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DOE Award No.: DE-FC26-05NT42657

SERVAgroup

Downhole Technologies LLC

10511 Fallstone Rd.

Houston, Texas 77099

Development of a Low-Cost Rotary Steerable Drilling System

Final Report

Project Director/Principal Author:

Roney Nazarian

Date Submitted:

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Period Covered:

November 1, 2007 – December 31, 2008

ABSTRACT

The project had the goal to develop and commercialize a low-cost rotary steerable system (LCRSS) capable of operating downhole at conventional pressures and temperatures to reduce operating costs by a minimum of 50% and lost-in-hole charges by at least 50% over the currently offered systems. The LCRSS system developed under this project does reduce operating costs by 55% and lost-in-hole charges by at least 50%. The developed product is not commercializable in its current form.

Table of Contents

1. Executive Summary

This final report satisfies the requirements of Task 12 under the Department of Energy's National Energy Technology Laboratory's Cooperative Agreement having an Instrument Number of DE-FC26-05NT42657.

Objectives

The overall objective was to develop and commercialize a low cost rotary steerable system (LCRSS) capable of operating downhole at conventional pressures and temperatures (20,000 psi / 150° C) while reducing the operating costs by 50% and the lost-in-hole charges by 50% over the currently available systems. The proposed reduction in costs were to be realized through the significant reduction in tool complexity, a corresponding increase in tool reliability as expressed in the mean-time between failure (MTBF), and a reduction in the time and costs required to service tools after each field operation. Ultimately, the LCRSS system was to be capable of drilling 7 7/8 in. to 9 5/8 in. borehole diameters.

The project was divided into three Phases, of which Phases I & II were previously completed and reported on, and are part of the case file. Therefore, the previously reported information is not repeated herein. Phase III included the fabrication of two field ready prototypes that were to be subjected to a series of drilling tests at GTI Catoosa, DOE RMOTC, and at customer partnering wells, if possible, as appropriate in the timing of the field test objectives to fully exercise all elements of the LCRSS. These tests were conducted in an iterative process based on a performance/reliability improvement cycle with the goal of demonstrating the system met all aspects required for commercial viability. These tests were conducted to achieve continuous runs of 100+ hours with well trajectories that fully exercised the tool's build/turn/drop/hold target capabilities and its higher end ratings for bit weight, torque and rotary speed. The tool teardowns were rigorously analyzed at the conclusion of each field run to assess component wear rates and to fully document any detrimental behavior(s) observed.

Summary of Phase III

Task 9 – RSS Manufacture for Field Testing

DBDHT / SGDHT qualified and utilized two low-cost RSS tools during the field-test operations. This task was originally planned to include the building of two additional prototype LCRSS tools. However, based upon the required redesign effort, an alternative tack was taken to build critical spares for the unitized hydraulic and electronics subassemblies as well as buying substantial quantities of the consumable parts such as elastomeric seals, bearings, etc. for the two prototypes built in Phase II. This approach worked well by reducing rebuild times.

Task 10 – Conduct Graduated Series of Field Tests

The purpose of this task was to conduct a graduated series of field tests to demonstrate that the LCRSS operated to its design specifications under a wide range of typically encountered drilling conditions. As such, each successive test was planned to be more demanding than the prior ones in terms of the environmental loads, drilling duration and well trajectories. Each test sought to maximize drilling time as dictated by the rig's availability.

At the conclusion of each test sequence, each tool that had been run would be completely disassembled and thoroughly inspected to identify any damage incurred, measure actual versus expected wear rates, and most importantly to identify any substantial deficiencies which were eliminated through component reinforcement and/or redesign so the LCRSS could become a commercially successful alternative to competitive offerings in the marketplace. These tests also provided a direct gauge of the time and costs involved in servicing the tool for consecutive runs.

Originally, the program plan called for a total of four multi-week sequences to be scheduled with allowances between the sequences for a 30-day period to implement any design changes. In actuality, a much more aggressive test plan was undertaken with a total of nine test sequences conducted since the March 2008 run at the DOE RMOTC facility outside of Casper, Wyoming. This path proved to be very beneficial, as it allowed for additional runs to validate important modifications made to improve directional performance and LCRSS reliability.

Task 11 – Address Noted Deficiencies / Validate Design Changes

This task addressed the changes in the tool design, the tool assembly procedures, the tool servicing, and the field operating procedures needed to achieve the desired performance and reliability specifications prior to commercialization. The success of revisions were fully demonstrated and properly documented. The failure mode effects and criticality reviews were continued during Phase III after each field-test sequence (with supplemental testing in the laboratory performed as necessary) to minimize risk and cost factors.

Phase III Conclusions & Recommendations

1. The objectives of reducing fabrication and low-in-hole costs were successfully met. The LCRSS prototype costs were 55% less than the prior generation tools.

2. The LCRSS was more reliable when run on batteries than on the alternator.

3. Additional intermediate bearings were required on the shaft for support.

4. The original design required a redesign (material, form, fit & function) of the end seals and bearings to eliminate failures encountered during testing.

5. Servicing costs and turnaround time varied depending on the wear and tear of equipment.

6. The final system is not yet mature enough to pursue commercialization. As such, DBDHT/SGDHT will continue developing the system under their own initiative.

2. LCRSS System Description

Diamondback / SERVAgroup Downhole Technologies, LLC Low Cost Rotary Steerable System (LCRSS) represented the latest generation, state-of-the-art design. The company's engineering team applied the "lessons learned" from past RSS development and testing activities to produce a new design that was significantly more robust and much less costly to build and service. The new LCRSS tool adopted a "plug and play" approach that allowed tool assembly and service to be accomplished 75% faster than predecessor systems. In addition, the new design had well under half the part count and had proven far more amenable to downsizing to a 4 ¾ in. tool size. This design is illustrated in the FIGURE 1 below. The additional proprietary re-design information may be obtained by contacting the Project Director.

Key design elements realized in satisfying the objectives of producing a less expensive, more reliable tool included:

- **Unitized 150°C Electronics** – All electronics resided inside a single 20,000 WPSIG pressure canister having one multi-pin booted electrical connector. This design minimized the number of soldered connections with none required except those made on the PCB board level.

- **Unitized Hydraulics** – Like the electronics, all hydraulic components including the system oil compensation resided in a single housing. This was in sharp contrast to prior design where the hydraulics was dispersed in multiple modules that required more complete mating requirements. The net result was a substantial reduction in costs, assembly time and most importantly, the elimination of a large number of O-rings and fasteners. The hydraulic canister was also rated for 20,000 WPSIG.

- **Top Loading Drive Shaft** – The LCRSS employed a top loading drive shaft that simplified the assembly. The drive shaft featured dual sets of radial bearings at the top and bottom sections along with intermediate radial bearings run in the immediate vicinity of the shaft-drive hydraulic pump. On- and off-bottom thrust bearings were also included reacting to weight on bit and tripping forces. Proprietary seal technology was used at the top and bottom of the shaft/housing interfaces to prevent communication between the shaft oil and drilling mud.

- **Closed-Loop Operation** – The LCRSS was a 4-piston, closed-loop push-the-bit system. The closed loop control eliminated the need for a high level of operator training and optimized the rate at which given sets of target coordinates were obtained. Additionally, closed-loop assured a high level of fidelity (reduction in vertical and horizontal wander) once the target objectives have been met.

Figure 1. DBDHT 6 ¾ in. LCRSS

6 ¾ in. Low Cost Rotary Steerable System Specifications

Operational Parameters

Borehole Size	8 ½ in. – 9 5/8 in.
Build Rate	9°/100 ft.
Bit Connection	4 ½" API regular
Top End Connection	4 ½" XH
Maximum Flow Rate	600 GPM
Minimum Flow Rate	300 GPM
Maximum WOB	56,000 lbs.
RPM Range	50 – 200 RPM
Maximum Bit Torque	17,700 ft-lbs.
Maximum Operating Temperature	150° Celsius
Maxim Pressure	17,500 psi

Angular Accuracy:

Azimuth	±0.3°
Inclination	±0.1°
Roll	±0.1°

3. Summary of Accomplishments:

The specific objectives for Phase III were to make significant progress on tasks 9, 10 and 11.

Prior to the commencement of field tests, the tool electronics were subjected to a series of thermal (155°C ramp/hold/ramp) and vibration tests (5 G and 15 G rms random ½ sine, 10 – 1000 Hz all axes) during January and February 2008. These tests were conducted with the electronics packaged exactly as they are normally housed for the down-hole environment. The electronics successfully passed these tests and allowed DBDHT / SGDHT to start field test activities. The Quanta Laboratories reports, included in Attachments A and B, illustrates the test hardware and typical frequency profiles for the random vibration tests.

- A total of 19 LCRSS field runs were conducted during the Phase III period. Specifics for each of these runs are provided in Table 1. Table 1 shows 13 of the runs involved directional well trajectories with the remainder being operated in the vertical control mode.

- Downhole jars were set off multiple times in two of the 19 runs without causing any damage to the tool. The use of the jars were occasioned by shale sloughing on one well and by a rig failure which resulted in the inability to either circulate or POOH for an extended period of time in the second.

- The first two field test sequences suffered from erratic pulsing. The problem was primarily traced to improperly manufactured multi-pin electrical bulkhead connectors that leaked – resulting in loss of electrical isolation between the pins. This problem was addressed over a two-month period with the vendor and was subsequently corrected. Validation of proper connector fluid sealing was independently verified by DBDHT by building a pressure test cell that was filled with highly conductive salt water. The vessel was pressurized to 2500 psig and held while each pin was megged against every other pin at 500 volts. No subsequent issues were observed.

  In addition, these first tests led to modifications of the rotary seals gland dimensions and the middle and lower radial bearing assemblies. Under continued independent testing and as additional test data is collected, minor design changes are expected to further improve performance and reliability, as well as reduce fabrication costs of the production units.

- The last 10 runs beginning in June 2008 consisted of picking up a single LCRSS tool and completing the run objectives without a single failure. Tool teardowns were non-remarkable.

- Field tests were conducted with both PDC and tri-cone roller bits. Bit weights across these tests ranged from 10K – 45K. All tests were conducted with 8 ½ in. and 8 ¾ in. diameter drill bits.

- Rotary speeds ranged from 40 to 182 RPM. This included successfully running the LCRSS with Kelly – and top-drive rigs as well as in conjunction with a multi-lobe positive-displacement motor run above the LCRSS bottom-hole assembly. Flow rates ranged from 325 – 475 gallons per minute using water-base muds. Mud weights ran from 8.7 – 10.3 pounds per gallon.

- Build, hold, drop and vertical control well trajectories were successfully completed. Early tests identified changes that needed to be made to the steering rib extended and collapsed diameters in order to meet the desired build rate of 9 degrees / 100 ft. These changes were made with excellent agreement being found in actual versus theoretical build rates. No discernable DLS differences were found when either building up or dropping inclination angle.

- Downlinking to change target parameters was also tested on numerous occasions and its correct operation was verified.

4. Financial Report

	Approved Budget	Cumulative Expenditures
DOE Share	$502,711	$502,711
Recipient Share	$270,690	$270,690
Total Costs	$773,401	$773,401

5. Schedule Status

The actual schedule versus planned schedule is compared in Figure 2.

Task Description	Q4-07 OND	Q1-08 JFM	Q2-08 AMJ	Q3-08 JAS	Q4-08 OND	Q1-09 JFM	Q2-09 AMJ
Task 9 – Manufacture Prototype-RSS for Field Testing							
Planned	XX	XXX					
Actual	XX	XXX					

Task 10 – Conduct Graduate Series of Field Tests							
Planned			XXX	XXX	XXX	XXX	XXX
Actual		X	XXX	XXX	XXX	XXX	XXX
Task 11 – Address Noted Deficiencies/Validate Design Changes							
Planned			XXX	XXX	XXX	XXX	XXX
Actual		X	XXX	XXX	XXX	XXX	XXX

Figure 2. Project Time-Task Diagram

6. Changes in Approach

Other than discussed above, no changes in the project approach were required.

7. Problems

Other than discussed above, no significant problems occurred during Phase III.

8. Changes in Key Personnel

Noble Corporation sold the Noble Downhole Technology Division to Diamondback on November 1, 2007.

9. Products and Technology Transfer

No products or technology transfer activities occurred during this period.

10. Patent Certification Statement Regarding DOE F 2050.11

A DOE F 2050.11 Form is submitted contemporaneously with this Final Report. During the duration of this contractual effort, no patentable inventions were developed.

11. Property Certification Statement

The Property Certification is submitted contemporaneously with this Final Report. There is no residual Government-owned property of any description remaining at the completion of this contractual effort, contract no. DE-FC26-05NT42657.

ATTACHMENT A

QUANTA LABORATORIES 5G rms VIBRATIONAL REPORTS

QUANTA LABORATORIES
3199 De La Cruz Boulevard • Santa Clara, CA 95054-2483
TEL: (408) 988-0770 FAX: (408) 988-0762
E-MAIL: test@quantalabs.com

Certificate of Conformance

This is to certify that the results from the test(s) requested by DBDHT are on file under Quanta Laboratories Job No. QL-08-149 and conform to the specification(s) stated in P.O. No. 021808-01

These results apply to the following equipment and are available for review upon request.

Model No.: LCRS Electronics (3 Units)

S/N: 002; 003; 004

*** RANDOM VIBRATION TEST ***

Quanta Laboratories 02-20-08
Date

QL-TTS-151 Rev: 02/03/06

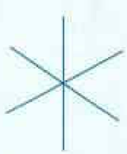
RANDOM VIBRATION TEST DATA

QUANTA LABORATORIES

3199 De La Cruz Blvd, Santa Clara, CA 95054
Phone: (408) 988-0770 FAX: (408) 988-0762
test@quantalabs.com www.quantalabs.com

CLIENT: DBDHT	P.O. NO: 021808-01
SPECIMEN: LCRS Electronics (3 Units)	JOB NO: QL-08-149
SPECIFICATION: DBDHT'S SPECIFICATION	PAGE 1 OF 1

DATE	S/N	AXIS	FREQUENCIES & LEVELS	REMARKS
02/15/2008	002 003 004	X Y Z	10 – 1000 Hz: 10- 80 Hz @ +6 dB 80 – 300 Hz @ 0.041 G^2/Hz 300- 1000 Hz @ -3 dB Overall: 5.0 G RMS DURATION: 15 MIN/AXIS	OPERATIONAL TEST, TEST COMPLETED TO THE SPEC. REQUIREMENTS.



DEFINITION OF AXES

TEST CONDUCTOR: YM G. Sun	DATE: 02-15-2008
TEST ENGINEER:	DATE: 02-15-2008
WITNESS:	DATE:
Q. A. ENGINEER:	DATE: 02-15-2008

QL-TTS-007 Rev: 02/03/06

EQUIPMENT LIST FOR VIBRATION TEST

QUANTA LABORATORIES
3199 De La Cruz Blvd, Santa Clara, CA 95054
Phone: (408) 988-0770 FAX: (408) 988-0762
test@quantalabs.com www.quantalabs.com

CLIENT	DBDHT	JOB NO.	QL-08-149
		P.O. NO.	021808-01

MFR	DESCRIPTION	RANGE	EQUIP. USED	ASSET NO.	SERIAL NO.	CALIBRATION DUE DATE
DACTRON	DSP	0.1Hz - 3 KHz RES. 0.1dB	X	QL-0665	5542452	2/12/09
				QL-0650	8204911	
				QL-0659	6313890	
				QL-0655	7385467	
				SEISMIC QL-0517 QL-0518	8177263 6904178	
LING ELECTRONICS	5/6-1 AMPLIFIER A-175 SHAKER (SILVER)	5Hz - 3 KHz		QL-0016 QL-0015	1672 67	TIME OF TEST
	5/6-5 AMPLIFIER(AGREE)			QL-0511	241	
	20/35 AMPLIFIER B-300 SHAKER (GREEN)			QL-0151 QL-0013	30 80	
	35/70 AMPLIFIER			QL-0150	34	
	60/100 AMPLIFIER B335 SHAKER (GOLD)			QL-0014 QL-0135	22 153	
	DMA-48 SOLID STATE AMPLIFIER		X	QL-0504	46	
	8024-SOLID STATE AMP #2 B335 SHAKER (BLUE)			QL-0510 QL-0509	12 92	
	B-300 SHAKER (BLUE)			QL-0512	52	
	B-300 SHAKER (AGREE)			QL-0216	43	
	B335 SHAKER (RED)		X	QL-0256	03	
	B335 SHAKER (GREEN)		X	QL-0253	91	
MTS	2456 HYDR. SHAKER 406 CONTROL UNIT 436 CONTROL UNIT	1 Hz - 500 Hz 6" MAX DIS		QL-0003 QL-0006 QL-0007	160 863 3964	
TEAM CORP	SYSTEM 7269 HYDR. SHAKER	13" MAX DIS		QL-0522	533	
DYTRAN	ACCELEROMETER 3141A ACCELEROMETER 3055A2	F.S. 50 g's SENS. 100 mV/G	X	QL-0194	101	10/16/08
				QL-		
	ACCELEROMETER 3055A2			QL-		
	ACCELEROMETER 3030A4 ACCELEROMETER 3141A ACCELEROMETER 3031AG ACCELEROMETER 3101B	F.S. 500 g's SENS. 10 mV/G		QL-		
				QL-		
				QL-		
				QL-		
	ACCELEROMETER 3093M3 (TRIAXIAL ACC)	F.S. 200 g's SENS. 50 mV/G		QL-		
				QL-		
	ACCELEROMETER	F.S. 200 g's SENS. 50 mV/G		QL-		
				QL-		
ENDEVCO	ACCELEROMETER 7254-10	F.S. 500 g's SENS. 10 mV/G		QL-		
PCB	ACCELEROMETER					

QL-TTS-091 Rev: 02/03/06

QUANTA LABORATORIES
SANTA CLARA, CALIFORNIA

DBDHT

Random Vibration Test

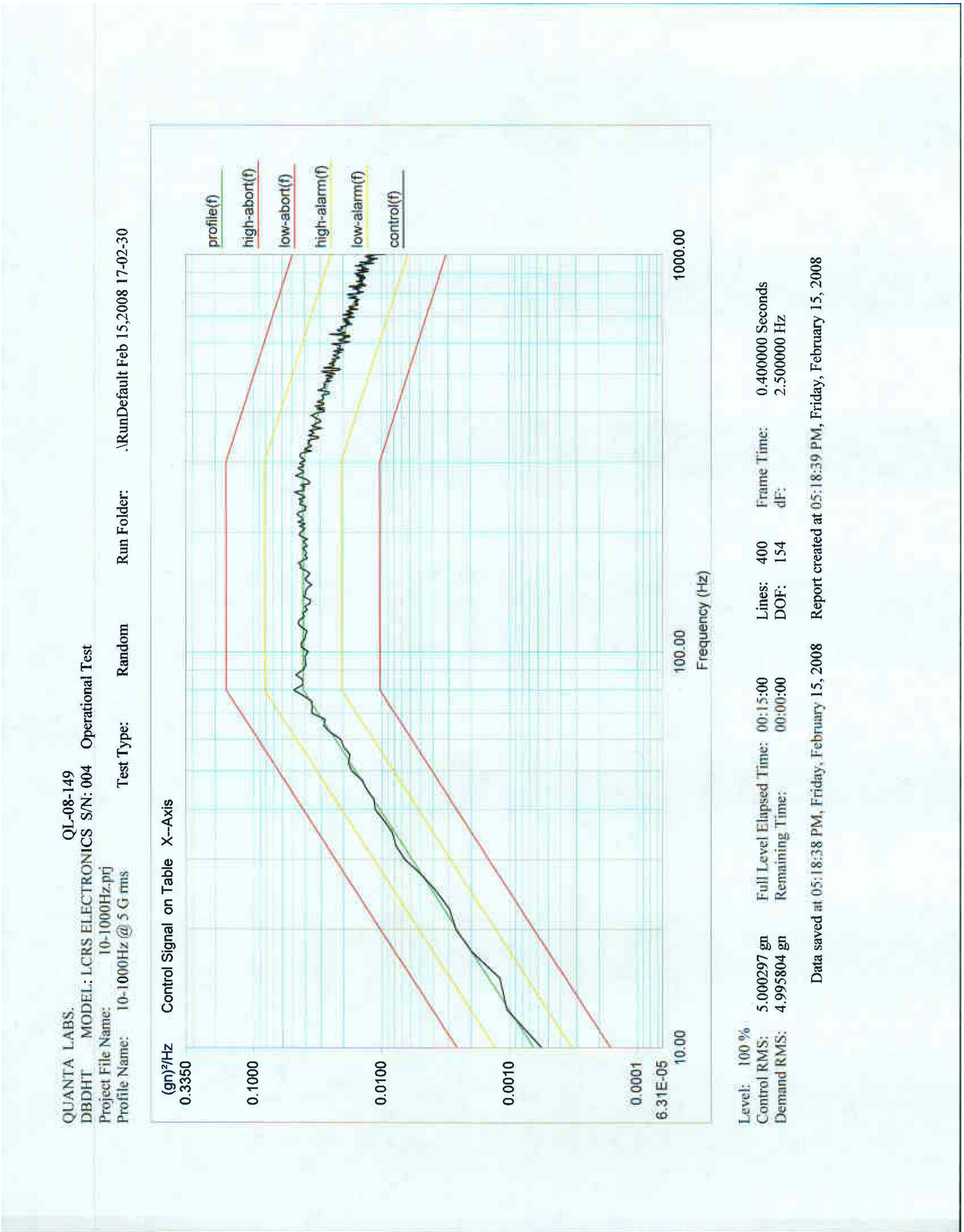
X-AXIS

Y-AXIS

Z-AXIS

JOB NO. : QL-08-103 10-1000 HZ @ 5 G rms

02-15-2008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100.00
1000.00
Frequency (Hz)
profile(f)
high-abort(f)
low-abort(f)
high-alarm(f)
low-alarm(f)
control(f)
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Control RMS: 5.000297 gn
Demand RMS: 4.995804 gn
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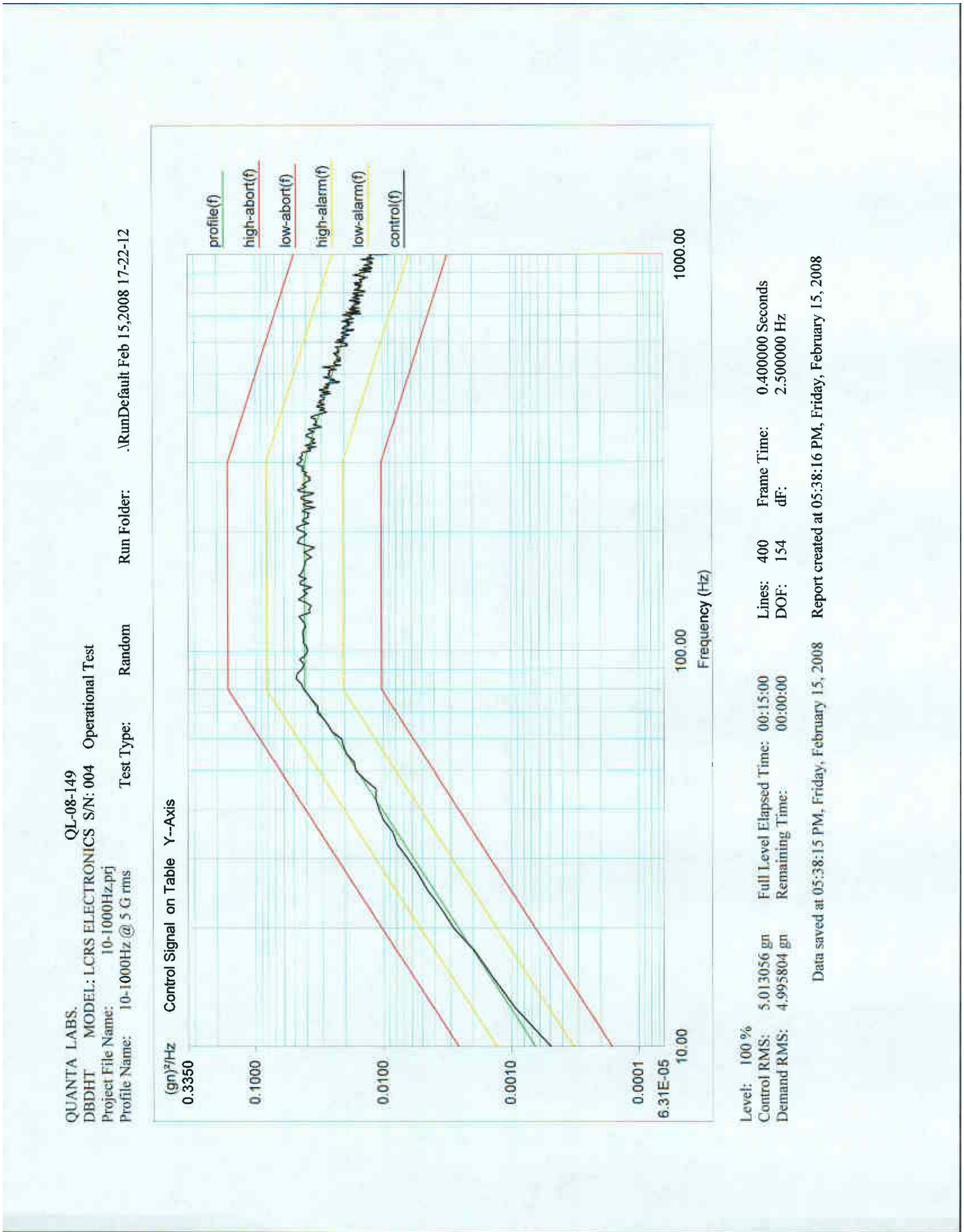
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1000.00
Frequency (Hz)
profile(f)
high-abort(f)
low-abort(f)
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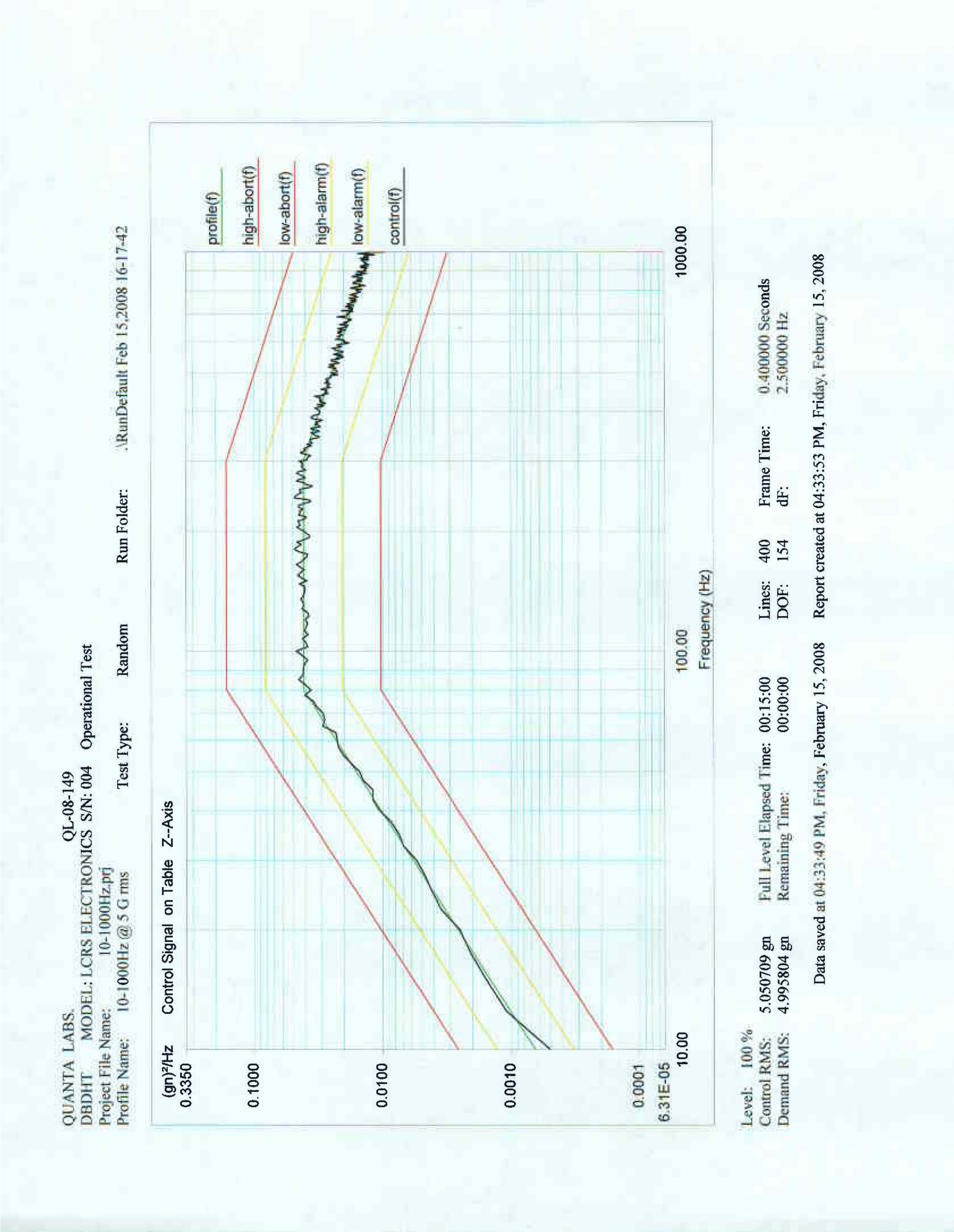
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profile(f)
high-abort(f)
low-abort(f)
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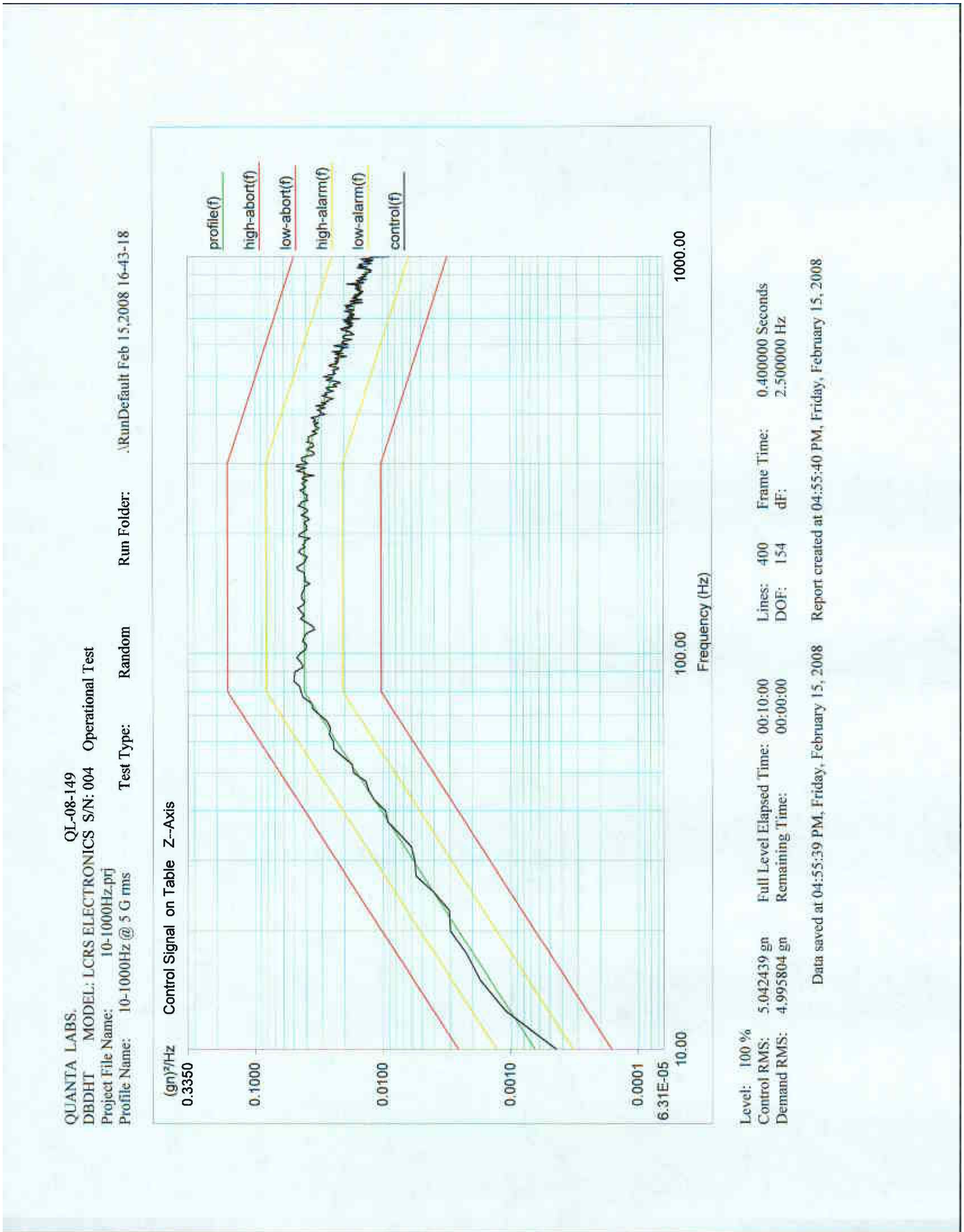
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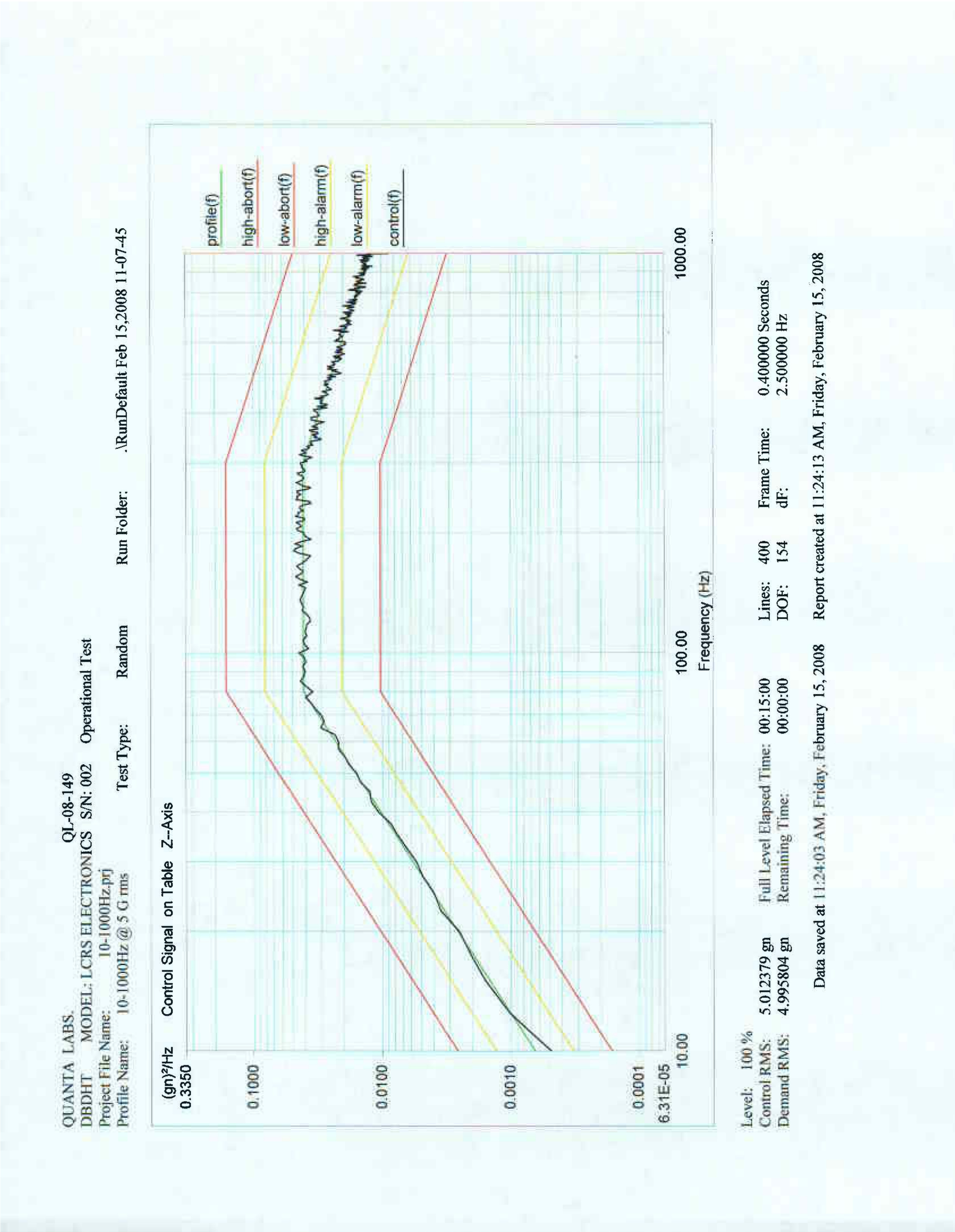
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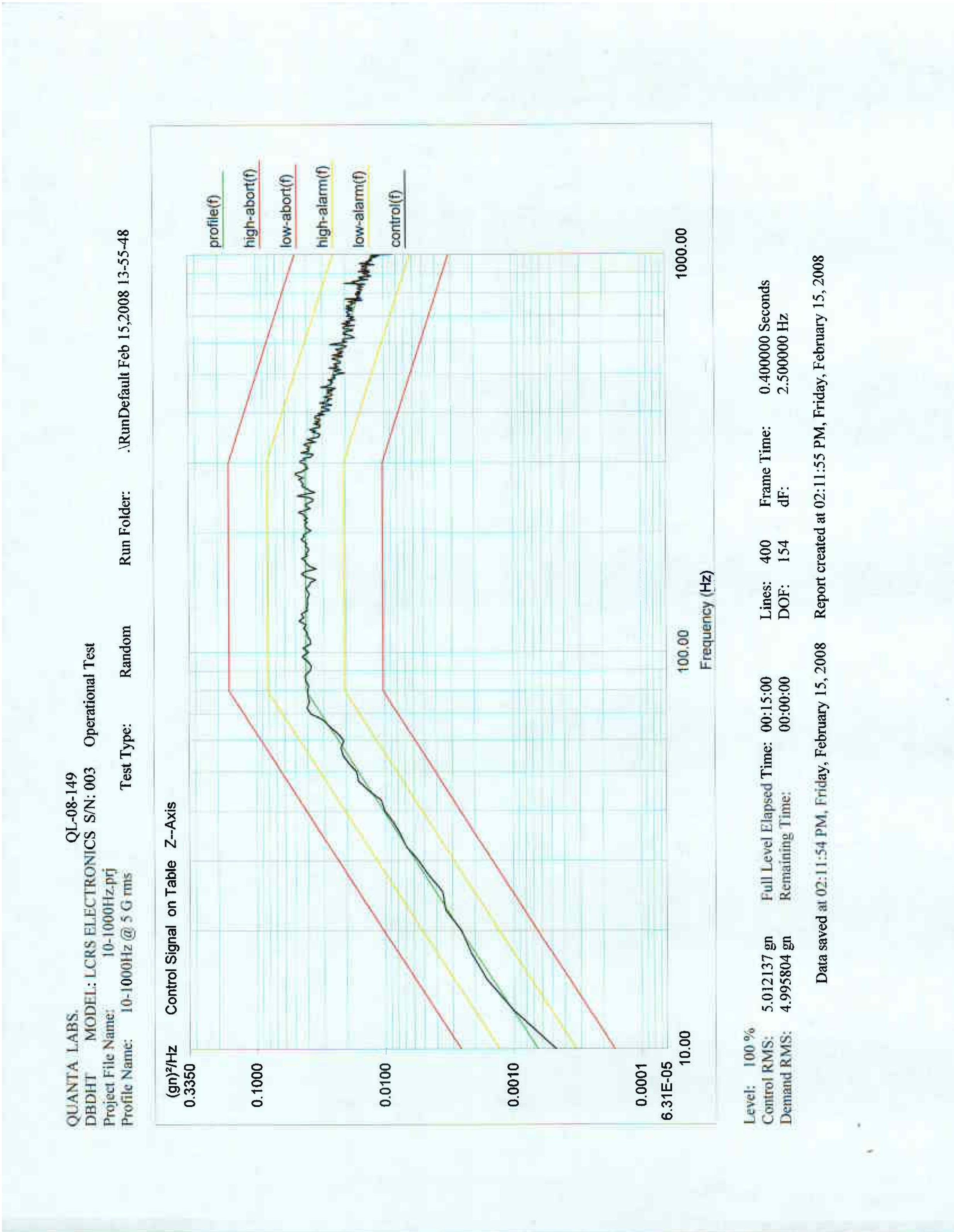
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0.0001
6.31E-05
10.00
100.00
1000.00
Frequency (Hz)
profile(f)
high-abort(f)
low-abort(f)
high-alarm(f)
low-alarm(f)
control(f)
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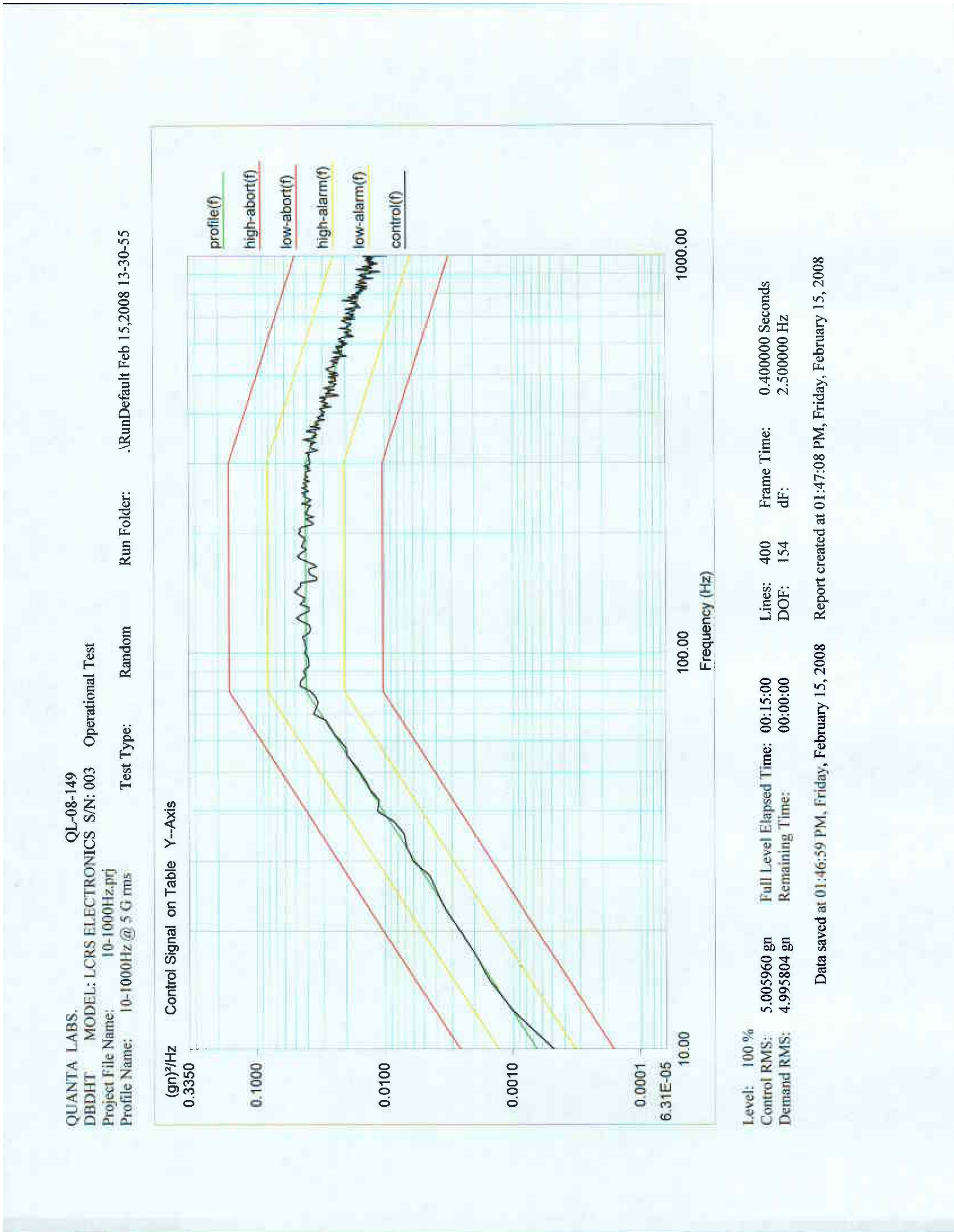
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1000.00
Frequency (Hz)
profile(f)
high-abort(f)
low-abort(f)
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low-alarm(f)
control(f)
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Control RMS: 5.005960 gn
Demand RMS: 4.995804 gn
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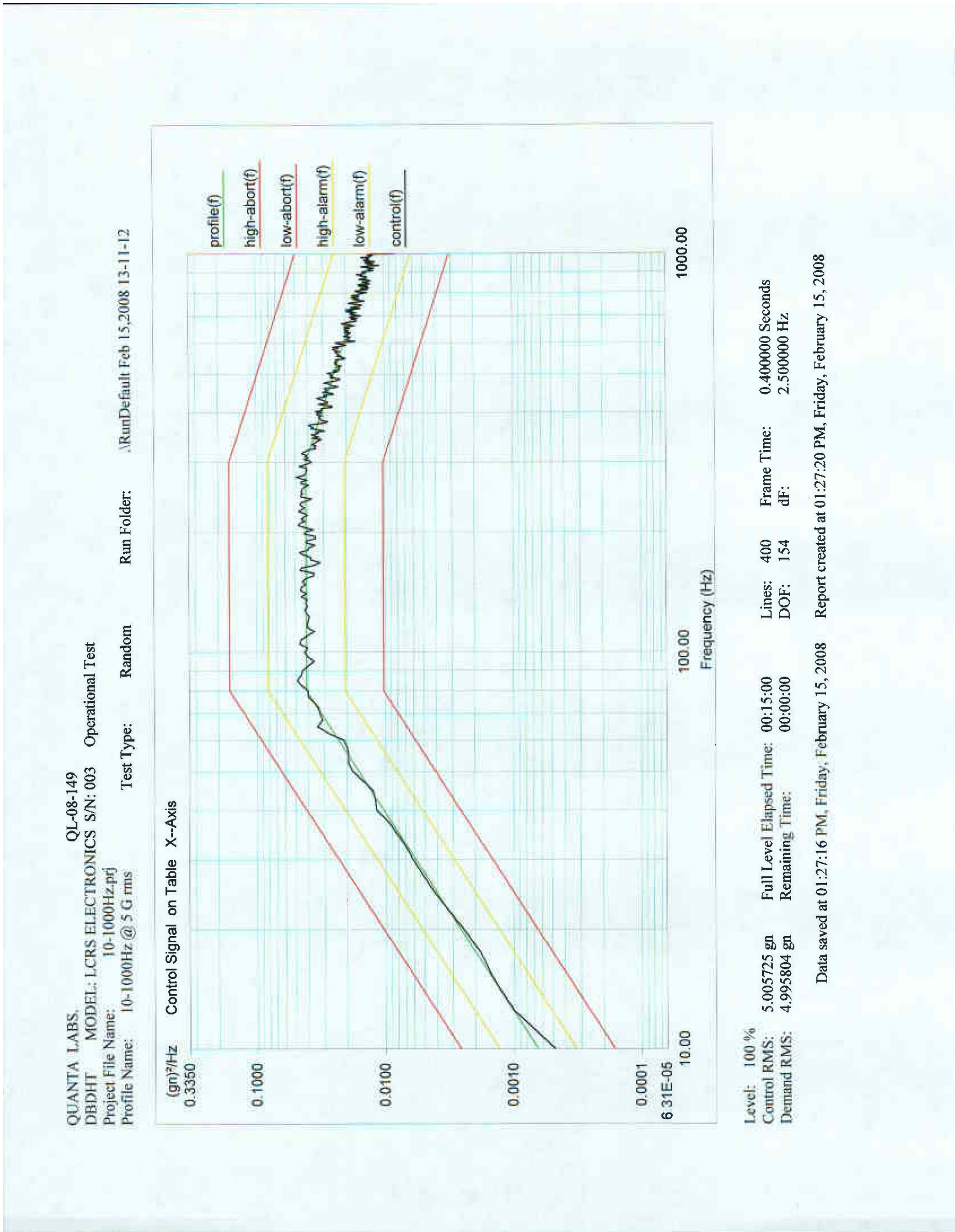
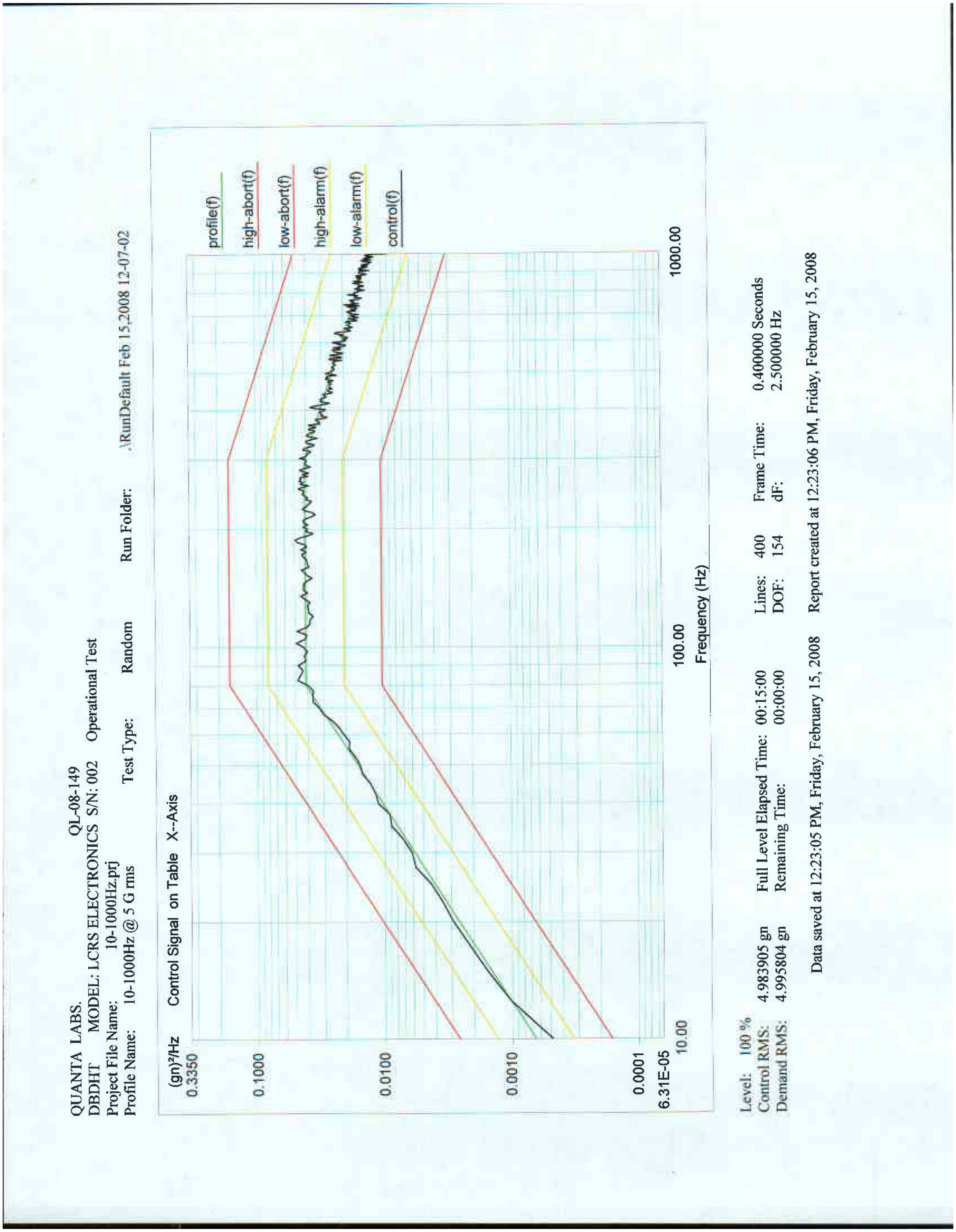

QUANTA LABS. QL-08-149
DBDHT MODEL: LCRS ELECTRONICS S/N: 003 Operational Test
Project File Name: 10-1000Hz.prj
Profile Name: 10-1000Hz @ 5 G rms
Test Type: Random
Run Folder: \RunDefault Feb 15,2008 13-11-12
Control Signal on Table X--Axis
(gn)²/Hz
0.3350
0.1000
0.0100
0.0010
0.0001
6.31E-05
10.00
100.00
1000.00
Frequency (Hz)
profile(f)
high-abort(f)
low-abort(f)
high-alarm(f)
low-alarm(f)
control(f)
Level: 100 %
Control RMS: 5.005725 gn
Demand RMS: 4.995804 gn
Full Level Elapsed Time: 00:15:00
Remaining Time: 00:00:00
Lines: 400
DOF: 154
Frame Time: 0.400000 Seconds
dF: 2.500000 Hz
Data saved at 01:27:16 PM, Friday, February 15, 2008
Report created at 01:27:20 PM, Friday, February 15, 2008


QUANTA LABS. QL-08-149
DBDHT MODEL: LCRS ELECTRONICS S/N: 002 Operational Test
Project File Name: 10-1000Hz.prj
Profile Name: 10-1000Hz @ 5 G rms
Test Type: Random
Run Folder: \RunDefault Feb 15,2008 12-07-02
Control Signal on Table X--Axis
(gn)²/Hz
0.3350
0.1000
0.0100
0.0010
0.0001
6.31E-05
10.00
100.00
1000.00
Frequency (Hz)
profile(f)
high-abort(f)
low-abort(f)
high-alarm(f)
low-alarm(f)
control(f)
Level: 100 %
Control RMS: 4.983905 gn
Demand RMS: 4.995804 gn
Full Level Elapsed Time: 00:15:00
Remaining Time: 00:00:00
Lines: 400
DOF: 154
Frame Time: 0.400000 Seconds
dF: 2.500000 Hz
Data saved at 12:23:05 PM, Friday, February 15, 2008
Report created at 12:23:06 PM, Friday, February 15, 2008

ATTACHMENT B

QUANTA LABORATORIES 15G rms VIBRATIONAL REPORTS

QUANTA LABORATORIES
3199 De La Cruz Boulevard • Santa Clara, CA 95054-2483
TEL: (408) 988-0770 FAX: (408) 988-0762
E-MAIL: test@quantalabs.com

Certificate of Conformance

This is to certify that the results from the test(s) requested by DBDHT are on file under Quanta Laboratories Job No. QL-08-103 and conform to the specification(s) stated in P.O. No. 011408-02

These results apply to the following equipment and are available for review upon request.

Model No.: LCRS Electronics

S/N: N/A

*** RANDOM VIBRATION TEST ***

Quanta Laboratories 02-04-08
Date

QL-TTS-151 Rev: 02/03/06

RANDOM VIBRATION TEST DATA

QUANTA LABORATORIES
3199 De La Cruz Blvd, Santa Clara, CA 95054
Phone: (408) 988-0770 FAX: (408) 988-0762
test@quantalabs.com www.quantalabs.com

CLIENT: DBDHT	P.O. NO: 011408-02
SPECIMEN: LCRS Electronics	JOB NO: QL-08-103
SPECIFICATION: DBDHT'S SPECIFICATION	PAGE 1 OF 1

DATE	S/N	AXIS	FREQUENCIES & LEVELS	REMARKS
02/01/2008	001	X, Y, Z	10 – 1000 Hz: 10- 80 Hz @ +6 dB 80 – 300 Hz @ 0.041 G^2/Hz 300- 1000 Hz @ -3 dB Overall: 5.0 G RMS DURATION: 15 MIN/AXIS 10 – 1000 Hz: 10- 80 Hz @ +6 dB 80 – 300 Hz @ 0.37 G^2/Hz 300- 1000 Hz @ -3 dB Overall: 15.0 G RMS DURATION: 15 MIN/AXIS	NON OPERATIONAL TEST, TEST COMPLETED TO THE SPEC. REQUIREMENTS.

DEFINITION OF AXES	TEST CONDUCTOR:	DATE: 02-01-2008
	TEST ENGINEER: Yu G. Sun	DATE: 02-01-2008
	WITNESS:	DATE:
	Q. A. ENGINEER:	DATE: 02-01-2008

QL-TTS-007 Rev: 02/03/06

EQUIPMENT LIST FOR VIBRATION TEST

QUANTA LABORATORIES
3199 De La Cruz Blvd, Santa Clara, CA 95054
Phone: (408) 988-0770 FAX: (408) 988-0762
test@quantalabs.com www.quantalabs.com

CLIENT	DBDHT	JOB NO.	QL-08-103
		P.O. NO.	011408-02

MFR	DESCRIPTION	RANGE	EQUIP. USED	ASSET NO	SERIAL NO.	CALIBRATION DUE DATE
DACTRON	DSP	0.1Hz - 3 KHz RES. 0.1dB		QL-0665	5542452	
				QL-0650	8204911	
			X	QL-0659	6313890	01/11/2009
				QL-0655	7385467	
				SEISMIC QL-0517 QL-0518	8177263 6904178	
LING ELECTRONICS	5/6-1 AMPLIFIER A-175 SHAKER (SILVER)	5Hz - 3 KHz		QL-0016 QL-0015	1672 67	TIME OF TEST
	5/6-5 AMPLIFIER(AGREE)			QL-0511	241	
	20/35 AMPLIFIER B-300 SHAKER (GREEN)			QL-0151 QL-0013	30 80	
	35/70 AMPLIFIER			QL-0150	34	
	60/100 AMPLIFIER		X	QL-0014	22	
	B335 SHAKER (GOLD)		X	QL-0135	153	
	DMA-48 SOLID STATE AMPLIFIER		X	QL-0504	46	
	8024-SOLID STATE AMP #2 B335 SHAKER (BLUE)			QL-0510 QL-0509	12 92	
	B-300 SHAKER (BLUE)			QL-0512	52	
	B-300 SHAKER (AGREE)			QL-0216	43	
	B335 SHAKER (RED)			QL-0256	03	
	B335 SHAKER (GREEN)		X	QL-0253	91	
MTS	2456 HYDR. SHAKER 406 CONTROL UNIT 436 CONTROL UNIT	1 Hz - 500 Hz 6" MAX DIS		QL-0003 QL-0006 QL-0007	160 863 3964	
TEAM CORP	SYSTEM 7269 HYDR. SHAKER	13" MAX DIS		QL-0522	533	
DYTRAN	ACCELEROMETER 3141A	F.S. 50 g's SENS. 100 mV/G	X	QL-0194	101	10/16/08
	ACCELEROMETER 3055A2			QL-		
	ACCELEROMETER 3055A2			QL-		
	ACCELEROMETER 3030A4	F.S. 500 g's SENS. 10 mV/G		QL-		
	ACCELEROMETER 3141A			QL-		
	ACCELEROMETER 3031AG			QL-		
	ACCELEROMETER 3101B			QL-		
	ACCELEROMETER 3093M3 (TRIAXIAL ACC)	F.S. 200 g's SENS. 50 mV/G		QL-		
				QL-		
	ACCELEROMETER	F.S. 200 g's SENS. 50 mV/G		QL-		
				QL-		
ENDEVCO	ACCELEROMETER 7254-10	F.S. 500 g's SENS. 10 mV/G		QL-		
PCB	ACCELEROMETER					

QL-TTS-091 Rev: 02/03/06

QUANTA LABORATORIES
SANTA CLARA, CALIFORNIA

DBDHT

Random Vibration Test

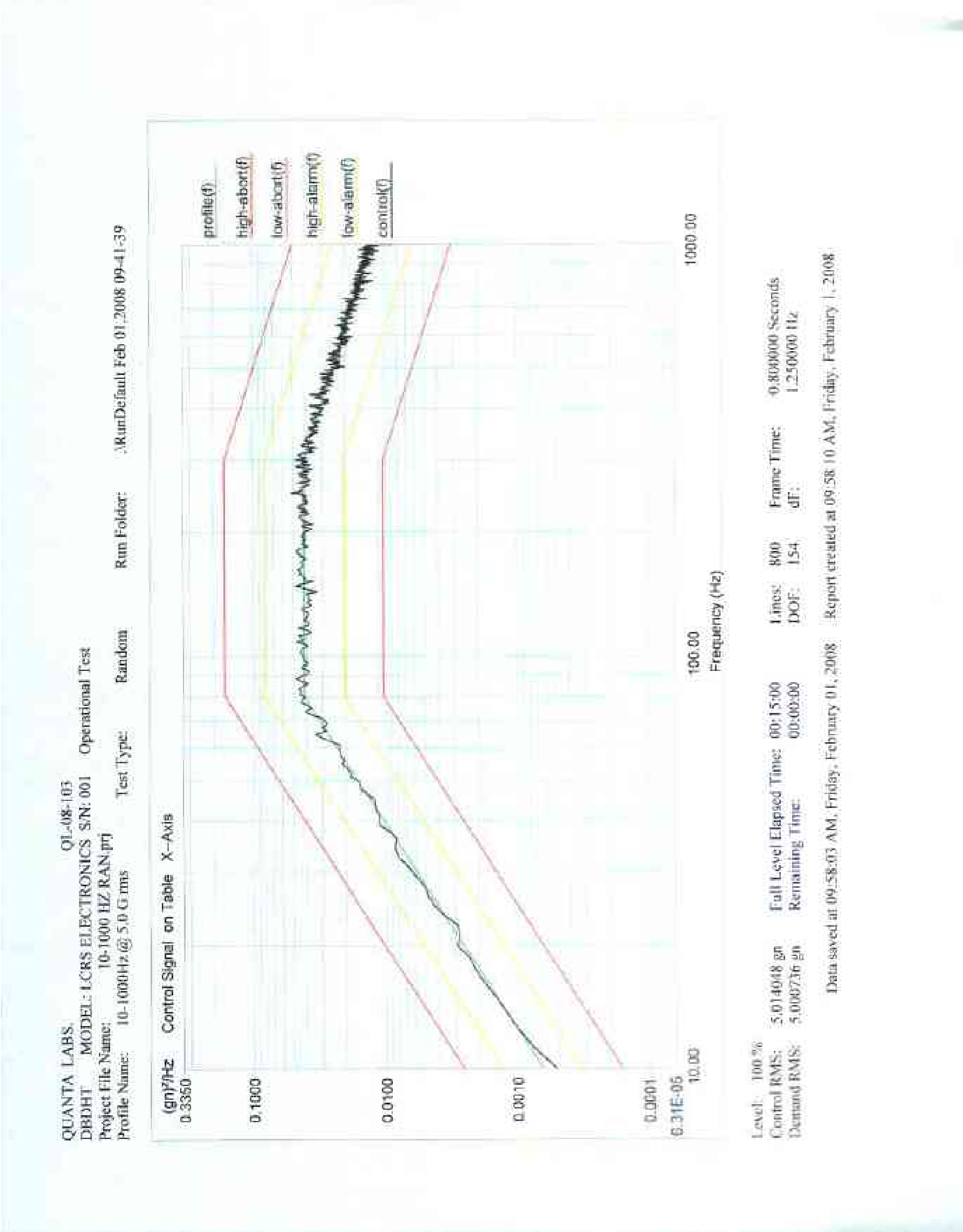
X-AXIS

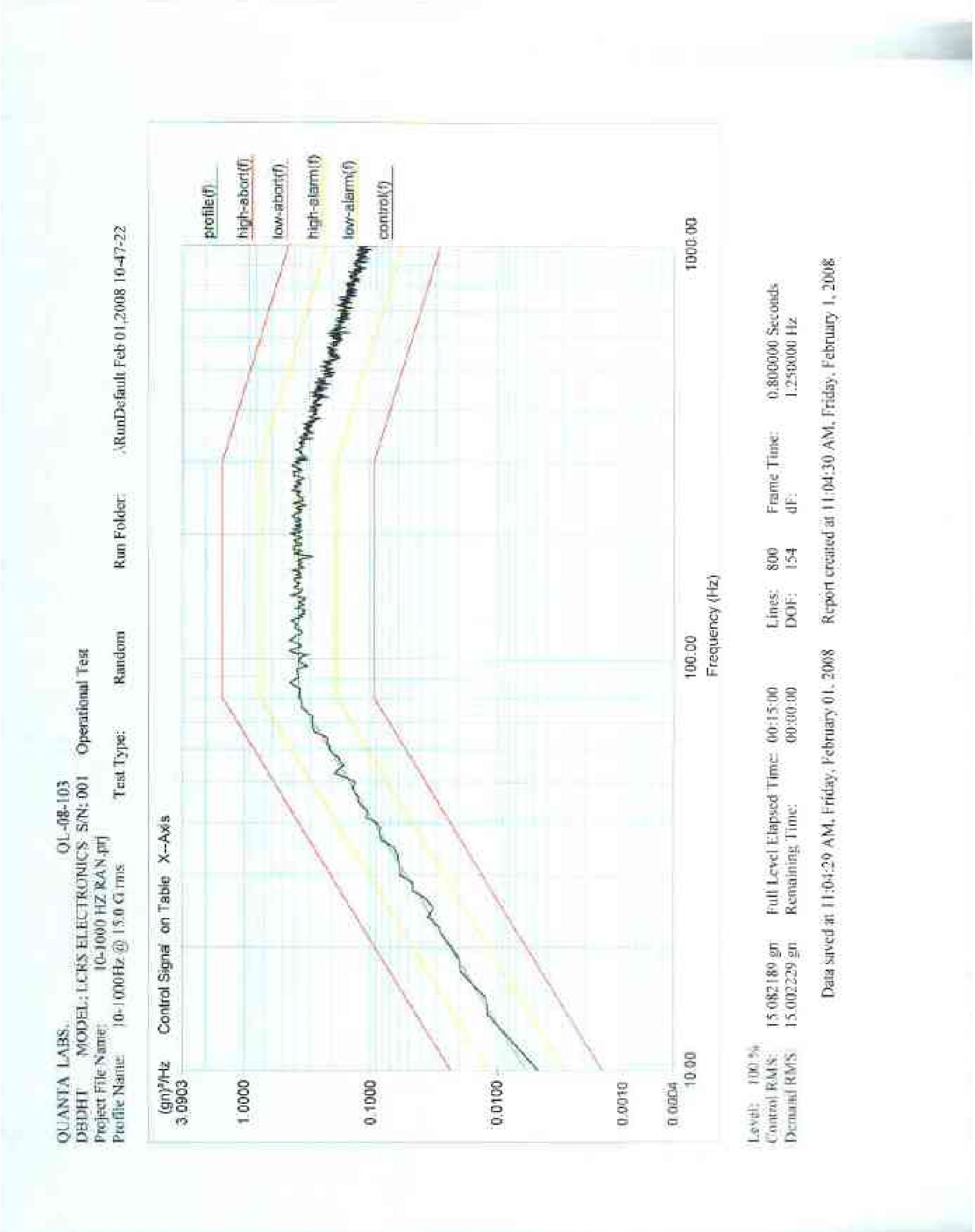
Y-AXIS

Z-AXIS

JOB NO. : QL-08-103   10-1000 HZ @ 5 G rms; 15 G rms

02-01-2008


QUANTA LABS. QL-08-103
DBDHT MODEL: LCRS ELECTRONICS S/N: 001 Operational Test
Project File Name: 10-1000 HZ RAN.prj
Profile Name: 10-1000Hz @ 5.0 G rms Test Type: Random Run Folder: \RunDefault Feb 01,2008 09-41-39
(gn)²/Hz
Control Signal on Table X-Axis
0.3350
0.1000
0.0100
0.0010
0.0001
6.31E-05
10.00
100.00
1000.00
Frequency (Hz)
profile(f)
high-abort(f)
low-abort(f)
high-alarm(f)
low-alarm(f)
control(f)
Level: 100 %
Control RMS: 5.014048 gn
Demand RMS: 5.000736 gn
Full Level Elapsed Time: 00:15:00
Remaining Time: 00:00:00
Lines: 800
DOF: 154
Frame Time: 0.800000 Seconds
dF: 1.250000 Hz
Data saved at 09:58:03 AM, Friday, February 01, 2008
Report created at 09:58:10 AM, Friday, February 1, 2008


QUANTA LABS. QL-08-103
DBDHT MODEL: LCRS ELECTRONICS S/N: 001 Operational Test
Project File Name: 10-1000 HZ RAN.prj
Profile Name: 10-1000Hz @ 15.0 G rms
Test Type: Random
Run Folder: \RunDefault Feb 01,2008 10-47-22
Control Signal on Table X--Axis
(gn)²/Hz
3.0903
1.0000
0.1000
0.0100
0.0010
0.0004
10.00
100.00
1000.00
Frequency (Hz)
profile(f)
high-abort(f)
low-abort(f)
high-alarm(f)
low-alarm(f)
control(f)
Level: 100 %
Control RMS: 15.082180 grn
Demand RMS: 15.002229 grn
Full Level Elapsed Time: 00:15:00
Remaining Time: 00:00:00
Lines: 800
DOF: 154
Frame Time: 0.800000 Seconds
dF: 1.250000 Hz
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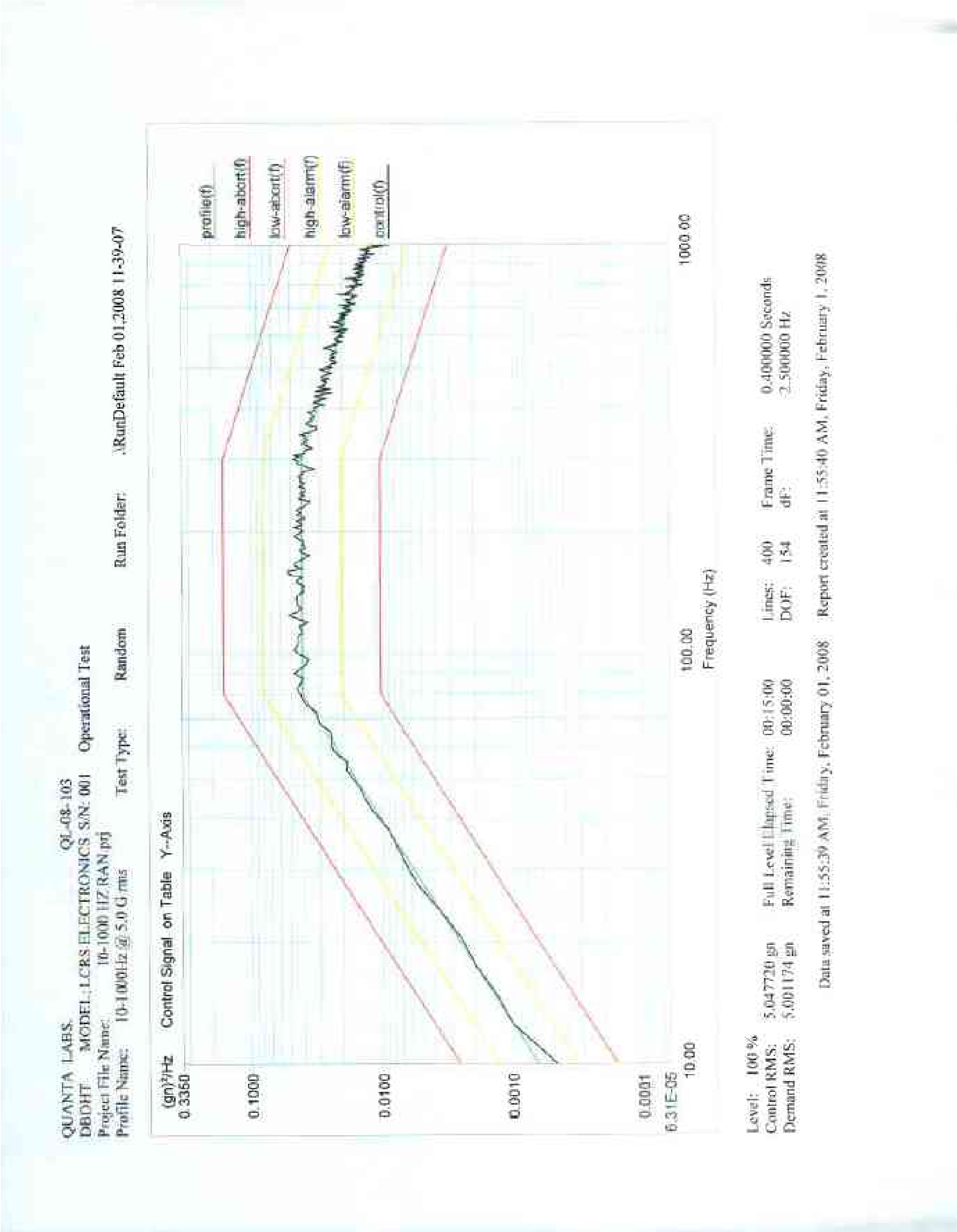
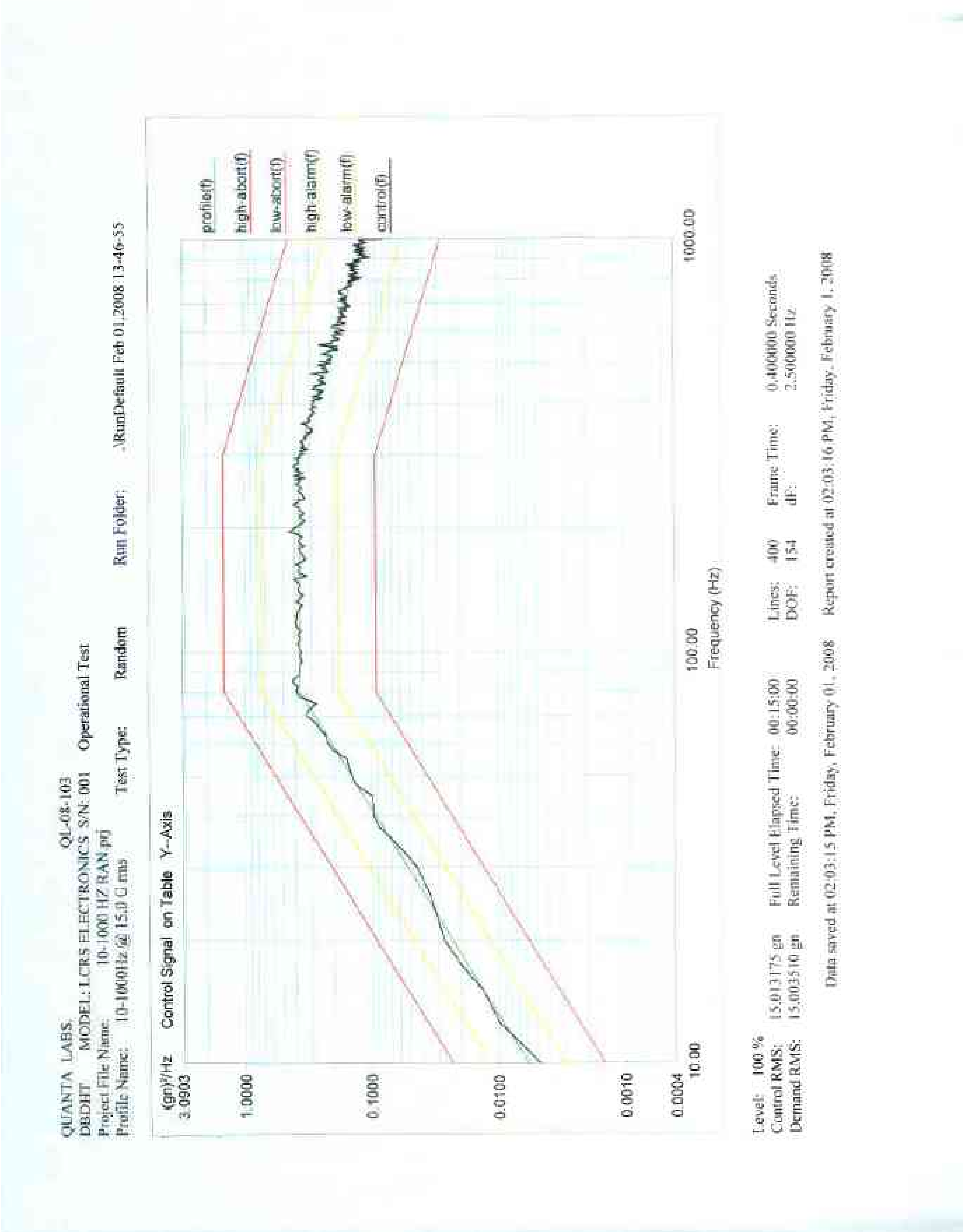
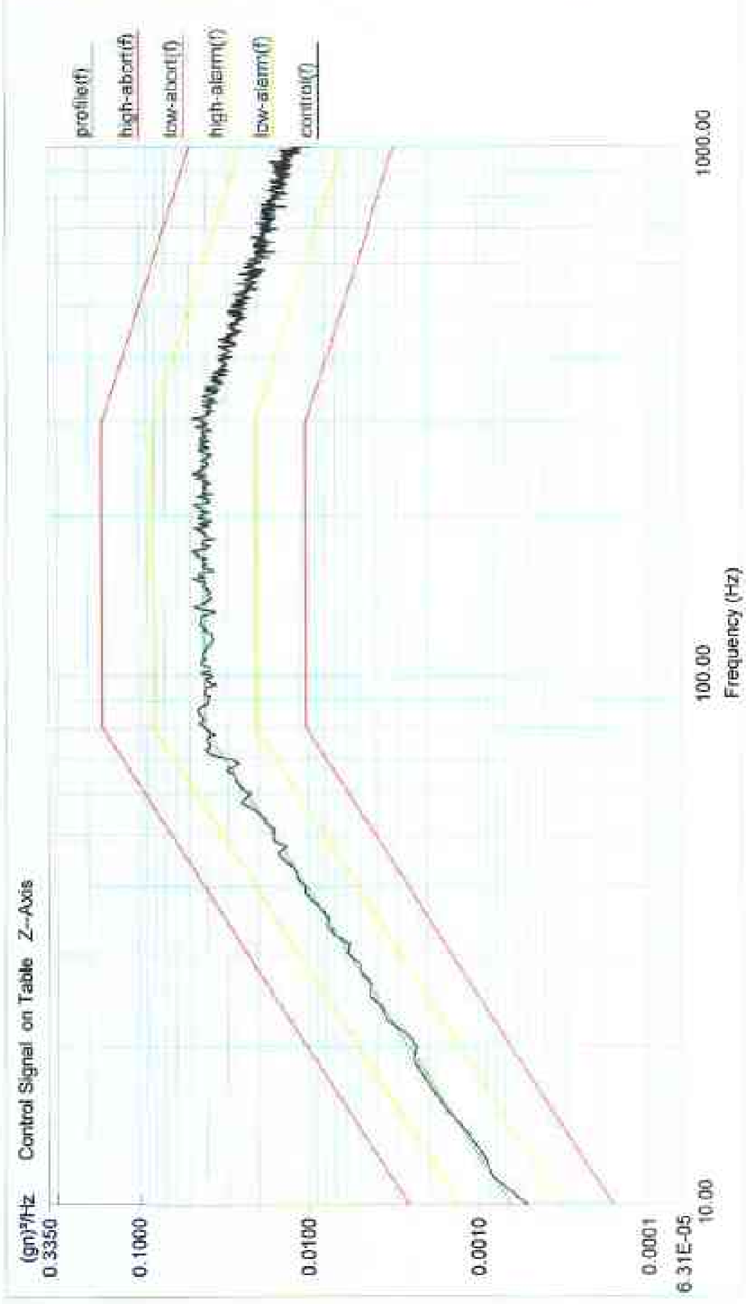
Report created at 11:04:30 AM, Friday, February 1, 2008


QUANTA LABS. QL-08-103
DBDHT MODEL: LCRS ELECTRONICS S/N: 001 Operational Test
Project File Name: 10-1000 HZ RAN.prj
Profile Name: 10-1000Hz @ 5.0 G rms Test Type: Random Run Folder: \RunDefault Feb 01,2008 11-39-07
Control Signal on Table Y--Axis
(gn)²/Hz
0.3350
0.1000
0.0100
0.0010
0.0001
6.31E-05
10.00
100.00
1000.00
Frequency (Hz)
profile(f)
high-abort(f)
low-abort(f)
high-alarm(f)
low-alarm(f)
control(f)
Level: 100 %
Control RMS: 5.047720 gn
Demand RMS: 5.001174 gn
Full Level Elapsed Time: 00:15:00
Remaining Time: 00:00:00
Lines: 400
DOF: 154
Frame Time: 0.400000 Seconds
dF: 2.500000 Hz
Data saved at 11:55:39 AM, Friday, February 01, 2008 Report created at 11:55:40 AM, Friday, February 1, 2008

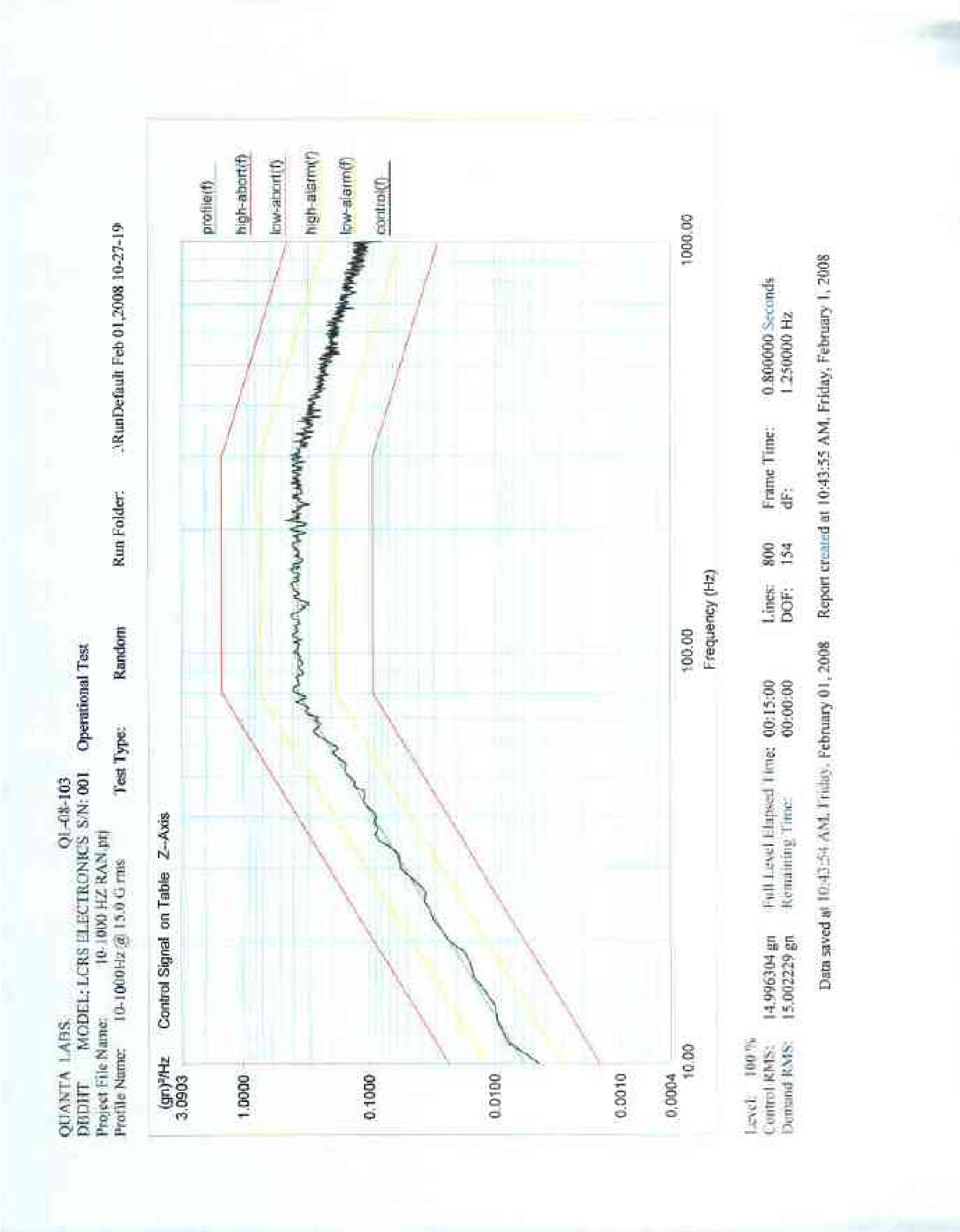

QUANTA LABS. QL-08-103
DBDHT MODEL: LCRS ELECTRONICS S/N: 001 Operational Test
Project File Name: 10-1000 HZ RAN.prj
Profile Name: 10-1000Hz @ 15.0 G rms
Test Type: Random
Run Folder: \RunDefault Feb 01,2008 13-46-55
Control Signal on Table Y--Axis
(gn)²/Hz
3.0903
1.0000
0.1000
0.0100
0.0010
0.0004
10.00
100.00
1000.00
Frequency (Hz)
profile(f)
high-abort(f)
low-abort(f)
high-alarm(f)
low-alarm(f)
control(f)
Level: 100 %
Control RMS: 15.013175 gn
Demand RMS: 15.003510 gn
Full Level Elapsed Time: 00:15:00
Remaining Time: 00:00:00
Lines: 400
DOF: 154
Frame Time: 0.400000 Seconds
dF: 2.500000 Hz
Data saved at 02:03:15 PM, Friday, February 01, 2008
Report created at 02:03:16 PM, Friday, February 1, 2008

QUANTA LABS QL-08-103
DBDHT MODEL: LCRS ELECTRONICS S/N: 001 Operational Test
Project File Name: 10-1000 HZ RAN.prj
Profile Name: 10-1000Hz @ 5.0 G rms Test Type: Random Run Folder: \RunDefault Feb 01,2008 10-05-13



Level: 100 %							
Control RMS:	5.004011 gn	Full Level Elapsed Time:	00:15:00	Lines:	800	Frame Time:	0.800000 Seconds
Demand RMS:	5.000736 gn	Remaining Time:	00:00:00	DOF:	154	dF:	1.250000 Hz

Data saved at 10:21:37 AM, Friday, February 01, 2008 Report created at 10:21:38 AM, Friday, February 1, 2008


QUANTA LABS
QI-08-103
DBDIIT MODEL: LCRS ELECTRONICS S/N: 001 Operational Test
Project File Name: 10-1000 HZ RAN.prj
Profile Name: 10-1000Hz @ 15.0 G rms
Test Type: Random
Run Folder: \RunDefault Feb 01,2008 10-27-19
Control Signal on Table Z-Axis
(grr)²/Hz
3.0903
1.0000
0.1000
0.0100
0.0010
0.0004
10.00
100.00
1000.00
Frequency (Hz)
profile(f)
high-abort(f)
low-abort(f)
high-alarm(f)
low-alarm(f)
control(f)
Level: 100 %
Control RMS: 14.996304 grn
Demand RMS: 15.002229 grn
Full Level Elapsed Time: 00:15:00
Remaining Time: 00:00:00
Lines: 800
DOF: 154
Frame Time: 0.800000 Seconds
dF: 1.250000 Hz
Data saved at 10:43:54 AM, Friday, February 01, 2008
Report created at 10:43:55 AM, Friday, February 1, 2008

ATTACHMENT C

FIELD TEST SUMMARY TABLES

Company	Cust. Partner	Cust. Partner	Cust. Partner
Well Name	Finley	Finley	GCF #1-17
Run No.	2	1	2
Start Date	12/12/2008	12/12/2008	10/29/2008
Finish Date	12/13/2008	12/12/2008	10/30/2008
LCRSS S/N	101	102	102
Results/Problems	Low Pump Pressure Readings, Pump OK at Teardown, Tool Spinning in Hole on Stand it was pulled	Tool Stopped Pulsing. Bad Puls+ Signal from Power Board	Electronics Failure IC Shaken loose due to excessive vibration. Bearing failure O-Ring extruded
Depth In	1151	1042	6268
Depth Out	1370	1151	6424
Distant Drilled	219	109	156
Hrs. Drilling	6.15	5.30	13.00
Hrs. Drill & Circ	7.30	7.00	14.00
Flow	425	425	450
Bit Type	PDC	PDC	Tri-cone Roller
Hole size	8.75	8.75	8.5
S.P.P	1400	1400	2010-2100
ROP	33	33	12
W.O.B.	15k	15k	15K
Mud Type	WBM	WBM	WBM
Mud Wt.	9.1	9.1	9.3 - 9.4
R.P.M.	60-80	60-80	50 - 90
Incl. In (deg)	1.41	1.9	0.29
Incl. Out (deg)	1.45	1.41	0.6
Azi in	189.6	219.9	277
Azi out	189.4	189.6	157
Pulser #	101	102	102
Power Supply #	Li-Ion Battery HN008	Li-Ion Battery HN016	Li-Ion Battery HN
Well Type	Vertical Control	Vertical Control	Vertical Control
Hole Temp	35 - 40 Celsius	35 - 40 Celsius	52 Celsius

Company	Cust. Partner	DBDHT	DBDHT	DBDHT
Well Name	GCF #1-17	Catoosa Rhonda 1B	Catoosa Rhonda 1B	RMOTC 45-4-X-21
Run No.	1	2	1	1
Start Date	10/24/2008	9/9/2008	9/8/2008	7/28/2008
Finish Date	10/29/1008	9/10/2008	9/9/2008	7/31/2008
LCRSS S/N	101	101	101	102
Results/Problems	No problem, POOH for Bit Change, Decision made to PU LCRSS 102 for remainder of job	No problem, TD well per plan, 2nd segment was to drop Inc to 0 Degrees, 3rd Segment was to build back up to 10 Degrees Inc. then try multiple downlinks. Downlinks successful.	No problems, 1st segment build up then TOOH to install mud motor (Run #2), Target for Segment 1 is 270 AZ/10 INC	Li-ion Battery exhausted after 128.76 downhole hours Target = 280 AZ/90 Inc
Depth In	1456	580	220	712
Depth Out	6268	1131	580	4263
Distant Drilled	4812	551	360	3551
Hrs. Drilling	116.00	12.50	8.25	59.00
Hrs. Drill & Circ	125.00	13.50	9.00	6500
Flow	450	348	348	380
Bit Type	PDC	Tri-cone Roller	Tri-cone Roller	PDC
Hole size	8.5	8.5	8.5	8.5
S.P.P	1200-2010	1100-1200	1100-1200	900-1300
ROP	41	44	44	55
W.O.B.	10-15K	15K	15K	10-15K
Mud Type	WBM	WBM	WBM	WBM
Mud Wt.	9.3 - 9.4	9.8	8.8	10
R.P.M.	50 - 90	112-182	82	80
Incl. In (deg)	0.59	9.87	0.76	1.08
Incl. Out (deg)	0.29	0.51	9.87	20.45
Azi in	84.92	271.6	330.8	238.57
Azi out	277	274.35	271.6	277.4
Pulser #	101	125	125	102
Power Supply #	Li-ion Battery HN009	Li-ion Battery HN004	Li-ion Battery HN004	Li-ion Battery HN006
Well Type	Vertical Control	Directional	Directional	Directional
Hole Temp	51 Celsius	48 Celsius	40 Celsius	57 Celsius

Company	DBDHT	DBDHT	DBDHT	DBDHT
Well Name	Catoosa Rhonda 3C	Catoosa Rhonda 5D	Catoosa Rhonda 5C	Catoosa Rhonda 5B
Run No.	2	1	3	2
Start Date	7/17/2008	7/15/2008	6/26/2008	6/25/2008
Finish Date	7/18/2008	7/16/2008	6/27/2008	6/24/2008
LCRSS S/N	102	102	102	102
Results/Problems	No problems, Well TD per plan, Target set at 90 Inc/330 Azimuth	No problems, Well TD per plan, Target set at 90 Inc/330 Azimuth BHA did not have upper IBS	No problems, Well TD per plan	No problems, Run TD per plan, Cement Back for New Directional
Depth In	241	190	195	836
Depth Out	1200	1200	1200	1200
Distant Drilled	959	1010	1005	364
Hrs. Drilling	11.50	13.00	9.67	3.59
Hrs. Drill & Circ	13.00	15.00	11.00	4.25
Flow	450	450	450	450
Bit Type	PDC	PDC	PDC	PDC
Hole size	8.5	8.5	8.5	8.5
S.P.P	1160	1160	1200-1400	1200-1400
ROP	83	78	104	101
W.O.B.	10-15K	10-15K	10-20K	10-20K
Mud Type	WBM	WBM	WBM	WBM
Mud Wt.	9.7-9.9	9.7-9.9	9.1-9.4	9.1-9.4
R.P.M.	80	80	80	80
Incl. In (deg)	0.29	0.27	1.2	0.18
Incl. Out (deg)	11.8	15.28	15.99	10.03
Azi in	201	355.57	139	220.03
Azi out	326.5	323.86	88	234
Pulser #	102	102	102	102
Power Supply #	Li-Ion Battery HN006	Li-Ion Battery HN006	Li-ion Battery HN006	Li-ion Battery HN006
Well Type	Directional	Directional	Directional	Directional
Hole Temp	45 Celsius	43 Celsius	43 Celsius	42 Celsius

Company	DBDHT	DBDHT	DBDHT	DBDHT
Well Name	Catoosa Rhonda 5B	Catoosa Rhonda 3B	Catoosa Rhonda 3B	RMOTC 84-TpX-3R
Run No.	1	2	1	3
Start Date	6/24/2008	6/3/2008	6/2/2008	4/16/2008
Finish Date	6/24/2008	6/6/2008	6/3/2008	4/16/2008
LCRSS S/N	102	102	101	101
Results/Problems	No problems, Run TD per plan, POOH to reprogram new target	No problems, Run TD based on worn-out drill bit	Tool stopped Pulsing	Tool Stopped Pulsing
Depth In	600	1303	738	1019
Depth Out	836	1887	1303	1112
Distant Drilled	236	584	565	93
Hrs. Drilling	4.00	22.00	6.50	3.00
Hrs. Drill & Circ	9.00	26.00	7.00	3.66
Flow	450	450	450	450
Bit Type	PDC	PDC	PDC	PDC
Hole size	8.5	8.5	8.5	8.5
S.P.P	1200-1400	1200-1650	1200-1400	900
ROP	59	27	87	31
W.O.B.	10-20K	10 - 45K	10-20K	8-15K
Mud Type	WBM	WBM	WBM	WBM
Mud Wt.	9.1-9.4	9.3-10.3	9.3-10.1	8.7-9.3
R.P.M.	80	80	80-90	65-100
Incl. In (deg)	4.67	0.04	3.43	4.5
Incl. Out (deg)	0.18	0.31	0.04	10
Azi in	291.6	73.76	283.29	221
Azi out	220.03	93.39	73.76	226
Pulser #	102	108	85	123
Power Supply #	Li-ion Battery HN006	Li-ion Battery HN006	Generator	Generator
Well Type	Directional	Vertical Control	Vertical Control	Directional
Hole Temp	42 Celsius	52 Celsius	46 Celsius	24 Celsius

Company	DBDHT	DBDHT	DBDHT	DBDHT
Well Name	RMOTC 84-TPx-3R	RMOTC 84-TPx-3R	RMOTC 84-TPx-3R	RMOTC 84-TPx-3R
Run No.	2	1	2	1
Start Date	4/15/2008	4/13/2008	3/6/2008	3/5/2008
Finish Date	4/15/2008	4/14/2008	3/6/2008	3/6/2008
LCRSS S/N	102	102	101	102
Results/Problems	Tool stopped Pulsing	TOOH to PU Motor to Kick Off Cement Plug	TOOH - Erratic Pulsing	TOOH - Erratic Pulsing. 15.5 Hrs. Downtime due to failure of rig generator
Depth In	862	717	715	664
Depth Out	1019	794	715	715
Distant Drilled	157	77	0	51
Hrs. Drilling	5.00			1.50
Hrs. Drill & Circ	5.50			2.00
Flow	425-475	360	450	450
Bit Type	PDC	PDC	PDC	PDC
Hole size	8.5	8.5	8.5	8.5
S.P.P	700	600	920	900
ROP	31		0	34
W.O.B.	10 - 20K	5-10K		5-10K
Mud Type	WBM	WBM		WBM
Mud Wt.	8.7-9.3	8.7-9.3		8.7
R.P.M.	65-100	65-100	80	80-85
Incl. In (deg)	3			
Incl. Out (deg)	9.28			
Azi in	273			
Azi out	222.5			
Pulser #	124	124	101	108
Power Supply #	Generator	Generator	Generator	Generator
Well Type	Directional	Directional	Directional	Directional
Hole Temp	24 Celsius	24 Celsius	24 Celsius	24 Celsius