The University of Michigan
Radiation Laboratory
3228 EECS Building
Ann Arbor, MI 48109-2122
Tel: (734) 764-0500
Fax: (734) 647-2106

Measured Radio Frequency Emissions
From

Bartec USA LLC Transceiver
FCC ID: SX8-TPR1
IC: 5736A-TPR1

Test Report No. 417124-520
September 29, 2009

For:
Bartec USA LLC
44231 Phoenix Drive
Sterling Heights, MI 48314
Contact: Scot Holloway
sholloway@bartecusa.com
Phone: 586-685-1300
Fax: 586-323-3801

Measurements made by: Joseph D. Brunett

Testing supervised by:
Report Approved by: Valdis V. Liepa
Research Scientist

Test report written by: Joseph D. Brunett

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: SX8-TPR1, IC: 5736A-TPR1. This device under test (DUT) is subject to the rules and regulations as a Transceiver.

In testing completed on September 9, 2009, the DUT tested met the allowed specifications for low frequency radiated emissions by 52.0 dB. Receiver spurious emissions and Digital emissions met the Class B limit by more than 5.6 dB. Conducted emissions are not subject to regulation as the DUT is powered by two 1.5 VDC (AA) batteries.

Table of Contents

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 7, June 2007. 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 tranceiver designed for LF activation (125 kHz) and RF reception (315 MHz and 433 MHz) of data from Tire Pressure Monitor Sensors. Also included in this product is a pre-certified fully modular Bluetooth device, FCC ID: QOQWT12, IC: 5123A-BGTWT12A with built-in antenna. The device is powered by two 1.5 VDC batteries and is housed in a plastic case approximately 16 x 6 x 3 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.

Device	[Make], Model	[S/N],P/N	EMC Consideration
Bartec Transceiver	[Bartec], TPR1	[Proto1]	Class A Digital Device, 125 kHz Tx., 315 MHz Rx., 433 MHz Rx.

Cable	[Make], Model	Length	EMC Consideration
USB	[Generic]	1 m	Class A Commercial Peripheral

3.2 Samples & Variants

There is only a single variant of the DUT, as tested, that is sold as a commercial product to automobile dealers and manufacturers. A single sample of the DUT was supplied with special software to allow for modulated 125 kHz transmission at the highest possible data rate, 125 kHz CW transmission, and a 315 MHz / 433 MHz receive only mode.

3.3 Modes of Operation

A large number of LF transmit modes of operation can be selected by the user on this device. All modes are listed in the associated exhibit, and the worst case emissions are reported herein. The CW mode was determined to have the highest fundamental and harmonic emissions, and is fully reported.

3.4 Exemptions

None.

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.

4.2 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

Worst case emissions were recorded with the device operates in CW mode, transmitting a CW LF signal for more than 100 ms. See Figure 6.1. Thus, no duty cycle is applied when demonstrating compliance.

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 25 kHz. The emission is 31.6 dBc in the 109 kHz restricted band.

6.1.4 Receiver & Digital Emissions

Receiver and Digital emissions are reported in Table 6.1(b).

6.1.5 Supply Voltage and Supply Voltage Variation

The DUT has been designed to be powered by a 9 VDC battery. For this test, relative radiated power was measured at the fundamental as the voltage was varied from 2.0 to 4.0 volts. The emission variation is shown in Figure 6.4.

Supply Voltage	V	=	3.0 V
Current	I	=	80 mA (cw)

6.2 Conducted Emissions

These tests do not apply, since the DUT is powered from two 1.5 VDC batteries, and does not draw power from the USB cable when employed.

The University of Michigan
Radiation Laboratory
3228 EECS Building
Ann Arbor, MI 48109-2122
Tel: (734) 764-0500
Fax: (734) 647-2106

Table 6.1(a) Highest Emissions Measured

Radiated Emission - LF Bartec TPR1; FCC/IC

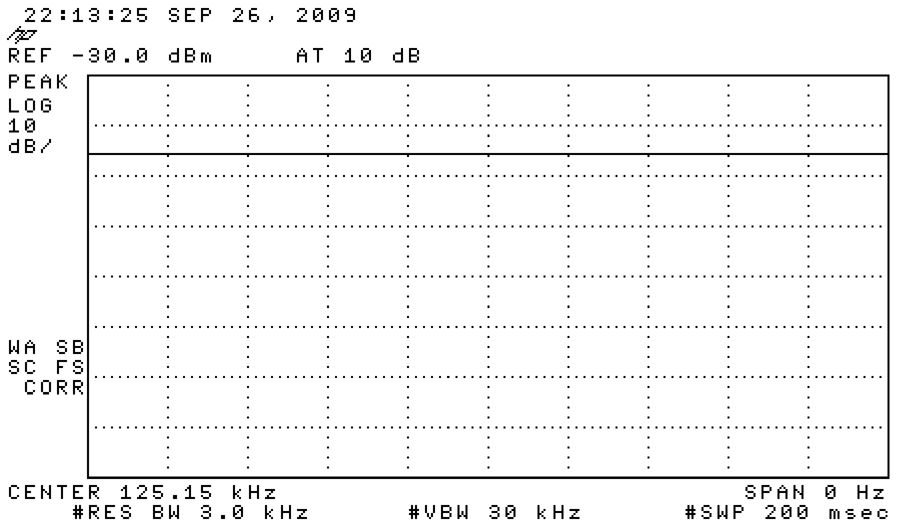
#	Freq. kHz	Ant. Used	Ant. Orien.	Pr, 3m dBm	Det. Used	Ka dB/m	Kg dB	Conv.** 3/30/300 m	E* dBμV/m	Elim dBμV/m	Pass dB	Comments
1	**CW Transmission**											
2	125.0	Loop	V/perp	-57.7	Pk	9.9	0.0	114.8	-55.6	25.7	81.3	loop perp. (axis in dir. of prop.)
3	125.0	Loop	V/par	-55.7	Pk	9.9	0.0	114.8	-53.6	25.7	79.3	loop paral. (loop in dir. of prop.)
4	125.0	Loop	H	-64.4	Pk	9.9	0.0	114.8	-62.3	25.7	88.0	loop horiz. (loop in horiz. plane)
5	250.0	Loop	V/perp	-78.0	Pk	9.8	0.0	110.4	-71.6	19.6	91.2	loop perp. (axis in dir. of prop.)
6	250.0	Loop	V/par	-75.4	Pk	9.8	0.0	110.4	-69.0	19.6	88.6	loop paral. (loop in dir. of prop.)
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)
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.)
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.)
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)
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
	Modulated (Highest Data Rate)											
	125.0	Loop	V/perp	-58.2	Pk	9.9	0.0	114.8	-56.1	25.7	81.8	loop perp. (axis in dir. of prop.)
18												
19	* Averaging applies up to 490 kHz, 0.0 dB employed in this case											
20	Limit at 300m for f<0.490MHz; 30m for f>0.490MHz											
21	Measurements made at 3 m, see Test Report for extrapolation reference.											
22	9 kHz RBW for f > 150 kHz, 200 Hz RBW for f ≤ 150 kHz.											
26	** Represents the worst case conversion factor for all possible orientations and ground materials.											
27												
28												
29												
30												
31												
32												
33												
34												
35												
36												
37												
38												
39												
40												

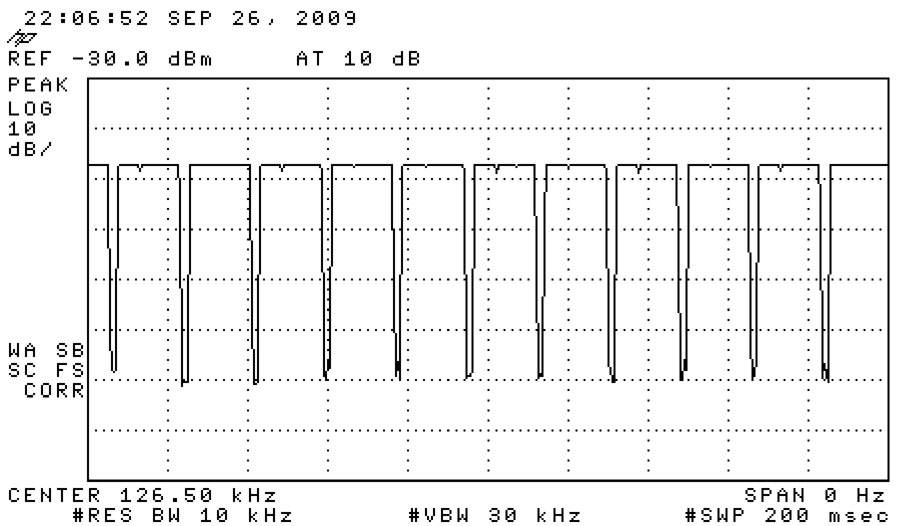
Meas. 09/13/2009; U of Mich.

Table 6.1(b) Highest Emissions Measured

Receiver Spurious & Digital Emissions											Bartec TPR1; 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											
2	316.0	Sbic	H	-84.1	Pk	18.9	20.3	21.5	46.0	24.5	max all, noise (315 MHz LO)
3	316.0	Sbic	V	-84.5	Pk	18.9	20.3	21.1	46.0	24.9	max all, noise (315 MHz LO)
4	432.0	Sbic	H	-86.5	Pk	21.8	19.1	23.2	46.0	22.8	max all, noise (433.9 MHz LO)
5	432.0	Sbic	V	-83.9	Pk	21.8	19.1	25.8	46.0	20.2	max all, noise (433.9 MHz LO)
6	632.0	Sbic	H	-84.0	Pk	25.2	17.2	31.0	46.0	15.0	max all, noise
7	632.0	Sbic	V	-82.3	Pk	25.2	17.2	32.7	46.0	13.3	max all, noise
8	864.0	Sbic	H	-79.0	QPk	28.1	15.7	40.4	46.0	**5.6**	max all, background
9	864.0	Sbic	V	-79.3	QPk	28.1	15.7	40.1	46.0	5.9	max all, background
10	948.0	Sbic	H	-81.7	Pk	28.9	15.2	39.0	46.0	7.0	max all, background
11	948.0	Sbic	V	-80.9	Pk	28.9	15.2	39.8	46.0	6.2	max all, background
12	1200.0	Horn	H	-66.8	Pk	20.4	28.1	32.5	54.0	21.5	max all, background
13	1440.0	Horn	H	-67.9	Pk	21.1	28.1	32.1	54.0	21.9	max all, noise
14	1498.0	Horn	H	-68.2	Pk	21.3	28.1	32.0	54.0	22.0	max all, noise
15	1958.0	Horn	H	-68.3	Pk	22.4	28.2	32.9	54.0	21.1	max all, noise
16	1038.0	Horn	H	-68.5	Pk	19.8	28.0	30.2	54.0	23.8	max all, noise
17	1843.0	Horn	H	-68.9	Pk	22.1	28.1	32.1	54.0	21.9	max all, noise
18	1793.0	Horn	H	-69.0	Pk	22.0	28.1	31.9	54.0	22.1	max all, noise
19											
20											
21											
22											
23											
24											
25											
26											
27											
28											
29											
30											
31											
32											
33											
34											
35											
36											
37											
38											
39											

Meas. 09/09/2009; U of Mich.


22:13:25 SEP 26, 2009
REF -30.0 dBm AT 10 dB
PEAK
LOG
10
dB/
WA SB
SC FS
CORR
CENTER 125.15 kHz
SPAN 0 Hz
#RES BW 3.0 kHz
#VBW 30 kHz
#SWP 200 msec


22:06:52 SEP 26, 2009
REF -30.0 dBm AT 10 dB
PEAK
LOG
10
dB/
WA SB
SC FS
CORR
CENTER 126.50 kHz
SPAN 0 Hz
#RES BW 10 kHz
#VBW 30 kHz
#SWP 200 msec

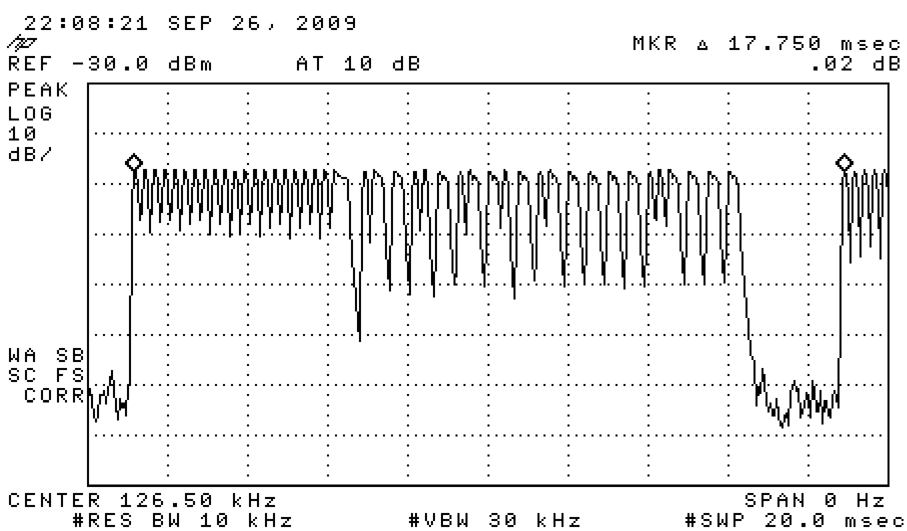

22:08:21 SEP 26, 2009
MKR Δ 17.750 msec
.02 dB
REF -30.0 dBm AT 10 dB
PEAK
LOG
10
dB/
WA SB
SC FS
CORR
CENTER 126.50 kHz
SPAN 0 Hz
#RES BW 10 kHz
#VBW 30 kHz
#SWP 20.0 msec

Figure 6.1(a). Transmission modulation characteristics. (top) CW Transmission, (middle) Highest Data Rate modulated transmission, (bottom) Highest Data Rate period.

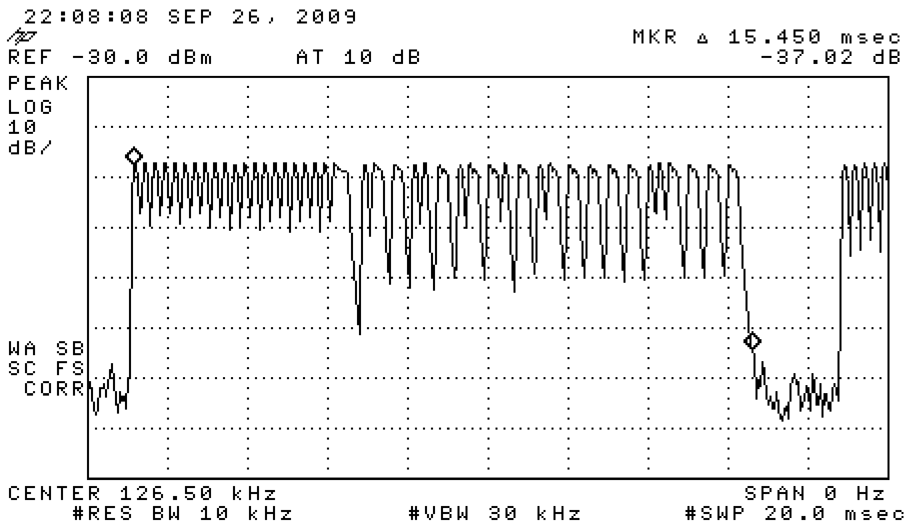


Figure 6.1(b). Transmission modulation characteristics. Highest Data Rate transmission length.

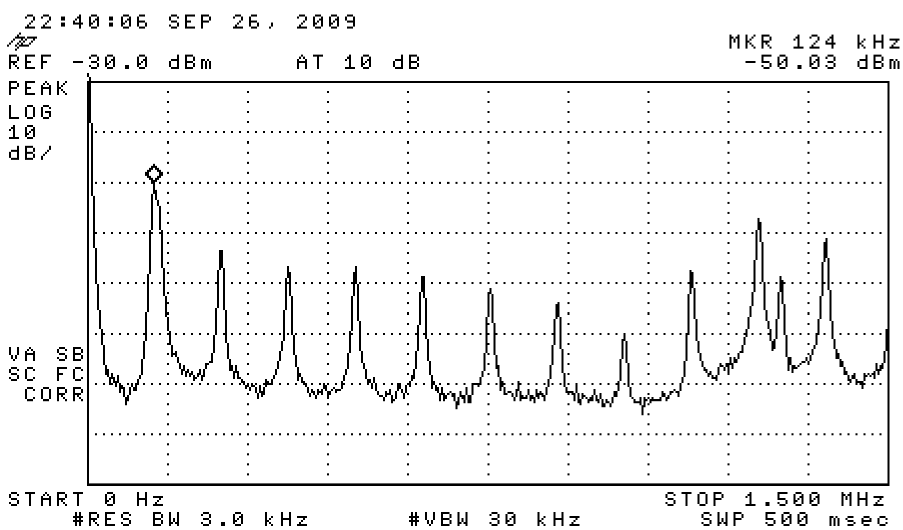


Figure 6.2. Emission spectrum of the DUT (pulsed emission). Amplitudes are only indicative (not calibrated).

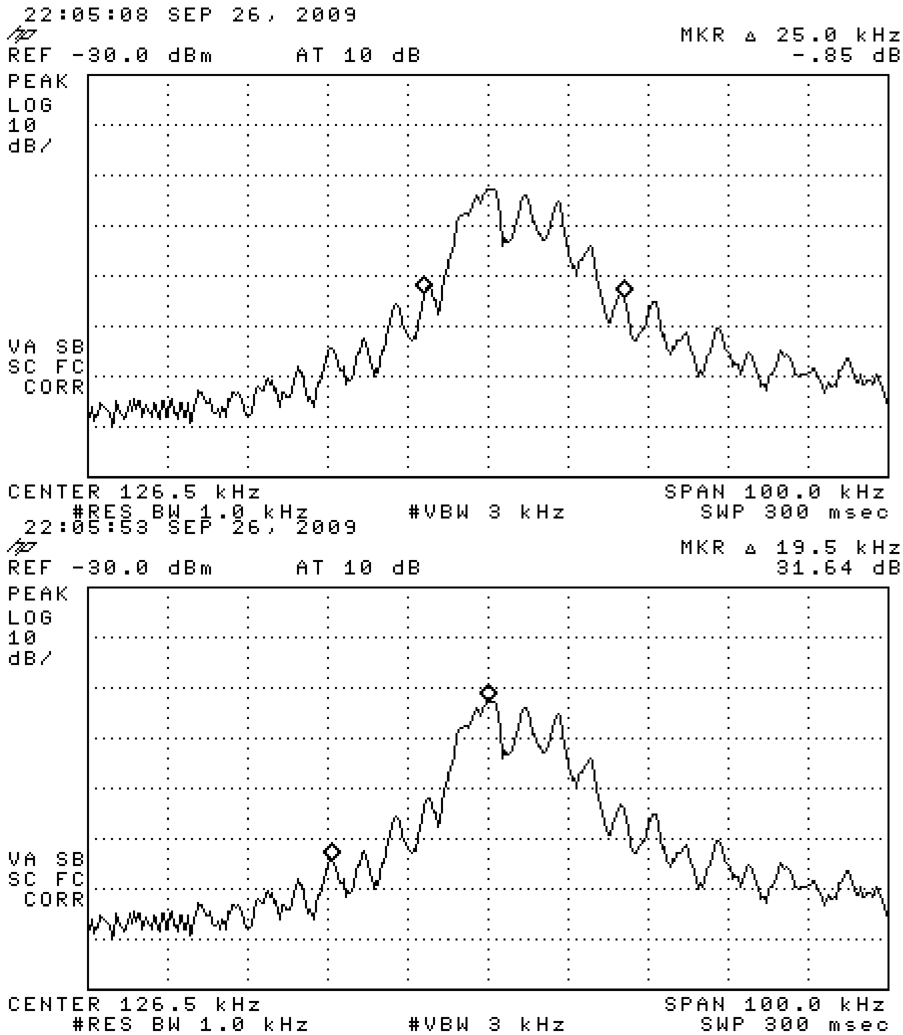


Figure 6.3. Measured emission bandwidth of the DUT (Highest Data Rate).

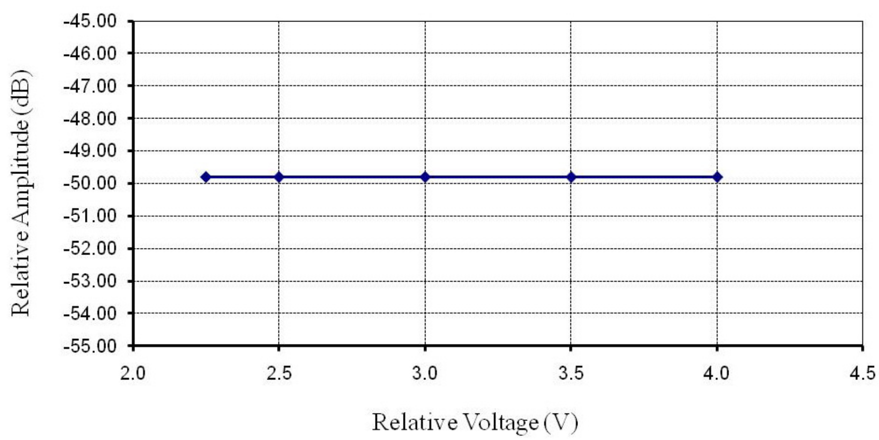


Figure 6.4. Relative emission at fundamental vs. supply voltage (pulsed).

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)