Triton Network Systems, Inc

FCC Part 101 Emissions Testing performed on the

Wireless Consecutive Point Millimeter-Wave Transmitter

Models: TNS29-ETPFE-100-XX
TNS29-ETPFE-200-XX (Verification Only)

FCC ID:OQT29ETP-FE-02

Date Tested	March 20, 2001		
Tested by:	Craig Perkins	Lead Engineer	
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Triton Network Systems, Inc.

47 CFR 101 Test Plan

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1. Summary

On March 20,2001, Triton Network Inc. located at 8337 South Park Circle, Orlando, FL 32819, tested the 29 GHz Fast Ethernet Wireless Consecutive Point to Point Millimeter Wave Transmitter System Models:

TNS29-ETPFE-100-XX
TNS29-ETPFE-200-XX

to determine if they were compliant with the FCC Part 101 emission standard. The difference between the models rests only on the selection of waveguide filters for the appropriate bands. We found that the units met applicable requirements when tested. The –100 and –200 models are a radio link pair. All data within this report that references the –200 model is for verification only, since the transmitter operates in the frequency range of 31.075 to 31.225 GHz.

2. Product Description

The 29 GHZ Fast Ethernet radio is a data-link radio device. A pair of radios, working together, forms a full duplex 100 Mbps data link. Within the radio network model, the radio link acts as a physical layer link, or pipe, similar to a bi-directional optical regenerator. The radio replicates data without regard to content.

The 29 GHz Fast Ethernet radio uses a 100 MHz channel pair (50 Mhz transmit, 50 Mhz receive) to carry an aggregate data rate of approximately 120 Mbps in each direction across the link. The Fast Ethernet payload accounts for 100 Mbps. The radios are designed to be installed by operators on rooftop, tower, or suitable structures to provide high-bandwidth communication links. Operators can use linked radios to provide fixed wireless technology services to an entire metropolitan service without using fiber optical cable.

2.1 Multiple list/Family information

Part number	Transmit Frequency Band
TNS29-ETPFE-100-XX	29,100 – 29,250 MHz
TNS29-ETPFE-200-XX	31,075 – 31,225 MHz

2.2 Frequency Availability

Radio Services	Frequency Bands (GHz)	Applicable Subparts	Note
Common Carrier (Pt 101)	29.100 – 29.250, 31.075 – 31.225	L	LMDS

2.3 Block Diagram of the product

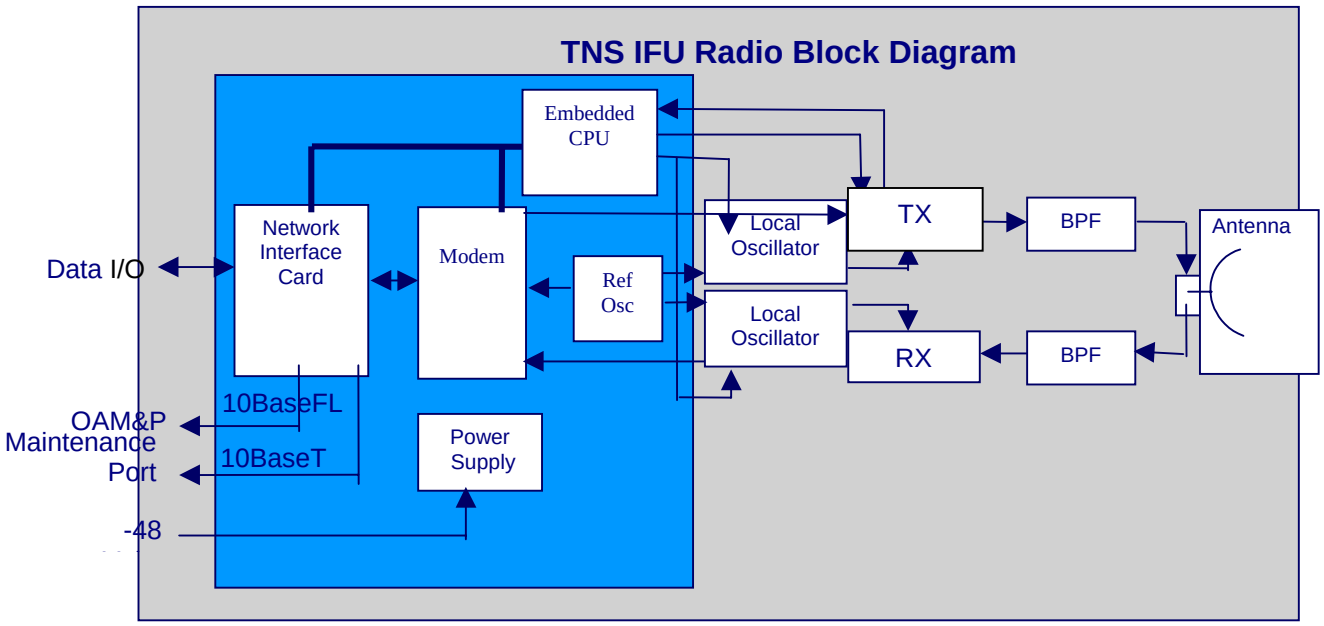

Figure 1 – IFU Radio Sub-Assembly Block Diagram

3. Summary of Tests and Results

Test	Part 101	Pass/Fail
Frequency Availability	101.101	**Pass**
Frequency Tolerance and frequency Stability	101.107	**Pass**
Occupied Bandwidth	101.109	**Pass**
Emission Limitations (Mask)	101.111	**Pass**
Spurious Conducted	101.111	**Pass**
Transmitter Power Limitations	101.113	**Pass**
RF Safety assessment	1.1307	**Performed/Complied**

4. Test Plan

4.1 General

All testing will be performed by Triton Networks Systems personnel, using test procedures applicable for the product and standards required. Testing will be performed at normal laboratory conditions unless specifically indicated otherwise in the test report.

4.2 Frequency stability

FCC rules Part 101,Section 107 defines the Frequency stability requirements for the transmitters in the 29.100 – 29.250 and 31.075 – 31.225 GHz ranges as 0.001% of the transmitter frequency over temperature ranges of –30 to +55 degrees Celsius and 85% to 115% of the nominal supply voltage range.

4.3 Output power

FCC rules Part 101,Section 113 requires that the output power of the transmitter does not exceed 23dBW/MHz EIRP with the additional stipulation that no higher power than necessary to carry out the desired communication shall be allowed.

The output power of this transmitter will be measured within the allocated frequency bands of 29.100 – 29.250 and 31.075 – 31.225 GHz. The output power will be measured in the low end, middle and the high end of both the A2 and A3 bands.

4.4 Bandwidth

The spectral output of the transceiver will be measured in the low end, middle and the high end of both the A2 and A3 bands, for each of the different models and modulation scheme at the nominal power rating of the transceiver. The 99% power bandwidth will be calculated from the spectral display.

4.5 Emission Limitation (Mask)

The spectral output of the transceiver will be measured to show that the emissions fall under the mask as defined in FCC rules, part 101.111. The shape of the mask will be calculated based on the nominal rated output power of 27dBm.

4.6 Spurious emissions

Conducted spurious emissions will be measured from 30 MHz to 220 GHz. For the frequency range above 40GHz, external mixers will be used to down convert the frequency.

4.7 Incidental radiation

Incidental radiation will be measured according to the requirements of FCC Part 15.B and ANSI C63.4:1992.

4.8 Receiver verification

The receiver section of the transceiver is covered under the requirements of the FCC Part 15 (verification). Specific attention will be paid to the potential emissions of the local oscillator frequencies appearing at the antenna terminals.

4.9 RF Safety evaluation

The transceiver is neither a portable nor mobile device. A determination will be made if the transceiver is categorically excluded from environmental assessment or not. A theoretical calculation of the safety zone will be made.

5. Test results

5.1 General

The 29 GHz Fast Ethernet transceiver was tested at the facilities of Triton Network Systems (TNS) on March 20, 2001 under the guideline of TNS in-house regulatory testing procedures. All testing was performed at nominal operating conditions at room ambient temperature unless otherwise specified

5.2 Frequency Tolerance and frequency Stability

The carrier frequency of each transmitter authorized in these services must be maintained within the following percentage of the reference frequency according to FCC Part 101.107.

Frequency Ranges MHz	Frequency Tolerance
29100 – 29250, 31075 – 31225	0.001 percent

Table 1. Frequency Stability vs Input Voltage

Maximum Allowed Frequency Deviation (Hz) 292250				
Voltage (VDC)	Reference Frequency (Hz)	Measured Frequency (Hz)	Deviation (Hz)	Pass/Fail
-40.8	29,225,000,298	29,2255,000,282	519	Pass
-48	29,225,000,298			
-55.2	29,225,000,298	29,225,000,225	576	Pass

Table 2. Frequency Stability vs Temperature

Maximum Allowed Frequency Deviation (Hz) 292550				
Temperature (degC)	Reference Frequency (Hz)	Measured Frequency (Hz)	Deviation (Hz)	Pass/Fail
-30	29,225,000,801	29,225,007,154	-6353	Pass
-20	29,225,000,801	29,225,006,204	-5403	Pass
-10	29,225,000,801	29,225,005,221	-4420	Pass
0	29,225,000,801	29,225,003,991	-3190	Pass
10	29,225,000,801	29,225,002,434	-1633	Pass
20	29,225,000,801			
30	29,225,000,801	29,225,000,093	708	Pass
40	29,225,000,801	29,224,998,800	2001	Pass
50	29,225,000,801	29,224,997,833	2968	Pass

5.3 Output power

FCC rules Part 101, Section 113 requires that the output power of the transmitter does not exceed 23dBW/MHz EIRP, with the additional stipulation that no higher than necessary to carry out the desired communication shall be allowed.

The output power of the transmitter is measured both with a Wattmeter and with the built-in function in the R&S spectrum analyzer to determine channel power. Both measurements are corrected for the 13.3 dB loss in the cable between the transmitter antenna output and the measurement instrumentation.
The transmitter was modulated with a 8 PSK signal with a quasi-random bit pattern. Consequently the measured average power is lower than the peak output power of the transmitter depending on the relative occurrence of the various amplitudes used in the 8PSK constellation diagram.
The numerical gain of the antenna (according to the manufacture) is 3981.1 or 36dB over an isotropic radiator. The transmitters will automatically reduce the output power to the minimum level required to maintain a reliable data transmission. The following table represents the maximum possible output power of 27dBm that is programmed into each individual transmitter as a factory setting. The output power can be varied over a range of at least 50dB.

EIRP specification: -100 model = 23dBW/MHz =
10Log(BW)+23dBW =
10Log(50MHz)+23dBW = 40dBW

-200 model = 55dBW

Table 3. Transmitter Maximum Output Power

Modulation	**Frequency (MHz)**	**Measured Power** Power at Ant. terminal **(dBm)**	**Calculated EIRP** Based on 36dB Antenna gain **(dBW)**	**EIRP Limit (dBW)**	**Pass/Fail**
8 PSK	31100	27.23	33.23	55	Pass
8 PSK	29125	27.20	33.20	40	Pass
8 PSK	31150	27.01	33.01	55	Pass
8 PSK	29175	27.21	33.21	40	Pass
8 PSK	31200	27.04	33.04	55	Pass
8 PSK	29225	27.18	33.18	40	Pass

5.4 Bandwidth

The occupied bandwidth is determined by the 99% power bandwidth as calculated by the internal function of the R&S spectrum analyzer. The data is taken from the following figures showing the screen data of the spectrum analyzer.

Table 4. Occupied Bandwidth

Mode	Frequency (MHz)	Authorized BW (MHz)	Measured Occupied Bandwidth (MHz)	Detailed Information	Pass/Fail
8 PSK	31100	150	42.32	Figure 1a & 1b	Pass
8 PSK	29125	150	42.32	Figure 2a & 2b	Pass
8 PSK	31150	150	42.32	Figure 3a & 3b	Pass
8 PSK	29175	150	42.32	Figure 4a & 4b	Pass
8 PSK	31200	150	42.32	Figure 5a & 5b	Pass
8 PSK	29225	150	42.32	Figure 6a & 6b	Pass

5.5 Emission Designator

Part of the application (license or certification) require the inclusion of an emissions designator as determined by 47 CFR 2.201 and 2.202

The characteristics of the emissions designator are as follows:

	Value
Necessary Bandwidth - This may be calculated using the formulas of 2.202 or if that is not possible with the occupied bandwidth	42M4
First Symbol - Type of modulation of the main carrier	D
Second Symbol – Nature of signal(s) modulating the main carrier	1
Third Symbol - Type of information to be transmitted	D

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5.6 Emission Limitations (Mask)

The mean power of the emissions must be attenuated below the mean output power of the transmitter in accordance with the following schedule (from FCC 101.111).

Federal Communications Commission Emission Mask

Percentage Shift From Center Frequency	Attenuation Equation from 101.111 (a) 2 ii	Attenuation Below Un-modulated Channel Carrier Power (dB)	Spectrum Analyzer RBW
0 to 50	None	0	1 MHz
50 to 250	11 + 0.4(P-50) + 10 Log B	32.8 to 56	1 MHz
Greater than 250	43 + 10 Log (P_o)	40	4 KHz

P = Percent removed from carrier
B = Authorized bandwidth in MHz
P_o = Mean Output power in Watts
Attenuation greater than 56 dB is not required.

Emission mask plots shown in Figures 1 - 6 on the following pages show compliance of the EUT with the emission the emissions mask requirements defined in Part 101.111.2 (ii). The connecting cable between the transmitter antenna connector and the spectrum analyzer has a measured loss of 13.3 dB at the transmit frequencies. This value has been added as an offset in the spectrum analyzer display so that the display reads directly in the correct power (dBm) values.

The emission mask points are calculated as follows:
For the 150 MHz authorized bandwidth as outlined in the FCC part 101.109 and a nominal output power of 27 dBm.

Percent shift from center frequency	Attenuation equation from Part 101.111.2 (ii)	Attenuation below center frequency peak (dBc)	Frequency deviation from center in MHz
0 to 50	None	0	0 – 75.0
50	11 + 0.4(P-50) + 10 Log B	32.8	75.0
108.10	11 + 0.4(P-50) + 10 Log B or 56	56	162.147
250	11 + 0.4(P-50) + 10 Log B or 56	56	375.0
Greater than 250	43 + 10 Log (P_o)	40	>375.0

Figure 1a. 8 PSK, taken in block A3 (low end), Actual Output Power 27.23 dBm. Spectrum Analyzer attenuation set to show top of the mask.

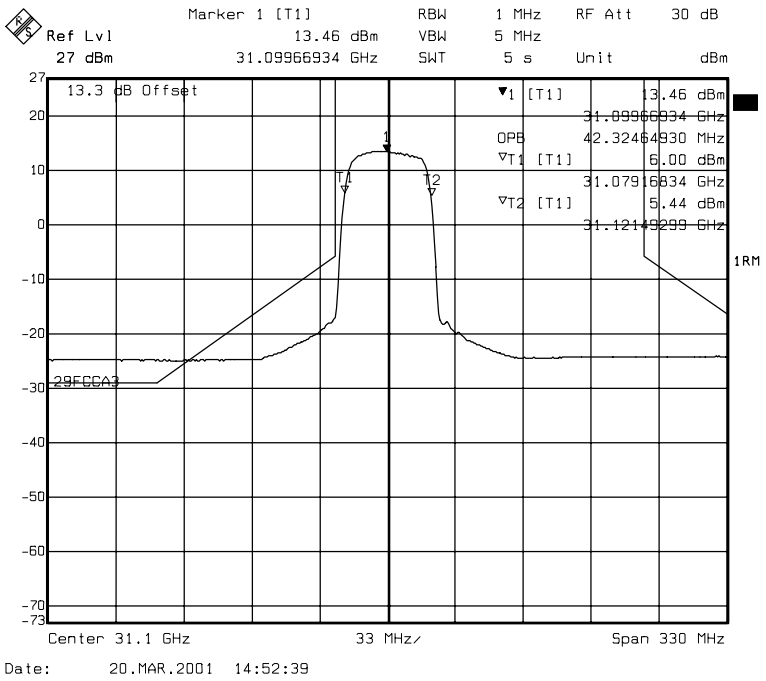


Figure 1b. 8 PSK, taken in block A3 (low end), Actual Output Power 27.23 dBm. Spectrum Analyzer attenuation reduced to show compliance of the lower skirt edges with the emission mask requirements.

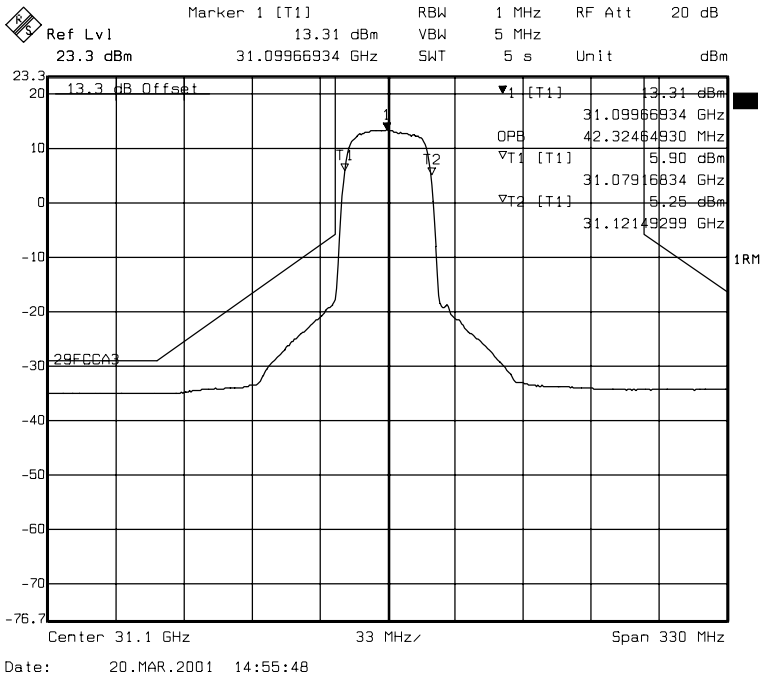


Figure 2a. 8 PSK, taken in block A2 (low end), Actual Output Power 27.20 dBm. Spectrum Analyzer attenuation set to show top of the mask.

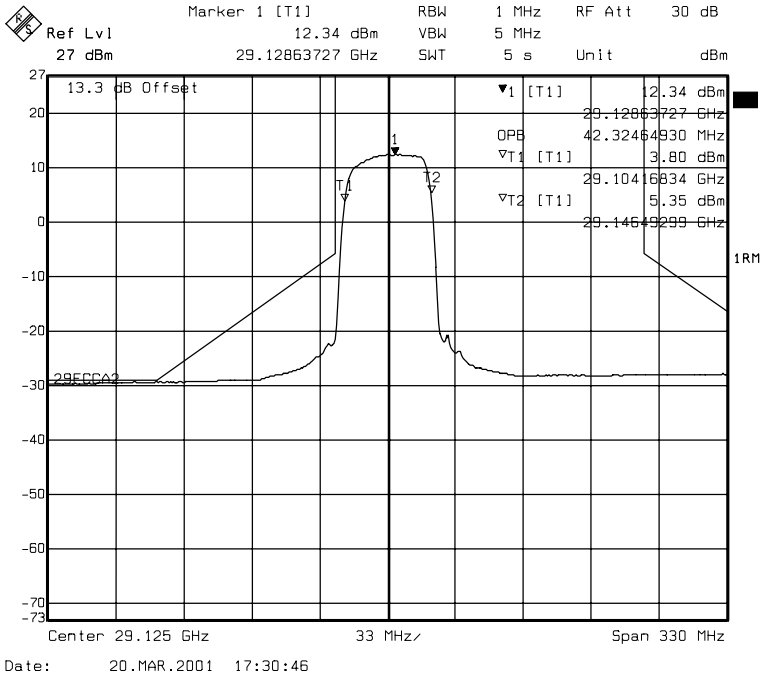


Figure 2b. 8 PSK, taken in block A2 (low end), Actual Output Power 27.20 dBm. Spectrum Analyzer attenuation reduced to show compliance of the lower skirt edges with the emission mask requirements.

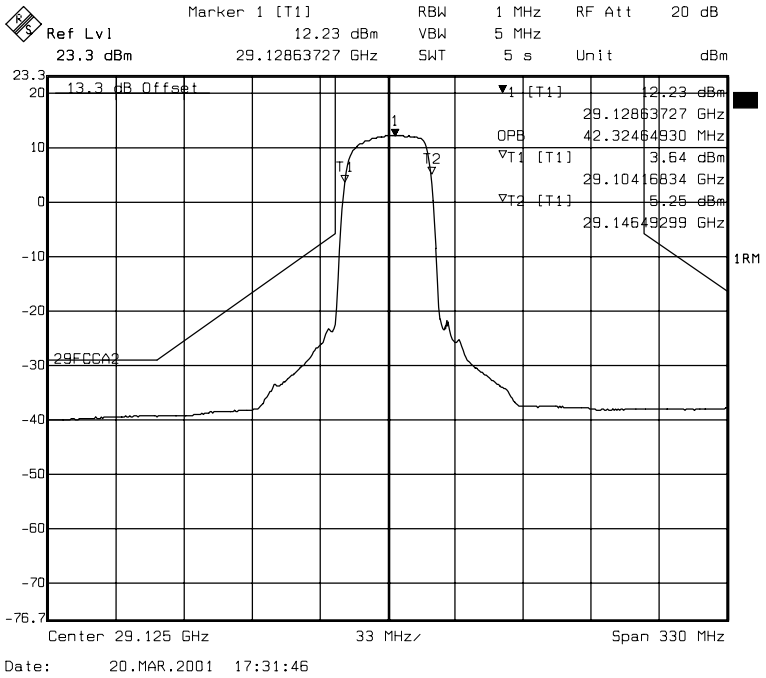


Figure 3a. 8 PSK, taken in block A3 (mid), Actual Output Power 27.01 dBm. Spectrum Analyzer attenuation set to show top of the mask.

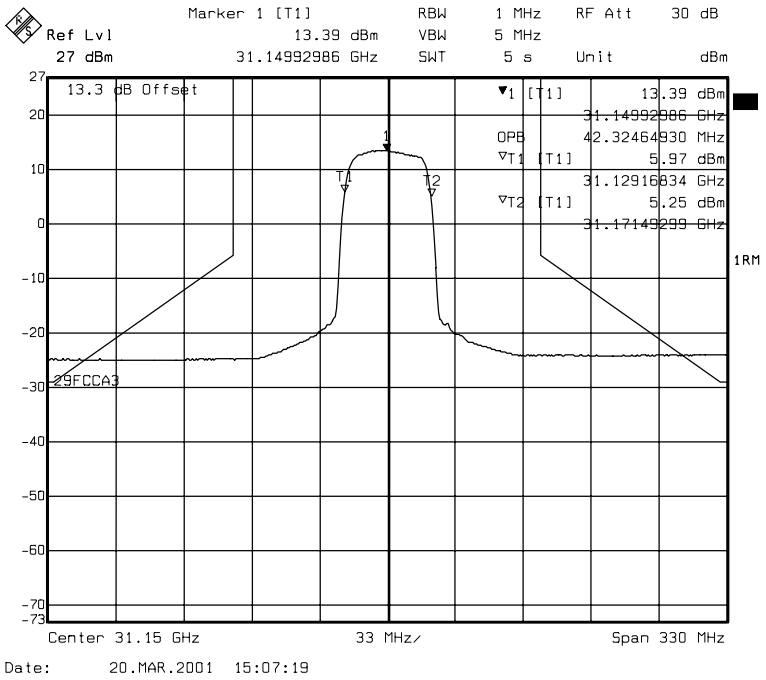


Figure 3b. 8 PSK, taken in block A3 (mid), Actual Output Power 27.01 dBm. Spectrum Analyzer attenuation reduced to show compliance of the lower skirt edges with the emission mask requirements.

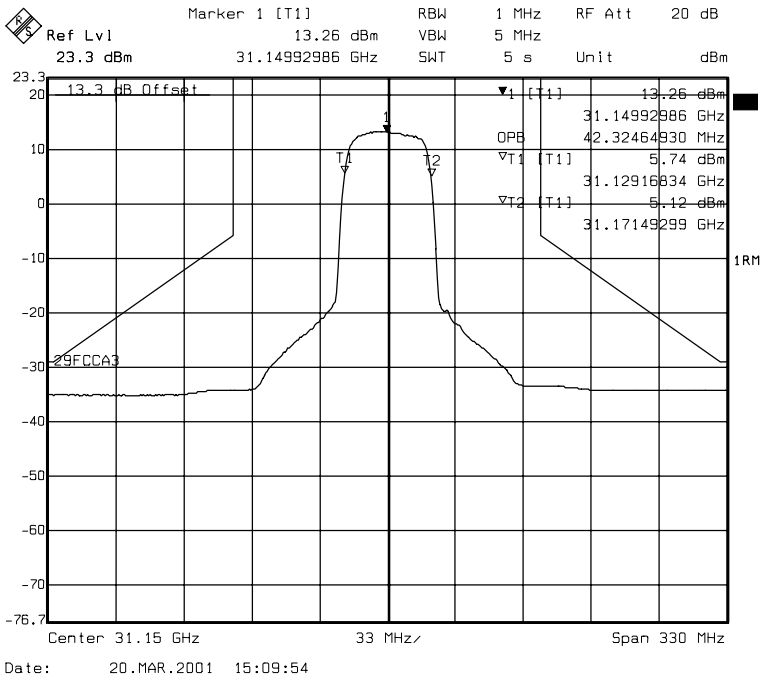


Figure 4a. 8 PSK, taken in block A2 (mid), Actual Output Power 27.21 dBm. Spectrum Analyzer attenuation set to show top of the mask.

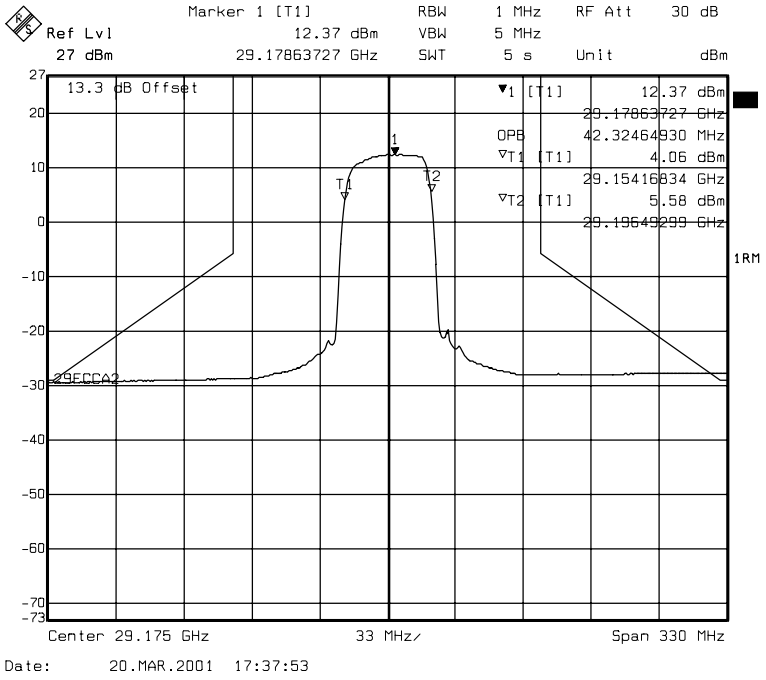


Figure 4b. 8 PSK, taken in block A2 (mid), Actual Output Power 27.21 dBm. Spectrum Analyzer attenuation reduced to show compliance of the lower skirt edges with the emission mask requirements.

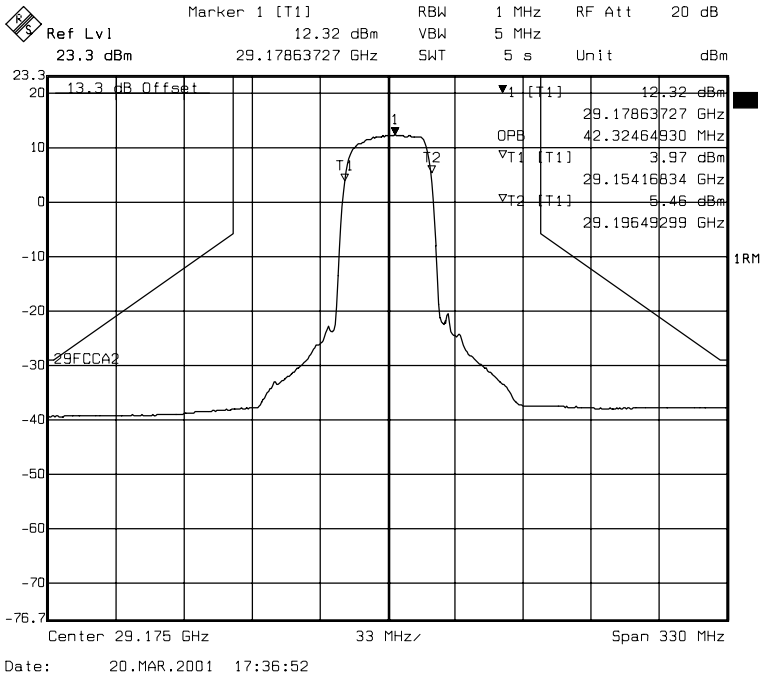


Figure 5a. 8 PSK, taken in block A3 (high end), Actual Output Power 27.04 dBm. Spectrum Analyzer attenuation set to show top of the mask.

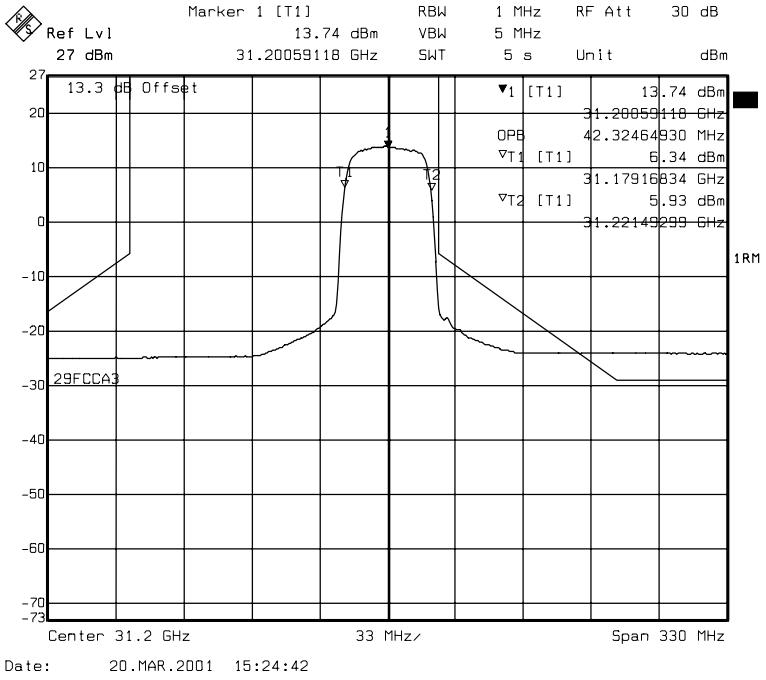


Figure 5b. 8 PSK, taken in block A3 (high end), Actual Output Power 27.04 dBm. Spectrum Analyzer attenuation reduced to show compliance of the lower skirt edges with the emission mask requirements.

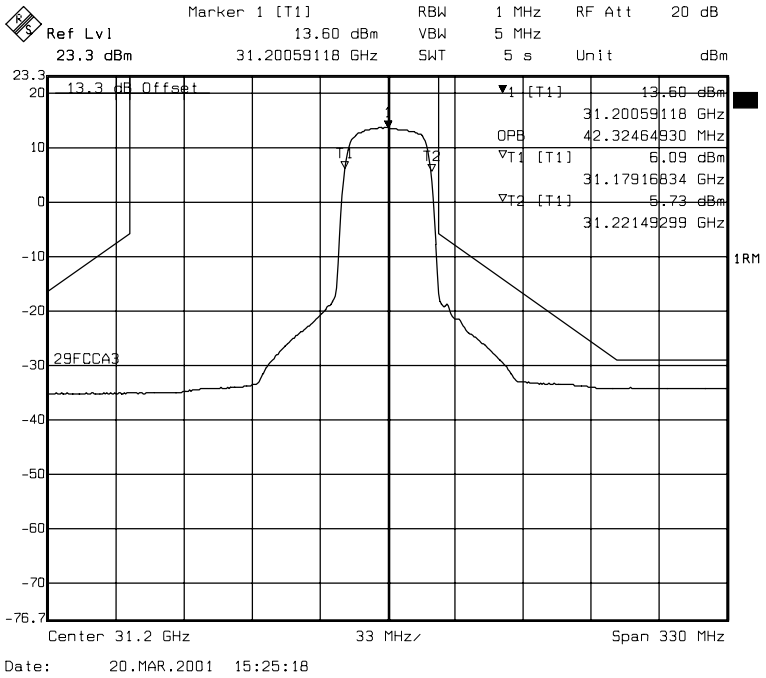


Figure 6a. 8 PSK, taken in block A2 (high end), Actual Output Power 27.18 dBm. Spectrum Analyzer attenuation set to show top of the mask.

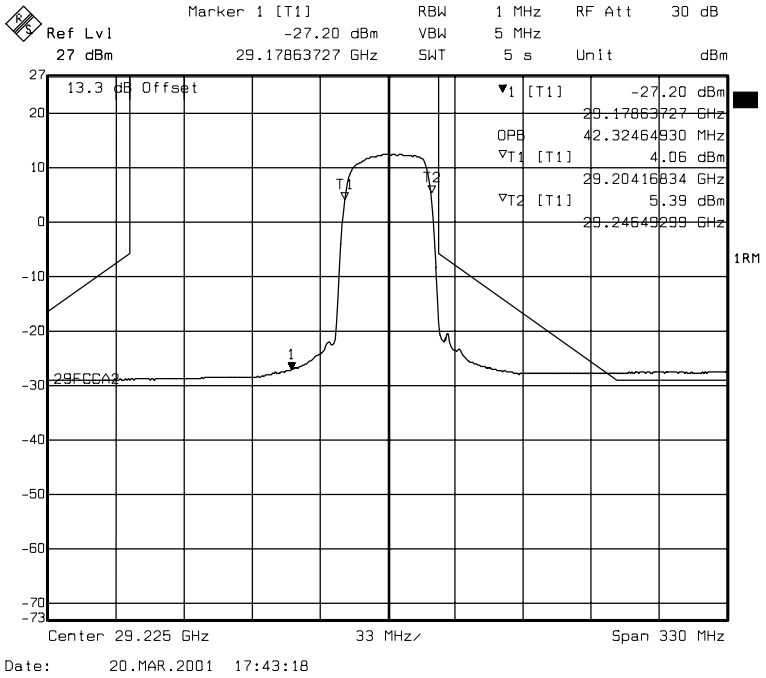
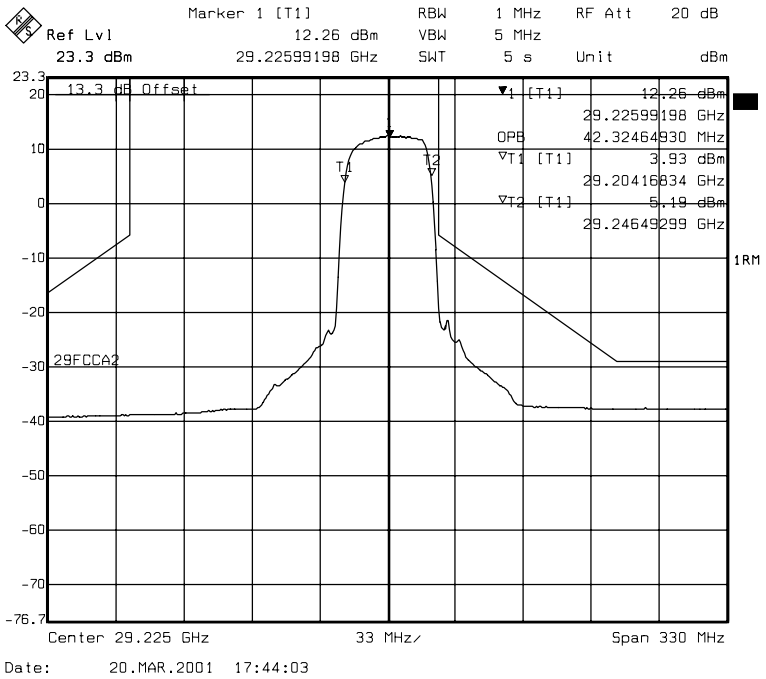


Figure 6b. 8 PSK, taken in block A2 (high end), Actual Output Power 27.18 dBm. Spectrum Analyzer attenuation reduced to show compliance of the lower skirt edges with the emission mask requirements.



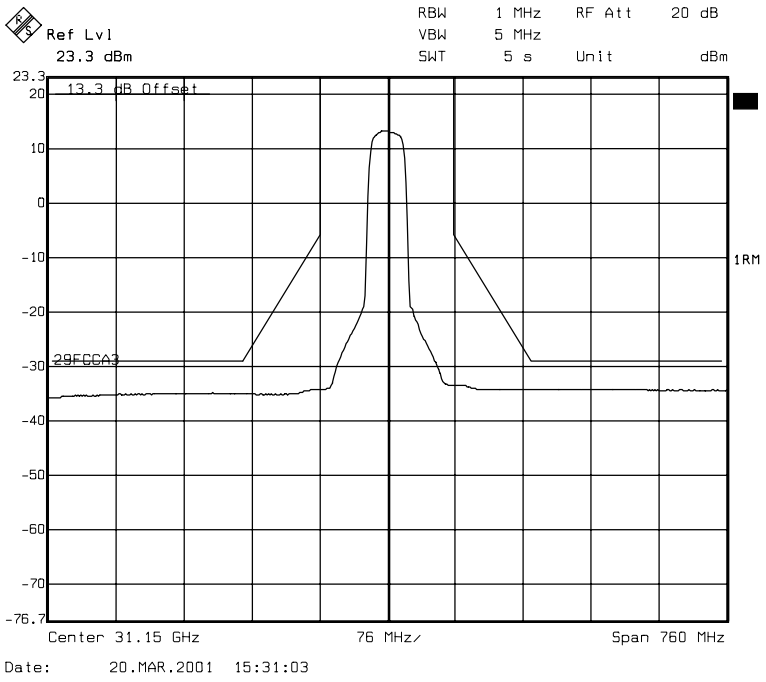
5.7 Spurious Emissions

Frequency (GHz)	Reading (dBμv)	Net Reading	Limit	Margin
No spurious emissions were detected within 56 dB from the carrier level. *				

*Measurement sensitivity was such that any signal within –56 dB from the carrier could be detected. Measurements were made conducted in the range of 1 – 220 GHz. For the frequency range from 30MHz to 1 GHz, refer to conclusion drawn in paragraph 5.8 Incidental Radiation.

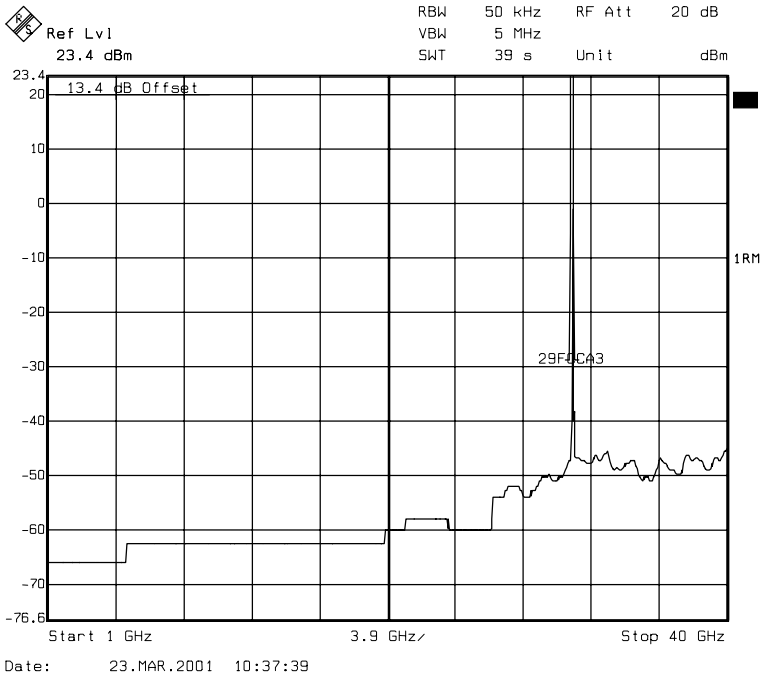
Figure 7 shows a wide band spectral display proving that the transmitter complies with the requirement of 56 dB attenuation below the carrier.

Figure 7. Wide band view around the center band. Span 760 Mhz (2 x 250 percent authorized BW)



On any frequency removed from the assigned frequency by more than 250% of the authorized bandwidth, the attenuation of unwanted signals in any 4 kHz band shall be at least 43+ 10Log(P) dB. Measurements were made conducted at the transmit output port from 1- 40 Ghz (Figure 8), and was collected with a bandwidth of 50 kHz in order to speed up measurement time.

Figure 8. Spurious emission search from 1 – 40 GHz



Measurements were made conducted at the transmitter output port from 40 - 220 Ghz,. The following plots (Figures 9 – 12) are interrupted in such manner that if the signals in the top test trace are not identical to the signals in the bottom reference trace (in frequency and amplitude) then the signals are identified as the unwanted mixer products of the test setup. No occurrences of any valid spurious signals were detected with the available instrumentation.

Figure 9. Spurious emissions search from 40-60 Ghz

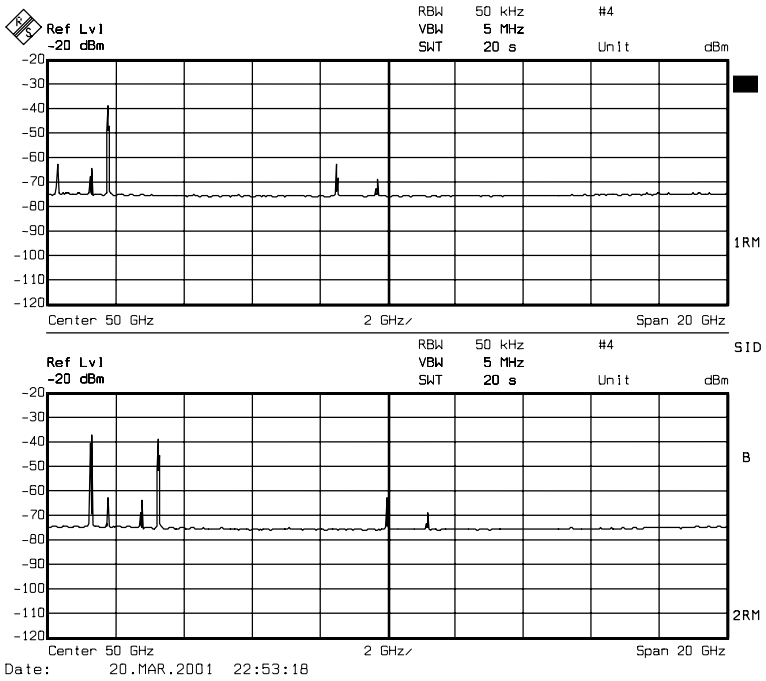


Figure 10. Spurious emissions search from 60-90 Ghz

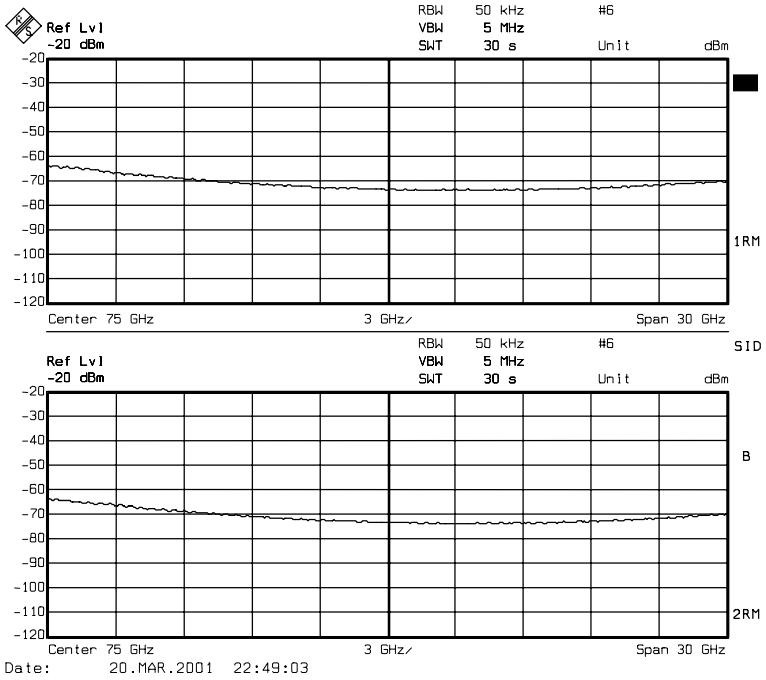


Figure 11 . Spurious emissions search from 90-140 Ghz

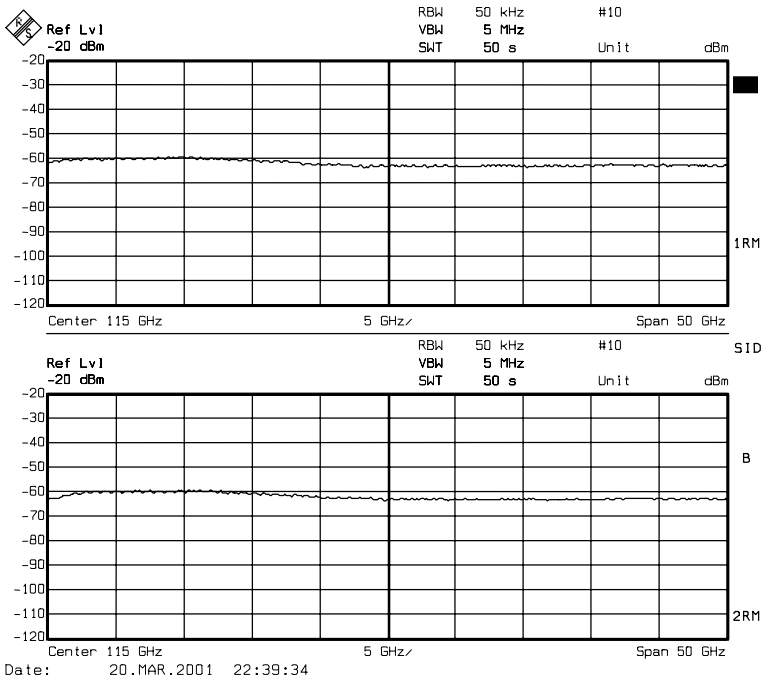
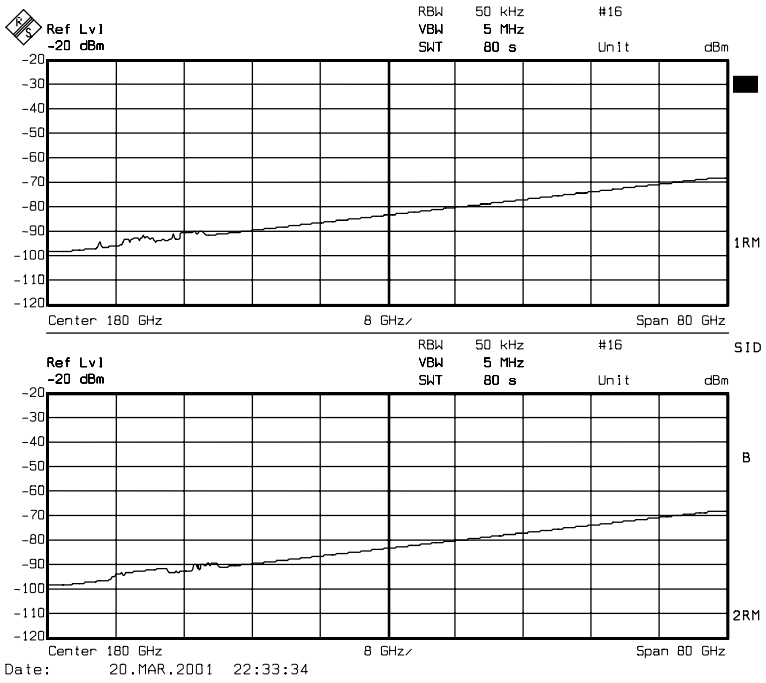


Figure 12. Spurious emissions search from 140-220 Ghz



5.8 Incidental Radiation

Triton Network Systems (TNS) engineering assessment indicates that the radio equipment models covered in this report are assembled with identical sub-assemblies, shown in shaded area of Figure A, with radio equipment that were previously tested by Intertek Testing Services (ITS) to meet FCC Part 15B / ICES-003 verification compliance for the radio equipment covered in ITS test report J20021364B.

Sub-assemblies outside the shaded area shown in Figure A are microwave & millimeter-wave frequency modules tested to radio equipment compliance under the FCC Part 101 requirements as covered in this report. In addition, all aspects of the radio equipment housing, power supply, grounding schemes and any digital / CPU clock speeds are identical between radio equipment previously tested by ITS and the radio equipment models covered in this report.

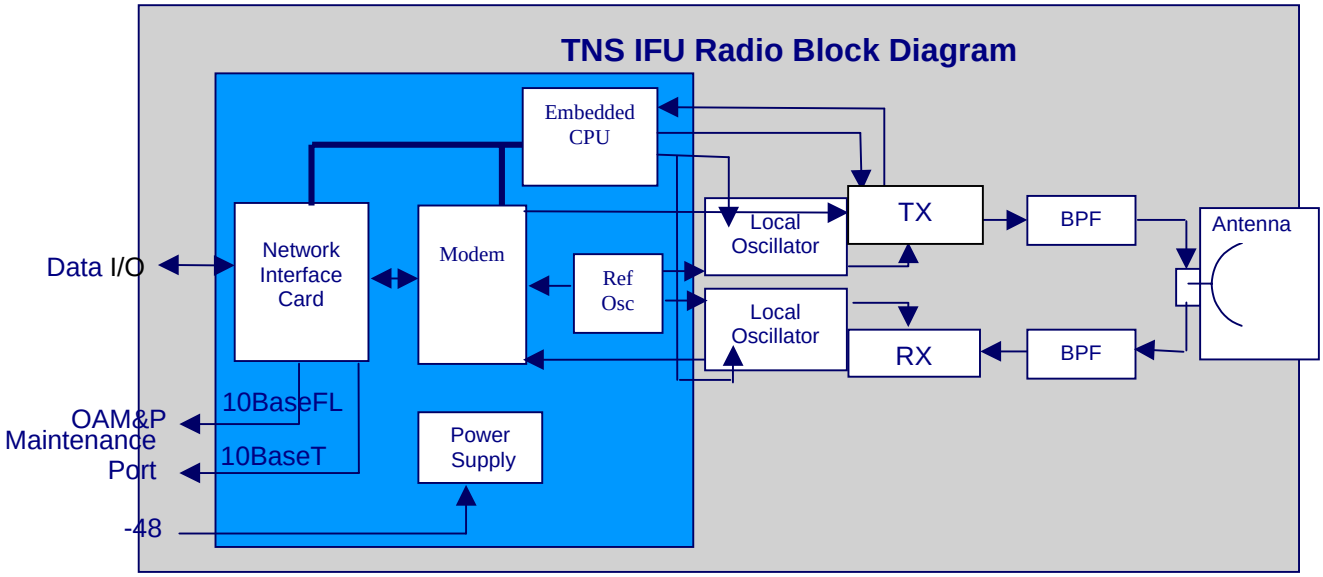


Figure A –IFU Sub-Assembly Block Diagram

5.9 RF Safety evaluation

The wireless consecutive point millimeter-wave transceiver models TNS29-ETPFE-100-XX, TNS29-ETPFE-200-XX are stationary fixed-mounted units with a maximum EIRP of 1,995 watts effective radiated power in the main lobe of the antenna. This is greater than the 1,640 watts EIRP established by the FCC for RF safety evaluation, therefore the transmitter is not excluded from environmental assessment.

The radio equipment has the following physical characteristics:

Conducted Antenna Power	27 dBm
Antenna Gain	3981.1
Maximum Antenna Dimension	34.29 cm
Minimum Operating Frequency	29.100 GHz

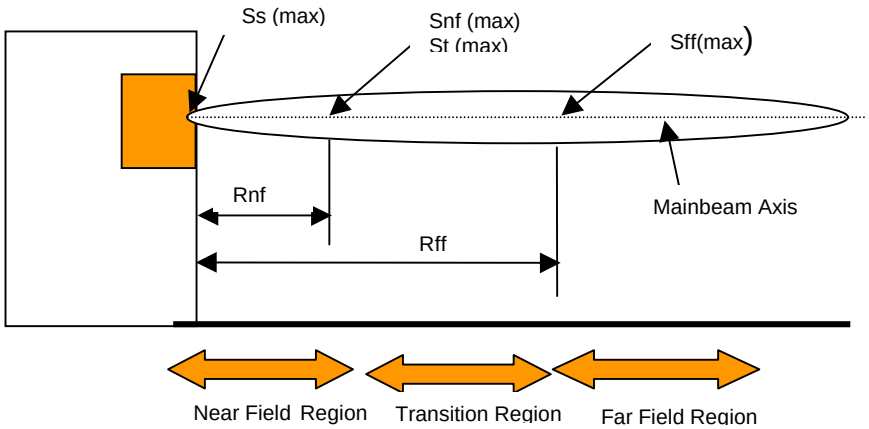
The applicable theoretical calculation per FCC OET Bulletin-65 is shown below based on physical characteristics described above.

			FCC OET Bulletin-65 (Ed. 97-01) Equation Reference
Near Field Distance from Antenna Surface (m) Rnf =	2.85		Pg 31 - (12)
Distance to Beginning of Far Field from Antenna (m) Rff =	6.84		Pg 33 - (16)
Distance to Reach 1mW / cm^2 from antenna surface (m)	2.26		Pg 33 – (17,18)
		% of MPE 5mW / cm^2	
Max Power Density at Antenna Surface (mW/cm^2) Ss =	2.17	43.42%	Pg 31 - (11)
Max Mainbeam Near-Field Power Density (mW/cm^2) Snf =	0.79	15.83%	Pg 32 - (13)
Max Mainbeam Transition-Region Power Density (mW/cm^2) St =	0.79	15.83%	Pg 33 - (17)
Max Mainbeam Far-Field Power Density (mW/cm^2) Sff =	0.34	6.78%	Pg 33 - (18)

From the above the following conclusions can be reached:

- The TNS29 series transceivers comply with the 5mW/cm^2 RF safety limits for occupational RF workers.
- A safety zone in front of the unit of at least 2.3 meters for the protection of the general public can be established by appropriate warning signs and wordings, per the applicable FCC 47 CFR 1.1307, OSHA regulation 29 CFR 1910.97 or similar successor regulation(s).
- A RF safety warning label will be presented on the transceiver. The user / installation manual provides information on the proper mounting such that a safe minimum separation distance is maintained.

MPE evaluation diagram

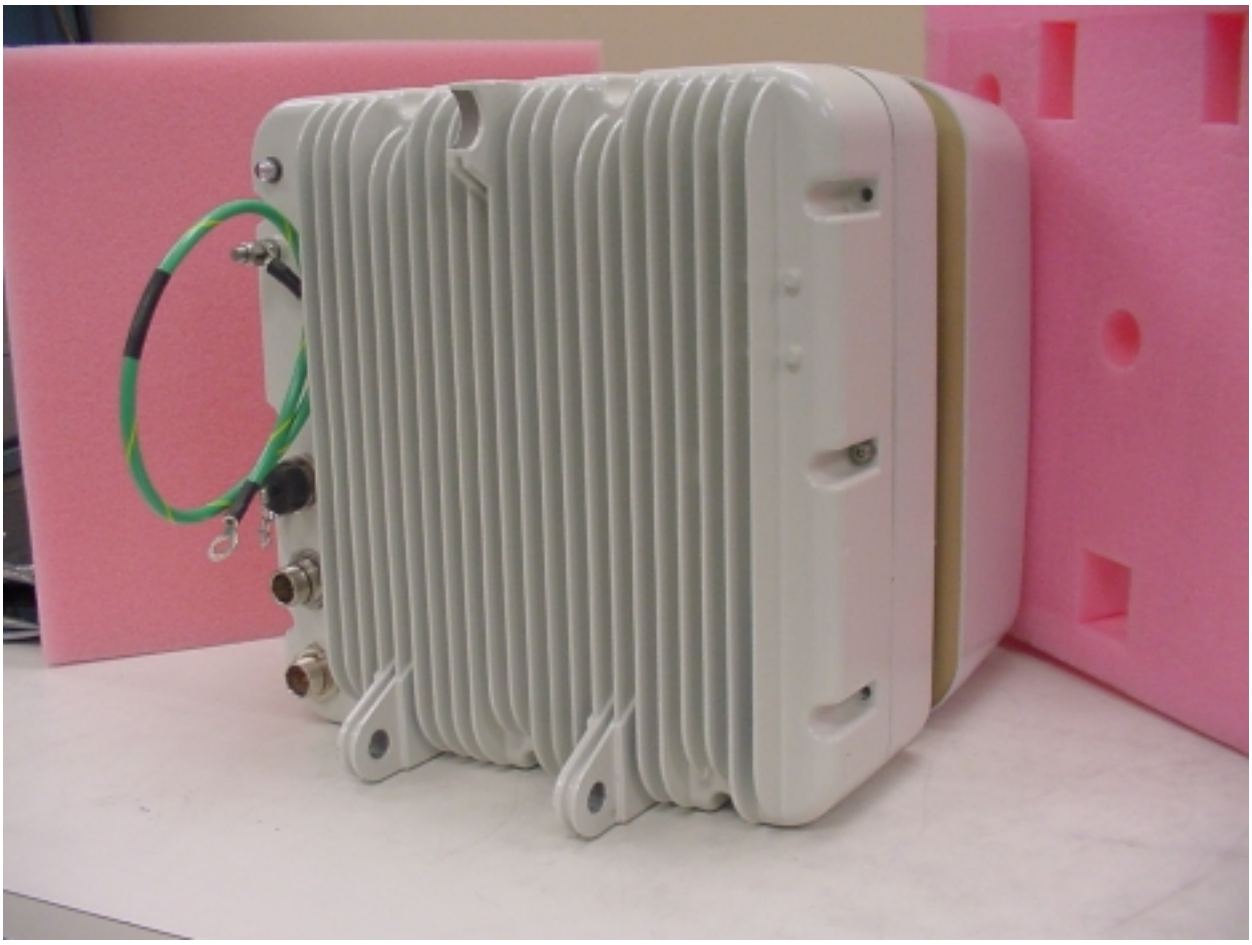


5.10 Equipment List

Equipment	Manufacturer	Model	Serial	Cal Due
Spectrum Analyzer	Rohde & Schwarz	FSEK20	1088.1491.25	6/5/01
Power Meter	Anritsu	ML2438A	97180017	1/8/02
Power Sensor	Anritsu	MA2474A	003170	7/12/01
Power Supply	Hewlett Packard	6554A	US36340103	10/6/01
Signal Generator	Rohde & Schwarz	SMP04	DE34238	4/13/01
Temp Chamber	Tenney	T10C	26790-03	9/23/01
Harmonic Mixer	OLESON MICROWAVE LABS (OML)	OMLWR05	G00620-1	N/A
Harmonic Mixer	OLESON MICROWAVE LABS (OML)	OMLWR08	F00620-1	N/A
Harmonic Mixer	OLESON MICROWAVE LABS (OML)	OMLWR12	E00620-1	N/A
Harmonic Mixer	OLESON MICROWAVE LABS (OML)	OMLWR19	U00620-1	N/A
Cable/ Attenuator assembly	-----	-----	13.3 dB loss	-----

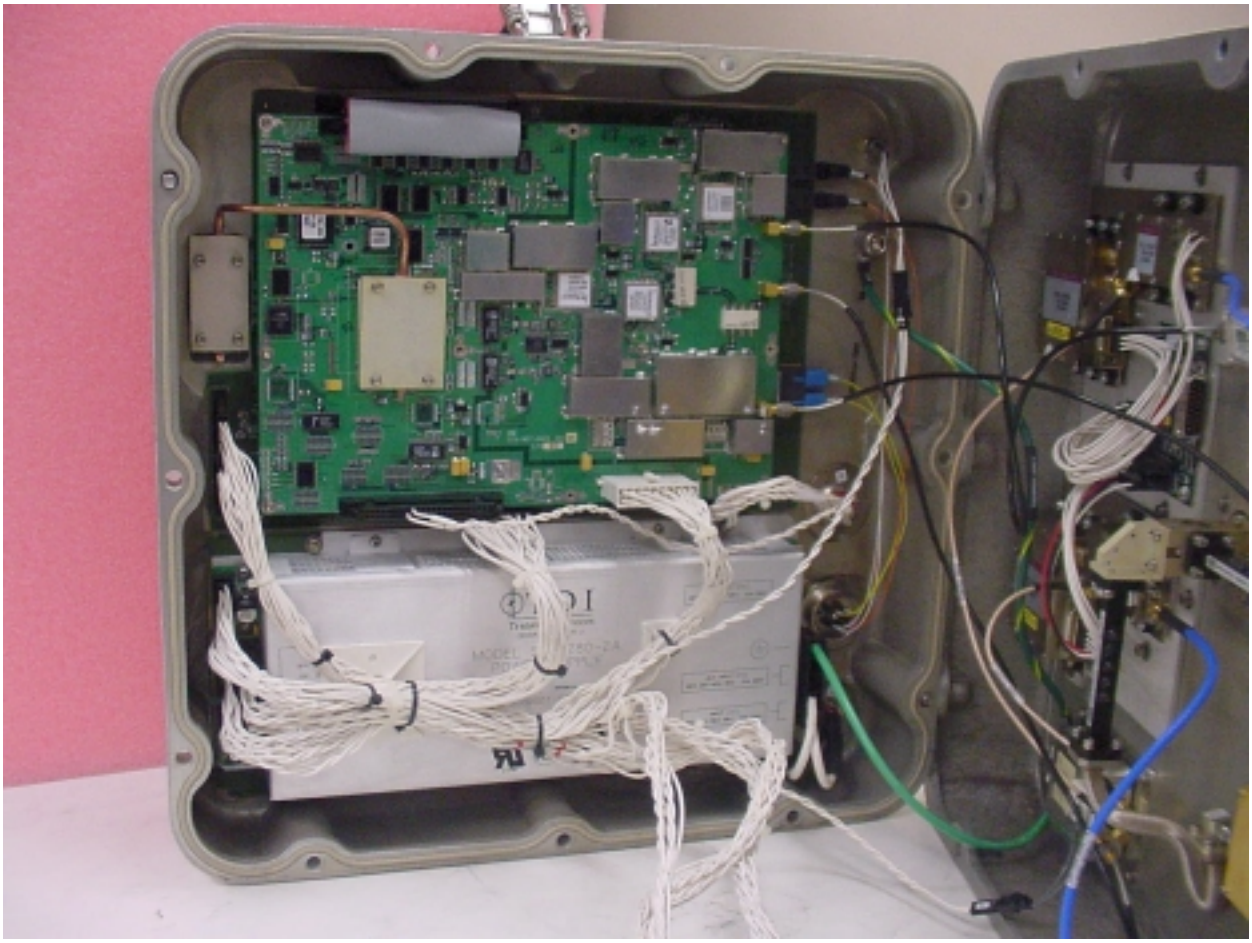
6. Photographs

Right rear view of the EUT

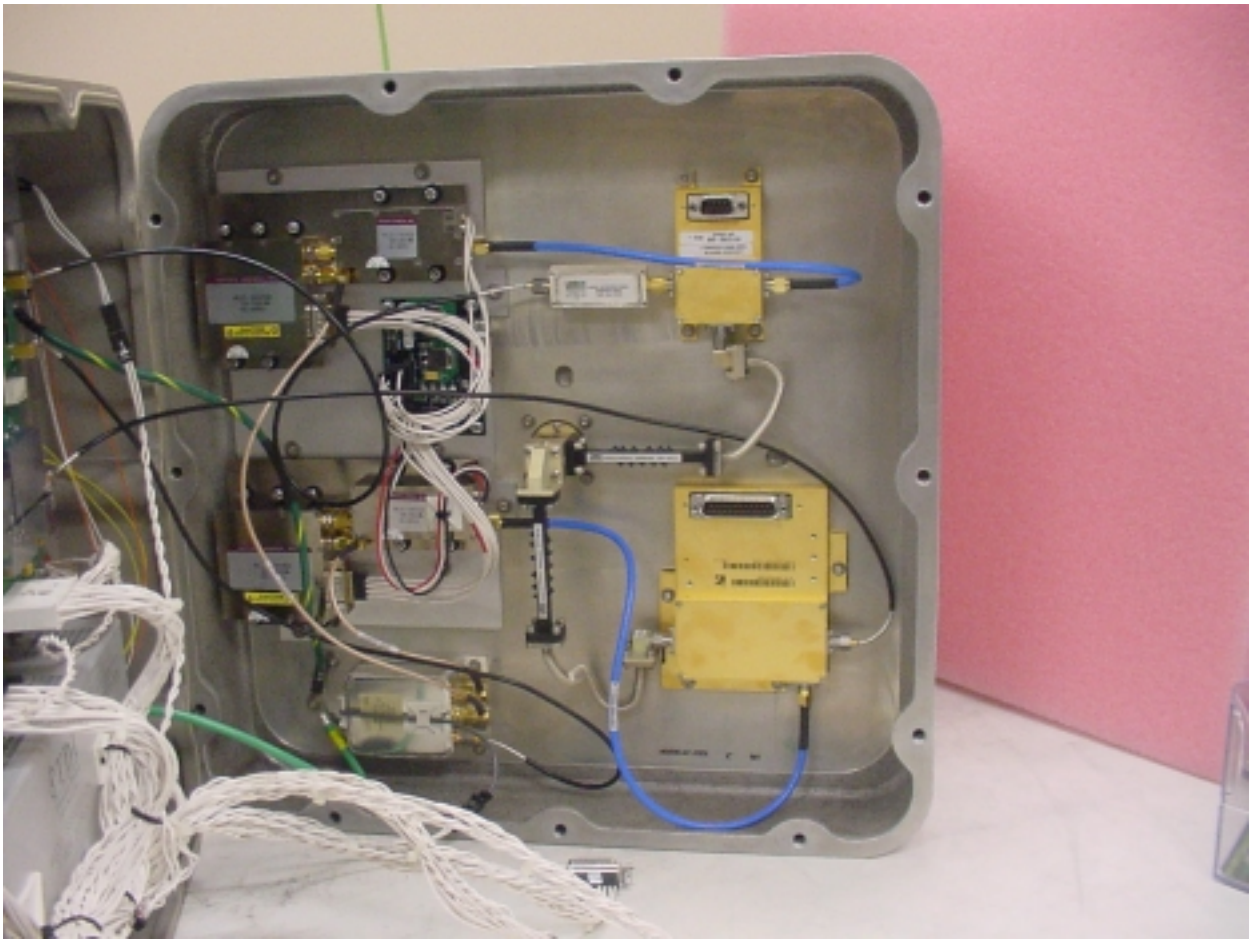


Front view of the EUT

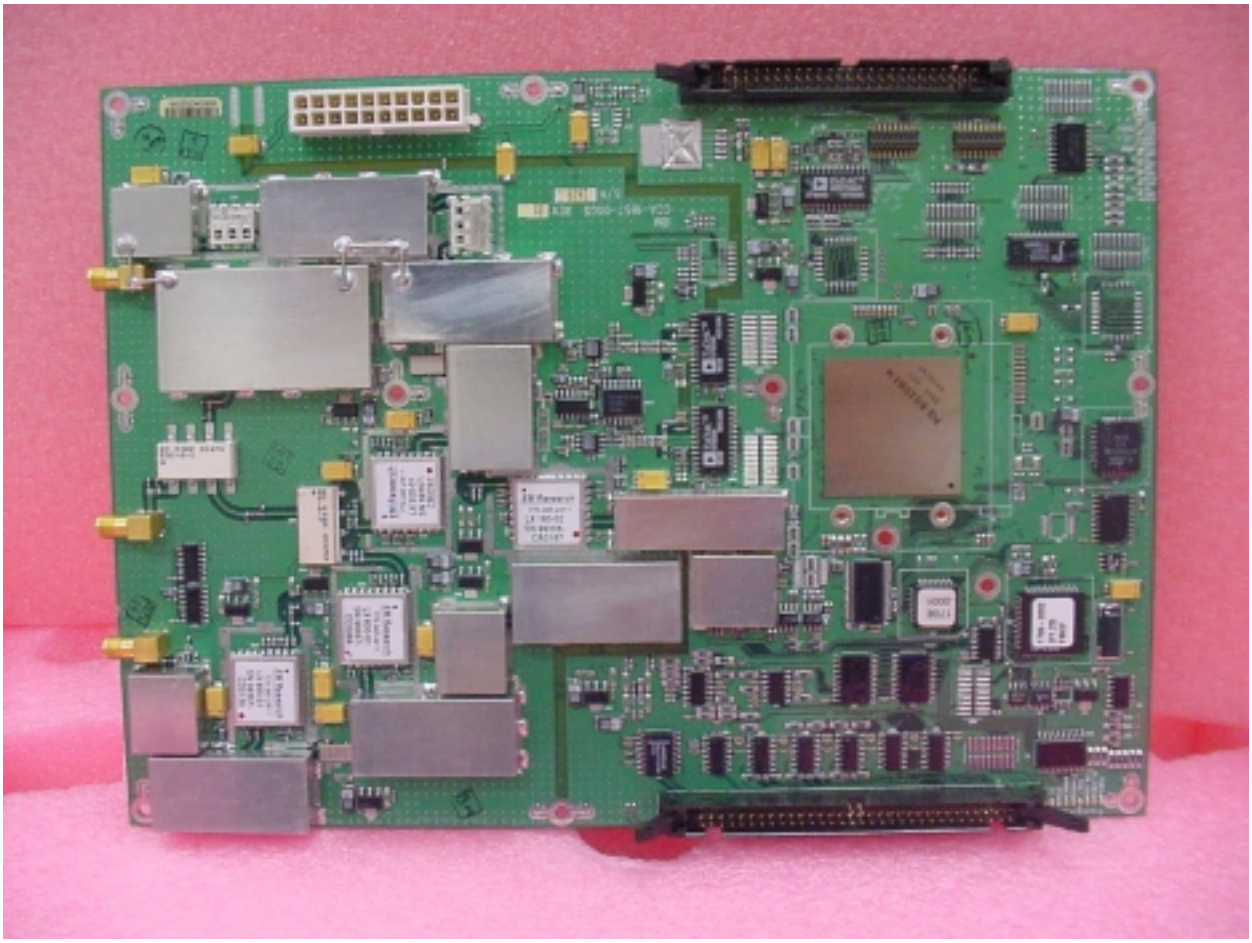
Internal photograph of CPU/NIC, Modem, Power Supply section



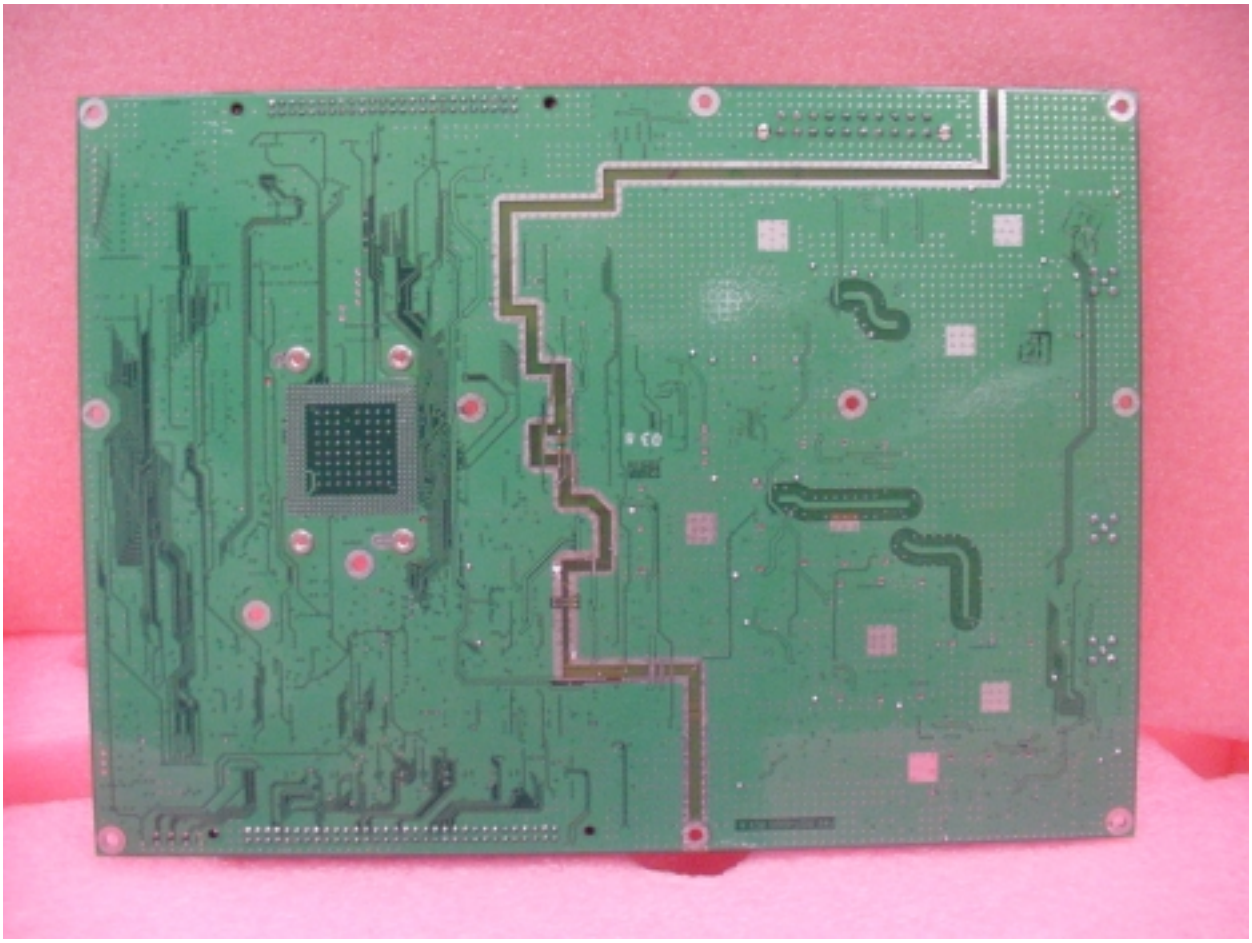
Internal photograph of transmitter, receiver, synthesizer, and filter/attenuator section



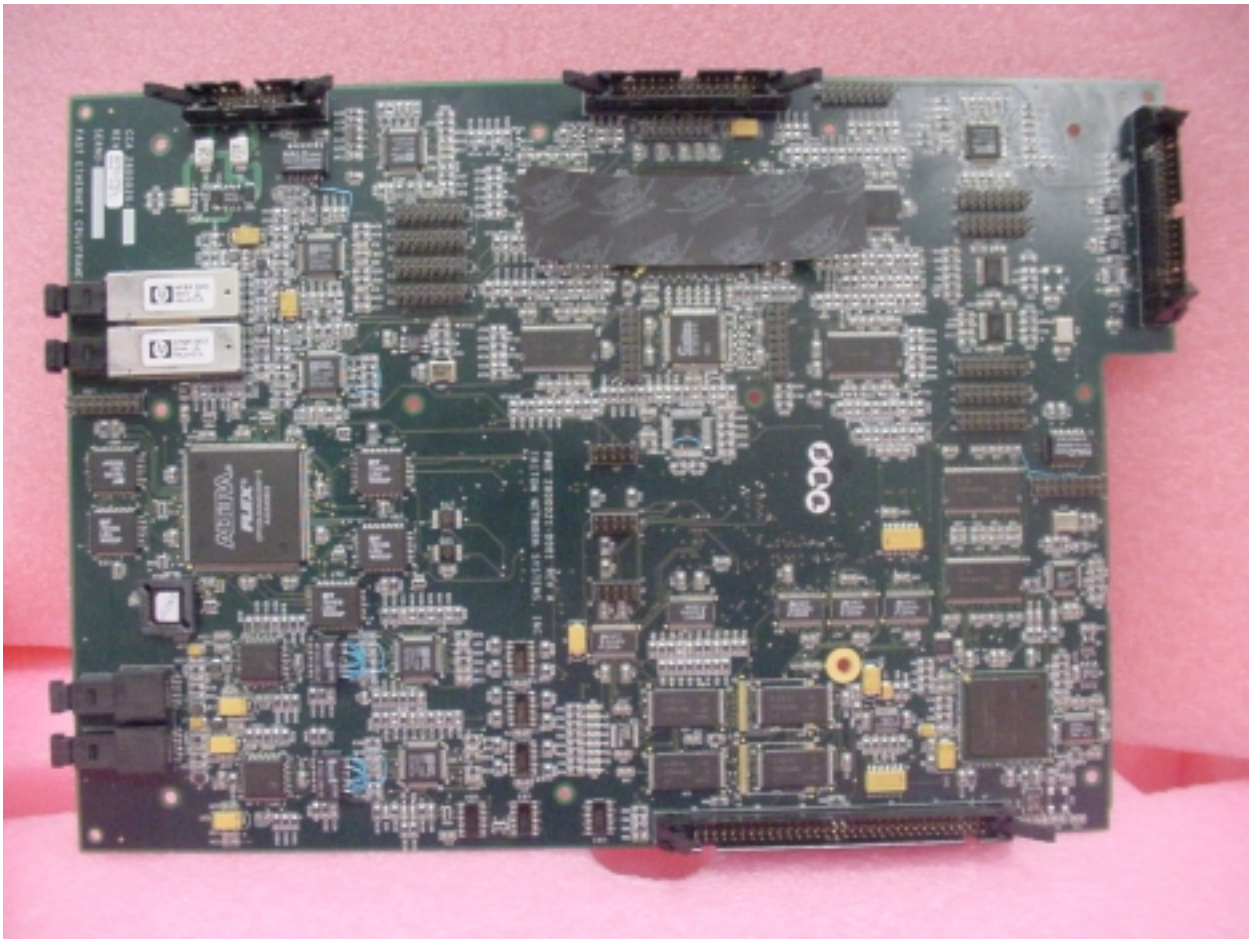
Top view Modem board



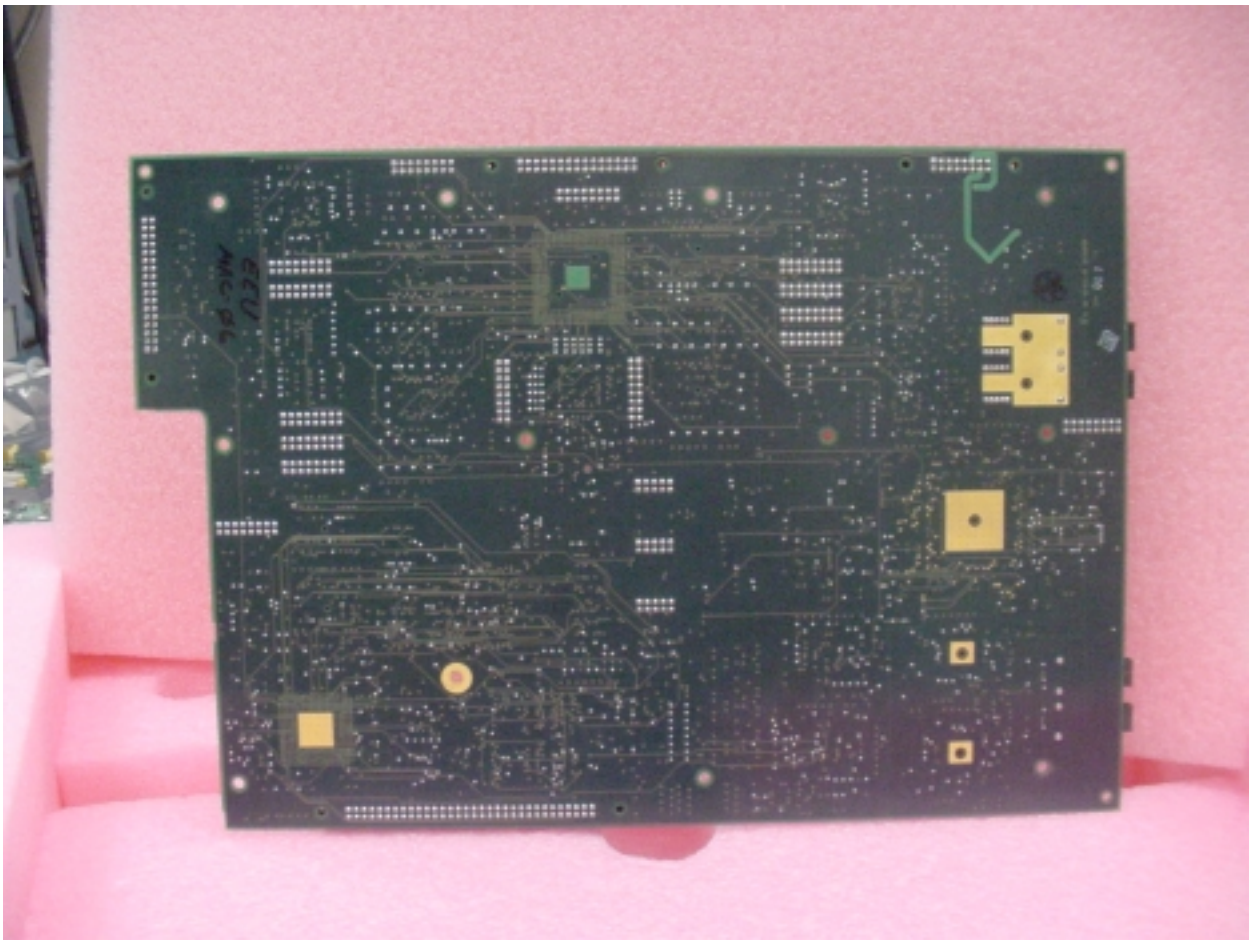
Bottom view Modem board



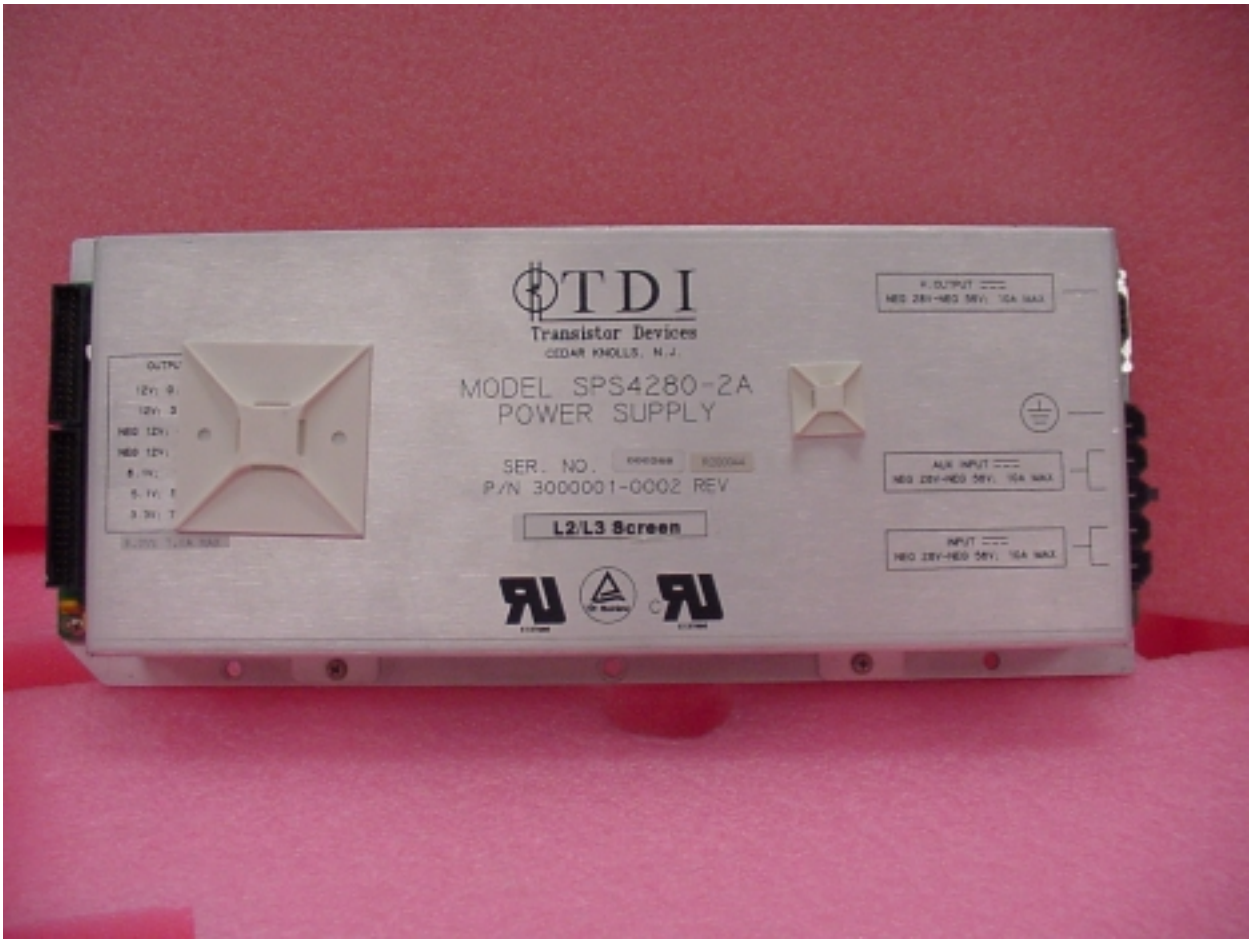
Top view of CPU/NIC board



Bottom view of CPU/NIC board



Top view Power Supply



Bottom view Power supply