Introduction

The following information is submitted for the Certification of the TRU3-1900 Transceiver by Northern Telecom, Inc., in accordance with Part 24, Subpart E and Part 2, subpart J of the FCC Rules and Regulations. The measurement procedures were in accordance with the requirements of Part 2.

2.1033(c)(1)Name of Applicant

Applicant:	Nortel Networks Corp.Ltd. Northern Telecom, Inc. 2305 Mission College Blvd. Santa Clara, CA 95054
Manufacturer:	Nortel Networks Corp. Ltd. Northern Telecom Canada Limited 5111 Th. Street NE Calgary, Alberta, CANADA T5J 3G1

2.1033(c)(2) Equipment Identification

Model No:	NTTG90AA
Trade Name:	TRU3-1900
FCC ID:	AB6NTTG90AA

The TRU3-1900 will be produced in quantity.

2.1033(c)(3) Installation and Operating Instructions

See the User Manual attachment

2.1033(c)(4) Types of Emissions

The TRU3-1900 Transceiver is designed to operate in digital mode. The emission type designator is 30K0DXW.

2.1033(c)(5) Frequency Range

The 1900 MHz TDMA Base Station will operate in the 1850 to 1990 MHz band, using 1930-1990 MHz for the transmitter and 1850 - 1910 MHz for the receiver. The channel bandwidth is 30 kHz. The channel separation is 30 kHz.

For the base transmit channel frequency, the following formula is used:

$0.030N + 1930.02$

$$1 \leq N \geq 1999$$

Frequency Block	Transmit Frequency Range (MHz)	Receiver Frequency Range (MHz)
A	1930 - 1945	1850 - 1865
B	1950 - 1965	1870 - 1885
C	1975 - 1990	1895 - 1910
D	1945 - 1950	1865 - 1870
E	1965 - 1970	1885 - 1890
F	1970 - 1975	1890 - 1895

TRU channels 1 and 1999 are prohibited from use in the MTX software. The customer will not be able to successfully datafill and use either channel 1 or channel 1999 in their network, and therefore, neither channel will ever be activated in a customer network.

2.1033(c)(6) Operating Power

The transmit power can be set to levels covering the range from -3 dBm to 25.5 dBm.

2.1033(c)(7) Maximum Power Rating

The maximum RF power output is 25.5 dBm (0.355 W).

2.1033(c)(8) DC Power Consumption for RF Tx

The DC current consumption of the RF module in the Transmit Receive Unit (TRU) is:

5 Vdc	typ.	0.90 A	max.	1.5 A
-5 Vdc	typ.	0.31 A	max.	0.6 A
10 Vdc	typ.	0.64 A	max.	1.0 A

2.1033(c)(9) Tune-up Procedure

A set of tests are performed during the production process to insure the product meets the specifications. A similar set of tests are also performed during the installation phase of the product in the field. A subset of the tests include:

- Channel numbering and frequency check
- Residual Modulation Check
- Modulation Accuracy
- RF output power and power stepping checks

2.1033(c)(10) RF Circuits Description

Circuit schematics of the TRU3-1900 Transceiver are attached to this application.

Frequency Determining and Stabilizing

All RF frequencies are derived from the Very Stable Master Oscillator (VSMO) which is external to the TRU3-1900. The VSMO provides eight accurate 4.8 MHz reference signal to the TRU3-1900. It contains two Oven Controlled Digital Voltage Controlled Crystal Oscillators (OCDCXO). Failure of an active oscillator automatically causes a switch-over to the standby unit with an oscillator alarm indication. The VSMO has a frequency stability better than 0.1 ppm.

Spurious Radiation Suppression

Spurious radiation is suppressed through proper shielding techniques of the TRU3-1900 main boards and via frequency selective combining and isolating equipment between the TRU3-1900 and the antenna. The transmit signal path always contains a frequency selective duplexer which typically provide an additional 30 dB rejection/isolation outside its passband. Unless otherwise noted, all measurements contained in this report were made at the TRU3-1900 output.

Modulation Limiting

Modulation limiting is performed by a digital device which is responsible for modulating the I and Q into an IF carrier. The modulated RF signal is filtered to remove any high frequency components before it is fed to the PA.

2.1033(c)(11) Equipment Identification Label

A drawing and placement location of the equipment identification label is attached to this application.

2.1033(c)(12) Product Photographs

Product photographs are attached to this application.

2.1033(c)(13) Digital Modulation

The modulation used is Pi/4 DQPSK.

2.1033(c)(14) Measurement Results

The measurement data required by FCC Part 2 sections 2.1046 through 2.1057, inclusive, measured in accordance with the procedures set out in section 2.1031 can be found in the following sections of this report.. An attestation confirming compliance with IEEE C95.1-1991 is also attached to this application.

Measurement Results Summary

Table 1 is a summary of the measurement results for the TRU3-1900.

Table 1: Measurement Results Summary

FCC Measurement Specification	FCC Limit Specification	Description	Result
2.1046	24.232	RF Power Output	$Power_{(max)}$=25.4 dBm
2.1047		Modulation Characteristics	NA
2.1049		Occupied Bandwidth	$OBW_{(max)}$= 27.7 kHz
2.1051, 2.1057	24.238	Spurious Emissions at Antenna Terminals	Minimum of 32 dB margin
2.1053, 2.1057	24.238	Field Strength of Spurious Radiation	Minimum of 13.6dB margin
2.1055	24.235	Frequency Stability	<0.023 ppm

Declaration of the Accuracy of Data

The undersigned attest to the accuracy of the measurement data contained in this document.

Denis Lalonde
Radio Compatibility Engineer
Nortel Networks

Stephen Cassidy
Radio Compatibility Engineer
Nortel Networks

General Test Setup

Figure 1 shows the general test setup used during testing of the TRU3-1900.

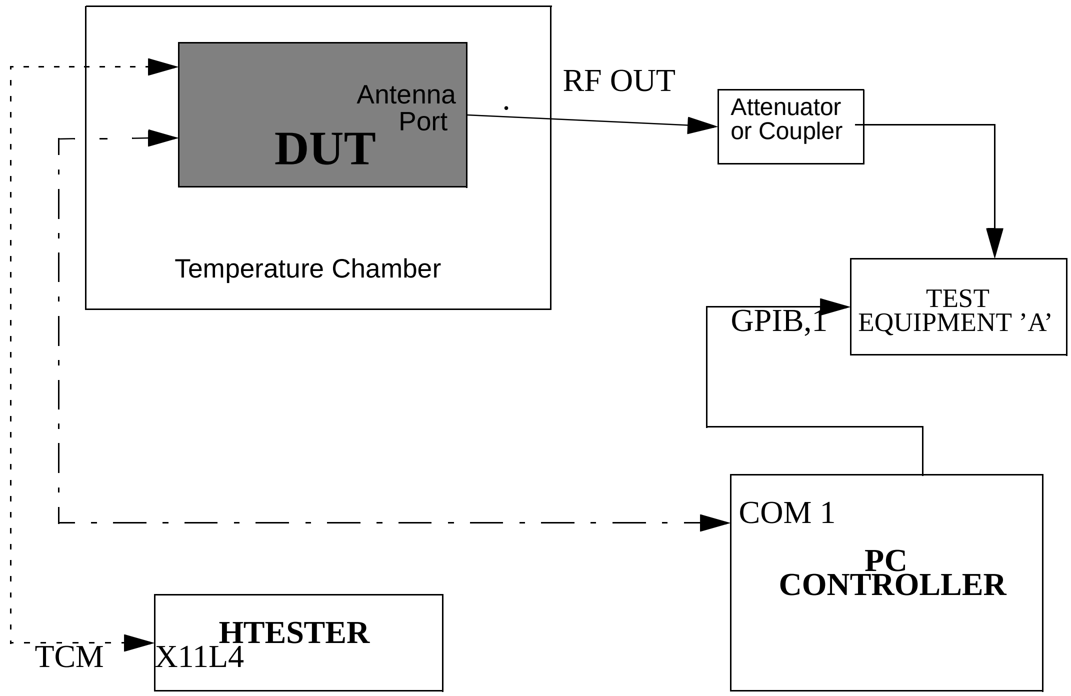


Figure 1: General Test Setup

TEST EQUIPMENT 'A':

- HP 438A Power Meter include the power sensor for Power output test.
- HP 89441A Vector Signal Analyzer for frequency stability test.
- R&S FSEM30 Spectrum Analyzer for Spurious Emission and Occupied Bandwidth tests.

Measurement Results

The following section contains the measurement results.

Name of Test:2.1046 RF Power Output

1.0 FCC Requirements

1.1 FCC Part 24.232

(a) Base stations are limited to 1640 Watts peak equivalent isotropically radiated power (e.i.r.p.) with an antenna height up to 300 meters HAAT. See 24.53 for HAAT calculation method. Base station antenna heights may exceed 300 meters with a corresponding reduction in power. In no case may the peak output power of a base station transmitter exceed 100 Watts.

(c) Peak transmit power must be measured over any interval of continuous transmission using instrumentation calibrated in terms of an rms-equivalent voltage. the measurement results shall be properly adjusted for any instrument limitations, such as detector response times, limited resolution bandwidth capability when compared to the emission bandwidth, sensitivity, etc., so as to obtain a true peak measurement for the emission in question over the full bandwidth of the channel.

2.0 Test Results

Table 2 shows the test results for RF Output Power.

Table 2: Test Results for RF Output Power

Ch. #	Freq. (MHz)	Measured Maximum Power (dBm)	Maximum Rated Power (dBm)	Limit (dBm)
2	1930.08	25.421	25.5	50
498	1944.96	25.139	25.5	50
502	1945.08	24.789	25.5	50
665	1949.97	24.764	25.5	50
668	1950.06	24.785	25.5	50
1165	1964.97	24.610	25.5	50

Table 2: Test Results for RF Output Power (continued)

Ch. #	Freq. (MHz)	Measured Maximum Power (dBm)	Maximum Rated Power (dBm)	Limit (dBm)
1168	1965.06	24.628	25.5	50
1332	1969.98	24.762	25.5	50
1335	1970.07	24.775	25.5	50
1498	1974.96	25.370	25.5	50
1502	1975.08	25.392	25.5	50
1998	1989.96	24.589	25.5	50

From the results shown in Table 2, the BTS complies with the requirement.

3.0 Test Procedure

The equipment was configured as shown in Figure 1.

The transmitter was modulated with pseudo-random Data Field bits for all time slots. The transmitter output was fed to a 10 dB coupler before connecting to the power head. The loss from the DUT antenna port output to the input of the power meter is calibrated to be 11.5 dB. The test was conducted under PSU Voltage at 27.0 V and Ambient Temperature at 60.0 deg. C, 25.0 deg. C, and -5.0 deg. C. The Measurement data shown in Table 2 represent the worst case from all the measurement data.

Name of Test:2.1049 Occupied Bandwidth

1.0 FCC Requirements

1.1 FCC Part 2.1049

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured under the following conditions as applicable:...

2.0 Test Results

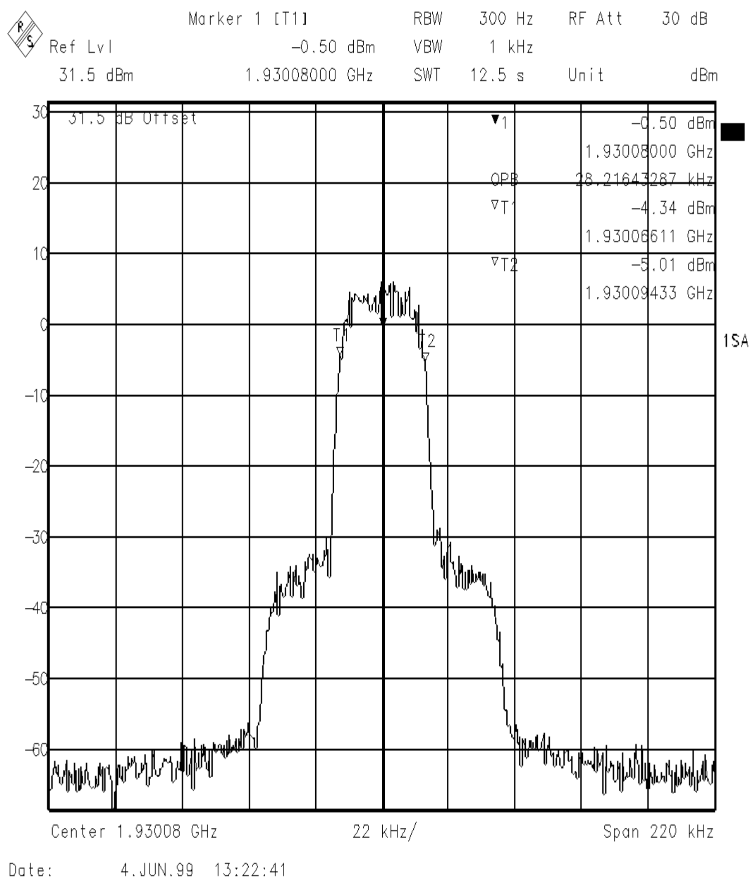
Table 3 shows the results for Occupied Bandwidth.

Table 3: Test Results for Occupied Bandwidth

Channel #	Frequency (MHz)	Measured Occupied Bandwidth (kHz)
2	1930.08	27.7
1000	1960.02	27.7
1998	1989.96	27.7

Figure 2 shows a sample plot for case of the maximum measured occupied bandwidth.

Figure 2: Sample Plot for Occupied Bandwidth



3.0 Test Procedure

The equipment was configured as shown in Figure 1.

The TRU3-1900 was configured to transmit at maximum power. The transmitter was modulated with pseudo-random Data Field bits for all time slots.

The measurements was performed under PSU = 27.0 V, ambient temperature = 27.0 C. This measurement was performed by setting the '% POWER BANDWIDTH' function in the spectrum analyzer to 99%. This function enables 99% of the signal power to be contained in the bandwidth. The difference between the two frequency markers set by this function is the occupied bandwidth.

The settings in the spectrum analyzer for the measurement is as followed:

span = 220 kHz, RBW = 300 Hz

Name of Test:2.1051 Spurious Emissions at Antenna Terminals

1.0 FCC Requirements

1.1 FCC Part 24.238

(a) On any frequency outside a licensee's frequency block, the power of any emission shall be attenuated below the transmitter power (P) by at least 43 + 10 log (P) dB.

(b) Compliance with these provisions is based on the use of measurement instrumentation employing a resolution bandwidth of 1 MHz or greater. However, in the 1 MHz bands immediately outside and adjacent to the frequency block a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed. The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.

(c) When measuring the emission limits, the nominal carrier frequency shall be adjusted as close to the licensee's frequency block edges, both upper and lower, as the design permits.

(d) The measurements of emission power can be expressed in peak or average values, provided they are expressed in the same parameters as the transmitter power.

2.0 Test Results

The emission bandwidth was found to be 27.7 kHz. This value was used to determine the resolution bandwidth (300 Hz) required for measurements in the first adjacent MHz outside the licensee's frequency block.

The reference level for spurious emissions at the antenna terminals was taken from the measured output power (25.4 dBm = 0.347 Watt). Therefore the spurious emissions must be attenuated by at least 43 + 10 log (0.347) = 38.4 dB. The measured output power was 25.4 dBm; therefore the limit is 25.4 - 38.4 = -13 dBm.

Table 4 shows the results for Spurious Emissions at Antenna Terminals.

Table 4: Test Results for Spurious Emissions at Antenna Terminals

Frequency (MHz)	Spurious Emissions Level (dBm)	Cell site relief (dB)	Limit (dBm)	Margin (dB)
(@Ch. 2)	-53 (1st Adjacent MHz)		-13	40
(@Ch. 1998)	-45 (1st Adjacent MHz)		-13	32
10 - 4000 (2nd Tx harmonic)	-12.3 dBm (Note 1) @ 3860.16 MHz	40	-13	39.3
4000 - 6000 (3rd Tx harmonic)	-10.4 (Note 1) @ 5790.24 MHz	40	-13	37.4
6000 - 20000 (4th Tx harmonic)	-46.8 dBm @ 7720.32 MHz		-13	33.8

Note 1: As demonstrated on Figure 3, the transceiver's second and third transmitter harmonic will be further attenuated by the duplexer and the RRM. The additional attenuation will be higher than 40 dB. The TRU3-1900 is always used with the duplexer and RRM identified in Figure 3.

Note 2: Maximum observed noise floor in resolution bandwidth of 1 MHz and RF attenuation of 40 dB is -45 dBm.

Figure 3: Insertion Loss of Tx path (Duplexer; model NTTG40 & RRM; model NTTG60)

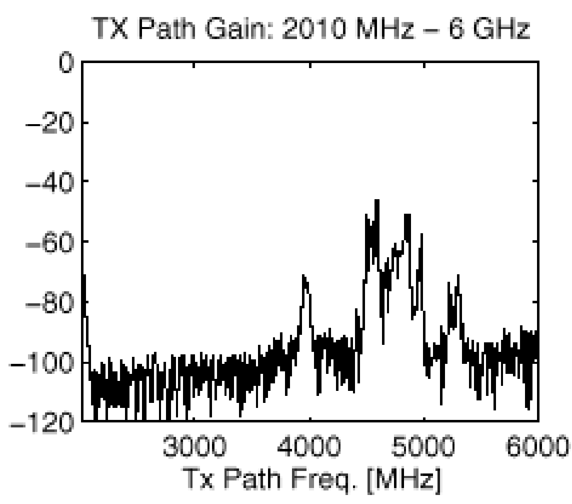


Figure 4 shows a sample plot for the case when the transmitter was tuned to Channel 2 (lowest channel in Tx band).

Figure 5 shows a sample plot for the case when the transmitter was tuned to Channel 1998 (highest channel in Tx band).

Figure 4: Sample Plot for Ch. 2 (1st Adjacent MHz)

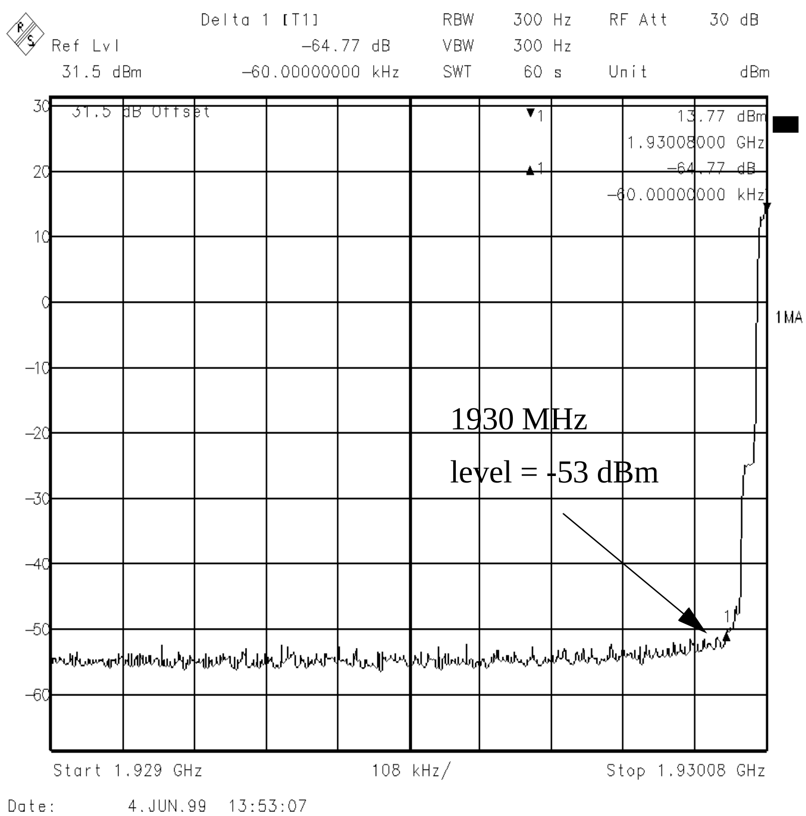
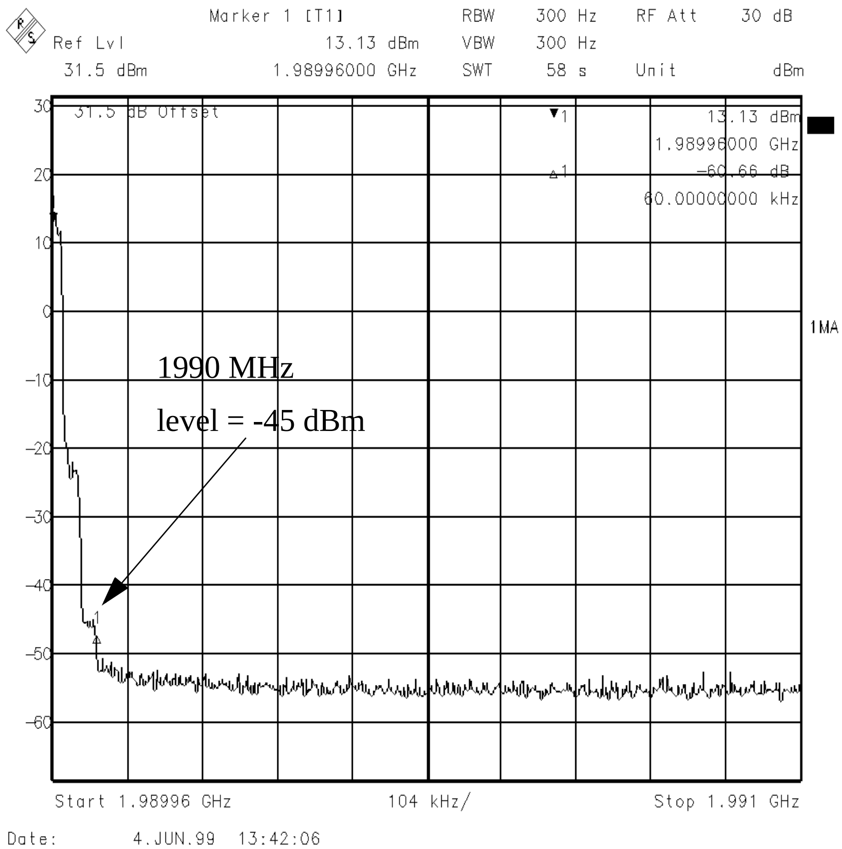


Figure 5: Sample Plot for Ch. 1998 (1st Adjacent MHz)



From the results shown in Table 4, the TRU3-1900 complies with the requirement.

3.0 Test Procedure

The spectrum analyzer setting is span = 1 MHz, RBW = 300 Hz. The offset on the spectrum analyzer is 32.0 dB. The trace was set to Max Hold.

First adjacent MHz

The transmitter was modulated with pseudo-random Data Field bits for all time slots. The transmitter output was fed to a 30 dB attenuator for a total loss of 31.5 dB (Low loss RF cables and attenuator), and connected to the Rhode & Schwarz FSEM30 spectrum analyzer. Modulation was first disabled to establish the carrier power. The DUT was set to the desired test channel, and then the output power was set to 25.0 dBm. The transmit channels for this test were 2 and 1998.

30 MHz to 6 GHz

The Rhode & Schwarz FSEM30 spectrum analyzer was set to span = 50 MHz, RBW = 1 MHz. The RF attenuation was set to 40 dB. The spectrum analyzer trace was set to max-peak to capture the spurious emission and harmonics level. The region from 1 Hz to 6 GHz was scanned for emission with step of 50 MHz.

6 GHz to 20 GHz

The spectrum analyzer setting is span = 400 MHz, RBW = 1 MHz. The offset on the spectrum analyzer is 32.0 dB.

The transmitter was modulated with pseudo-random Data Field bits for all time slots. The transmitter output was fed to a 30 dB attenuator for a total loss of 32.0 dB (Low loss RF cables, attenuator, and filter), follow by connecting to a high pass filter, and connected to the Rhode & Schwarz FSEM30 spectrum analyzer. The purpose of the High pass filter is to filter out the carrier so that the noise floor of the spectrum analyzer can be reduced.

Name of Test:2.1053 Field Strength of Spurious Radiation

1.0 FCC Requirements

1.1 FCC Part 24.238

(a) On any frequency outside a licensee's frequency block, the power of any emission shall be attenuated below the transmitter power (P) by at least 43 + 10 log (P) dB.

1.2 FCC Part 2.1053

(a) Measurements shall be made to detect spurious emissions that may be radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation. Curves or equivalent data shall be supplied showing the magnitude of each harmonic and other spurious emission.

2.0 Test Results

Table 5 shows the results for radiated spurious emissions measurements. Only measurement results with less than 20 dB margin are shown.

Table 5: Test Results for Spurious Emissions

Frequency (MHz)	Measured Level (dBμV)	Correction Factor (dB)	Corrected Level (dBμV/m)	Limit (dBμV/m) @ 3m	Margin (dB)
3862.98	50.5	5.5	56	73.9	17.9
3940.44	48.7	5.5	54.2	73.9	19.7
3944.76	48.6	6.1	54.7	73.9	19.2
3946.20	48.3	6.1	54.4	73.9	19.5
3947.64	48.5	6.1	54.6	73.9	19.3
3950.52	49.3	6.1	55.4	73.9	18.5
5790.15	51.7	8.6	60.3	73.9	13.6
5792.31	50.1	8.6	58.7	73.9	15.2
5794.47	45.9	8.6	54.5	73.9	19.4
5796.63	46	8.6	54.6	73.9	19.3
5803.11	48	8.6	56.6	73.9	17.3
5921.46	50.1	8.99	59.09	73.9	14.81

Table 5: Test Results for Spurious Emissions

Frequency (MHz)	Measured Level (dBμV)	Correction Factor (dB)	Corrected Level (dBμV/m)	Limit (dBμV/m) @ 3m	Margin (dB)
5925.78	48.8	8.99	57.79	73.9	16.11
7723.08	42.8	11.6	54.4	73.9	19.5
7880.88	47.8	11.6	59.4	73.9	14.5
7883.76	43.2	11.78	54.98	73.9	18.92
9851.10	45.6	14.65	60.25	73.9	13.65

The field strength is calculated by adding a correction factor to the measured level to obtain the corrected level. A sample calculation is as follows:

$\text{Correction Factor}_{(dB)} = \text{Cable Losses}_{(dB)} + \text{Antenna Factor}_{(dB)} - \text{pre-amplifier gain}_{(dB)}$

$\text{Correction Factor}_{(dB)} = 6.6\text{ dB} + 33.6\text{ dB} - 26.6\text{ dB} = 13.6\text{ dB}$

$\text{Corrected Level}_{(dB\mu V/m)} = \text{Measured Level}_{(dB\mu V/m)} + \text{Correction Factor}_{(dB)}$

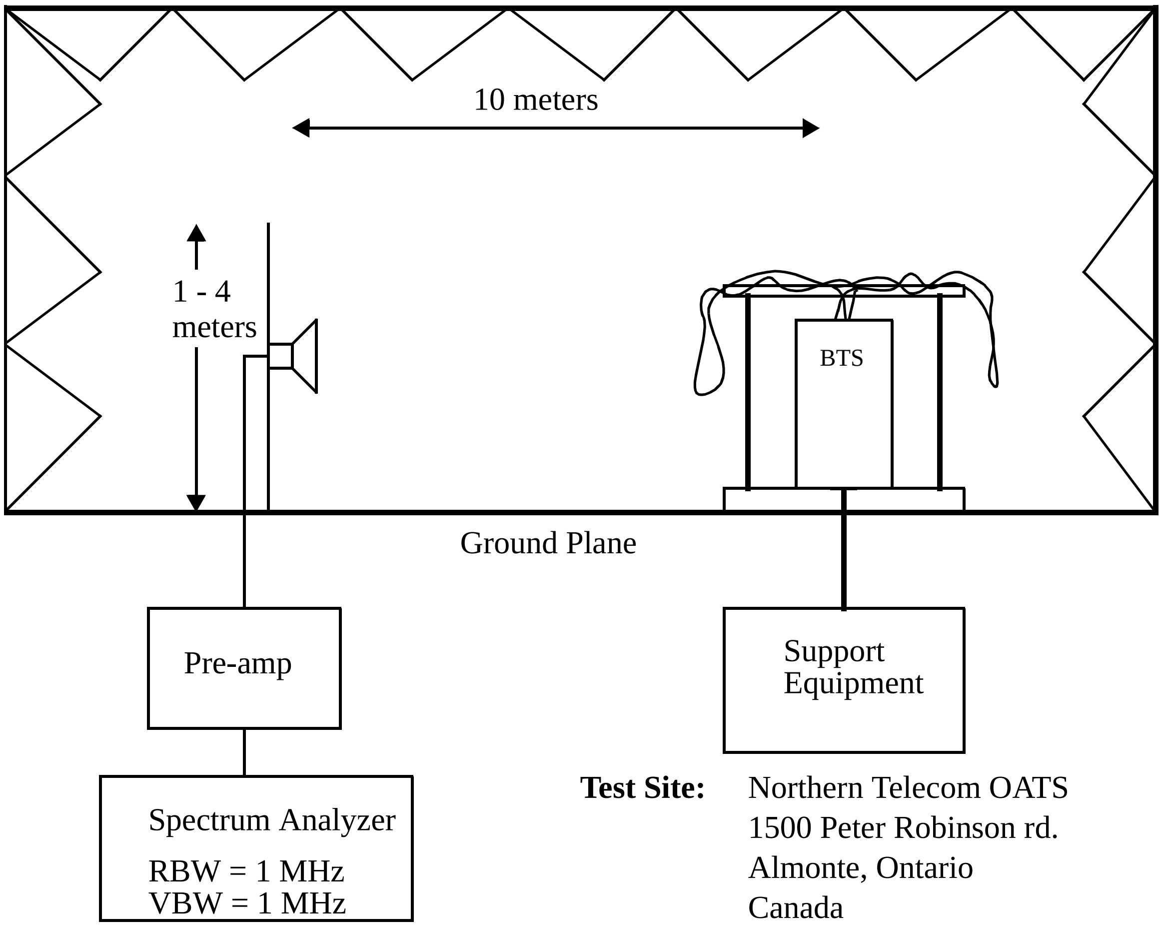
Corrected Level = 32.4 + 13.6 = 42.0 dBμV/m

All spurious emissions were below the limit by greater than 13.6 dB. The TRU3-1900 complies with the requirement.

3.0 Test Procedure

The equipment was configured as shown in Figure 6.

Figure 6: Test Configuration for Radiated Spurious Emissions



Test Site: Northern Telecom OATS
1500 Peter Robinson rd.
Almonte, Ontario
Canada

The BTS was configured with 12 TRU3-1900s transmitting at maximum power. Six transceivers were set to different frequencies in the A band and the 6 others were set to different frequencies in the F band.

Measurements were made according to the procedures outlined in ANSI C63.4.

The emissions were investigated up to the tenth harmonic of the fundamental emission (20 GHz). The measured level of the emissions was recorded and compared to the limit.

The reference level for spurious radiation was taken with reference to an ideal dipole antenna excited by the rated output power according to the following relationship:

$$E\left(\frac{V}{m}\right) = \frac{1}{R(m)} \bullet \sqrt{30 \bullet Pt \bullet G}$$

Where,

E = Field Strength in Volts/meter,
R = Measurement distance in meters,
Pt = Transmitter Rated Power in Watts,
G = Gain of Ideal Dipole (linear)

Therefore:

$$E\left(\frac{V}{m}\right) = \frac{1}{10} \bullet \sqrt{30 \bullet (0.355) \bullet 1.64}$$

E = 0.418 V/m = 112.4 dBμV/m

The spurious emissions must be attenuated by at least 43 + 10 log (0.355) = 38.5 dB

Therefore the field strength limit at 10 meters is:

E = 112.4 dBμV/m - 38.5 dB = 73.9 dBμV/m

And at 3 meters is:

E = 84.4 dBμV/m

Name of Test:2.1055 Frequency Stability

1.0 FCC Requirements

1.1 FCC Part 24.235

The frequency stability shall be sufficient to ensure that the fundamental emission stays within the authorized frequency block.

2.0 Test Results

Table 6 shows the results for Frequency Stability versus Temperature and Voltage Variation.

Table 6: Frequency Stability versus Temperature and Voltage Variation

Temperature (deg. C)	Frequency Stability (ppm)		
	Supply Voltage (85% of Nominal) 23.0 V	Supply Voltage (nominal) 27.0 V	Supply Voltage (115% of Nominal) 31.0 V
-30	0.022455	0.022548	0.021156
-20	0.022820	0.022459	0.022197
-10	0.021423	0.023357	0.022188
0	0.022470	0.022164	0.022876
10	0.022542	0.022496	0.021362
20	0.022324	0.021414	0.022116
30	0.022050	0.022802	0.023078
40	0.022514	0.022400	0.022801
50	0.021805	0.021761	0.021190
60	0.022391	0.022658	0.022970
70	0.021649	0.022521	0.022513
80	0.022071	0.021864	0.022205

The maximum frequency deviation was found to be 0.023 ppm. This deviation is more than sufficient to ensure that the fundamental emission stays within the authorized frequency block. Therefore the TRU3-1900 complies with the requirement.

3.0 Test Procedure

This test measurement was performed under nominal PSU voltage at 27.0 V and 85% and 115% of nominal voltage. The transmit frequency of the DUT was measured from the external antenna port every minute for a period of ten minutes. The recorded value in Table 6 is the frequency after the first minute of transmission. The DUT was placed in the thermal chamber. The thermal chamber was set to -30 C, and the DUT remained in chamber for a period of 1 hour before the transmitter was keyed on. The test was repeated for chamber ambient temperature from -20.0 deg. C to 80.0 deg. C with step of 10 degree Celsius. The Vector Signal Analyzer was set to NADC standard setting.

The transmitter was modulated with pseudo-random Data Field bits for all time slots. The transmitter output was fed to a 30 dB attenuator for a total loss of 32.0 dB (RF cables and Direct path of the Narda 10 dB coupler), and connected to the HP vector signal analyzer. The DUT output power was set to maximum output power at 25.0 dBm.

Measurement Equipment List

Table 7 is a list of all of the measurement equipment used in this report.

Table 7: Measurement Equipment List

Equipment Description	Manufacturer	Model No.	Serial No.	Cal. Due Date
Spectrum Analyzer	Rhode & Schwarz	FSEM 30	846821/029	Jan. 29, 1999
Spectrum Analyzer	Rhode & Schwarz	FSEM 30	Asset L0535956	Jan 27, 1999
Power Meter	Hewlett Packard	HP 438A	3513U06089	Feb. 17, 1999
Power Sensor	Hewlett Packard	8482 A	NA	Sep. 28, 1998
Vector Signal Analyzer	Hewlett Packard	89441A	IF: 3416A02214 RF: 3509A01085	April 22 1998
Temperature Chamber	Thermotron	S-4C	28450	Aug. 14, 1998
Power Supply	Hewlett Packard	6673A	351A-00960	April 22, 1998
Attenuator	Narda	776 B (30 dB)	NA	NA
Bidirectional Coupler	Narda	4242-10 (10 dB)	NA	NA
Filter	Daden-Anthony	5.8 GHz High-Pass	806743-01	NA

EUT Identification List

Table 10 is a identification list of the equipment tested in this report.

Table 8: EUT Identification List

Equipment Description	Technical Status	Manufacturer	Serial No.
TRU3-1900	NTTG90AA	Nortel	NNTM532KPV8G