ITS Intertek Testing Services

FCC Part 101 Certification
for

Triton Network Systems, Inc.

28 GHz Fast Ethernet
Wireless Consecutive Point to Point
Millimeter-Wave Transceiver
Models: TNS-28-ETP-FE-100, -200, -300, -400, -500, -600
FCC ID: OQT28ETP-FE-02

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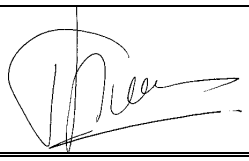
Function	Contractor	Function	ITS Team leader
Report date	August 25, 2000	Review date	
Signature		Signature	

Table of Contents

1. Introduction

On August 21 through 24 we tested the 28 GHz Fast Ethernet Wireless Consecutive Point to Point Millimeter Wave Transmitter System, Models:

TNS-28-ETP-FE-100,
TNS-28-ETP-FE-200,
TNS-28-ETP-FE-300,
TNS-28-ETP-FE-400,
TNS-28-ETP-FE-500,
TNS-28-ETP-FE-600

to determine if they were compliant with the FCC Part 101 emission standard.
The difference between the models rests only on the selection of wave guide filters for the appropriate bands. We found that the units met the applicable requirements when tested as received.

2. Product Description

The 28 GHz Fast Ethernet 3 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 bit pipe, similar to a bi-directional optical regenerator. The radio replicates data without regard to content.

The 28 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 radios are designed to be installed by operators on building rooftop, towers, or other suitable structures to provide high-bandwidth communication links. Operators can use linked radios to provide broadband fixed wireless technology services to an entire metropolitan service without using fiber optical cable.

2.1. Multiple list/ Family information

Part number coding					Transmit Frequency Band
TNS	FF	PPA	BB	XXX	
TNS	28	ETP	FE	100	27.500 GHz to 27.700 GHz
TNS	28	ETP	FE	200	27.700 GHz to 27.900 GHz
TNS	28	ETP	FE	300	27.950 GHz to 28.150 GHz
TNS	28	ETP	FE	400	28.150 GHz to 28.350 GHz
TNS	28	ETP	FE	500	27.500 GHz to 27.850 GHz
TNS	28	ETP	FE	600	28.000 GHz to 28.350 GHz

2.2. Frequency Availability
The frequencies available for this particular device operating under FCC rules, Part 101.101 as:

Radio Services	Frequency Band (GHz)	Applicable Subparts	Note
Common Carrier (Pt 101)	27.500 – 28.350	C and L	

The units are intended to operate in the 50 MHz wide paired channel blocks as described on FCC rules part 101.147 with two radios forming a bi-directional link.

2.3. **Block Diagram of the product**

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3. Summary of Tests and results

Test Performed	Reference	Pass/Fail Criteria
Frequency Availability	101.101	Pass
Frequency Tolerance and Frequency Stability	101.107	Pass
Bandwidth	101.109	Pass
Occupied Bandwidth	2.1049	Pass
Emission Limitations (Mask)	101.111	Pass
Transmitter Power Limitations	101.113	Pass
RF Safety assessment	1.1307	Performed

4. Test plan

4.1. General

All testing will be performed by or under supervision of ITS test personnel, using ITS 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 requirement for transmitters in the 27.5 – 28.35 GHz range as 0.001% of the transmitter frequency over the temperature range of –30 to +50 degrees Celsius and 85% to 115% of the nominal supply voltage range.

Four vendors for the basic reference oscillator in the product are contemplated, however not all are available at this moment. Only the stability of the available reference oscillators will be tested by measuring the transmit frequency over the specified voltage and temperature range. When further vendors for the reference oscillator become available, subsequent stability tests must be performed and documented.

4.3. Output power

FCC rules Part 101, Section 113 requires that the output power of the transmitter does not exceed 55dBW 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 over the allocated frequency band from 27,500 MHz to 28,350 MHz in the low end, the middle and the high end of the band for all operating modes of the transceiver.

4.4. Bandwidth

The spectral output of the transceiver will be measured in the low end of the band, approximately in the middle of the band and at the high end of the band, for each of the different models and/or modulation schemes and at the nominal power rating(s) 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 in the low end of the band, approximately in the middle of the band and at the high end of the band 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 1 Watt (30 dBm).

4.6. Spurious emissions

Radiated spurious emissions will be measured at a distance of 1 or 3 meters from the product in the frequency range for 30 MHz to 200 GHz. For the frequency range above 40 GHz, external mixers connected to standard gain horns will be used to down convert the frequency and only radiated measurements will be made.

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 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 a mobile device. A determination will be made if the transceiver is categorically excluded from MPE evaluation or not. If an MPE evaluation is required, the theoretical calculations of the safety zone will be made and an experimental test will be made to substantiate these calculations.

5. Test results

5.1. General

The Triton 28 GHz Fast Ethernet transceiver was tested at the facilities of ITS Boxborough from August 21 to August 23, 2000. 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 RSS191. Note that FCC rules, part 101 do not require specific frequency stability for the 38.6 to 40 GHz band.

Frequency Range (MHz)	Frequency Tolerance
27350 - 28500	0.001 percent

Table 1. Frequency Stability versus Voltage

Maximum Allowed Frequency Deviation (Hz): 273500				
Voltage (VDC)	**Reference Frequency (Hz)**	**Measured Frequency (Hz)**	**Deviation (Hz)**	**Pass/Fail**
40.8	28,274,987,222	28,274,987,275	53	Pass
48	28,274,987,222	----------	-------	-------
55.2	28,274,987,222	28,274,987,268	46	Pass

Table 2. Frequency Stability versus Temperature

Maximum Allowed Frequency Deviation (Hz): 273500				
Temperature (°C)	**Reference Frequency (Hz)**	**Measured Frequency (Hz)**	Deviation (Hz)	Pass/Fail
-30	28,274,987,222	28,274,988,011	789	Pass
-20	28,274,987,222	28,274,987,890	668	Pass
-10	28,274,987,222	28,274,987,884	662	Pass
0	28,274,987,222	28,274,987,671	449	Pass
10	28,274,987,222	28,274,987,430	208	Pass
20	28,274,987,222	----------	-------	-------
30	28,274,987,222	28,274,987,049	-173	Pass
40	28,274,987,222	28,274,986,888	-334	Pass
50	28,274,987,222	28,274,986,588	-634	Pass

5.3. Output power

FCC rules Part 101, Section 113 requires that the output power of the transmitter does not exceed 55dBW IERP, with the additional stipulation that no higher power 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 11.83 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.

The numerical gain of the antenna (according to the manufacturer) is 3981.1 or 36 dB 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 1 Watt (30 dBm) that is programmed into each individual transmitter as a factory setting. The output power can be varied over a range of at least 50 dB.

Table 3. Transmitter maximum output power

Modulation	**Frequency (MHz)**	**Measured Power (dBm)**	**Calculated EIRP based on 36 dB antenna gain (dBW)**	**IERP Limit (dBW)**	**Pass/Fail**
8PSK	27,525	29.38	35.38	55	Pass
8PSK	27,775	29.70	35.70	55	Pass
8PSK	28,325	30.40	36.40	55	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 this spectrum analyzer.

Table 4. Occupied Bandwidth

Mode	Frequency (MHz)	Authorized BW (MHz)	Measured Occupied Bandwidth (MHz)	Detail information	Pass/Fail
8PSK	27525	850	43.58	Figure 2	Pass
8PSK	27775	850	43.58	Figure 3	Pass
8PSK	28325	850	43.58	Figure 4	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:

Emission designator	Value
Necessary Bandwidth – This may be calculated using the formulas of 2.202 or if that is not possible with the occupied bandwidth	43M6
First Symbol – Type of modulation of the main carrier	G
Second Symbol – Nature of signal(s) modulating the main carrier	1
Third Symbol – Type of information be transmitted	D

5.6. Emission Limitation (Mask)

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

Table 5. Emission Limitations Mask Schedule

Percentage Shift From Center Frequency	**Attenuation Equation From Part 101.111.2(ii)**	**Attenuation Below Center Frequency Peak (dBc)**	**Spectrum Analyzer RBW**
0 to 50	None	0	1 MHz
50 to 250	11 + 0.4(P-50) + 10 Log B	28 to 56	1 MHz
Greater than 250	43 + 10 Log(P_o)	43	4 kHz

P = Percent removed from the carrier frequency.
B = Authorized bandwidth in MHz.
P_o = Mean output power in Watts.
Attenuation greater than 56 dB is not required.
For a 1 Watt system: 43 + 10Log (1) Watts) = 43 + 0 = 43 dB.

Note: Emission mask plots shown in Figures 2 through 7 on the following pages show compliance of the EUT with the emission 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 11.83 dB at 27.5 and 28.5 GHz. 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 50 MHz authorized bandwidth as outlined in FCC part 101.109 and a nominal output power of 1 Watt (30dBm)

Percentage 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 - 425
50	11 + 0.4(P-50) + 10 Log B	40.3	425
89.25	11 + 0.4(P-50) + 10 Log B or 56	56	758.625
250	11 + 0.4(P-50) + 10 Log B or 56	56	2125
Greater than 250	43 + 10 Log(P_o)	43	>2125

Figure 8 shows a wide band spectral display proving that the transmitter complies with the requirement of 56 dB attenuation below the carrier level.

Figure 1. FCC mask for the 28 GHz band

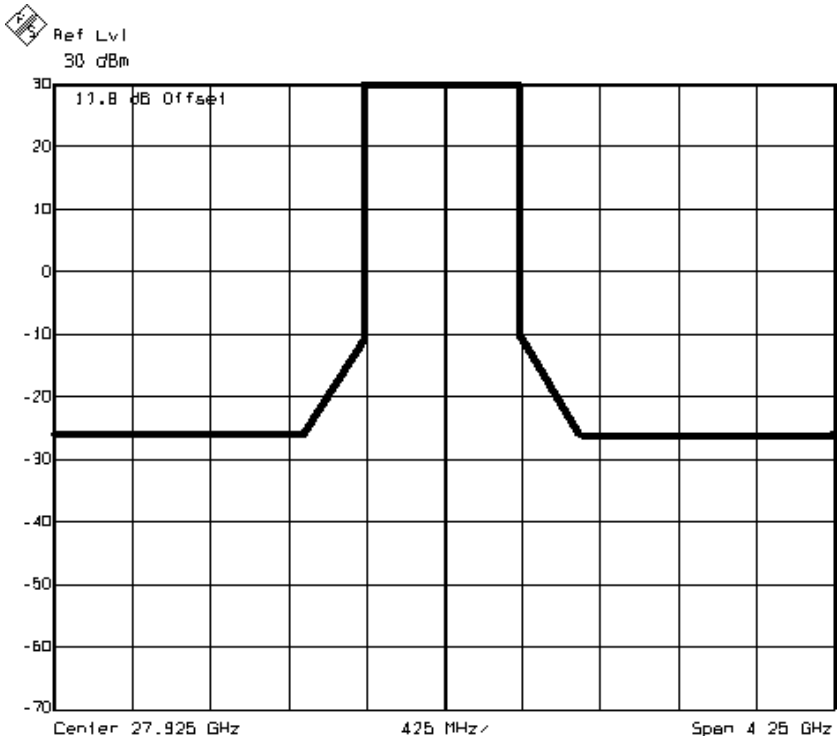


Figure 2. – 8PSK, 1Watt output at the lower band edge. Actual output power 29.38dBm

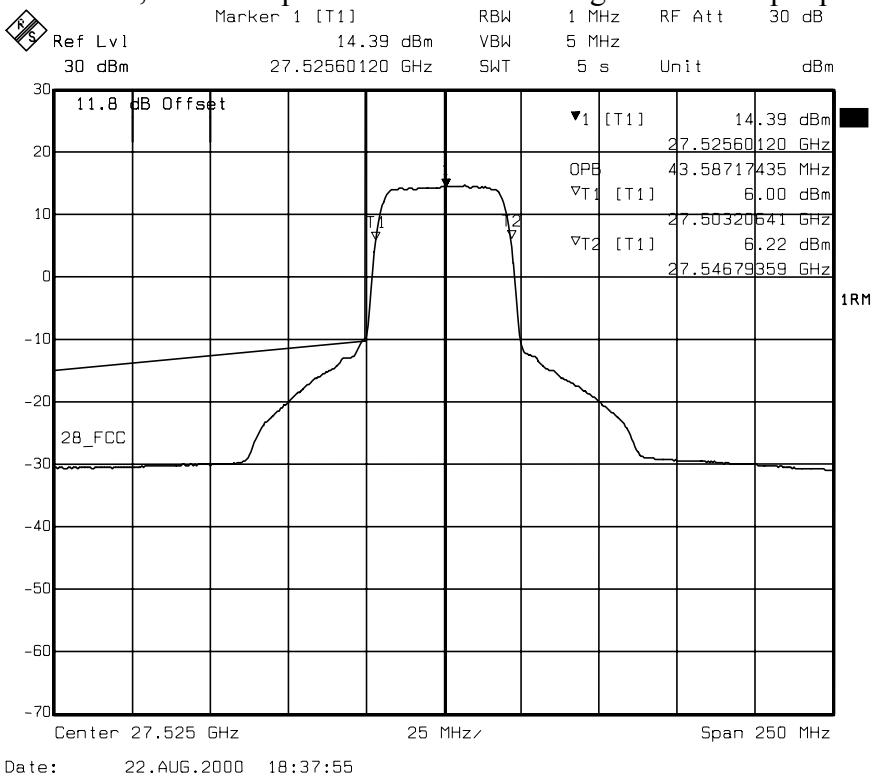


Figure 3. – 8PSK, 1Watt output at the middle of the band. Actual output power 29.7 dBm

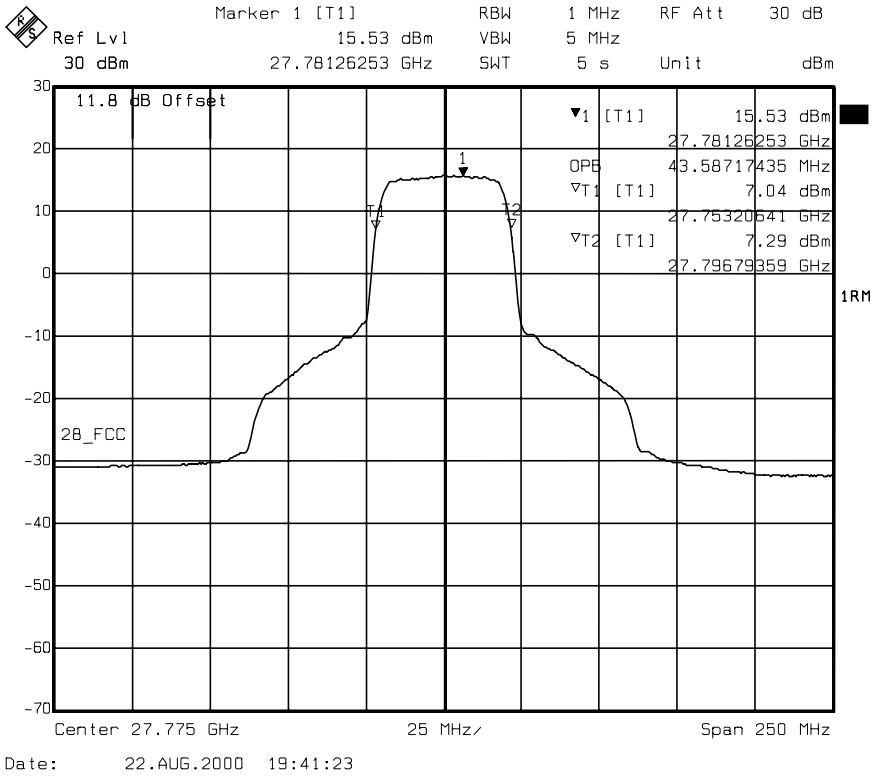


Figure 4. – 8PSK, 1Watt output at the top of the band. Actual output power 30.40 dBm

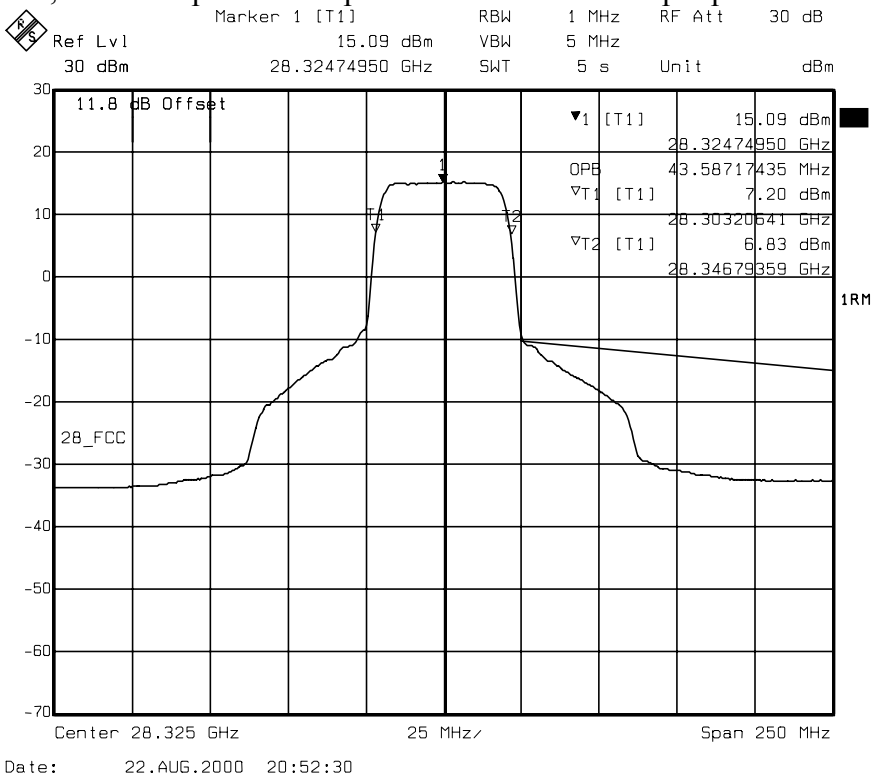


Figure 5. Wide band view around the center of the band

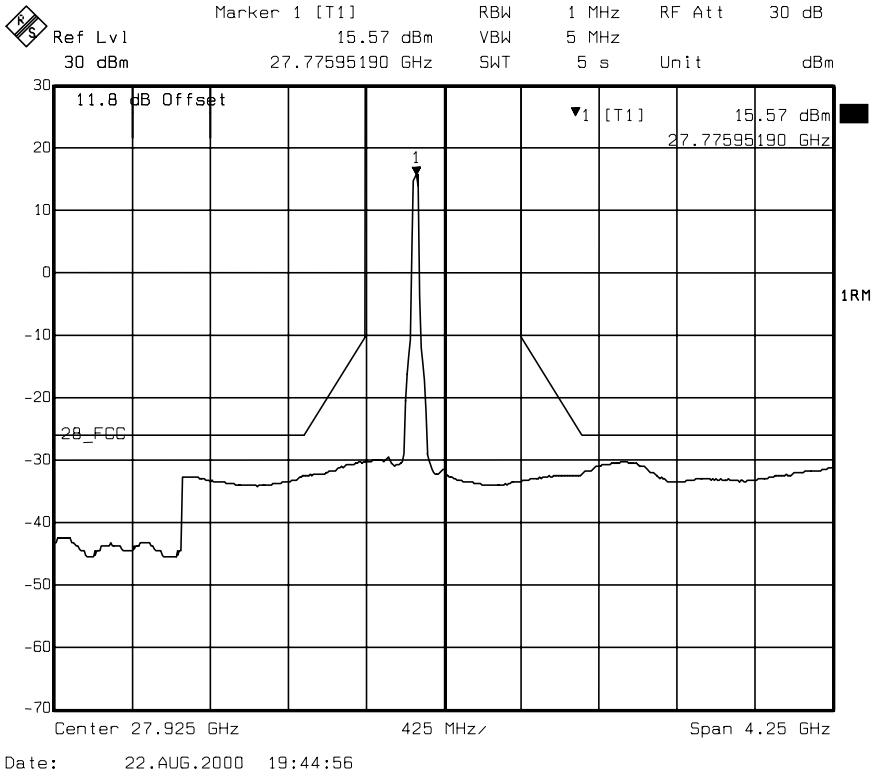


Figure 6. Spurious scan on transmitter output 30 – 40 GHz

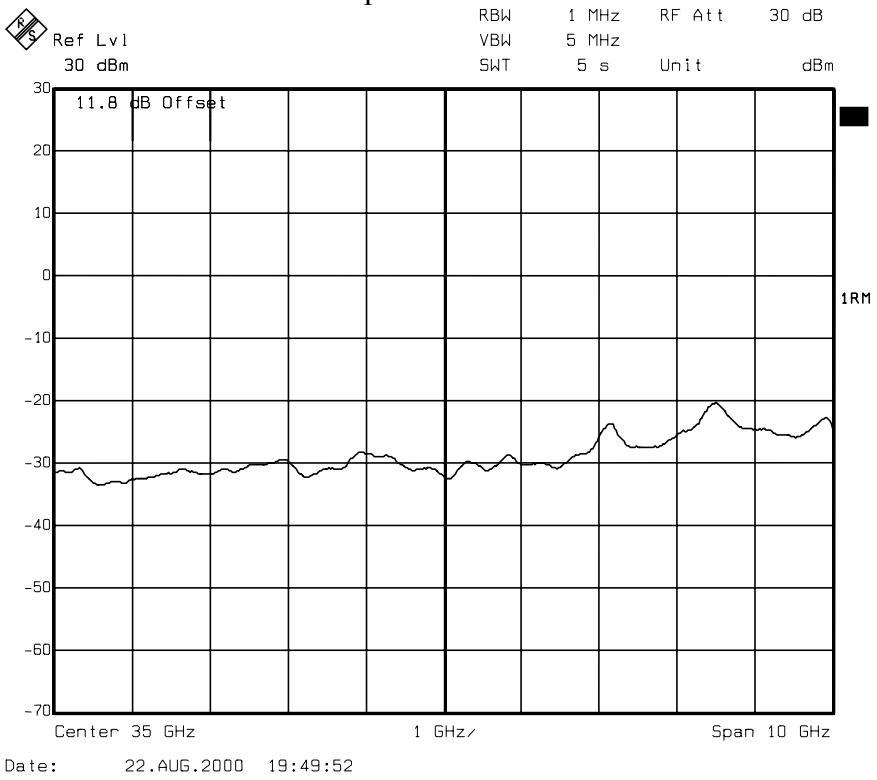


Figure 7. Spurious scan on transmitter output 20 –30 GHz

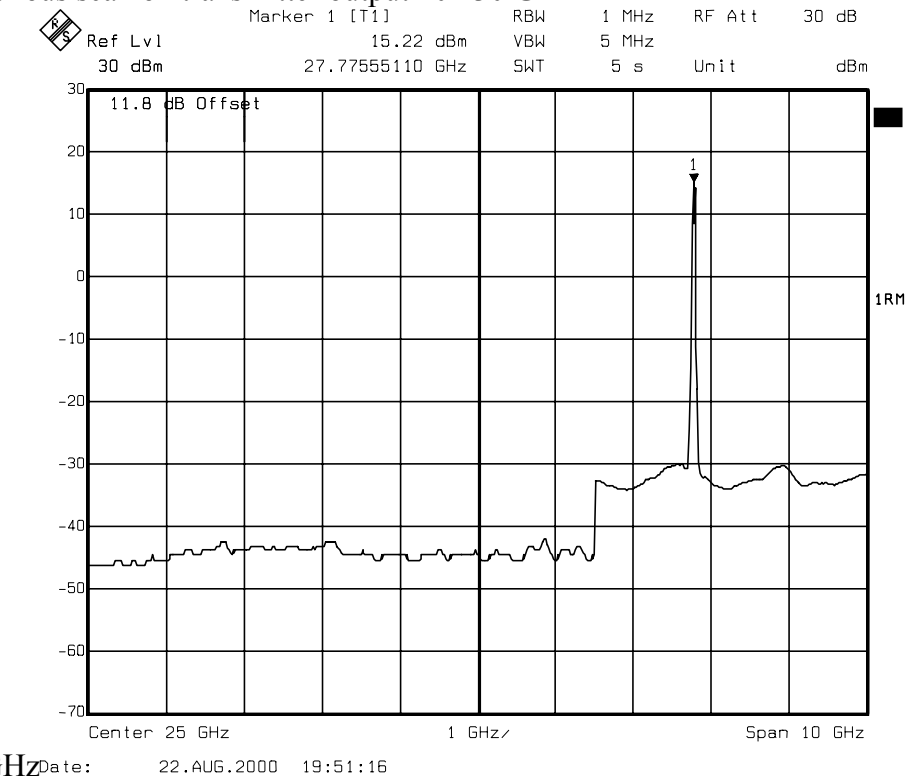


Figure 8. Spurious scan on transmitter output 10 - 20 GHz

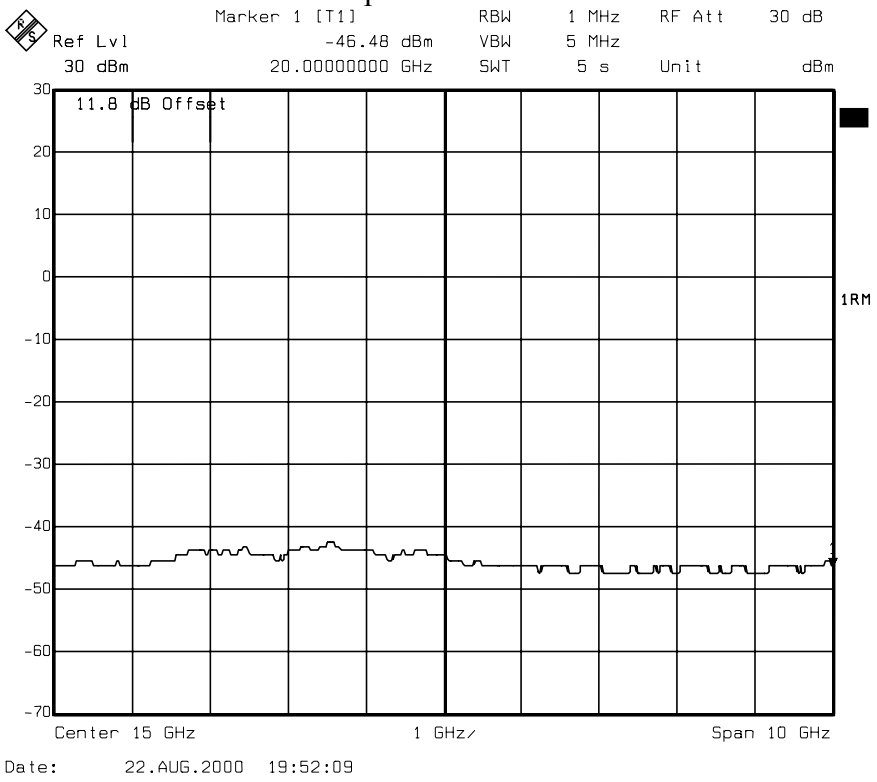
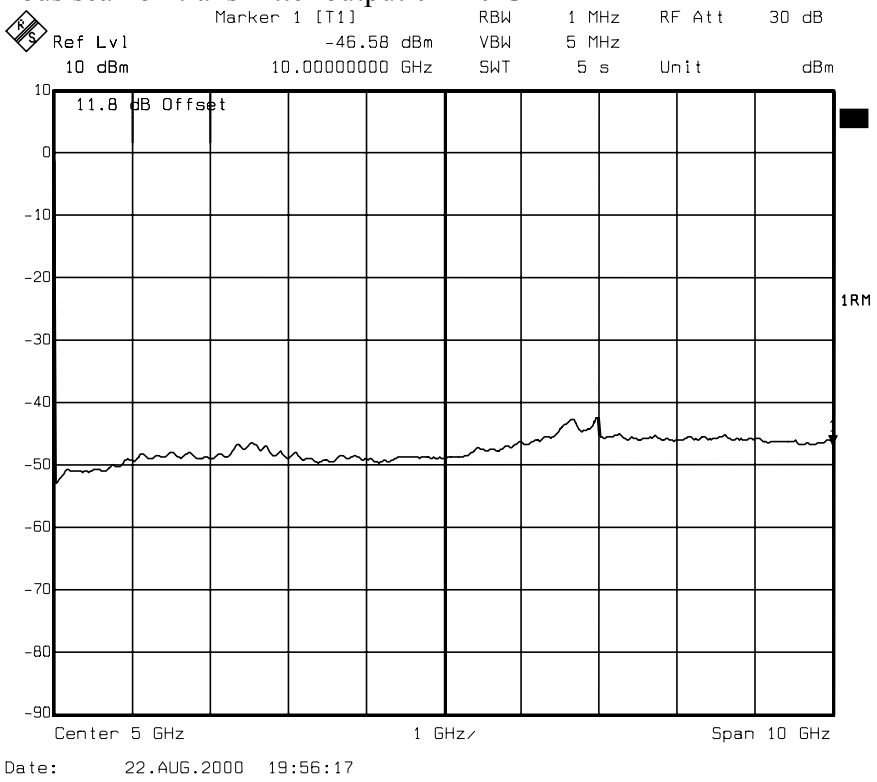


Figure 9. Spurious scan on transmitter output 0 – 10 GHz



5.7. Incidental radiation

The Triton Network Systems 38 GHz Fast Ethernet transceiver meets the requirements of FCC Part, Class B for incidental radiators. A full report substantiating that is available under ITS report J20019792B

5.8. RF Safety evaluation

The Wireless Consecutive Point to Point Millimeter-Wave Transceiver models TNS-28-ETP-FE-100, -200, -300, -400, -500 and -600 are stationary, fixed-mounted units with a maximum EIPR of 36 dBW or 7943 Watt effective radiated power in the main lobe of the antenna.
This is more than the 1640 W EIRP threshold established by the FCC for RF safety evaluation, therefore the transmitter is not categorically excluded from MPE evaluation.
Based on the following physical characteristics

Conducted antenna power	1 Watt
Antenna Gain	3981.1
Maximum antenna dimension	34.5 cm

and the theoretical formulas FCCC OET 65, the following RF safety parameters can be calculated for operation on 28 GHz:

1. Transition between near and far field; $0.5D^2/\lambda$ is 5.55 meters
2. Maximum near field power; 4P/A is 33.6 W/m^2
3. Power density at the far field transition point; $S=PG/(4.\pi.R^2)$ is 10.28 W/m^2
4. Distance for power density to equal 10 W/m^2 ; $PG/(4.\pi.R^2)$ is 5.63 meters.

Experimentally we determined that the field strength as measured with a broadband E-field probe closely followed the theoretical predictions. The results are tabulated below:

Distance (m)	E-field (V/m)	Calculated IERP (W/m2)	Theoretical far field (W/m2)
5.0	71	13.37	na
5.3	63	10.52	na
6.8	50	6.63	6.85

From the above, the following conclusions can be reached:

- The Triton TNS 28 series transceivers comply with the 50 W/m^2 RF safety limits for occupational RF workers.
- A safety zone in front of the unit of at least 6 meters for the protection of the general public needs to be established.
- A RF safety-warning label needs to be present on the transceiver. The user/installation manual needs to provide information on the proper mounting such that the safety zone is maintained.
- When multiple antennas are installed in the same location, a RF exposure assessment will have to be made at the time of installation.

6. Equipment list

The following equipment was used for radiated and conducted emissions testing in accordance with FCC Part 101.

Table 7. Equipment List

Equipment	Manufacturer	Model	Serial	Cal Due
Spectrum Analyzer	Tektronix	2784	B010153	02/03/00
Spectrum Analyzer	R&S	FSEK	1088.1491.25	05-jun-2001
Horn Antenna	EMCO	3116	2090	15 mar 01
Harmonic Mixer	MILLITECH	MHB-10-R00W0 75-110GHz	015	N/A
Harmonic Mixer	MILLITECH	MHB-15-R00W0 50-75GHz	019	N/A
Harmonic Mixer	MILLITECH	MSH-05-8FDCSN 140-220GHz	017	N/A
Harmonic Mixer	MILLITECH	MHB-06-R00WN 110-170 GHz	022	N/A
Harmonic Mixer	MILLITECH	MHB-22-R00W0 33-50GHz	013	N/A
Wattmeter	HP	437 B	3125U23390	7/7/01
Wattmeter probe	HP	8487A	1093452G	6/6/01
Attenuator	Weinschel	54-20	09632	--
K-connector cable,10’	--	--	10.4	--
K-connector cable, 10’	--	--	10.6	--
K-connector cable, 18”	--	--	CBL001	11/03/00
Temperature chamber	Watlow	Series 1500	--	--
Power supply	HP	6554A	3844A00845	28/04/01
E field probe	AR	FP2080	21150	9-aug-2000

7. Photos of the EUT

See Separate files

8. Additional Materials

8.1. Final RF amplifier diagram

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8.2. Bill of Materials

The following list gives the part numbers for the major assemblies present in the equipment as tested. Only where multiple vendors for the same part are contemplated, the vendor or other identifier for the specific part is listed.

Description	Triton part number
Reference Oscillator	3100000-1001
Transmitter Module	3328730-1000, 0001
Receiver Module	3228780-1000, 0001
Exciter assembly	2528002-0001 2528001-0001
Antenna assembly	2300004-0001
IF filter	2600000-0001
Wave guide filters	2628001-0001,2,3,4,5,6 2600001-0001,2
Power supply	3000001-0002
Network Interface card (ENET)	2800040-1001
Modem	2700000-0002