EMC MEASUREMENT/TECHNICAL REPORT
FOR PART 15.247 APPLICATION

MANUFACTURER : Intermec Corp.
PRODUCT: *MODEL RM181*
PCMCIA Radio

FCC ID: *HN2RM181-24*

October 5, 1998

This report concerns : *(check one)* Original grant___**X**___ Class II change _____ *Class B verification_____ Class A verification_____ **Class I change_____ Equipment type: **2.4 GHz Spread Spectrum Transceiver**
Limits used: *(check one)* CISPR 22 __**for digital emissions portion** Part 15 __**for RF portion**
Measurement procedure used is ANSI C63.4-1992 unless another is specified. Other test procedure: _____
This report is based on the measurements on Model __**RM181**___. EUT Serial number: _**0020A63488A6**__.
Report reviewed and approved by Kursat Eroglu, EMC Engineer _____ 6001 36th Ave. W Everett WA 98203 Phone: 206 356 1765 Fax: 206 348 2633 E-Mail keroglu@intermec.com

Do not bind or staple this report. A horizontal rubber band plus paper clip at top of document is preferred.
**Not to be filed with Equipment Authorization Branch of FCC unless requested.*

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1 GENERAL INFORMATION

1.1 Summary of Test Results

Model RM181 was tested to the requirements of Part 15 of the FCC Rules for 2.4 GHz band transceivers to verify its continued compliance with Intermec's antenna set and in a different host. The transceiver module is manufactured by Proxim Inc. As can be seen in section 4 of this report, the product passed all tests with comfortable margins beyond test instrument tolerances.

1.2 Product Description

Model RM181 is a 2.4 GHz FHSS transceiver in PCMCIA (PC-Card) form. It is manufactured by Proxim Inc. of Mountain View, CA. It has already been certified by the FCC under FCC ID: IMKRL21PC. Intermec Technologies integrates this module into our data automation products such as handheld barcode terminals, access points, PenKey terminals etc. Since some of these products use different antennas than the ones listed by Proxim and as a result of our contractual obligations, we would like to apply for a new grant to Intermec Technologies for the same transceiver. The product is in a standard PCMCIA (PC-Card) enclosure with an MMCX antenna connector. Detailed pictures of the product and the circuit boards are included in the application. Power levels, frequency ranges and channel characteristics are **not** user adjustable.

1.3 Antenna System and Part 15.203 Compliance

For Part 15.203 compliance see separate declarations file included in the application. A complete list of antennas to be used with this product and their drawings are also included in a separate file included in the schematics part of the application.

1.4 Class A Justification (Parts 15.107/109)

For Class A justification of Parts 15.107 and 15.109 compliance see separate declarations file included in the application.

1.5 RF Exposure Compliance

For compliance with the RF Exposure rules as described in OET Bulletin 65 see separate declarations file included in the application.

1.6 Related Submittal(s)/Grant(s)

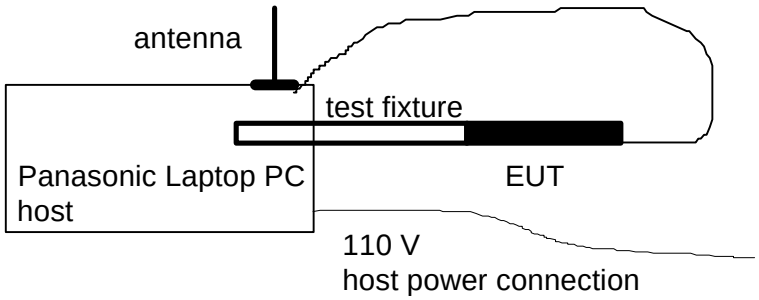
The radio transceiver was previously certified by Proxim Inc. under the FCC identifier IMKRL21PC.

2 Test Conditions

2.1 Tested System Details

Since it is being tested as a module, the transceiver was tested on a special test fixture (a PCMCIA card extender) totally outside the host device. The host device used during the test was a Panasonic 150 MHz Pentium Laptop PC. Other host devices to be used by Intermec Technologies include handheld terminals 6110, 6400 and Raptor. These devices integrate the transceiver through a PC-card port similar to the laptop PC. Worst case antennas of each type were used during radiated emission tests. Conducted emissions tests were performed by direct connection through a custom made adapter cable. Conducted tests were repeated under worst case power supply conditions (–+10%).

2.2 Diagram of Tested System



2.3 Test Methodology

Digital emissions tests were performed according to the procedures in ANSI C63.4-1992. For radio performance tests procedures given in Part 15 (paragraphs 109, 247, 205, 209) and described in “Test Procedure Hints” , published by Authorization and Evaluation Division.

2.4 Test Facility

The open area test site and conducted measurement facility used to collect the radiated data is in Intermec Corp. facilities at 6001 36th Ave. W Everett, WA 98203. This site has been fully described in a report dated 25 Feb. 94 submitted to your office, and accepted in a letter dated May 24, 1994 (31040/SIT). Latest continued compliance report for the OATS site was submitted to FCC in July 1997.

2.5 Test Summary

Specification Paragraph	Description	Test Data Section	Status
15.207	Powerline Conducted RFI	5.6	N/A
15.109	Radiated Emissions	5.5.1	passed
15.247(a)(1)	Channel Utilization	5.1	passed
15.247(a)(1)	Channel Bandwidth	5.3	passed
15.247(b)	Maximum Peak Output Power	5.2	passed
15.247(c)	Conducted Out of Band Emissions	5.4	passed
15.205	Restricted Band Emissions	5.4, 5.5	passed
15.209	Radiated Spurious Emissions	5.5.2	passed

2.6 Environmental Conditions

All tests were performed at Intermec test facilities under following conditions:

Temperature: ambient (10 °C to 25 °C)

Humidity: 50% to 80%

Altitude: 550 ft

3 TEST EQUIPMENT

3.1 Test Equipment

Type	Manufacturer/ Model No.	Serial No.	Last Cal.	Cal. Interval
Spectrum Analyzer/ EMI Receiver	Rohde & Schwartz ESMI 100Hz - 26.5 GHz	DE11220	12/24/97	1 year
Biconical Antenna	EMCO 3110B	1412	5/28/98	1 year
Log-periodic Antenna	EMCO 3146	1512	6/1/98	1 year
Horn Antenna	EMCO 3115	3720	5/28/98	2 years
LISN	EMCO	3825/2	9/11/98	1 year
Spectrum Analyzer	8591A	2932A00296	11/6/97	1 year
Preamplifier	HP8447F	2944A03597	4/2/98	1 year

3.2 Accessories

All accessories used at Intermec OATS and EMC Lab such as cables, attenuators, filters etc. are measured in predetermined intervals and their loss factors are recorded for adjustment of measured values.

4 TEST DATA AND RESULTS

4.1 Transmit Range and Channel Utilization Measurement

4.1.1 Procedure

The EUT was put into a hopping mode to cover all channels. The analyzer was setup to cover the frequencies between 2.390 GHz and 2.490 GHz with a resolution and video bandwidth of 300 kHz. The EUT was operated with the analyzer in max hold mode for 10 minutes and the result plotted. No external attenuator was used. Cable losses were automatically compensated by the analyzer.
To investigate band edge spectral components the analyzer was set to 2.397 - 2.407 GHz and 2.475 - 2.485 GHz consecutively and max hold measurement performed while the radio was transmitting randomly utilizing all channels.
To verify channel dwell time the EUT was put into a random transmission mode with a typical worst case package. The analyzer was set up to three channels (low, medium high) with 0 span and 100 kHz RBW. The sweep time was set to 1 sec. The number of hits in that channel (one hit = one transmission in that channel) were recorded in max. hold mode over 30 seconds. The number of hits over 30 seconds times the transmission time (32 ms) shows the usage of that channel and must be under 0.4 sec.

4.1.2 Results

As can be seen on the plot, the EUT's operation band (2.402-2.480 GHz) was within the allowed band of 2.400 - 2.483 GHz. All frequencies were evenly used and the range was not exceeded.

No abnormal spectral components were detected at the lower and upper band edges.

As can be seen on the following plots, the selected channels were used 2 times over 30 seconds. Therefore the dwell time is 2* 32 ms (standard transmit time for 1.6 Mb operation) = 64 ms, which is under the 400 ms limit.

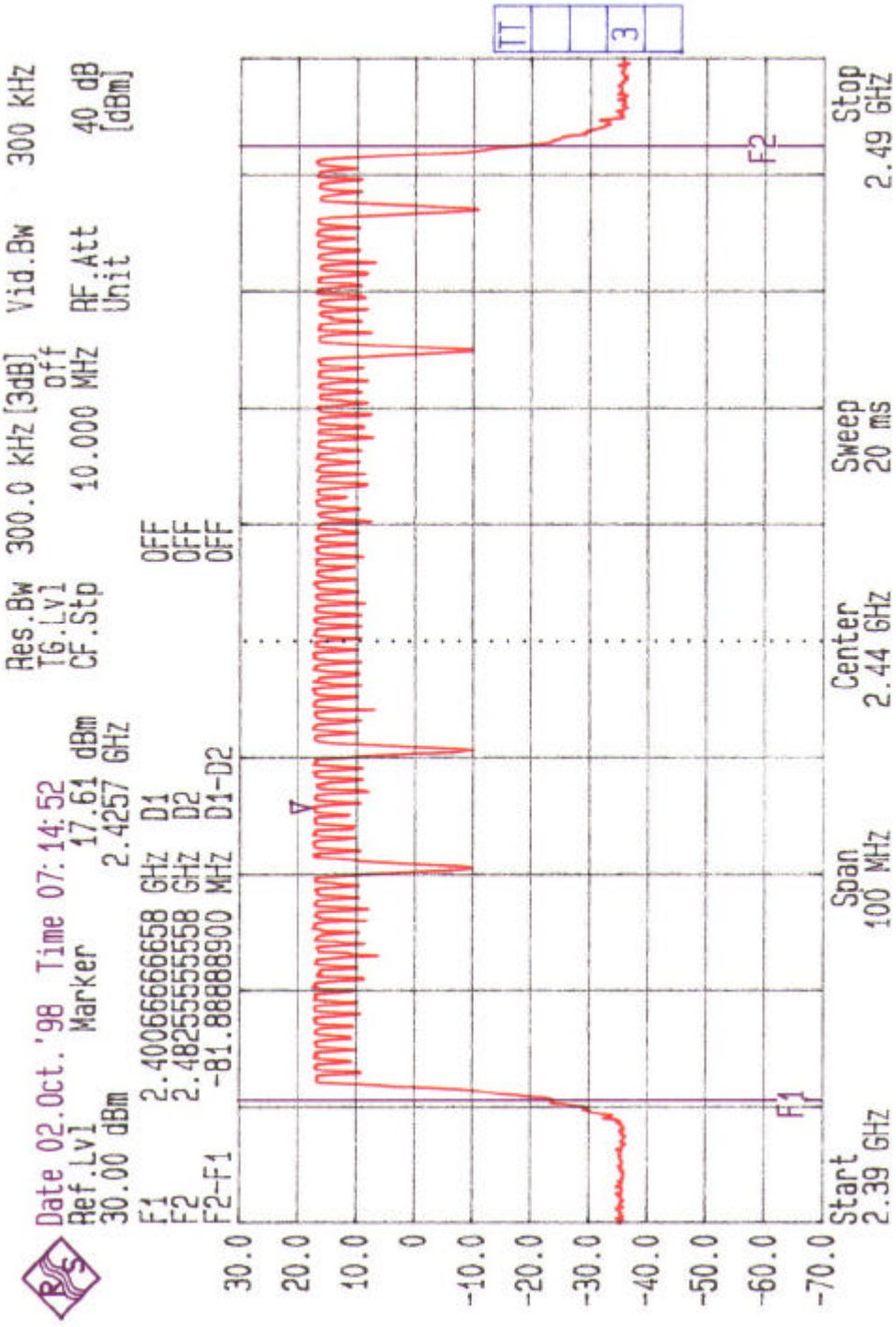
4.2 Peak Power Measurement

4.2.1 Procedure

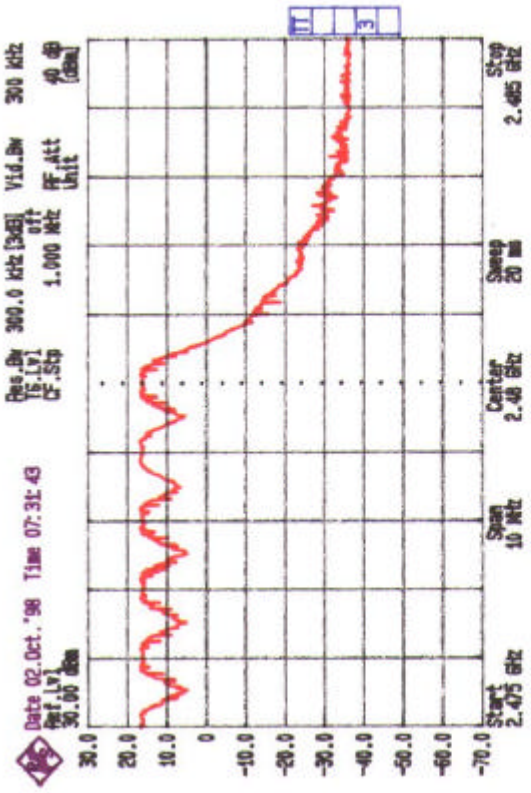
The EUT was put into a continuous transmit mode. The analyzer was set to a 20 MHz span around the selected channel with 3 MHz resolution bandwidth and 3 MHz video bandwidth. No external attenuator was used. Cable losses were automatically compensated by the analyzer. The analyzer was put into max hold mode and the peak value measured. Peak power of low, medium and high channels was measured.

4.2.2 Results

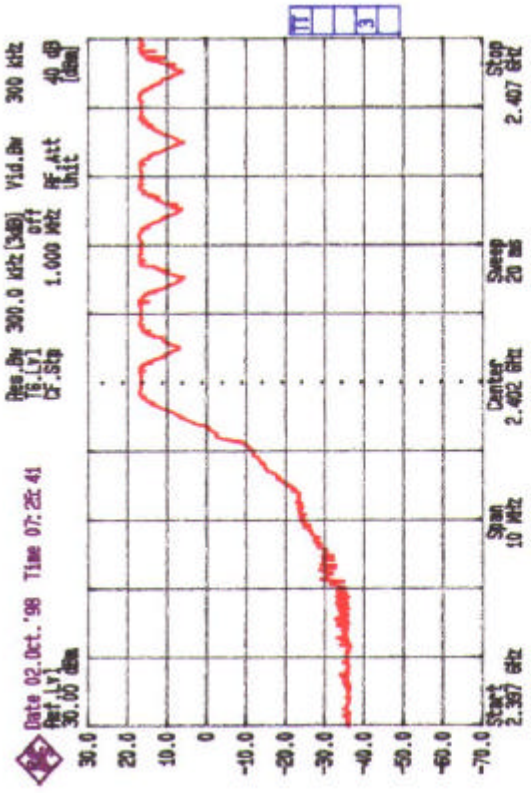
The highest measured peak value was 17.97 dBm at 2.440 GHz.



Band Usage Measurement Plot

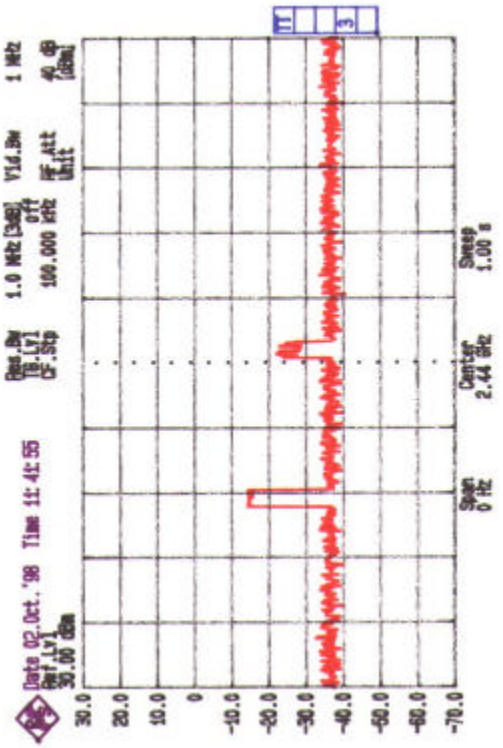


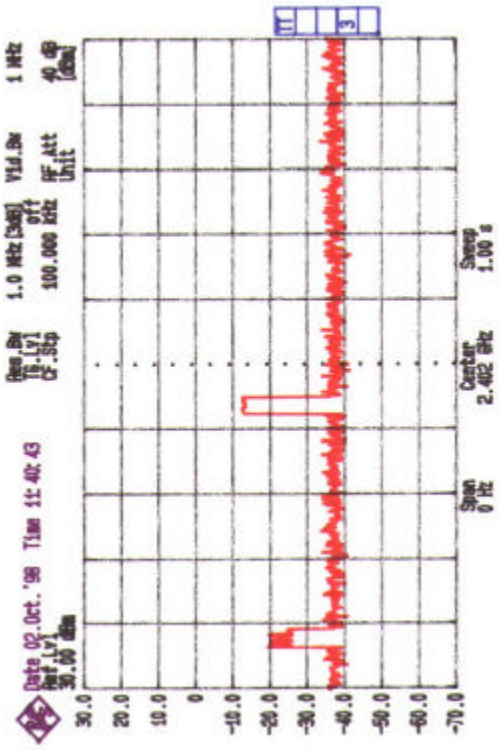
High End

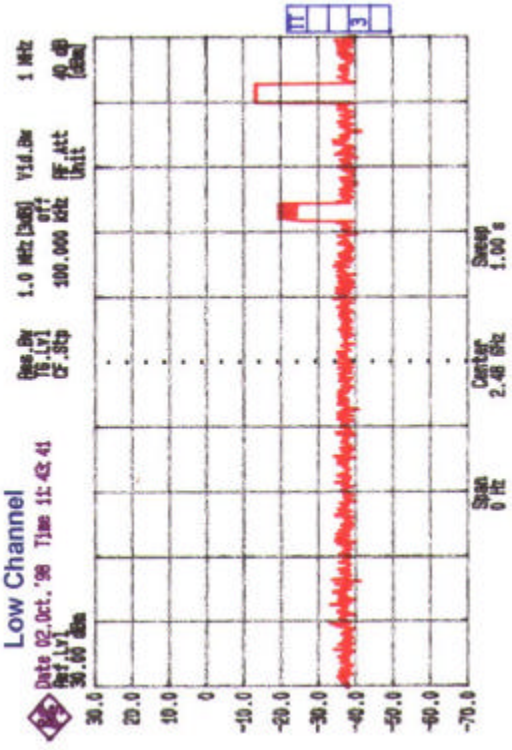


Low End

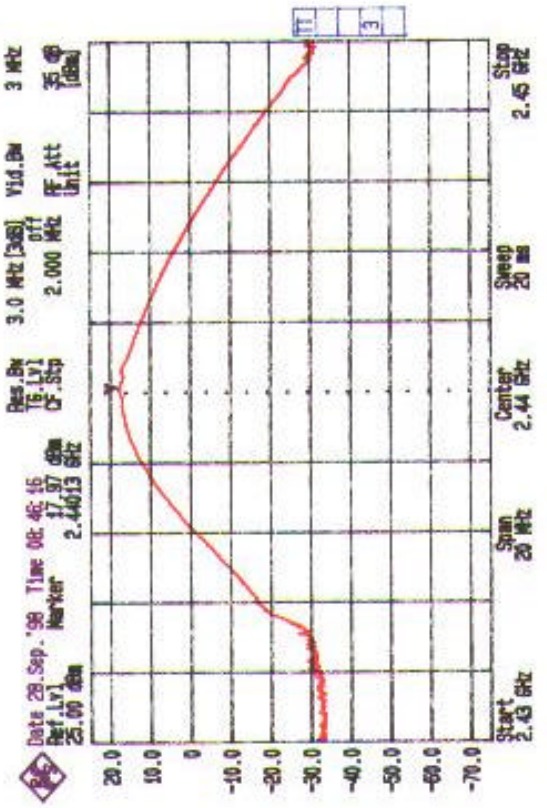
Band Edge Measurements



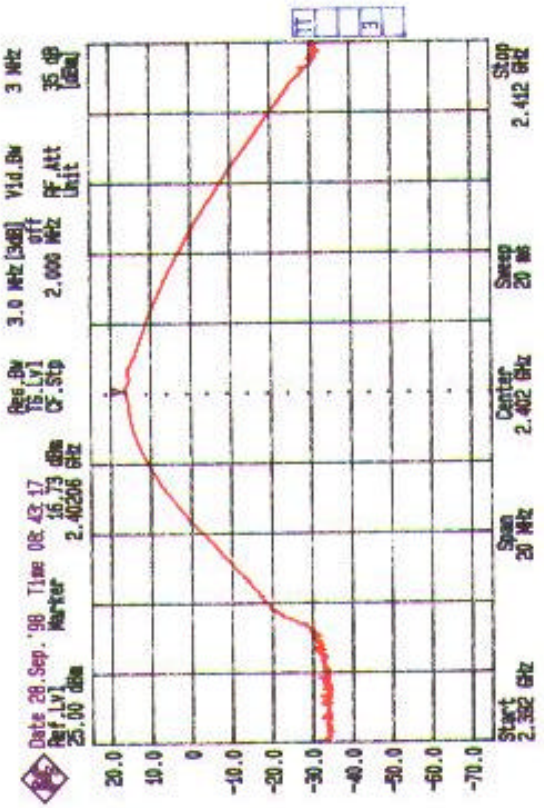




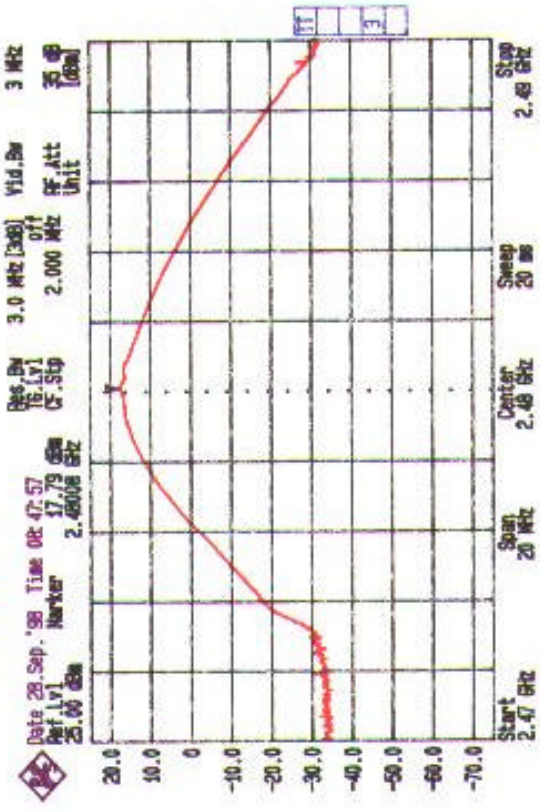
Dwell Time Measurements



Mid Channel



Low Channel



High Channel

Maximum Peak Power Measurements

4 TEST DATA AND RESULTS (continued)

4.3 Channel Bandwidth Measurement

4.3.1 Procedure

The EUT was put into a continuous transmit mode. The analyzer was set to a 2 MHz span around the selected channel with 30 kHz resolution bandwidth and 30 kHz video bandwidth. The analyzer was put into max hold mode and the peak value measured. A threshold line was put 20 dB below the peak. Two markers were set at the intersection of the signal and the 20 dB line. The frequency difference between the markers was recorded as the 20 dB bandwidth. No external attenuator was used. Cable losses were automatically compensated by the analyzer. The same procedure was repeated for three different channels (low, medium and high) to cover the transmit range.

4.3.2 Results

The widest 20 dB bandwidth measured was 975 kHz at 2.440 GHz. The other two channels shown on the following plots had bandwidths of 968 kHz (2.402 GHz) and 951 kHz (2.480 GHz). All bandwidths were below the required 1 MHz limit.

Note:
All conducted measurements were repeated with radio supply voltage modified to 90% and 110% of the nominal 5V. Since the module power is regulated on-board, no differences due to the voltage variation were observed.

4.4 Conducted Out-of-band Emissions

4.4.1 Procedure

The EUT was put into continuous transmit mode. The analyzer was set to 300 kHz RBW (1 MHz for ranges 2,3,4) and 300 kHz VBW (1MHz for rangeS 2,3,4). Then four scans were performed in max hold mode with 30 MHz - 1 GHz, 1 GHz - 3 GHz, 3 GHz - 10 GHz and 10 GHz - 24 GHz ranges. Also the 50 MHz region around the fundamental was investigated. Found peaks are listed in the results section. No external attenuator was used. Cable losses were automatically compensated by the analyzer. The measurements were repeated for channels at 2.402, 2.440 and 2.480 GHz

4 TEST DATA AND RESULTS (continued)

4.4 Conducted Out-of-band Emissions

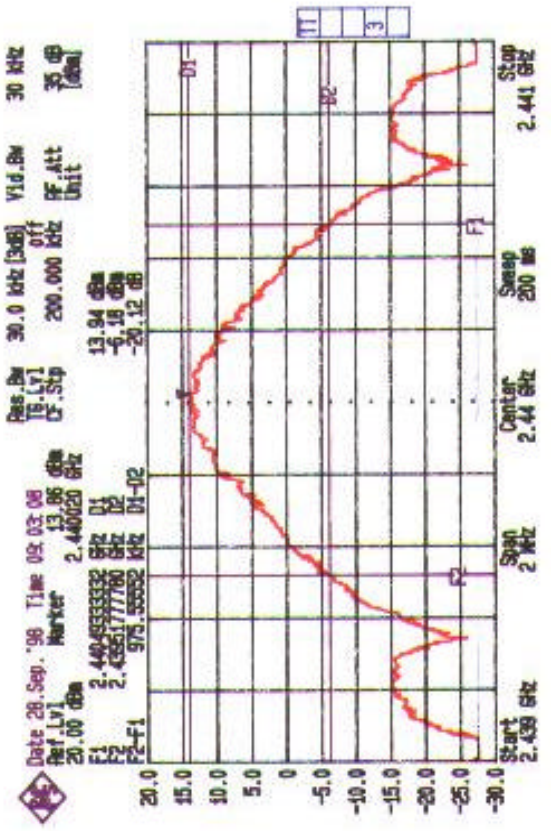
4.4.2 Results

Plots in following pages show the harmonic and spurious out-of-band emissions of the EUT measured at the antenna connector. All found peaks and their margins are listed in the following tables The EUT was found compliant with the requirements for conducted out-of-band emissions.

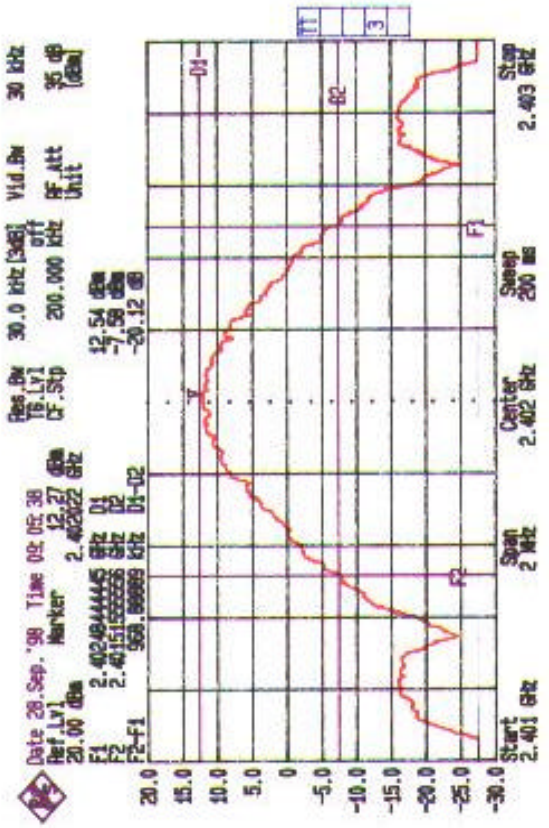
Frequency (GHz)	Emission Type	Level (dBm)	QP/Avg. Level (dBm)	Limit (dBm) (*)	Margin (dB)
Transmit on channel 1					
7.206	harmonic	-70.20	-73.00	-2	71
9.608	harmonic	-61.19	-62.27	-2	60.27
16.814	harmonic	-69.82	-70.34	-2	68.34
Transmit on channel 39					
7.320	harmonic	-67.46	-68.25	-2	66.25
9.760	harmonic	-50.84	-51.61	-2	49.61
Transmit on channel 79					
7.440	harmonic	-59.23	-60.38	-2	58.38
9.920	harmonic	-60.04	-60.31	-2	58.31

(*) Limit for harmonics is 20 dB below the lowest fundamental signal (~18 dBm). For all other emission the limit is given in Part 15 paragraph 209.

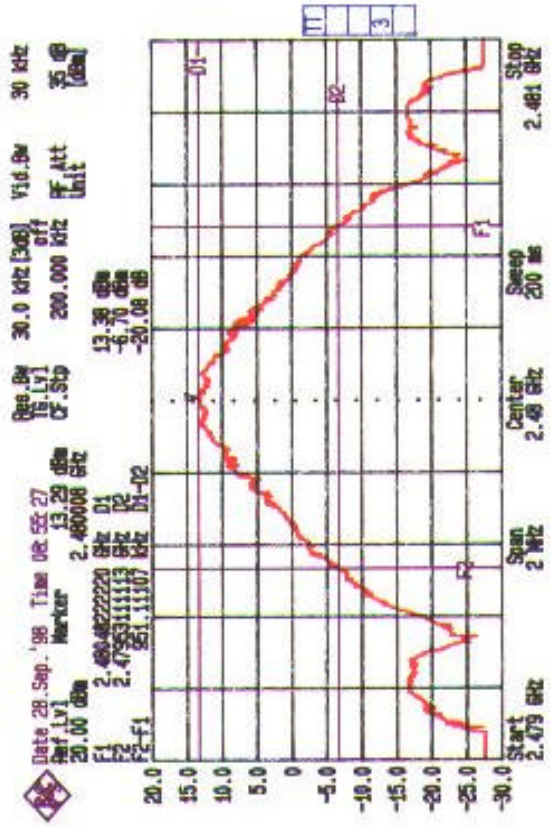
20 dB Bandwidth Measurements



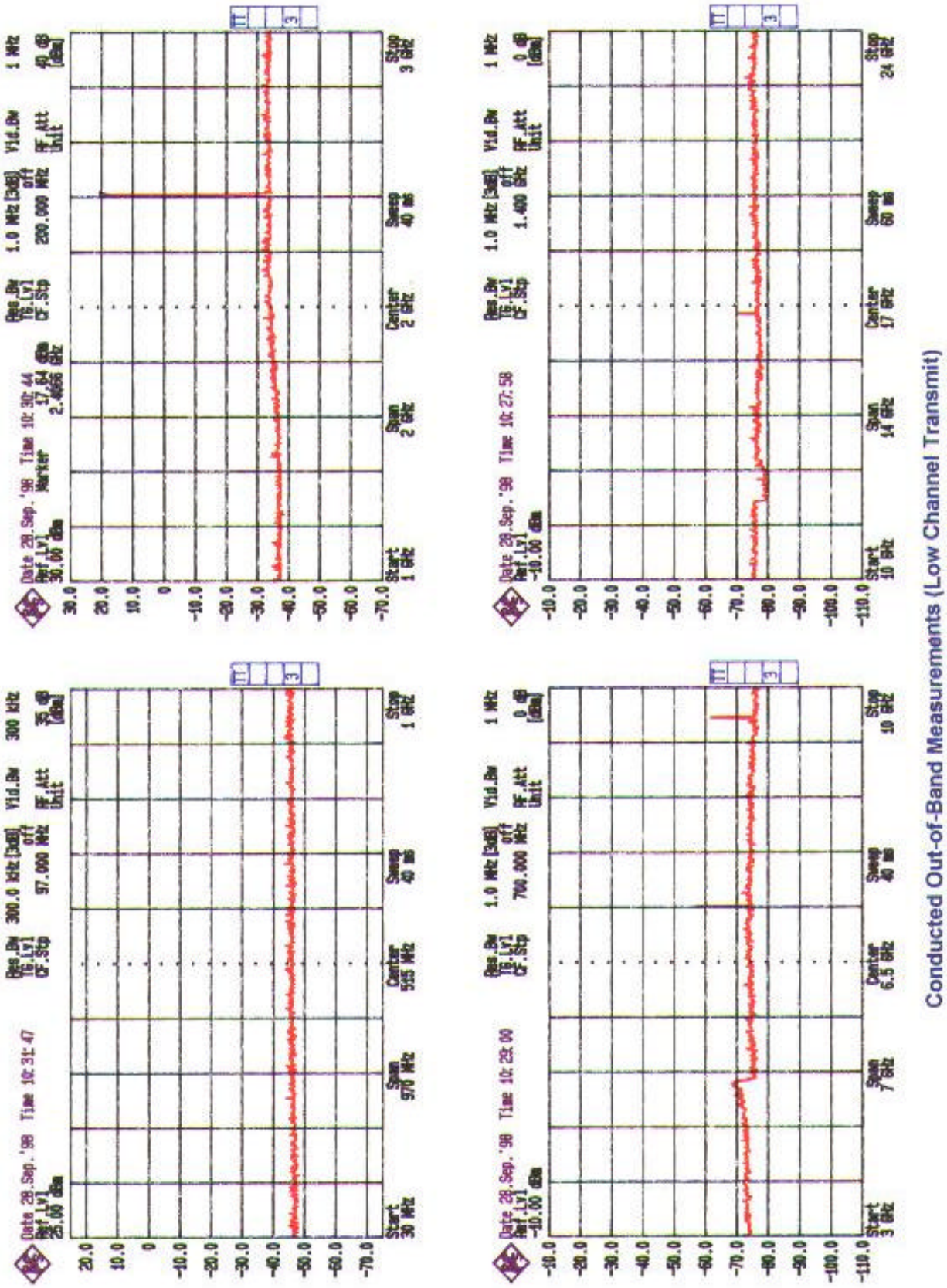
Mid Channel



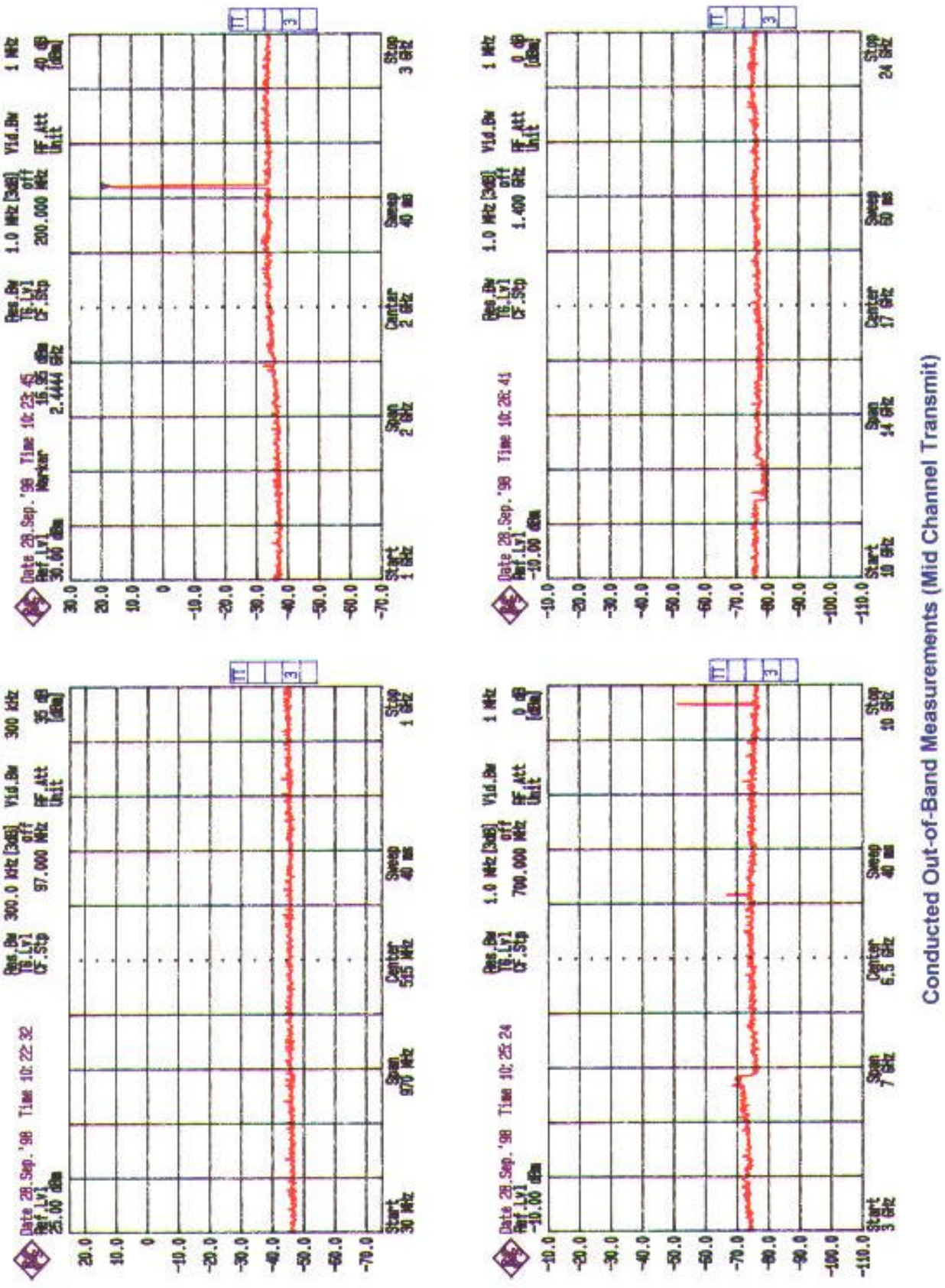
Low Channel



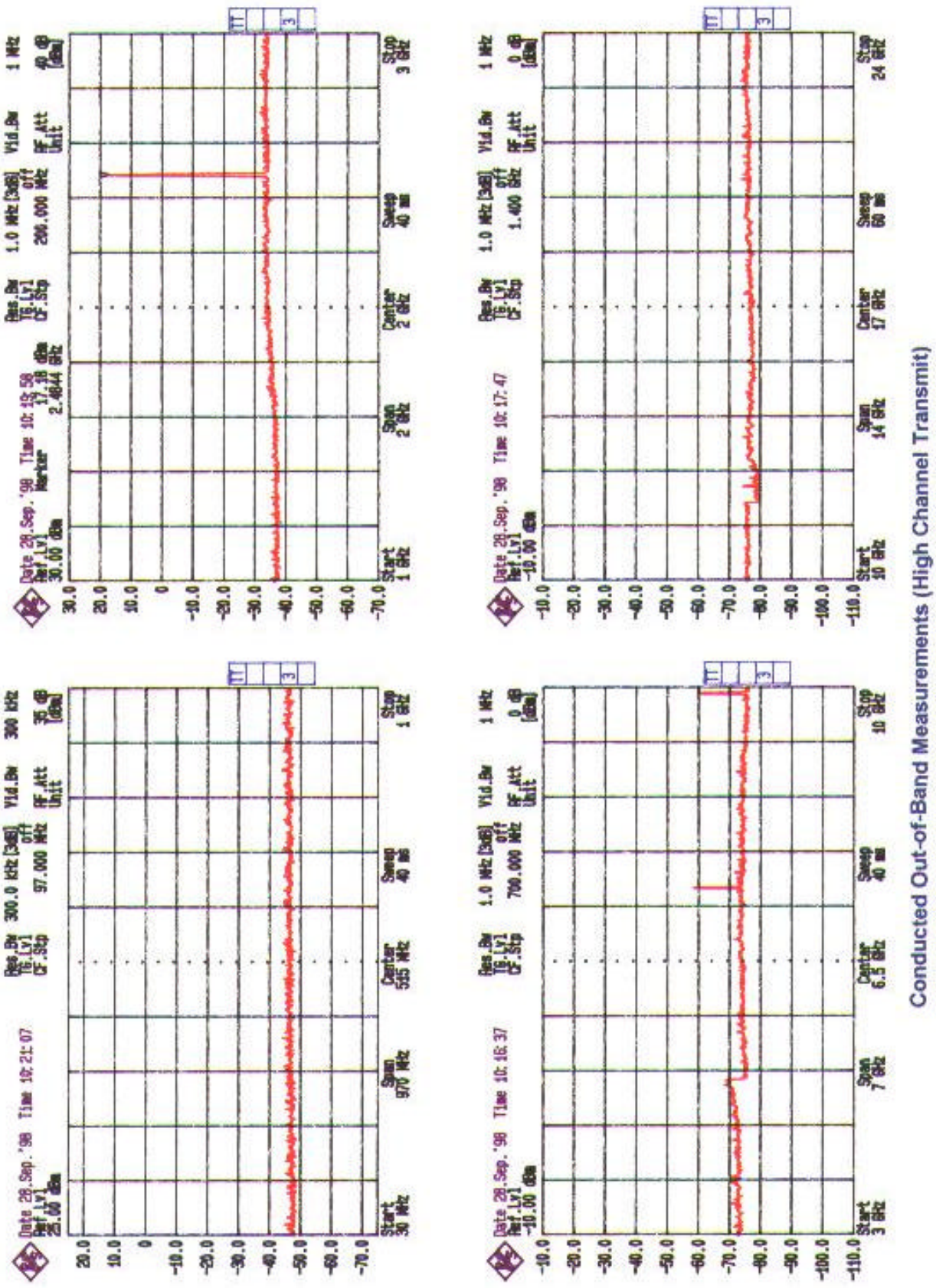
High Channel



Conducted Out-of-Band Measurements (Low Channel Transmit)



Conducted Out-of-Band Measurements (Mid Channel Transmit)



Conducted Out-of-Band Measurements (High Channel Transmit)

4.5 RADIATED SPURIOUS EMISSIONS

4.5.1.1 30 MHz - 1 GHz Band Procedure

First with the transmitter turned off, the EUT was powered up and a pre-scan was performed at 3m by rotating the EUT 360° and changing the antenna height between 1 m and 4 m. All suspicious peaks were noted. Then with the quasi-peak detector at 120 kHz RBW all suspicious peaks were scanned in the maximized EUT direction and antenna height. Same measurements were made for both polarizations of the antenna. The analyzer/receiver was programmed to compansate for all loss and gain factors (such as cables, antennas, preamplifiers etc.). The peak and quasi-peak readings were recorded. The limit used was FCC Part 15 class B radiated emissions limit. Then the same measurements were repeated with the transmitter in a constant transmit mode. This time only suspicious peaks in restricted bands (Part 15.205) were investigated. The measurements were performed four times for each each of the antennas (dipole, tab, omnidirectional and patch).

4.5.1.2 30 MHz - 1 GHz Band Results

All emissions measured were below the limit. The table on following pages shows the measured values above 20 dB margin, system loss/gain factors for those emissions and the position of the EUT and the measurement antenna.

4.5.2.1 1 GHz - 24 GHz Band Procedure

With the transmitter in continuous transmit mode, a pre-scan of the EUT was performed at 1m by rotating the EUT 360° and changing the antenna height between 1m and 4m. All suspicious peaks were noted. Then with the average-peak detector at 1 MHz RBW all suspicious peaks were scanned in the maximized EUT direction and antenna height. Same measurements were made for both polarizations of the antenna. The analyzer/receiver was programmed to compansate for all loss and gain factors (such as cables, antennas, preamplifiers etc.). A 10 dB correction factor was added to the readings for the reduction of measurements distance. The peak and average readings were recorded. The limits used were the limits specified in paragraphs 205 (restricted bands), 209 (spurious emissions), 247 (c) (harmonic emissions) of Part 15. The measurements were performed four times for each of the four worst case antennas (dipole, tab, omnidirectional and patch).

4.5.2.2 1 GHz - 24 GHz Band Results

The tables on following pages show the measured values, system loss/gain factors for those emissions and the position of the EUT and the antenna.
Since no emissions were found above 12.5 GHz, the band between 18 GHz and 24 GHz was not scanned.

Frequency (MHz)	Reading Peak (dBuV/m)	Reading QP (dBuV/m)	Antenna Factor (dB)	System Loss (dB)	Limit (dBuV/m)	Azimuth Angle (°)	Antenna Height (m)	Polariz.	Margin (dB)
Dipole Antenna Measurements									
120.00	37.40	33.20	11.23	18.16	43.50	350.00	1.00	V	**10.30**
180.30	24.38	23.87	13.59	16.58	43.50	185.00	1.00	V	**19.63**
208.18	26.40	26.11	15.75	16.12	43.50	115.00	1.50	V	**17.39**
239.40	28.12	27.54	17.09	15.91	46.00	120.00	1.00	V	**18.46**
511.80	40.99	38.56	18.42	21.42	46.00	355.00	1.00	V	**7.44**
180.30	36.89	34.22	13.59	16.58	43.50	330.00	1.00	H	**9.28**
184.44	27.24	27.10	13.95	16.50	43.50	100.00	1.00	H	**16.40**
208.18	37.77	34.32	15.75	16.12	43.50	155.00	1.00	H	**9.18**
224.00	32.83	30.15	16.44	16.01	46.00	125.00	1.50	H	**15.85**
239.40	28.76	27.34	17.09	15.91	46.00	160.00	1.00	H	**18.66**
511.80	42.72	41.60	18.42	21.42	46.00	160.00	1.00	H	**4.40**
Tab Antenna Measurements									
120.00	36.32	31.94	11.23	18.16	43.50	340.00	1.00	V	**11.56**
180.30	26.52	25.11	13.59	16.58	43.50	185.00	1.00	V	**18.39**
208.18	26.21	25.65	15.75	16.12	43.50	115.00	1.50	V	**17.85**
239.40	30.23	28.24	17.09	15.91	46.00	135.00	1.00	V	**17.76**
511.80	38.56	36.88	18.42	21.42	46.00	320.00	1.00	V	**9.12**
180.30	34.51	33.10	13.59	16.58	43.50	245.00	1.00	H	**10.40**
184.44	29.34	28.92	13.95	16.50	43.50	100.00	1.00	H	**14.58**
208.18	36.22	34.15	15.75	16.12	43.50	180.00	1.00	H	**9.35**
224.00	32.45	30.56	16.44	16.01	46.00	125.00	1.50	H	**15.44**
239.40	29.41	28.17	17.09	15.91	46.00	110.00	1.00	H	**17.83**
511.80	42.33	41.55	18.42	21.42	46.00	155.00	1.00	H	**4.45**
Omni-directional Antenna Measurements									
120.00	36.18	32.84	11.23	18.16	43.50	330.00	1.00	V	**10.66**
180.30	25.46	24.25	13.59	16.58	43.50	170.00	1.00	V	**19.25**
208.18	25.64	25.48	15.75	16.12	43.50	90.00	1.50	V	**18.02**
239.40	27.43	26.35	17.09	15.91	46.00	120.00	1.00	V	**19.65**
511.80	42.31	39.24	18.42	21.42	46.00	310.00	1.00	V	**6.76**
180.30	36.89	34.22	13.59	16.58	43.50	140.00	1.00	H	**9.28**
184.44	28.58	27.41	13.95	16.50	43.50	80.00	1.00	H	**16.09**
208.18	35.13	33.26	15.75	16.12	43.50	210.00	1.00	H	**10.24**
224.00	33.45	30.67	16.44	16.01	46.00	100.00	1.50	H	**15.33**
239.40	26.73	26.10	17.09	15.91	46.00	160.00	1.00	H	**19.90**
511.80	40.34	39.85	18.42	21.42	46.00	130.00	1.00	H	**6.15**
Patch Antenna Measurements									
120.00	35.82	31.16	11.23	18.16	43.50	290.00	1.00	V	**12.34**
180.30	26.44	25.72	13.59	16.58	43.50	230.00	1.00	V	**17.78**
184.44	26.17	24.88	13.95	16.50	43.50	120.00	1.00	V	**18.62**
208.18	27.24	25.48	15.75	16.12	43.50	160.00	1.50	V	**18.02**
239.40	28.40	27.45	17.09	15.91	46.00	140.00	1.00	V	**18.55**
511.80	42.66	38.97	18.42	21.42	46.00	300.00	1.00	V	**7.03**
180.30	37.32	35.12	13.59	16.58	43.50	200.00	1.00	H	**8.38**
184.44	27.31	26.40	13.95	16.50	43.50	120.00	1.00	H	**17.10**
208.18	36.45	35.18	15.75	16.12	43.50	200.00	1.00	H	**8.32**
224.00	32.81	29.34	16.44	16.01	46.00	110.00	1.50	H	**16.66**
239.40	27.76	26.84	17.09	15.91	46.00	125.00	1.00	H	**19.16**
511.80	41.20	40.36	18.42	21.42	46.00	160.00	1.00	H	**5.64**

Radiated Emissions Results (below 1 GHz)

Frequency MHz	Ant. Factors dB	Sys. Gain dB	Peak value (*) dBµV/m	AVG value (*) dBµV/m	FCC Limit dBµV/m	Ant. Height m	Antenna Polarization	Azimuth deg.	Margin dB
Dipole Antenna									
7206	38.3	-1.2	44.5	38.1	54	1	V	90	**15.90**
7320	38.3	-1.2	43.7	37.4	54	1	V	90	**16.60**
7440	38.1	-1.2	45.8	38.9	54	1	V	90	**15.10**
9608	37.8	-1.4	48.3	42.5	54	1	V	90	**11.50**
9760	38.1	-1.4	47.8	41.4	54	1	V	90	**12.60**
9920	38.1	-1.6	47.2	40.8	54	1	V	90	**13.20**
Tab Antenna									
7206	38.3	-1.2	47.3	42.5	54	1	H	90	**11.50**
7320	38.3	-1.2	45.8	39.1	54	1	H	90	**14.90**
7440	38.1	-1.2	46.5	39.7	54	1	H	90	**14.30**
9608	37.8	-1.4	51.5	44.6	54	1	H	90	**9.40**
9760	38.1	-1.4	50.4	43.8	54	1	H	90	**10.20**
9920	38.1	-1.6	51.3	44.9	54	1	H	90	**9.10**
Patch Antenna									
7206	38.3	-1.2	45.6	34.5	54	1	V	30	**19.50**
7320	38.3	-1.2	46.8	33.9	54	1	V	30	**20.10**
7440	38.1	-1.2	44.2	31.8	54	1	V	30	**22.20**
9608	37.8	-1.4	42.5	31.4	54	1	V	0	**22.60**
9760	38.1	-1.4	42.2	32.9	54	1	V	0	**21.10**
9920	38.1	-1.6	44.1	34.1	54	1	V	0	**19.90**
Omni-Directional Antenna									
7206	38.3	-1.2	39.8	33.7	54	1	V	45	**20.30**
7320	38.3	-1.2	41.6	33.8	54	1	V	45	**20.20**
7440	38.1	-1.2	40.8	32.5	54	1	V	45	**21.50**
9608	37.8	-1.4	43.1	33.5	54	1	V	30	**20.50**
9760	38.1	-1.4	44.3	34.5	54	1	V	30	**19.50**
9920	38.1	-1.6	43.7	34	54	1	V	30	**20.00**

(*) Measurement is made at 1m distance; therefore, a 10 dB correction factor added.
RBW = 1 MHz VBW = 1 MHz

Radiated Emissions Results (above 1 GHz)