:30
remaining: 000:00:00

Date: 08-08-14
Time: 15:00:59
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech. peter urso
Eng. j. Sookhdeo Plot: 6A 3

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_002.rsd



Sine Dwell

R1 Board 1 (2xintegr)

Axis: up/down
Condition: Exploratory Frequency

```
Chan.no:         3
Chan.type:           M Filtered
Sweep type:     logarithmic
Sweeps done:    0
Sweeps req.:    1
Sweep direct.: up
Contr.strat.:  Average
Unit:           inDA
Contr.strat.:  Closed loop

-- Testing time --
elapsed:        000:07:30
remaining:      000:00:00

Date:           08-08-14
Time:           15:00:59
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1
```

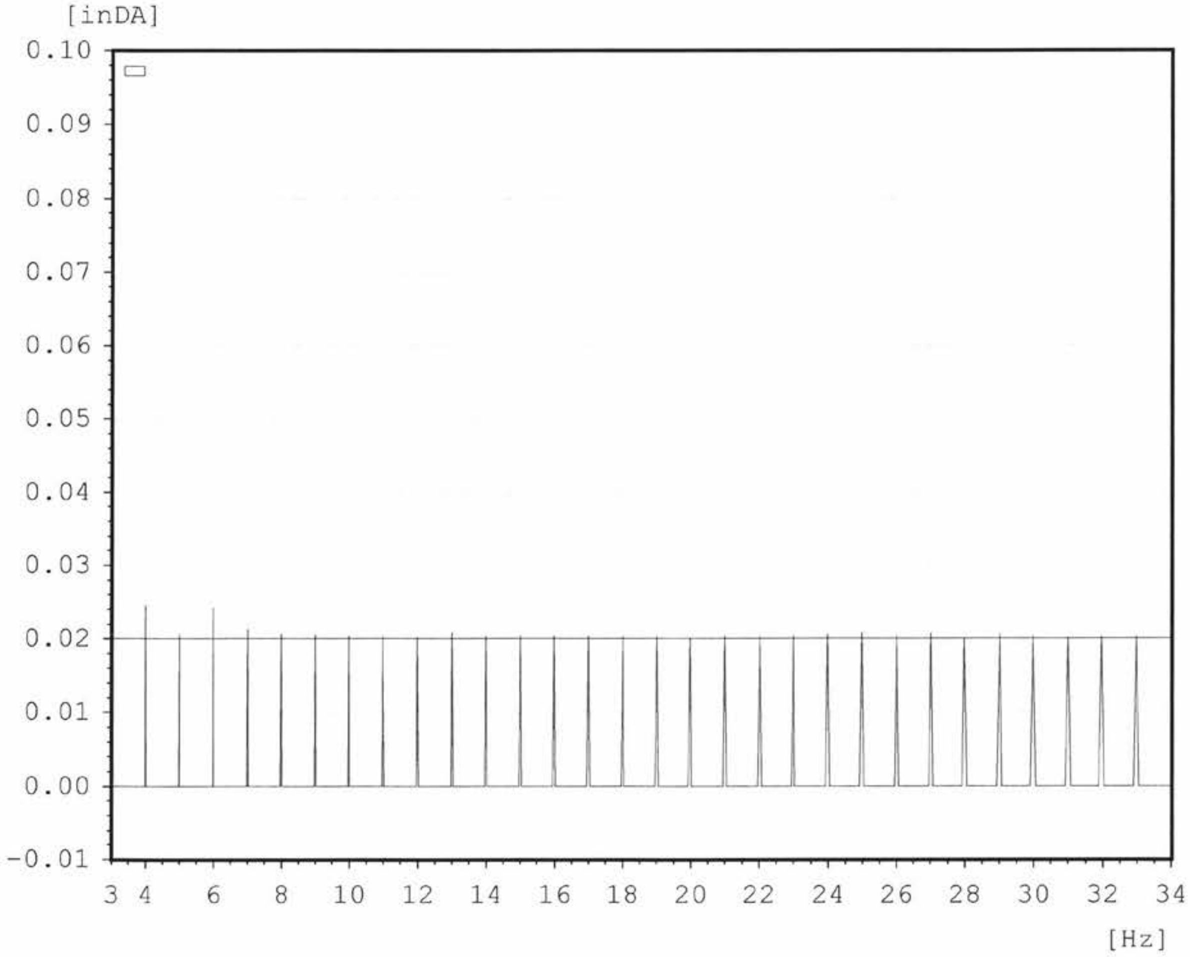
Tech. peter urso
Eng. j. Sookhdeo   Plot: 6A 4

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_002.rsd

Sine Dwell

R2 Board 2 (2xintegr)

Axis: up/down
Condition: Exploratory Frequency



```
Chan.no:        4
Chan.type:          M Filtered
Sweep type:     logarithmic
Sweeps done:    0
Sweeps req.:    1
Sweep direct.:  up
Contr.strat.:   Average
Unit:           inDA
Contr.strat.:   Closed loop

-- Testing time --
elapsed:        000:07:30
remaining:      000:00:00

Date:           08-08-14
Time:           15:00:59
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1
```

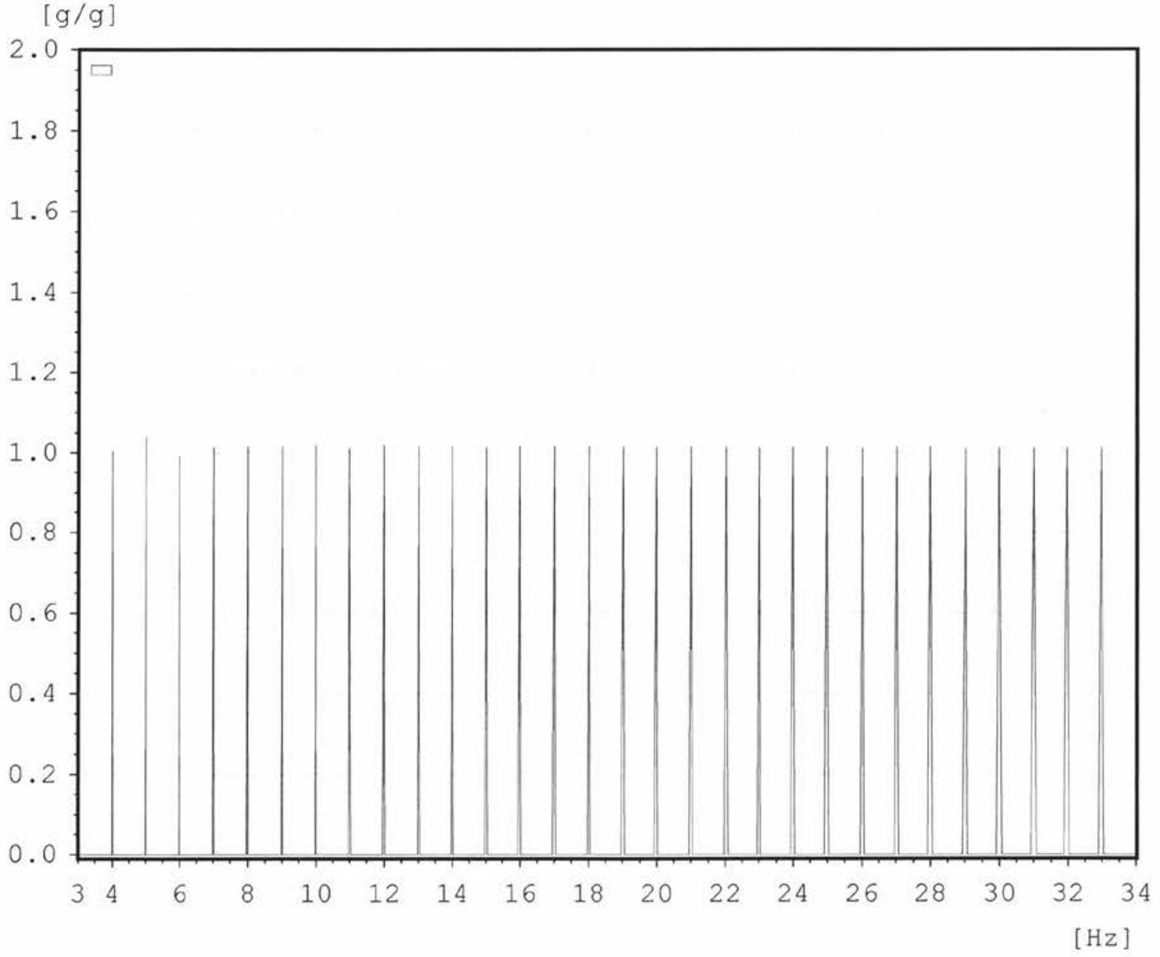
Tech. peter urso
Eng. j. Sookhdeo   Plot: 6A 5

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_002.rsd

Sine Dwell C1 Fixture top vs. Control channel

Axis: up/down

Condition: Exploratory Frequency



```
Ref.Chan.type: X
Chan.no:        1
Chan.type:      CW   Filtered
Sweep type:     logarithmic
Sweeps done:    0
Sweeps req.:    1
Sweep direct.: up
Contr.strat.:  Average
Unit:           g/g
Contr.strat.:  Closed loop

-- Testing time --
elapsed:        000:07:30
remaining:      000:00:00

Date:           08-08-14
Time:           15:00:59
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1
```

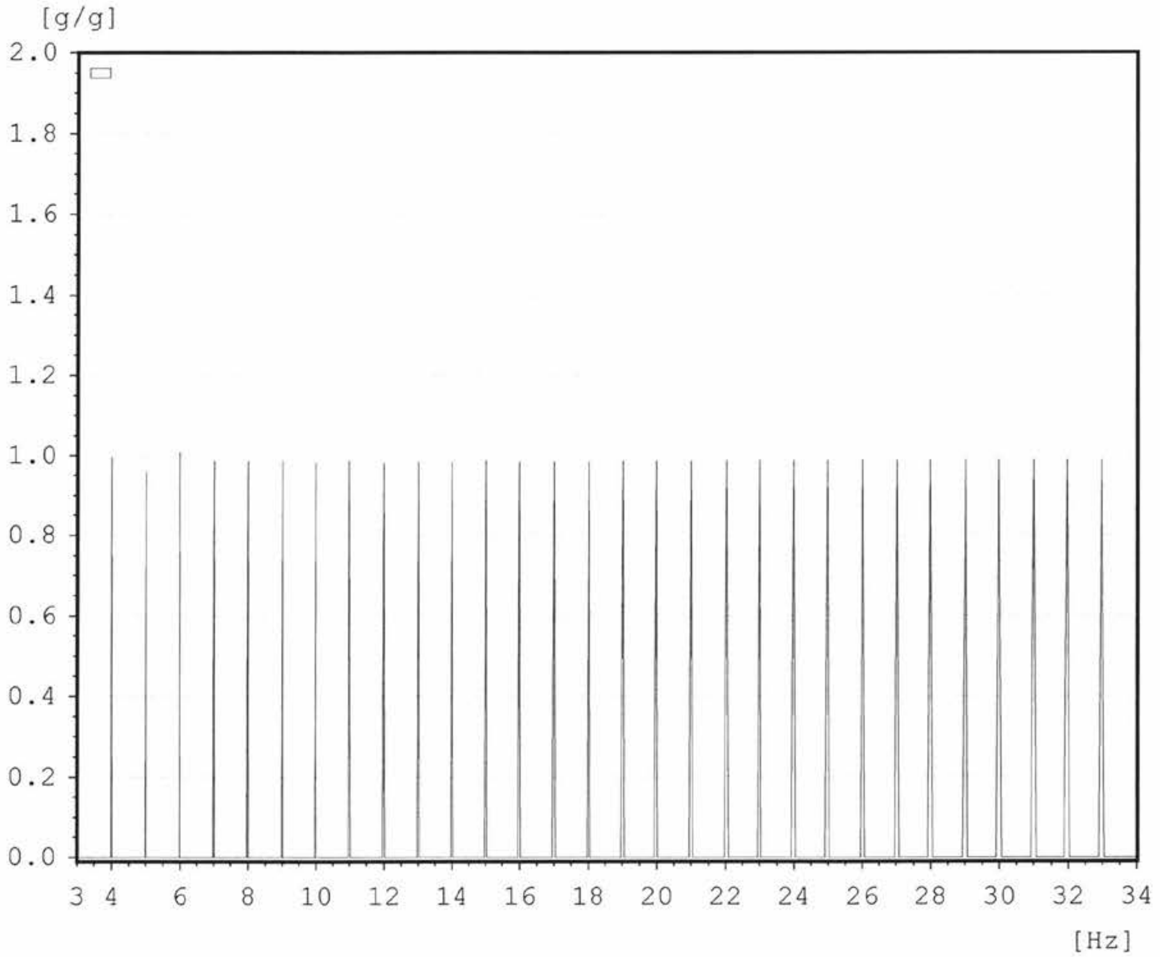
Tech. peter urso

Eng. j. Sookhdeo   Plot: 6A 6

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_002.rsd

Sine Dwell C2 Fixture Bottom vs. Control channel

Axis: up/down
Condition: Exploratory Frequency



Ref.Chan.type: X
Chan.no: 2
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:07:30
remaining: 000:00:00

Date: 08-08-14
Time: 15:00:59
Product version: :

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

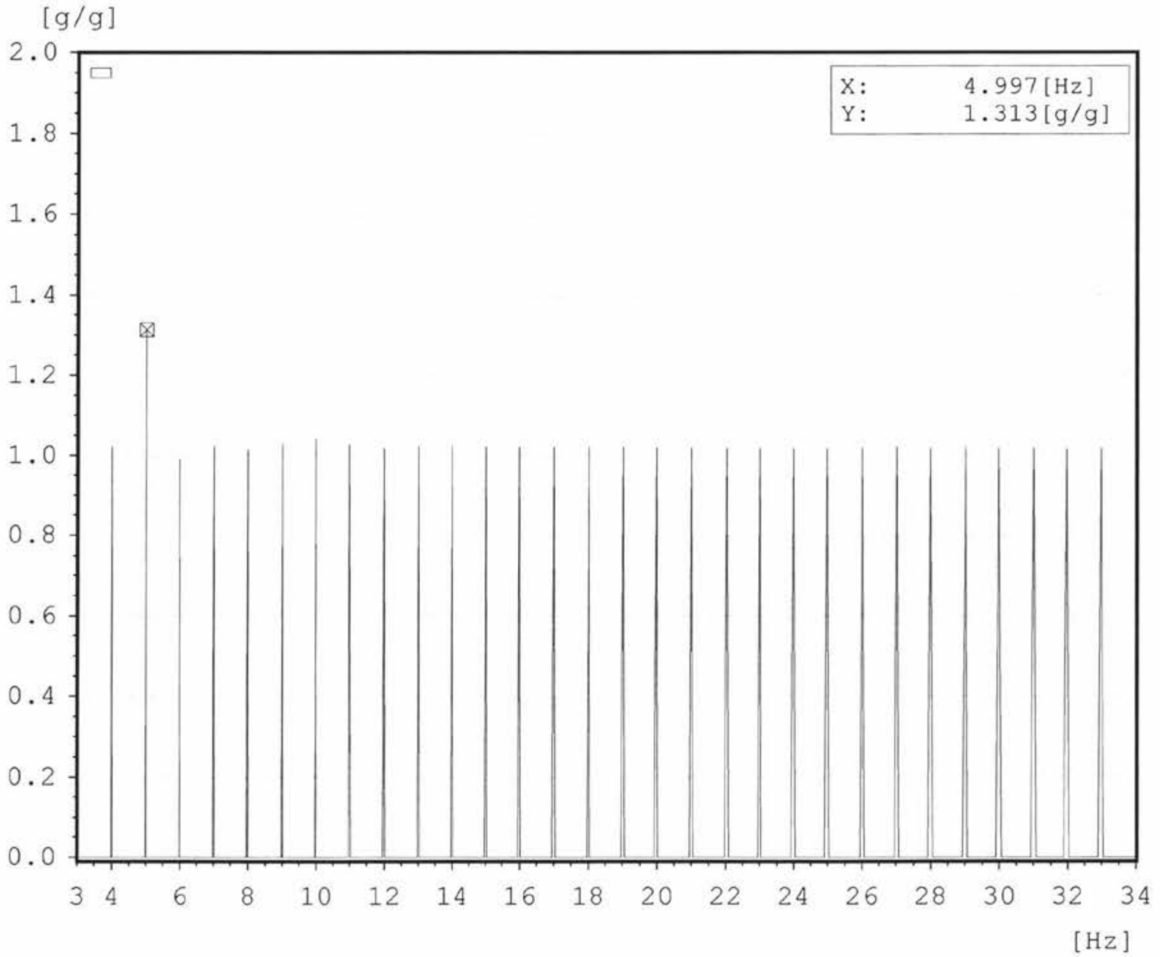
Tech. peter urso
Eng. j. Sookhdeo Plot: 6A 7

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_002.rsd

Sine Dwell

R1 Board 1 vs. Control channel

Axis: up/down
Condition: Exploratory Frequency



Ref.Chan.type: X
Chan.no: 3
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:07:30
remaining: 000:00:00

Date: 08-08-14
Time: 15:00:59
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

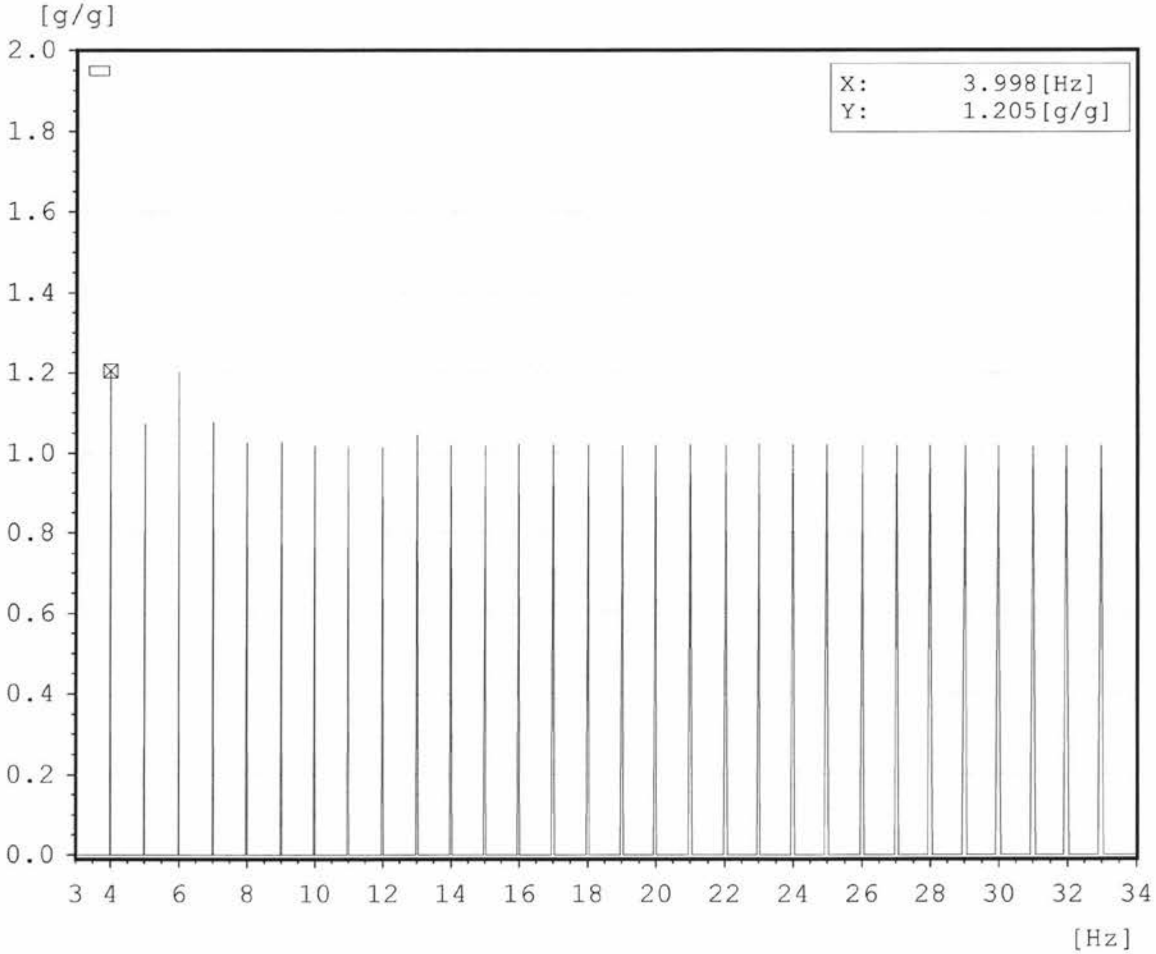
Tech. peter urso
Eng. j. Sookhdeo Plot: 6A 8

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_002.rsd

Sine Dwell

R2 Board 2 vs. Control channel

Axis: up/down
Condition: Exploratory Frequency



Ref.Chan.type: X
Chan.no: 4
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:07:30
remaining: 000:00:00

Date: 08-08-14
Time: 15:00:59
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

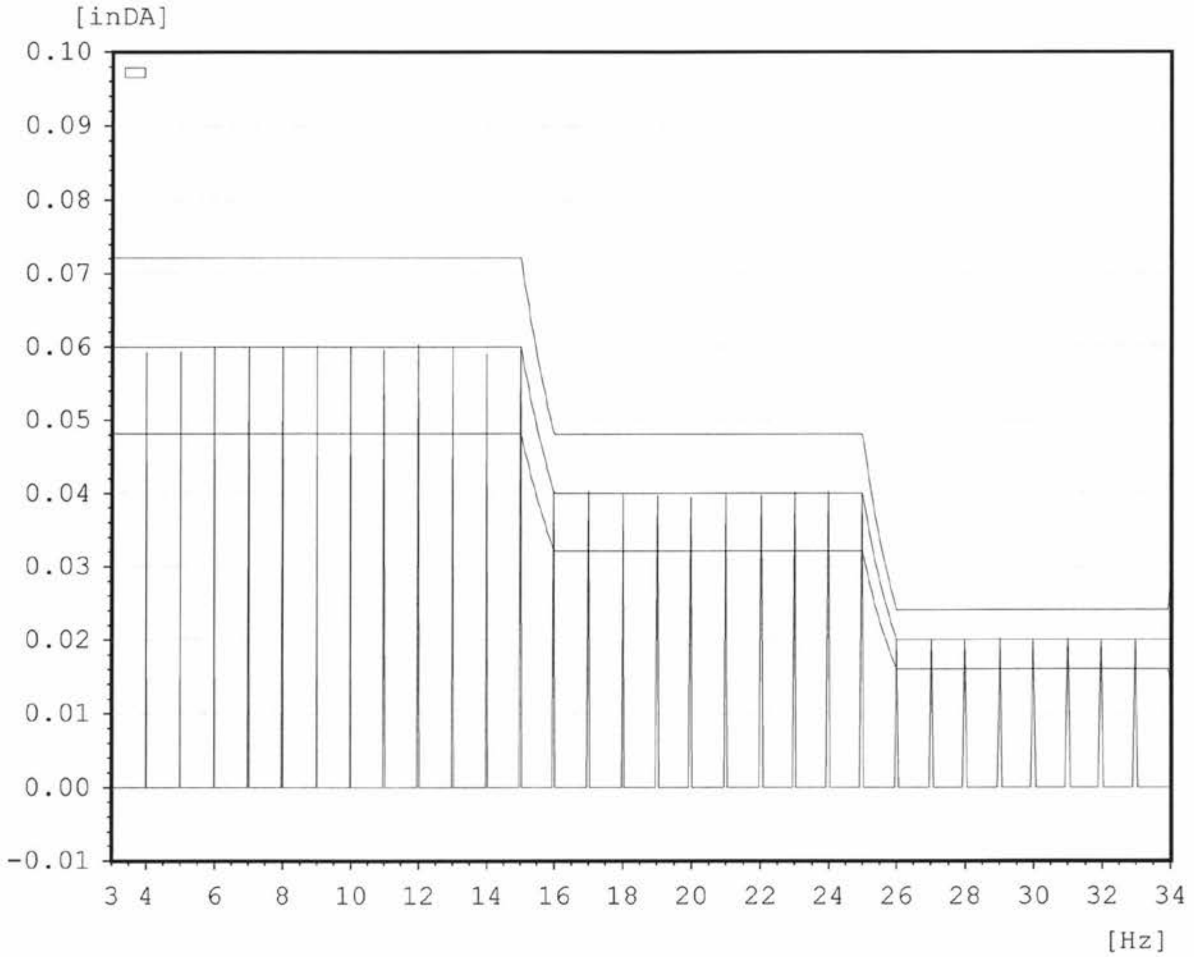
Tech. peter urso
Eng. j. Sookhdeo
Plot: 6A 9

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_002.rsd

Sine Dwell

Control channel (2xintegr)

Axis:Up/Down
Condition: Variable Frequency



Chan.type: X
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:30:00
remaining: 000:00:00

Date: 08-08-14
Time: 17:58:31
Product version:

Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

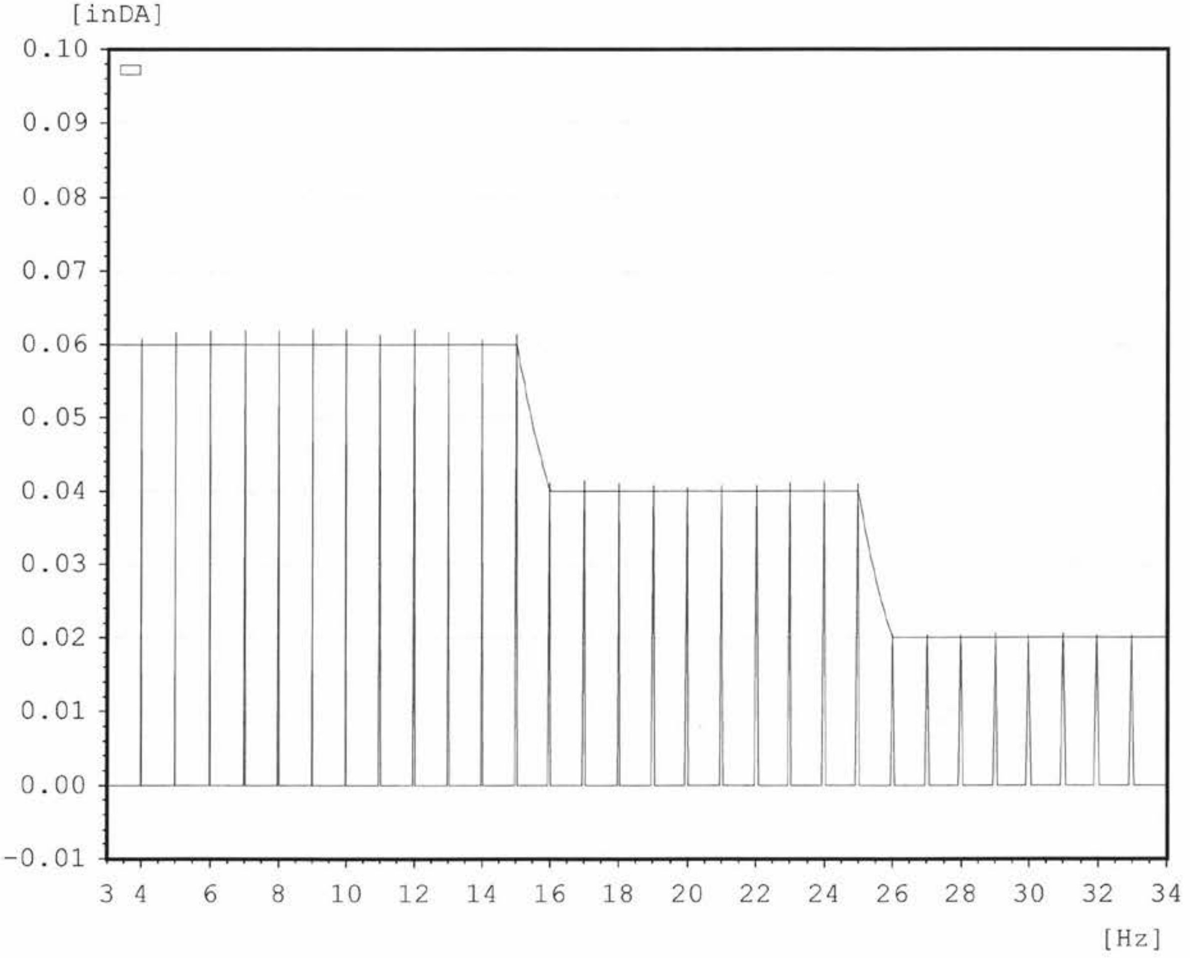
Tech.: F. Baumbach
Engineer: J. Sookhdeo   Plot: 7A /

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_003.rsd

Sine Dwell

C1_Fixture Top (2xintegr)

Axis:Up/Down
Condition: Variable Frequency



Chan.no: 1
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:30:00
remaining: 000:00:00

Date: 08-08-14
Time: 17:58:31
Product version:

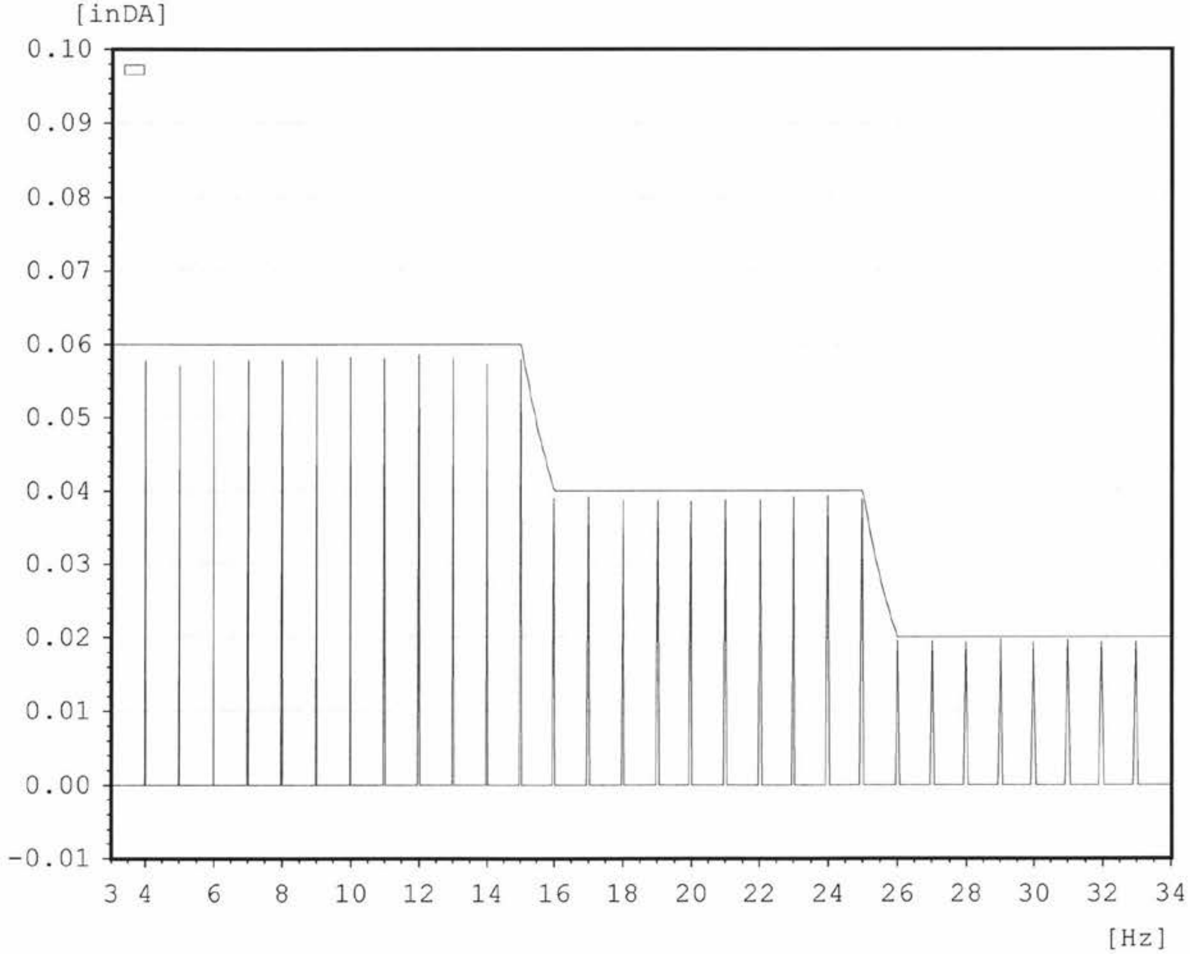
Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 7A 2

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_003.rsd

Sine Dwell **C2 Fixture Bottom (2xintegr)**

Axis:Up/Down
Condition: Variable Frequency



Chan.no:	2
Chan.type:	CW Filtered
Sweep type:	logarithmic
Sweeps done:	0
Sweeps req.:	1
Sweep direct.:	up
Contr.strat.:	Average
Unit:	inDA
Contr.strat.:	Closed loop

-- Testing time --
elapsed: 002:30:00
remaining: 000:00:00

Date: 08-08-14
Time: 17:58:31
Product version:

Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 7A 3

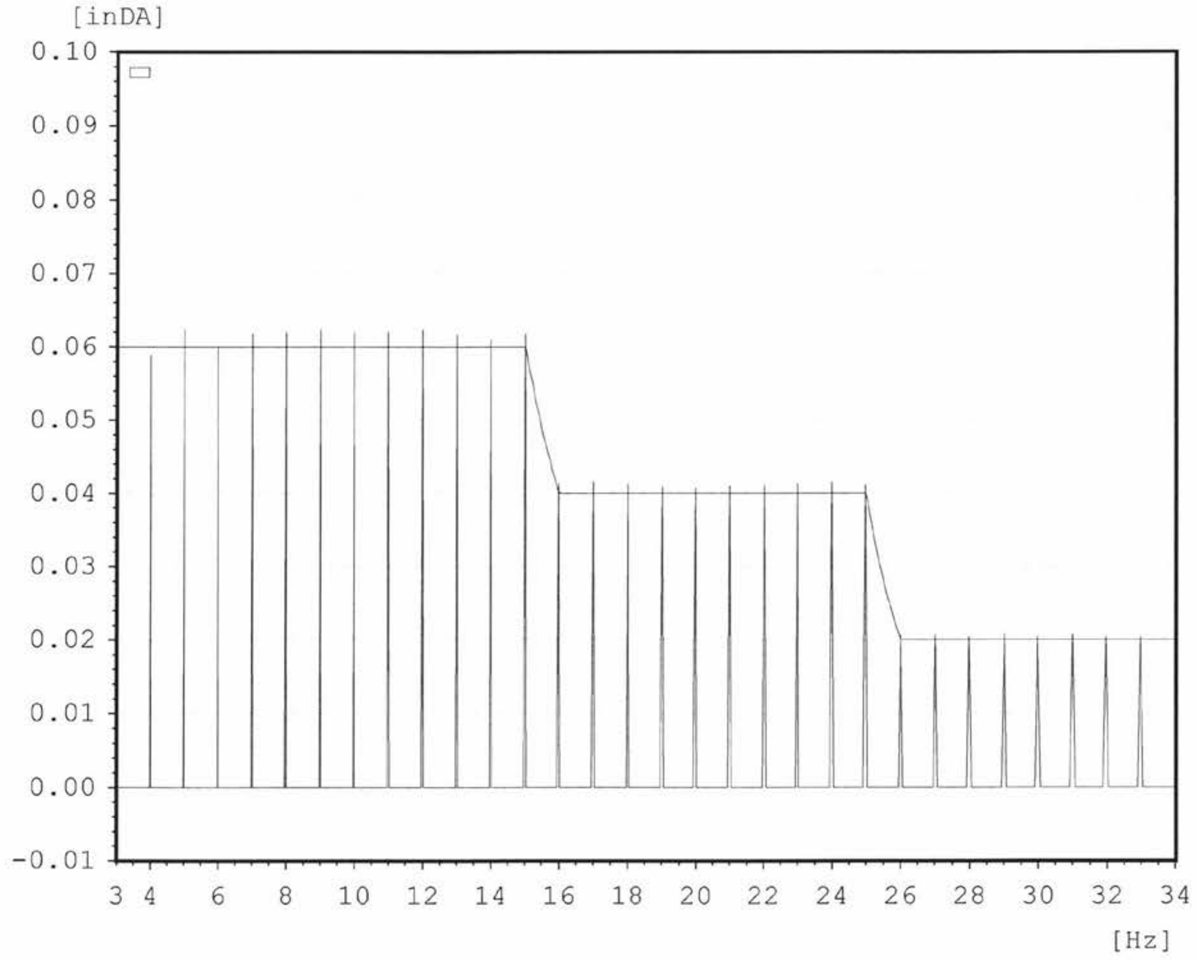
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_003.rsd

Sine Dwell

R1 Board 1 (2xintegr)

Axis:Up/Down

Condition: Variable Frequency



Chan.no: 3
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:30:00
remaining: 000:00:00

Date: 08-08-14
Time: 17:58:31
Product version:

Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

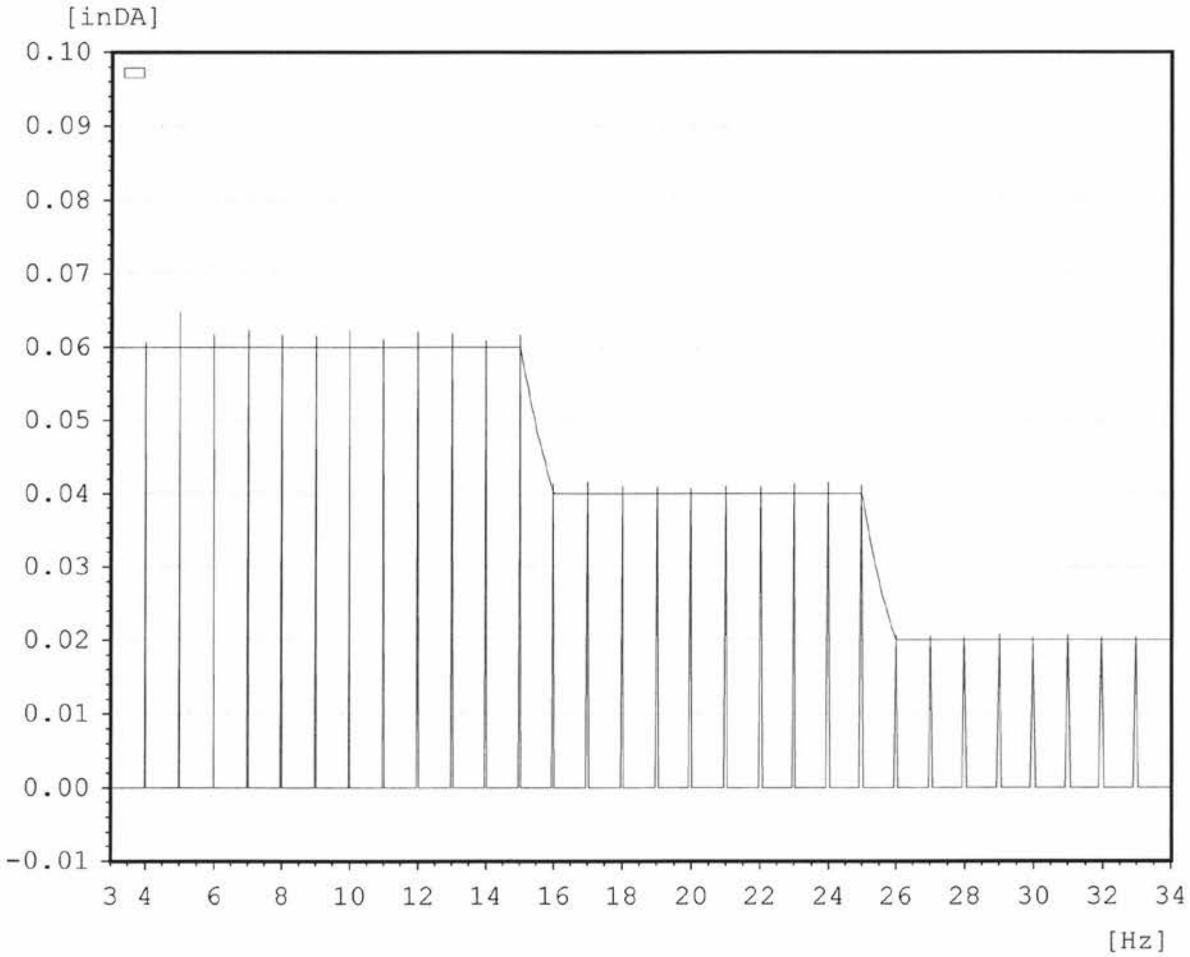
Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 7A4

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_003.rsd

Sine Dwell

R2 Board 2 (2xintegr)

Axis:Up/Down
Condition: Variable Frequency



Chan.no: 4
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:30:00
remaining: 000:00:00

Date: 08-08-14
Time: 17:58:31
Product version:

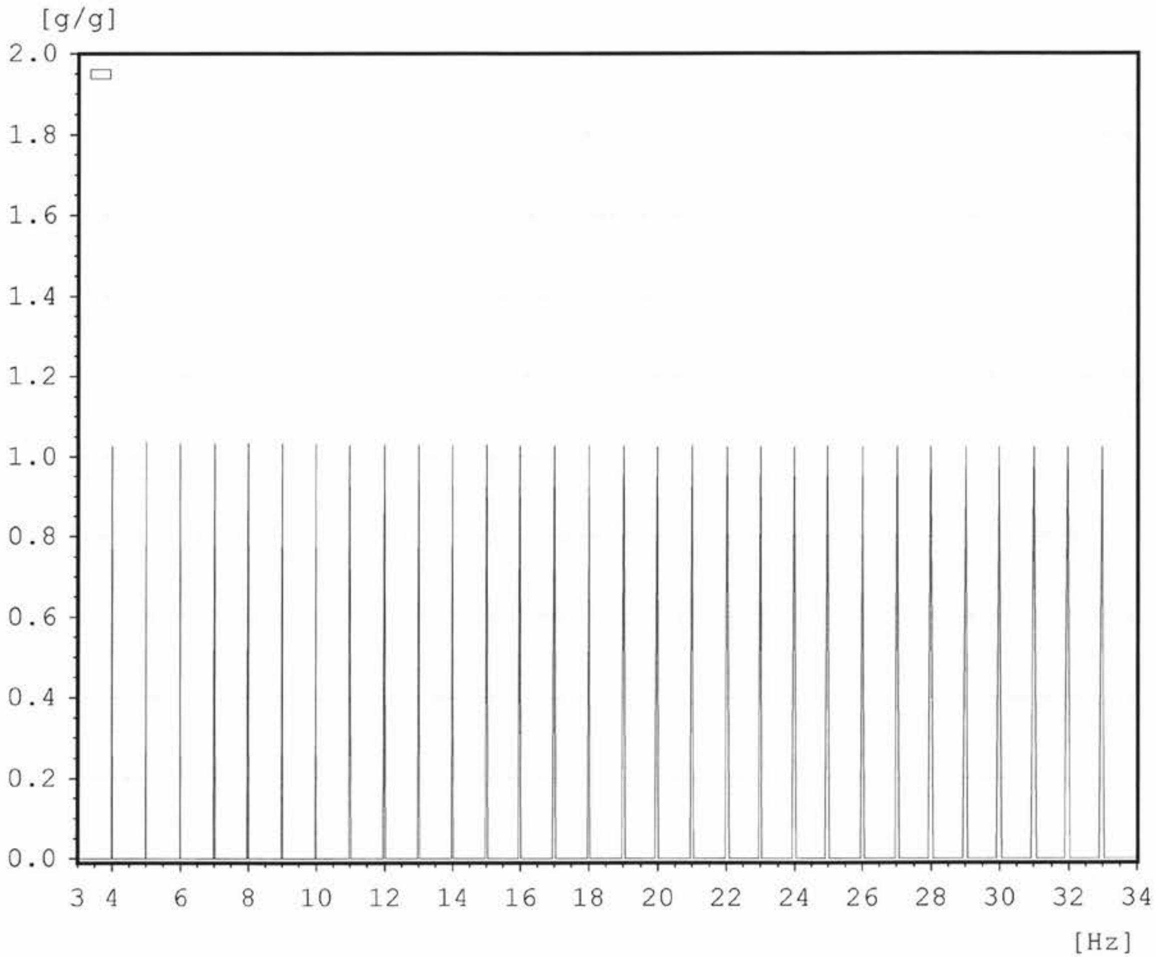
Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach
Engineer: J. Sookhdeo
Plot: 7A 5

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_003.rsd

Sine Dwell C1_Fixture Top vs. Control channel

Axis:Up/Down
Condition: Variable Frequency



Ref.Chan.type: X
Chan.no: 1
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:30:00
remaining: 000:00:00

Date: 08-08-14
Time: 17:58:31
Product version:

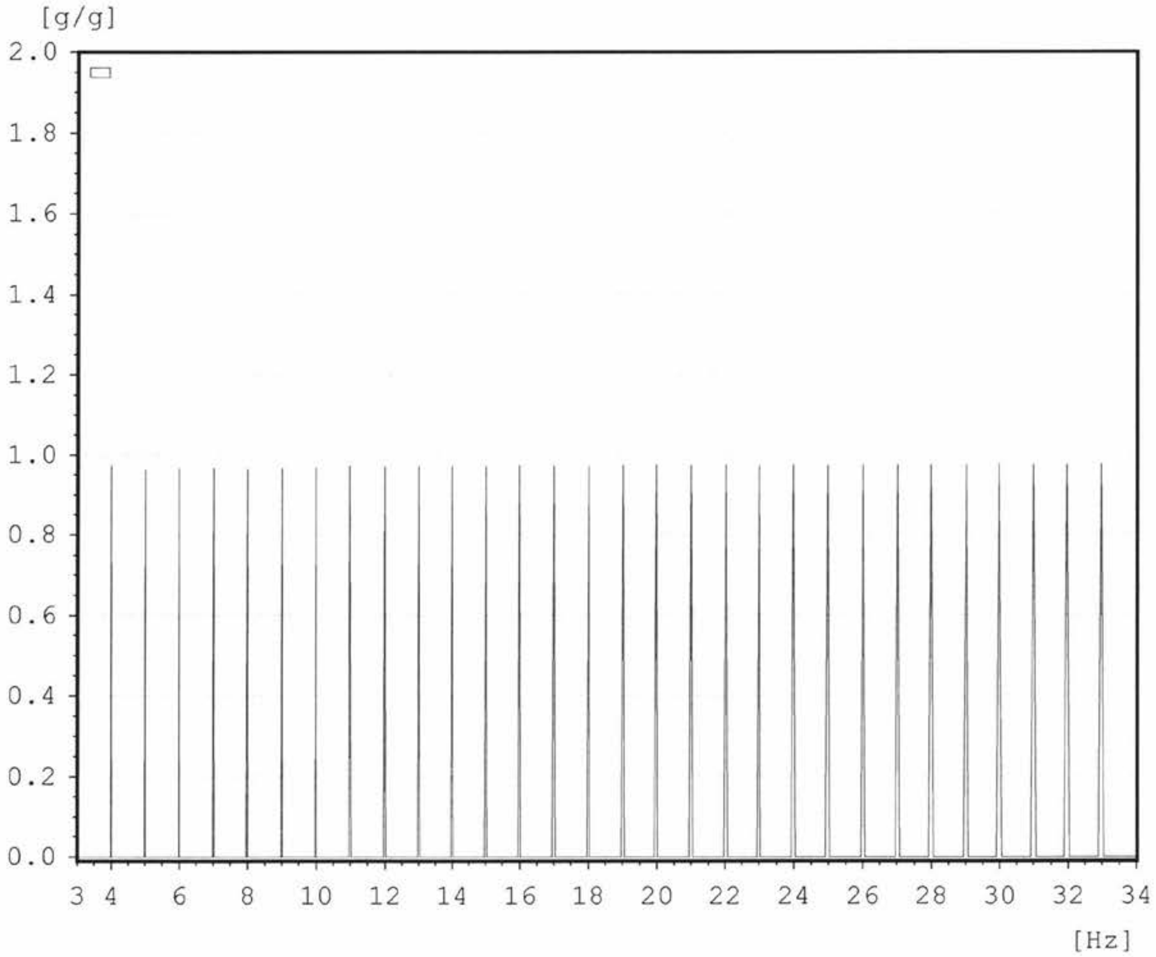
Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 7A 6

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_003.rsd

Sine DwellC2 **Fixture Bottom vs. Control channel**

Axis:Up/Down
Condition: Variable Frequency



Ref.Chan.type: X
Chan.no: 2
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:30:00
remaining: 000:00:00

Date: 08-08-14
Time: 17:58:31
Product version:

Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

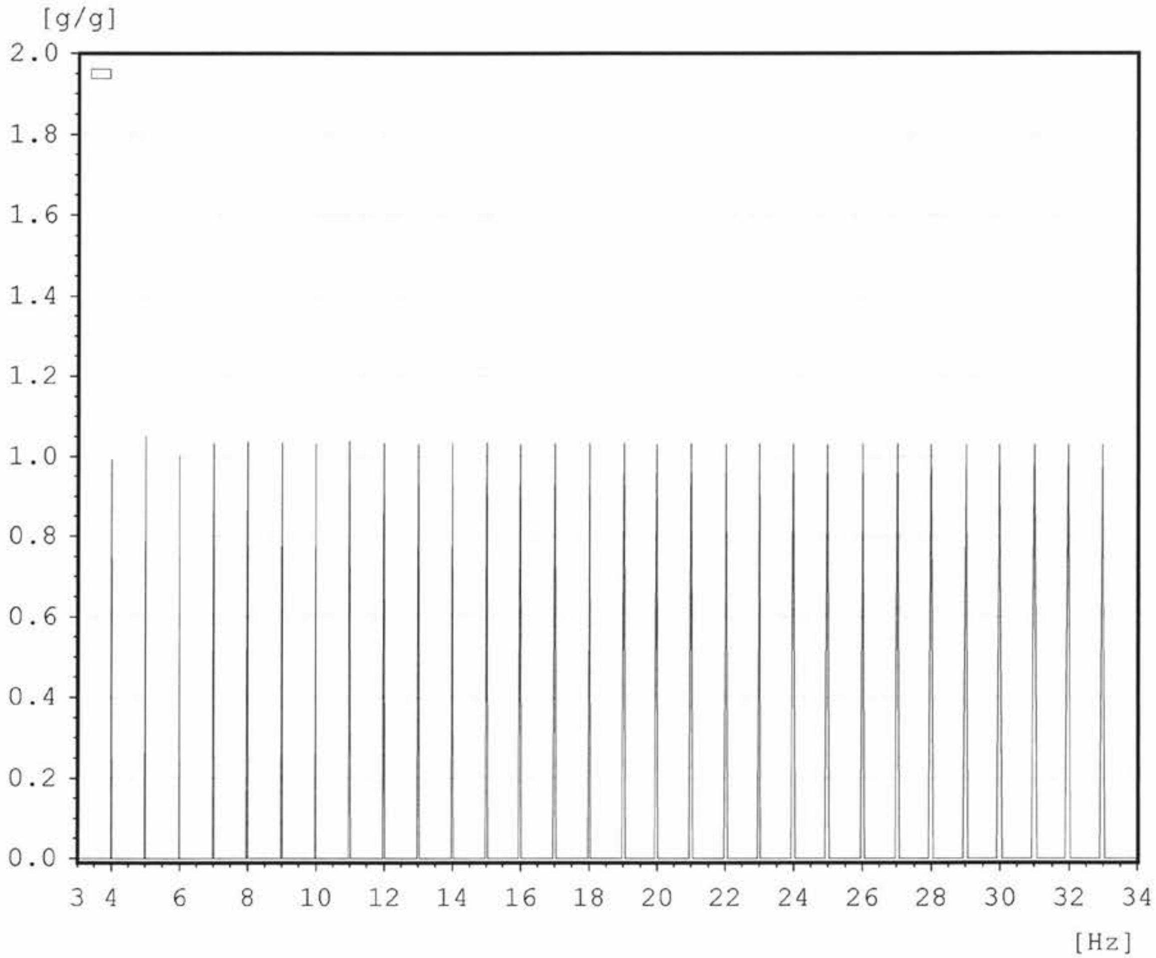
Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 7A 7

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_003.rsd

Sine Dwell

R1 Board 1 vs. Control channel

Axis:Up/Down
Condition: Variable Frequency



```
Ref.Chan.type: X
Chan.no:        3
Chan.type:          M Filtered
Sweep type:     logarithmic
Sweeps done:    0
Sweeps req.:    1
Sweep direct.: up
Contr.strat.:  Average
Unit:           g/g
Contr.strat.:  Closed loop

-- Testing time --
elapsed:        002:30:00
remaining:      000:00:00

Date:           08-08-14
Time:           17:58:31
Product version:

 Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1
```

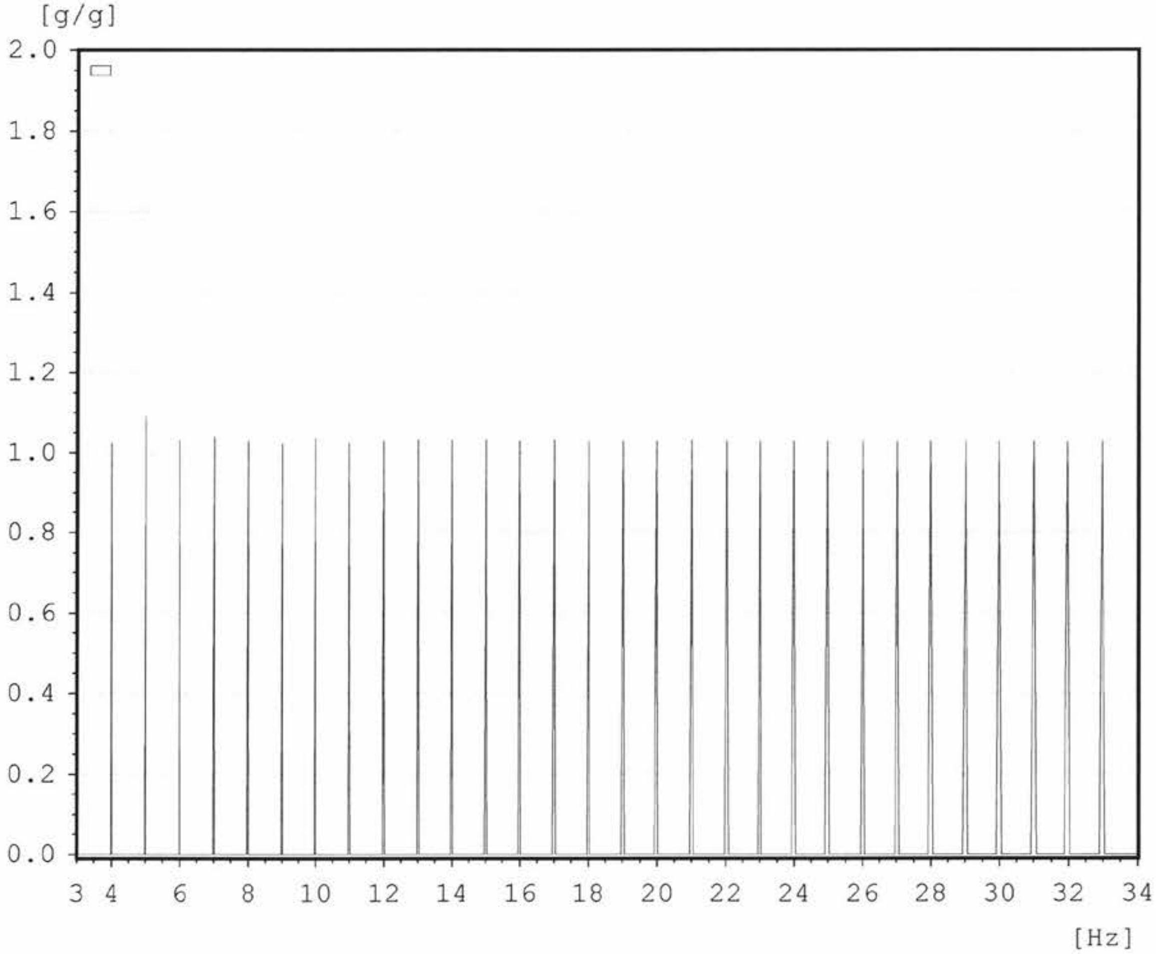
Tech.: F. Baumbach
Engineer: J. Sookhdeo   Plot: 7A8

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_003.rsd

Sine Dwell

R2 Board 2 vs. Control channel

Axis:Up/Down
Condition: Variable Frequency



Ref.Chan.type: X
Chan.no: 4
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:30:00
remaining: 000:00:00

Date: 08-08-14
Time: 17:58:31
Product version:

Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

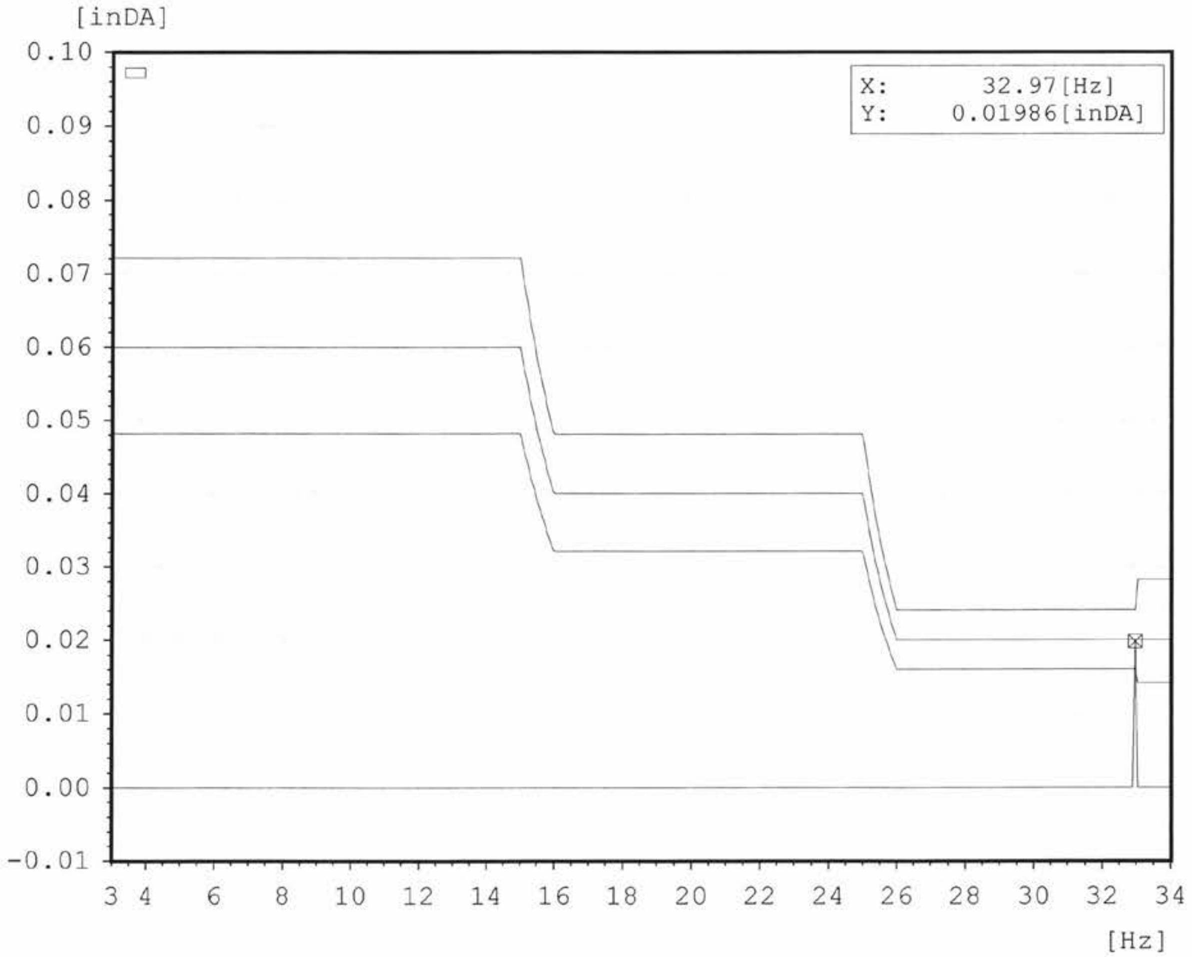
Tech.: F. Baumbach
Engineer: J. Sookhdeo
Plot: 7A 9

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_003.rsd

Sine Dwell

Control channel (2xintegr)

Axis: Up/Down
Condition: Endurance



Chan.type: X
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-08-14
Time: 20:21:28
Product version:

AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

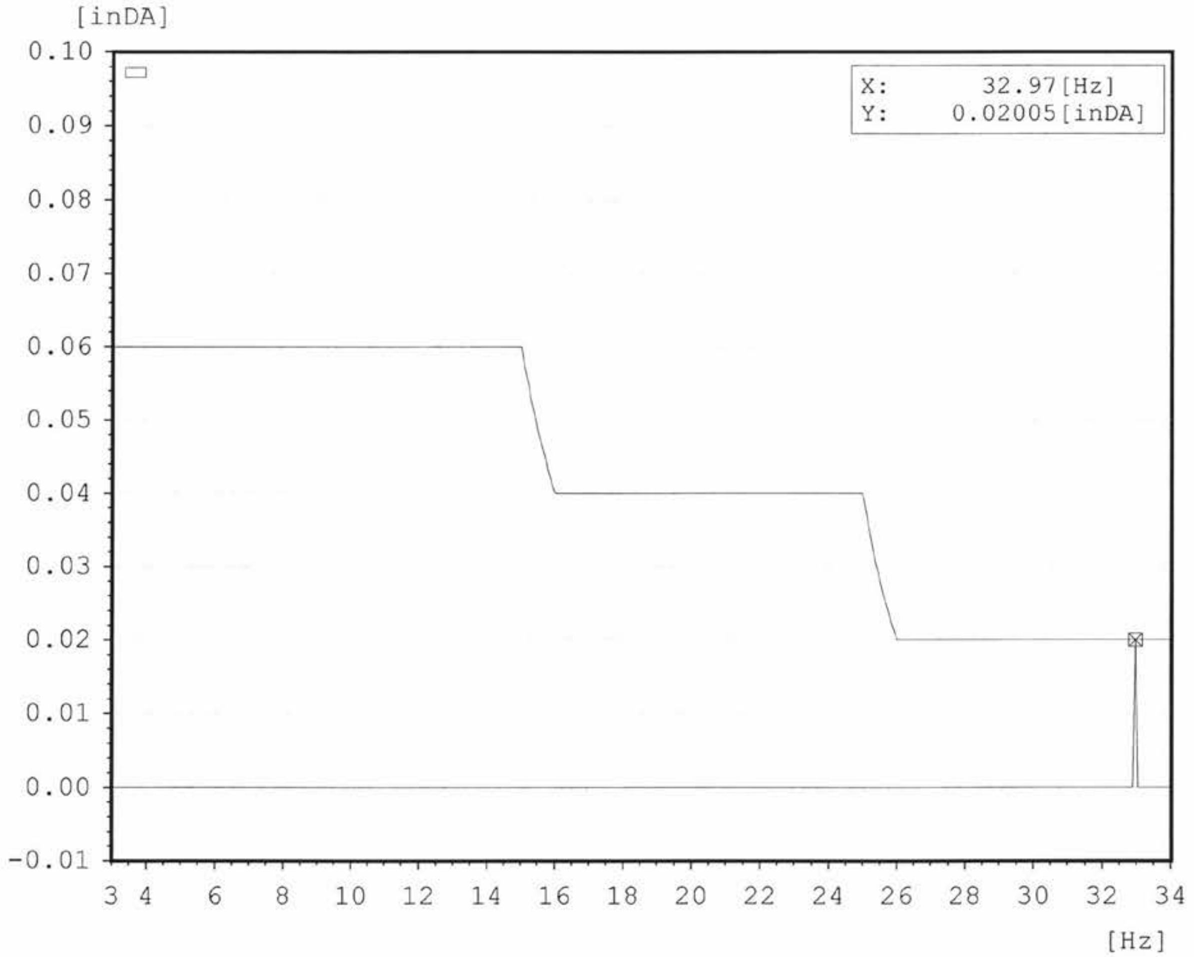
Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 8A

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_003.rsd

Sine Dwell

C1 Fixture Top (2xintegr)

Axis: Up/Down
Condition: Endurance



Chan.no: 1
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-08-14
Time: 20:21:28
Product version:

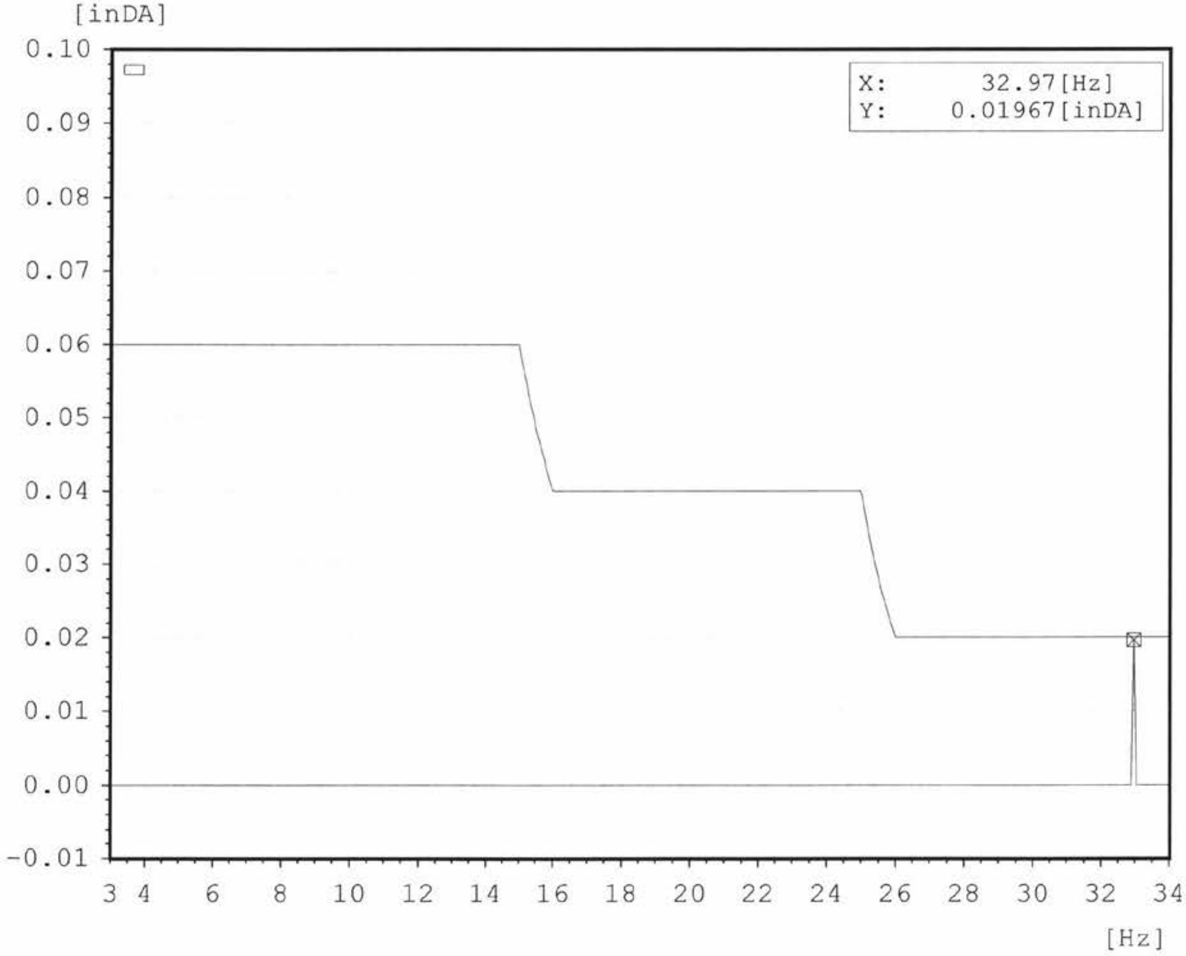
AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 8A 20

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_003.rsd

Sine Dwell **C2 Fixture Bottom (2xintegr)**

Axis: Up/Down
Condition: Endurance



Chan.no: 2
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-08-14
Time: 20:21:28
Product version:

AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

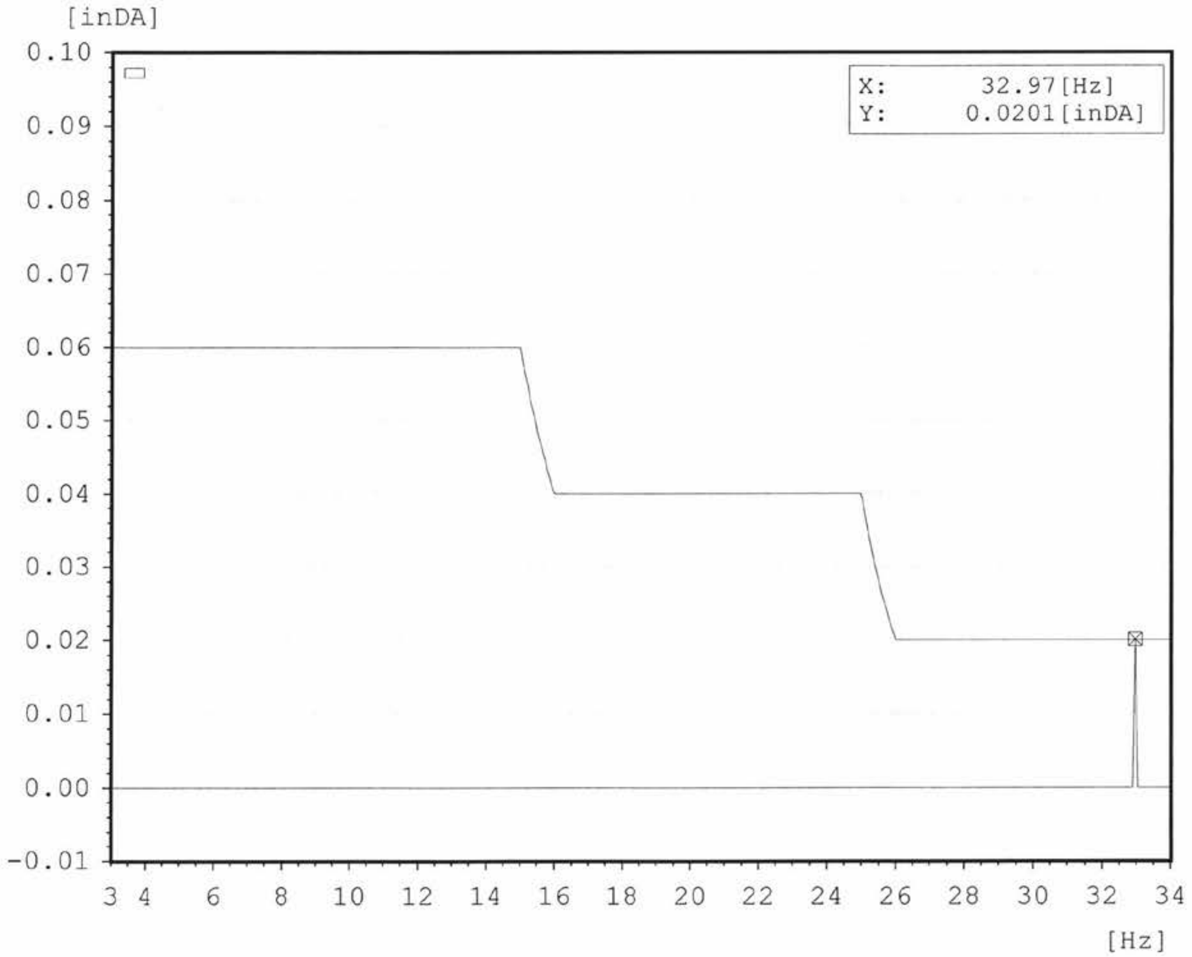
Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 8A 3

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_003.rsd

Sine Dwell

R1 Board 1 (2xintegr)

Axis: Up/Down
Condition: Endurance



Chan.no: 3
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-08-14
Time: 20:21:28
Product version:

AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

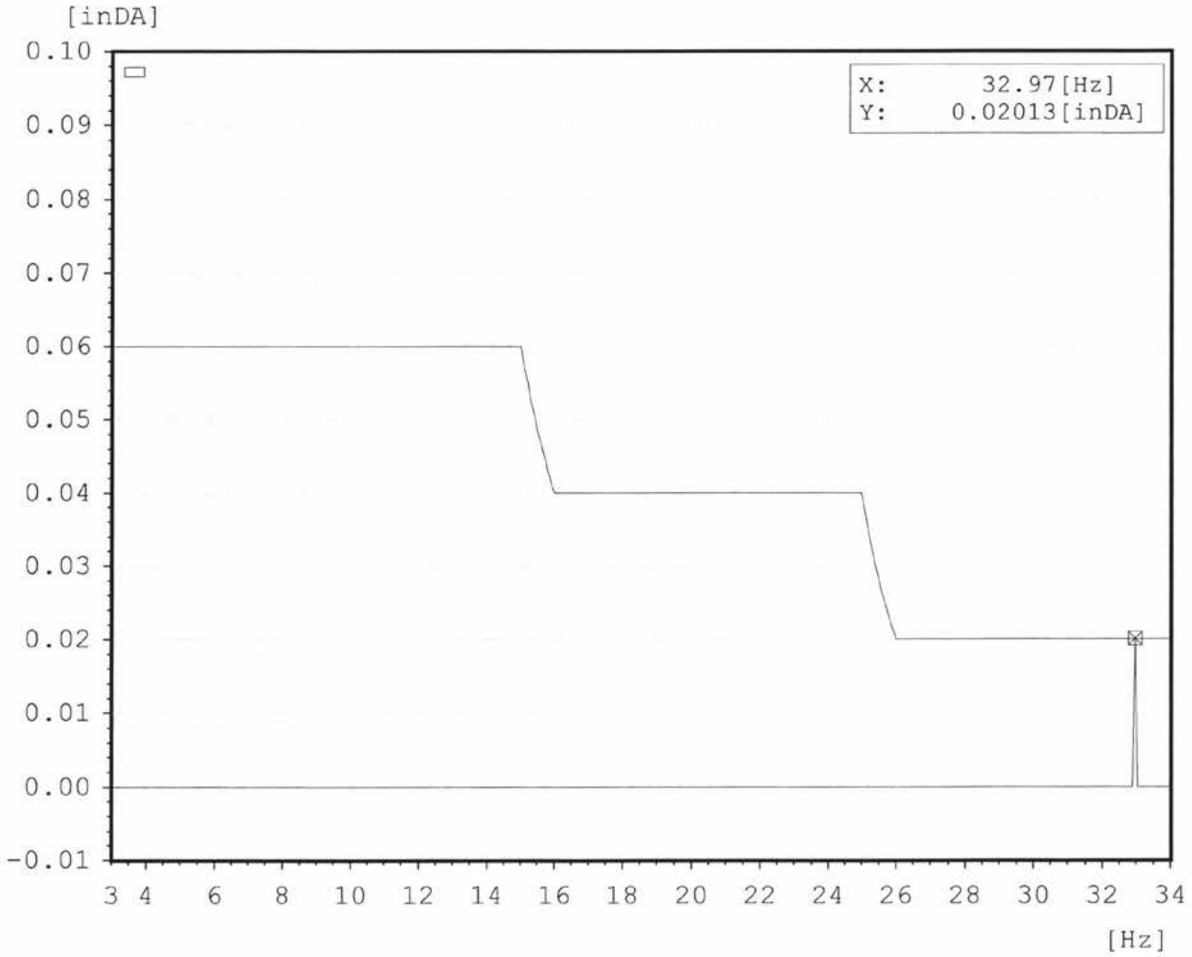
Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 8A 4

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_003.rsd

Sine Dwell

R2 Board 2 (2xintegr)

Axis: Up/Down
Condition: Endurance



Chan.no: 4
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-08-14
Time: 20:21:28
Product version:

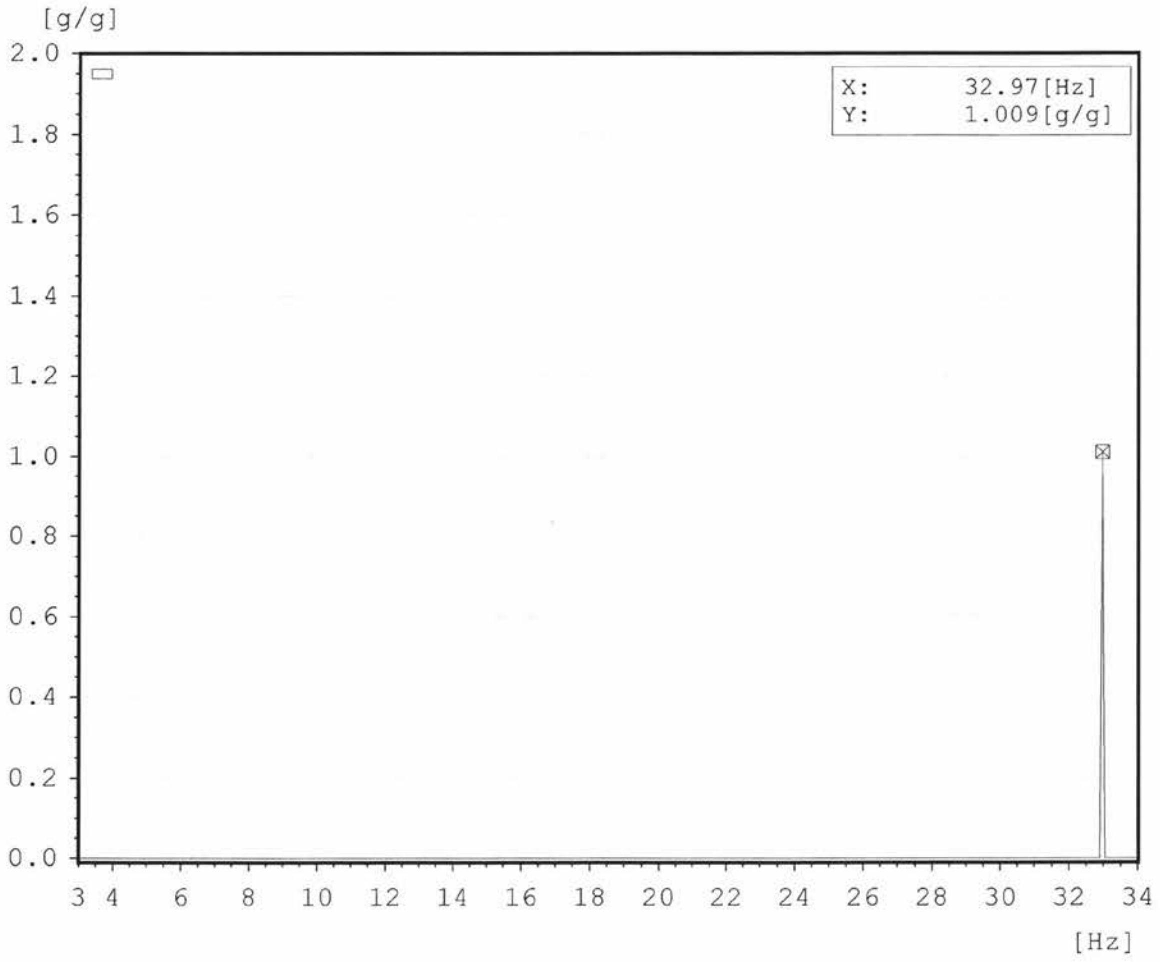
AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 8A

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_003.rsd

Sine Dwell **C1 Fixture Top vs. Control channel**

Axis: Up/Down
Condition: Endurance



Ref.Chan.type: X
Chan.no: 1
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-08-14
Time: 20:21:28
Product version:

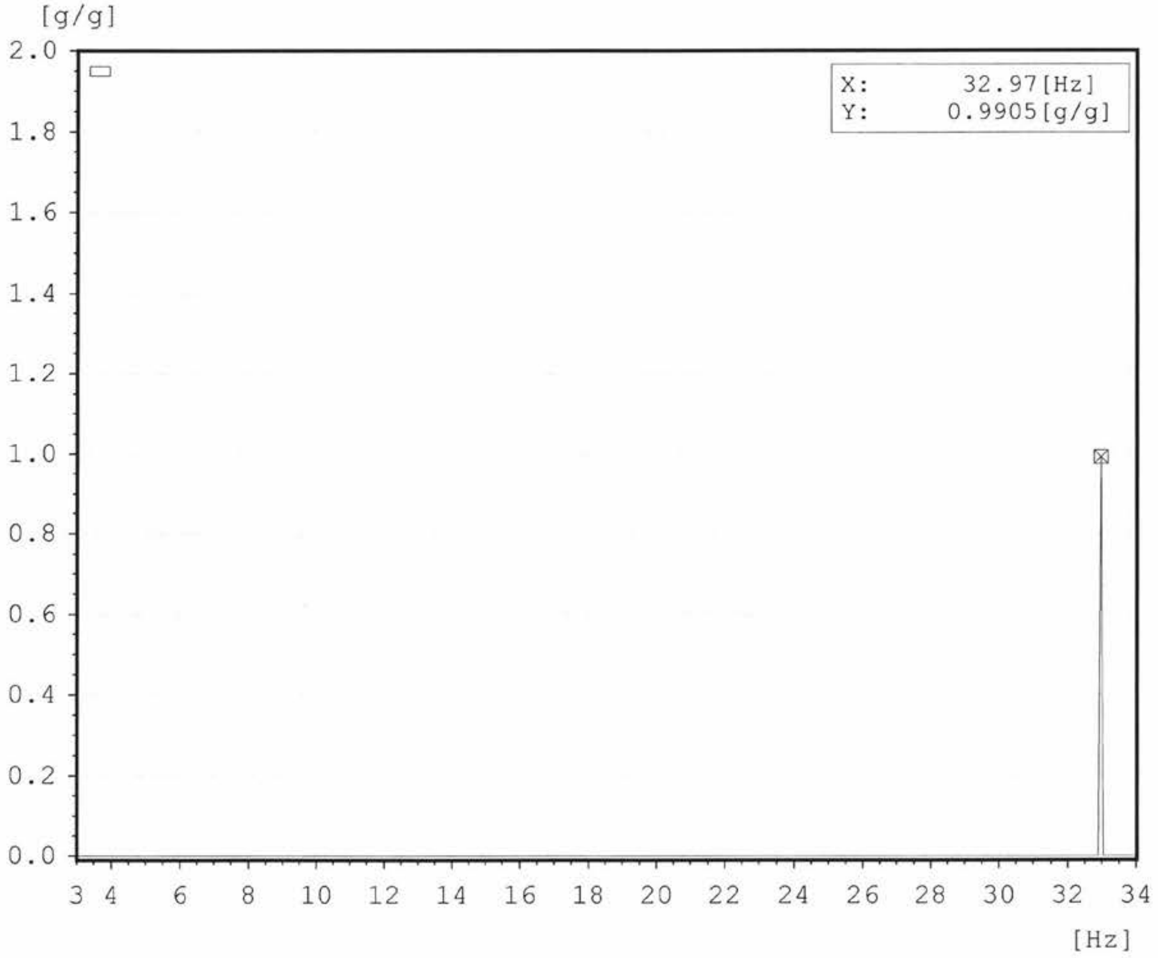
AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 8A 6

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_003.rsd

Sine DwelC2 Fixture Bottom vs. Control channel

Axis: Up/Down
Condition: Endurance



Ref.Chan.type: X
Chan.no: 2
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-08-14
Time: 20:21:28
Product version:

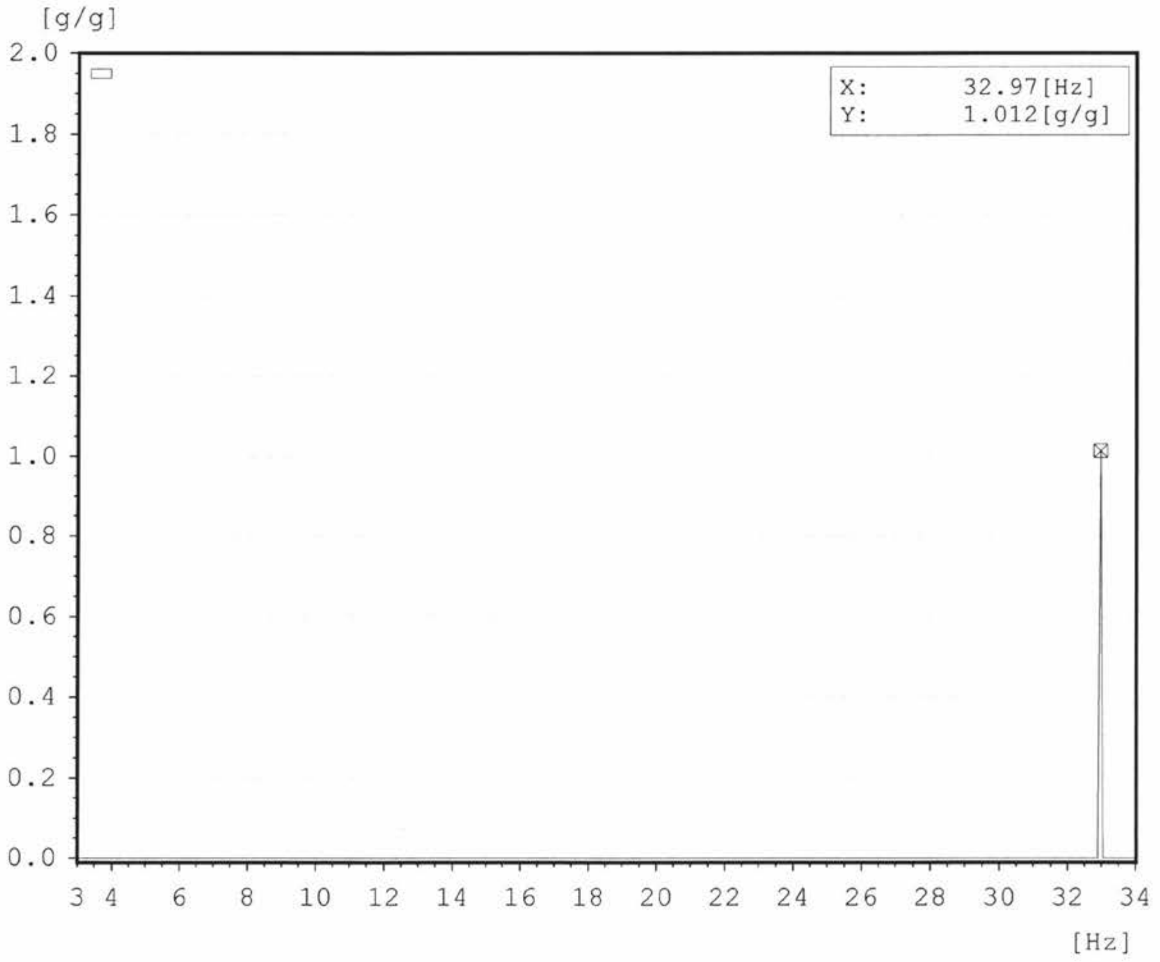
AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 8A 7

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_003.rsd

Sine Dwell **R1 Board 1 vs. Control channel**

Axis: Up/Down
Condition: Endurance



Ref.Chan.type: X
Chan.no: 3
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-08-14
Time: 20:21:28
Product version:

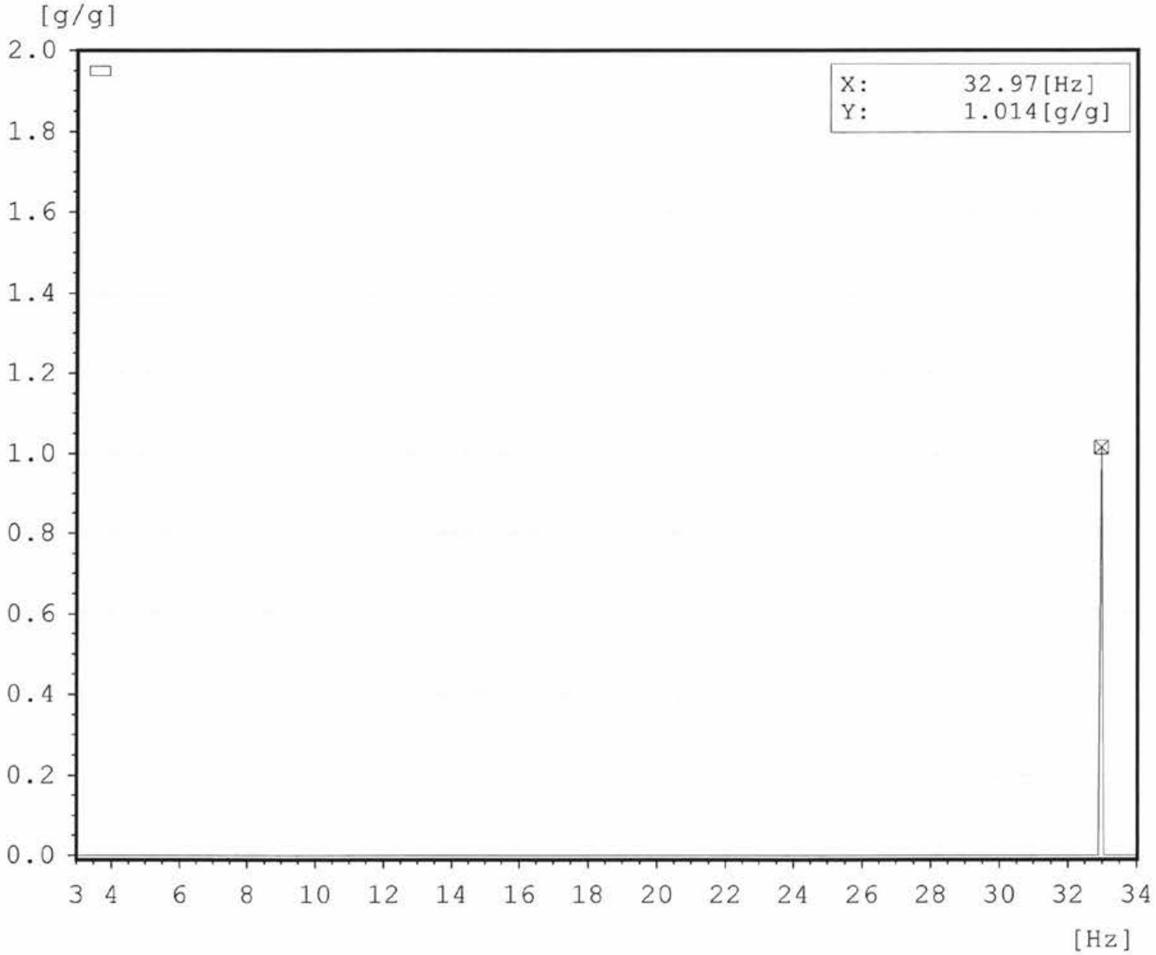
AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 8A

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_003.rsd

Sine Dwell **R2 Board 2 vs. Control channel**

Axis: Up/Down
Condition: Endurance



Ref.Chan.type: X
Chan.no: 4
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-08-14
Time: 20:21:28
Product version:

AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach
Engineer: J. Sookhdeo Plot: 8A

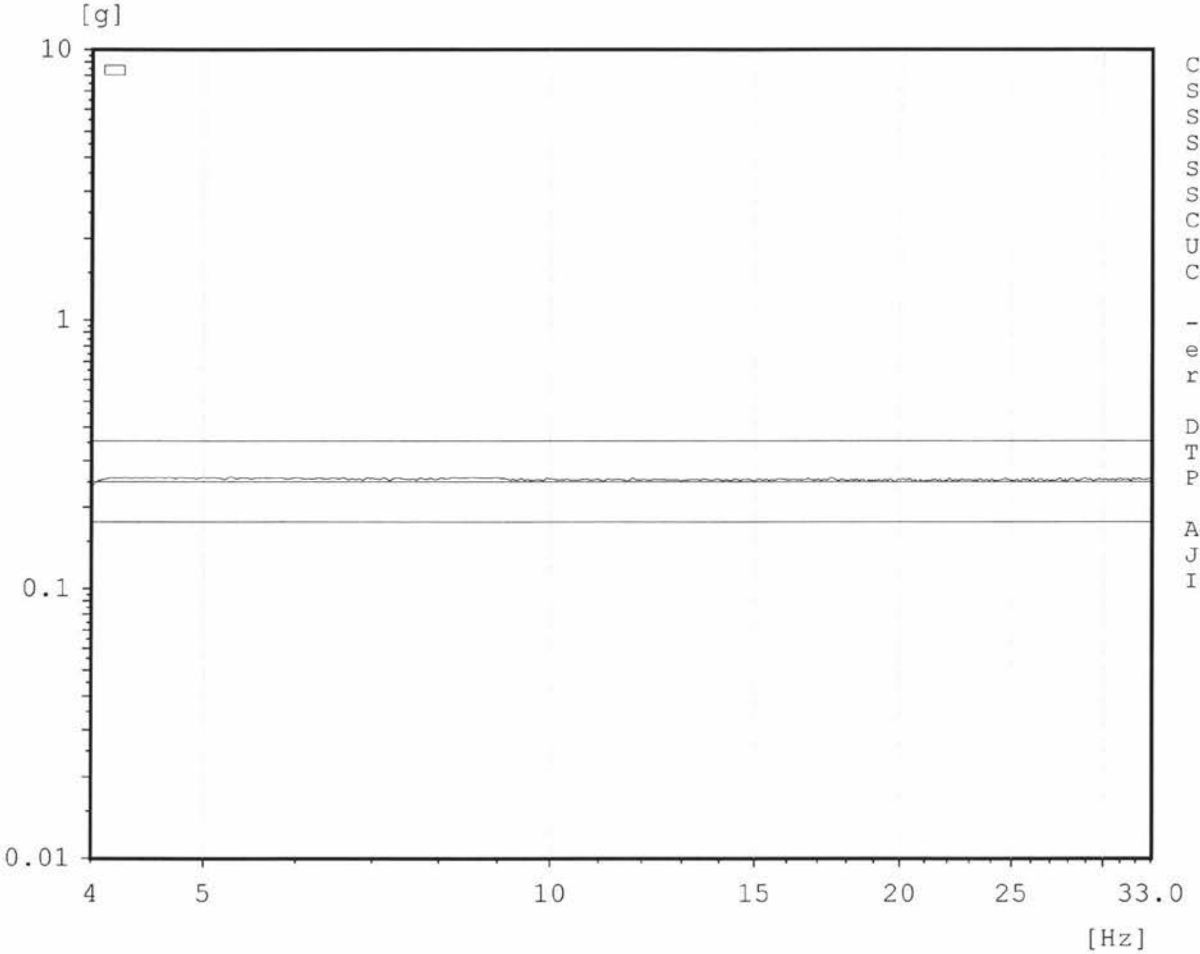
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_003.rsd

Sine

Control channel

Axis: Side/Side

Condtion: Fixture Survey



Chan.type: X
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 21:21:34
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

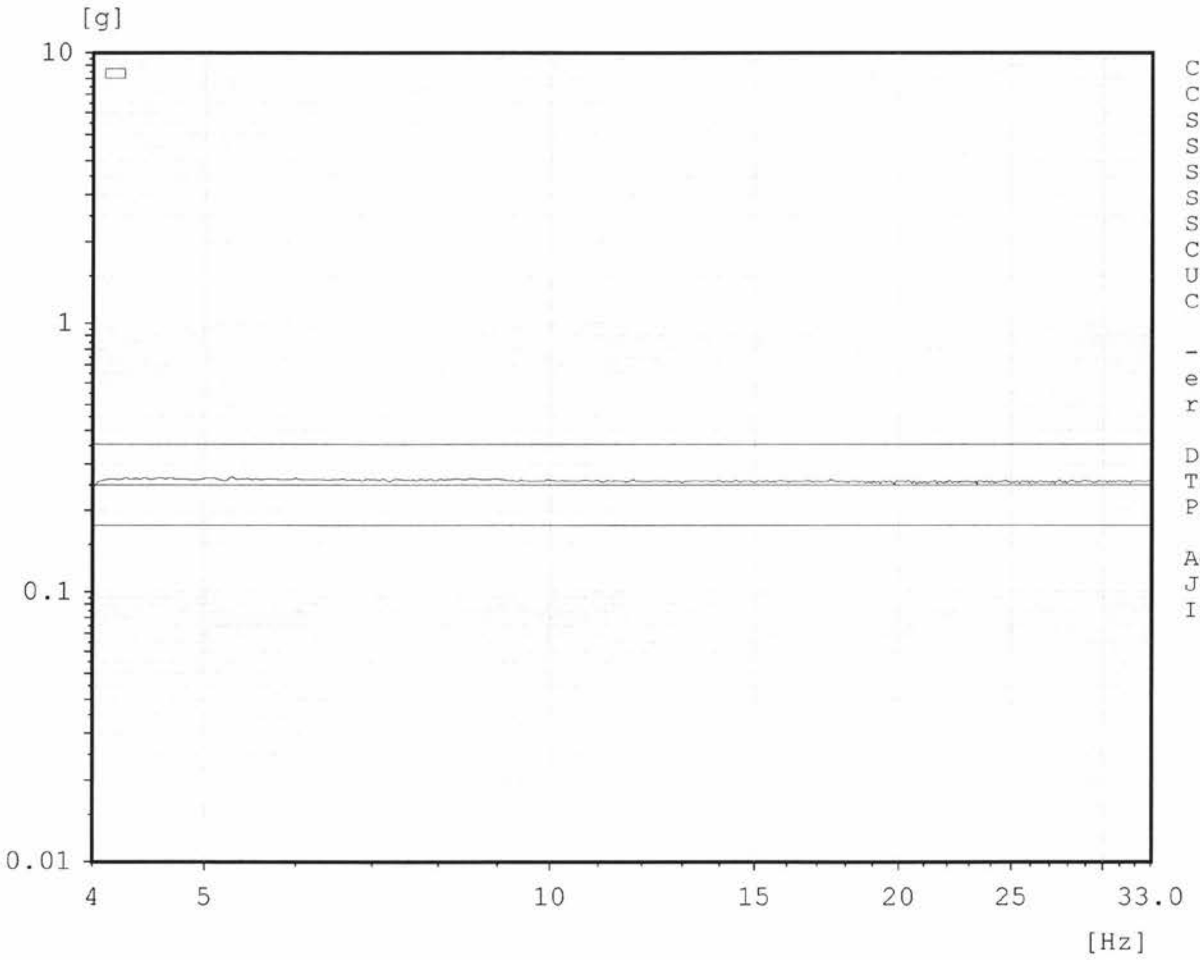
Tech: F. Baumbach
Eng.: J. Sookhdeo Plot: 9A /

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_004.rsn

Sine

C1 Fixture top

Axis: Side/Side
Condtion: Fixture Survey



```
Chan.no:          1
Chan.type:        CW   Filtered
Sweep type:       logarithmic
Sweeps done:      1
Sweeps req.:      1
Sweep direct.:up
Sweep rate:         1.00 Oct/min
Contr.strat.:  Average
Unit:             g
Contr.strat.:  Closed loop

-- Testing time --
elapsed:          000:03:02
remaining:        000:00:00

Date:             08-08-14
Time:             21:21:34
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick
```

Tech: F. Baumbach
Eng.: J. Sookhdeo   Plot: 9Ax20

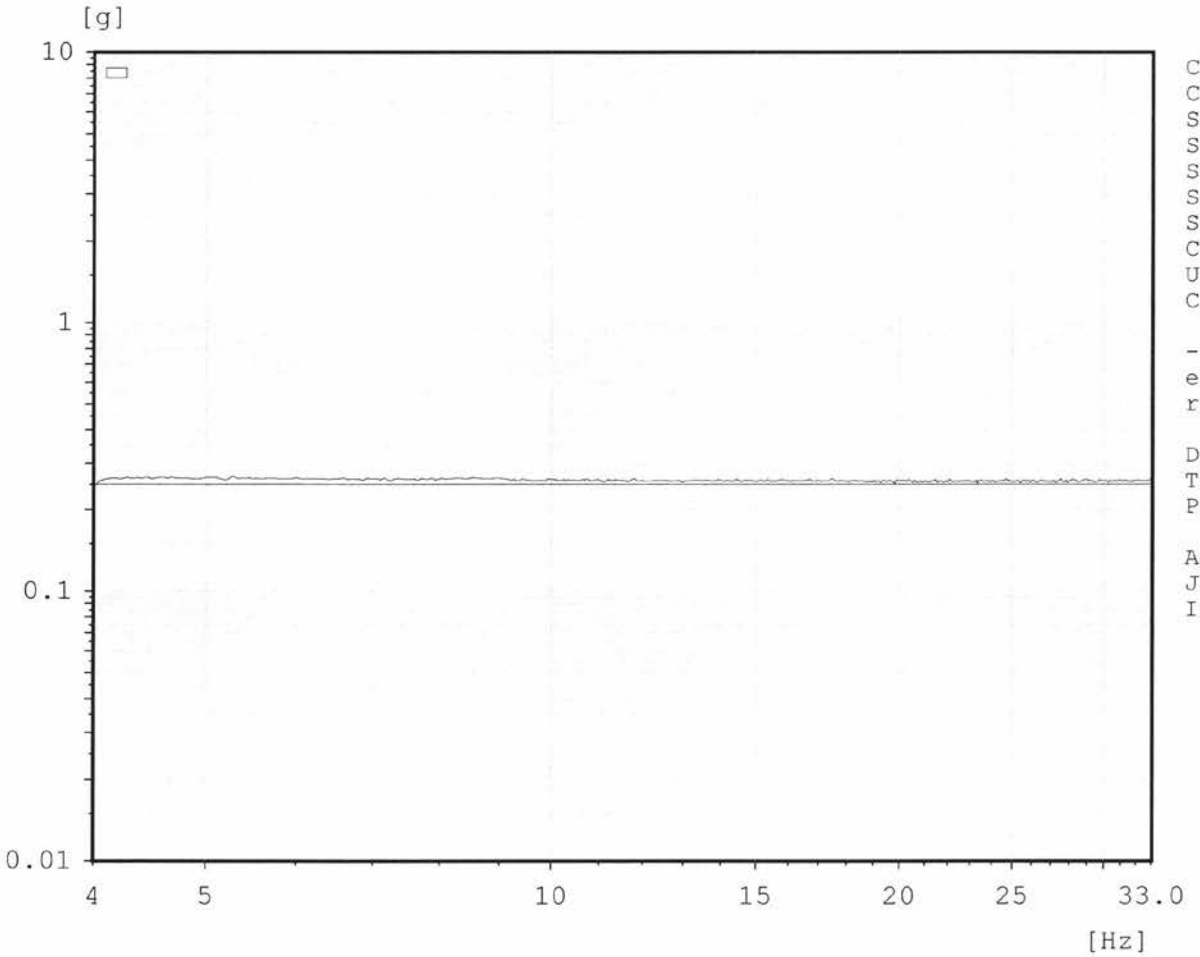
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_004.rsn

Sine

C1 Fixture top

Axis: Side/Side

Condtion: Fixture Survey



Chan.no: 1
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 21:21:34
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

Tech: F. Baumbach

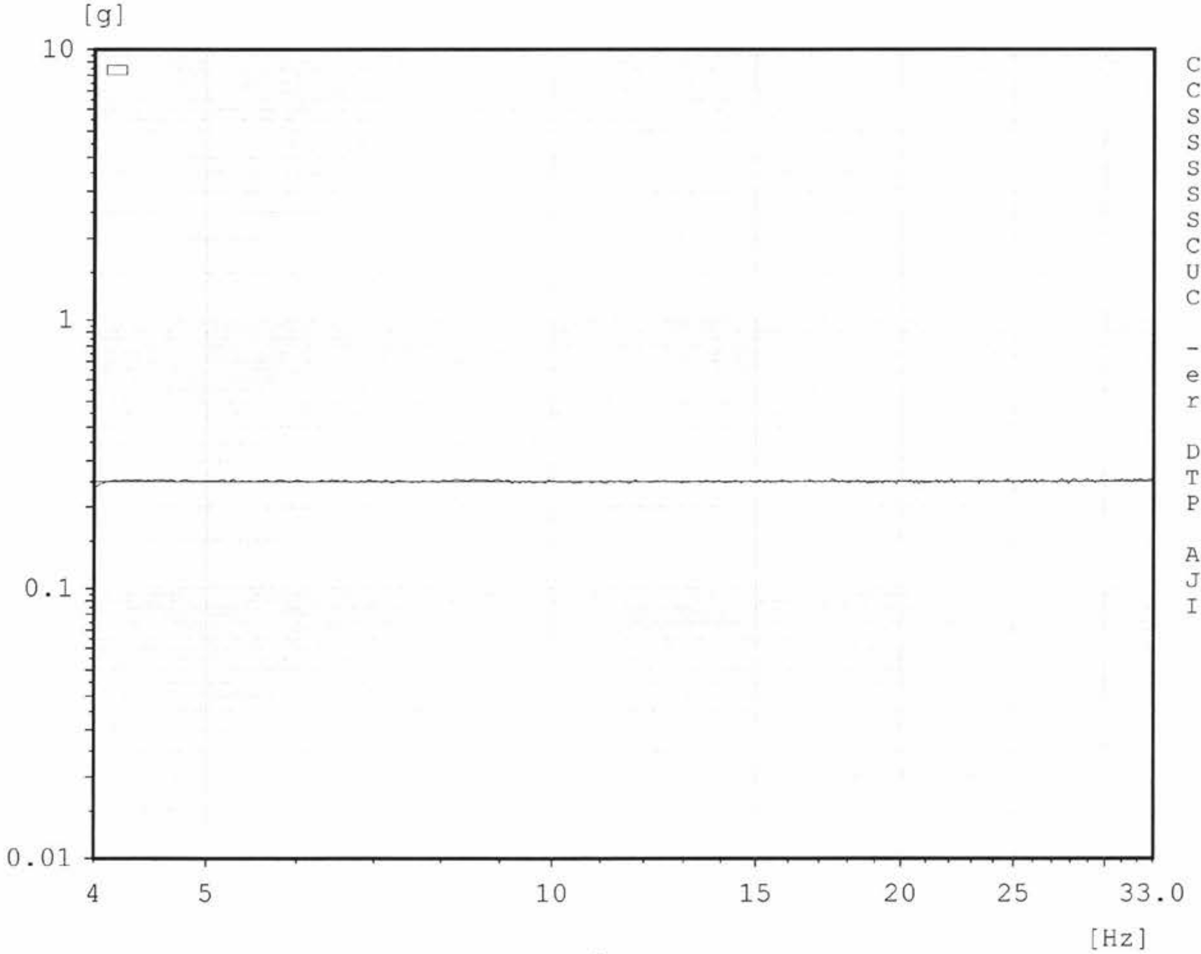
Eng.: J. Sookhdeo Plot: 9A 230

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_004.rsn

Sine

C2 Fixture Bottom

Axis: Side/Side
Condtion: Fixture Survey



Chan.no: 2
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 21:21:34
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

Tech: F. Baumbach
Eng.: J. Sookhdeo Plot: 9A B4

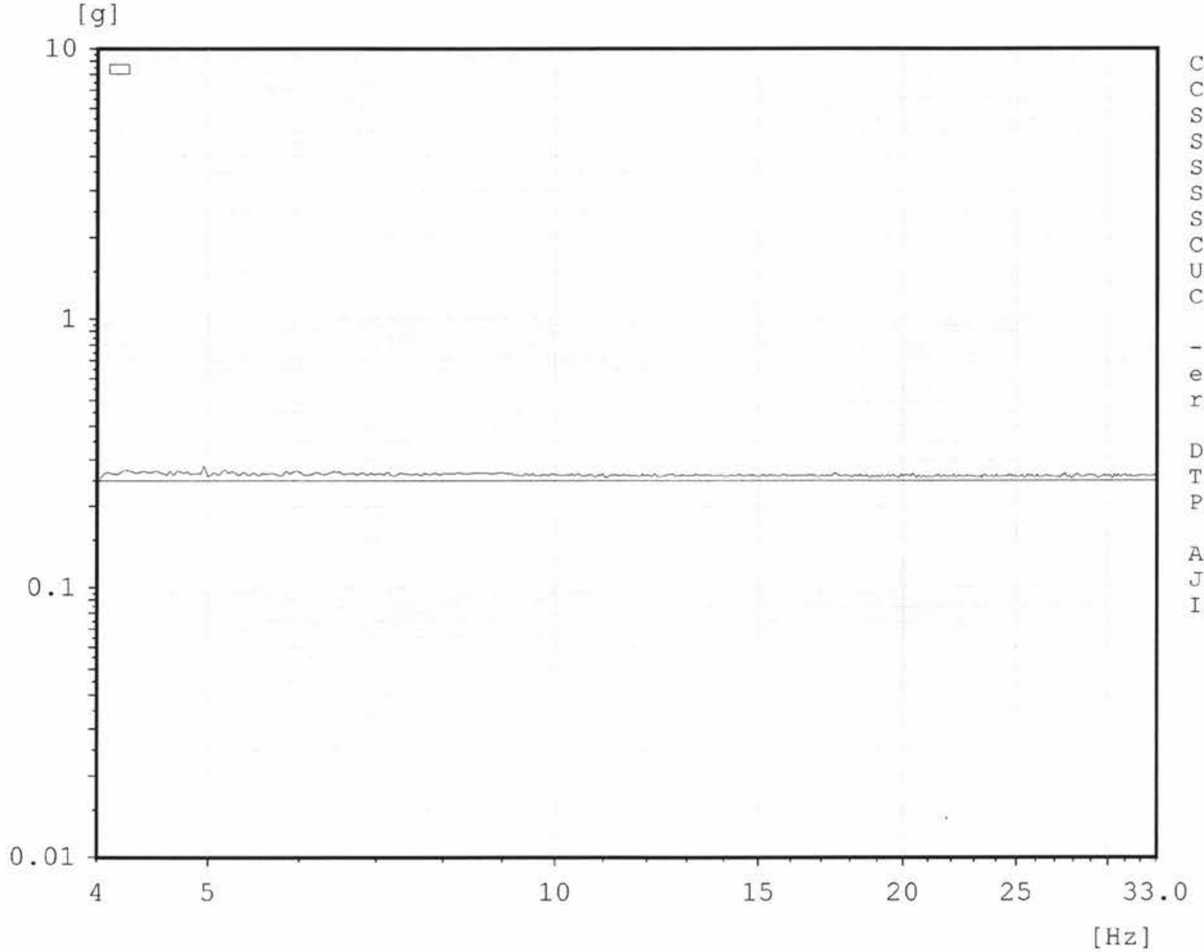
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_004.rsn

Sine

R1 Board 1 Fixture

Axis: Side/Side

Condtion: Fixture Survey



Chan.no: 3
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 21:21:34
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

Tech: F. Baumbach
Eng.: J. Sookhdeo
Plot: 9A K50

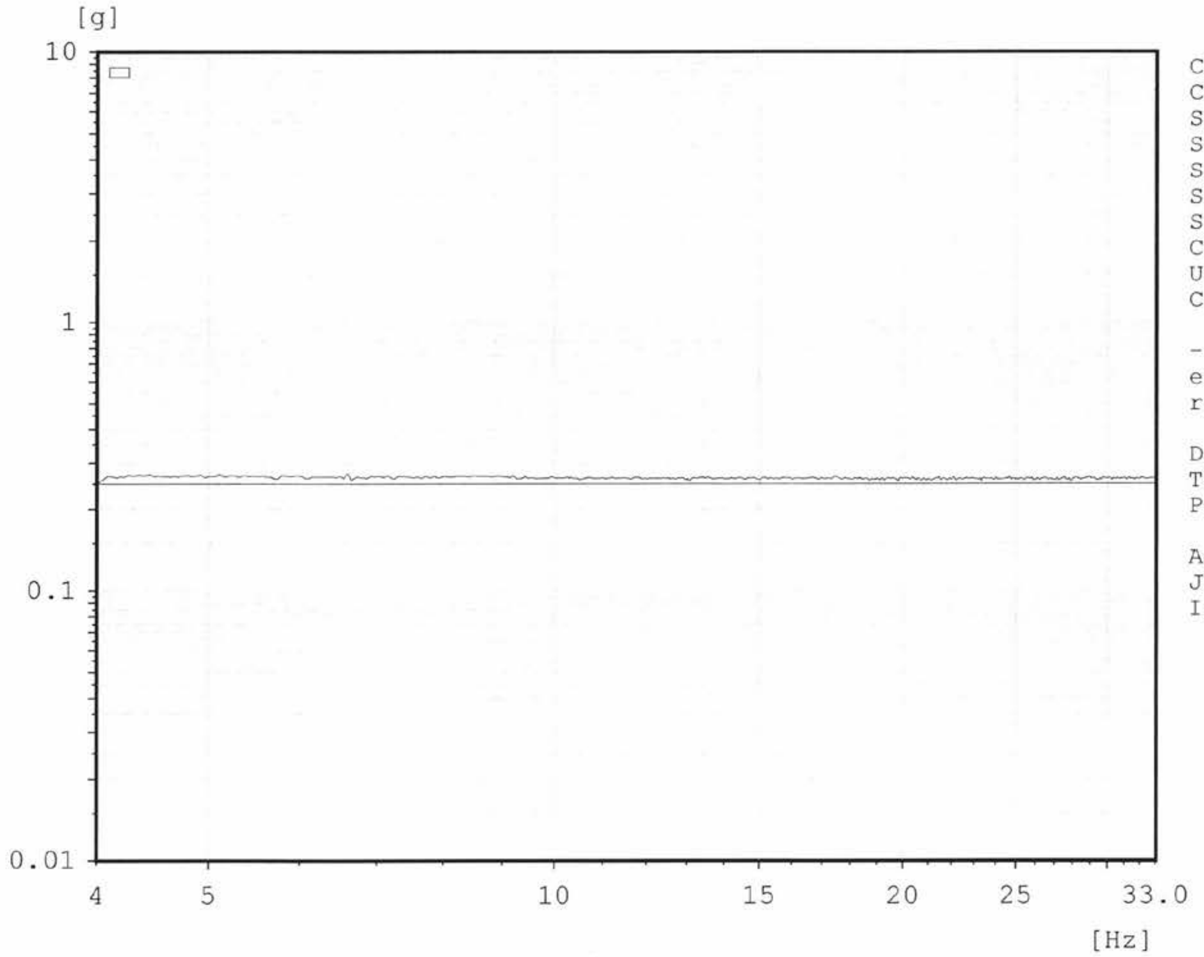
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_004.rsn

Sine

R2 Board 2 Fixture

Axis: Side/Side

Condtion: Fixture Survey



Chan.no: 4
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 21:21:34
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

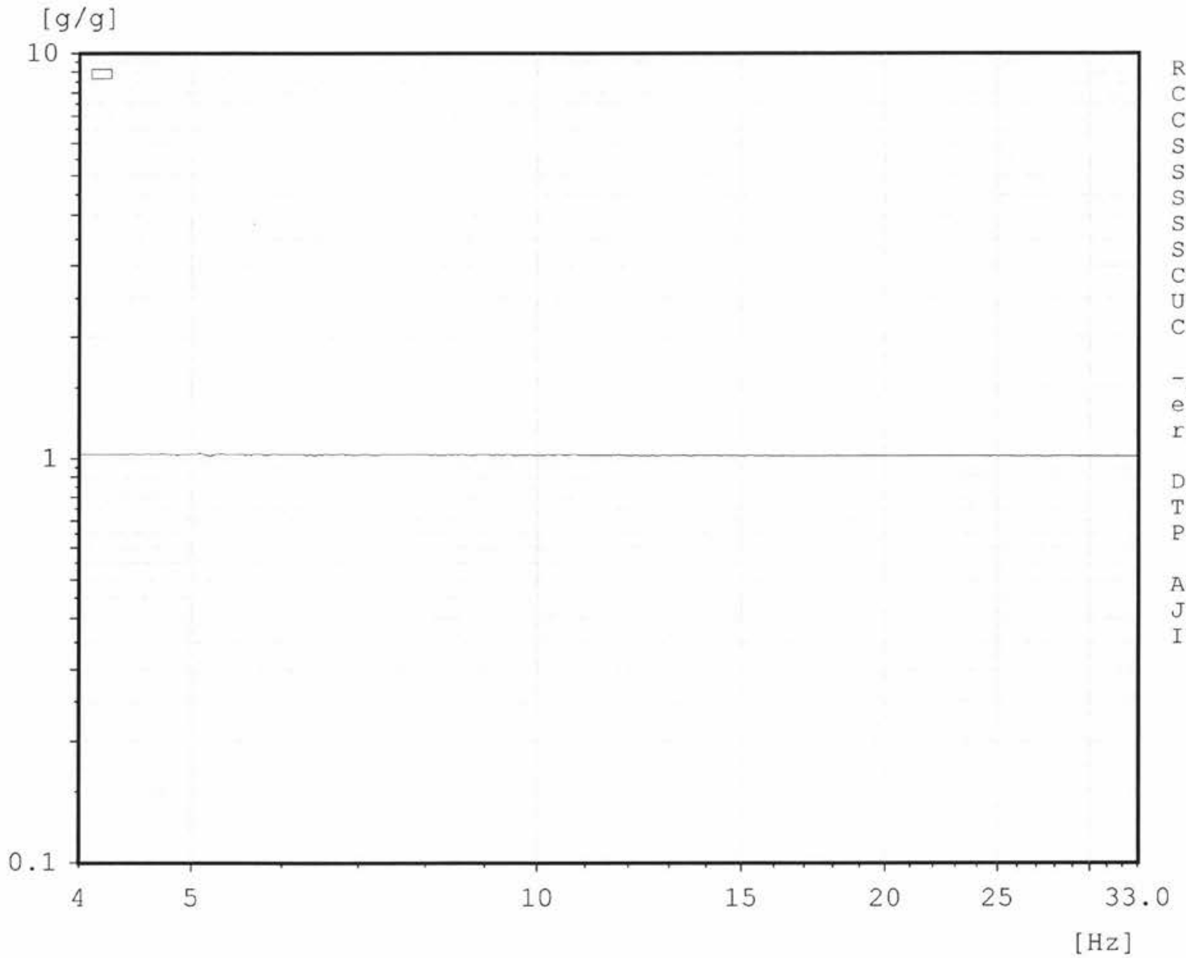
Tech: F. Baumbach
Eng.: J. Sookhdeo Plot: 9A~~6~~ ~~5~~ 6

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_004.rsn

Sine

C1 Fixture top vs. Control channel

Axis: Side/Side
Condtion: Fixture Survey



Ref.Chan.type: X
Chan.no: 1
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 21:21:34
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

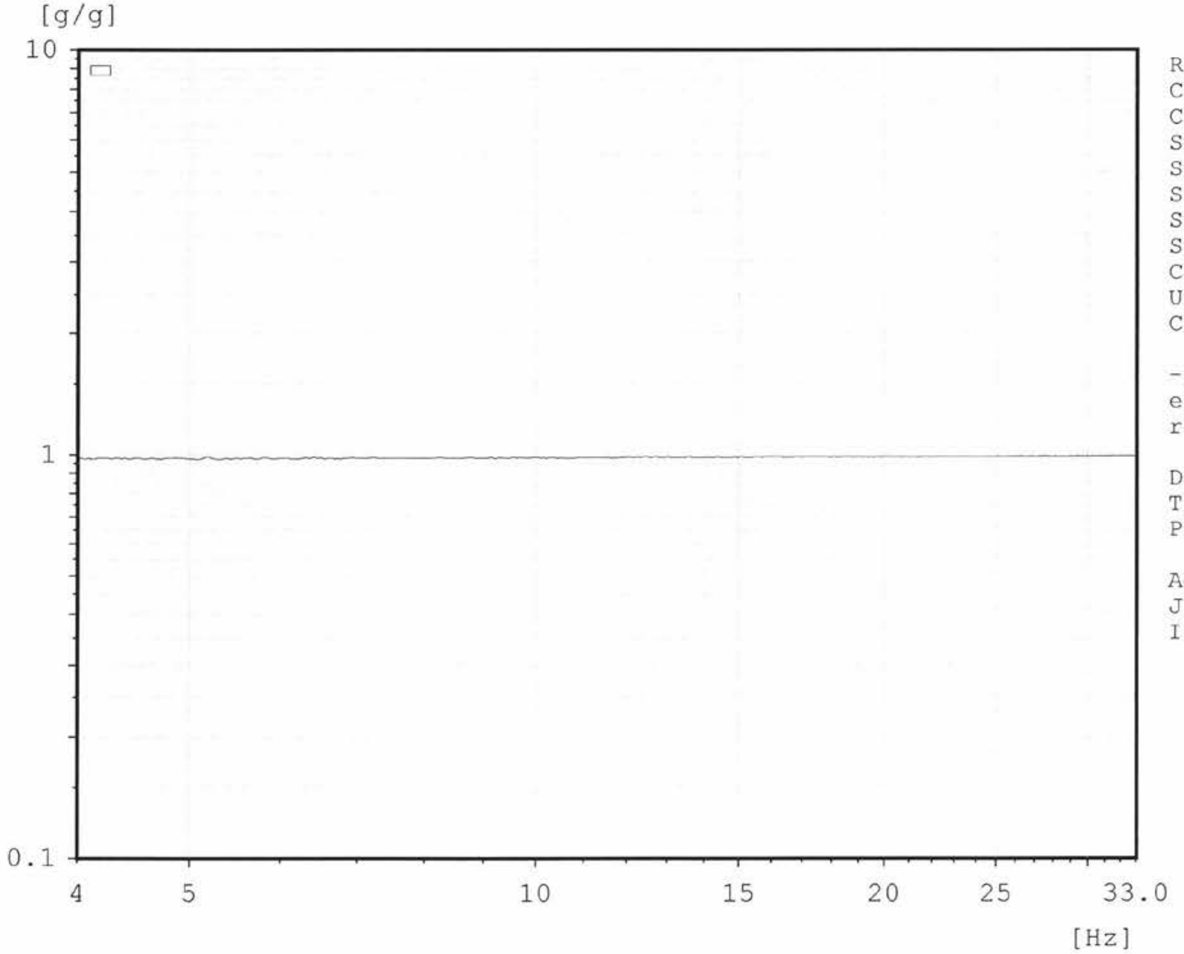
Tech: F. Baumbach
Eng.: J. Sookhdeo Plot: 9A & 72

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_004.rsn

Sine

C2 Fixture Bottom vs. Control channel

Axis: Side/Side
Condtion: Fixture Survey



Ref.Chan.type: X
Chan.no: 2
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 21:21:34
Product version:

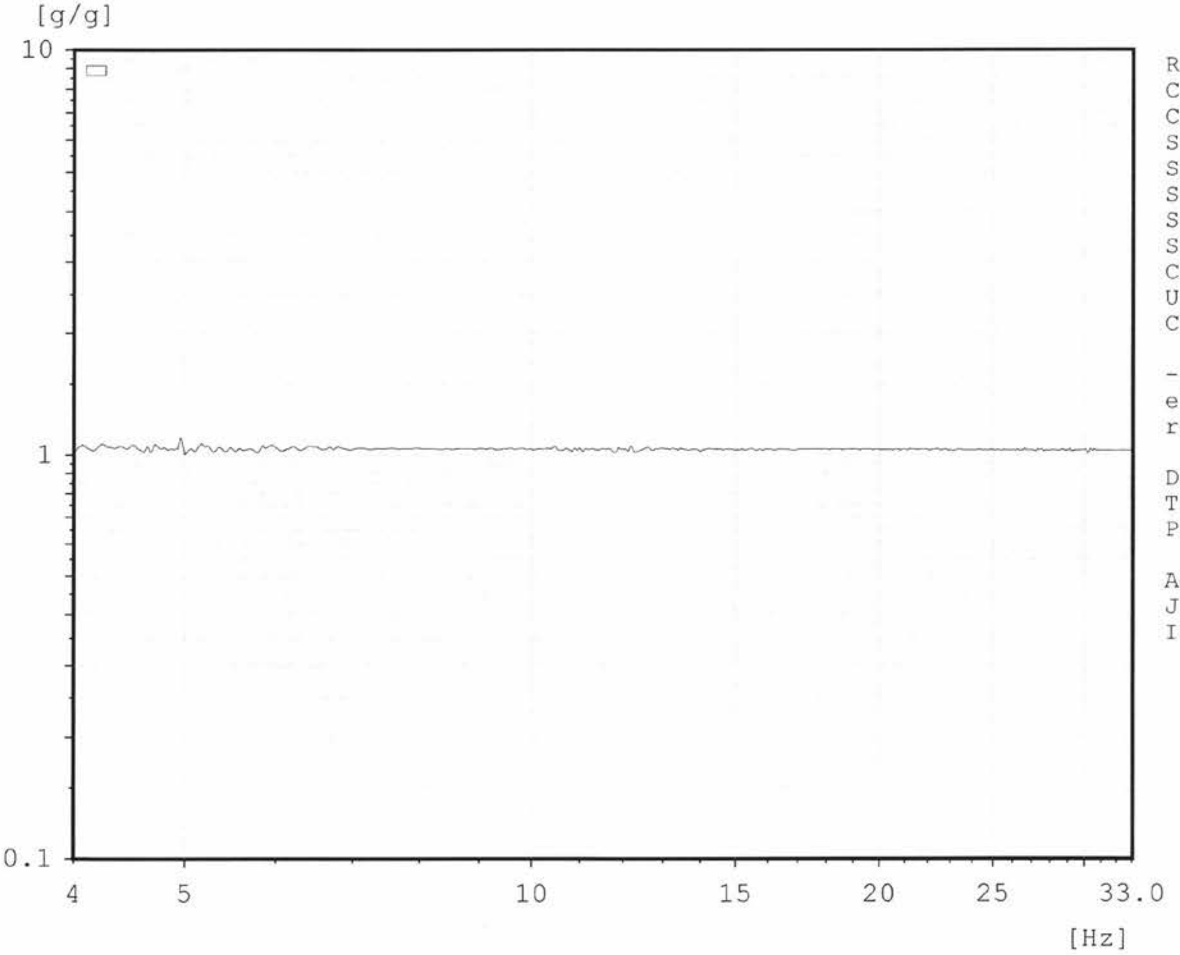
Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

Tech: F. Baumbach
Eng.: J. Sookhdeo
Plot: 9A

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_004.rsn

Sine **R1 Board 1 Fixture vs. Control channel**

Axis: Side/Side
Condtion: Fixture Survey



Ref.Chan.type: X
Chan.no: 3
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 21:21:34
Product version:

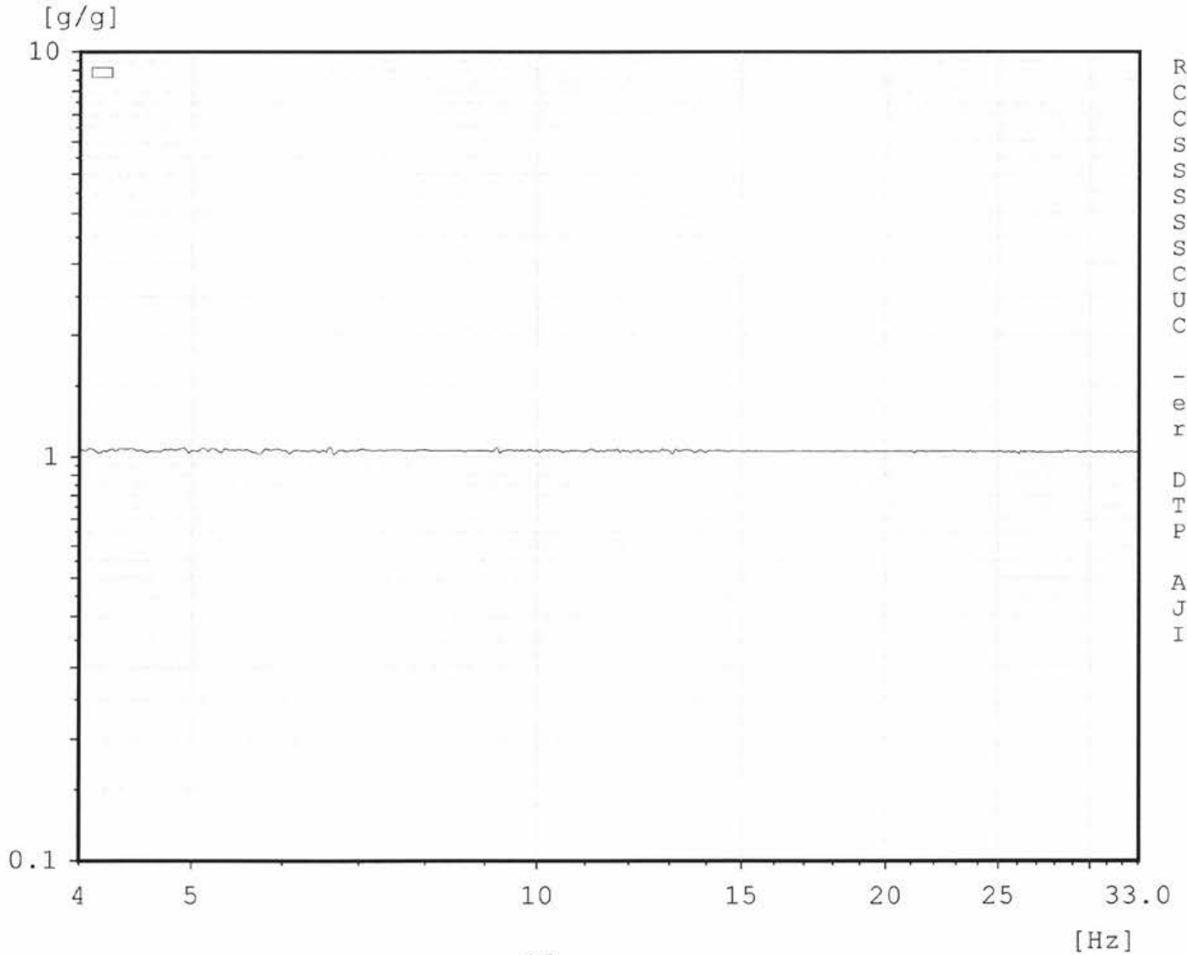
Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

Tech: F. Baumbach
Eng.: J. Sookhdeo Plot: 9A 90

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_004.rsn

Sine **R2 Board 2 Fixture vs. Control channel**

Axis: Side/Side
Condtion: Fixture Survey



Ref.Chan.type: X
Chan.no: 4
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 1
Sweeps req.: 1
Sweep direct.: up
Sweep rate: 1.00 Oct/min
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:03:02
remaining: 000:00:00

Date: 08-08-14
Time: 21:21:34
Product version:

Advanced Tech
J/N: 413980-03
Item: Low Voltage Quick

10

Tech: F. Baumbach
Eng.: J. Sookhdeo Plot: 9A

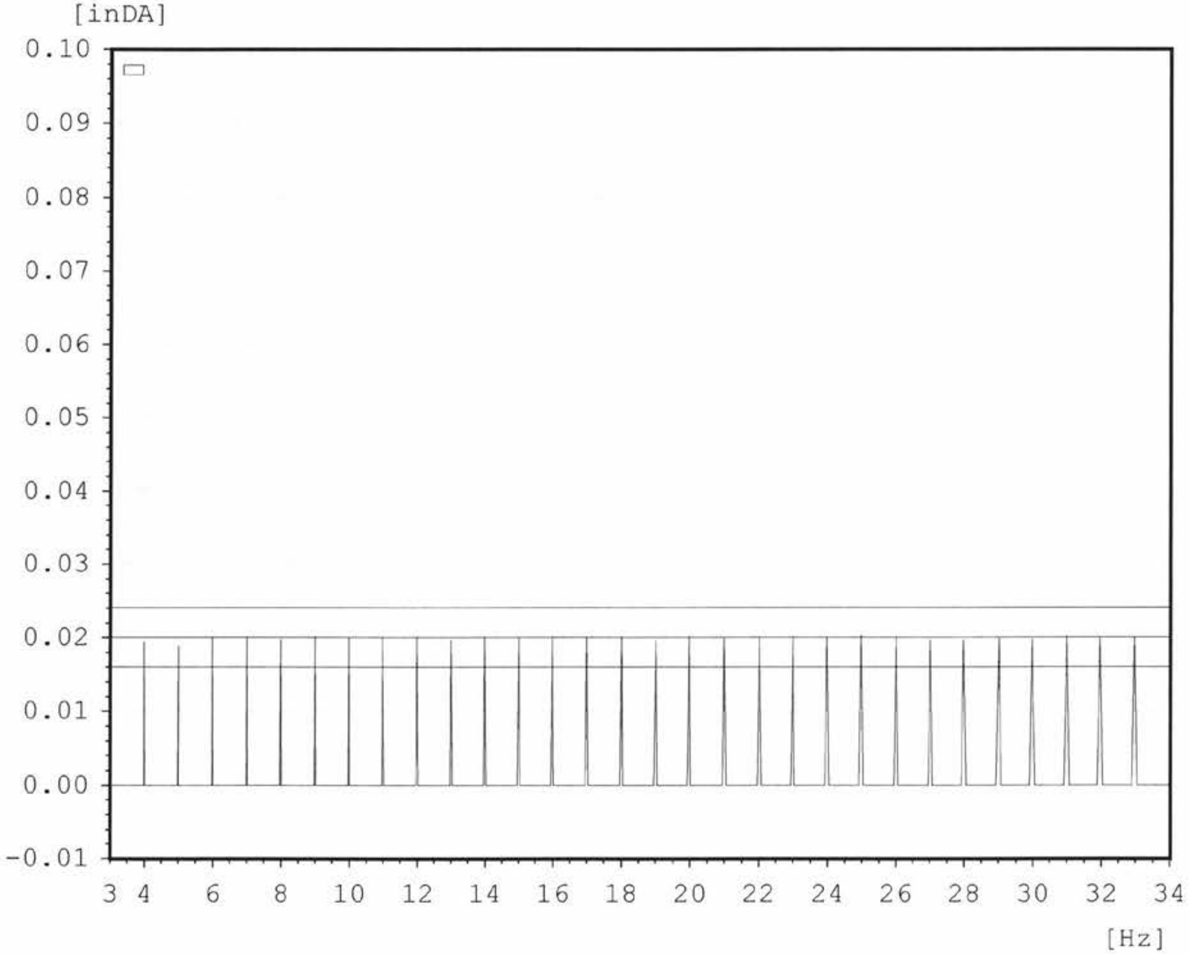
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Sine survey_004.rsn

Sine Dwell

Control channel (2xintegr)

Axis: Side/Side

Condition: Exploratory Frequency



Chan.type: X
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:07:30
remaining: 000:00:00

Date: 08-08-14
Time: 22:13:31
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach
Eng.: J. Sookhdeo Plot: 10A /

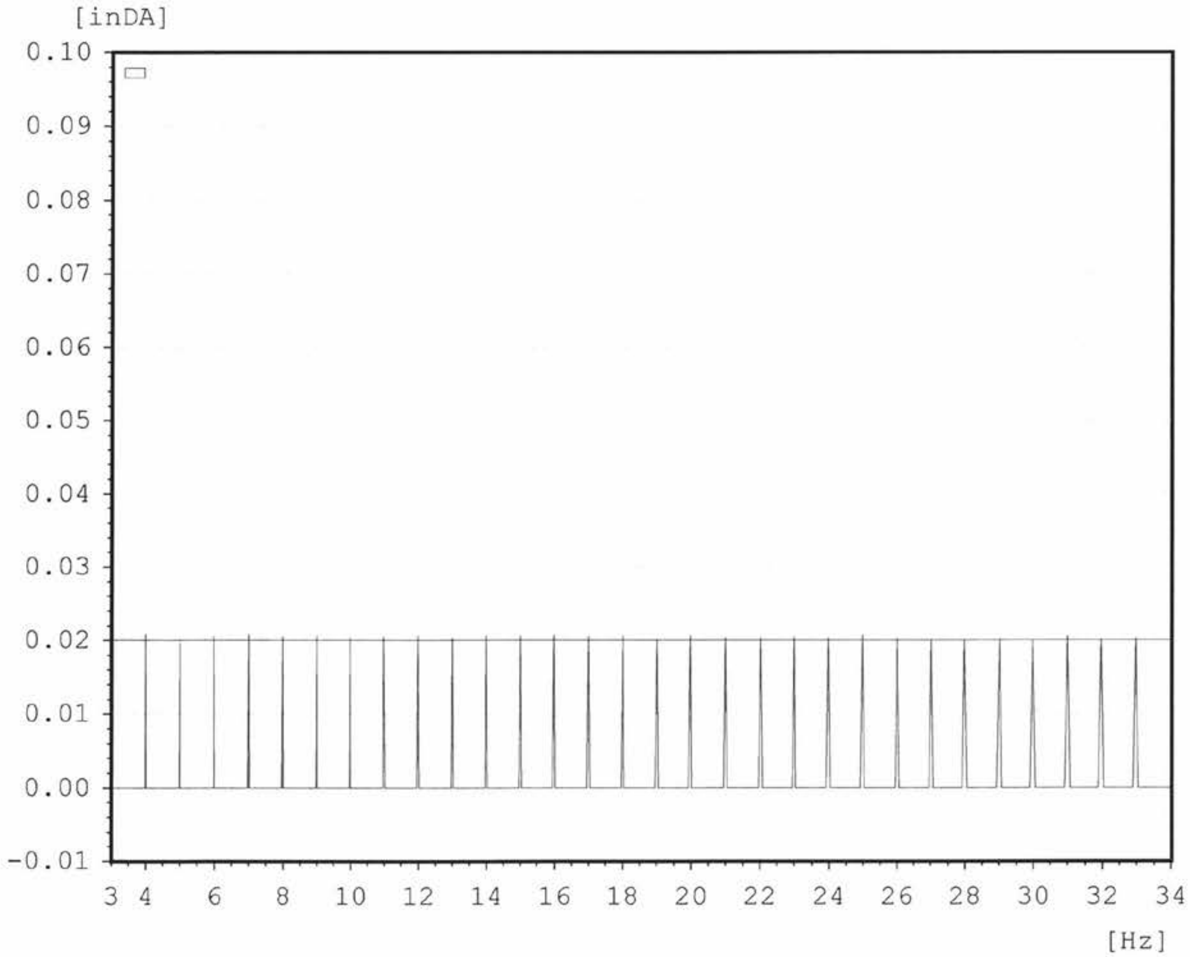
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_003.rsd

Sine Dwell

C1 Fixture top (2xintegr)

Axis: Side/Side

Condition: Exploratory Frequency



Chan.no: 1
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:07:30
remaining: 000:00:00

Date: 08-08-14
Time: 22:13:31
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach

Eng.: J. Sookhdeo Plot: 10A

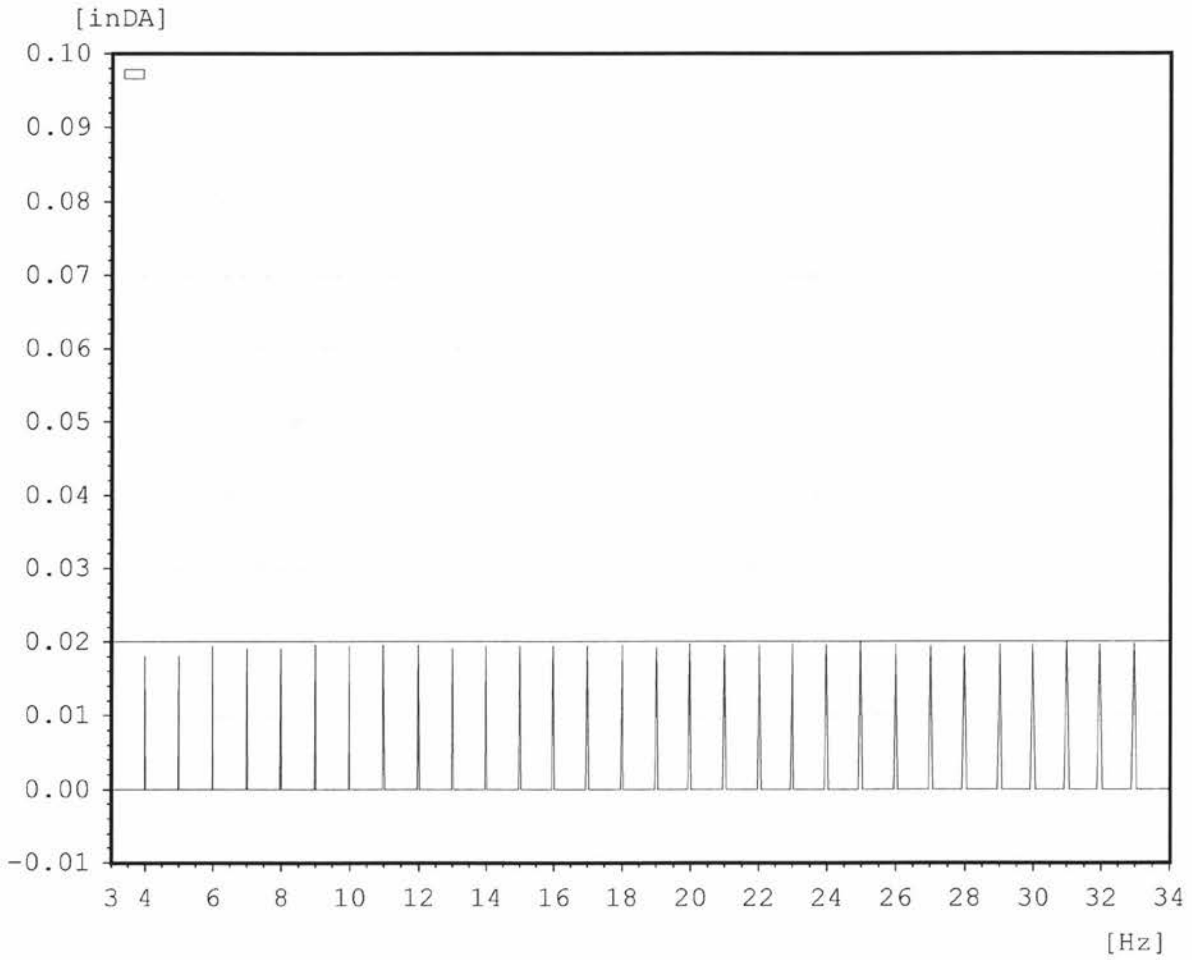
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_003.rsd

Sine Dwell

C2 Fixture Bottom (2xintegr)

Axis: Side/Side

Condition: Exploratory Frequency



Chan.no: 2
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:07:30
remaining: 000:00:00

Date: 08-08-14
Time: 22:13:31
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach

Eng.: J. Sookhdeo Plot: 10A 3

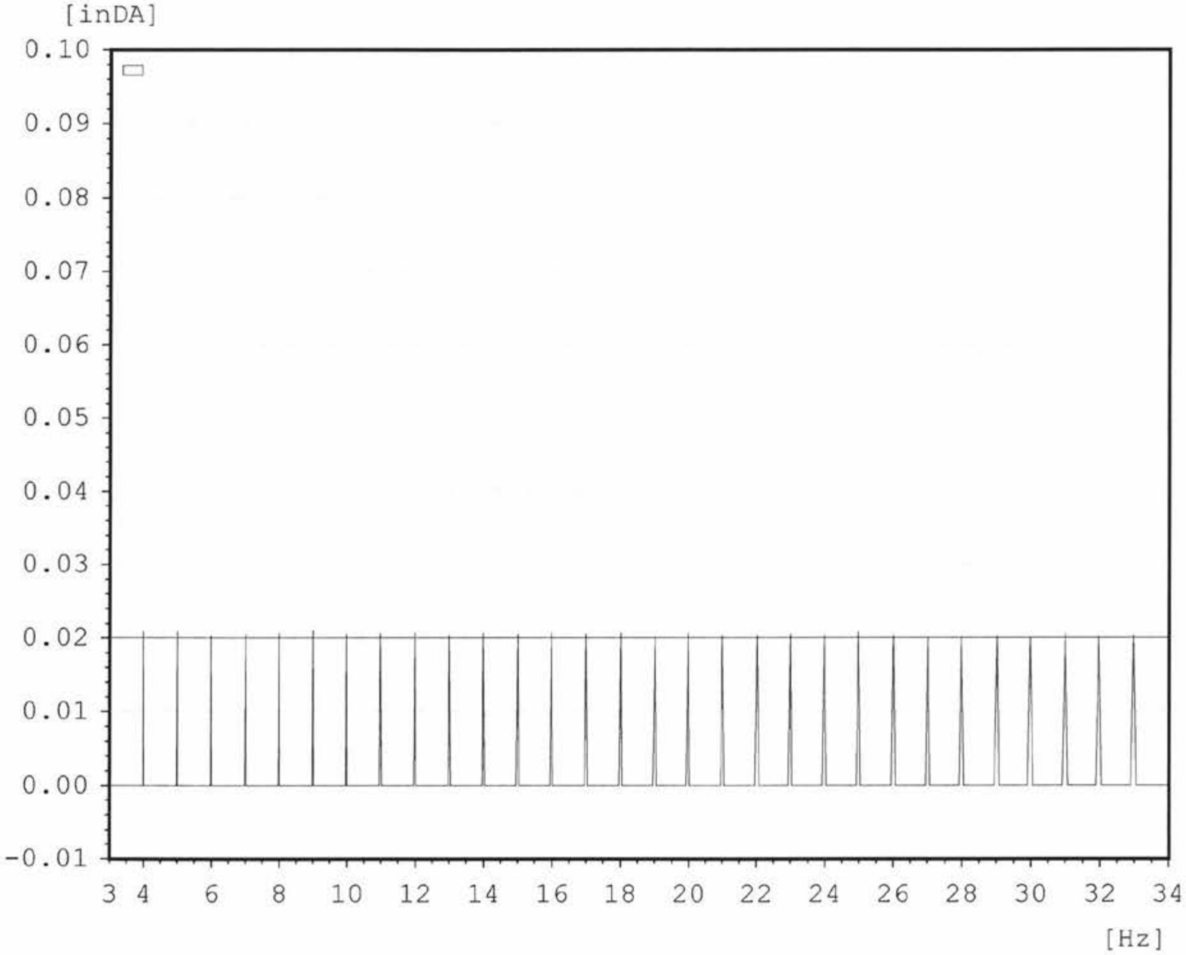
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_003.rsd

Sine Dwell

R1 Board 1 (2xintegr)

Axis: Side/Side

Condition: Exploratory Frequency



Chan.no: 3
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:07:30
remaining: 000:00:00

Date: 08-08-14
Time: 22:13:31
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach
Eng.: J. Sookhdeo Plot: 10A 4

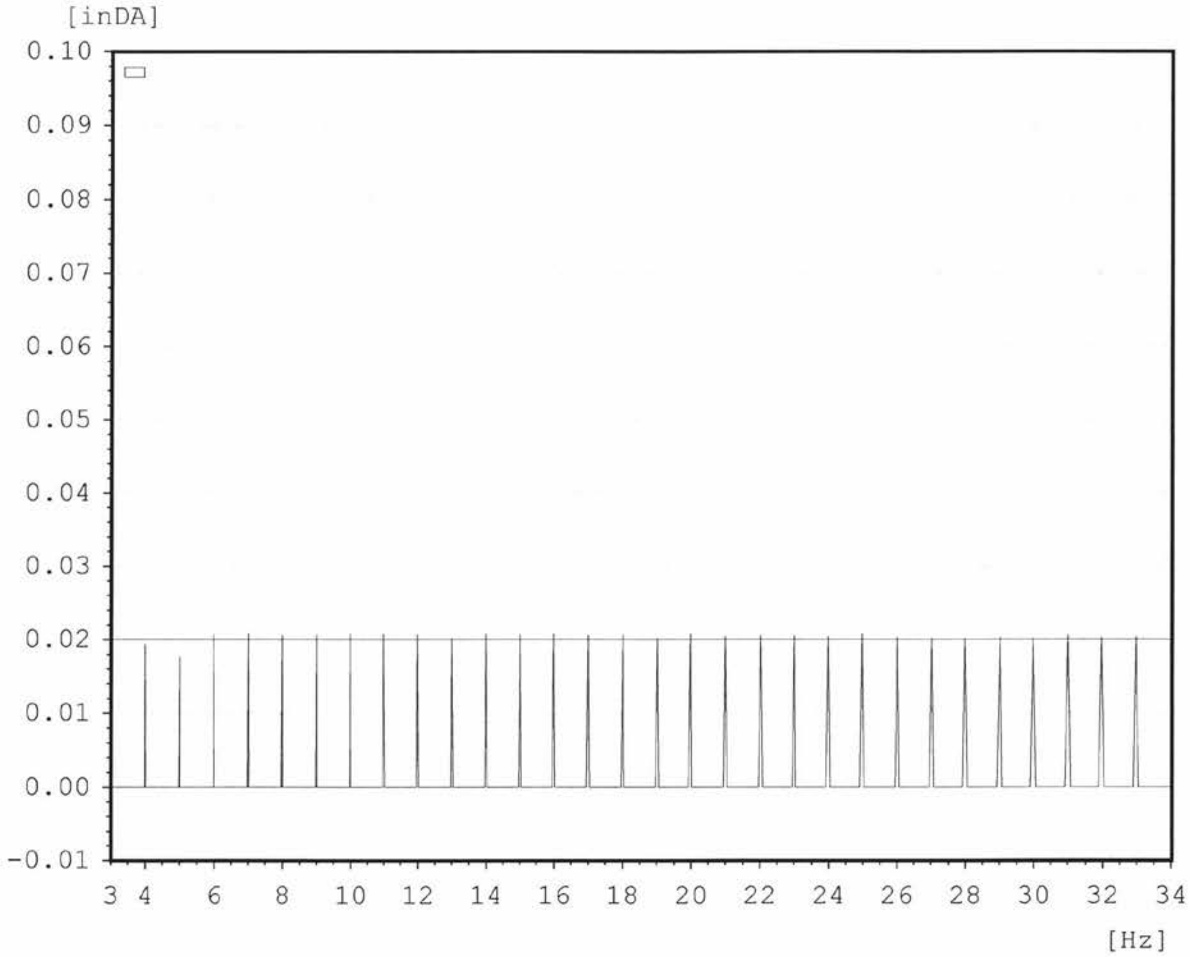
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_003.rsd

Sine Dwell

R2 Board 2 (2xintegr)

Axis: Side/Side

Condition: Exploratory Frequency



```
Chan.no:        4
Chan.type:          M Filtered
Sweep type:     logarithmic
Sweeps done:    0
Sweeps req.:    1
Sweep direct.:  up
Contr.strat.:   Average
Unit:           inDA
Contr.strat.:   Closed loop

-- Testing time --
elapsed:        000:07:30
remaining:      000:00:00

Date:           08-08-14
Time:           22:13:31
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1
```

Tech.: F. Baumbach

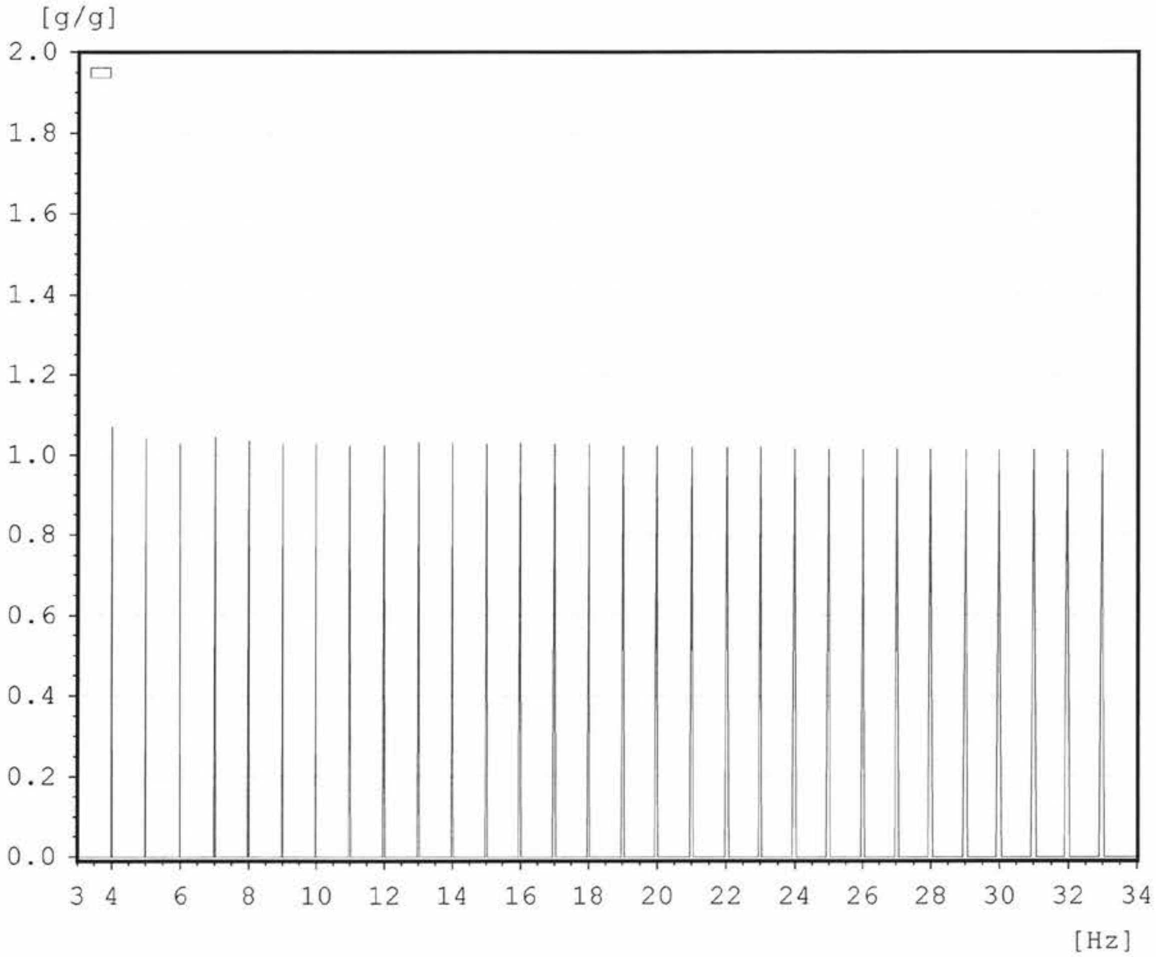
Eng.: J. Sookhdeo   Plot: 10A5

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_003.rsd

Sine Dwell **C1 Fixture top vs. Control channel**

Axis: Side/Side

Condition: Exploratory Frequency



Ref.Chan.type: X
Chan.no: 1
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:07:30
remaining: 000:00:00

Date: 08-08-14
Time: 22:13:31
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach

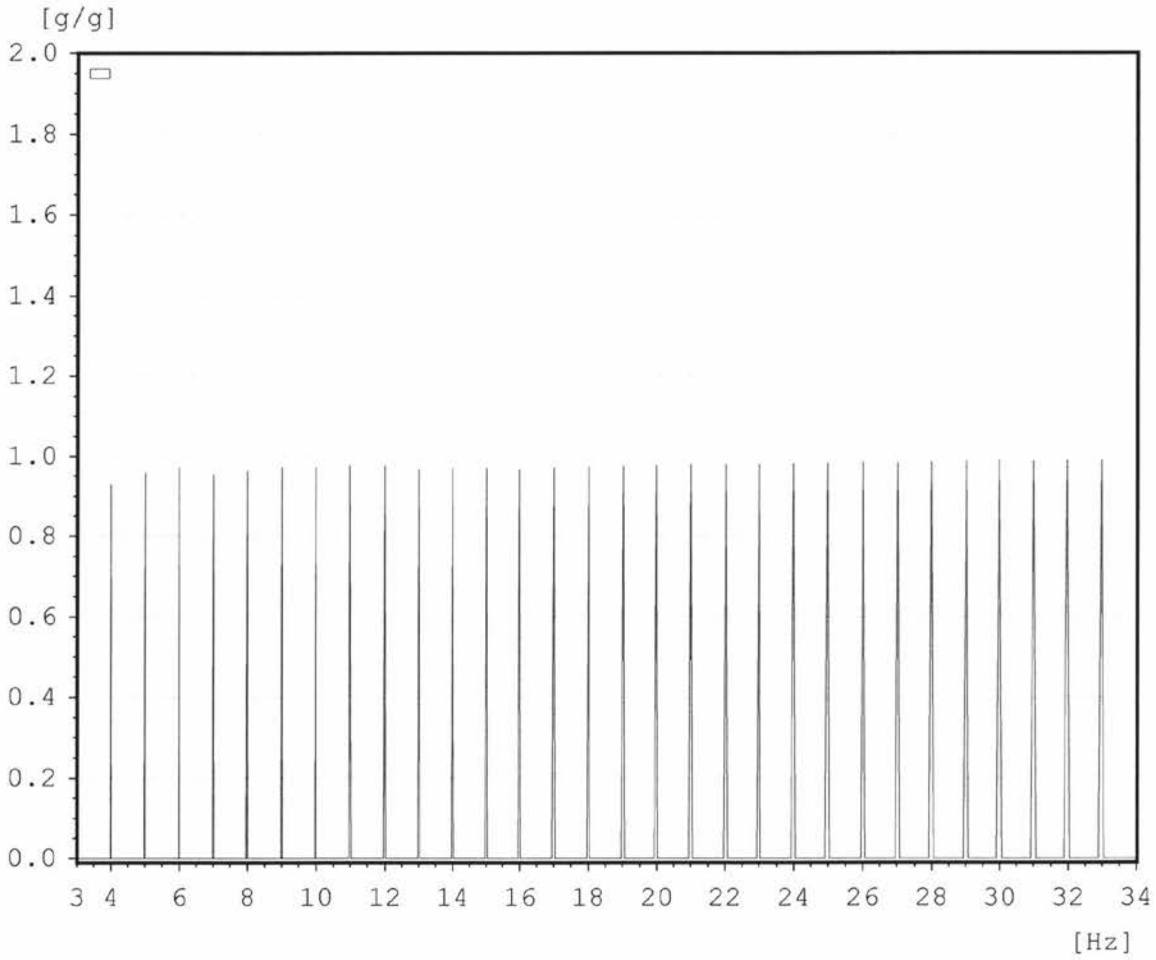
Eng.: J. Sookhdeo Plot: 10A

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_003.rsd

Sine Dwell C2 Fixture Bottom vs. Control channel

Axis: Side/Side

Condition: Exploratory Frequency



```
Ref.Chan.type: X
Chan.no:       2
Chan.type:     CW   Filtered
Sweep type:    logarithmic
Sweeps done:   0
Sweeps req.:   1
Sweep direct.: up
Contr.strat.:  Average
Unit:          g/g
Contr.strat.:  Closed loop

-- Testing time --
elapsed:       000:07:30
remaining:     000:00:00

Date:          08-08-14
Time:          22:13:31
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1
```

Tech.: F. Baumbach

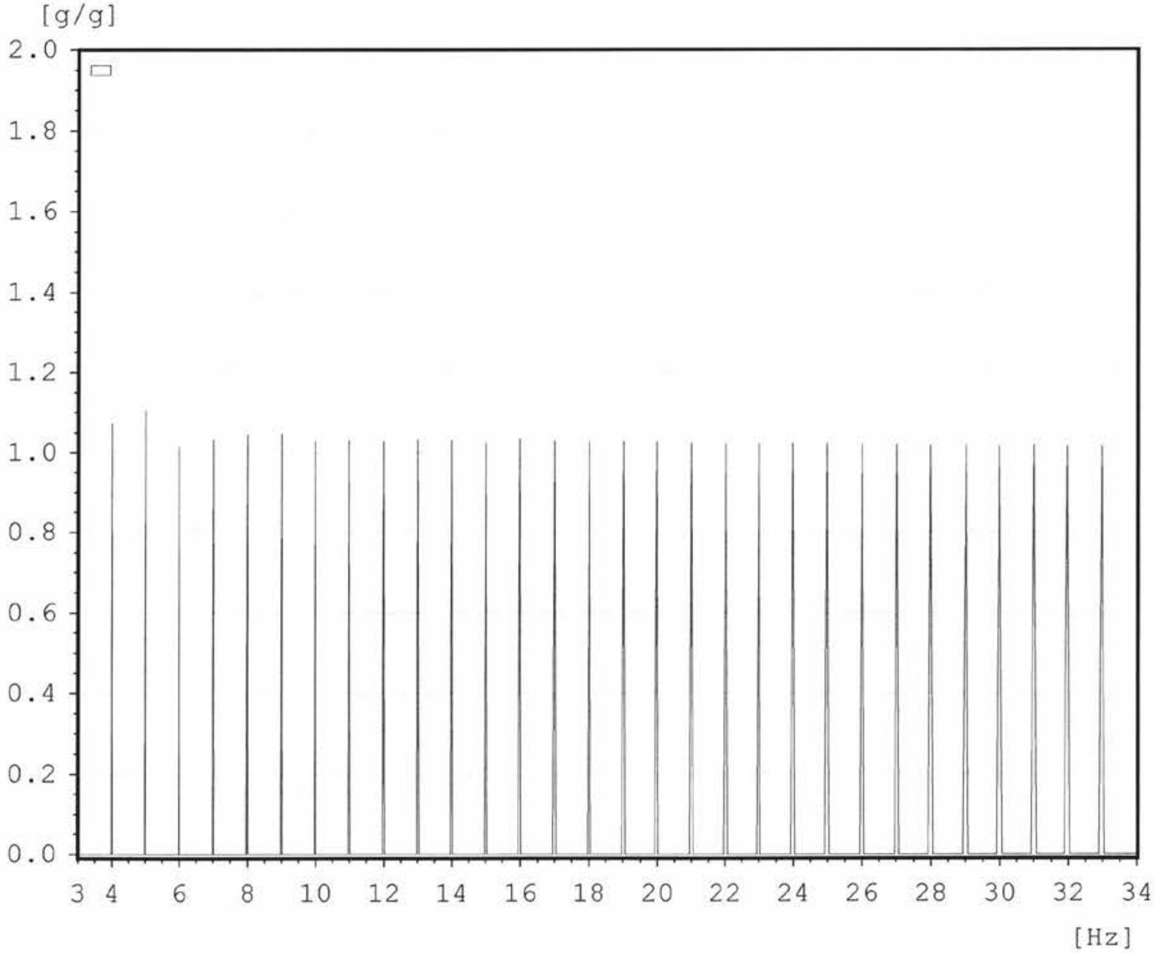
Eng.: J. Sookhdeo   Plot: 10A 7

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_003.rsd

Sine Dwell

R1 Board 1 vs. Control channel

Axis: Side/Side
Condition: Exploratory Frequency



Ref.Chan.type:	X
Chan.no:	3
Chan.type:	M Filtered
Sweep type:	logarithmic
Sweeps done:	0
Sweeps req.:	1
Sweep direct.:	up
Contr.strat.:	Average
Unit:	g/g
Contr.strat.:	Closed loop

-- Testing time --

elapsed:	000:07:30
remaining:	000:00:00

Date:	08-08-14
Time:	22:13:31
Product version:	:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

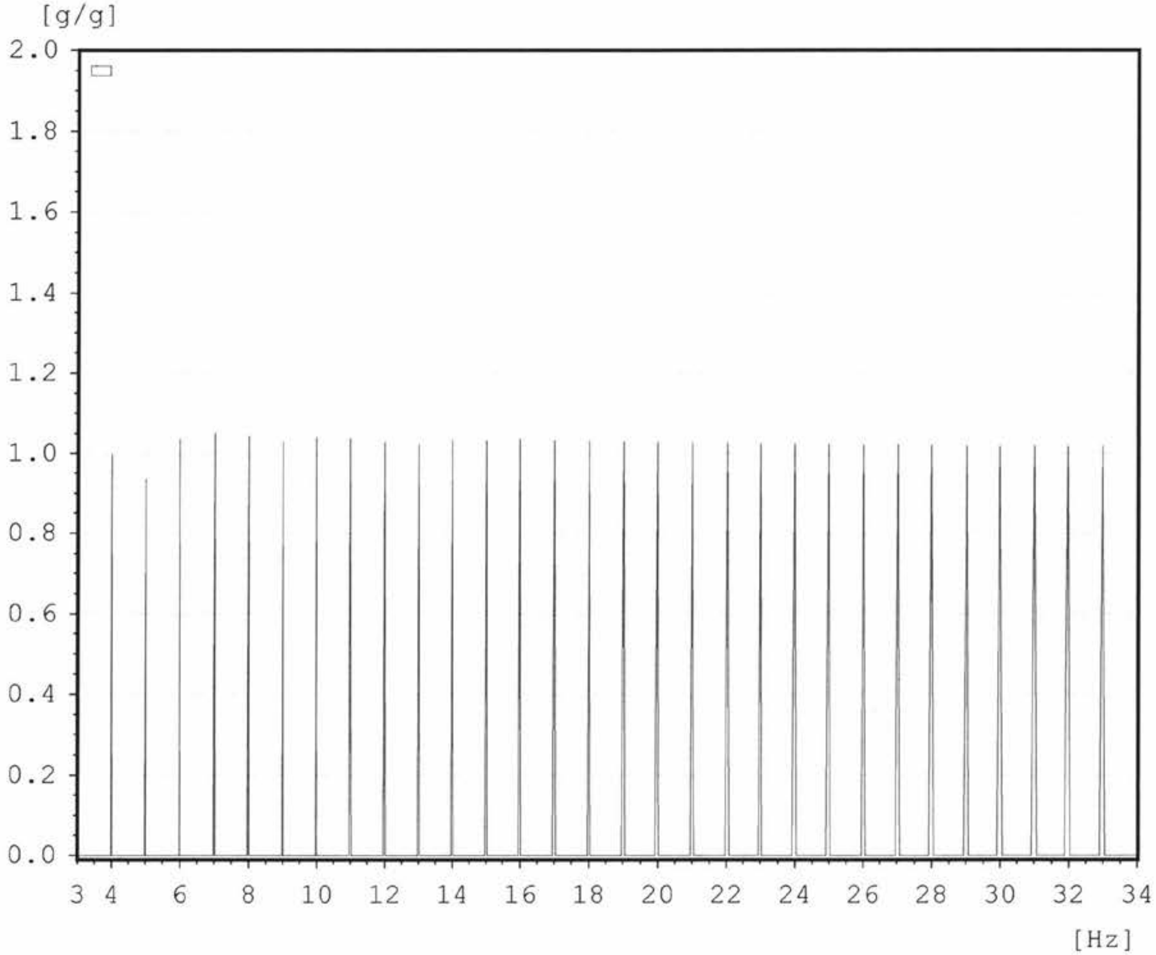
Tech.: F. Baumbach
Eng.: J. Sookhdeo Plot: 10A 8

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_003.rsd

Sine Dwell

R2 Board 2 vs. Control channel

Axis: Side/Side
Condition: Exploratory Frequency



Ref.Chan.type: X
Chan.no: 4
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 000:07:30
remaining: 000:00:00

Date: 08-08-14
Time: 22:13:31
Product version:

Advanced Tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach
Eng.: J. Sookhdeo
Plot: 10A 9

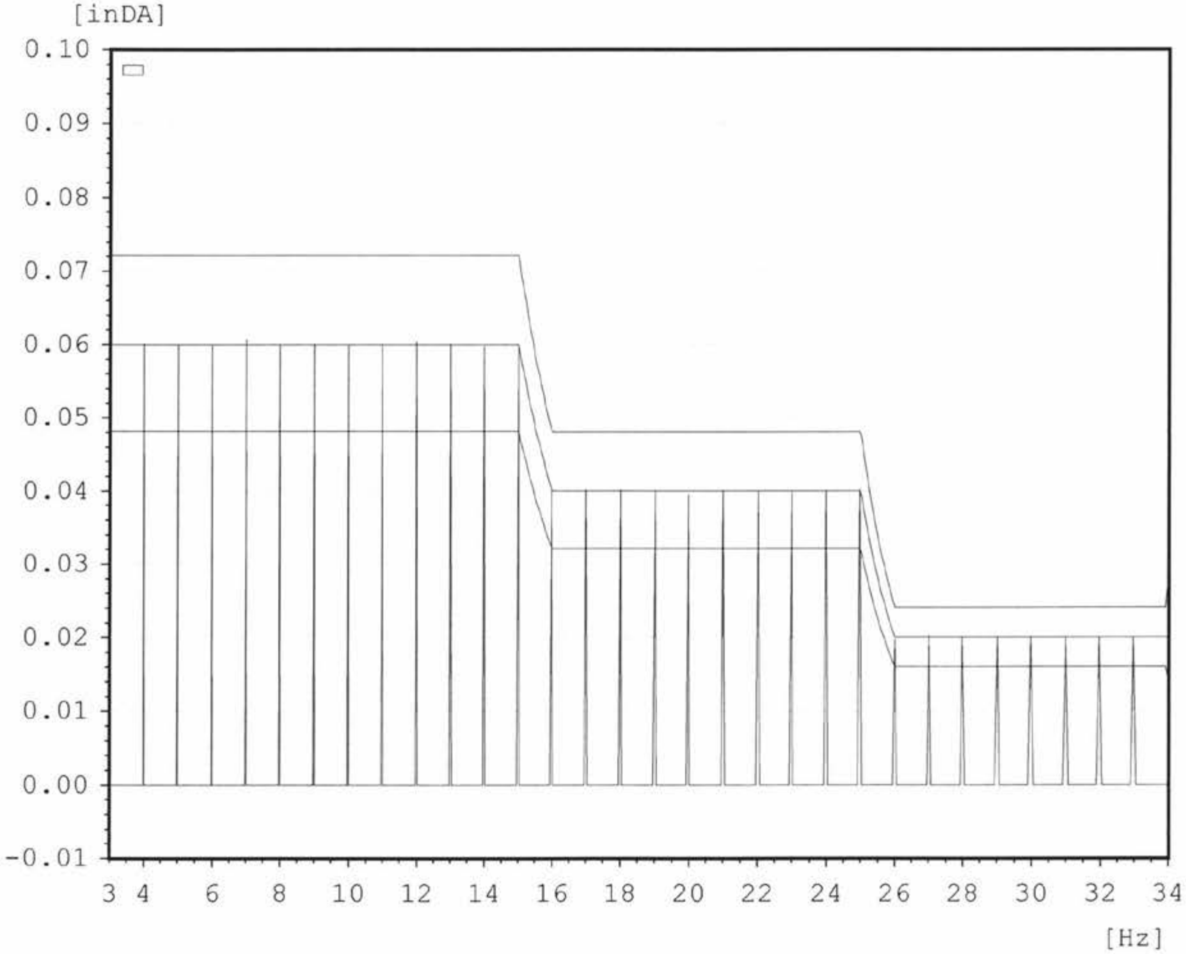
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Exploratory_003.rsd

Sine Dwell

Control channel (2xintegr)

Axis: Side/Side

Condition: Variable Frequency



Chan.type: X
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:30:00
remaining: 000:00:00

Date: 08-09-14
Time: 00:56:30
Product version:

Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach

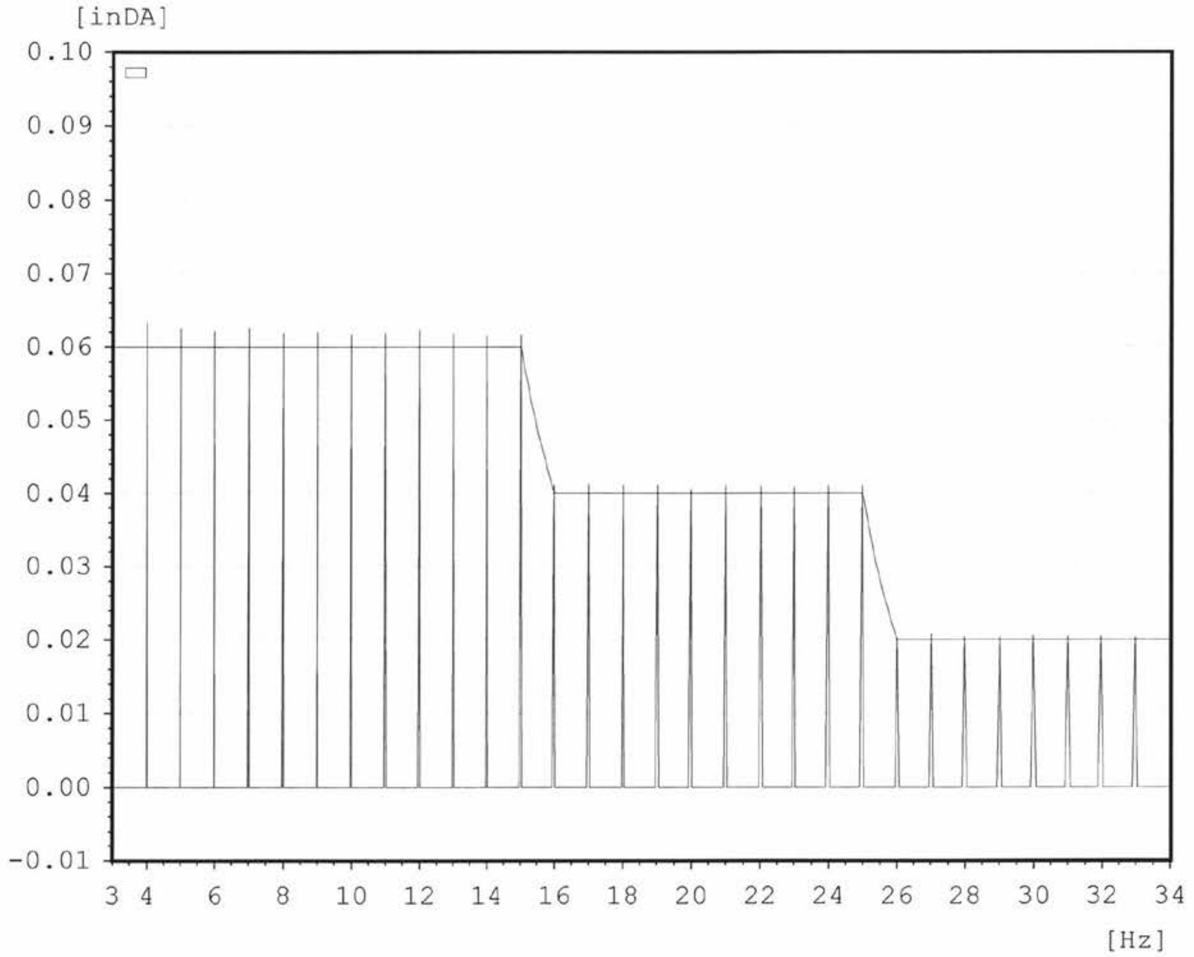
Engineer: J. Sookhdeo Plot: 11A /

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_004.rsd

Sine Dwell

C1_Fixture Top (2xintegr)

Axis: Side/Side
Condition: Variable Frequency



```
Chan.no:         1
Chan.type:       CW   Filtered
Sweep type:      logarithmic
Sweeps done:     0
Sweeps req.:     1
Sweep direct.:   up
Contr.strat.:    Average
Unit:            inDA
Contr.strat.:    Closed loop

-- Testing time --
elapsed:         002:30:00
remaining:       000:00:00

Date:            08-09-14
Time:            00:56:30
Product version:

 Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1
```

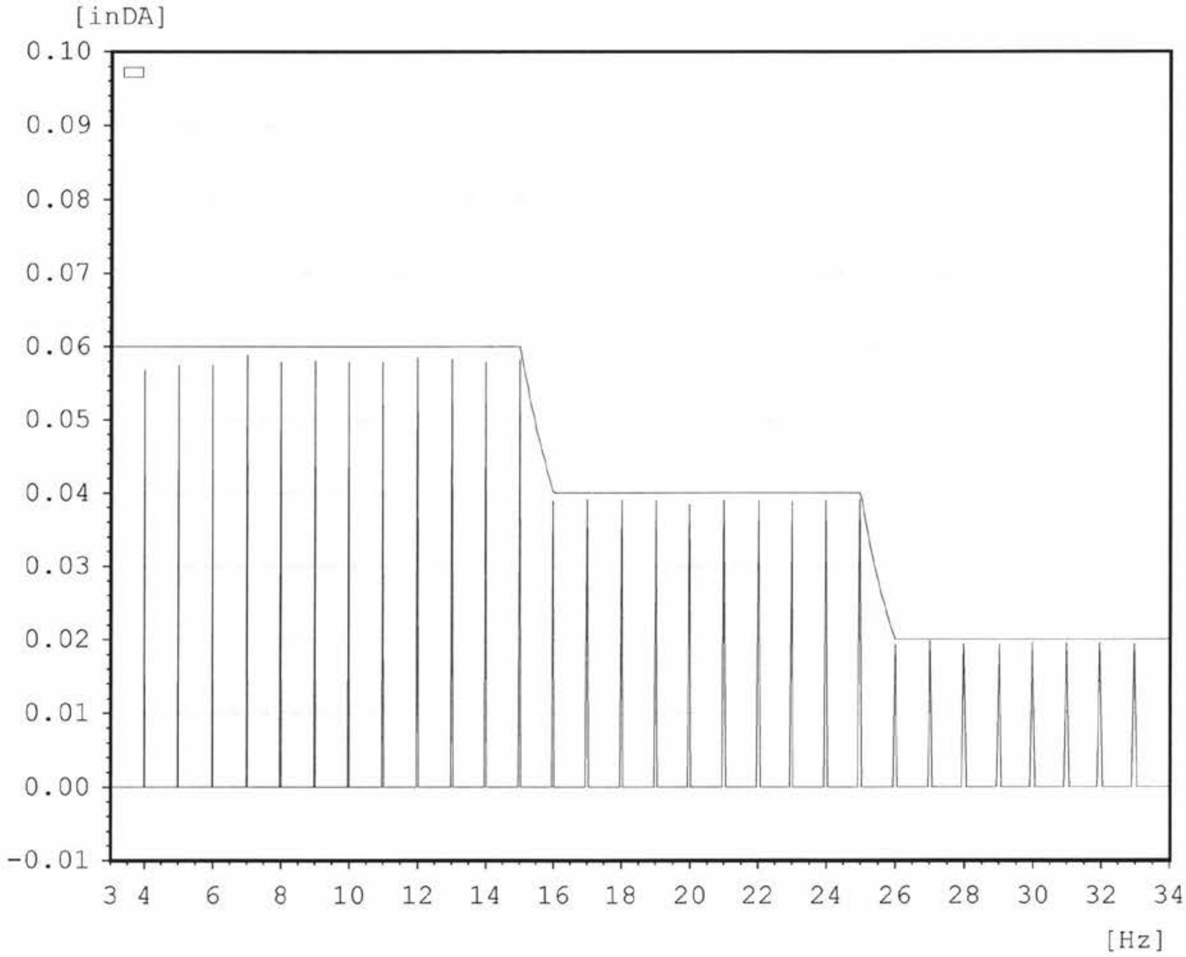
Tech.: F. Baumbach
Engineer: J. Sookhdeo   Plot: 11A2

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_004.rsd

Sine Dwell **C2 Fixture Bottom (2xintegr)**

Axis: Side/Side

Condition: Variable Frequency



Chan.no: 2
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:30:00
remaining: 000:00:00

Date: 08-09-14
Time: 00:56:30
Product version:

Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach

Engineer: J. Sookhdeo Plot: 11A ℓ 30

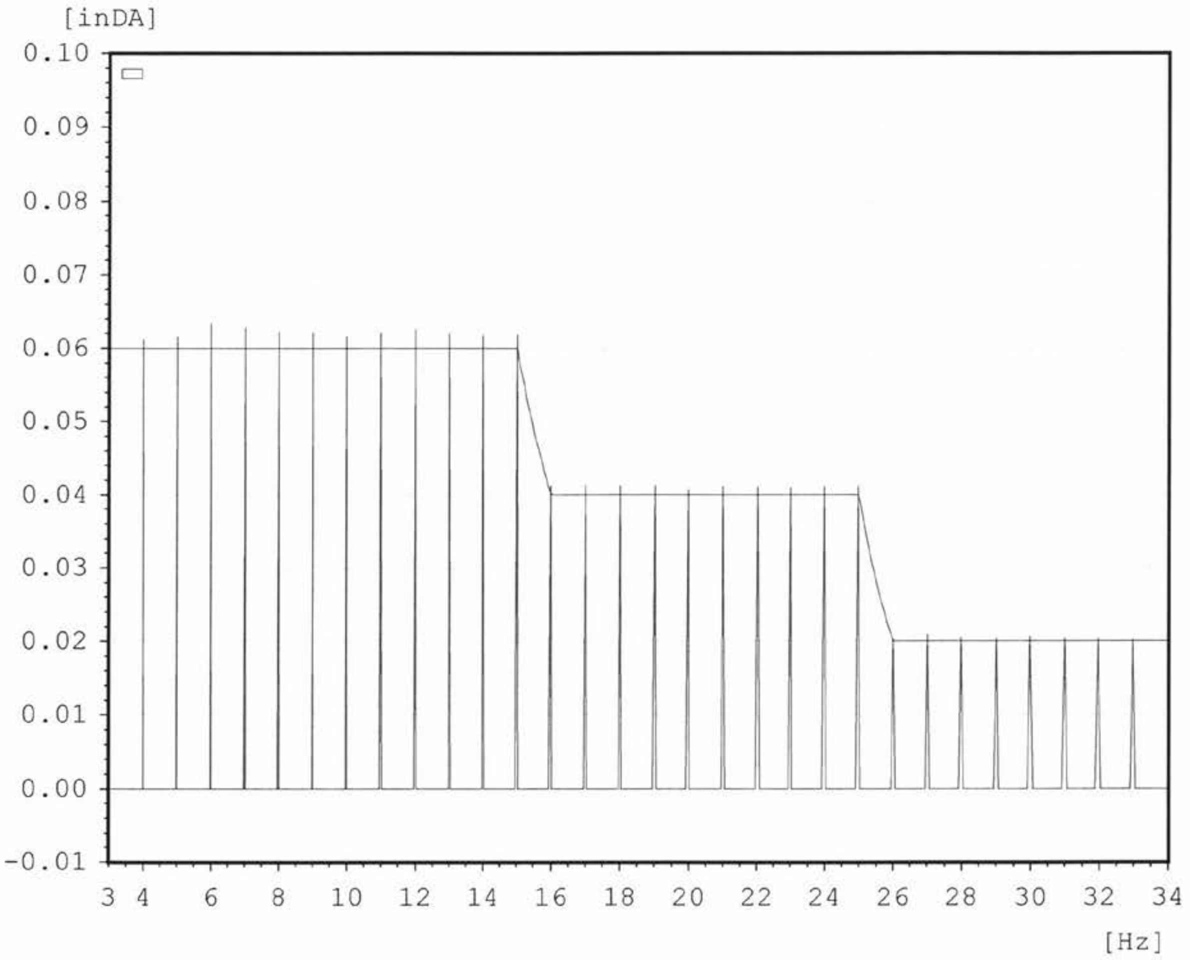
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_004.rsd

Sine Dwell

R1 Board 1 (2xintegr)

Axis: Side/Side

Condition: Variable Frequency



```
Chan.no:          3
Chan.type:            M Filtered
Sweep type:       logarithmic
Sweeps done:      0
Sweeps req.:      1
Sweep direct.: up
Contr.strat.:  Average
Unit:             inDA
Contr.strat.:  Closed loop

-- Testing time --
elapsed:          002:30:00
remaining:        000:00:00

Date:             08-09-14
Time:             00:56:30
Product version:

 Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1
```

Tech.: F. Baumbach

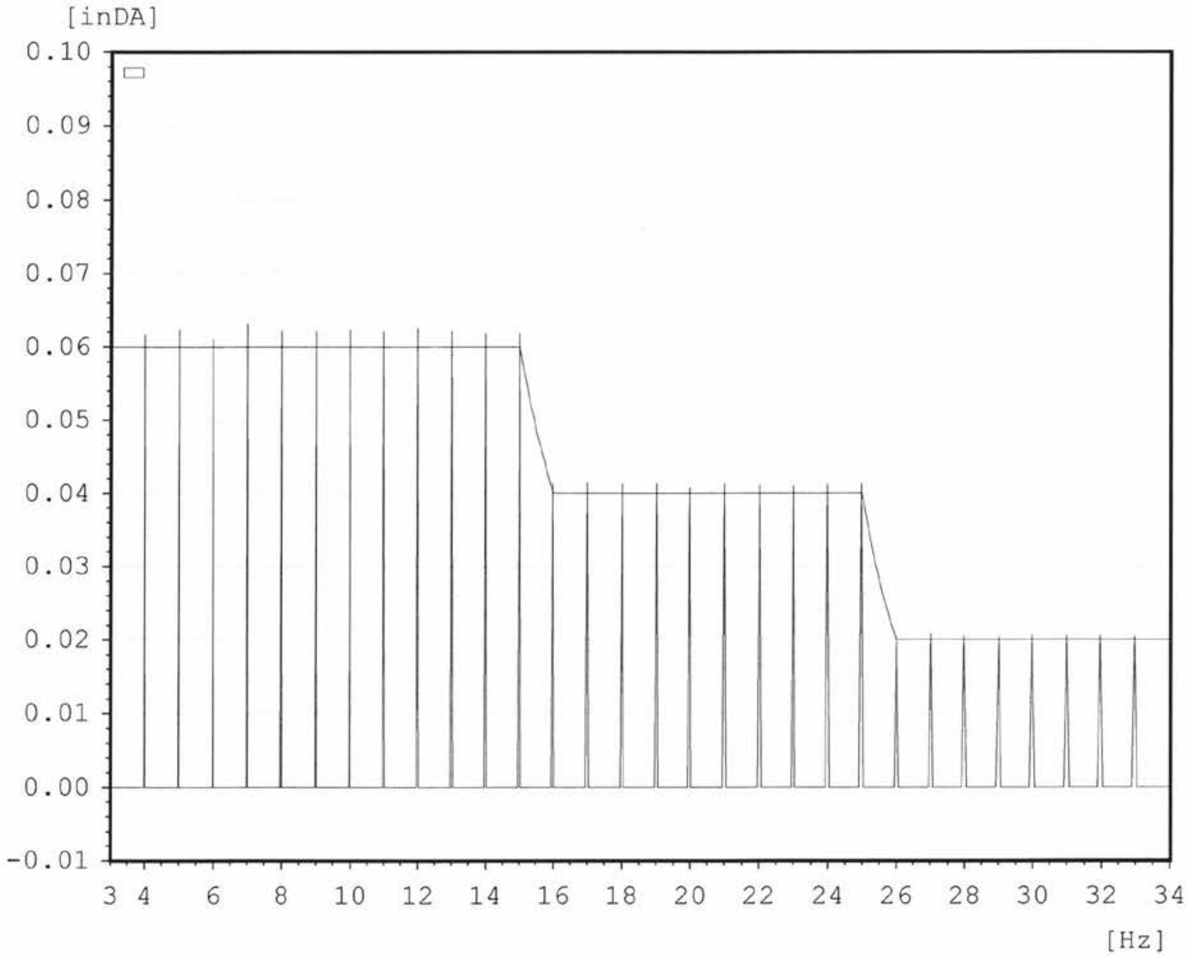
Engineer: J. Sookhdeo   Plot: 11A 4

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_004.rsd

Sine Dwell

R2 Board 2 (2xintegr)

Axis: Side/Side
Condition: Variable Frequency



Chan.no: 4
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:30:00
remaining: 000:00:00

Date: 08-09-14
Time: 00:56:30
Product version:

Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

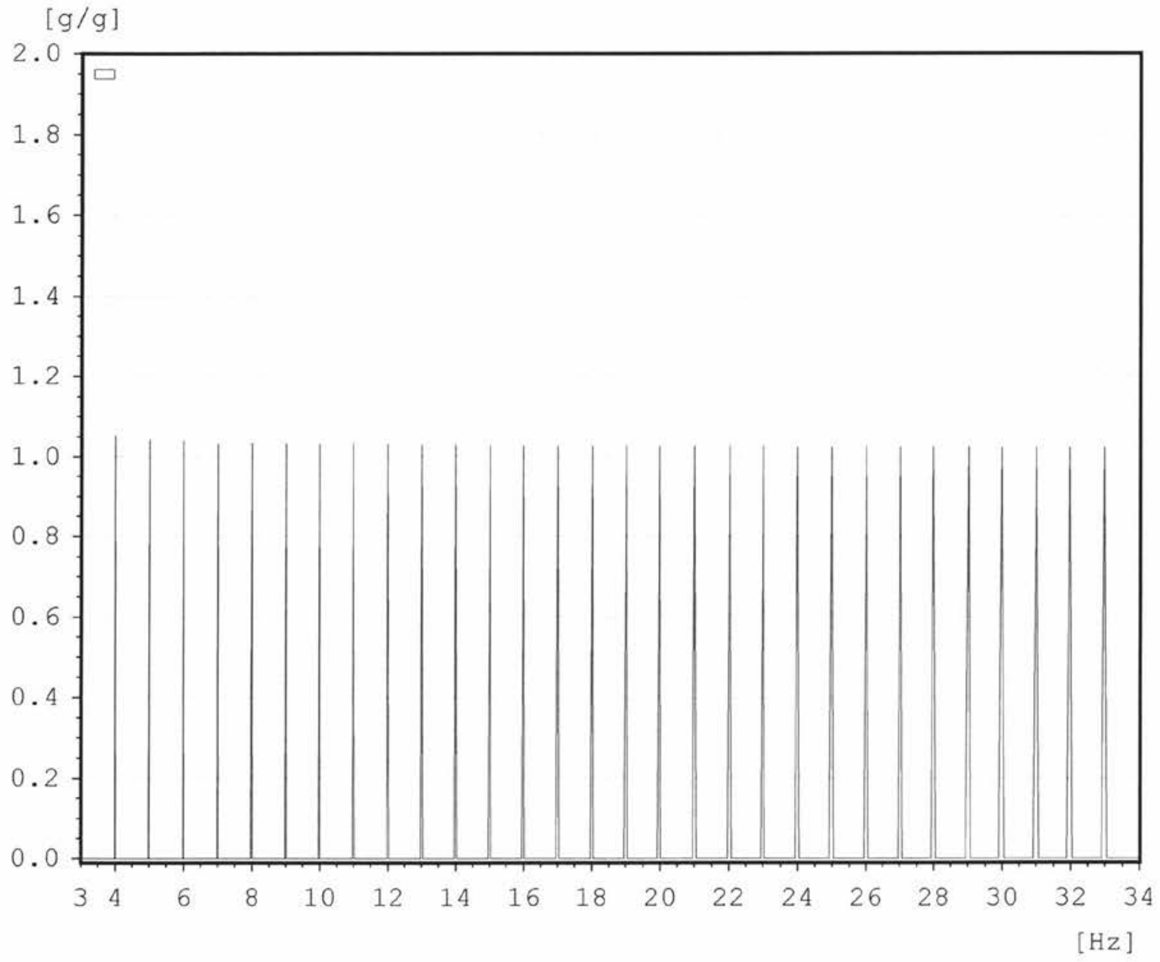
Tech.: F. Baumbach
Engineer: J. Sookhdeo
Plot: 11A 5

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_004.rsd

Sine Dwell **C1_Fixture Top vs. Control channel**

m+p

Axis: Side/Side
Condition: Variable Frequency



```
Ref.Chan.type: X
Chan.no:        1
Chan.type:      CW   Filtered
Sweep type:     logarithmic
Sweeps done:    0
Sweeps req.:    1
Sweep direct.: up
Contr.strat.:  Average
Unit:           g/g
Contr.strat.:  Closed loop

-- Testing time --
elapsed:        002:30:00
remaining:      000:00:00

Date:           08-09-14
Time:           00:56:30
Product version:

 Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1
```

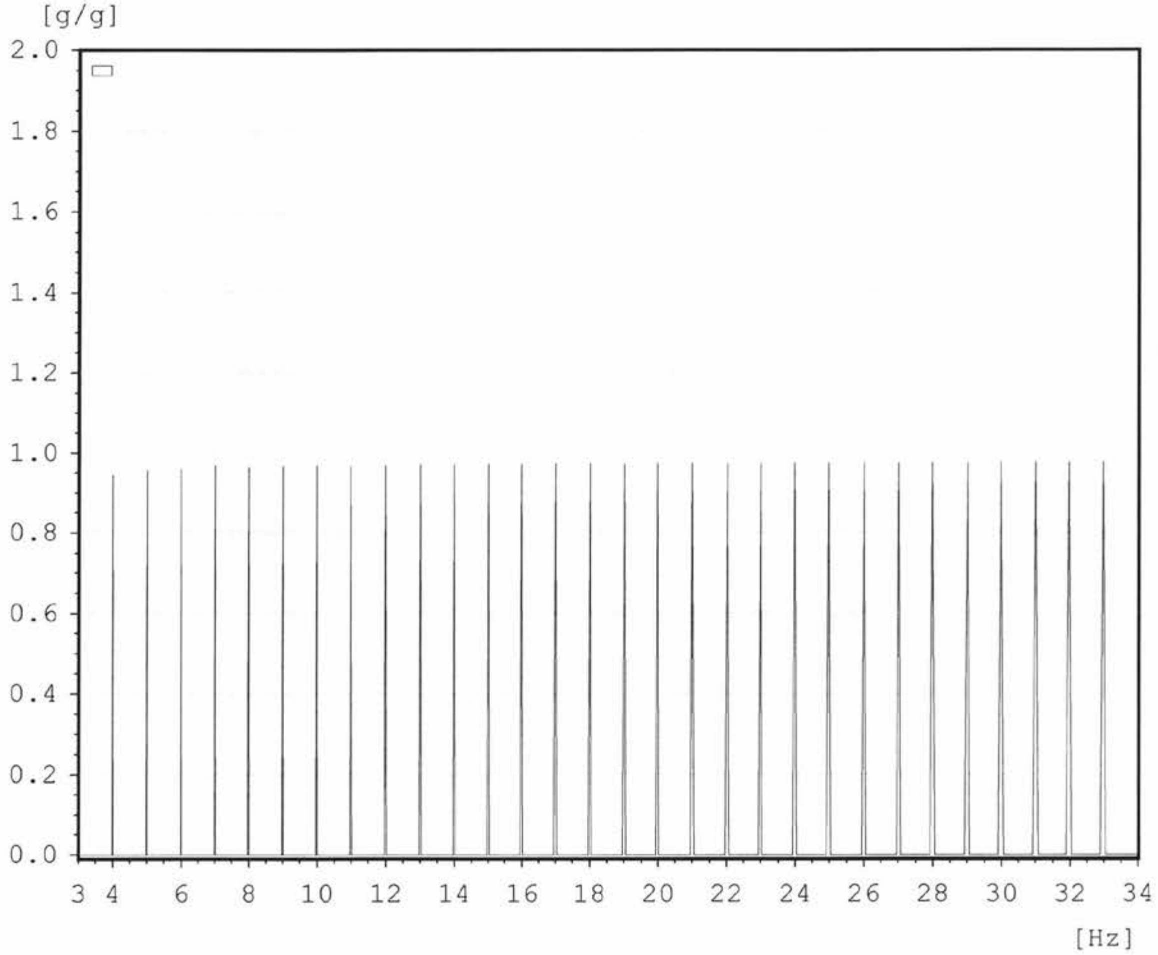
Tech.: F. Baumbach
Engineer: J. Sookhdeo   Plot: 11A 6

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_004.rsd

Sine DwellC2 **Fixture Bottom vs. Control channel**

Axis: Side/Side

Condition: Variable Frequency



```
Ref.Chan.type: X
Chan.no:       2
Chan.type:     CW   Filtered
Sweep type:    logarithmic
Sweeps done:   0
Sweeps req.:   1
Sweep direct.: up
Contr.strat.:  Average
Unit:          g/g
Contr.strat.:  Closed loop

-- Testing time --
elapsed:       002:30:00
remaining:     000:00:00

Date:          08-09-14
Time:          00:56:30
Product version:

 Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1
```

Tech.: F. Baumbach

Engineer: J. Sookhdeo   Plot: 11A 7

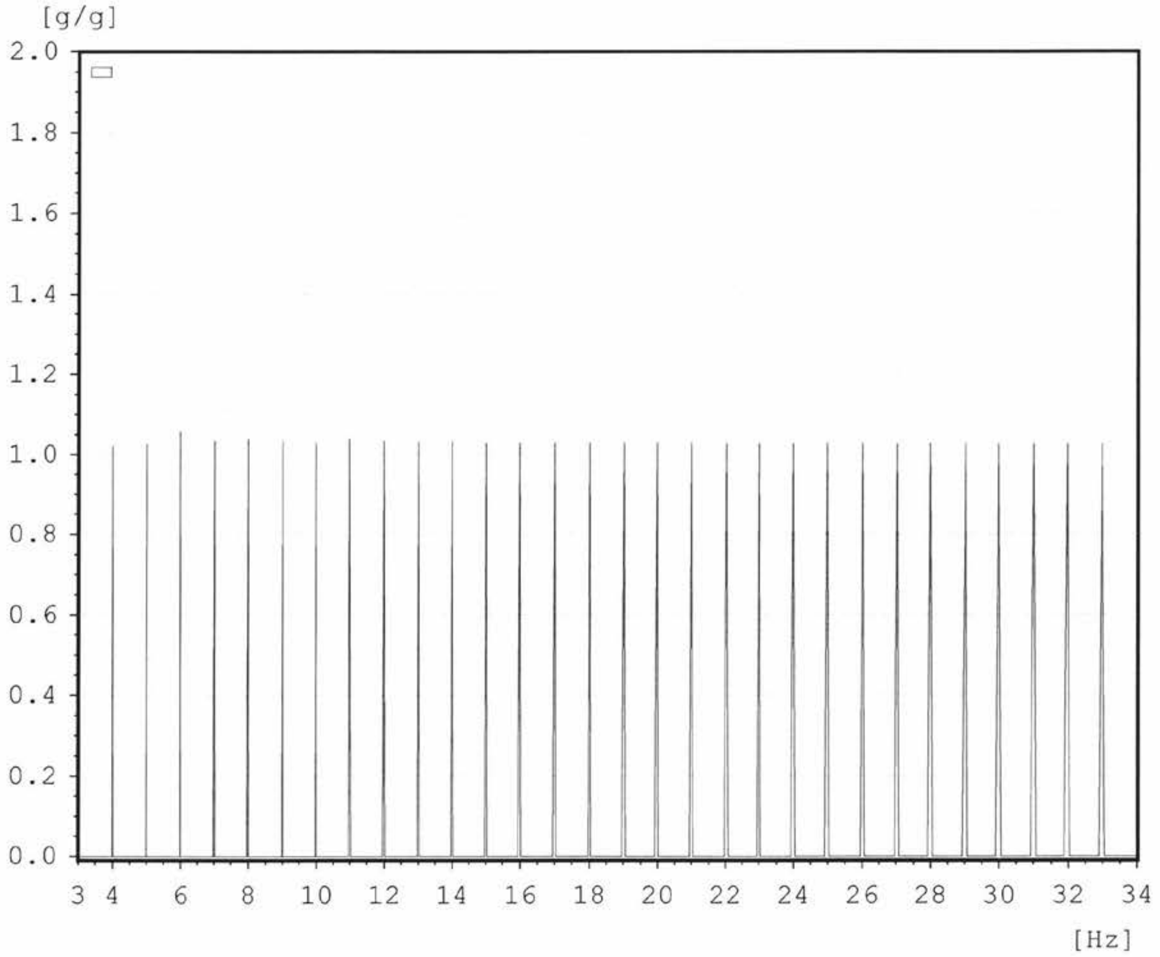
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_004.rsd

Sine Dwell

R1 Board 1 vs. Control channel

Axis: Side/Side

Condition: Variable Frequency



Ref.Chan.type: X
Chan.no: 3
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:30:00
remaining: 000:00:00

Date: 08-09-14
Time: 00:56:30
Product version:

Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach
Engineer: J. Sookhdeo
Plot: 11A

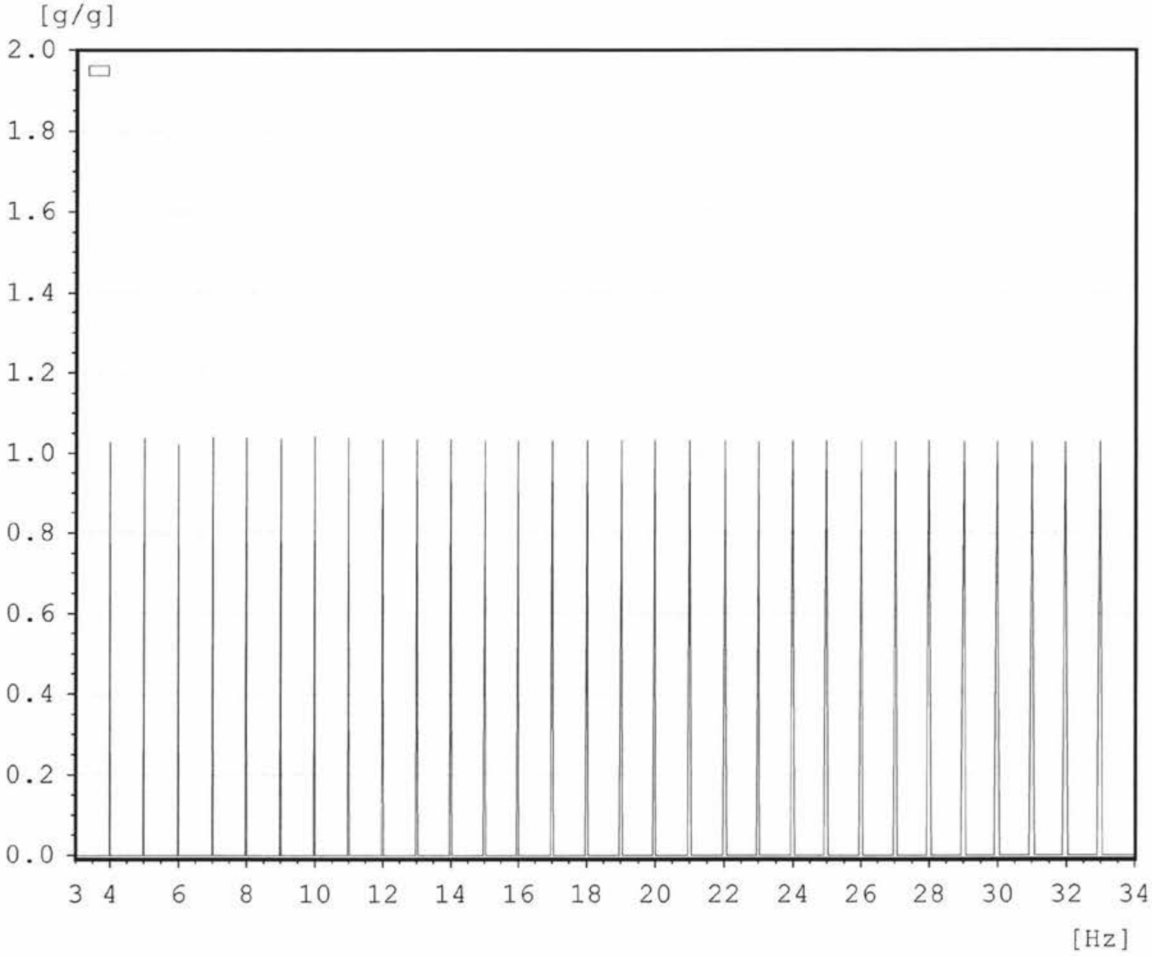
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_004.rsd

Sine Dwell

R2 Board 2 vs. Control channel

Axis: Side/Side

Condition: Variable Frequency



Ref.Chan.type: X
Chan.no: 4
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:30:00
remaining: 000:00:00

Date: 08-09-14
Time: 00:56:30
Product version:

Advanced tech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: F. Baumbach
Engineer: J. Sookhdeo
Plot: 11A

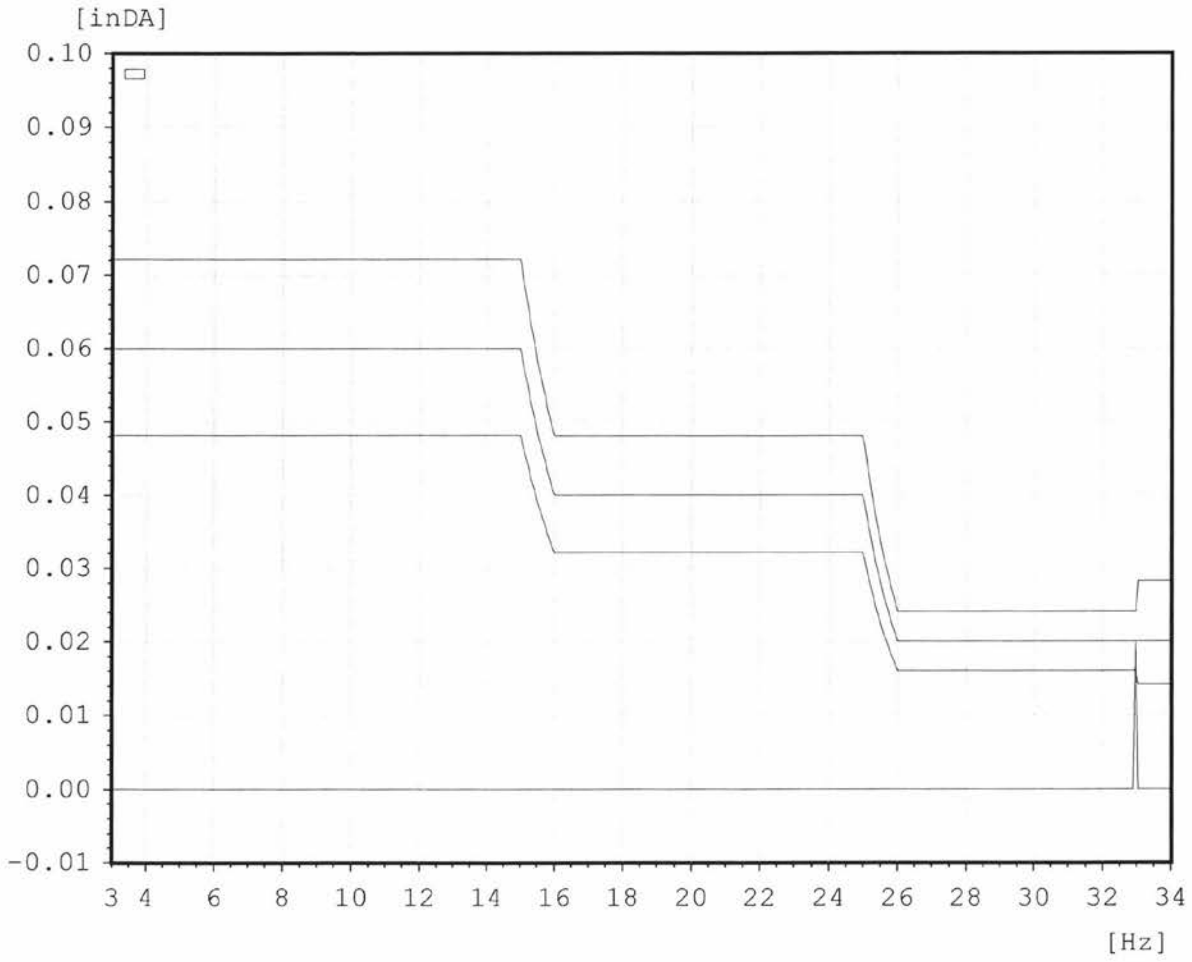
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced tech Variable_004.rsd

Sine Dwell

Control channel (2xintegr)

Axis: side/side

Condition: Endurance



Chan.type: X
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-11-14
Time: 11:29:02
Product version:

AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: P Urso

Engineer: J. Sookhdeo Plot: 12A /

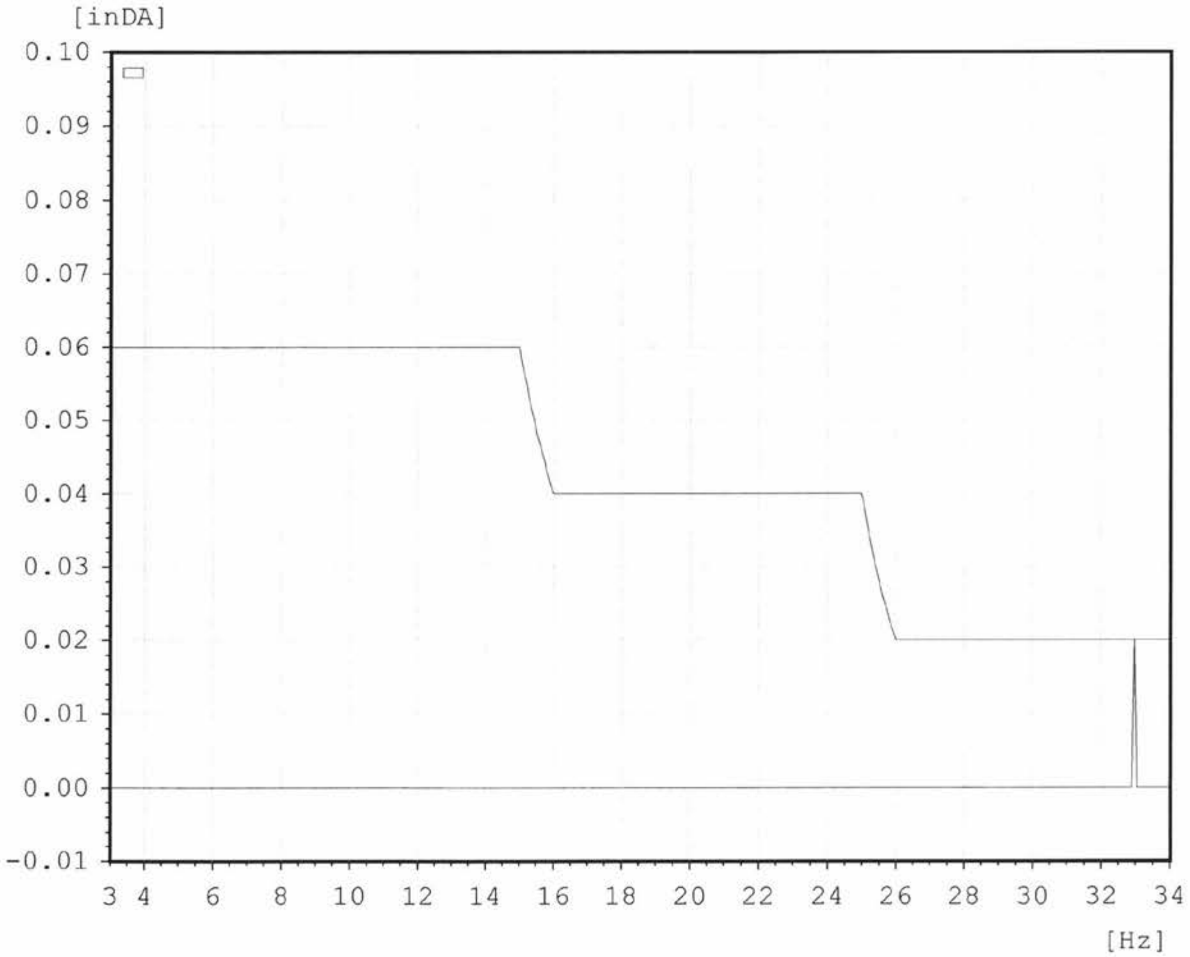
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_005.rsd

Sine Dwell

C1 Fixture Top (2xintegr)

Axis: side/side

Condition: Endurance



Chan.no: 1
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-11-14
Time: 11:29:02
Product version:

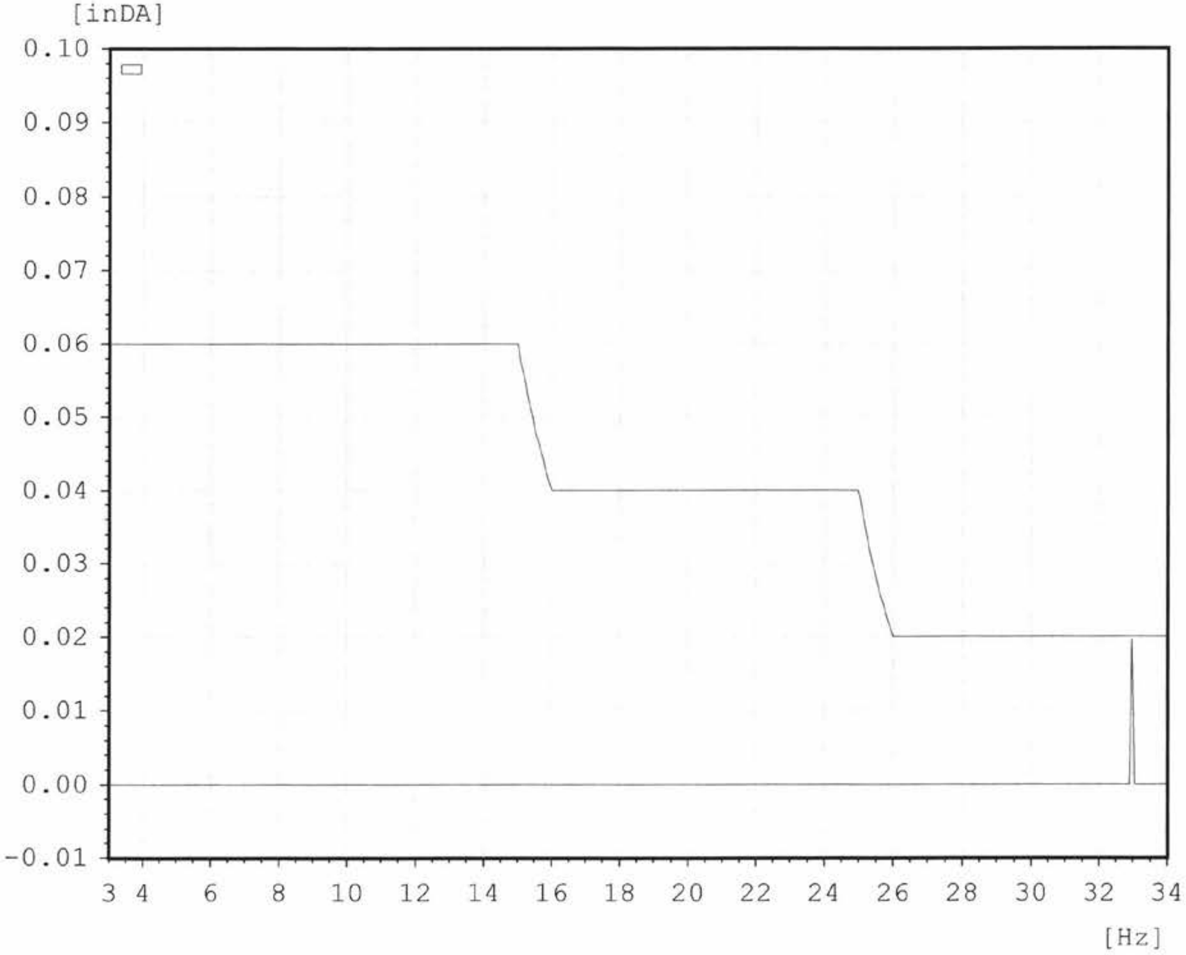
AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: P Urso
Engineer: J. Sookhdeo Plot: 12A 2

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_005.rsd

Sine Dwell **C2 Fixture Bottom (2xintegr)**

Axis: side/side
Condition: Endurance



```
Chan.no:          2
Chan.type:        CW   Filtered
Sweep type:       logarithmic
Sweeps done:      0
Sweeps req.:      1
Sweep direct.:    up
Contr.strat.:     Average
Unit:             inDA
Contr.strat.:     Closed loop

-- Testing time --
elapsed:          002:00:00
remaining:        000:00:00

Date:             08-11-14
Time:             11:29:02
Product version:

AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1
```

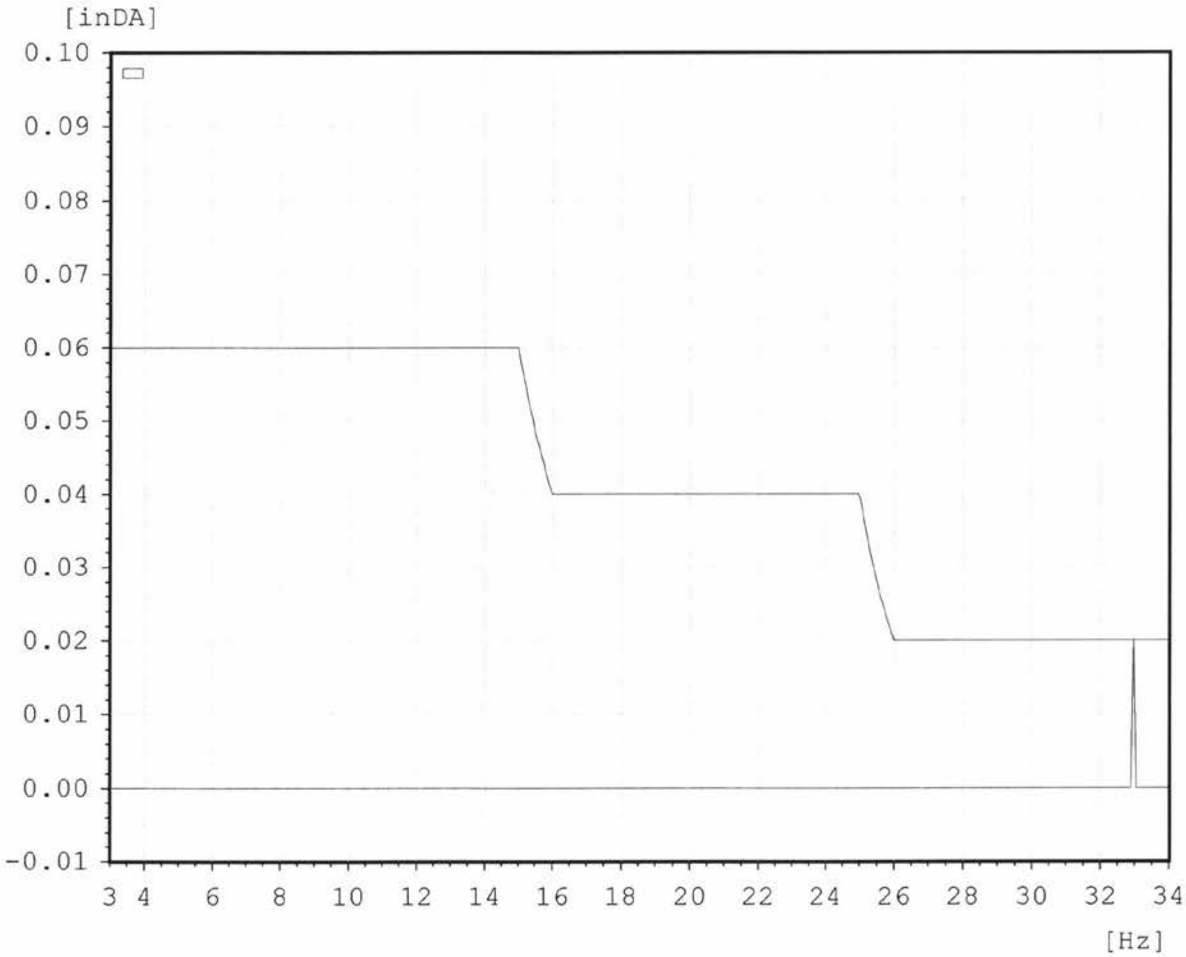
Tech.: P Urso
Engineer: J. Sookhdeo   Plot: 12A 3

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_005.rsd

Sine Dwell

R1 Board 1 (2xintegr)

Axis: side/side
Condition: Endurance



Chan.no: 3
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-11-14
Time: 11:29:02
Product version:

AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: P Urso
Engineer: J. Sookhdeo Plot: 12A 4

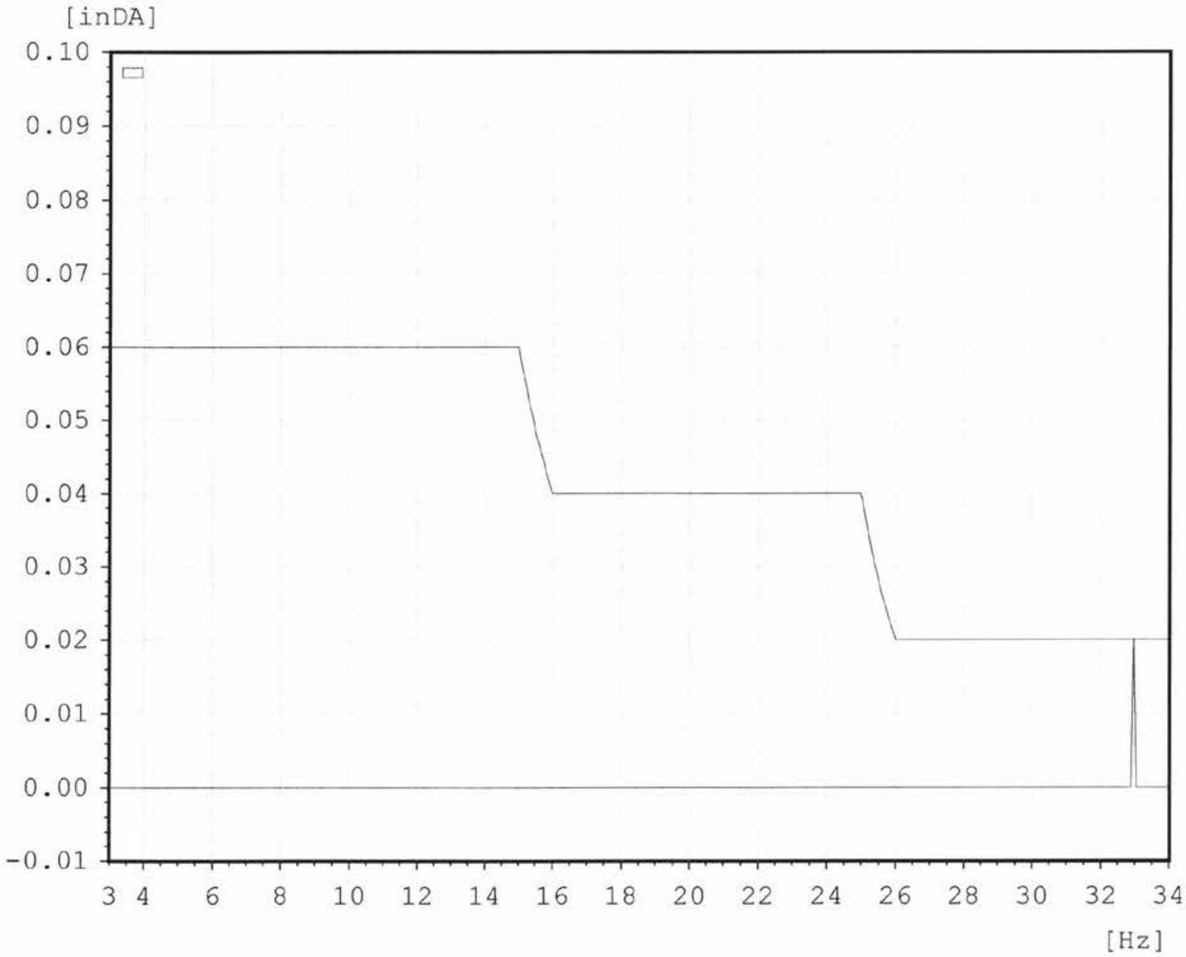
C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_005.rsd

Sine Dwell

R2 Board 2 (2xintegr)

Axis: side/side

Condition: Endurance



Chan.no: 4
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: inDA
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-11-14
Time: 11:29:02
Product version:

AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

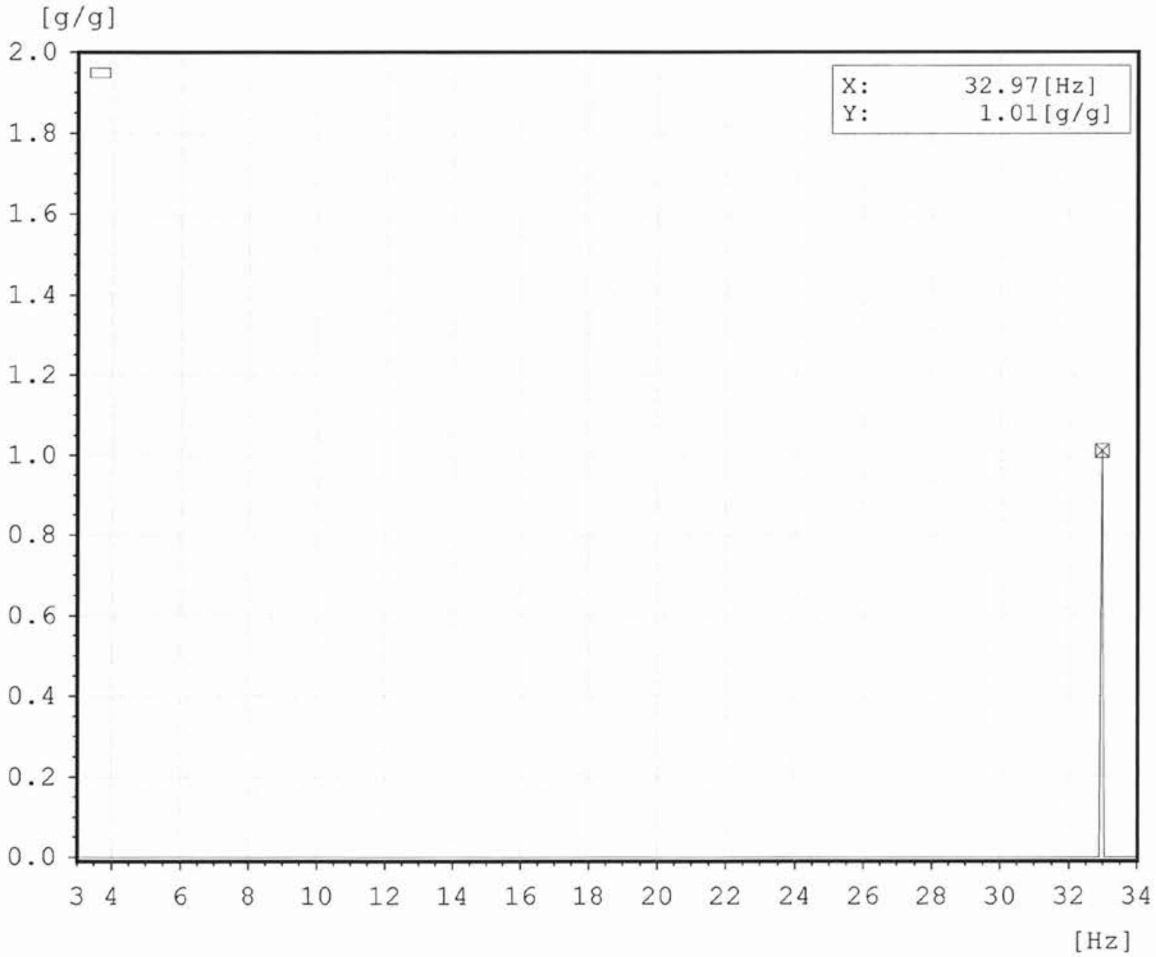
Tech.: P Urso

Engineer: J. Sookhdeo Plot: 12A 5

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_005.rsd

Sine Dwell **C1 Fixture Top vs. Control channel**

Axis: side/side
Condition: Endurance



Ref.Chan.type: X
Chan.no: 1
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-11-14
Time: 11:29:02
Product version:

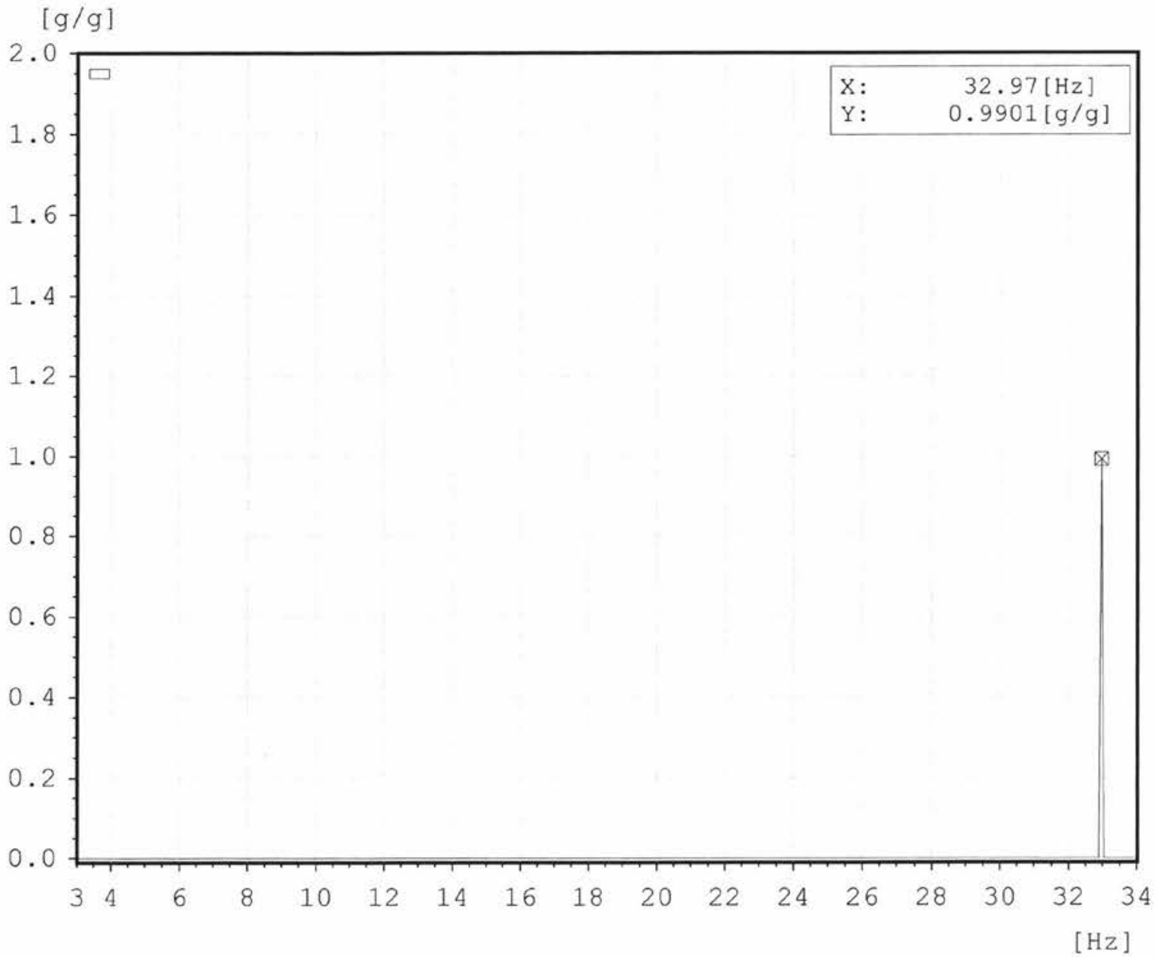
AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: P Urso
Engineer: J. Sookhdeo Plot: 12A 6

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_005.rsd

Sine DwelC2 Fixture Bottom vs. Control channel

Axis: side/side
Condition: Endurance



Ref.Chan.type: X
Chan.no: 2
Chan.type: CW Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-11-14
Time: 11:29:02
Product version:

AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

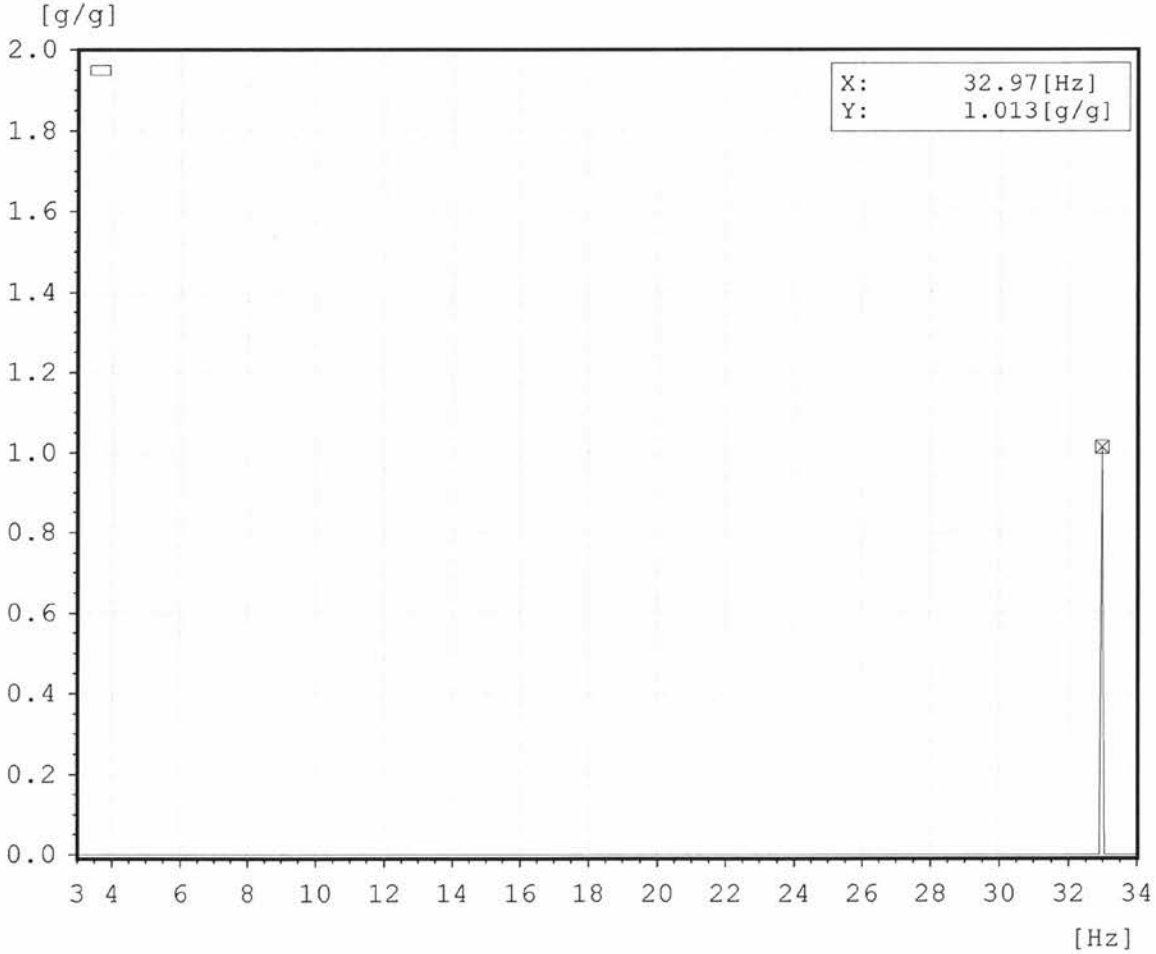
Tech.: P Urso
Engineer: J. Sookhdeo Plot: 12A 7

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_005.rsd

Sine Dwell

R1 Board 1 vs. Control channel

Axis: side/side
Condition: Endurance



Ref.Chan.type: X
Chan.no: 3
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-11-14
Time: 11:29:02
Product version: :

AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

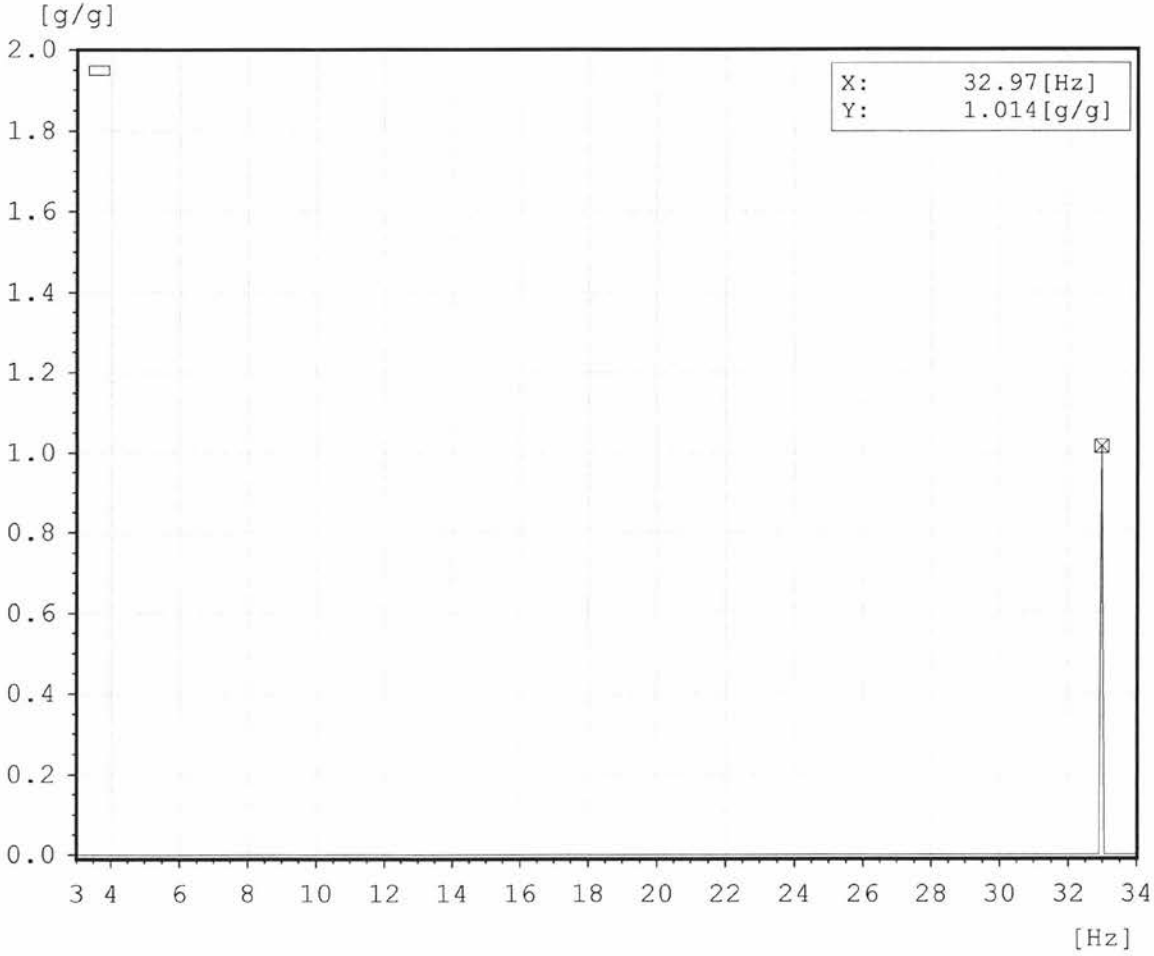
Tech.: P Urso
Engineer: J. Sookhdeo Plot: 12A 8

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_005.rsd

Sine Dwell

R2 Board 2 vs. Control channel

Axis: side/side
Condition: Endurance



Ref.Chan.type: X
Chan.no: 4
Chan.type: M Filtered
Sweep type: logarithmic
Sweeps done: 0
Sweeps req.: 1
Sweep direct.: up
Contr.strat.: Average
Unit: g/g
Contr.strat.: Closed loop

-- Testing time --
elapsed: 002:00:00
remaining: 000:00:00

Date: 08-11-14
Time: 11:29:02
Product version:

AdvancedTtech
J/N: 413980-03
Low Voltage Quick Connector Pane
S/N: DTB #1

Tech.: P Urso
Engineer: J. Sookhdeo Plot: 12A 9

C:\VcpNT\Daten\DTB\Advanced Tech 413980\Advanced Tech Endurance_005.rsd

**Test equipment utilized for the program reported herein was within its assigned interval of calibration.
Details are on file at Dayton T. Brown, Inc. and will be made available upon request.**

Job Sub: **413980-03** **TEST: VIBRATION**

ITEM	MANUFACTURER	MODEL	DTB NO.	ACCURACY	CAL DUE DATE
VIBRATION EXCITER, HYDRAULIC (HORIZONTAL)	TEAM	810.5/17.5	04V-028	N/A	N.C.R.
CONTROLLER, HYDRAULIC MANIFOLD (HORIZONTAL)	TEAM	1510-F	04V-029	N/A	N.C.R.
VIBRATION EXCITER, HYDRAULIC (VERTICAL)	TEAM	1010.5/17.5-10.5	04V-030	N/A	N.C.R.
CONTROLLER, HYDRAULIC MANIFOLD (VERTICAL)	TEAM	1510-F	04V-031	N/A	N.C.R.
MAINFRAME, VXI C-SIZE 5 SLOT	VXI TECHNOLOGY	CT-310A	10-364	MAINTENANCE ONLY	02/01/2015
ARBITRARY SOURCE, 2 CHANNEL	VXI TECHNOLOGY	VT1434A	10-365	MFR	02/01/2015
INPUT MODULE, 16 CHANNEL	VXI TECHNOLOGY	VT1436	10-366	MFR	02/01/2015
INPUT MODULE, 16 CHANNEL	VXI TECHNOLOGY	VT1436	10-367	MFR	02/01/2015
DETECTOR, CONTACT CHATTER	TRIG-TEK	850A	11-5	MFR	10/19/2014
DETECTOR, CONTACT CHATTER	EADS	850B	11-6	MFR	04/05/2015
DETECTOR, CONTACT CHATTER	TRANS-TEK	850A	11-7	MFR	04/19/2015
ACCELEROMETER, ICP	PCB PIEZOTRONICS	352C33	32-188	MFR	05/24/2015
ACCELEROMETER, ICP	PCB PIEZOTRONICS	333B32/ACS-4/ACS-30	32-243	MFR	01/25/2015
ACCELEROMETER, ICP	PCB PIEZOTRONICS	333B32/ACS-4/ACS-30	32-244	MFR	01/25/2015

Test equipment utilized for the program reported herein was within its assigned interval of calibration.
Details are on file at Dayton T. Brown, Inc. and will be made available upon request.

Job Sub: **413980-03** **TEST: VIBRATION**

ITEM	MANUFACTURER	MODEL	DTB NO.	ACCURACY	CAL DUE DATE
ACCELEROMETER, ICP	PCB PIEZOTRONICS	353B03	32-527	MFR	05/24/2015

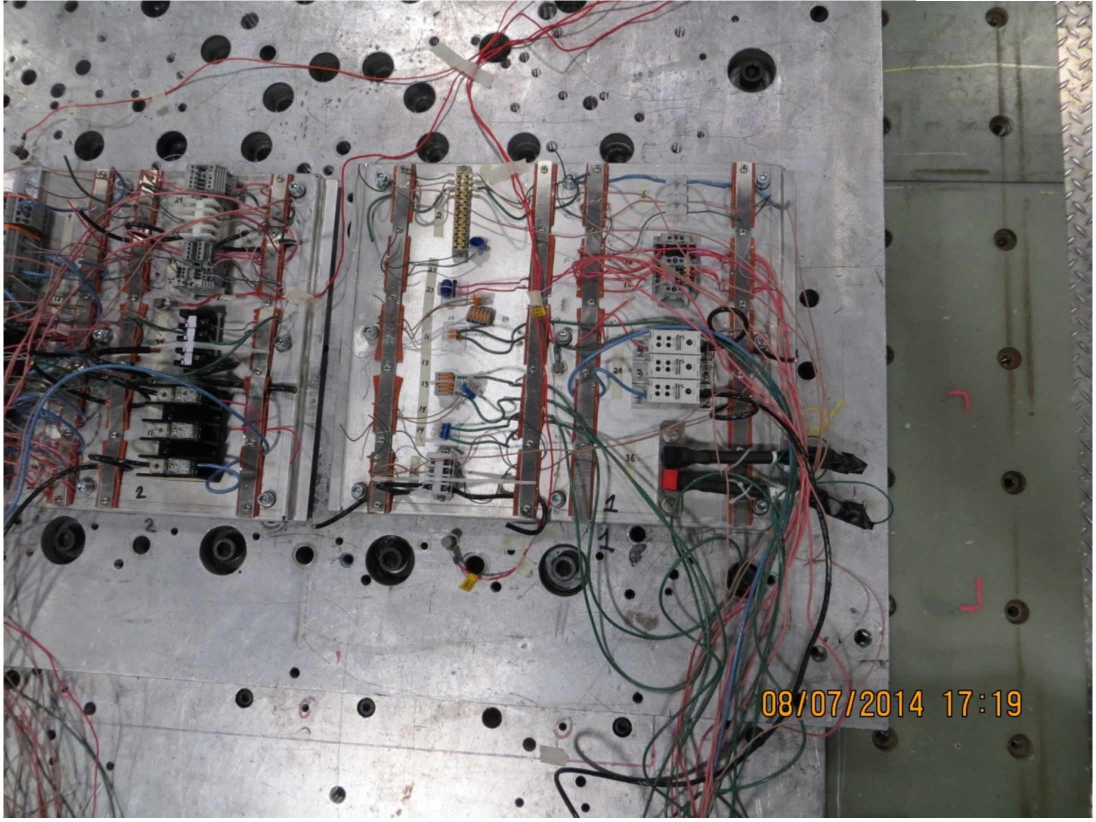


Photo 1 – File No. FB14-0560
Vibration test setup in the front/back axis

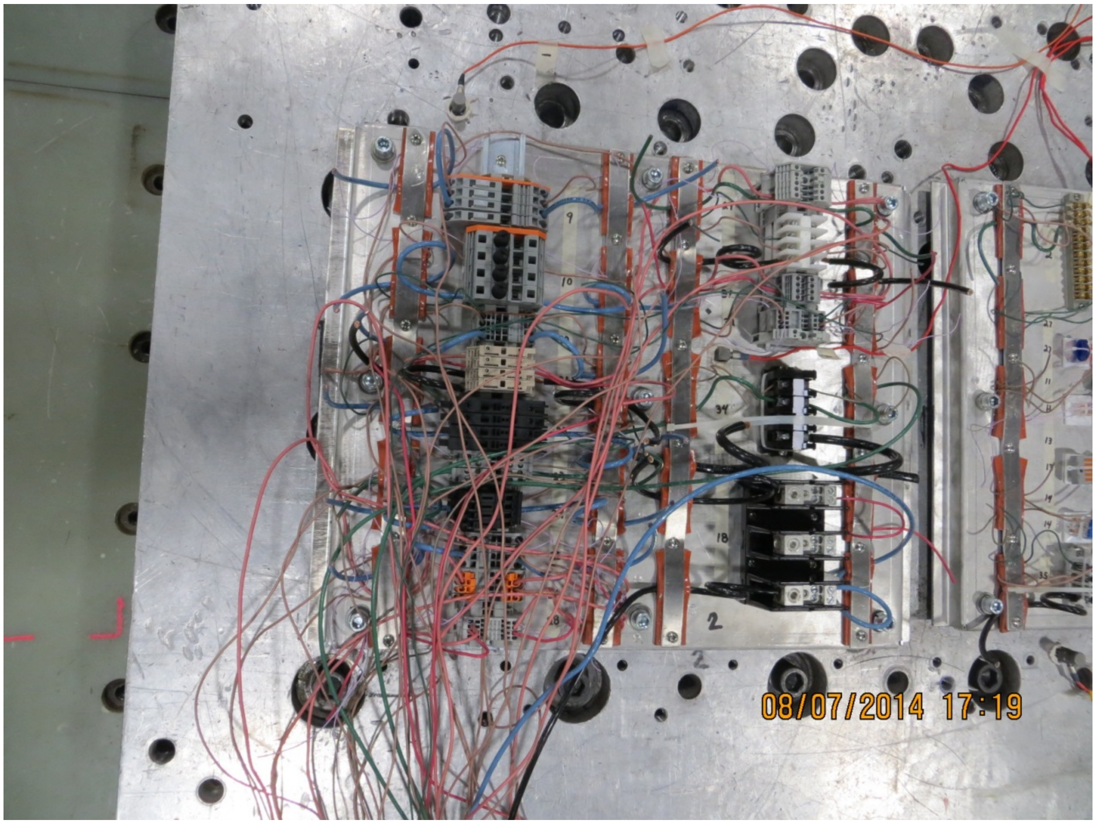


Photo 2 – File No. FB14-0561
Vibration test setup in the front/back axis

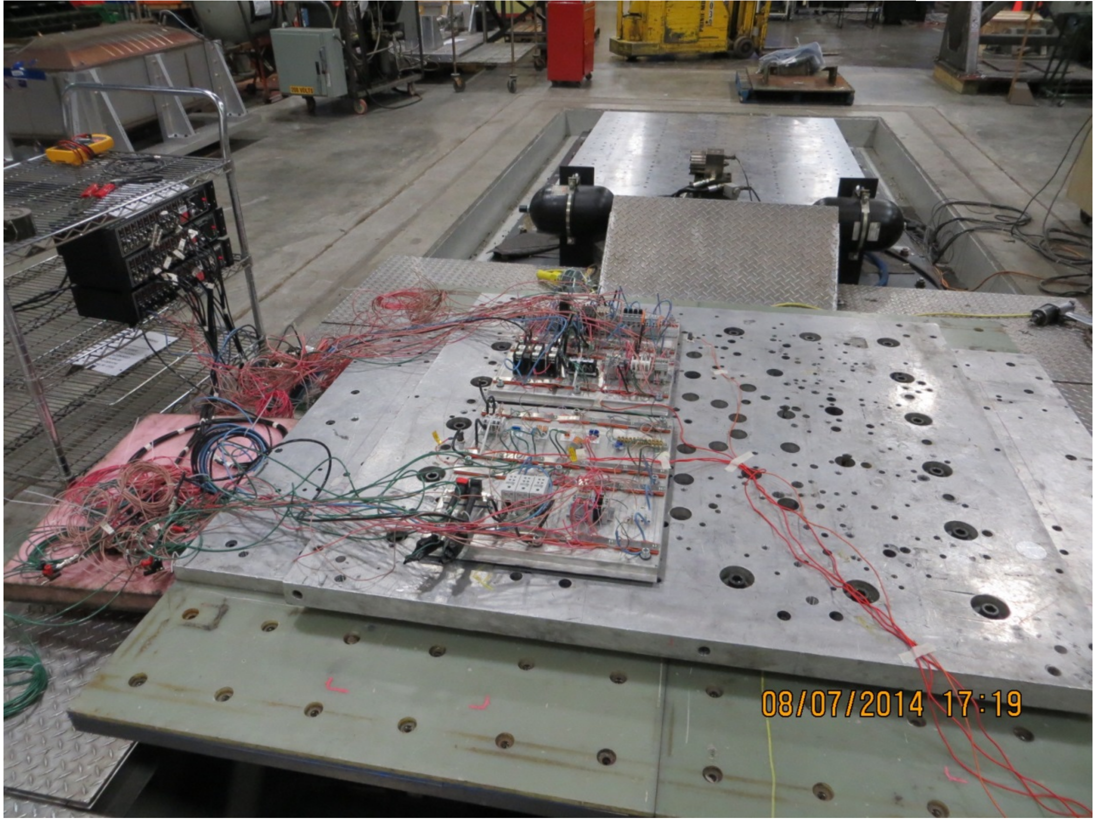


Photo 3 – File No. FB14-0562
Vibration test setup in the front/back axis

Photo 4 – File No. FB14-0563
Vibration test setup in the up/down axis

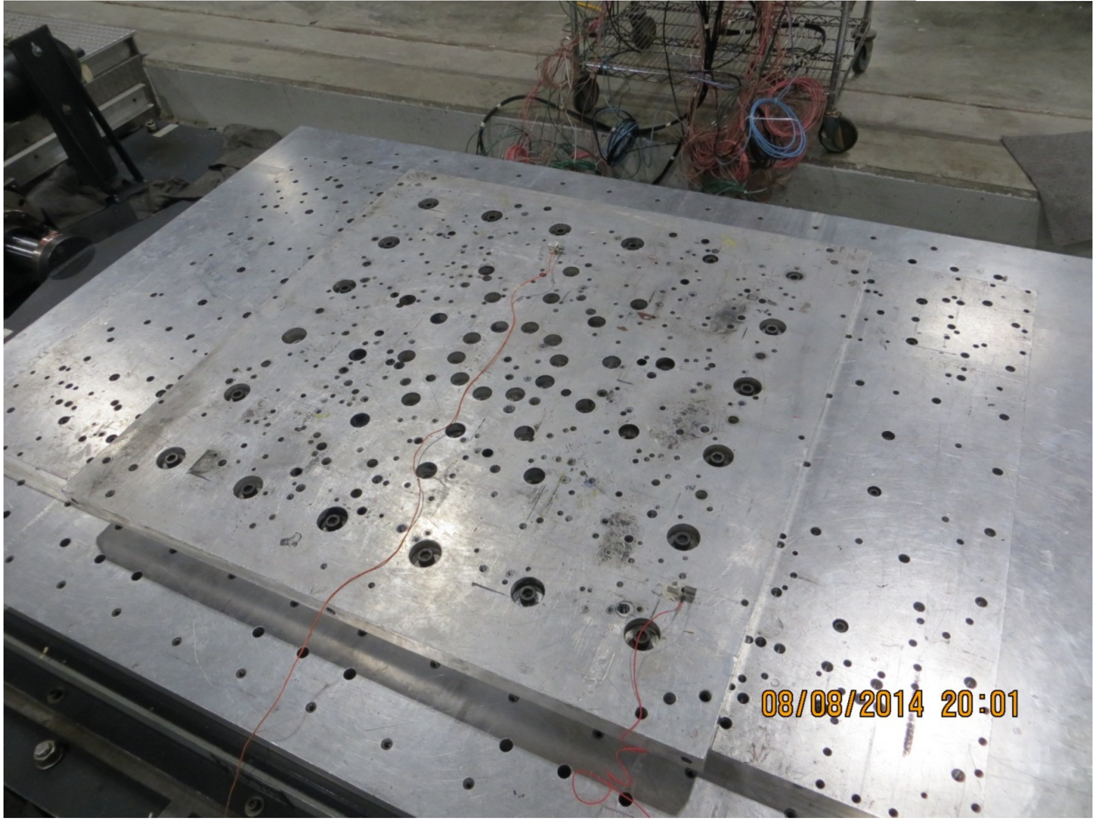

08/08/2014 20:01

Photo 5 – File No. FB14-0564
Vibration test setup in the up/down axis for fixture survey

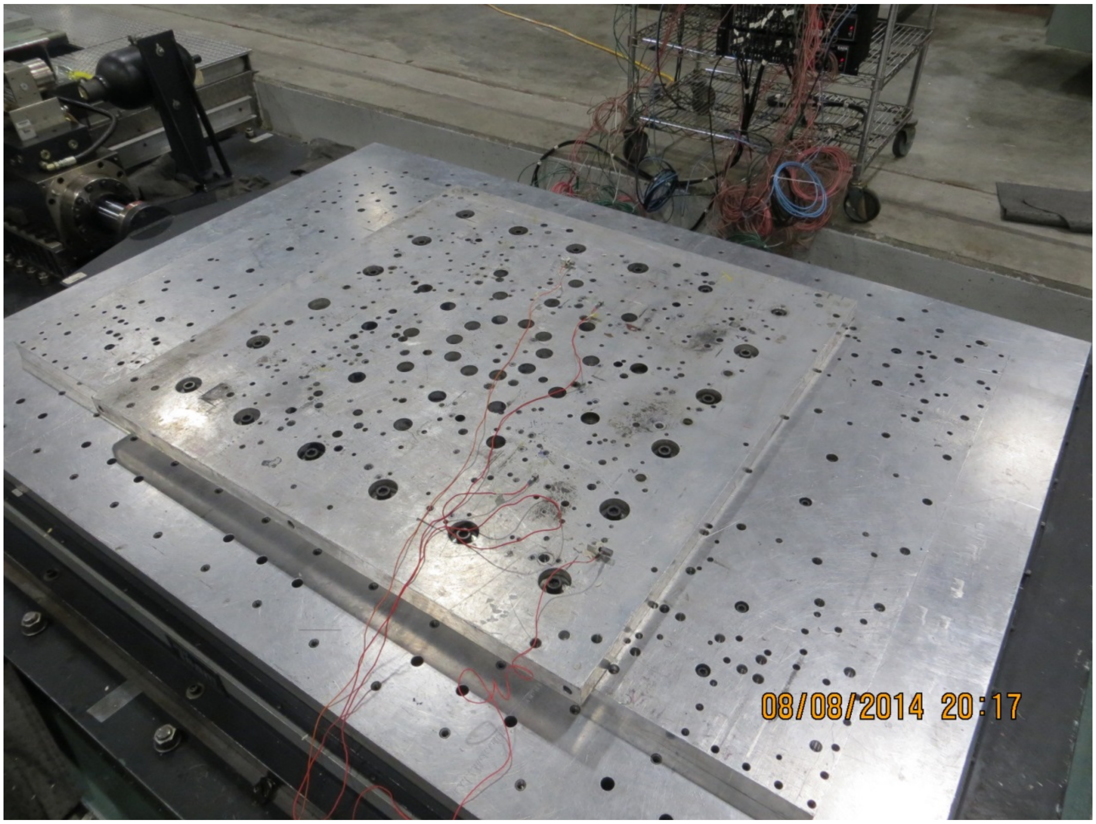

08/08/2014 20:17

Photo 6 – File No. FB14-0566
Vibration test setup in the side/side axis for the fixture survey

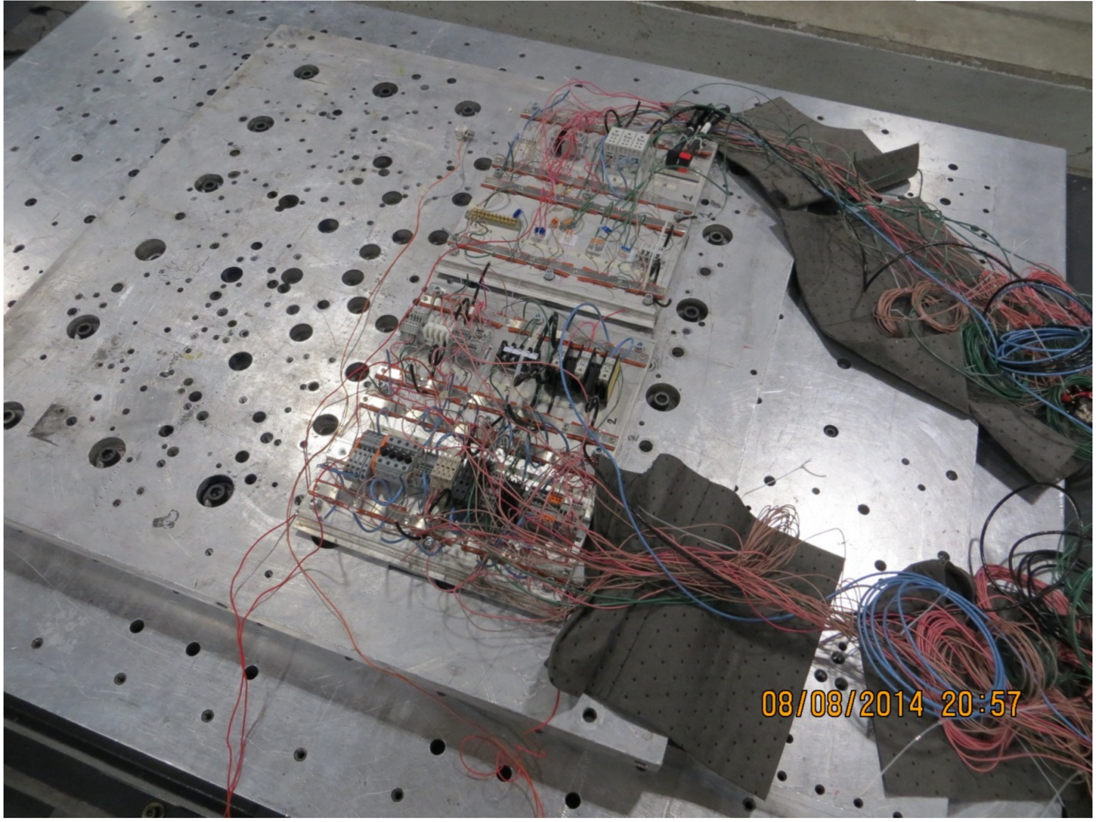


Photo 7 – File No. FB14-0567
Vibration test setup in the side/side axis for exploratory

Enclosure 3

Thermal Cycling Test and Results

TEST REQUIREMENT

The thermal cycling test shall be conducted in accordance with references (c) and (d).

TEST RESULTS

A pretest visual inspection of the test items revealed that connectors #34 and #35, which suffered damage during previous testing had been replaced with spare parts.

All testing was performed in accordance with the referenced specification with the exception that the test items were not energized during the last two cycles.

At the request of the customer the test items were monitored for chatter throughout the entire test. No chatter was detected during any of the cycles.

Refer to the following pages of this enclosure for the test data.

The test item completed all phases of testing.

A post-test visual inspection of the test item revealed no anomalies due to testing.

DAYTON T. BROWN INC.
Founded 1950

THERMAL CYCLING TEST DATA SHEET

JOB No.: 413980-02-000 **DATE** 12 AUG 14

TIME	CHAMBER TEMP (°C)	HOURS INTO SOAK	CYLES OF 10	REMARKS	TECH.
1810	25.5	—	1	go to -55°C	SD
1818	-53.2	—	1	Await Unit STAB	SD
1916	-56.1	0	1	UNITS STAB - BEGIN 1HR SOAK	VD
2016	-55.4	1	1	END SOAK - GOTO 85°C	VD
2029	85.4	—	1	AWAIT UNIT STAB	VD
2117	85.1	0	1	UNITS STAB - BEGIN 1HR SOAK	VD
2217	85.3	1	1/2	END SOAK - GOTO -55°C	VD
2231	-63.7	—	2	AWAIT CHAMB/UNIT STAB	VD
2235	-58.2	—	2	CHAMB. STAB.	VD
2300	-56.3	0	2	UNIT STAB - SOAK 1HR	VD
0002	-55.0	1	2	END SOAK - GOTO 85°C	VD
0018	84.0	—	2	AWAIT UNIT STAB	RB
0057	85.4	0	2	UNIT STAB SOAK. 1HR	RB
0157	85.5	1	2/3	END SOAK - GOTO -55°C	RB
0214	-54.5	—	3	AWAIT UNIT STAB	RB
0242	-55.1	0	3	UNIT STAB SOAK 1HR	RB
0344	-55.4	1	3	SWITCH TO 85°C	RB
0359	84.4	-	3	AWAIT UNIT STAB	RB
0440	85.4	0	3	BEGIN SOAK	RB
0540	85.3	1	3	SWITCH TO -55°C	RB
0553	-56.1	—	4	AWAIT UNIT STAB	RB
0626	-56.2	0	4	BEGIN SOAK	RB

COMMENTS

ENGINEER

Dept 04 Standard Test Paperwork, Released 20 MAY 2013
FILE NAME: 413980-02 Thermal Cycling.xlsx

SHEET: DATA SHEET, 5 COLUMNS

DAYTON T. BROWN INC.
Founded 1950

THERMAL CYCLING TEST DATA SHEET

JOB No.: 413980-02-000

DATE 13AUG14

TIME	CHAMBER TEMP (°C)	HOURS INTO SOAK	CYLES OF 10	REMARKS	TECH.
0726	-55.2	1	4	SWITCH TO 85°C	VJ
0741	84.4	—	4	AWAIT STAB	R
0747	85.4	0	4	BEGIN SOAK	JW
0907 ~~0847~~	85.4	1.3	4/5	END SOAK go to L/T	SD
0921	-57.1	—	5	Await Unit STAB	SD
1033	-54.4	0	5	Begin SOAK	SD
1133	-54.6	1	5	END SOAK go to H/T	SD
1147	82.8	—	5	Await Unit STAB	SD
1230	85.1	0	5	Begin SOAK	SD
1351	85.1	1.3	5/6	END SOAK - Switch to L/T	SD
1404	-58.9	—	6	Await Unit STAB	SD
1448	-56.2	0	6	Begin SOAK	SD
1548	-54.4	1	6	END SOAK, Switch to H/T	SD
1602	83.4	—	6	Await Unit STAB	SD
1650	85.0	0	6	UNIT STAB - SOAK 1HR.	VD
1756	85.2	1.1	6/7	END SOAK - GOTO L/T	VD
1808	-56.8	—	7	AWAIT UNIT STAB	VD
1840	-55.2	0	7	BEGIN 1 HR. SOAK	VD
1948	-55.4	1.1	7	END SOAK - GOTO H/T	VD
2001	86.7	—	7	AWAIT UNIT STAB	VD
2044	85.3	0	7	UNIT STAB - SOAK 1HR	VD
2146	85.4	1.0	7/8	END SOAK - GOTO L/T	VD

COMMENTS

ENGINEER

Dept 04 Standard Test Paperwork, Released 20 MAY 2013
FILE NAME: **413980-02 Thermal Cycling.xlsx**

SHEET: **DATA SHEET, 5 COLUMNS**

DAYTON T. BROWN INC.
Founded 1950

THERMAL CYCLING TEST DATA SHEET

JOB No.: 413980-02-000

DATE 13AUG14

TIME	CHAMBER TEMP (°C)	HOURS INTO SOAK	CYLES OF 10	REMARKS	TECH.
2200	-55.2	—	8	AWAIT UNIT STAB	VD
2232	-56.0	0	8	BEGIN @ 1 HR SOAK - UNIT STAB	VD
2348	-55.3	1.2	8	END SOAK - GOTO H/T	VD
0002	85.0	—	8	AWAIT UNIT STAB	VD
0045	85.4	0	8	BEGIN SOAK	[illegible]
0145	85.3	1	8/9	END SOAK - SWITCH TO L/T	[illegible]
0201	-56.5	—	9	AWAIT UNIT STAB	[illegible]
0230	-55.7	0	9	BEGIN SOAK	[illegible]
0330	-55.1	1	9	END SOAK - SWITCH TO H/T	[illegible]
0348	86.8	—	9	AWAIT UNIT STAB	[illegible]
0425	85.4	0	9	BEGIN SOAK	[illegible]
0525	85.5	1	9/10	END SOAK - SWITCH TO L/T	[illegible]
0541	-55.7	—	10	AWAIT UNIT STAB	[illegible]
0611	-55.6	0	10	BEGIN SOAK	[illegible]
0711	-55.2	1	10	END SOAK - SWITCH TO H/T	[illegible]
0726	84.5	—	10	AWAIT UNIT STAB	[illegible]
0807	85.4	0	10	Begin SOAK	SD
0925	85.3	1.3	10	END SOAK GO TO AMB	SD
0932	25.9	—	10	@ AMB AWAIT Unit STAB	SD
1015	230	—	10	Unit STAB @ AMB	SD

COMMENTS

ENGINEER

Dept 04 Standard Test Paperwork, Released 20 MAY 2013
FILE NAME: **413980-02 Thermal Cycling.xlsx**

SHEET: **DATA SHEET, 5 COLUMNS**

Test equipment utilized for the program reported herein was within its assigned interval of calibration.
Details are on file at Dayton T. Brown, Inc. and will be made available upon request.

Job Sub: **413980-02** **TEST: THERMAL CYCLING**

ITEM	MANUFACTURER	MODEL	DTB NO.	ACCURACY	CAL DUE DATE
CHAMBER, TEMPERATURE	THERMOTRON	F32-CHV-15-15	04E-009	N/A	N.C.R.
DATA ACQUISITION SYSTEM, THERMOCOUPLE TYPE "T" & VOLTAGE	NATIONAL INSTRUMENTS	NI-4351	10-353	MFR	07/05/2015
DETECTOR, CONTACT CHATTER	TRIG-TEK	850A	11-5	MFR	10/19/2014
DETECTOR, CONTACT CHATTER	EADS	850B	11-6	MFR	04/05/2015
DETECTOR, CONTACT CHATTER	TRANS-TEK	850A	11-7	MFR	04/19/2015
RECORDER, CHART TRULINE	HONEYWELL	DR4500	12-8	RTD ± 0.3°C, RH ± 0.2% RH	11/02/2014
CONTROLLER, ENVIRONMENTAL CHAMBER	JC SYSTEMS	600A	25-152	RTD ± 1.08°F, RH ± 1% RH	11/02/2014

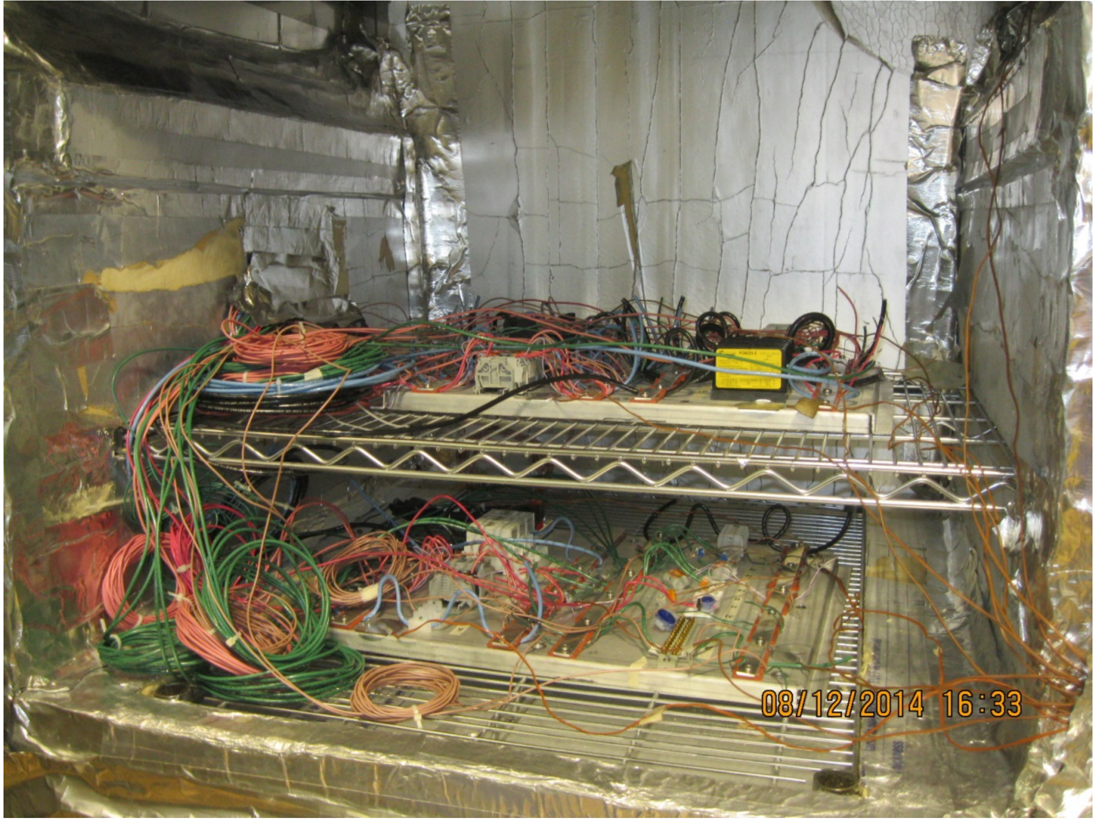


Photo 1 – File No. SD14-1144
Thermal cycling test setup

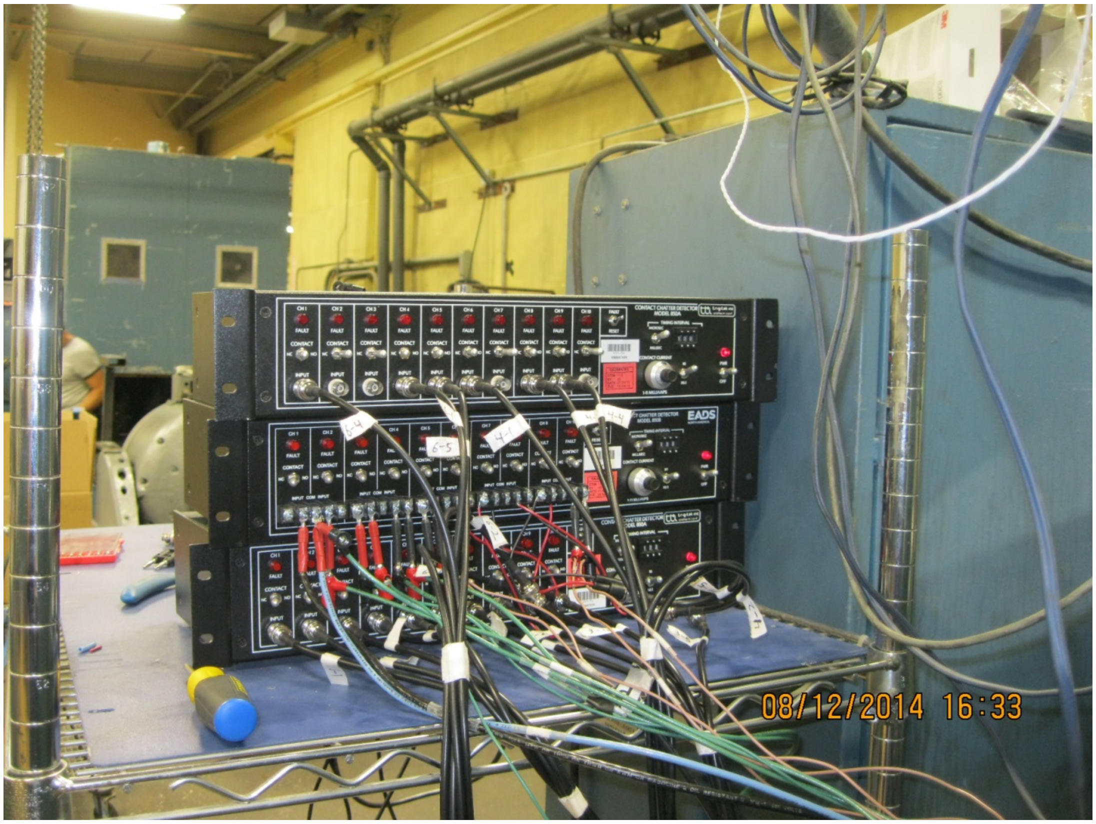


Photo 2 – File No. SD14-1145
Thermal cycling test setup showing the test support equipment

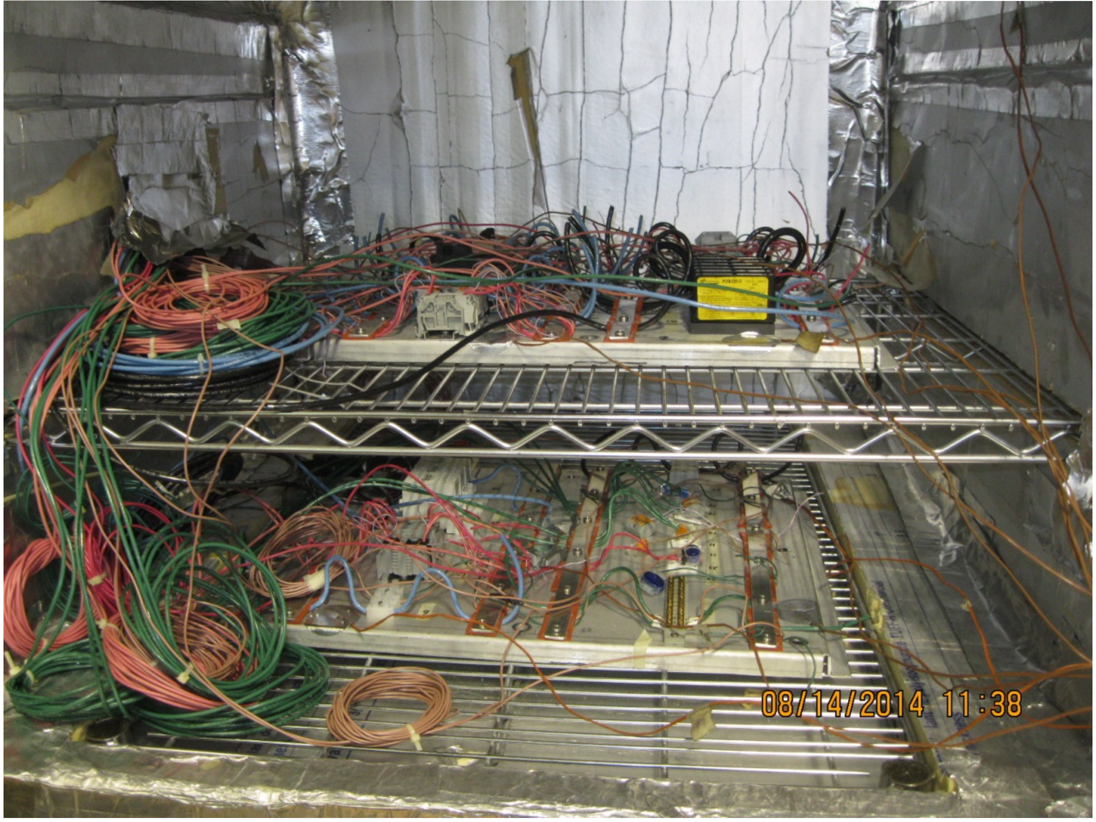


Photo 3 – File No. SD14-1161
Post-test view showing the Low Voltage Quick Connector Panels

Enclosure 4

Contact/Pull Resistance Test and Results

TEST REQUIREMENT

The contact/pull resistance test shall be conducted in accordance with references (c) and (d).

TEST RESULTS

A pretest visual inspection of the test items revealed that all items were intact and ready for the pull test.

All testing was performed in accordance with the referenced specifications and were pulled to a maximum of 10 pounds within 10 seconds.

Most of the test items completed all testing satisfactorily, except #14 which failed at 6 lbs.

A post-test visual inspection of the test items revealed that all test items except #14 were still intact after the pull check.

Test equipment utilized for the program reported herein was within its assigned interval of calibration.
Details are on file at Dayton T. Brown, Inc. and will be made available upon request.

DAYTON T. BROWN INC.
Founded 1950

Job Sub: **413979-01** **TEST: PULL CHECK**

ITEM	MANUFACTURER	MODEL	DTB NO.	ACCURACY	CAL DUE DATE
SCALE, PUSH/PULL 50 LBS.	CHATILLON	DPP-50	61-17	± 2% OF F.S.	02/01/2015