LS Research, LLC
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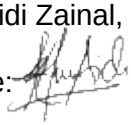
ENGINEERING TEST REPORT # 311239 Digital Device
LSR Job #: C-1273

Compliance Testing of:
T:Slim

Test Date(s):
June 8th 2012

Prepared For:
Tandem Diabetes
11045 Roselle Street, Suite 200
San Diego, CA 92121

This Test Report is issued under the Authority of:
Khairul Aidi Zainal, Senior EMC Engineer

Signature:  Date:6/8/12

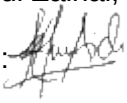
Test Report Reviewed by:	**Project Engineer:**
Tom Smith, Manager EMC Test Services	Khairul Aidi Zainal, Senior EMC Engineer
Signature:  Date: 6/8/12	Signature:  Date:6/8/12

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EXHIBIT 1. INTRODUCTION

1.1 SCOPE

References:	RSS-GEN, CFR 47 15.109 ICES-003, 2004
Title:	General Requirements and Information for the Certification of Radiocommunication Equipment
Purpose of Test:	To gain IC and FCC Certification Authorization for a Digital Device operated in Receive Mode
Test Procedures:	Both conducted and radiated emissions measurements were conducted in accordance with American National Standards Institute ANSI C63.4 – American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
Environmental Classification:	• Commercial, Industrial or Business • Residential

1.2 NORMATIVE REFERENCES

Publication	Title
RSS-Gen Issue 3, 2010	Spectrum Management and Telecommunications Radio Standards Specification
ICES -003	Spectrum Management and Telecommunications Policy Interference-Causing Equipment Standard: Digital Apparatus.
CFR 47 Part 15	Radio Frequency devices
ANSI C63.4	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
CISPR 16-1-1	Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-1: Measuring Apparatus.

1.3 LS Research, LLC TEST FACILITY

LS Research, LLC is accredited by A2LA (American Association for Laboratory Accreditation) to conform to ISO/IEC 17025, 2005 “General Requirements for the Competence of Calibration and Testing Laboratories”.

LS Research, LLC’s scope of accreditation includes all test methods listed herein, unless otherwise noted.

1.4 LOCATION OF TESTING

All testing was performed at LS Research, LLC, W66 N220 Commerce Court, Cedarburg, Wisconsin, 53012 USA, utilizing the facilities listed below, unless otherwise noted.

List of Facilities Located at LS Research, LLC:

- Compact Chamber
- Semi-Anechoic Chamber
- Open Area Test Site (OATS)

1.5 TEST EQUIPMENT UTILIZED

A complete list of equipment utilized in testing is provided in Appendix A of this test report. Calibration dates are indicated in Appendix A. All test equipment is calibrated in accordance with A2LA standards.

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1 CLIENT INFORMATION

Manufacturer Name:	Tandem Diabetis
Address:	11045 Roselle Street, Suite 200, San Diego, CA 92121
Contact Name:	Chad Eastridge

2.2 EQUIPMENT UNDER TEST (EUT) INFORMATION

The following information has been supplied by the applicant.

Product Name:	T:Slim
Model Number:	N/A
Serial Number:	Engineering Unit

2.3 ASSOCIATED ANTENNA DESCRIPTION

The antenna associated with the EUT is a Johanson ceramic chip antenna, P/N 2450AT18A100, with a peak gain of 0.5 dBi.

2.4 EUT'S TECHNICAL SPECIFICATIONS

Additional Information:

Operating Voltage	5.0 VDC
Highest Clock Frequency on Board	32 MHz
Spurious Emission (worst case) at 3m	36.9dBµV/m at 66.7MHz
EUT will be operated under FCC part(s) and IC Rule	IC: RSS-GEN, ICES-003 FCC: CFR 47 part 15

2.5 PRODUCT DESCRIPTION

The T-Slim ambulatory pump is intended to be used for continuous subcutaneous insulin infusion therapy in persons requiring insulin for the management of diabetes.

EXHIBIT 3. EUT OPERATING CONDITIONS & CONFIGURATIONS DURING TESTS

3.1 CLIMATE TEST CONDITIONS

Temperature:	72 ° Fahrenheit
Humidity:	34%
Pressure:	731mmHg

3.2 APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

ICES-003 Section	Test Requirements	Compliance (yes/no)
5.3	Power Line Conducted Emissions Measurements	Yes
5.5	Un-Intentional Radiated Emissions	Yes

RSS Paragraph	Test Requirements	Compliance (yes/no)
7.2.4	Power Line Conducted Emissions Measurements	Yes
6	Un-Intentional Radiated Emissions	Yes

CFR 47 Part 15 section	Test Requirements	Compliance (yes/no)
107	Power Line Conducted Emissions Measurements	Yes
109	Un-Intentional Radiated Emissions	Yes

3.3 MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

☒ **None** ☐ **Yes (explain below)**

3.4 DEVIATIONS & EXCLUSIONS FROM TEST SPECIFICATIONS

☒ **None** ☐ **Yes (explain below)**

EXHIBIT 4. DECLARATION OF CONFORMITY

The EUT was found to MEET the requirements as described within the specification of CFR 47 part 15, ICES-003 and Industry Canada RSS-Gen Issue 3.

If some emissions are seen to be within 3 dB of their respective limits:
As these levels are within the tolerances of the test equipment and site employed, there is a possibility that this unit, or a similar unit selected out of production may not meet the required limit specification if tested by another agency.

LS Research, LLC certifies that the data contained herein was taken under conditions that meet or exceed the requirements of the test specifications. The results in this Test Report apply only to the item(s) tested on the above-specified dates. Any modifications made to the EUT subsequent to the indicated test date(s) will invalidate the data herein, and void this certification.

EXHIBIT 5. RADIATED EMISSIONS TEST

5.1 Test Setup

The test setup was assembled in accordance with Title 47, CFR FCC Part 15, RSS GEN and ANSI C63.4. The EUT was placed on an 80cm high non-conductive pedestal, centered on a flush mounted 2-meter diameter turntable inside a 3 meter Semi-Anechoic, FCC listed Chamber.

The EUT was operated in continuous data transfer mode with a laptop PC. This constant link was provide via Hyperterminal on the laptop PC. A script file was loaded onto hyperterminal which allowed for continuous communication with the EUT

The applicable limits apply at a 3 meter distance. The calculations to determine these limits are detailed in the following pages. Please refer to Appendix A for a complete list of test equipment.

5.2 Test Setup Photo(s) – Radiated Emissions Test

5.3 Test Procedure

Radiated RF measurements were performed on the EUT in a 3 meter Semi-Anechoic, FCC listed Chamber. The frequency range from 30 MHz to 11000 MHz was scanned and investigated. The radiated RF emission levels were manually noted at the various fixed degree settings of azimuth on the turntable and antenna height. The EUT was placed on a non-conductive pedestal in the 3 meter Semi-Anechoic Chamber, with the antenna mast placed such that the antenna was 3 meters from the EUT. A Biconical Antenna was used to measure emissions from 30 MHz to 300 MHz, and a Log Periodic Antenna was used to measure emissions from 300 MHz to 1000 MHz. A Double-Ridged Waveguide Horn Antenna with a low noise amplifier was used from 1 GHz to 18 GHz.

The maximum radiated RF emissions were found by raising and lowering the antenna between 1 and 4 meters in height while the polarity of the antenna was switched between horizontal and vertical polarity.

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5.4 Test Equipment Utilized

A list of the test equipment and antennas utilized for the Radiated Emissions test can be found in Appendix A. This list includes calibration information and equipment descriptions. All equipment is calibrated and used according to the operation manuals supplied by the manufacturers. All calibrations of the antennas used were performed at an IEC/ISO 17025 accredited calibration laboratory, traceable to the SI standard. In addition, the Connecting Cables were measured for losses using a calibrated Signal Generator and an EMI Receiver. **The resulting correction factors and the cable loss factors from these calibrations were entered into the EMI Receiver database. As a result, the data taken from the EMI Receiver accounts for the antenna correction factor as well as cable loss or other corrections, and can therefore be entered into the database as a corrected meter reading.** The EMI Receiver was operated with resolution bandwidths as prescribed in ANSI C63.4.

5.5 Test Results

The EUT was found to **MEET** the Radiated Emissions requirements of Canada RSS GEN, ICES 003 and CFR 47 Part 15. The frequencies with significant RF signal strength were recorded and plotted as shown in the Data Charts and Graphs.

5.6 CALCULATION OF RADIATED EMISSIONS LIMITS

The following table depicts the Class B limits for an unintentional radiator. These limits are obtained from RSS-Gen Section 6, Table 1, for radiated emissions measurements.

Frequency (MHz)	3 m Limit μV/m	3 m Limit (dBμV/m)	1 m Limit (dBμV/m)
30-88	100	40.0	-
88-216	150	43.5	-
216-960	200	46.0	-
960-24,000	500	54.0	63.5

Sample conversion from field strength μV/m to dBμV/m:
$dB\mu V/m = 20 \log_{10} (100)$
= 40 dBμV/m (from 30-88 MHz)

For measurements made at 1.0 meter, a 9.5 dB correction has been invoked.

960 MHz to 10,000 MHz
500μV/m or 54.0 dB/μV/m at 3 meters
54.0 + 9.5 = 63.5 dB/μV/m at 1 meter

For measurements made at 0.3 meter, a 20 dB correction has been invoked.

960 MHz to 10,000 MHz
500μV/m or 54.0 dB/μV/m at 3 meters
54.0 + 20 = 74 dB/μV/m at 0.3 meters

Reported data:

For both fundamental and spurious emissions measurement, the data reported includes all necessary correction factors. These correction factors are loaded onto the EMI receiver when measurements are performed.

Reported Measurement data = Raw receiver measurement (dBμV/m) + Antenna correction Factor + Cable factor (dB) + Miscellaneous factors when applicable (dB) – amplification factor when applicable (dB).

Generic example of reported data at 200 MHz:

Reported Measurement data = 18.2 (raw receiver measurement) + 15.8 (antenna factor) + 1.45 (cable factor) = 35.45 (dBμV/m).

5.7 DATA CHART – RADIATED EMISSIONS TEST

Manufacturer:	Tandem Diabetes						
Date(s) of Test:	June 8, 2012						
Project Engineer:	Khairul Aidi Zainal						
Test Engineer(s):	Khairul Aidi Zainal						
Voltage:	5 VDC						
Operation Mode:	continuous receive						
Environmental Conditions in the Lab:	Temperature: 71˚ F Relative Humidity: 34 %						
EUT Power:		Single Phase 120 VAC		3 Phase ___VAC			
		Battery	X	Other: Laptop PC			
EUT Placement:	X	80cm non-conductive table		10cm Spacers			
EUT Test Location:	X	3 Meter Semi-Anechoic FCC Listed Chamber		3/10m OATS			
Measurements:		Pre-Compliance		Preliminary	X	Final	
Detectors Used:	X	Peak	X	Quasi-Peak	X	Average	

The following table depicts the level of significant spurious radiated RF emissions found:

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Quasi Peak Reading (dBµV/m)	Average Reading (dBµV/m)	Quasi Peak Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation	NOTES
222.0	1.00	102	37.9	27.0	20.1	46.0	19.0	H	TT	N/A
66.5	4.00	0	40.1	35.1	28.2	40.0	4.9	H	TT	1
66.7	1.00	0	41.6	36.9	29.8	40.0	3.1	V	TT	1
197.4	1.00	176	38.1	32.9	25.2	43.5	10.6	V	TT	N/A
338.5	1.00	305	43.9	31.8	10.3	46.0	14.2	H	TT	N/A
339.5	1.00	0	42.4	30.7	11.3	46.0	15.3	H	TT	N/A

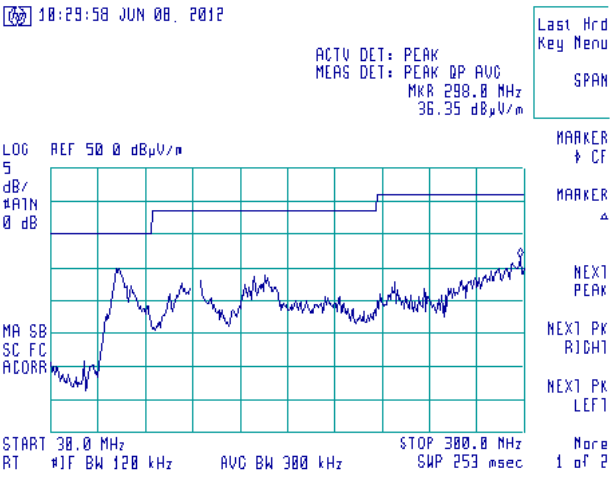
Notes:
1. This spurious emission was determined to be not of the EUT
2. H: Horizontal; V: Vertical; TT: Table Top

5.8 Screen Captures - Radiated Emissions Testing

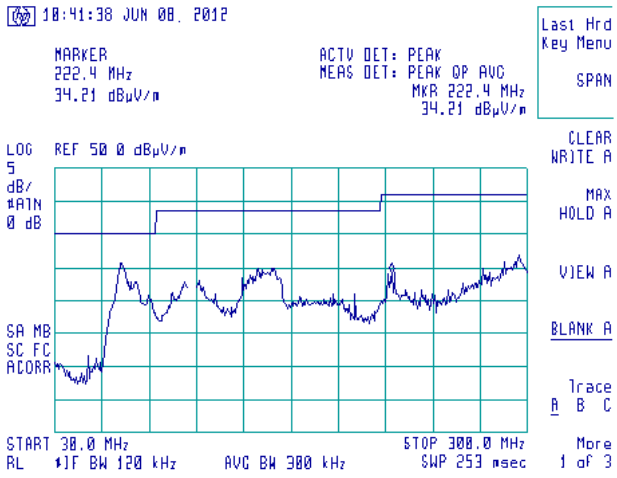
These screen captures represent Peak Emissions. For radiated emission measurements, a Quasi-Peak detector function is utilized when measuring frequencies below 1 GHz.

The signature scans shown here are from worst-case emissions, as measured with the sense antenna both in vertical and horizontal polarity for worst case presentations.

30-300 MHz Horizontal, at 3m

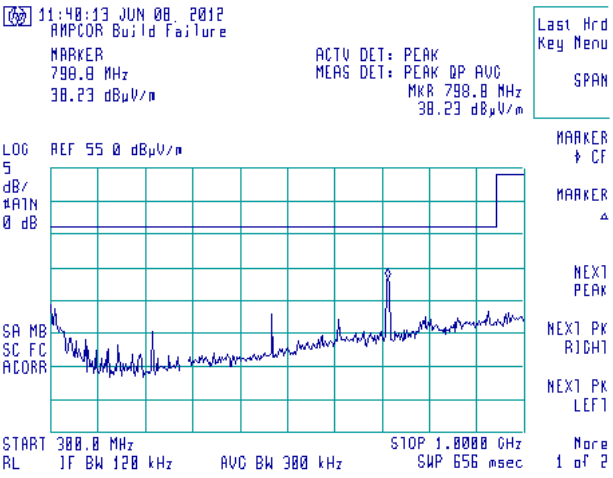


Baseline

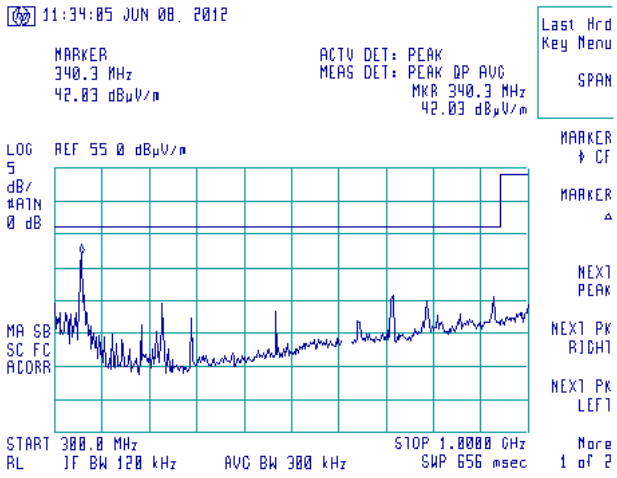


With EUT communicating

300-1000 Horizontal, at 3m



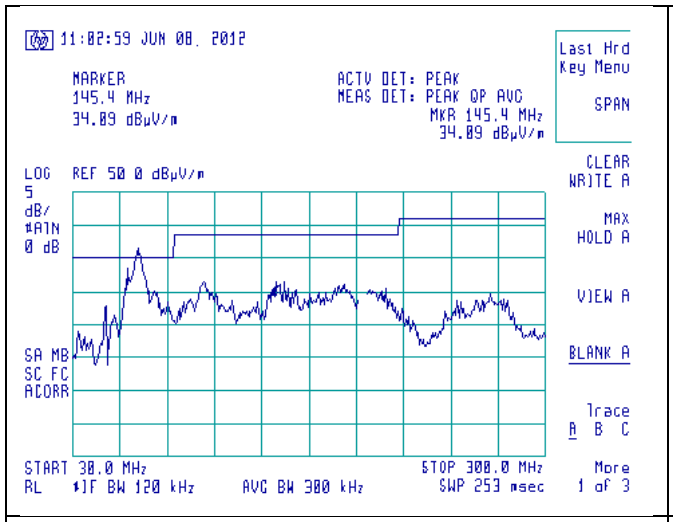
Baseline



With EUT communicating

Screen Captures - Radiated Emissions Testing *(continued)*

30-300 MHz Vertical, at 3m



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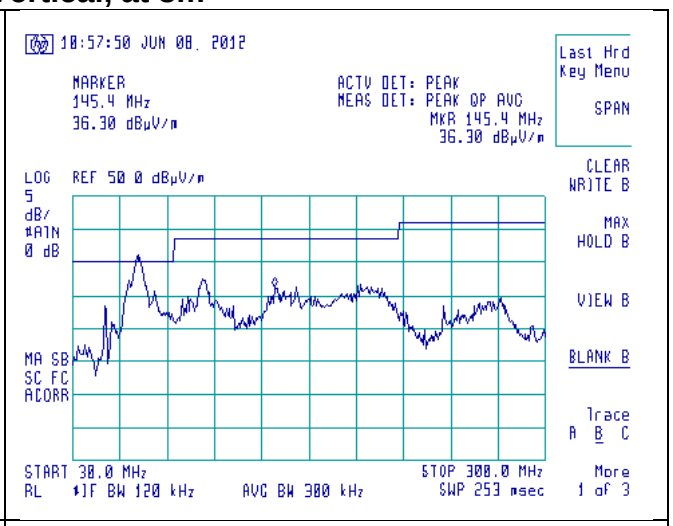
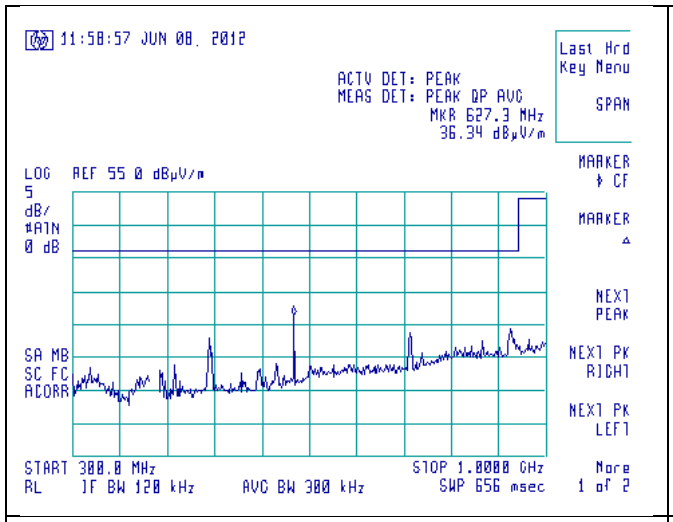
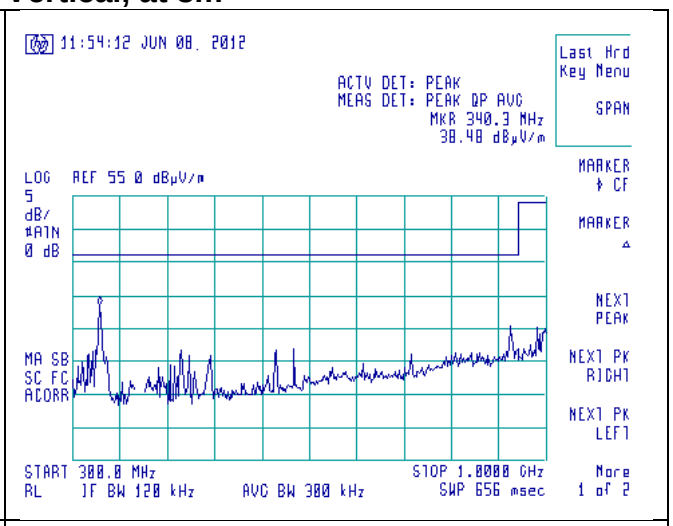


With EUT communicating

300-1000 MHz Vertical, at 3m



Baseline



With EUT communicating

EXHIBIT 6. CONDUCTED EMISSIONS TEST, AC POWER LINE:

6.1 Test Setup

The test area and setup are in accordance with ANSI C63.4 and with Title 47 CFR, FCC Part 15, Industry Canada RSS GEN. The EUT was placed on a non-conductive wooden table, with a height of 80 cm above the reference ground plane. The EUT's power cable was plugged into a 50Ω (ohm), 50/250 μH Line Impedance Stabilization Network (LISN). The AC power supply of 120V was provided via an appropriate broadband EMI Filter, and then to the LISN line input. Final readings were then taken and recorded. After the EUT was setup and connected to the LISN, the RF Sampling Port of the LISN was connected to a 10 dB Attenuator-Limiter, and then to EMI receiver System. The EMCO LISN used has the ability to terminate the unused port with a 50Ω (ohm) load when switched to either L1 (line) or L2 (neutral).

The EUT was set to constantly communicate with the laptop PC. This was done by using Hyperterminal and a script file to enable this sort of communication. The EUT while connected to the laptop PC is charging. The laptop PC power supply was plugged into the LISN and investigated.

6.2 Test Procedure

The EUT was investigated in continuous modulated transmit mode for this portion of the testing. The appropriate frequency range and bandwidths were selected on the EMI Receiver, and measurements were made. The bandwidth used for these measurements is 9 kHz, as specified in CISPR 16-1, Section 1, Table 1, for Quasi-Peak and Average detectors in the frequency range of 150 kHz to 30 MHz. Final readings were then taken and recorded.

6.3 Test Equipment Utilized

A list of the test equipment and accessories utilized for the Conducted Emissions test is provided in Appendix A. This list includes calibration information and equipment descriptions. All equipment is calibrated and used according to the operation manuals supplied by the manufacturers. Calibrations of the LISN and Limiter were performed at an IEC/ISO 17025 accredited calibration laboratory, traceable to the SI standard. All cables are calibrated and checked periodically for conformance. **The emissions are measured on the EMI System, which has automatic correction for all factors stored in memory and allows direct readings to be taken.**

6.4 Test Results

The EUT was found to **MEET** the Conducted Emission requirements of FCC Part 15 and RSS GEN for Conducted Emissions for an Intentional Radiator. See the Data Charts and Graphs for more details of the test results.

6.5 FCC Limits of Conducted Emissions at the AC Mains Ports

Frequency Range (MHz)	Class B Limits (dBµV)		Measuring Bandwidth
	Quasi-Peak	Average	
0.150 -0.50 *	66-56	56-46	RBW = 9 kHz VBW ≥ 9 kHz for QP VBW = 1 Hz for Average
0.5 – 5.0	56	46	
5.0 – 30	60	50	
* The limit decreases linearly with the logarithm of the frequency in this range.			

6.6 CONDUCTED EMISSIONS TEST DATA CHART

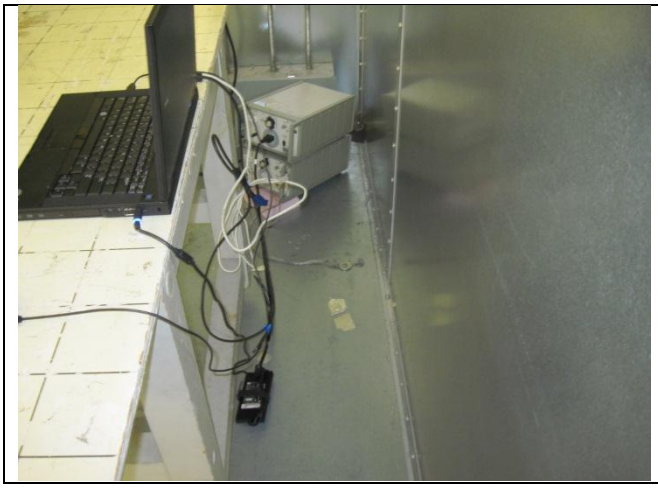
Manufacturer:	Tandem Diabetes					
Date(s) of Test:	June 8, 2012					
Project Engineer:	Khairul Aidi Zainal					
Test Engineer:	Khairul Aidi Zainal					
Voltage:	120 VAC					
Operation Mode:	continuous communication					
Environmental Conditions in the Lab:	Temperature: 71˚ F Relative Humidity: 34 %					
Test Location:	X	AC Mains Test area				Chamber
EUT Placed On:	X	40cm from Vertical Ground Plane				10cm Spacers
	X	80cm above Ground Plane				Other:
Measurements:		Pre-Compliance		Preliminary	X	Final
Detectors Used:		Peak	X	Quasi-Peak	X	Average

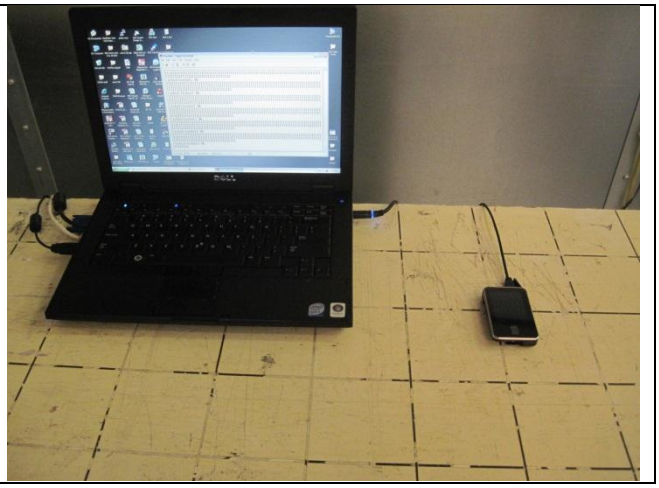
		QUASI-PEAK			AVERAGE		
Frequency (MHz)	Line	Q-Peak Reading (dBµV)	Q-Peak Limit (dBµ V)	Quasi-Peak Margin (dB)	Average Reading (dBµV)	Average Limit (dBµ V)	Average Margin (dB)
0.232	L1	43.5	62.4	18.9	31.3	52.4	21.1
0.955	L1	40.9	56.0	15.1	25.4	46.0	20.6
1.849	L1	37.0	56.0	19.0	27.7	46.0	18.3
0.250	L2	41.7	61.8	20.1	29.7	51.8	22.1
0.512	L2	40.6	56.0	15.4	24.0	46.0	22.0
1.301	L2	38.4	56.0	17.6	23.1	46.0	22.9

Notes:

1) The emissions listed are characteristic of the power supply used, and did not change by the EUT.

6.7 Test Setup Photo(s) – Conducted Emissions Test

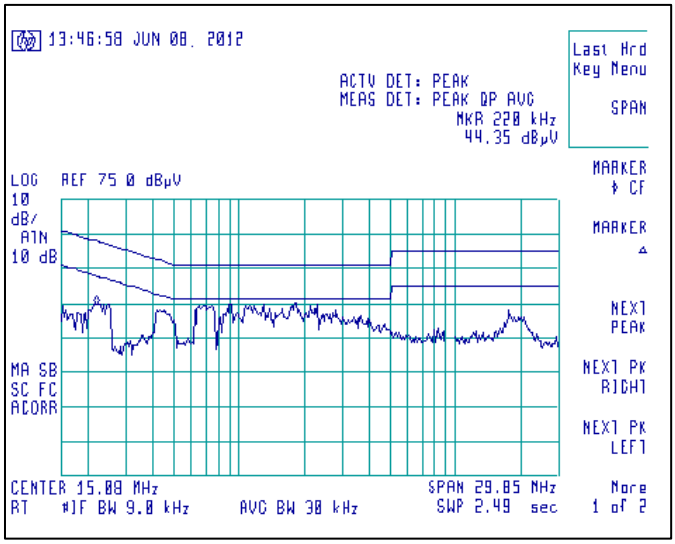




6.8 Screen Captures – Conducted Emissions Test

These screen captures represent Peak Emissions. For conducted emission measurements, both a Quasi-Peak detector function and an Average detector function are utilized. The emissions must meet both the Quasi-peak limit and the Average limit as described in 47 CFR 15.107 and RSS GEN.

Line 1



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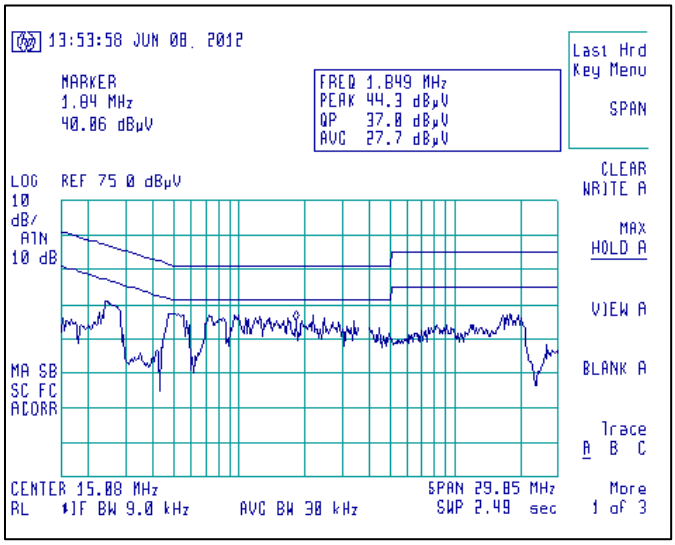

APPENDIX A: Test Equipment List

LS RESEARCH LLC
Wireless Product Development
Equipment Calibration

Date : 8-Jun-2012 Type Test : AC Mains Emissions Job # : C-1273

Prepared By: Aidi Customer : Tandem Diabetes Care Quote #: 311239

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960013	EMI Receiver	HP	8546A System	3617A00320;3448A	11/22/2011	11/22/2012	Active Calibration
2	EE 960014	EMI Receiver-filter section	HP	85460A	3448A00296	11/22/2011	11/22/2012	Active Calibration
3	AA 960008	LISN	EMCO	3816/2NM	9701-1057	1/3/2012	1/3/2013	Active Calibration
4	AA 960072	Transient Limiter	HP	11947A	3107A02515	11/2/2011	11/2/2012	Active Calibration

Project Engineer: Aidi Quality Assurance: SDR

LS RESEARCH LLC
Wireless Product Development
Equipment Calibration

Date : 8-Jun-2012 Type Test : Radiated Emissions Job # : C-1273

Prepared By: Aidi Customer : Tandem Diabetes Care Quote #: 311239

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960013	EMI Receiver	HP	8546A System	3617A00320;3448A	11/22/2011	11/22/2012	Active Calibration
2	EE 960014	EMI Receiver-filter section	HP	85460A	3448A00296	11/22/2011	11/22/2012	Active Calibration
3	AA 960078	Log Periodic Antenna	EMCO	93146	9701-4855	11/15/2011	11/15/2012	Active Calibration
4	AA 960005	Biconical Antenna	EMCO	93110B	9601-2280	6/10/2011	6/10/2012	Active Calibration

Project Engineer: Aidi Quality Assurance: SDR

APPENDIX B: TEST STANDARDS – CURRENT PUBLICATION DATES RADIO

STANDARD #	DATE	Am. 1	Am. 2
ANSI C63.4	2003		
ANSI C63.10	2009		
CISPR 16-1-1 Edition 3	2010-01		
FCC, CFR Title 47 Part 15	2012		
RSS GEN Issue 3	2010		
ICES 003 Issue 4	2004-02		

Appendix C: Uncertainty Statement

This uncertainty represents an expanded uncertainty expressed at approximately the 95 % confidence level, using a coverage factor of k=2.

Table of Expanded Uncertainty Values, (K=2) for Specified Measurements

Measurement Type	Particular Configuration	Uncertainty Values
Radiated Emissions	3 – Meter chamber, Biconical Antenna	4.24 dB
Radiated Emissions	3-Meter Chamber, Log Periodic Antenna	4.8 dB
Radiated Emissions	10-Meter OATS, Biconical Antenna	4.18 dB
Radiated Emissions	10-Meter OATS, Log Periodic Antenna	3.92 dB
Conducted Emissions	Shielded Room/EMCO LISN	1.60 dB
Radiated Immunity	3 Volts/Meter in 3-Meter Chamber	1.128 Volts/Meter
Conducted Immunity	3 Volts level	1.0 V