ITS Intertek Testing Services

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Measurement Report
In suppor of
APPLICATION FOR CERTIFICATION
AirNet Communications Corporation
Model: Broadband Transceiver System

FCCID: MZKBPU3000-1900

This report is under a confidentiality agreement

TABLE OF CONTENTS

1.0 Statement of Certification

The technical data supplied with this application, having been taken under my supervision is hereby duly certified. The following is a statement of my qualifications:

1) BSEE from Auburn University, Alabama

2) 4 years of experience in the field of electromagnetic emissions testing

I certify that the above application was prepared under my direction and that to the best of my knowledge and belief, the facts set forth in the application and accompanying technical data are true and correct.

____

David J. Schramm
Position: Technical Supervisor
ITS Norcross, GA

Date: January 12, 1999

2.0 Identification Label

The label and label location are located in a separate exhibit.

2.1 Label Material Specification

Material:	Brady XB-302
Temperature Range:	-40 °F to +230 °F
Adhesive:	Permanent cold temperature pressure sensitive acrylic

3.0 General Information

3.1 Production plans following 2.981 (c)

Quantity Production of this device is planned.

3.2 Application References following 2.1061

Reference is made to the following:

1. PCS1900 Air Interface Specification - JCT (AIR)/94.08.04-231R4
2. Radiated emissions report numbers JA1624-1 and JA1624-2 from Rubicom Systems, Inc.
3. Similar application: FCCID: MZKBPU2000-1900

3.3 Data Submittal Procedure:

Data is supplied according to Part 2, Sub-part J of CFR 47.

3.4 General Description:

The AirNet Broadband Transceiver System (AirNet BTS) is the primary equipment realizing the functionality of a PCS-1900 Base Transceiver System (BTS). The AirNet BTS uses AirNet's patented broadband technology to achieve its compact size and high capacity. The AirNet BTS is designed around the philosophy of the software-defined radio. AirNet's broadband technology comprises AirNet's software defined radio implemented with its DSPs, Combinelizers, and Broadband RF Transceiver (BRT). These components are completely software-configurable and are programmed with modulation type, RF channel bandwidth, channel spacing, and frequency, and the parameters of cellular radio signals. This technology allows the same hardware to be configured for various wireless air-interface protocols, with the exception of the BRT, which is designed to operate in a specific frequency band.

AirNet's broadband technology also eliminates the need for bank of cavity filters and RF combiners that are traditionally required with narrowband systems. Transmitted signals are combined digitally into a single broadband signal that is upconverted to the appropriate RF band by the BRT and amplified by an external linear, multi-carrier amplifier. The AirNet PCS-1900 BTS can combine up to 12 TRXs. Likewise individually received RF carriers are digitally filtered, which provides significantly more flexibility and control for out-of-band signal rejection than analog filtering used in traditional BTS transceivers.

In addition to an indoor unit, the AirNet BTS is available in a weatherized NEMA-4 outdoor enclosure that also incorporates a bulk power system with battery backup, environmental control, and transient (lightning) protection on all external BTS connections.

Per past direction from the OET office at the FCC (see FCC ID MZKBPU2000-1900), this application covers the RF transceiver portion of the BTS; it does not include the high power amplifiers (HPA) that are sold with the product. This is a result of AirNet's ability to use different amplifiers from different vendors with the same base BRT and digital BTS hardware. Each amplifier type has it's own part 24 certification.

Therefore, this application is written for the RF output of the BRT - the HPA and the post HPA RF duplexer/filter have been bypassed for all transmit tests shown herein.

This application refers to the complete BTS product with an HPA when discussing means for limiting output power and when referring to power limitations for channels at the band edge. As in the previous application, ARFCNs adjacent to the band edge are limited in the AirNet BTS to a power of 2 Watts or less. It has been shown previously that a 2 Watt GMSK carrier centered 200 kHz from a band edge meets the FCC requirements for out of band spurious emissions. While strictly speaking, there is no limitation for the BRT alone because of it's very low RF output power, it was deemed prudent to include these topics in this application; recognizing the spirit of the regulations.

Total power out of the BTS with an HPA will be governed by the equipment authorization granted for the HPA and other applicable FCC regulations as described in Part 24 for PCS transmitters at 1900 MHz.

4.0 Description

4.1 Transmitter Technical Characteristics - Pursuant 2.983 (d)

RF Power Output of transceiver	6.9 milliwatts
Number of Simultaneous Channels	12
Tunable Channels	284
Frequency Range	1930 to 1990 MHz; Downlink
	1850 to 1910 MHz; Uplink
Frequency Stability:	0.38 ppm
Emission Designation:	300KGXW
Spurious Emissions:	>70 dBc
DC Voltage	27 Vdc
DC Current:	120 amps

4.2 Transmitter Application

Recommended Antennas	
Antenna Type, Ground -10 dBd Low Profile Omni-directional	12.1 dBi typical gain
	< 1.5:1 VSWR

Housing	As indicated the External Photographs Exhibit

BRT Final Stage Amplifier	Fujitsu FLL120MK
	12V, 4A, 10 dB gain,

5.0 Tune-up Procedure

5.1 Frequency

The parameters for programming the transceiver synthesizers are stored in a file in flash memory on the Broadband Transceiver System (BTS) SCSI flash drive module. This file is configured at the factory and the system user cannot change it. These parameters determine the receive and transmit frequencies and their separation. The transceiver has a 5 MHz receiver and a 5 MHz transmit bandwidth at this base frequency. The parameters are downloaded to the flash non-volatile memory during BTS installation based on the frequency plan for that particular PCS licensee. The BTS transceiver will automatically tune to these frequencies at power-up. This data, or list of tuning frequencies, is required in order for the base station to transmit; if lost, the system will not transmit. There is no user accessible way of retuning the BTS.

5.2 Output Power

At the time of installation, the maximum number of BTS channels is transmitted into the high power amplifier, which is terminated with a high-power load. The high power amplifier (HPA) output power is controlled by adjusting the combiner gain to limit the total transmit power to the rated level. A license file that is downloaded to the BTS non-volatile memory at installation defines the licensed band that the particular BTS is authorized to operate in, as well as the usable channels within that band. This file is configured at the factory and the system user is unable to edit it.

6.0 Circuit Description

A general description of the overall circuit is covered in the installation manual for this device. This section provides the description of circuits required by CFR 47 subpart 2.983. Circuits not described in the manual are covered in this exhibit.

6.1 Means for Frequency Stabilization

The synthesizer circuitry uses a National LMX2325 frequency synthesizer. Essentially, it phase locks a Voltage Controlled Oscillator (VCO) output to a reference as shown in the simplified figure below. The 10 MHz output of the Ovenized Quartz Oscillator (OCXO) is divided by 50 to generate a 200 kHz reference. This is phase compared to a divided down VCO output. A programmable divide ratio determines the VCO frequency. The internal comparator error signal is then loop filtered and used as the control input to the VCO. Thus the VCO output signal is phase locked to the reference, giving the LO signals the same accuracy as the reference. This output is buffered and amplified to create an LO for a particular mixer. Each downconvert and upconvert circuit is essentially the same -- the synthesizer chip is just programmed for a different divide ratio, e.g., LO frequency. The stability of the transmit carrier frequency is derived from the LO frequency stability and ultimately, that of the 10 MHz OCXO

LOCAL OSCILLATOR GENERATION

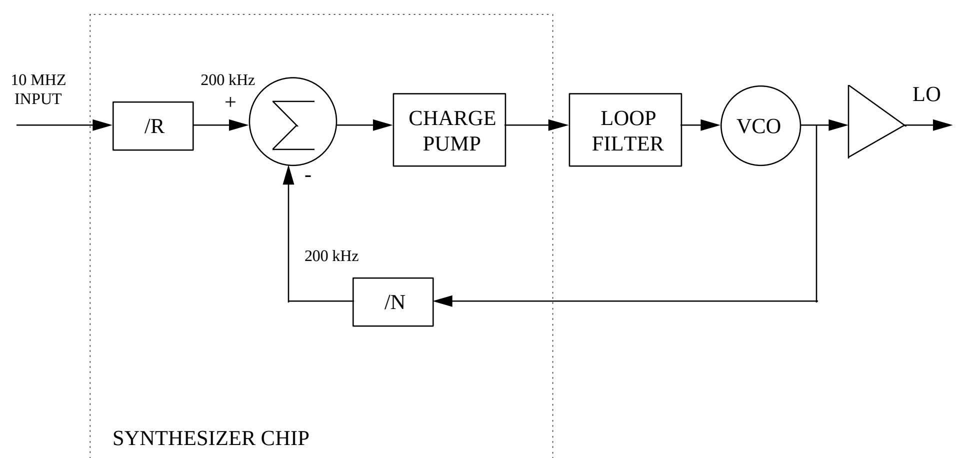


Figure 6.1

6.2 Means for Harmonic Suppression

Conducted Harmonic Suppression --The upconverter stage is immediately followed by a SAW band-pass filter centered at 1960 MHz with a 60 MHz bandwidth. For the purposes of this type acceptance application it was desirable to characterize the transceiver without the external duplexer filter connected in the transmit path. This is to ensure that any type-accepted amplifier can be connected between the transceiver output and the duplexer filter input and continue to meet the requirements.

Similarly, each downconverter stage is preceded by a 60 MHz SAW filter center at 1880 MHz. A C-band duplexer filter was used during the conducted spurious testing. This filter represents the BTR's performance in any of the PCS bands.

The duplexer is a cavity based 8-pole filter tuned to a particular PCS band depending on the specific licensee's application. This filter provides additional attenuation of all spurious emissions generated by or passing through an amplifier (80 dB out of band suppression). Note that the output of the transceiver is attenuated well below FCC defined limits and the duplexer is not required to meet the FCC requirements. It was not used to make any of the transmitter measurements that are a part of this report.

6.3 Means for Limiting Power

The dynamic range of the wideband digital signal coming to the transceiver from the combiner board is set in an initialization file that is automatically downloaded at system power-up. This value is chosen to give the maximum power out of the transceiver for the desired maximum number of carriers, while preventing the combiner's digital output from overflowing and thus clipping the signals. The base station controller has the capability, through software download, of changing the combiner gain value to yield a lower maximum power level out of the transceiver. The level can only be decreased, not increased. The granularity of the control is in 6 dB steps. There are no other methods for a system user to vary the power level.

Per the PCS-1900 Air Interface Specification, the system provides 15 levels of dynamic power control in steps of 2 dB each. This variable attenuation is used by the power control algorithm running on the digital signal processor boards to optimize the power level of the signal from the base station to the mobile handset. (Only use as much power as necessary to achieve an acceptable signal to noise ratio (SNR).) When a traffic channel is first turned on, it is at maximum attenuation, i.e., 30 dB below maximum power. The power control algorithm will then continually optimize this level based on the strength of the received mobile signal. This power adjustment mechanism is automatic and implemented in DSP software.

Typical high power amplifiers will shutdown if their input signal level is too high, if the VSWR at the output port is too high, if the output power is too high, or if a number of other error conditions occur. Additionally, the BTS has a built-in forward power monitor at the output of the HPA mainframe where the total forward transmit power is continuously monitored. The power control software algorithms are designed to monitor this composite power level and adjust the individual carrier power to within the rated power level, or to disable the amplifier(s) if necessary. This helps to ensure that the BTS will not transmit at power levels higher than authorized should a system equipment failure occur.

7.0 Measured Data

7.1 RF Power output data

The RF power output was measured with the indicated voltage and current applied into the final stage of the RF amplifying device. The outputs of the downlink channel were measured at the BRT transmit port using the HP 8563E Spectrum Analyzer. Figure 7.1.1 contains the RF Output Power plot obtained using a spectrum analyzer and direct connection to the transmit port. Spectrum analyzer settings for this plot are as follows:

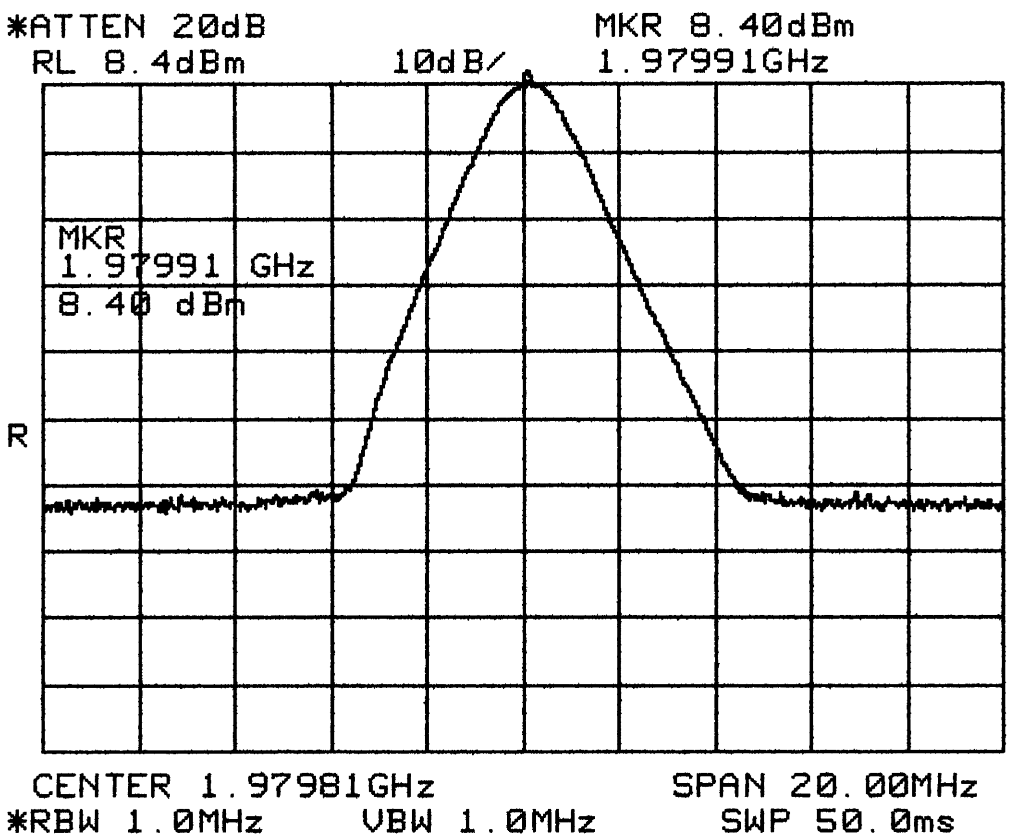
Detection: Peak, with max hold

RBW: 1 MHz

VBW: 1 MHz

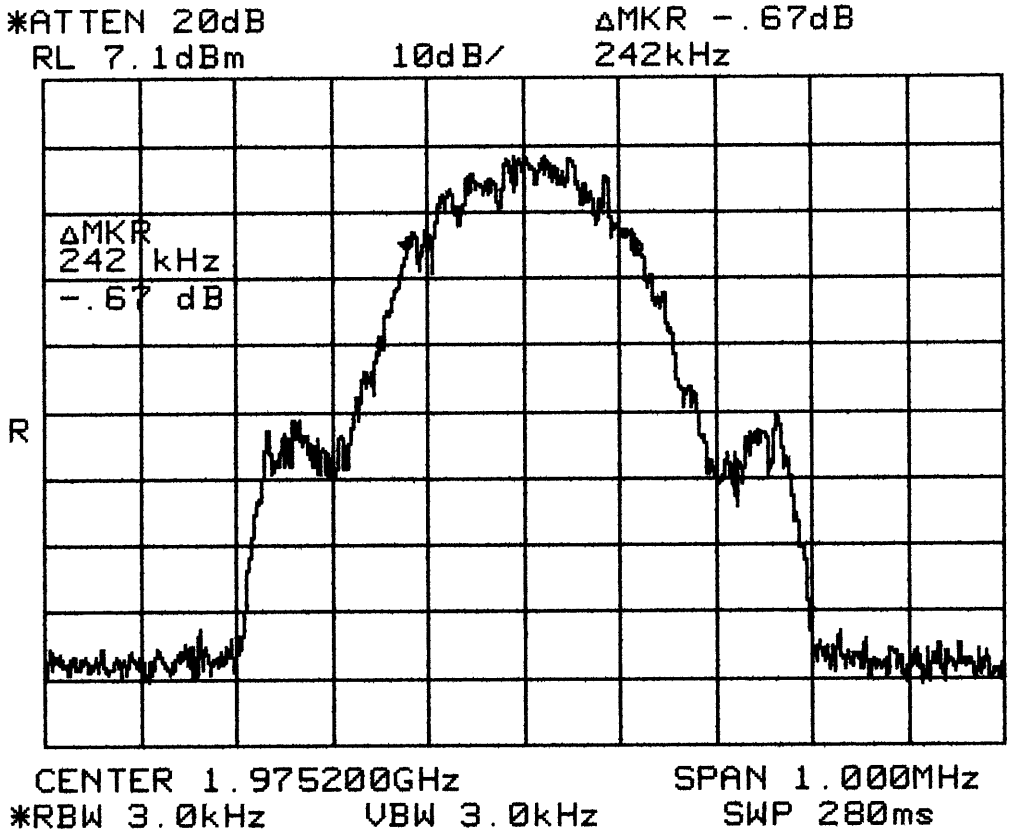
The reference level offset is 1.5 dB to account for the system losses at 1.9 GHz. The downlink output level was measured to be 8.4 dBm.

Figure 7.1.1: RF Output Power Plot, Downlink



7.2 Occupied Bandwidth

The industry accepted bandwidth for GMSK signaling is 300KGXW.



7.3 Emissions at edge of Frequency Block

7.3.1 Downlink

In order to meet the conducted spurious requirements at the band edges AirNet will limit the power in the channel adjacent to any band edge to 2 Watts maximum (with external amplification).

The power limit will be set in software by AirNet and will not be configurable by the user. The following table indicates the channels affected, based upon the licensed band of the user. It also shows the unused channels that straddle the band edges.

Licensed Band	Power Limited ARFCNs	Unused ARFCNs
'A' Band: 1930-1945 MHz	512,585	586
'D' Band: 1945-1950 MHz	587,610	611
'B' Band: 1950-1965 MHz	612,685	686
'E' Band: 1965-1970 MHz	687,710	711
'F' Band: 1970-1975 MHz	712,735	736
'C' Band: 1975-1990 MHz	737,810	

Figure 7.3.1: Lower Band Edge Plot

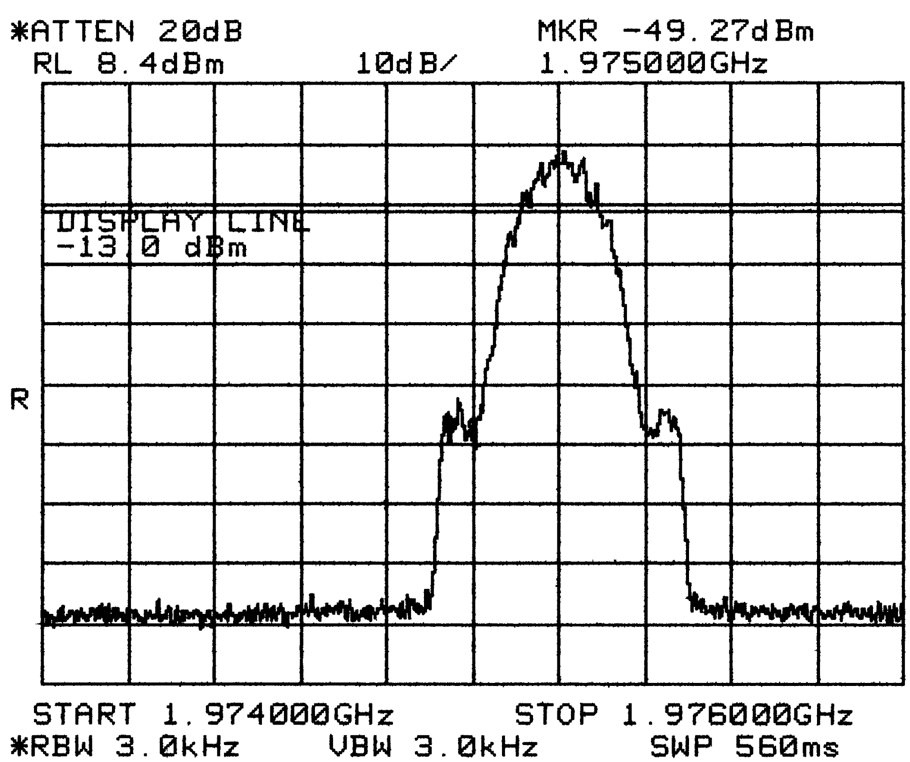


Figure 7.3.2: Upper Band Edge Plot

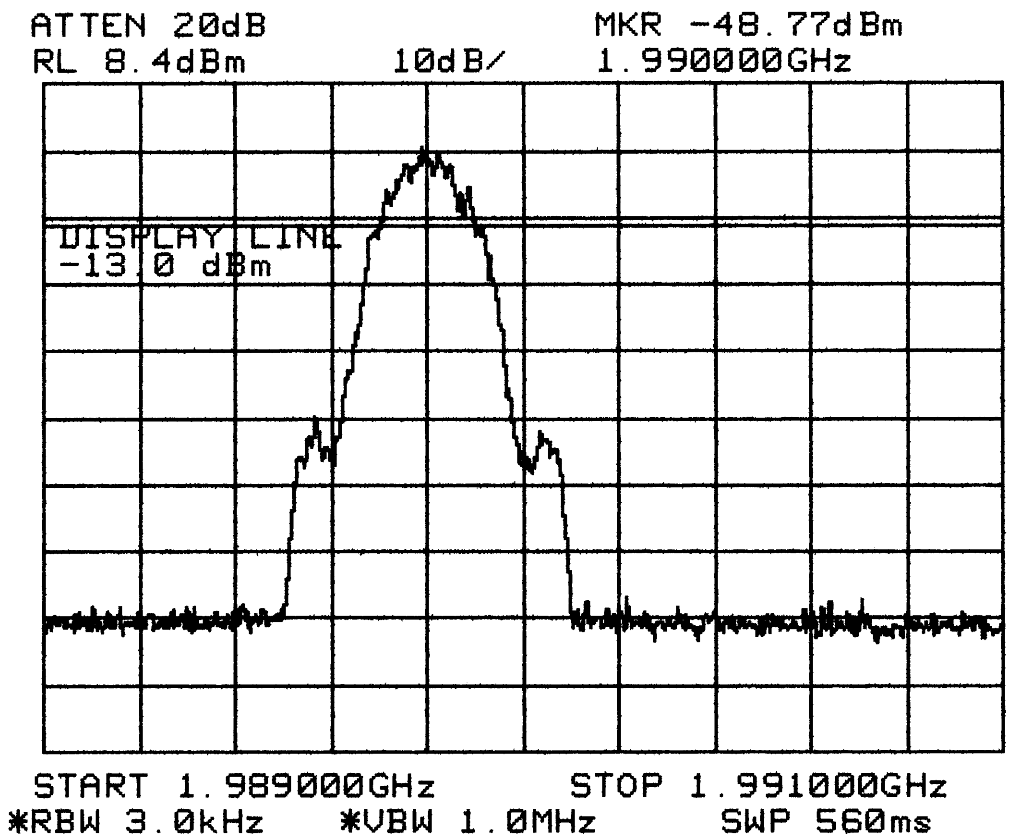
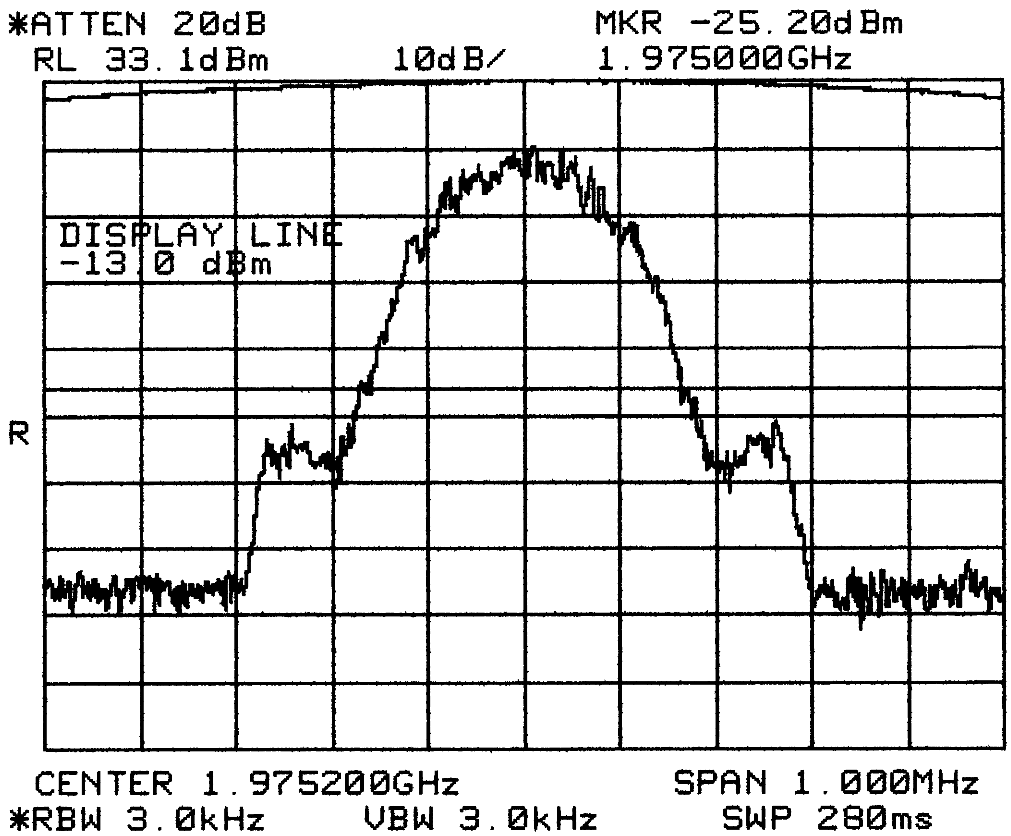


Figure 7.3.3: Lower Band Edge Plot, Assuming 2-Watt Channel at Band Edge



7.4 Antenna Conducted Spurious Emissions

The following plots show the conducted spurious emissions for each amplifier tested in the Broadband Transceiver System. All measurements above 1 GHz were made with a RBW of 1 MHz and a VBW of at least 1 MHz. All measurements below 1 GHz were made with a quasi-peak detector, a RBW of at least 120 kHz, a VBW of at least 1 MHz. The limit is displayed at –13 dBm. Any emission detected within 20 dB of the limit was recorded.

Table 7.4.1: Conducted Spurious Emission, Transmit Port

Frequency MHz	Net Reading dBm	Limit dBm	Margin dB
34.475	-48	-13	-35
2098.00	-51	-13	-38
4195.18	-51	-13	-38

Figure 7.4.1: Conducted Spurious, Transmit Port, 30 to 1000 MHz

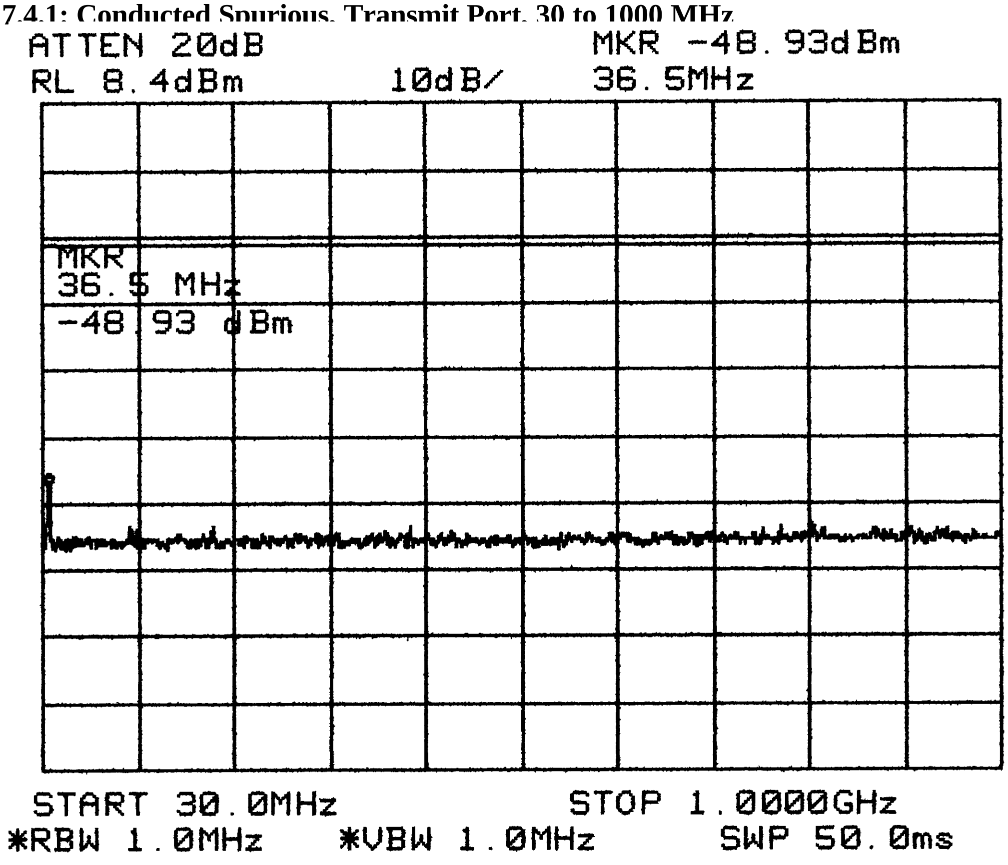


Figure 7.4.2: Conducted Spurious, Transmit Port, 1 to 20 GHz

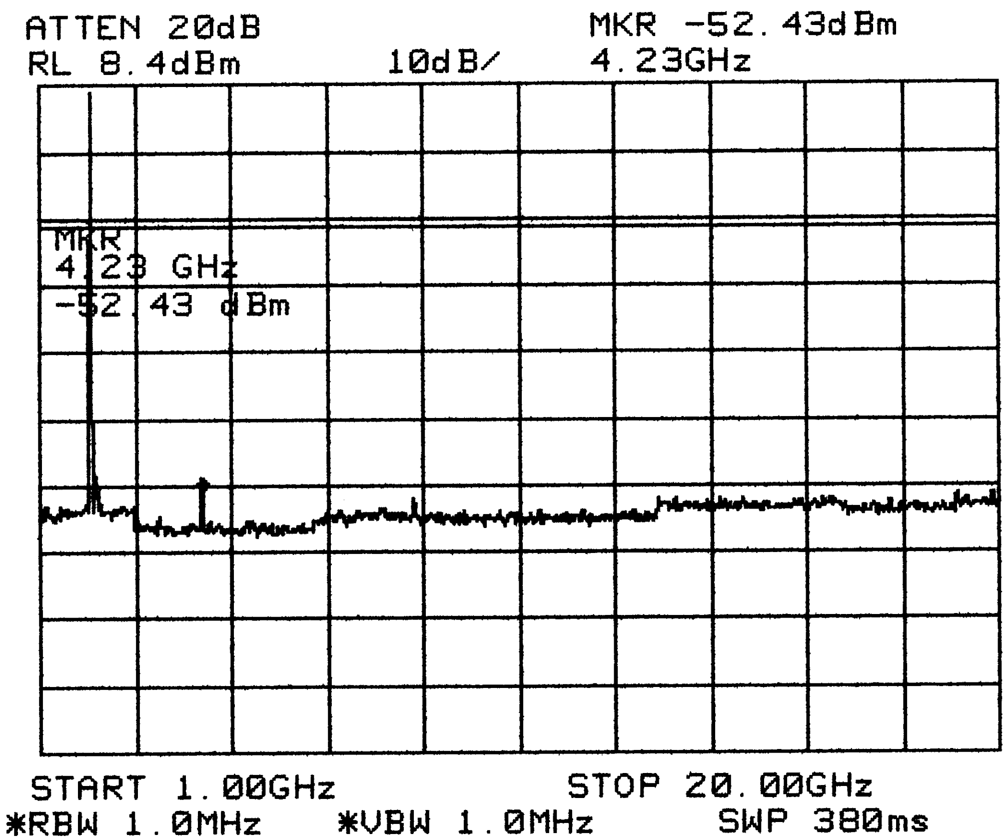


Table 7.4.2: Conducted Spurious Emission, Receive Port A

Frequency MHz	Net Reading dBm	Limit dBm	Margin dB
482.7	-64	-13	-52
15030.00	-61	-13	-55

Figure 7.4.3: Conducted Spurious, Receive Port A, 30 to 1000 MHz

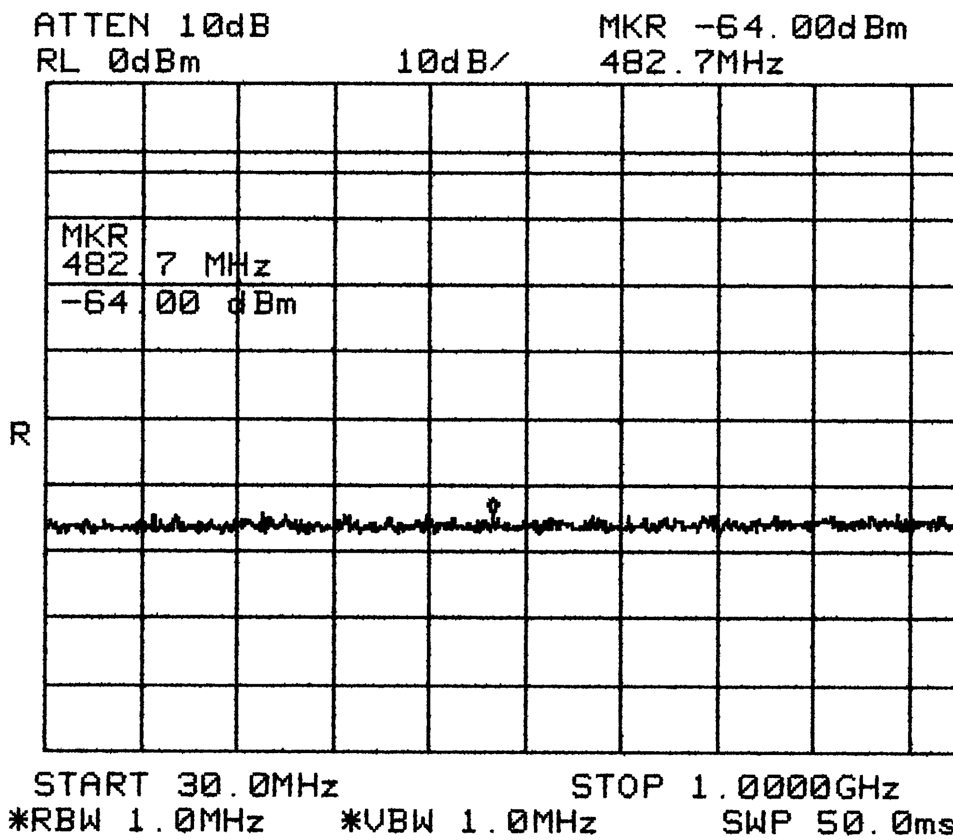


Figure 7.4.4: Conducted Spurious, Receive Port A, 1 to 20 GHz

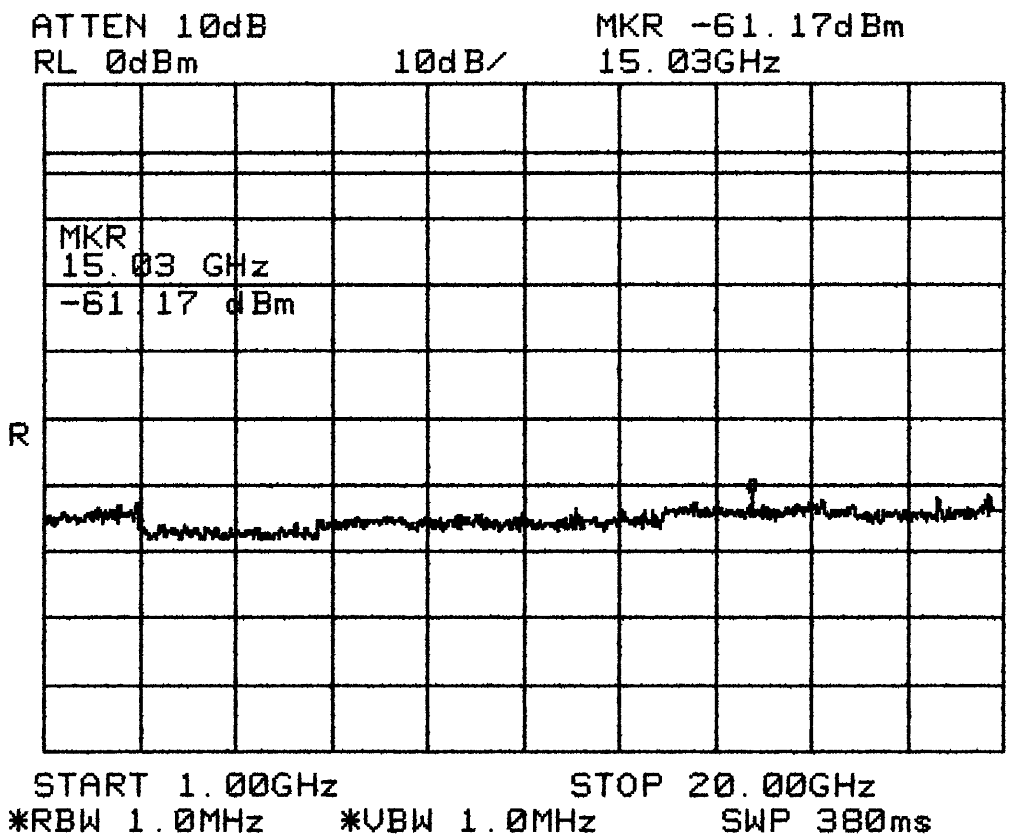


Table 7.4.3: Conducted Spurious Emission, Receive Port B

Frequency MHz	Net Reading dBm	Limit dBm	Margin dB
4016.03	-67	-13	-54
6024.07	-65	-13	-52
8031.95	-68	-13	-55

Figure 7.4.5: Conducted Spurious, Receive Port B, 30 to 1000 MHz

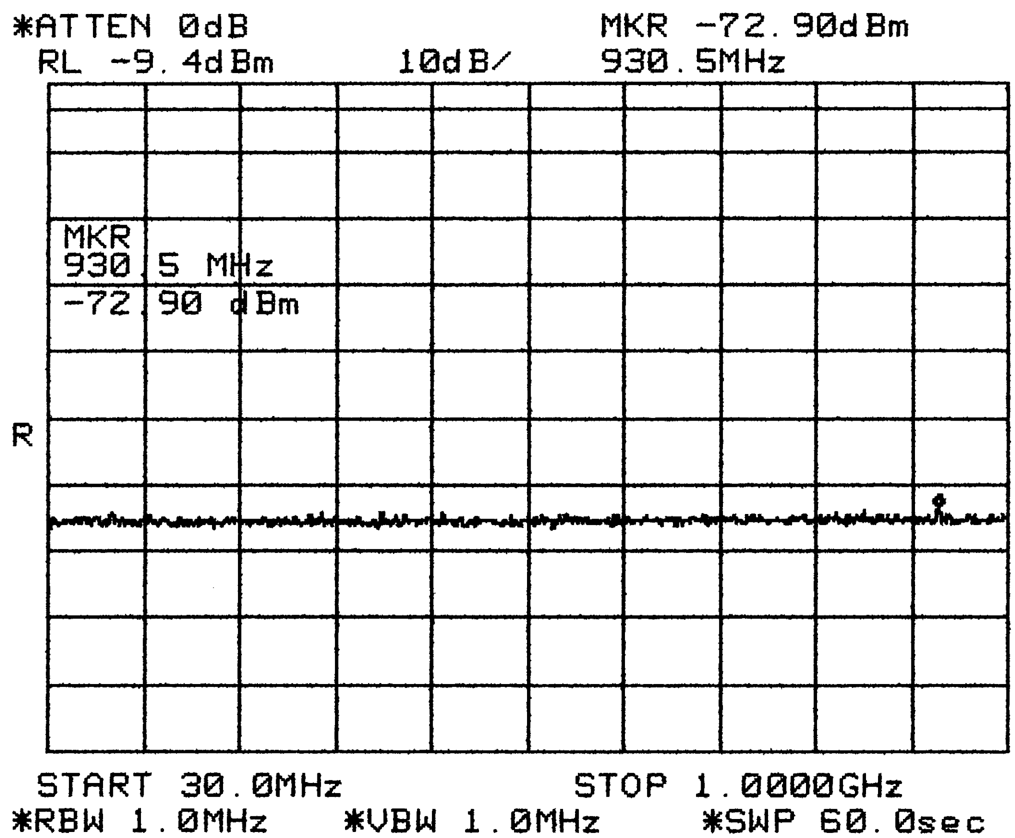
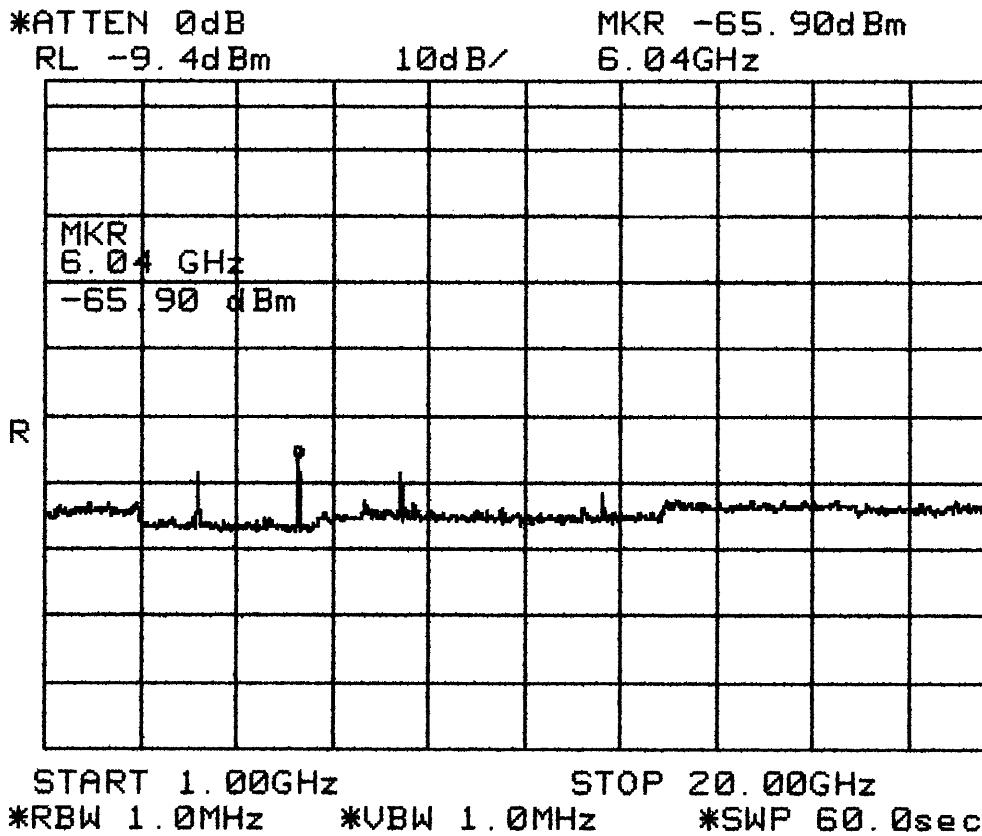


Figure 7.4.6: Conducted Spurious, Receive Port B, 1 to 20 GHz



7.5 Radiated Spurious Emissions

The following tables show the radiated spurious emissions for each amplifier tested in the Broadband Transceiver System (in both the outdoor and indoor enclosure). All measurements above 1 GHz were made with a RBW of 1 MHz and a VBW of at least 1 MHz. All measurements below 1 GHz were made with a quasi-peak detector, a RBW of 120 kHz, a VBW of 1 MHz. The measurement distance was 3 meters unless otherwise specified.

Net Reading is the measured field strength in dB (μV/m). Limit is calculated by subtracting 43-10LogP, in dB, from the theoretical field strength of the EUT's output power through a tuned dipole measured at 3 meters (Friss transmission formula). Margin is Net Reading minus the Limit.

Table 7.5.1: Radiated Spurious Emissions, Indoor Enclosure

Antenna Polarity	Frequency MHz	Net Reading dB (μV/m)	Limit dB (μV/m)	Margin dB
Horizontal TX	1975	69	84	-15
Vertical TX	1975	68	84	-16
Horizontal	3950	59	84	-25
Vertical	3950	51	84	-33

There were no other emissions detected for this enclosure. Please see Cabinet Radiation Exhibit for indoor enclosure for detailed plots.

Table 7.5.2: Radiated Spurious Emissions, Outdoor Enclosure

Antenna Polarity	Frequency MHz	Net Reading dB (μV/m)	Limit dB (μV/m)	Margin dB
Vertical	410	47	84	-37
Horizontal TX	1975	64	84	-20
Vertical TX	1975	59	84	-25

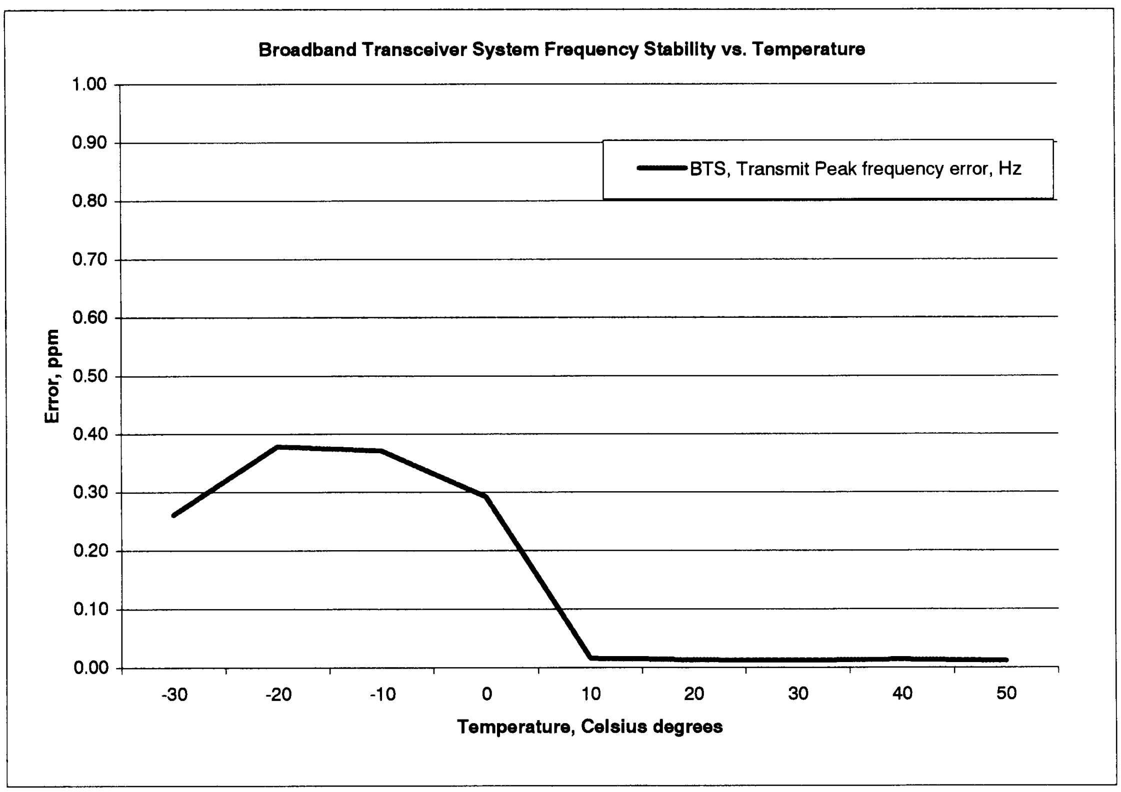
There were no other emissions detected for this enclosure. Please see Cabinet Radiation Exhibit for outdoor enclosure for detailed plots.

7.6 Frequency Stability

Table 7.6.1: Frequency Stability vs. Temperature, Broadband Transceiver System

Temperature, Celsius	BTS, Transmit Peak frequency error, Hz
-30	0.26
-20	0.38
-10	0.37
0	0.29
10	0.02
20	0.01
30	0.01
40	0.01
50	0.01

Figure 7.6.1: Frequency Stability vs. Temperature, Broadband Transceiver System



7.7 Inter-modulation

The following plots show the effects of inter-modulation for the Broadband Transceiver System.

Figure 7.7.1: Three Tone Plot

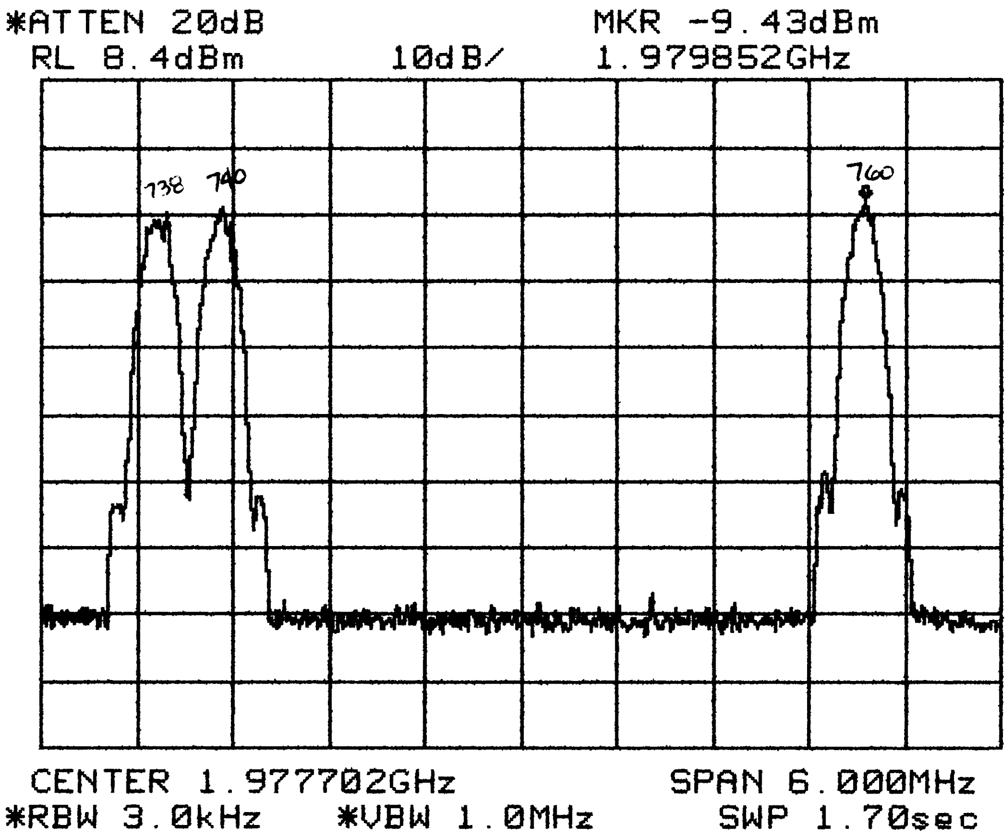


Figure 7.7.2: Inter-modulation below the band

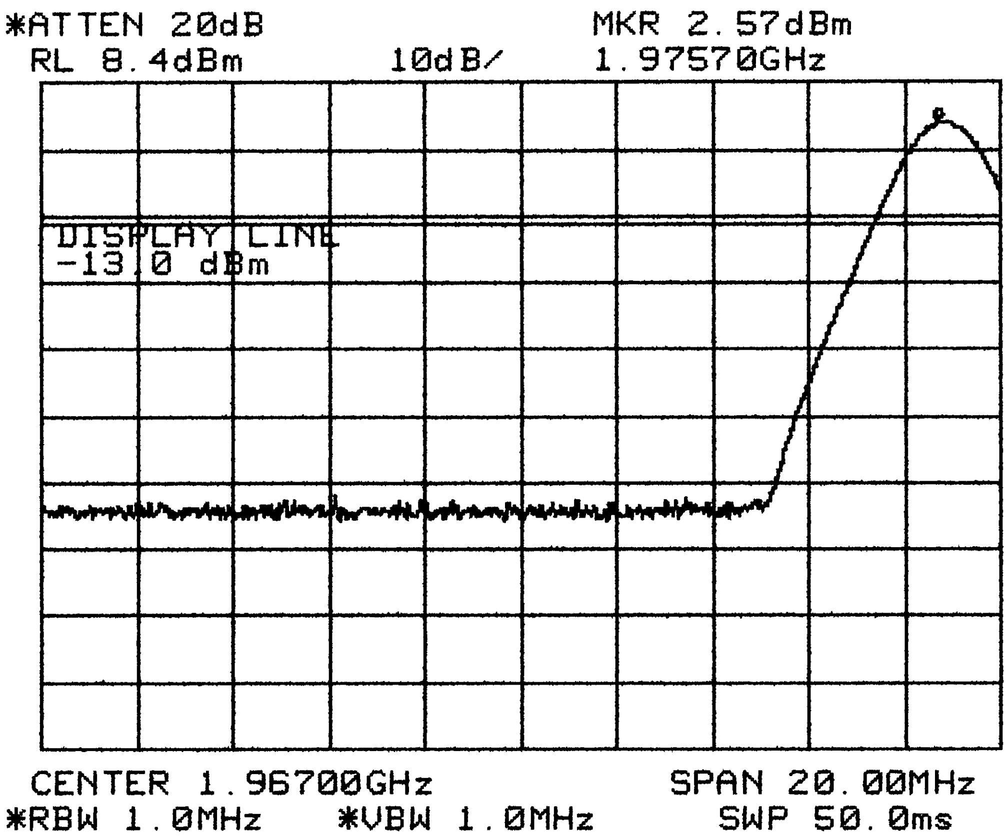
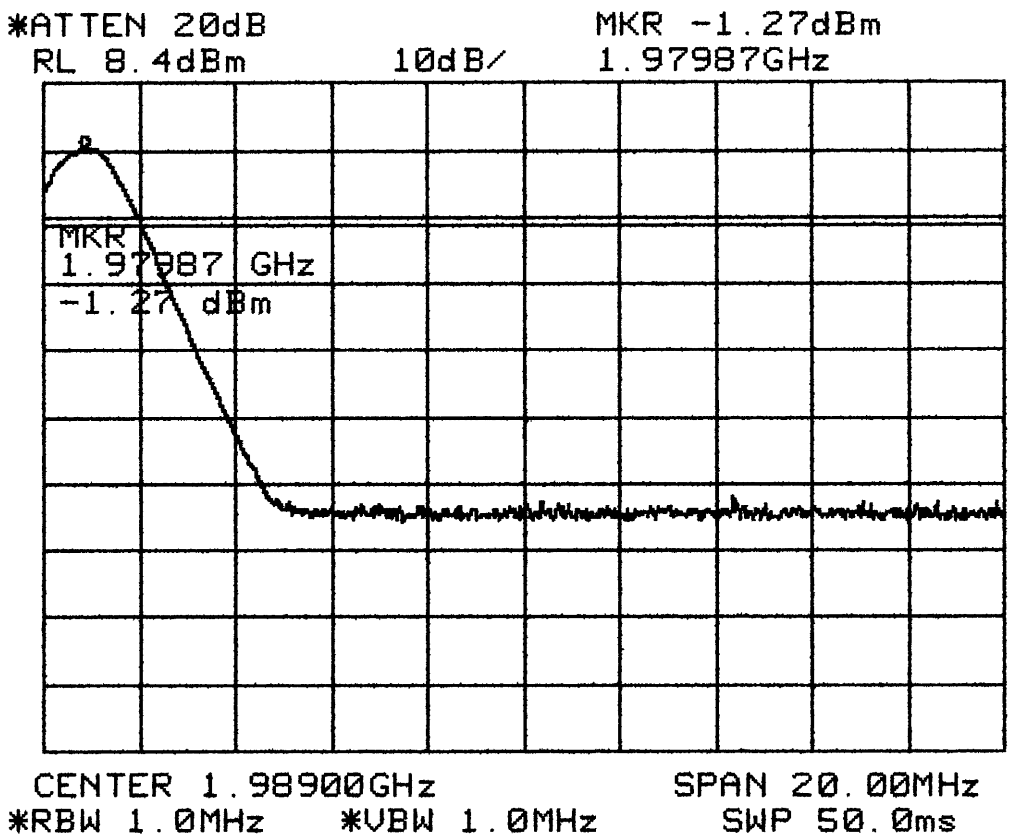


Figure 7.7.3: Inter-modulation above the band



8.0 Measurement Procedure and Test Equipment

This Exhibit provides a brief summary of the methods used for the indicated measurements. A full list of all test equipment is provided.

Table 8.1: Measurement Equipment – AirNet Communications Corporation

Description	Manufacturer	Model Number
Spectrum Analyzer	Hewlett Packard	8563E
Spectrum Analyzer, with PCS Personality	Hewlett Packard	8594E
Temperature Chamber	Thermotron	F110-CHV-25-25
Signal Generator	Marconi	2031
Attenuator	Weinschel	68-30-43
Cables, 0.6 m	Pasternack	RG-142LL

Table 8.2: Measurement Equipment – Rubicom Systems Inc.

Description	Manufacturer	Model Number
Spectrum Analyzer	Advantest	R3271
Antenna	Chase	CBL6111B
Preamplifier 1-8 GHz	Pacific Microwave	W2063-01
Preamplifier 8-18 GHz	Pacific Microwave	W5053-01
Preamplifier 18-20 GHz	Hewlett-Packard	8449A

8.1 RF Output Power - CFR 47 Part 2.985 (a)

RF output power is measured with the transmitter adjusted to the specified ratings. The output of the transceiver (before the amplifier) was connected directly to the 50 ohm input of an HP8563E Spectrum Analyzer. Note that the resolution bandwidth of the spectrum analyzer was greater than the bandwidth of the signal measured to ensure that the total power level was measured. Pulse desensitization of the spectrum analyzer was not present.

8.2 Occupied Bandwidth - CFR 47 Part 2.989

Occupied bandwidth measurements were made with the HP8563E using a resolution bandwidth of 3 kHz, which is approximately 1% of the emission bandwidth. All eight time slots were exercised with pseudo random data. Diagnostic testing showed that this setting was representative of lesser duty cycle modes and produced the worst-case occupied bandwidth. The bandwidth plots show a bandwidth of approximately 242 kHz, however, there is an industry-accepted bandwidth for GMSK signaling (300 kHz) that the FCC has instructed us to use in past applications.

8.3 Radiated Spurious - CFR 47 Part 2.993

Radiated spurious measurements were made at Rubicom Systems, Inc.'s Open Area Test Site in Melbourne, FL. The characteristics of this site are filed with the FCC.

The EUT was placed on a metal turntable. A 50 ohm coaxial load was connected to the transmitter output. The transmitter was set to radiate at its maximum power levels and measurements were performed. The maximum signal was detected by varying the receive antenna in height from one to four meters and rotating the turntable 360°. Measurements were made in both horizontal and vertical polarizations of the receiving antenna.

Cabinet radiation must be at least 43 + 10 Log (P) dB below the fundamental per CFR 47 §24.238(a). For a worst case calculation, the radiated field strength at the fundamental frequency can be calculated assuming the power is radiated from a theoretical dipole antenna with a gain of 1.64. Assuming an output power of 0.006 Watts and a test distance of 3 meters, the field strength can be calculated using the Friis Transmission Formula. The limit for the given power level calculates to be 84.4 dB(µV/m).

8.4 Conducted Spurious Emissions - CFR 47 Part 2.991

The transceiver was terminated into a 50-ohm input of a spectrum analyzer with appropriate attenuation. All spurious emissions greater than 20 dB below the specified value shall be recorded.

The conducted spurious emissions shall be attenuated below the maximum level of the carrier in accordance with the following formula: 43 + log (P), where P is the output power in Watts. This level is computed to be –13 dBm.

8.5 Frequency Stability - CFR 47 Part 2.995

Frequency stability shall be sufficient to ensure that the fundamental emission stays within the authorized frequency block. For the downlink channels, center frequencies nearest the band edges are no closer than 200 kHz. The industry accepted bandwidth of the transmitted signal is 300 kHz (150 kHz above and below the center frequency). The center frequency can deviate ±50 kHz and at all times, the emissions will be in the band.

Frequency Stability versus Temperature

The transmitter was placed in an environmental chamber and tested in the range of -30 to +50 degrees Celsius. The transmitter temperature was stabilized at each temperature setting. The power was applied to the transmitter and allowed to stabilize for at least 25 minutes. The frequency of the transmitter was measured. This procedure was repeated for each 10 degree step up to +50 degrees Celsius. The measurement apparatus was a Hewlett Packard 8594E spectrum analyzer with PCS 1900 Personality Module. This module allows for a frequency error measurement per GSM specifications that is very accurate for the GMSK signal.

9.0 ANSI C95.1 Compliance

Table 9.1: ERP Calculations

Transmit Maximum ERP Calculation	100' Coax Omni Antenna Downlink
Total Power for all Channels (Watts)	100.0
Maximum Antenna Gain (dBd)	10.0
Minimum TX Foam Cable Loss, 1-5/8" (dB)	1.30
Minimum TX Jumpers and Adapter Loss (dB)	1.0
Broadband Transceiver System EIRP (dBm)	59.8
Broadband Transceiver System EIRP (Watts)	966
Broadband Transceiver System ERP (dBm)	57.7
Broadband Transceiver System (Watts)	588

The Broadband Transceiver System uses a maximum of twelve channels at a maximum total power of 100 Watts.

EXAMPLE CALCULATION FOR THE OMNI ANTENNA
P is the maximum total power in Watts transmitted by the antenna.
CL is the Cable loss in dB.
JAL is the loss in dB due to jumpers and adapters.
AG is the maximum antenna gain in dBd.

$ERP(dBm) = 10 \cdot Log(P \cdot 1000) - CL - JAL + AG$
$ERP(dBm) = 10 \cdot Log(100 \cdot 1000) - 1.3 - 1.0 + 10$
$ERP(dBm) = 57.7$
$ERP(Watts) = 10^{[\{ERP(dBm) - 30\}/10]}$
$ERP(Watts) = 10^{[\{57.7 - 30\}/10]}$
$ERP(Watts) = 588$

$EIRP(dBm) = ERP(dBm) + 2.1$
$EIRP(dBm) = 50.7 + 2.1$
$EIRP(dBm) = 59.8$
$EIRP(Watts) = 10^{[\{EIRP(dBm) - 30\}/10]}$
$EIRP(Watts) = 10^{[\{59.8 - 30\}/10]}$
$EIRP(Watts) = 966$

9.1 MPE at 1.9 GHz

In typical installations, the antenna will be mounted to a tower or above a rooftop by a minimum of 10 meters. Since the total power of all channels is less than 1000W ERP (1640W EIRP), compliance testing with the MPE limits of FCC 96-326 is not required.

The limit for Maximum Permissible Exposure (MPE) at the frequency of 1.96 GHz is 6.53 mW/cm^2 for Occupational/Controlled Exposure using the equation Limit = f/300 per FCC 96-326. The limit is 1.31 mW/cm^2 for General Population/Uncontrolled Exposure using the equation Limit = f/300 per FCC 96-326. The EIRP at 1.96 GHz for the Broadband Transceiver System's omni-directional antenna is 966 Watts; the maximum transmitted power is 100 Watts.

The conversion from power to power density uses the following equation: $PD = P_r G/4\pi r^2$

Where: PD is Power Density (in W/m^2);
P_r is radiated power (in watts);
G is the numeric gain of the antenna; and
r is the distance (in meters) from the antenna.

The conversion from W/m^2 to mW/cm^2 is: mW/cm^2 = W/m^2/10

Calculations:

The distance, r, is dependant on Occupational/Controlled Exposure or Population/Uncontrolled Exposure. The following table illustrates the power density for the antennas used on the ARR. These antennas are located at the top of the cell site tower.

At a distance of r = 10 m from the antenna, the power density is (note that this power density will only be induced on an individual if that individual was physically 10 meters in line-of-site of the antenna):

Table 9.2: Power density calculations for MPE

	Downlink Path
Antenna Gain (dBi)	12.1
Numeric gain	16.2
Rated Power (Watts)	100
Power Density (W/m^2)	1.289
Power Density (mW/cm^2)	0.1289
Minimum distance, in m, for MPE	4.44

At this power level, an individual would need to be within 5 meters of the antenna in order to be at the limit for controlled exposure.

This EUT, at 10 meters away from the transmit antennas, is well within the limits for maximum permissible exposure