



FCC PART 90

TEST AND MEASUREMENT REPORT

For

Teledesign Systems, Inc.

1729 South Main Street,
Milpitas, CA 95035, USA

**FCC ID: JWFTS4000EH
Model: TS4000-05E45**

Report Type: Original Report	Product Type: UHF Radio Modem
Test Engineer: <u>Lionel Lara</u>	
Report Number: <u>R1202091-90EH</u>	
Report Date: <u>2012-03-19</u>	
Reviewed By: <u>Victor Zhang</u>	
Prepared By: <u>Bay Area Compliance Laboratories Corp.</u> <u>(84)</u> 1274 Anvilwood Avenue, Sunnyvale, CA 94085, U.S.A. Tel: (408) 732-9162 Fax: (408) 732 9164	

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* This report may contain data that are not covered by the NVLAP accreditation and are marked with an asterisk “*” (Rev. 2)

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R1202091-90EH	Original Report	2012-03-19

1. General Information

1.1 Product Description for Equipment under Test (EUT)

This test and measurement report was prepared on behalf of *Teledesign Systems, Inc.* and their product, FCC ID: JWFTS4000EH, model: TS4000-05E45, which will henceforth be referred to as the EUT (Equipment Under Test). The EUT is a UHF radio modem.

The EUTs are UHF radio modems that operate under FCC Part 90

Specifications	
Frequency Band	440-476 MHz
Modulation Type	GMSK
Emission Designator	11K2F1D
RF Output Power	Low: 1 Watts High: 5 Watts
Channel Spacing	12.5 kHz
Power Supply	13.8 VDC

1.2 Mechanical Description

The EUT measures approximately 17cm (L) x 8 cm (W) x 4.5 cm (H) and weighs approximately 780g.

The test data gathered are from production sample, serial number: 40996, provided by the manufacture.

1.3 Objective

This type approval report is prepared on behalf of *Teledesign System, Inc.* in accordance with Part 90 of the Federal Communication Commissions rules.

The objective was to determine the RF output power, Occupied Bandwidth, Spurious Emissions, Frequency Stability and Transient Frequency Behavior are in compliance with the FCC rules.

1.4 Related Submittal(s)/Grant(s)

None.

1.5 Test Methodology

All tests and measurements indicated in this document were performed in accordance with the Code of federal Regulations Title 47 Part 2, Sub-part J as well as the following individual parts:

Part 90 – Private Land Mobile Radio Service

Applicable Standards: TIA603-C and ANSI 63.4-2003, American National Standard for Method of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the range of 9 kHz to 40 GHz.

All emissions measurement was performed by Bay Area Compliance Laboratories Corp. The radiated testing was performed at an antenna-to-EUT distance of 3 meters.

1.6 Measurement Uncertainty

All measurements involve certain levels of uncertainties, especially in the field of EMC. The factors contributing to uncertainties are spectrum analyzer, cable loss, antenna factor calibration, antenna directivity, antenna factor variation with height, antenna phase center variation, antenna factor frequency interpolation, measurement distance variation, site imperfections, mismatch (average), and system repeatability.

Based on CISPR16-4-2:2003, The Treatment of Uncertainty in EMC Measurements, the values ranging from ± 2.0 dB for Conducted Emissions tests and ± 4.0 dB for Radiated Emissions tests are the most accurate estimates pertaining to uncertainty of EMC measurements at BACL Corp.

1.7 Test Facility

The test site used by BACL Corp. to collect radiated and conducted emissions measurement data is located at its facility in Sunnyvale, California, USA.

The test site at BACL Corp. has been fully described in reports submitted to the Federal Communication Commission (FCC) and Voluntary Control Council for Interference (VCCI). The details of these reports have been found to be in compliance with the requirements of Section 2.948 of the FCC Rules on February 11 and December 10, 1997, and Article 8 of the VCCI regulations on December 25, 1997. The test site also complies with the test methods and procedures set forth in CISPR 22:2008 §10.4 for measurements below 1 GHz and §10.6 for measurements above 1 GHz as well as ANSI C63.4-2003, ANSI C63.4-2009, TIA/EIA-603 & CISPR 24:2010.

The Federal Communications Commission and Voluntary Control Council for Interference have the reports on file and they are listed under FCC registration number: 90464 and VCCI Registration No.: R-3729, C-4176, G-469, and T-1206. The test site has been approved by the FCC and VCCI for public use and is listed in the FCC Public Access Link (PAL) database.

Additionally, BACL Corp. is a National Institute of Standards and Technology (NIST) accredited laboratory under the National Voluntary Laboratory Accredited Program (Lab Code 200167-0). The current scope of accreditations can be found at <http://ts.nist.gov/Standards/scopes/2001670.htm>

2 System Test Configuration

2.1 Justification

The EUT was configured for testing according to TIA/EIA-603-C.

The EUT was tested in the normal (native) operating mode to represent *worst-case* results during the final qualification test.

2.2 EUT Exercise Software

The software used was TS4000 Configuration Program V6.35 provided by the client.

2.3 Equipment Modifications

No modifications were made to the EUT.

2.4 Internal Configuration

Manufacturers	Descriptions	Model	Serial Numbers
Teledesign Systems, Inc.	Modem Board	TS4000	036121
CalAmp	Radio Board	DM-3443	8233443352 Rev. 0

2.5 Local Support Equipment

Manufacturer	Description	Model No.	Serial No.
Dell	Laptop	Inspiron 5100	CN-09U806-12961-349-366

2.6 Local Support Equipment Power Supply and Line Filters

Manufacturer	Description	Model	Serial Number
BK Precision	DC Power Supply	1621A	D185052265

2.7 External I/O Cabling List and Details

Cable Description	Length (m)	From	To
USB to RS232 cable	1.0	Laptop USB	EUT Serial Port
Power supply cable	1.0	Power Supply	EUT

3 Summary of Test Results

FCC Rules	Description of Tests	Results
§2.1091	RF Exposure	Compliant
§2.1046, §90.205	RF Output Power	Compliant
§2.1047	Modulation Characteristics, Audio Frequency Response and Audio Filter Response	N/A ¹
§2.1049, §90.209	Occupied Bandwidth and Emission Mask	Compliant
§2.1051, §90.210	Spurious Emissions at Antenna Terminals	Compliant
§2.1055, §90.213	Frequency Stability	Compliant
§2.1053, §90.210	Field Strength of Spurious Radiation	Compliant
§90.214	Transient Frequency Behavior	Compliant

Note 1: Modulation characteristic is not required for digital modulaton.

4 FCC §2.1091 - RF Exposure Information

4.1 Applicable Standards

FCC §2.1091, (a) Requirements of this section are a consequence of Commission responsibilities under the National Environmental Policy Act to evaluate the environmental significance of its actions. See subpart I of part 1 of this chapter, in particular §1.1307(b).

According to §1.1310 and §2.1091 RF exposure is calculated.

Limits for Exposure

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm ²)	Averaging Time (minutes)
(B) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*(100)	30
1.34-30	842/f	2.19/f	*(180/f ²)	30
30-300	27.5	0.073	0.2	30
300-1500	/	/	f/1500	30
1500-100,000	/	/	1	30

f = frequency in MHz

** = Plane-wave equivalent power density*

4.2 MPE Prediction

Predication of MPE limit at a given distance, Equation from OET Bulletin 65, Edition 97-01

$$S = PG/4\pi R^2$$

Where: *S* = power density

P = power input to antenna

G = power gain of the antenna in the direction of interest relative to an isotropic radiator

R = distance to the center of radiation of the antenna

<u>Maximum peak output power at antenna input terminal (dBm):</u>	<u>37.40</u>
<u>Maximum peak output power at antenna input terminal (mW):</u>	<u>5495.41</u>
<u>Prediction distance (cm):</u>	<u>165</u>
<u>Prediction frequency (MHz):</u>	<u>458.0</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>12.15</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>16.41</u>
<u>Power density of prediction frequency at 165 cm (mW/cm²):</u>	<u>0.264</u>
<u>MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>0.305</u>

4.3 Conclusion

The device complies with the MPE requirements by providing a safe separation distance of at least 165 cm between the antenna with maximum 12.15 dBi gain, including any radiating structure, and any persons when normally operated.

5 FCC §2.1046 & §90.205 – RF Output Power

5.1 Applicable Standard

According to FCC §2.1046, and §90.205, 450–470 MHz. (1) The maximum allowable station effective radiated power (ERP) is dependent upon the station's antenna HAAT and required service area and will be authorized in accordance with table 2.

5.2 Test Procedure

The RF output of the transmitter was connected to the input of the spectrum analyzer through sufficient attenuation.

5.3 Test Equipment List and Details

Manufacturer	Description	Model	Serial Number	Calibration Date
Agilent	Spectrum Analyzer	E4440A	US45303156	2010-08-09 ¹

Note¹: Based on a two-year calibration cycle.

Statement of Traceability: **BACL Corp.** attests that all calibrations have been performed per the NVLAP requirements, traceable to the NIST.

5.4 Test Environmental Conditions

Temperature:	20-23 °C
Relative Humidity:	45-50 %
ATM Pressure:	101-102 kPa

The testing was performed by Lionel Lara on 2012-02-15 in the RF Site.

5.5 Test Results

Bands (MHz)	Frequency (MHz)	Low Output Power		High Output Power	
		(dBm)	(Watt)	(dBm)	(Watt)
GMSK with BT=0.3 (Channel Baud Rate = 12600 bps)					
440-476	458	30.44	1.11	37.33	5.41
GMSK with BT=0.3 (Channel Baud Rate = 4000 bps)					
	458	30.45	1.11	37.40	5.50
GMSK with BT=0.5 (Channel Baud Rate = 8400 bps)					
	458	30.46	1.11	37.29	5.36
GMSK with BT=0.5 (Channel Baud Rate = 4000 bps)					
	458	30.42	1.10	37.18	5.22

6 FCC §2.1047 & §90.207 – Modulation Characteristic

6.1 Applicable Standard

FCC §2.1047 & §90.207:

- (a) Equipment which utilizes voice modulated communication shall show the frequency response of the audio modulating circuit over a range of 100 to 5000 Hz. for equipment which is required to have a low pass filter, the frequency response of the filter, or all of the circuitry installed between the modulation limited and the modulated stage shall be supplied.
- (b) Equipment which employs modulation limiting, a curve showing the percentage of modulation versus the modulation input voltage shall be supplied.

6.2 Test Result

N/A, modulation characteristic is not required for digital modulaton.

7 FCC §2.1049 & §90.210– Occupied Bandwidth & Emission Mask

7.1 Applicable Standard

According to FCC §90.210: *Emission Mask D—12.5 kHz channel bandwidth equipment.* For transmitters designed to operate with a 12.5 kHz channel bandwidth, any emission must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows:

- (1) On any frequency from the center of the authorized bandwidth f_0 to 5.625 kHz removed from f_0 : Zero dB.
- (2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5.625 kHz but no more than 12.5 kHz: At least $7.27(f_d - 2.88 \text{ kHz})$ dB.
- (3) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 12.5 kHz: At least $50 + 10 \log (P)$ dB or 70 dB, whichever is the lesser attenuation.

7.2 Test Procedure

The RF output of the transmitter was connected to the input of the spectrum analyzer through sufficient attenuation.

The resolution bandwidth of the spectrum analyzer was set at 100 Hz and the spectrum was recorded in the frequency band $\pm 50 \text{ kHz}$ from the carrier frequency.

7.3 Test Equipment List and Details

Manufacturer	Description	Model	Serial Number	Calibration Date
Agilent	Spectrum Analyzer	E4440A	US45303156	2010-08-09 ¹

Note¹: Based on a two-year calibration cycle.

Statement of Traceability: BACL Corp. attests that all calibrations have been performed per the NVLAP requirements, traceable to the NIST.

7.4 Test Environmental Conditions

Temperature:	20-23 °C
Relative Humidity:	45-50 %
ATM Pressure:	101-102 kPa

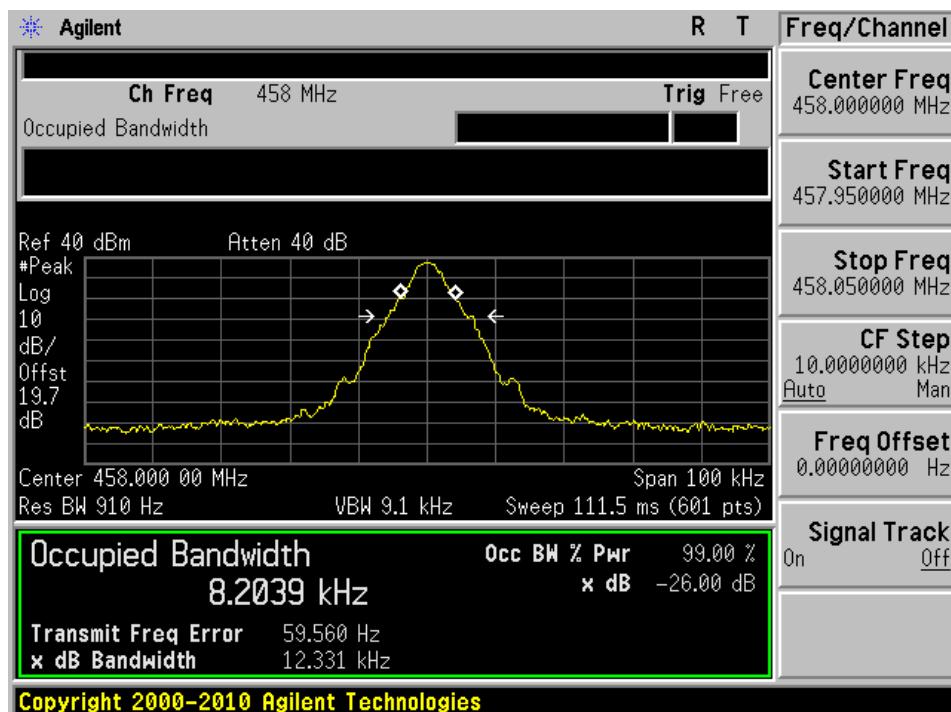
The testing was performed by Lionel Lara on 2012-02-15 in the RF Site.

7.5 Test Results

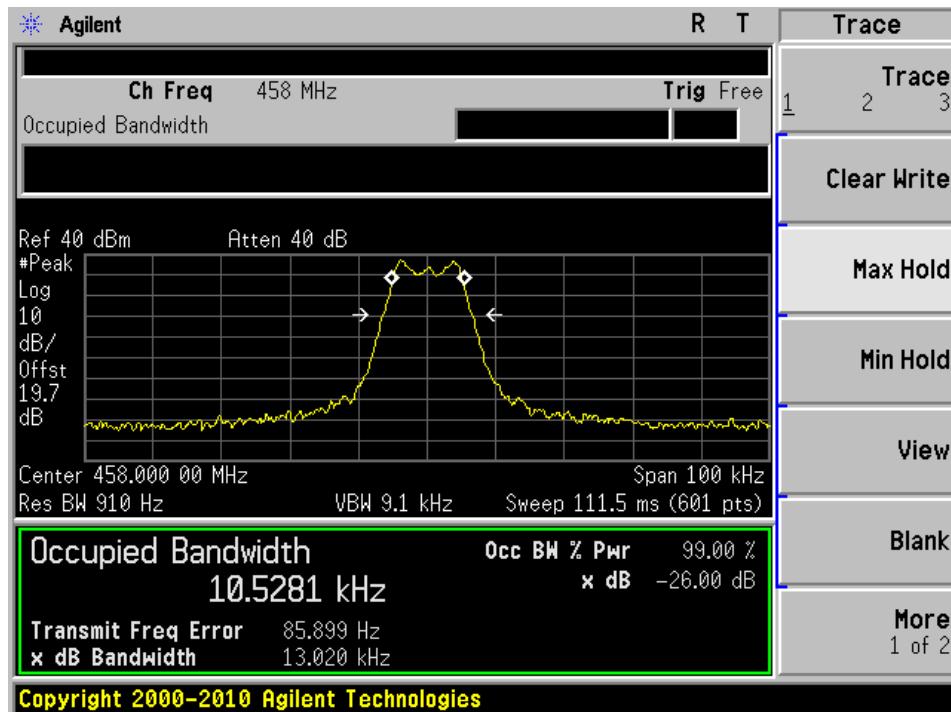
Please refer to the hereinafter plots.

Occupied Bandwidth (High Power Level)

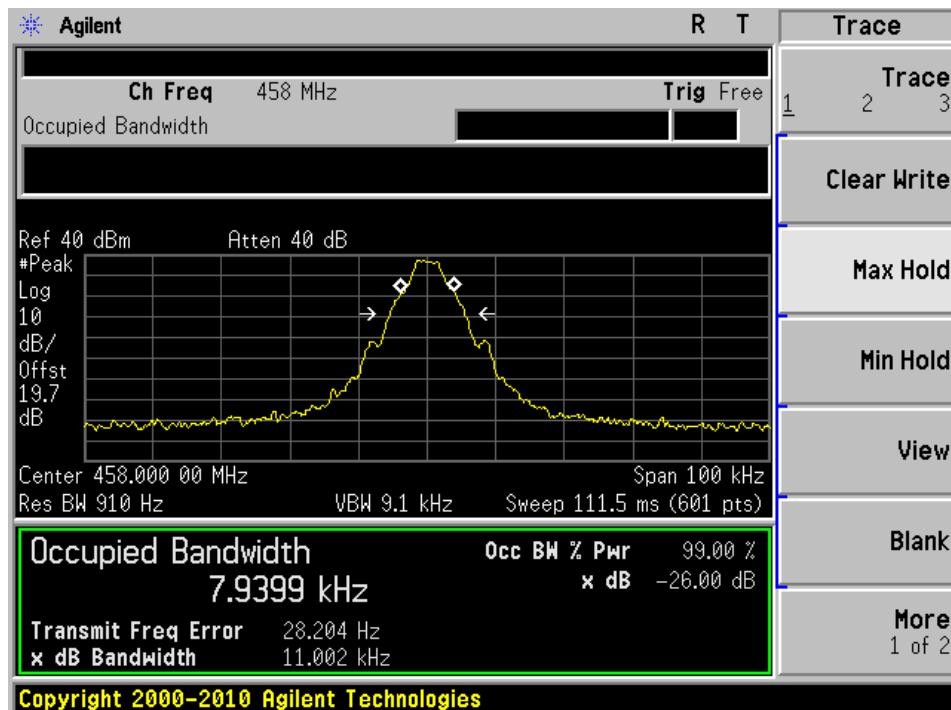
Modulation: GMSK with BT = 0.3, Channel Baud Rate: 12600bps



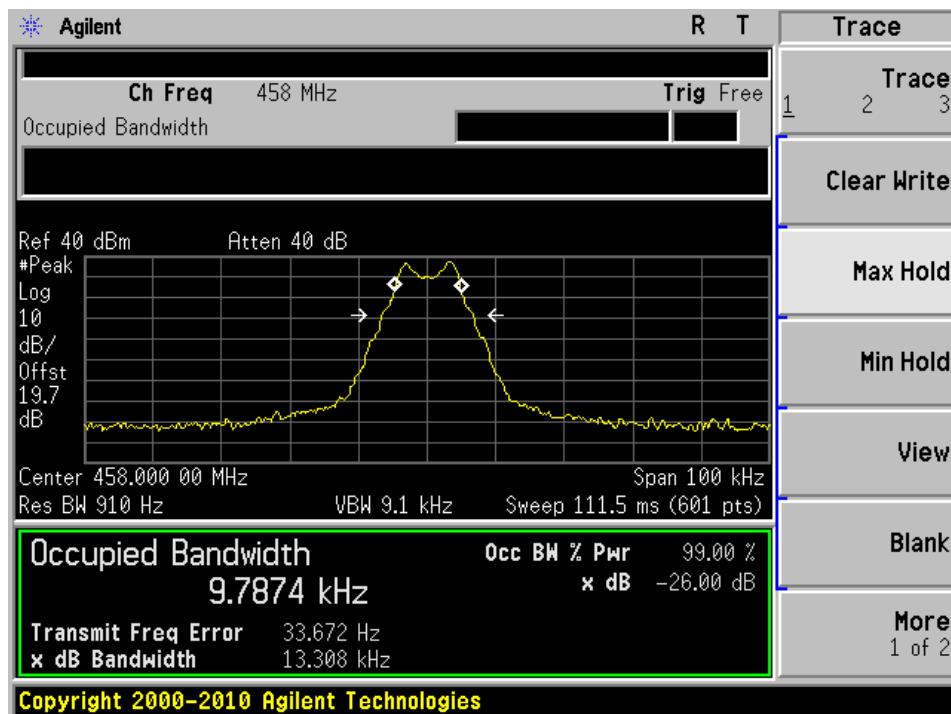
Modulation: GMSK with BT = 0.3, Channel Baud Rate: 4000bps



Modulation: GMSK with BT = 0.5, Data Rate: 8400bps

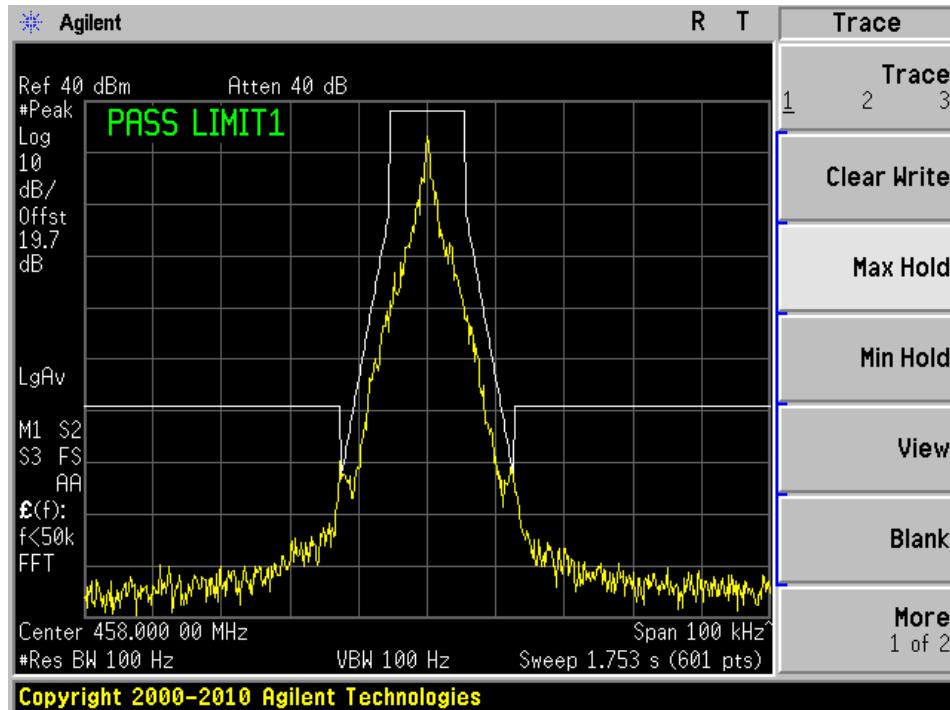


Modulation: GMSK with BT = 0.5, Data Rate: 4000bps

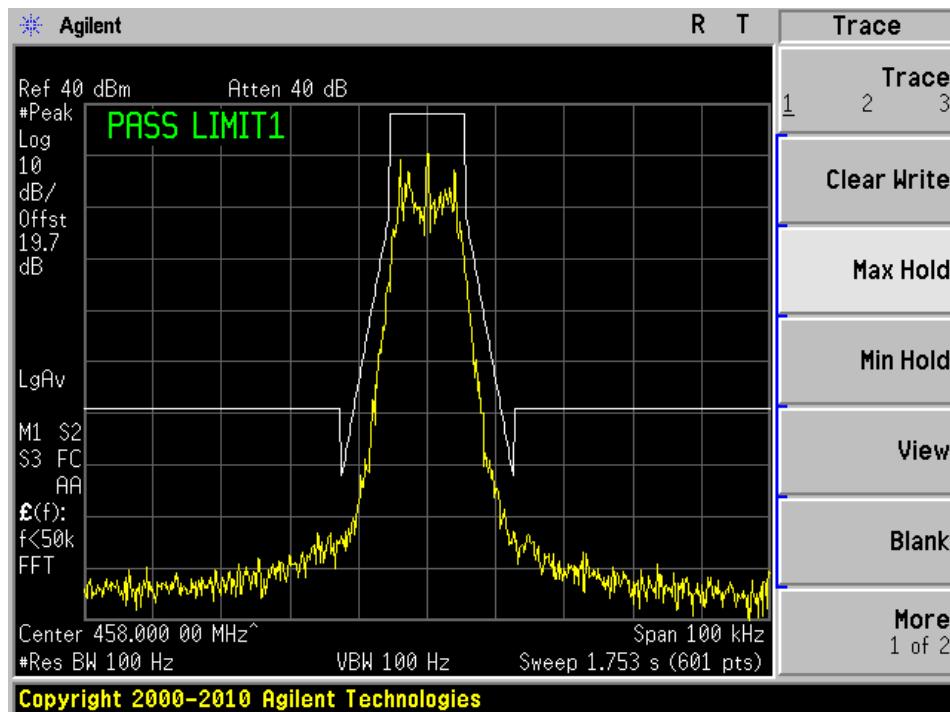


Emission Mask (High Power Level)

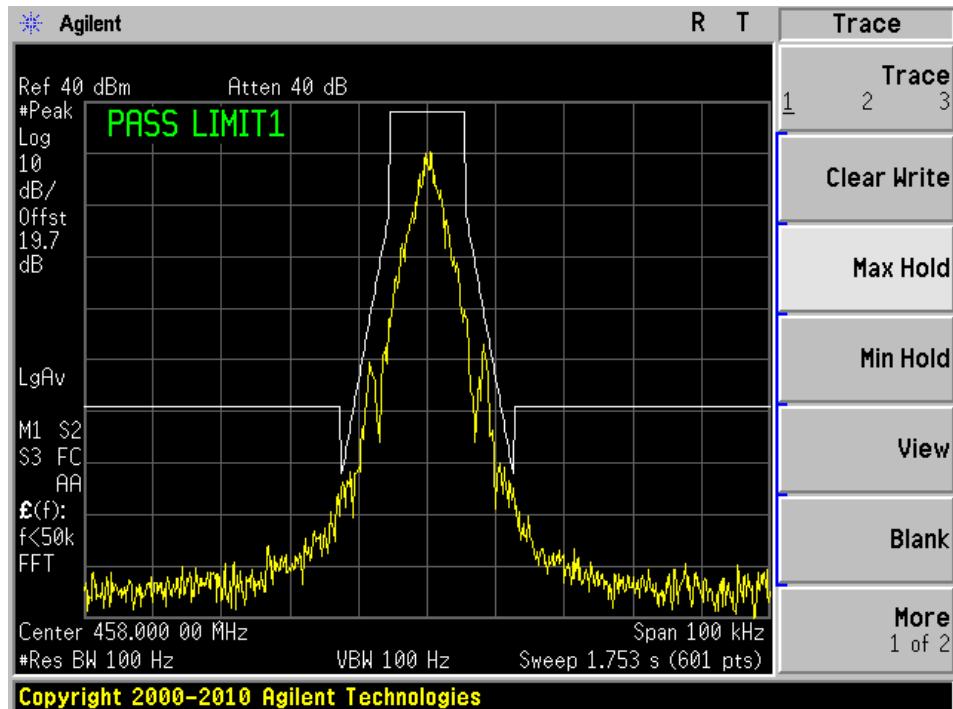
Modulation: GMSK with BT = 0.3, Channel Baud Rate: 12600bps



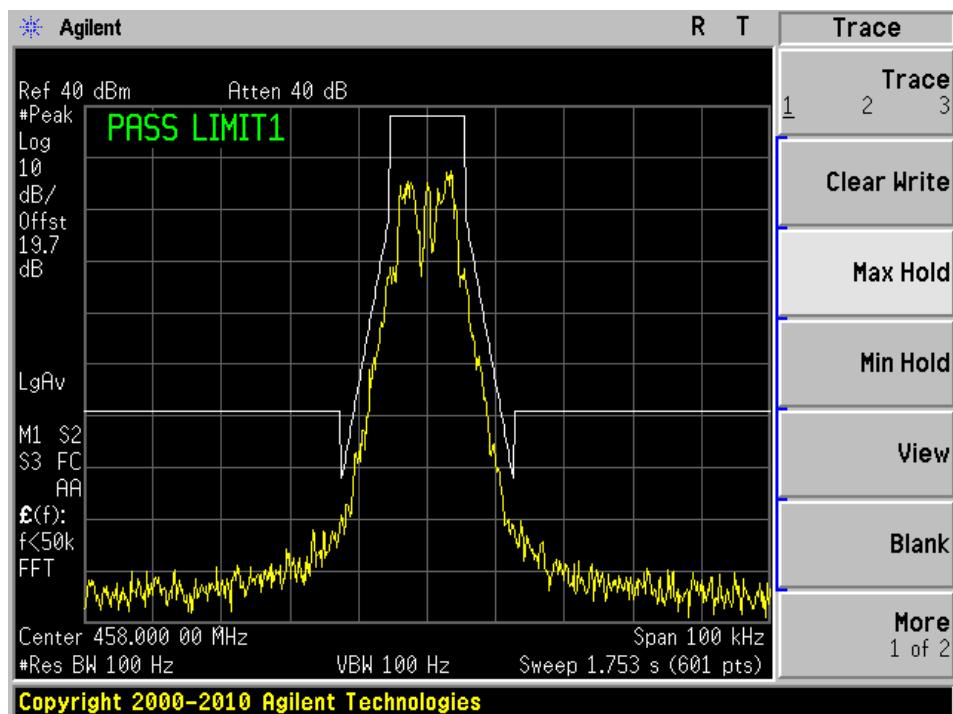
Modulation: GMSK with BT = 0.3, Channel Baud Rate: 4000bps



Modulation: GMSK with BT = 0.5, Data Rate: 8400bps



Modulation: GMSK with BT = 0.5, Data Rate: 4000bps



8 FCC §2.1051 & §90.210 - Spurious Emissions at Antenna Terminals

8.1 Applicable Standard

According to FCC §90.210: On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 12.5 kHz: At least $50 + 10 \log (P)$ dB or 70 dB, whichever is the lesser attenuation.

8.2 Test Procedure

The RF output of the transceiver was connected to a spectrum analyzer through appropriate attenuation. The resolution bandwidth of the spectrum analyzer was set at 100 kHz. Sufficient scans were taken to show any out of band emissions up to 10th harmonic.

8.3 Test Equipment List and Details

Manufacturer	Description	Model	Serial Number	Calibration Date
Agilent	Spectrum Analyzer	E4440A	US45303156	2010-08-09 ¹

Note¹: Based on a two-year calibration cycle.

Statement of Traceability: **BACL Corp.** attests that all calibrations have been performed per the NVLAP requirements, traceable to the NIST.

8.4 Test Environmental Conditions

Temperature:	20-23 °C
Relative Humidity:	45-50 %
ATM Pressure:	101-102 kPa

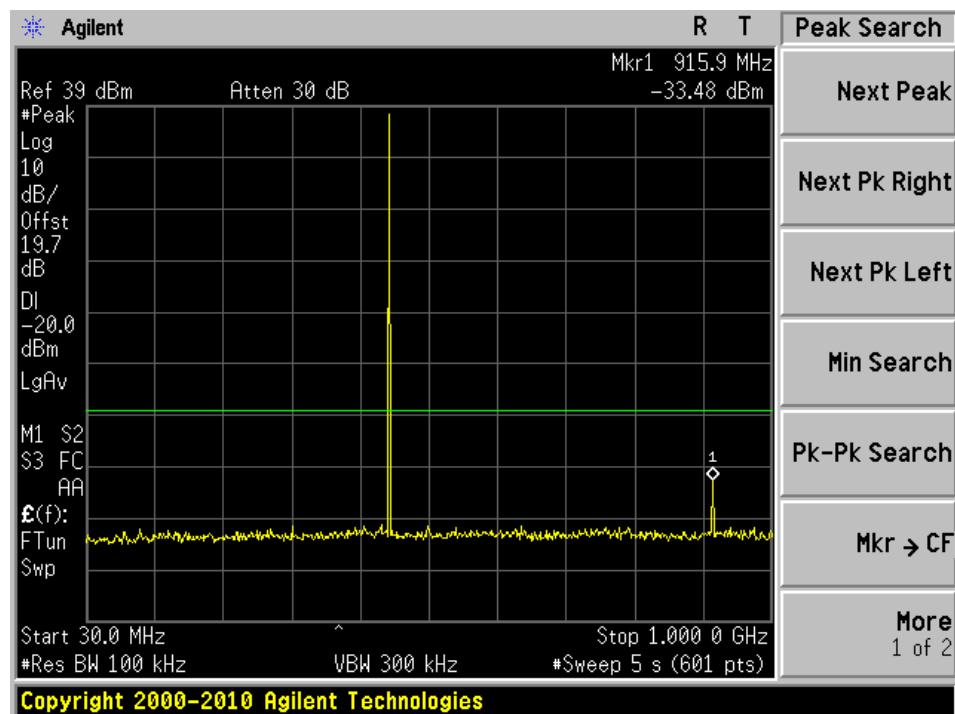
The testing was performed by Lionel Lara on 2012-02-15 in the RF Site.

8.5 Test Results

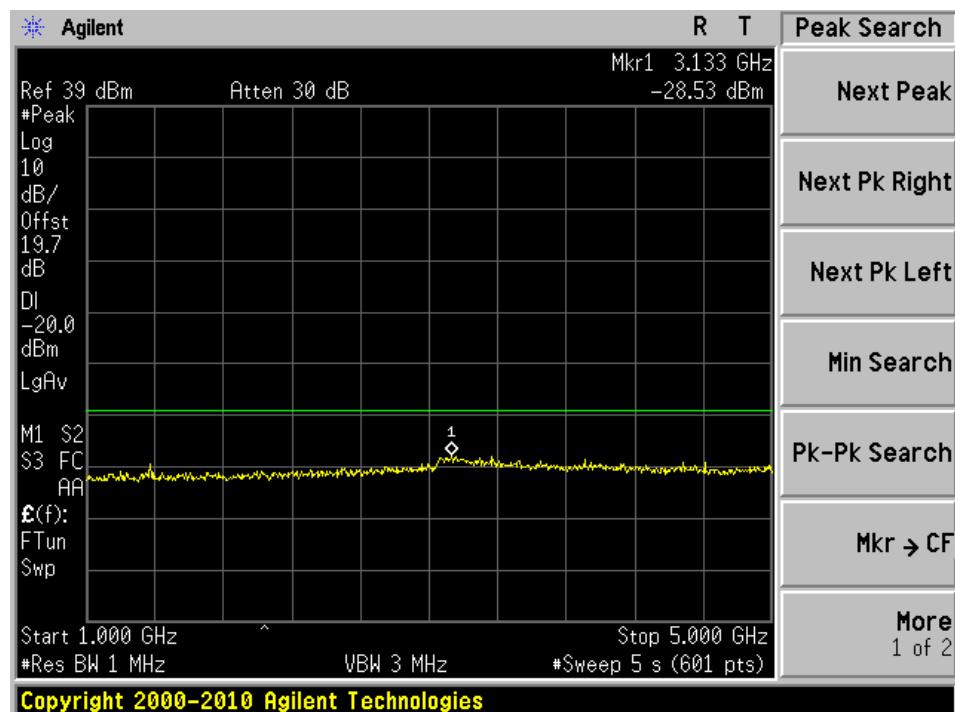
Please refer to the hereinafter plots.

High Power, 458 MHz

30 MHz – 1 GHz



1 – 5 GHz



9 FCC §2.1055 (d) & §90.213 - Frequency Stability

9.1 Applicable Standard

FCC §2.1055, §90.213

Frequency range (MHz)		Minimum Frequency Stability	
		Fixed and base stations	Mobile stations
Over 2 watts output power	2 watts or less output power		
Below 25	1,2,3 ¹⁰⁰	100	200
25–50	20	20	50
72–78	5		50
150–174	5,11 ¹⁵	65	4,6 ⁵⁰
216–220	1.0		1.0
220–222 ¹²	0.1	1.5	1.5
421–512	7,11, ¹⁴ 2.5	85	85
806–809	14 ^{1.0}	1.5	1.5
809–824	14 ^{1.5}	2.5	2.5
851–854	1.0	1.5	1.5
854–869	1.5	2.5	2.5
896–901	14 ^{0.1}	1.5	1.5
902–928	2.5	2.5	2.5
902–928 ¹³	2.5	2.5	2.5
929–930	1.5		
935–940	0.1	1.5	1.5
1427–1435	9 ³⁰⁰	300	300
Above 2450 ¹⁰			

⁷In the 421–512 MHz band, fixed and base stations with a 12.5 kHz channel bandwidth must have a frequency stability of 1.5 ppm. Fixed and base stations with a 6.25 kHz channel bandwidth must have a frequency stability of 0.5 ppm.

9.2 Test Procedure

Frequency Stability vs. Temperature: The equipment under test was connected to an external DC power supply and the RF output was connected to the Spectrum Analyzer via feed-through attenuators. The EUT was placed inside the temperature chamber. The DC leads and RF output cable exited the chamber through an opening made for the purpose.

After the temperature stabilized for approximately 20 minutes, the frequency output was recorded from the Spectrum Analyzer.

Frequency Stability vs. Voltage: An external variable DC power supply Source. The voltage was set to 115% and 85% of the nominal value. The output frequency was recorded for each voltage.

9.3 Test Equipment List and Details

Manufacturer	Description	Model	Serial Number	Calibration Date
Agilent	Spectrum Analyzer	E4440A	US45303156	2010-08-09 ¹
ESPEC	Humidity Chamber	ESL-4CA	18010	2012-02-10

Note¹: Based on a two-year calibration cycle.

Statement of Traceability: **BACL Corp.** attests that all calibrations have been performed per the NVLAP requirements, traceable to the NIST.

9.4 Test Environmental Conditions

Temperature:	20-23 °C
Relative Humidity:	45-50 %
ATM Pressure:	101-102 kPa

The testing was performed by Lionel Lara on 2012-02-16 in the RF Site.

9.5 Test Results

Test Condition		Reference Frequency (MHz)	Measured Frequency (MHz)	Frequency Error (PPM)	Limit (PPM)
Voltage (Vdc)	Temperature (°C)	Frequency vs. Temperature			
13.8	60	458	458.000000	0	± 5
13.8	50	458	457.999830	0.371	± 5
13.8	40	458	457.999883	0.255	± 5
13.8	30	458	457.999967	0.072	± 5
13.8	20	458	458.000067	-0.146	± 5
13.8	10	458	458.000167	-0.365	± 5
13.8	0	458	458.000150	-0.328	± 5
13.8	-10	458	458.000100	-0.218	± 5
13.8	-20	458	458.000133	-0.290	± 5
13.8	-30	458	458.000267	-0.583	± 5
Frequency vs. Voltage					
24.0	20	458	458.000067	-0.146	± 5
11.7	20	458	458.000083	-0.181	± 5

10 FCC §2.1053 & §90.210 – Field Strength of Spurious Radiation

10.1 Applicable Standard

According to FCC §90.210: On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 12.5 kHz: At least $50 + 10 \log (P)$ dB or 70 dB, whichever is the lesser attenuation.

10.2 Test Procedure

The transmitter was placed on Styrofoam on the turntable, and it was normal transmitting with 50ohm termination which was also placed on the turntable.

The measurement antenna was placed at a distance of 3 meters from the EUT. During the tests, the antenna height and polarization as well as EUT azimuth were varied in order to identify the maximum level of emissions from the EUT.

The frequency range up to tenth harmonic of the fundamental frequency was investigated.

Remove the EUT and replace it with substitution antenna. A signal generator was connected to the substitution antenna by a non-radiating cable. The absolute levels of the spurious emissions were measured by the substitution.

Spurious emissions in dB = $10 \lg (\text{TXpwr in Watts}/0.001)$ – the absolute level

10.3 Test Equipment List and Details

Manufacturer	Description	Model	Serial Number	Calibration Date
Agilent	Spectrum Analyzer	E4440A	US45303156	2010-08-09 ¹
Sunol Science Corp	System Controller	SC99V	122303-1	N/R
Rohde & Schwarz	EMI Test Receiver	ESCI 1166.5950K03	100338	2011-09-14
Sunol Science Corp	Combination Antenna	JB3	A020106-3	2011-06-29
A.R.A	Horn antenna	DRG-118/A	1132	2012-01-04
Agilent	Generator, Signal	E4438C	MY45091309	2011-04-28
Hewlett Packard	Signal Generator	8350B	2512A05829	2011-02-27
Hewlett Packard	Pre-amplifier	8447D	2944A10187	2011-03-08
Mini-Circuits	Pre-amplifier	ZVA-183-S	667400960	2011-05-08

Note¹: Based on a two-year calibration cycle.

Statement of Traceability: BACL attests that all calibrations have been performed per the NVLAP requirements, traceable to NIST.

10.4 Test Environmental Conditions

Temperature:	20-23 °C
Relative Humidity:	45-50 %
ATM Pressure:	101-102 kPa

The testing was performed by Lionel Lara on 2012-02-17 in 5 meter chamber 2.

10.5 Test Results

Worst Margin: -18.91 dB at 1832 MHz in the Horizontal polarization.

Please see following table for detailed results.

High Power, f = 458 MHz

Indicated		Azimuth Degrees	Test Antenna		Substituted					Limit (dBm)	Margin (dB)
Freq. (MHz)	Amp. (dBuV)		Height (m)	Polar (H/V)	Freq. (MHz)	Level (dBm)	Antenna Cord. (dBi)	Cable Loss (dB)	Absolute Level (dBm)		
654	40.91	231	142	H	654	-66.61	0	0.4	-67.01	-20	-47.01
654	41.47	313	100	V	654	-66.05	0	0.4	-66.45	-20	-46.45
916	52.18	138	108	H	916	-48.98	0	1	-49.98	-20	-29.98
916	53.55	288	138	V	916	-47.61	0	1	-48.61	-20	-28.61
1832	55.03	197	147	H	1832	-46.52	9.01	1.4	-38.91	-20	-18.91
1832	53.64	253	150	V	1832	-47.91	9.09	1.4	-40.22	-20	-20.22
4580	44.42	317	150	H	4580	-48.81	11.08	1.6	-39.33	-20	-19.33
4580	39.45	267	152	V	4580	-53.78	11.01	1.6	-44.37	-20	-24.37

11 FCC §90.214 - Transient Frequency Behavior

11.1 Applicable Standard

FCC §90.214: Transmitters designed to operate in the 150–174 MHz and 421–512 MHz frequency bands must maintain transient frequencies within the maximum frequency difference limits during the time intervals indicated:

Time intervals ^{1,2}	Maximum frequency difference ³	All equipment
		421 to 512 MHz
Transient Frequency Behavior for Equipment Designed to Operate on 25 kHz Channels		
t_1 ⁴	± 25.0 kHz	10.0 ms
t_2	± 12.5 kHz	25.0 ms
t_3 ⁴	± 25.0 kHz	10.0 ms
Transient Frequency Behavior for Equipment Designed to Operate on 12.5 kHz Channels		
t_1 ⁴	± 12.5 kHz	10.0 ms
t_2	± 6.25 kHz	25.0 ms
t_3 ⁴	± 12.5 kHz	10.0 ms

¹ t_{on} is the instant when a 1 kHz test signal is completely suppressed, including any capture time due to phasing.

t_1 is the time period immediately following t_{on} .

t_2 is the time period immediately following t_1 .

t_3 is the time period from the instant when the transmitter is turned off until t_{off} .

t_{off} is the instant when the 1 kHz test signal starts to rise.

²During the time from the end of t_2 to the beginning of t_3 , the frequency difference must not exceed the limits specified in §90.213.

³Difference between the actual transmitter frequency and the assigned transmitter frequency.

⁴If the transmitter carrier output power rating is 6 watts or less, the frequency difference during this time period may exceed the maximum frequency difference for this time period.

11.2 Test Procedure

TIA/EIA-603-C 2.2.19

11.3 Test Equipment List and Details

Manufacturer	Description	Model	Serial Number	Calibration Date
Tektronix	Digital Phosphor Oscilloscope	TDS7104	B020557	2011-06-09
Agilent	Generator, Signal	E4438C	MY45091309	2011-04-28
HP	Modulation Analyzer	8901A	2026A00847	2011-08-09

Statement of Traceability: BACL attests that all calibrations have been performed per the NVLAP requirements, traceable to NIST.

11.4 Test Environmental Conditions

Temperature:	20-23 °C
Relative Humidity:	45-50 %
ATM Pressure:	101-102 kPa

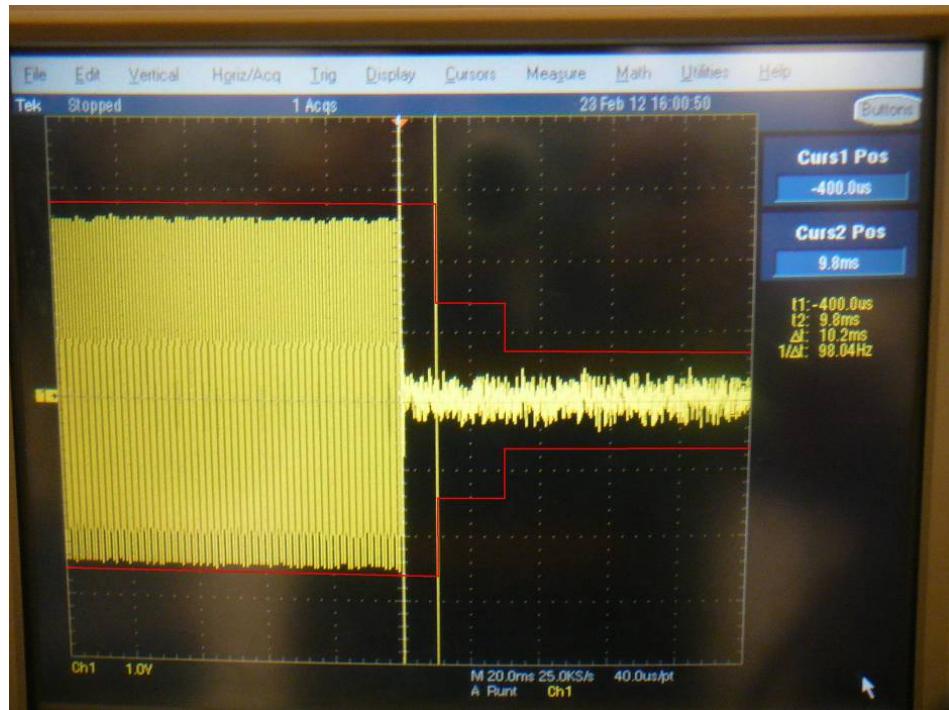
The testing was performed by Lionel Lara on 2012-02-23 in the RF Site.

11.5 Test Results

Please refer to the hereinafter plots.

High Power, f = 458 MHz

Powering Up



Powering Down

