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Measured Radio Frequency Emissions
From

Bartec USA LLC Transceiver
FCC ID: SX8TPMS-PAD
IC: 5736A-TPMSPAD

Test Report No. 417124-613
September 30, 2011

For:
Bartec USA LLC
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Summary

Tests for compliance with FCC Regulations, CFR 47, Part 15 and with Industry Canada RSS-210/Gen, were performed on a Bartec, FCC ID: SX8TPMS-PAD, IC: 5736A-TPMSPAD. This device under test (DUT) is subject to the rules and regulations as a Transceiver.

In testing completed on September 25, 2011, the DUT tested met the allowed specifications for radiated emissions by more than 0.2 dB. AC Mains conducted emissions met the regulatory limit by 7.2 dB.

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1. Introduction

This Bartec Transceiver was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989 as subsequently amended, and with Industry Canada RSS-210/Gen, Issue 10, December 2010. Tests were performed at the University of Michigan Radiation Laboratory Willow Run Test Range following the procedures described in ANSI C63.4-2003 "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz". The Site description and attenuation characteristics of the Open Site facility are on file with FCC Laboratory, Columbia, Maryland (FCC Reg. No: 91050) and with Industry Canada, Ottawa, ON (File Ref. No: IC 2057A-1).

2. Equipment Used

The test equipment commonly used in our facility is listed in Table 2.1. Except where indicated as a pre-test, monitoring, or support device; all equipment listed below is a part of the University of Michigan Radiation Laboratory (UMRL) quality system. This quality system has been established to ensure all equipment has a clearly identifiable classification, calibration expiry date, and that all calibrations are traceable to national standards.

Table 2.1 Test Equipment.

Test Instrument	Used	Manufacturer/Model	Q Number
Spectrum Analyzer (9kHz-26GHz)	☒	Hewlett-Packard 8593E, SN: 3412A01131	HP8593E1
Spectrum Analyzer (9kHz-6.5GHz)	☒	Hewlett-Packard 8595E, SN: 3543A01546	JDB8595E
Power Meter	☐	Hewlett-Packard, 432A	HP432A1
Harmonic Mixer (26-40 GHz)	☐	Hewlett-Packard 11970A, SN: 3003A08327	HP11970A1
Harmonic Mixer (40-60 GHz)	☐	Hewlett-Packard 11970U, SN: 2332A00500	HP11970U1
Harmonic Mixer (75-110 GHz)	☐	Hewlett-Packard 11970W, SN: 2521A00179	HP11970W1
Harmonic Mixer (140-220 GHz)	☐	Pacific Millimeter Prod., GMA, SN: 26	PMPGMA1
S-Band Std. Gain Horn	☐	S/A, Model SGH-2.6	SBAND1
C-Band Std. Gain Horn	☐	University of Michigan, NRL design	CBAND1
XN-Band Std. Gain Horn	☐	University of Michigan, NRL design	XNBAND1
X-Band Std. Gain Horn	☐	S/A, Model 12-8.2	XBAND1
X-band horn (8.2- 12.4 GHz)	☐	Narda 640	XBAND2
X-band horn (8.2- 12.4 GHz)	☐	Scientific Atlanta , 12-8.2, SN: 730	XBAND3
K-band horn (18-26.5 GHz)	☐	FXR, Inc., K638KF	KBAND1
Ka-band horn (26.5-40 GHz)	☐	FXR, Inc., U638A	KABAND1
U-band horn (40-60 GHz)	☐	Custom Microwave, HO19	UBAND1
W-band horn(75-110 GHz)	☐	Custom Microwave, HO10	WBAND1
G-band horn (140-220 GHz)	☐	Custom Microwave, HO5R	GBAND1
Bicone Antenna (30-250 MHz)	☒	University of Michigan, RLBC-1	LBBIC1
Bicone Antenna (200-1000 MHz)	☒	University of Michigan, RLBC-2	HBBIC1
Dipole Antenna Set (30-1000 MHz)	☐	University of Michigan, RLDP-1,-2,-3	UMDIP1
Dipole Antenna Set (30-1000 MHz)	☐	EMCO 3121C, SN: 992 (Ref. Antennas)	EMDIP1
Active Rod Antenna (30 Hz-50 MHz)	☐	EMCO 3301B, SN: 3223	EMROD1
Active Loop Antenna (30 Hz-50 MHz)	☒	EMCO 6502, SN:2855	EMLOOP1
Ridge-horn Antenna (300-5000 MHz)	☒	University of Michigan	UMRH1
Amplifier (5-1000 MHz)	☒	Avantek, A11-1, A25-1S	AVAMP1
Amplifier (5-4500 MHz)	☒	Avantek	AVAMP2
Amplifier (4.5-13 GHz)	☐	Avantek, AFT-12665	AVAMP3
Amplifier (6-16 GHz)	☐	Trek	TRAMP1
Amplifier (16-26 GHz)	☐	Avantek	AVAMP4
LISN Box	☒	University of Michigan	UMLISN1
Signal Generator	☐	Hewlett-Packard 8657B	HPSG1

3. Device Under Test

3.1 Description & Block Diagram

The DUT is a 125 kHz Transmitter with a dual 315 MHz and 433.9 MHz superheterodyne receiver. The product designed for used commercial tire service personnel and is considered a Class A commercial product. It is powered at 5 VDC over a PC USB cable. The device is housed in a plastic case approximately 10 x 10 x 2.5 cm in dimension. For testing, a generic USB cable was provided by the manufacturer. The DUT is designed and manufactured by Bartec USA LLC, 44231 Phoenix Drive, Sterling Heights, MI 48314.

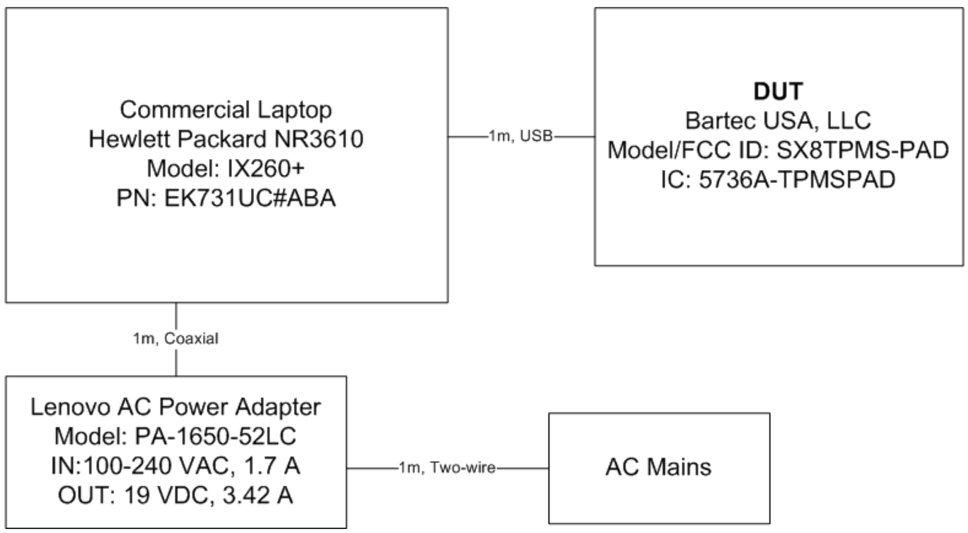

Figure 3.1 Block Diagram

3.2 Variants and Samples

There is only a single variant of the DUT, as tested. One sample was provided for testing with two PC based software packages. One program enabled the device for continuous LF transmission at the highest possible modulation rate. The second program is the normal operating software for the device.

3.3 Modes of Operation

The DUT is capable of only a single mode of operation (i.e. communication to and from a tire pressure monitor sensor), but can employ a number of AM modulation schemes for the LF transmitter, as detailed in the confidential modes of operation exhibit. The highest data rate AM modulation was tested herein to demonstrate worst case emissions bandwidth.

3.4 Exemptions

This product is sold only to commercial tire dealers and vehicle dealerships and is thus considered a Class A commercial PC peripheral.

3.5 EMC Relevant Modifications

No EMI Relevant Modifications were performed by this test laboratory.

4. Emissions Limits

4.1 Radiated Emissions Limits

The DUT tested falls under the category of an Intentional Radiator. The applicable testing frequencies and corresponding emission limits set by both the FCC and IC are given in Tables 4.1 and 4.2 below.

Table 4.1. Transmitter Radiated Emission Limits (FCC: 15.205, 15.35; IC: RSS-210, 2.6 Tab. 1,3)

Frequency (MHz)		Fundamental and Spurious* (μV/m)
0.009-0.490 0.490-1.705		2400/F(kHz), 300m 24,000/F(kHz), 30m
0.090-0.110 0.49-0.51 2.1735-2.190 3.020-3.026 (IC) 4.125-4.128 4.17725-4.17775 4.20725-4.20775 5.677-5.683 (IC) 6.215-6.218 6.26775-6.26825 6.31175-6.31225	8.291-8.294 8.37625 - 8.38675 8.41425 - 8.41475 12.29 - 12.293 12.51975 - 12.52025 12.57675 - 12.57725 13.36 - 13.41 16.42 - 16.423 16.69475 - 16.69525 16.80425 - 16.80475 25.5 - 25.67	Restricted Bands

* Harmonics must be below the fundamental. To translate measurements to the 300/30 m distance, we refer to the journal paper: "Extrapolating Near-Field Emissions of Low-Frequency Loop Transmitters," J. D. Brunett, V. V. Liepa, D. L. Sengupta, IEEE Trans. EMC, Vol. 47, No. 3, August 2005.

Table 4.2. Spurious Emission Limits (FCC: 15.33, .35, .109/209; IC: RSS-210 2.7, T2)

Freq. (MHz)	E_{lim} (3m) μV/m	E_{lim} dB(μV/m)
30-88	100	40.0
88-216	150	43.5
216-960	200	46.0
960-2000	500	54.0

Note: Average readings apply above 1000 MHz (1 MHz BW), Quasi-Peak readings apply to 1000 MHz (120 kHz RBW), PRF of intentional emissions > 20 Hz for QPK to apply.

Power Line Conducted Emissions Limits

Table 4.3 Emission Limits (FCC:15.107 (CISPR); IC: RSS-Gen, 7.2.2 T2).

Frequency (MHz)	Class A (dBμV)		Class B (dBμV)	
	Quasi-peak	Average	Quasi-peak	Average
.150 - 0.50	79	66	66 - 56*	56 - 46*
0.50 - 5	73	60	56	46
5 - 30	73	60	60	50

Notes:
1. The lower limit shall apply at the transition frequency
2. The limit decreases linearly with the logarithm of the frequency in the range 0.15-0.50 MHz:
   *Class B Quasi-peak: dBμV = 50.25 - 19.12*log(f)
   *Class B Average: dBμV = 40.25 - 19.12*log(f)
3. 9 kHz RBW

5. Measurement Procedures

5.1 Semi-Anechoic Chamber Radiated Emissions

To become familiar with the radiated emission behavior of the DUT, the device is first studied and measured in our shielded semi-anechoic chamber. In the chamber there is a set-up similar to that of an outdoor 3-meter site, with a turntable, an antenna mast, and a ground plane. Instrumentation includes spectrum analyzers and other equipment as needed.

The DUT is laid on the test table as shown in the included block diagram and/or photographs. A shielded loop antenna is employed when studying emissions from 9 kHz to 30 MHz. Above 30 MHz and below 250 MHz a biconical antenna is employed. Above 250 MHz a ridge or and standard gain horn antennas are used. The spectrum analyzer resolution and video bandwidths are set so as to measure the DUT emission without decreasing the emission bandwidth (EBW) of the device. Emissions are studied for all orientations (3-axes) of the DUT and all test antenna polarizations. In the chamber, spectrum and modulation characteristics of intentional carriers are recorded. Receiver spurious emissions are measured with an appropriate carrier signal applied. Associated test data is presented in subsequent sections.

5.2 Outdoor Radiated Emissions

After measurements are performed indoors, emissions on our outdoor 3-meter Open Area Test Site (OATS) are made, when applicable. If the DUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in ANSI C63.4 are employed. Alternatively, an on-table layout more representative of actual use may be employed if the resulting emissions appear to be worst-case in such a configuration. Any intentionally radiating elements are placed on the test table flat, on their side, and on their end (3-axes) and worst case emissions are recorded. For each configuration the DUT is rotated 360 degrees about its azimuth and the receive antenna is raised and lowered between 1 and 4 meters to maximize radiated emissions from the device. Receiver spurious emissions are measured with an appropriate carrier signal applied. For devices with intentional emissions below 30 MHz, our shielded loop antenna at a 1 meter receive height is used. Low frequency field extrapolation to the regulatory limit distance is employed as needed. Emissions between 30 MHz and 1 GHz are measured using tuned dipoles and/or biconical antennas. Care is taken to ensure that the RBW and VBW used meet the regulatory requirements, and that the EBW of the DUT is not reduced. The Photographs included in this report show the Test Setup.

5.3 Radiated Field Computations

To convert the dBm values measured on the spectrum analyzer to dB(μV/m), we use expression

$$E3(dB\mu V/m) = 107 + PR + KA - KG + KE - CF$$

where

PR	=	power recorded on spectrum analyzer, dBm, measured at 3 m
KA	=	antenna factor, dB/m
KG	=	pre-amplifier gain, including cable loss, dB
KE	=	duty correction factor, dB
CF	=	distance conversion (employed only if limits are specified at alternate distance), dB

When presenting the data at each frequency, the highest measured emission under all of the possible DUT orientations (3-axes) is given.

5.4 Indoor Power Line Conducted Emissions

When applicable, power line conducted emissions are measured in our semi-anechoic chamber. If the DUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in ANSI C63.4 are employed. Alternatively, an on-table layout more representative of actual use may be employed if the resulting emissions appear to be worst-case in such a configuration.

The conducted emissions measured with the spectrum analyzer and recorded (in dBμV) from 0-2 MHz and 2-30 MHz for both the ungrounded (Hi) and grounded (Lo) conductors. The spectrum analyzer is set to peak-hold mode in order to record the highest peak throughout the course of functional operation. Only when the emission exceeds or is near the limit are quasi-peak and average detection used.

5.5 Supply Voltage Variation

Measurements of the variation in the fundamental radiated emission were performed with the supply voltage varied by no less than 85% and 115% of the nominal rated value. For battery operated equipment, tests were performed using a new battery, and worst case emissions are re-checked employing a new battery.

6. Test Results

6.1 Radiated Emissions

6.1.1 Correction for Pulse Operation

When the transmitter is activated by software button press on the PC, it is capable of transmitting a large number of different AM modulation schemes as listed in the confidential modes of operation exhibit associated with this report. However, in the worst case this device is capable of CW transmission and thus no duty cycle is applied in demonstrating compliance. The highest data rate modulation is reported and was tested for measurement of worst-case emission bandwidth .

6.1.2 Emission Spectrum

The relative DUT emission spectrum is recorded and is shown in Figure 6.2.

6.1.3 Emission Bandwidth

The emission bandwidth of the signal is shown in Figure 6.3. From the plot we see that the 99% bandwidth is 136.94 kHz – 99.54 kHz = 37.4 kHz. The principle lobe of the modulated signal does not overlap into the 109 kHz restricted band, even as the highest possible data rate (as tested).

6.1.4 Supply Voltage and Supply Voltage Variation

Supply voltage variation was not performed as the device is powered by a regulated commercial PC USB port.

6.2 Conducted Emissions

AC Mains conducted emissions were measured from the commercial PC with the device connected and operating. The resulting data tables are presented in Table 6.3.

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Table 6.1(a) Highest Emissions Measured

				Radiated Emission - LF								Bartec TPMS-PAD; FCC/IC
#	Freq. kHz	Ant. Used	Ant. Orien.	Pr, 3m dBm	Det. Used	Ka dB/m	Kg dB	Conv.** 3/30/300 m	E* dBµV/m	Elim dBµV/m	Pass dB	Comments
1	**Modulated (Highest Data Rate)**											
2	125.0	Loop	V/perp	-74.4	Pk	9.9	0.0	114.8	-72.4	25.7	98.0	loop perp. (axis in dir. of prop.)
3	125.0	Loop	V/par	-75.6	Pk	9.9	0.0	114.8	-73.6	25.7	99.2	loop paral. (loop in dir. of prop.)
4	125.0	Loop	H	-80.9	Pk	9.9	0.0	114.8	-78.9	25.7	104.5	loop horiz. (loop in horiz. plane)
5	250.0	Loop	V/perp	-85.1	Pk	9.8	0.0	110.4	-78.7	19.6	98.3	loop perp. (axis in dir. of prop.), noise
6	250.0	Loop	V/par	-85.4	Pk	9.8	0.0	110.4	-79.0	19.6	98.6	loop paral. (loop in dir. of prop.), nois
7	250.0	Loop	H	-83.0	Pk	9.8	0.0	110.4	-76.6	19.6	96.2	loop horiz. (loop in horiz. plane), nois
8	375.0	Loop	V/perp	-82.0	Pk	9.8	0.0	104.5	-69.7	16.1	85.8	loop perp. (axis in dir. of prop.),noise
9	375.0	Loop	V/par	-83.4	Pk	9.8	0.0	104.5	-71.1	16.1	87.2	loop paral. (loop in dir. of prop.),noise
10	375.0	Loop	H	-87.1	Pk	9.8	0.0	104.5	-74.8	16.1	90.9	loop horiz. (loop in horiz. plane), nois
11	500.0	Loop	V/perp	-86.5	Pk	9.8	0.0	56.3	-26.0	33.6	59.6	max all, noise
12	625.0	Loop	V/perp	-88.6	Pk	9.8	0.0	56.1	-27.9	31.7	59.6	max all, noise
13	750.0	Loop	All	-92.4	Pk	9.8	0.0	55.9	-31.5	30.1	61.6	max all, noise
14	875.0	Loop	All	-94.2	Pk	9.8	0.0	55.6	-33.0	28.8	61.8	max all, noise
15	1000.0	Loop	All	-95.9	Pk	9.8	0.0	55.4	-34.5	27.6	62.1	max all, noise
16	1125.0	Loop	All	-96.0	Pk	9.8	0.0	55.1	-34.3	26.6	60.9	max all, noise
17	1250.0	Loop	All	-88.4	Pk	9.8	0.0	54.8	-26.4	25.7	**52.0**	max all, background
18												
19												
20	* Averaging applies up to 490 kHz, 0.0 dB employed in this case											
21	Limit at 300m for f<0.490MHz; 30m for f>0.490MHz											
22	Measurements made at 3 m, see Test Report for extrapolation reference.											
23	9 kHz RBW for f > 150 kHz, 200 Hz RBW for f ≤ 150 kHz.											
24	** Represents the worst case conversion factor for all possible orientations and ground materials.											
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Meas. 09/21/2011; U of Mich.

Table 6.1(b) Highest Emissions Measured

Receiver Spurious & Digital Emissions											Bartec TPMS-PAD; FCC/IC
#	Freq. MHz	Ant. Used	Ant. Pol.	Pr dBm	Det. Used	Ka dB/m	Kg dB	E3 dBμV/m	E3lim dBμV/m	Pass dB	Comments
1	48.9	Bic	H	-44.9	Pk	9.2	23.8	47.6	49.5	1.9	from laptop
2	48.9	Bic	V	-43.2	Pk	9.2	23.8	49.3	49.5	0.2	from laptop
3	66.9	Bic	H	-54.6	Pk	7.7	23.5	36.6	49.5	12.9	from laptop
4	66.9	Bic	V	-57.6	Pk	7.7	23.5	33.6	49.5	15.9	from laptop
5	113.2	Bic	V	-57.6	Pk	9.4	22.9	36.0	54.0	18.0	from laptop
6	132.4	Bic	H	-67.8	Pk	11.0	22.6	27.6	54.0	26.4	from laptop
7	132.4	Bic	V	-64.4	Pk	11.0	22.6	31.0	54.0	23.0	from laptop
8	205.9	Bic	H	-71.9	Pk	14.7	21.6	28.2	54.0	25.8	from laptop
9	205.9	Bic	V	-69.9	Pk	14.7	21.6	30.2	54.0	23.8	from laptop
10	232.5	Bic	H	-71.8	Pk	14.7	21.3	28.6	56.9	28.3	from laptop
11	232.5	Bic	V	-71.9	Pk	14.7	21.3	28.5	56.9	28.4	from laptop
12	245.6	Bic	V	-67.6	Pk	14.64	21.15	32.9	56.9	24.0	from laptop
13	312.0	Sbic	H	-75.3	Pk	18.8	20.4	30.2	46.0	15.8	max all, noise (315 MHz LO)
14	312.0	Sbic	V	-77.2	Pk	18.8	20.4	28.3	46.0	17.7	max all, noise (315 MHz LO)
15	432.0	Sbic	H	-77.1	Pk	21.8	19.1	32.6	46.0	13.4	max all, noise (433.9 MHz LO)
16	432.0	Sbic	V	-76.8	Pk	21.8	19.1	32.9	46.0	13.1	max all, noise (433.9 MHz LO)
17	624.0	Sbic	H	-76.7	Pk	25.1	17.3	38.1	46.0	7.9	max all, noise
18	624.0	Sbic	V	-77.7	Pk	25.1	17.3	37.1	46.0	8.9	max all, noise
19	864.0	Sbic	H	-80.5	QPk	28.1	15.7	38.9	46.0	**7.1**	max all, background
20	864.0	Sbic	V	-81.2	QPk	28.1	15.7	38.2	46.0	7.8	max all, background
21	936.0	Sbic	H	-83.2	QPk	28.8	15.3	37.3	46.0	8.7	max all, background
22	936.0	Sbic	V	-82.9	QPk	28.8	15.3	37.6	46.0	8.4	max all, background
23	1248.0	Horn	H	-67.5	Pk	20.6	28.1	32.0	54.0	22.0	max all, background
24	1296.0	Horn	H	-68.5	Pk	20.7	28.1	31.1	54.0	22.9	max all, noise
25	1560.0	Horn	H	-64.2	Pk	21.4	28.1	36.2	54.0	17.8	max all, noise
26	1728.0	Horn	H	-65.8	Pk	21.8	28.1	35.0	54.0	19.0	max all, noise
27											
28											
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Meas. 09/21/2011; U of Mich.

Table 6.2 Highest AC Power Line Conducted Emissions Measured

HP Laptop + Lenovo PS + Bartec TPMSPAD; FCC/IC/CISPR B												
	Freq.	Line	Peak Det., dBμV		Pass	QP Det., dBμV		Pass	Ave. Det., dBμV		Pass	
#	MHz	Side	Vtest	Vlim*	dB*	Vtest	Vlim	dB	Vtest	Vlim	dB	Comments
1	0.18	Lo	47.3	54.6	7.3		64.6			54.6		
2	0.23	Lo	37.0	52.3	15.3		62.4			52.3		
3	0.48	Lo	32.8	46.2	13.4		56.3			46.2		
4	0.55	Lo	33.3	46.0	12.7		56.0			46.0		
5	0.92	Lo	34.5	46.0	11.5		56.0			46.0		
6	0.95	Lo	33.7	46.0	12.3		56.0			46.0		
7	1.14	Lo	32.1	46.0	13.9		56.0			46.0		
8	1.39	Lo	34.5	46.0	11.5		56.0			46.0		
9	1.53	Lo	34.0	46.0	12.0		56.0			46.0		
10	1.84	Lo	36.4	46.0	9.6		56.0			46.0		
11	3.96	Lo	38.8	46.0	**7.2**		56.0			46.0		
12	7.11	Lo	33.2	50.0	16.8		60.0			50.0		
13	17.19	Lo	34.8	50.0	15.3		60.0			50.0		
14	19.36	Lo	42.3	50.0	7.7		60.0			50.0		
15	21.53	Lo	42.5	50.0	7.5		60.0			50.0		
16	24.12	Lo	35.1	50.0	14.9		60.0			50.0		
17	26.64	Lo	30.4	50.0	19.6		60.0			50.0		
18												
19	0.18	Hi	46.2	54.6	8.4		64.6			54.6		
20	0.24	Hi	38.1	52.0	13.9		62.0			52.0		
21	0.29	Hi	33.3	50.4	17.1		60.5			50.4		
22	0.36	Hi	35.7	48.6	12.9		58.7			48.6		
23	0.47	Hi	33.8	46.5	12.7		56.5			46.5		
24	0.79	Hi	32.7	46.0	13.3		56.0			46.0		
25	0.89	Hi	33.1	46.0	12.9		56.0			46.0		
26	0.97	Hi	33.4	46.0	12.6		56.0			46.0		
27	1.08	Hi	34.8	46.0	11.2		56.0			46.0		
28	1.31	Hi	35.9	46.0	10.1		56.0			46.0		
29	3.82	Hi	38.2	46.0	7.8		56.0			46.0		
30	15.02	Hi	34.9	50.0	15.1		60.0			50.0		
31	19.71	Hi	41.9	50.0	8.1		60.0			50.0		
32	21.74	Hi	39.8	50.0	10.3		60.0			50.0		
33	23.98	Hi	31.9	50.0	18.1		60.0			50.0		
34	28.36	Hi	28.4	50.0	21.6		60.0			50.0		
35	30.75	Hi	30.8	50.0	19.3		60.0			50.0		
36	31.71	Hi	31.7	50.0	18.3		60.0			50.0		
37												
38												
39												
40												
41												
42												
40												

**Average limit* Meas. 10/10/2011; U of Mich.

Since Vpeak >= Vqp >= Vave and if Vtestpeak < Vavelim, then Vqplim and Vavelim are met.

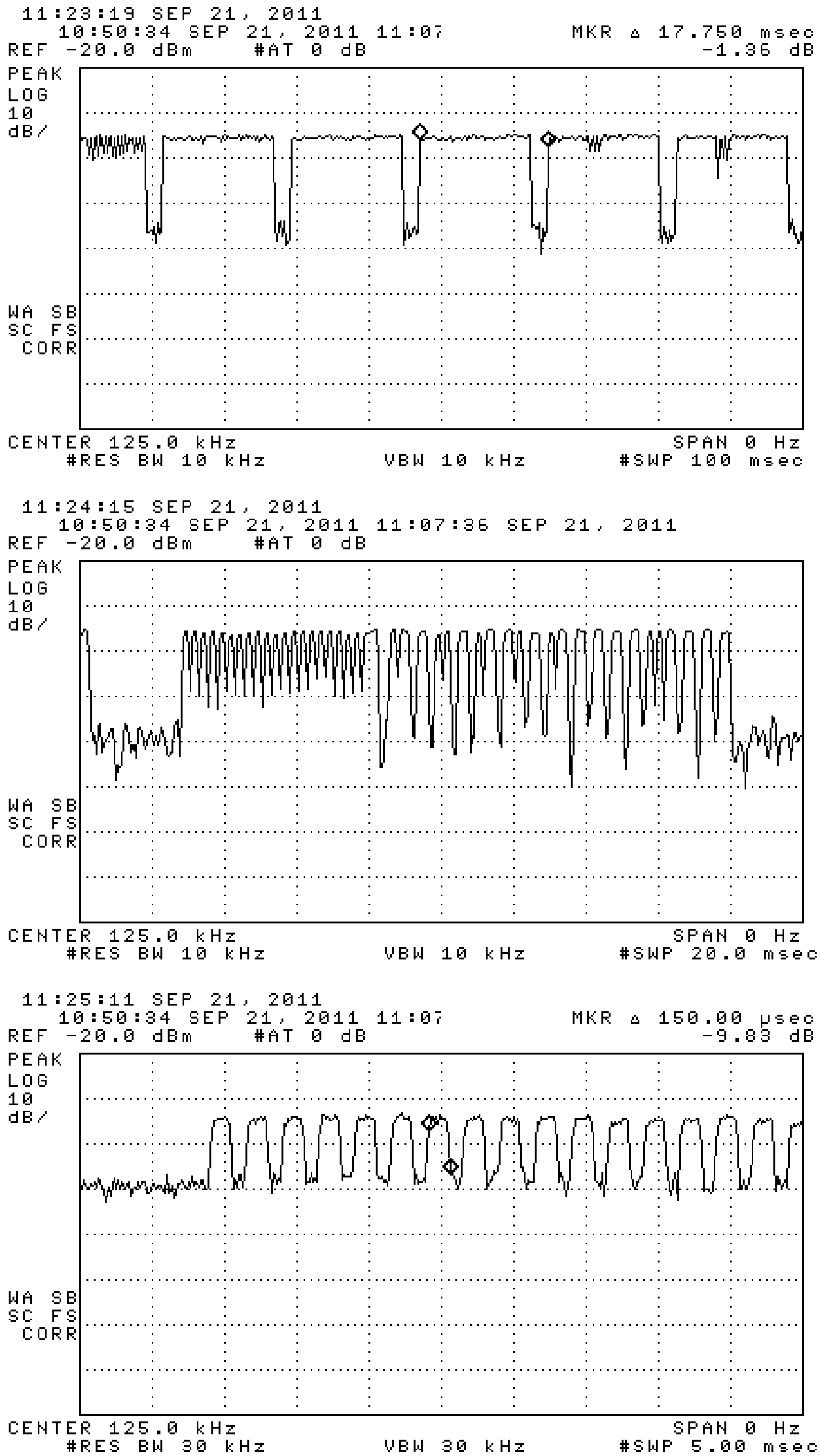


Figure 6.1. Highest Data Rate Transmission modulation characteristics. (top) repeated transmission, (center) expanded frame, (bottom) frame minimum pulse width.

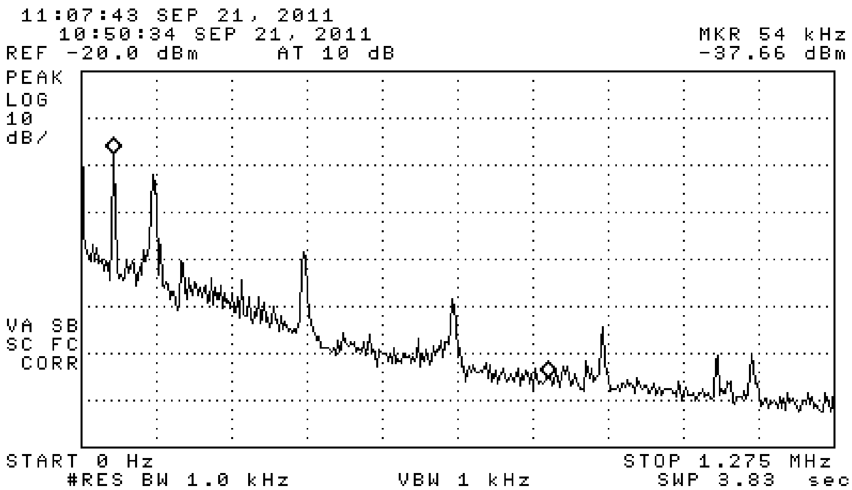


Figure 6.2. Emission spectrum of the DUT (pulsed emission). Amplitudes are only indicative (not calibrated).

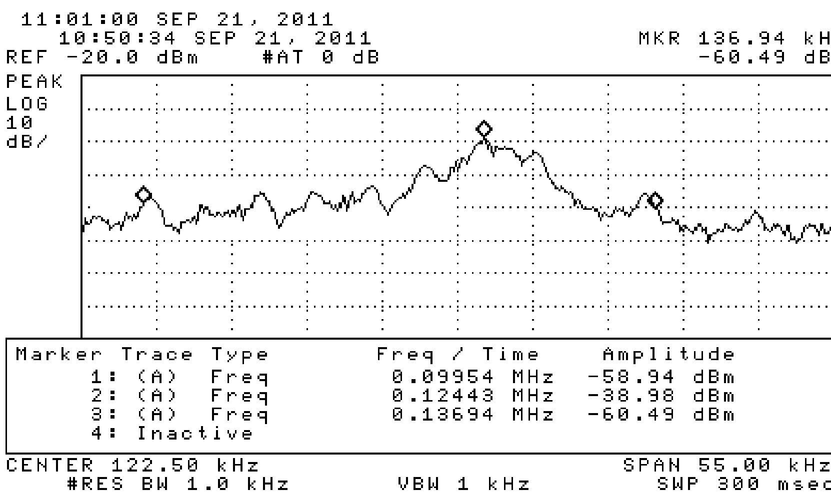
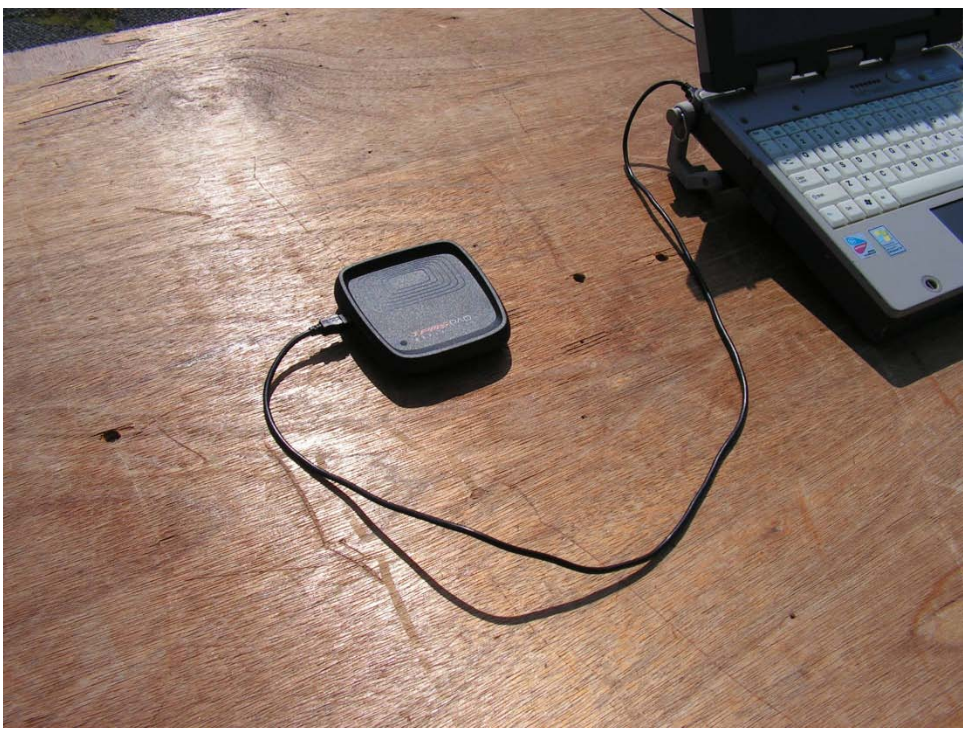


Figure 6.3. Measured emission bandwidth of the DUT (pulsed).

Photograph 6.5. DUT on OATS (one of three axes tested)



Photograph 6.6. Close-up of DUT on OATS (one of three axes tested)