



Applicant: Daniels Electronics Ltd.
43 Erie St
Victoria, BC V8V 1P8

Equipment Under Test: VT-4E150 VHF Transmitter

FCC ID: H4JVT-4E150

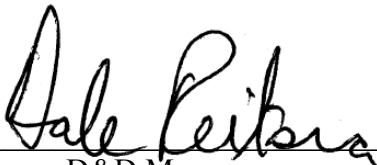
In Accordance With: FCC Part 22
FCC Part 80
FCC Part 90

Tested By: Daniels Electronics Ltd.
43 Erie St
Victoria, BC, V8V 1P8

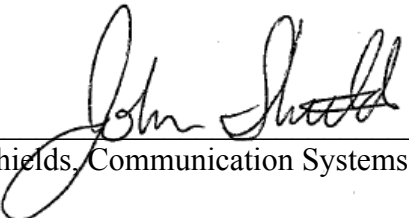
And

Acme Testing Co.
2002 Valley Highway
Acme, WA, 98220-0003

Authorized By:


Dale Reitsma, D&D Manager

Testing Verified By:


John Shields, Communication Systems Designer

Date: 2 Aug 2006

Total Number of Pages: 28

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Appendix A: VT-4E150 VHF Transmitter **– Measurements of Field Strength of Spurious Radiation**

1. Summary of Test Results

General

All measurements are traceable to national standards.

These tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with FCC Part 22, 80, and 90.

This application is a new submission for approval of the **VT-4E150 VHF Transmitter**, operating in the 136 to 174 MHz frequency band of the Land Mobile Services. The equipment under test are pre-production units.

✓ New Submission
Modification Filing
Family Listing

Production Unit
✓ Pre-Production Unit

Summary of Test Data

Name of Test	Para No.	Result
RF Power Output	47 CFR §2.1046	Complies
Audio Frequency Response	47 CFR §2.1047 a)	Complies
Audio Low-Pass Filter Response	47 CFR §2.1047 a)	Complies
Modulation Limiting	47 CFR §2.1047 b)	Complies
Occupied Bandwidth (with Audio Low-Pass Filter Installed)	47 CFR §2.1049 g), h) 47 CFR §90.210 d)	Complies
Spurious Emissions at Antenna Terminals	47 CFR §2.1051 47 CFR §90.210 d)	Complies
Field Strength of Spurious Emissions	47 CFR §2.1053 47 CFR §90.210 d)	Complies
Frequency Stability	47 CFR §2.1055 47 CFR §90.213 47 CFR §90.539	Complies
Transient Frequency Behaviour	47 CFR §90.214	Complies

Test Conditions:

The following conditions apply to all of the testing except when otherwise specified.

Temperature: 23°C
Humidity: 30%

2. General Equipment Specifications

Manufacturer:	Daniels Electronics Ltd.	
Model Number:	VT-4E150	
FCC ID:	H4JVT-4E150	
Starting Date of Testing:	June 8, 2006	
Serial Numbers of EUTs:	R&D 10010	Note: Used for the majority of the tests.
	R&D 10011	Note: Used for Frequency Stability and Transient Frequency Behaviour Testing.
	R&D 10001	Note: Used for Field Strength of Spurious Emissions Testing
Primary Power:	13.8V _{DC}	
Emission Designators (Analog)		
12.5kHz Channel Spacing:	11K0F3E	
25kHz Channel Spacing:	16K0F3E	
Emission Designators (Digital):		
Voice: 12.5kHz Channel Spacing:	8K10F1E	
Data: 12.5kHz Channel Spacing:	8K10F1D	
Data: Paging with external modulator:	9K2F1D	
Rated RF Power Output:	Variable: 0.5 to 8.0W	
Channel Spacing:	12.5kHz & 25kHz	
Frequency Range:	136 to 174MHz	

3. RF Power Output

Test Results: Complies
Minimum Standard: 47 CFR §2.1046
 $\pm 1\text{dB}$ (defined by the manufacturer)
Test Procedure: TIA-603-C Sect 2.2.1

Notes:

The center frequency is tested at the maximum and minimum output power; 8.0W (39.0dBm) and 0.5W (27.0dBm) respectively.

EUT Model #: VT-4E150
Serial Number: R&D 10010

Test Equipment: Power Meter, Sensor, 50 ohm Load } Rohde & Schwarz CMS 54 (DE #1545)

Measurement Data:

Rated Power = 8.0W (39.0dBm)

Frequency (MHz)	Rated Power (dBm)	Measured Power (dBm)
159	8.0W (39.0dBm)	7.98W (39.0dBm)

Rated Power = 0.5W (27.0dBm)

Frequency (MHz)	Rated Power (dBm)	Measured Power (dBm)
159	0.5W (27.0dBm)	0.495W (26.9dBm)

4. Audio Frequency Response

Test Results: Complies
Minimum Standard: 47 CFR §2.1047 a)
Test Procedure: TIA-603-C Sect 2.2.6

Notes:

The center frequency is tested using a 12.5kHz and 25kHz channel spacing.

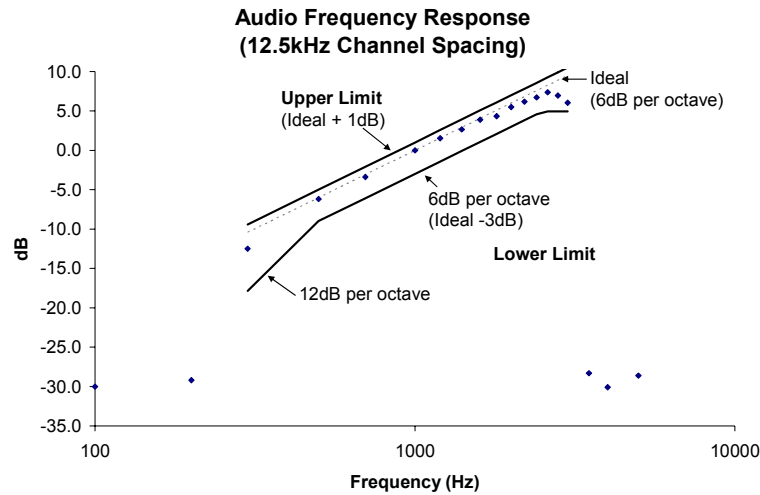
EUT Model #: VT-4E150
Serial Number: R&D 10010

Test Equipment: Audio Generator, } Rohde & Schwarz CMS 54 (DE #1545)
Test Receiver }
Audio Level Meter Fluke 45 (DE #1720)

Measurement Data: See the graphs and tables below

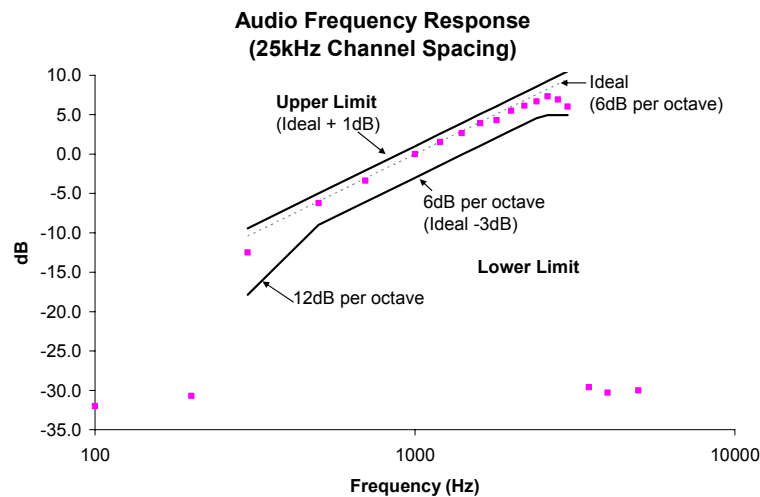
12.5kHz Channel Spacing (159MHz)

Audio Freq (Hz)	12.5kHz (dB)
100	-30.0
200	-29.2
300	-12.5
500	-6.2
700	-3.4
1000	0.0
1200	1.5
1400	2.7
1600	3.9
1800	4.3
2000	5.5
2200	6.2
2400	6.7
2600	7.4
2800	7.0
3000	6.1
3500	-28.3
4000	-30.1
5000	-28.6



25kHz Channel Spacing (159MHz)

Audio Freq (Hz)	25kHz (dB)
100	-32.0
200	-30.7
300	-12.5
500	-6.2
700	-3.4
1000	0.0
1200	1.5
1400	2.7
1600	3.9
1800	4.3
2000	5.5
2200	6.1
2400	6.7
2600	7.3
2800	6.9
3000	6.0
3500	-29.6
4000	-30.3
5000	-30.0



5. Audio Low-Pass Filter Response

Test Results: Complies
Standard: 47 CFR §2.1047 a)
Test Procedure: TIA-603-C Sect 2.2.15

Notes:

The Audio Low-Pass Filter Response is not dependant on RF frequency. The response of the 12.5kHz and 25kHz channel spacing is measured.

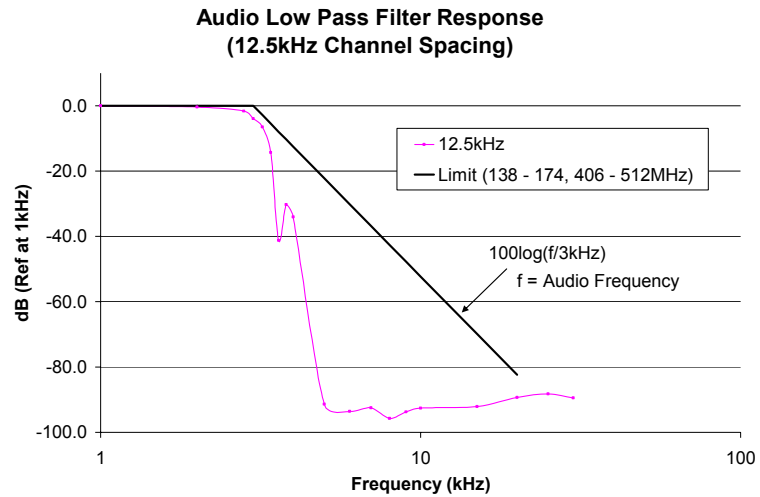
EUT Model #: VT-4E150
Serial Number: R&D 10010

Test Equipment: Audio Generator Rohde & Schwarz CMS 54 (DE #1545)
Audio Spectrum Analyzer IFR 2965A (DE #1396)

Measurement Data: See the graphs and tables below

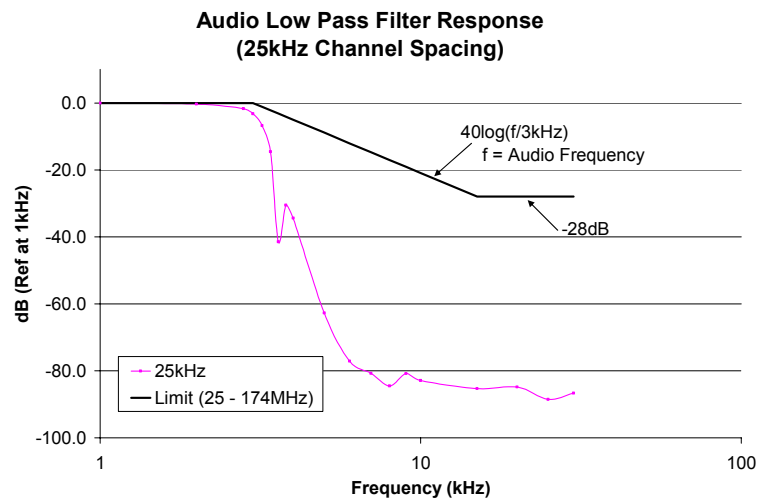
12.5kHz Channel Spacing

Audio Freq (kHz)	12.5kHz & 15kHz (dB rel. to 1kHz)
1	0.0
2	-0.4
2.8	-1.6
3	-3.9
3.2	-6.5
3.4	-14.3
3.6	-41.3
3.8	-30.3
4	-34.1
5	-91.4
6	-93.6
7	-92.5
8	-95.7
9	-93.7
10	-92.6
15	-92.1
20	-89.3
25	-88.3
30	-89.4



25kHz Channel Spacing

Audio Freq (kHz)	25kHz & 30kHz (dB rel. to 1kHz)
1	0.0
2	-0.4
2.8	-1.7
3	-3.2
3.2	-6.8
3.4	-14.6
3.6	-41.5
3.8	-30.5
4	-34.4
5	-62.8
6	-77.1
7	-80.7
8	-84.5
9	-80.8
10	-82.9
15	-85.3
20	-84.9
25	-88.5
30	-86.7



6. Modulation Limiting

Test Results: Complies
Standard: 47 CFR §2.1047 b)
Test Procedure: 47 CFR §2.1047 b)

Notes:

The modulation limiting is tested at the recommended audio frequencies of 300, 1000, 2500 and 3000Hz. The input level for each of these curves range from -20dBm to +15dBm. This input range allows the modulation limiting at the 1000Hz audio frequency to be more than 16dB greater than the input level necessary for 50% of the maximum modulation. The test receiver employs a 20kHz low pass audio filter.

The test procedure is specifically for analog; therefore the digital modulation inputs are not used.

The modulation limiting for 12.5kHz and 25kHz channel spacing are measured at the center frequency, with the maximum output power, 8W (39dBm).

EUT Model #: VT-4E150
Serial Number: R&D 10010

Test Equipment: Audio Generator }
Test Receiver } Rohde & Schwarz CMS 54 (DE #1545)
Audio Level Meter }

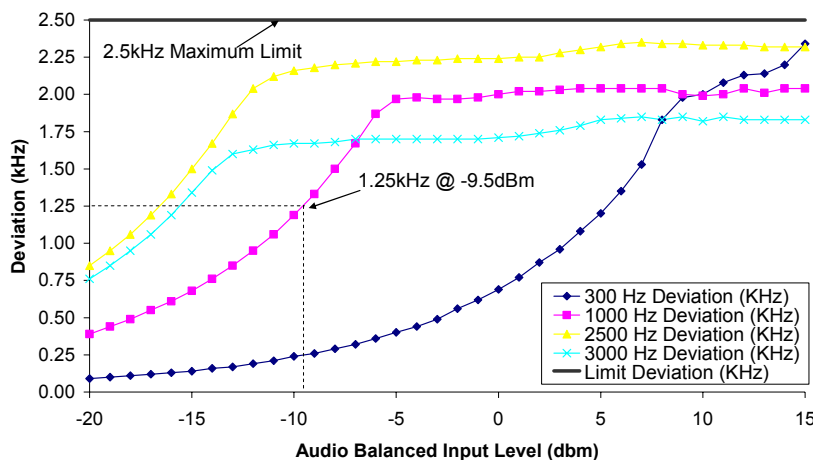
Measurement Data: See the graphs and tables below

12.5kHz Channel Spacing (159MHz), 8W (39dBm)

Modulation versus Input Signal Test Results

Audio Freq	300 Hz	1000 Hz	2500 Hz	3000 Hz
Balance Input	Deviation	Deviation	Deviation	Deviation
(dBm)	(KHz)	(KHz)	(KHz)	(KHz)
-20	0.09	0.39	0.85	0.76
-19	0.10	0.44	0.95	0.85
-18	0.11	0.49	1.06	0.95
-17	0.12	0.55	1.19	1.06
-16	0.13	0.61	1.33	1.19
-15	0.14	0.68	1.50	1.34
-14	0.16	0.76	1.67	1.49
-13	0.17	0.85	1.87	1.60
-12	0.19	0.95	2.04	1.63
-11	0.21	1.06	2.12	1.66
-10	0.24	1.19	2.16	1.67
-9	0.26	1.33	2.18	1.67
-8	0.29	1.50	2.20	1.68
-7	0.32	1.67	2.21	1.70
-6	0.36	1.87	2.22	1.70
-5	0.40	1.97	2.22	1.70
-4	0.44	1.98	2.23	1.70
-3	0.49	1.97	2.23	1.70
-2	0.56	1.97	2.24	1.70
-1	0.62	1.98	2.24	1.70
0	0.69	2.00	2.24	1.71
1	0.77	2.02	2.25	1.72
2	0.87	2.02	2.25	1.74
3	0.96	2.03	2.28	1.76
4	1.08	2.04	2.30	1.79
5	1.20	2.04	2.32	1.83
6	1.35	2.04	2.34	1.84
7	1.53	2.04	2.35	1.85
8	1.83	2.04	2.34	1.83
9	1.98	2.00	2.34	1.85
10	2.00	1.99	2.33	1.82
11	2.08	2.00	2.33	1.85
12	2.13	2.04	2.33	1.83
13	2.14	2.01	2.32	1.83
14	2.20	2.04	2.32	1.83
15	2.34	2.04	2.32	1.83

Modulation Limiting vs Input Signal
(12.5kHz Channel Spacing) at 159MHz



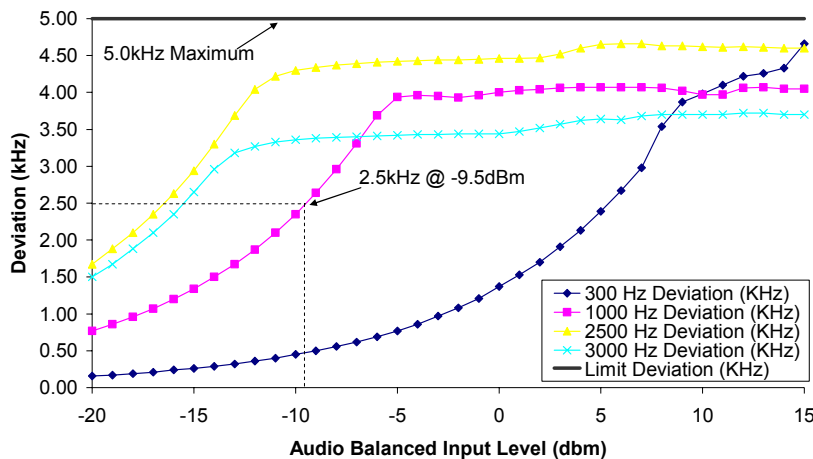
The modulation is within the maximum modulation limit.

25kHz Channel Spacing (159MHz), 8W (39dBm)

Modulation versus Input Signal Test Results

Audio Freq	300 Hz	1000 Hz	2500 Hz	3000 Hz
Balance Input	Deviation	Deviation	Deviation	Deviation
(dBm)	(KHz)	(KHz)	(KHz)	(KHz)
-20	0.16	0.77	1.67	1.50
-19	0.17	0.86	1.88	1.67
-18	0.19	0.96	2.10	1.88
-17	0.21	1.07	2.35	2.10
-16	0.24	1.20	2.63	2.35
-15	0.26	1.34	2.94	2.65
-14	0.29	1.50	3.30	2.96
-13	0.32	1.67	3.69	3.18
-12	0.36	1.87	4.04	3.27
-11	0.40	2.10	4.22	3.33
-10	0.45	2.35	4.30	3.36
-9	0.50	2.64	4.34	3.38
-8	0.56	2.96	4.37	3.39
-7	0.62	3.31	4.39	3.40
-6	0.69	3.69	4.41	3.41
-5	0.77	3.94	4.42	3.42
-4	0.86	3.96	4.43	3.43
-3	0.97	3.95	4.44	3.43
-2	1.08	3.93	4.44	3.44
-1	1.21	3.96	4.45	3.44
0	1.37	4.00	4.46	3.44
1	1.53	4.03	4.46	3.47
2	1.70	4.04	4.47	3.52
3	1.91	4.06	4.52	3.57
4	2.13	4.07	4.60	3.62
5	2.39	4.07	4.65	3.64
6	2.67	4.07	4.66	3.63
7	2.98	4.07	4.66	3.68
8	3.54	4.06	4.63	3.70
9	3.87	4.02	4.63	3.70
10	3.98	3.97	4.62	3.70
11	4.10	3.97	4.61	3.70
12	4.22	4.06	4.62	3.72
13	4.26	4.07	4.61	3.72
14	4.33	4.05	4.60	3.70
15	4.66	4.05	4.60	3.70

Modulation Limiting vs Input Signal
(25kHz Channel Spacing) at 159MHz



The modulation is within the maximum modulation limit.

7. Occupied Bandwidth (with audio low-pass filter installed)

Test Results: Complies
Standard: 47 CFR §2.1049 g), h)
47 CFR §90.210 d)
47 CFR §90.210 d) 4)

Test Procedure: TIA-603-C Sect 2.2.11
TIA-102.CAAA-B 2.2.5

Notes:

The center frequency is tested under each of the modulation inputs 11K0F3E, 16K0F3E, 8K10F1D, 8K10F1E, and 9K2F1D. The center frequency will also be tested for the 99% Occupied BW under all modulation inputs listed above.

The band edges will be tested for their associated masks under modulation inputs 11K0F3E and, 8K10F1D or 8K10F1E only.

All of the Occupied Bandwidth tests are performed at the maximum output power, 8W (39dBm).

When transmitting in Digital mode, the signal characteristics of RF output are identical for both 8K10F1D and 8K10F1E modulation formats. Therefore, for purposes of brevity, test results for 8K10F1D modulation are included as representative of both modulation formats in this report.

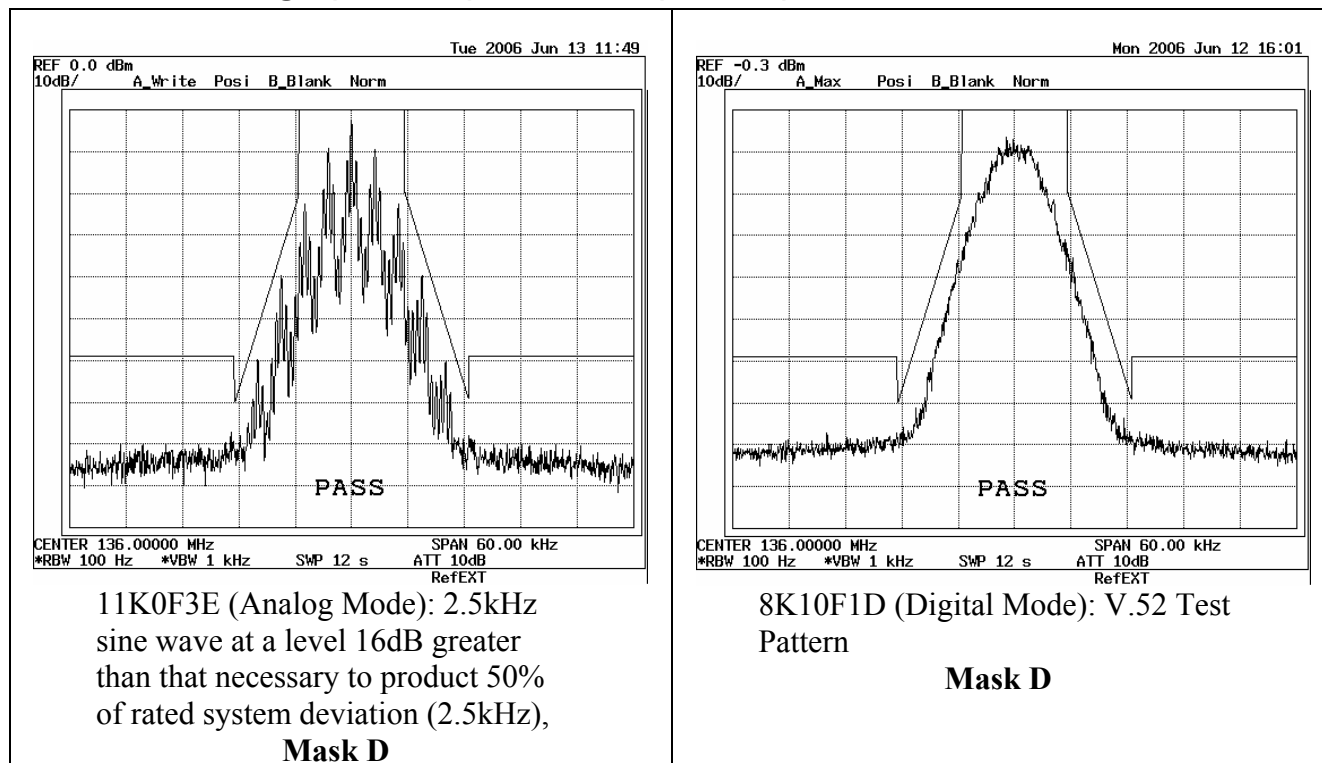
EUT Model #: VT-4E150
Serial Number: R&D 10010

Test Equipment:

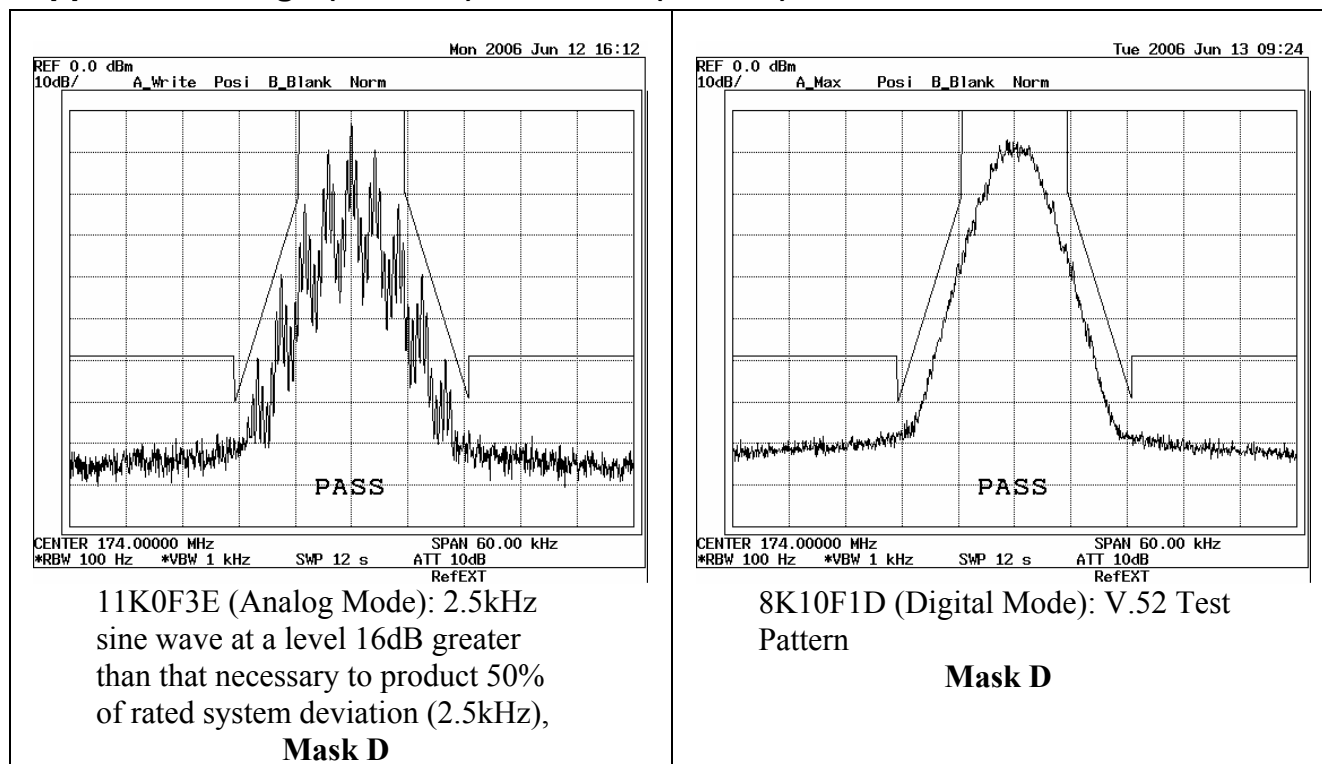
Audio Generator	}	IFR 2975 (DE #1334)
Power Meter		
Power Sensor		
Directional Coupler		HP 778D
Spectrum Analyzer		Advantest R3132 (DE #1717)
50ohm Loads	}	General Lab Equipment
Attenuators		

Measurement Data: See the following graphs:

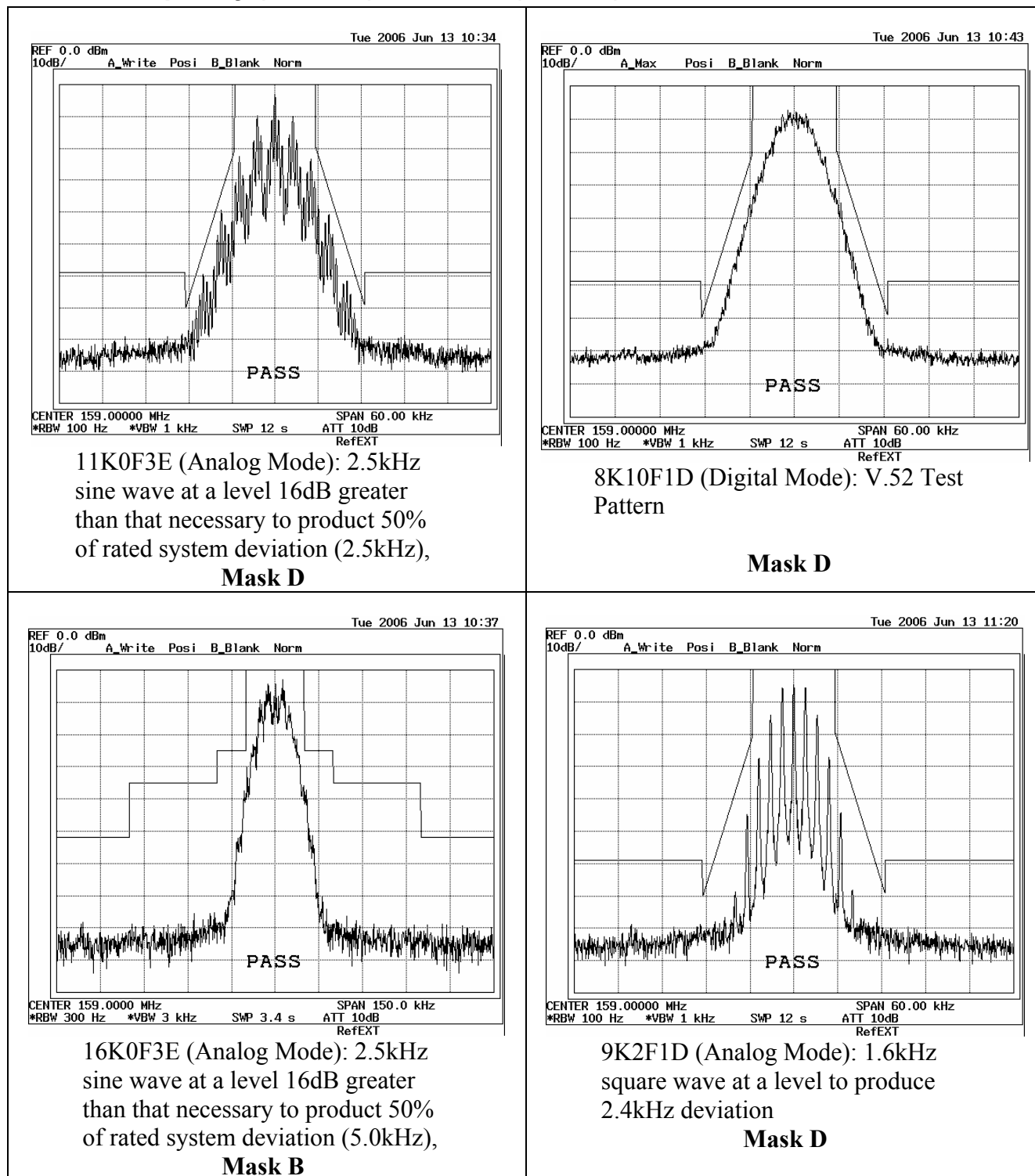
Lower Band Edge (136MHz) OBW, 8W (39dBm)



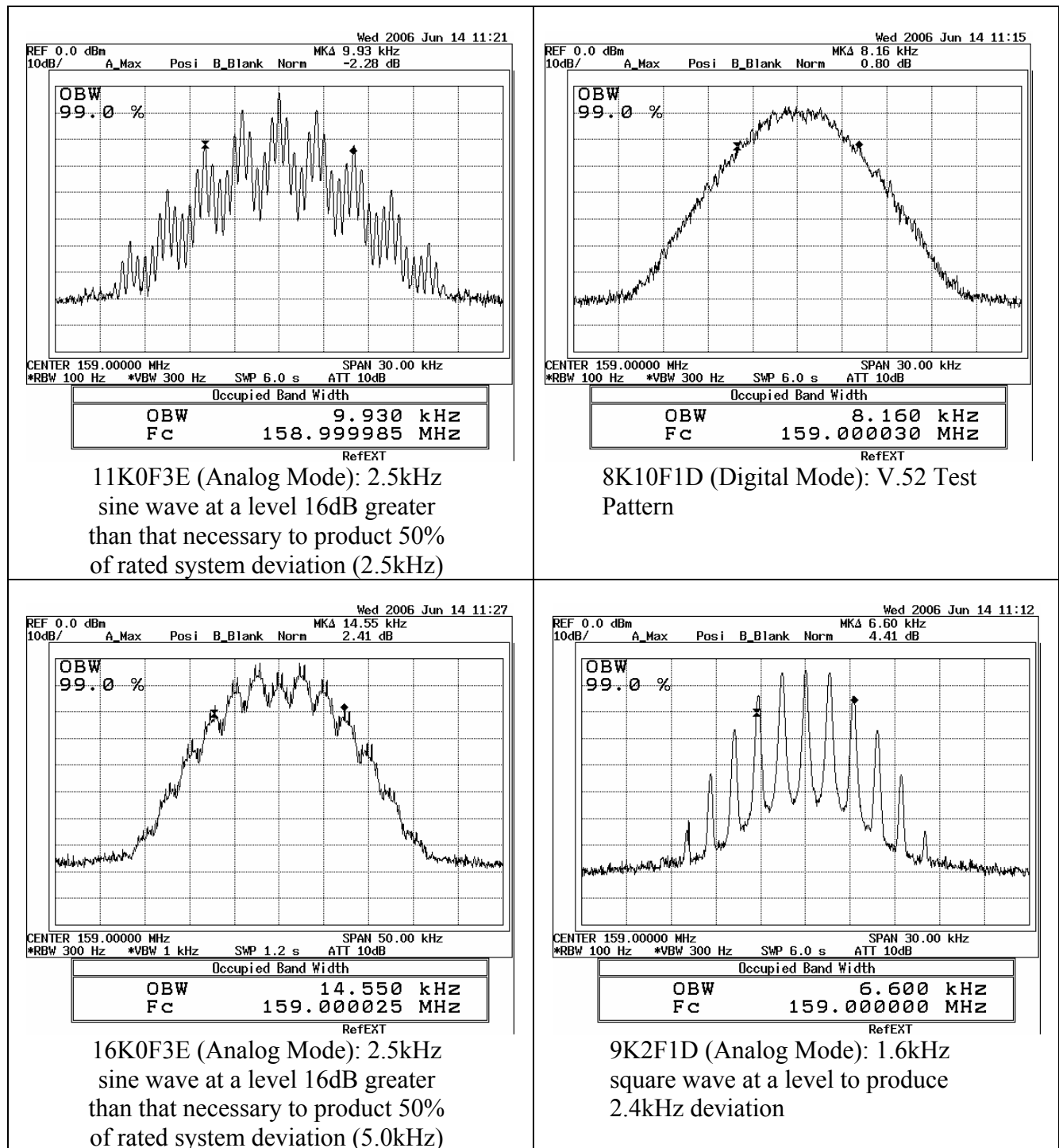
Upper Band Edge (174MHz) OBW, 8W (39dBm)



Center Frequency (159MHz) OBW, 8W (39dBm)



Center Frequency (159MHz) 99% OBW, 8W (39dBm)



8. Spurious Emissions at Antenna Terminals

Test Results: Complies
Standard: 47 CFR §2.1051
47 CFR §90.210 d)

Test Procedure: TIA-603-C Sect 2.2.13

Notes:

At the maximum rated output power, 8W (39dBm), a full sweep from 20MHz to 2GHz (or the 10th harmonic of the center frequency) is performed at the center frequency using each of the modulation inputs: 11K0F3E, 16K0F3E, 8K10F1D, 8K10F1E, and 9K2F1D.

At the lowest output power level 0.5W, a full sweep from 20MHz to 2GHz (or the 10th harmonic of the center frequency) is also performed at the center frequency using 11K0F3E and, 8K10F1D or 8K10F1E.

When transmitting in Digital mode, the signal characteristics of RF output are identical for both 8K10F1D and 8K10F1E modulation formats. Therefore, for purposes of brevity, test results for 8K10F1D modulation are included as representative of both modulation formats in this report.

The limit line that is shown on all the graphs is $50 + 10 \log P$ or -20dBm. For the 25kHz channel spacing (16K0F3E) the limit line is the more relaxed limit of $43 + 10 \log P$. In this case the more stringent -20dBm limit line is still used for testing simplicity.

EUT Model #: VT-4E150
Serial Number: R&D 10010

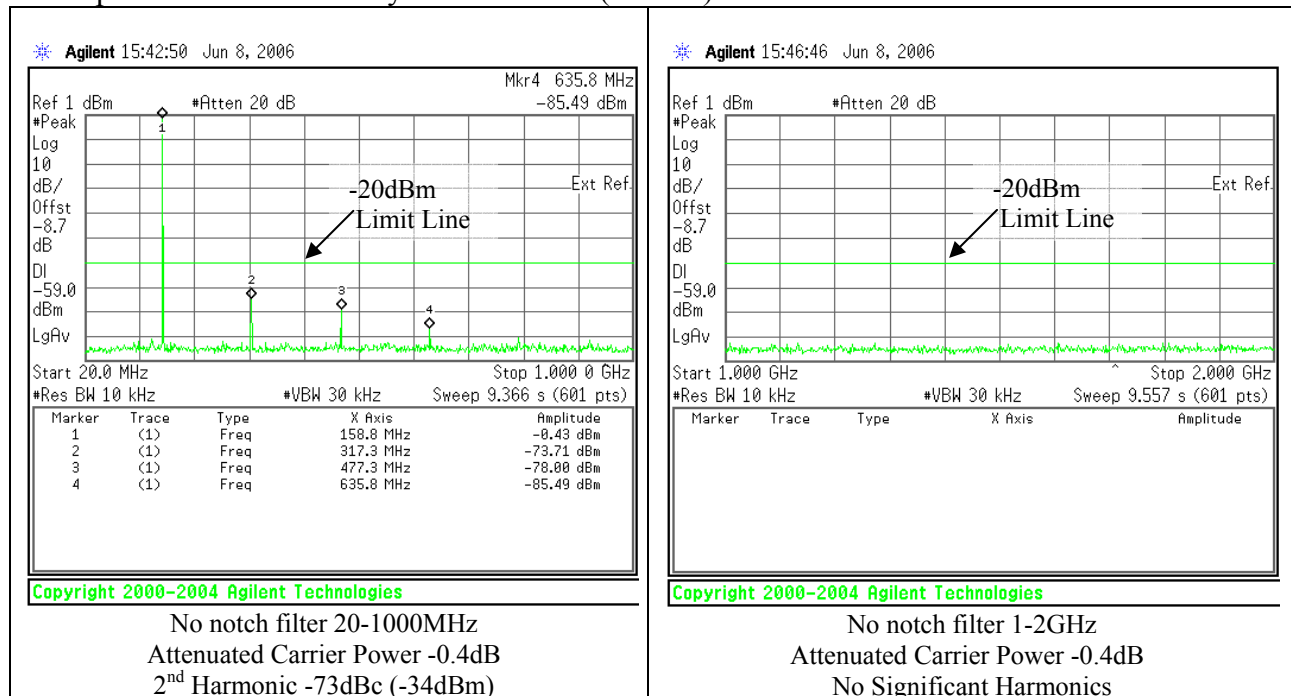
Test Equipment:

Audio Generator	}	IFR 2975 (DE #1334)
Power Meter		
Power Sensor		
Directional Coupler		HP 778D
Spectrum Analyzer		Agilent E4440A (DE# 1414)
50ohm Loads	}	General Lab Equipment
Attenuators		

Measurement Data: See following graphs:

Center Frequency (159MHz) 11K0F3E Modulation Input, 8W (39dBm)

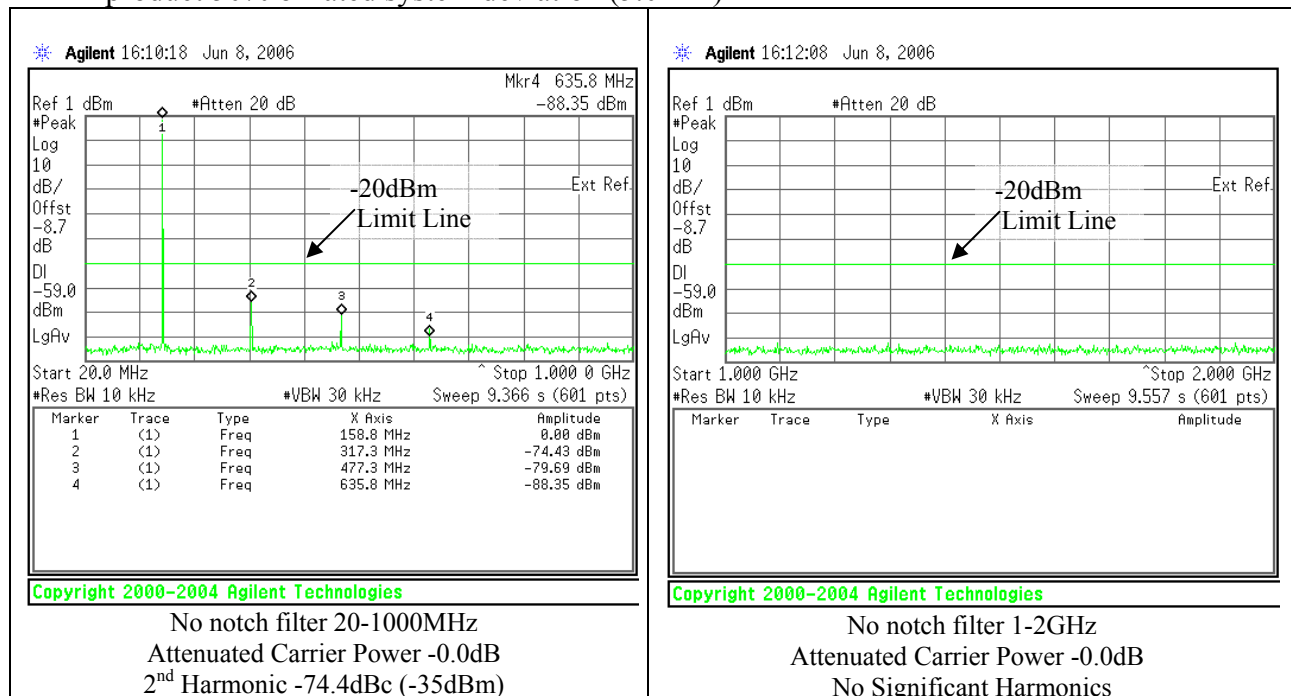
11K0F3E (Analog Mode): 2.5kHz sine wave at a level 16dB greater than that necessary to product 50% of rated system deviation (2.5kHz)



The worst case is the 2nd harmonic at -73dBc (-34dBm), which is 14dB below the limit.

Center Frequency (159MHz) 16K0F3E Modulation Input, 8W (39dBm)

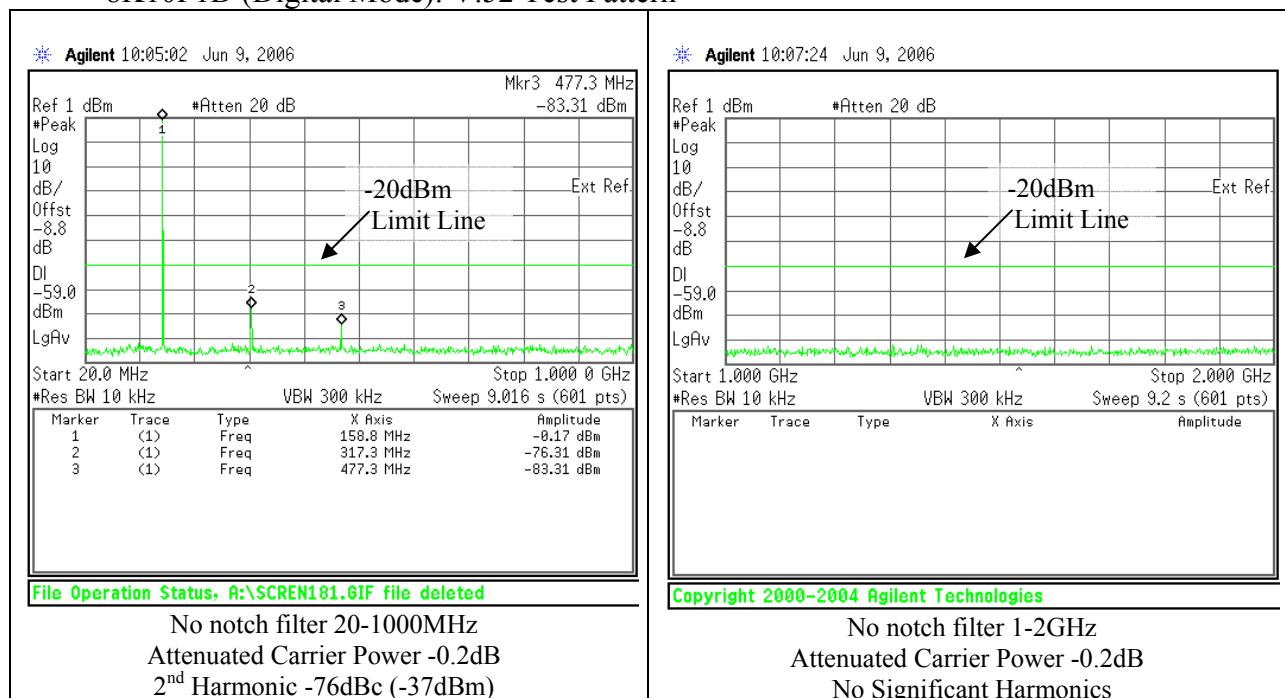
16K0F3E (Analog Mode): 2.5kHz sine wave at a level 16dB greater than that necessary to product 50% of rated system deviation (5.0kHz)



The worst case is the 2nd harmonic at -74dBc, which is 15dB below the limit.

Center Frequency (159MHz) 8K10F1D Modulation Input, 8W (39dBm)

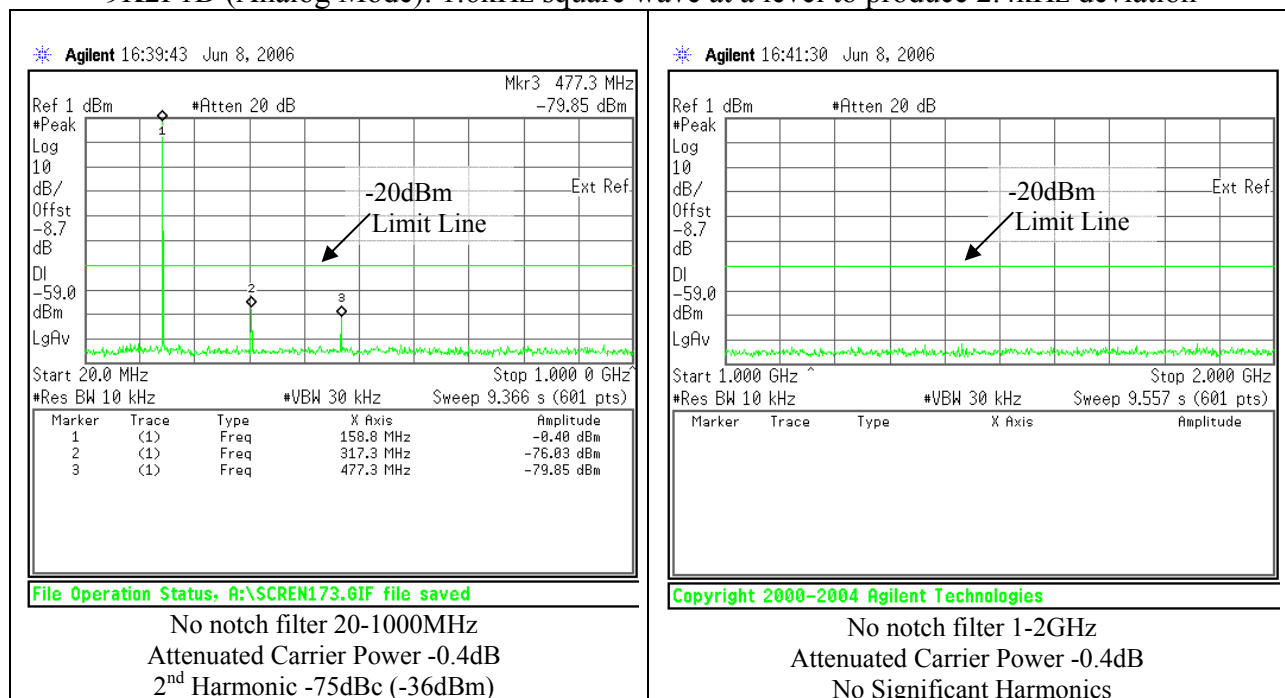
8K10F1D (Digital Mode): V.52 Test Pattern



The worst case is the 2nd harmonic at -76dBc, which is 17dB below the limit.

Center Frequency (159MHz) 9K2F1D Modulation Input, 8W (39dBm)

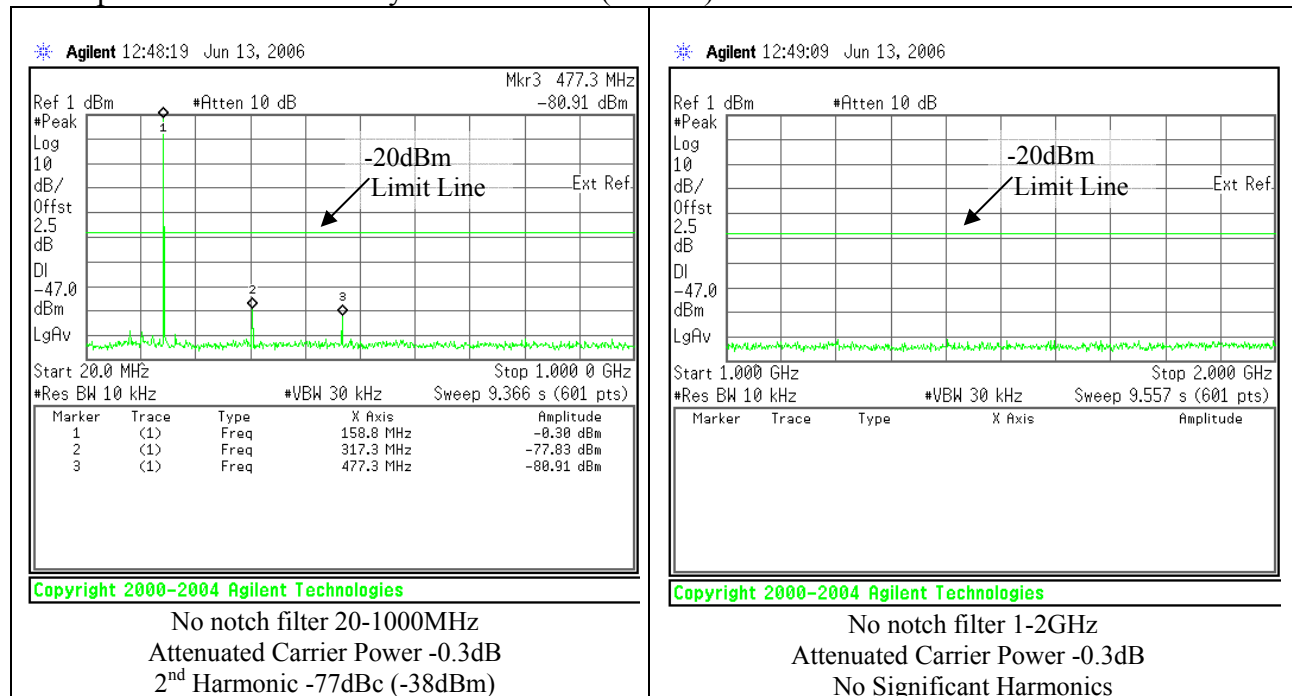
9K2F1D (Analog Mode): 1.6kHz square wave at a level to produce 2.4kHz deviation



The worst case is the 2nd harmonic at -75dBc, which is 16dB below the limit.

Center Frequency (159MHz) 11K0F3E Modulation Input, 0.5W (27dBm)

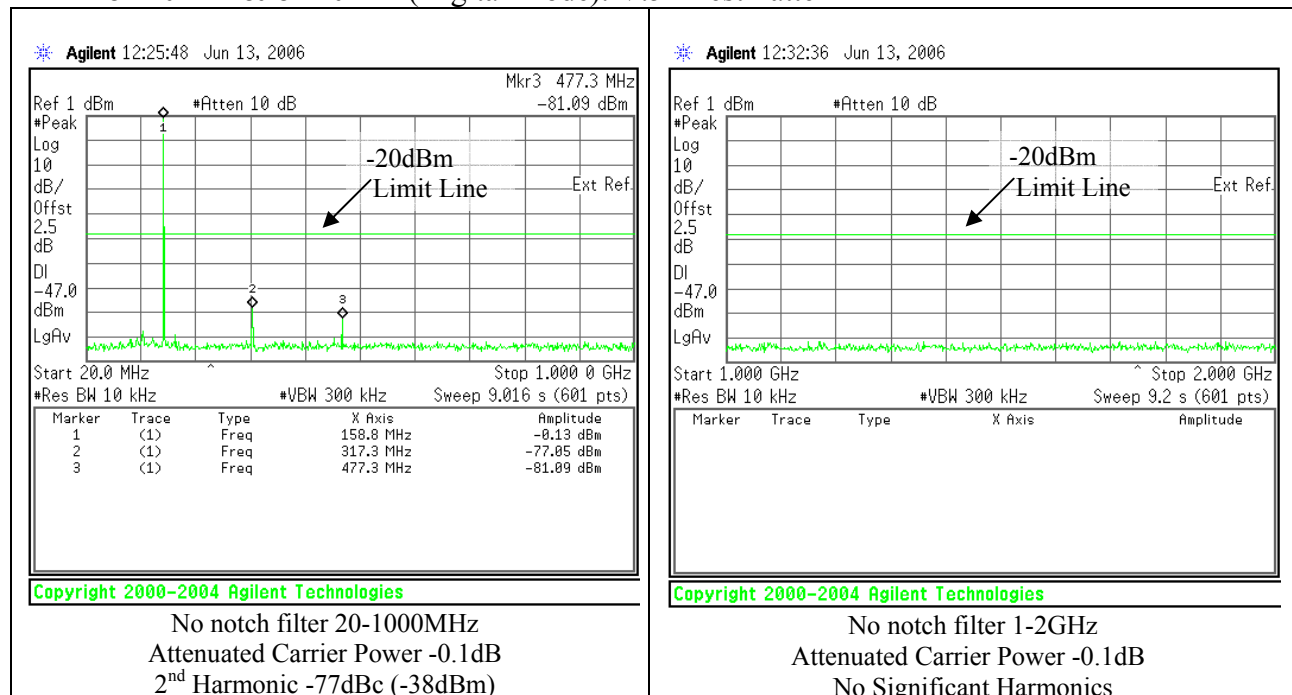
11K0F3E (Analog Mode): 2.5kHz sine wave at a level 16dB greater than that necessary to product 50% of rated system deviation (2.5kHz)



The worst case is the 2nd harmonic at -77dBc, which is 18dB below the limit.

Center Frequency (159MHz) 8K10F1D Modulation Input, 0.5W (27dBm)

8K10F1D & 8K10F1E (Digital Mode): V.52 Test Pattern



The worst case is the 2nd harmonic at -77dBc, which is 18dB below the limit.

9. Field Strength of Spurious Emissions

Test Results:

Complies

Note: Radiated Emissions at the center frequency were tested at an accredited measurement facility operated by Acme Testing Co. in Acme, Washington 98220-0003.

Standard:

47 CFR §2.1053

47 CFR §90.201 d)

Test Procedure:

TIA-603-C Sect 2.2.12

EUT Model #:

VT-4E150

Serial Number:

R&D 10001

Test Results:

See attached **Appendix A: VT-4E150 UHF Transmitter – Measurements of Field Strength of Spurious Radiation** for full test results.

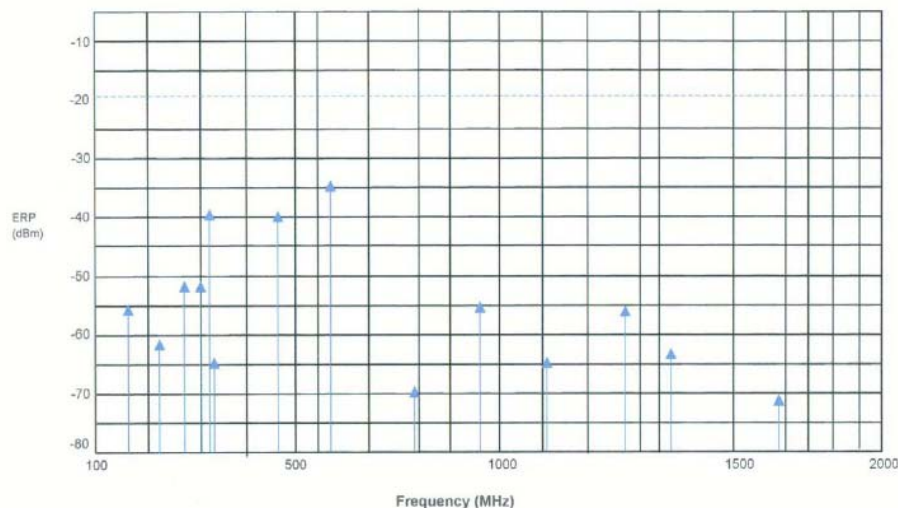
Test Results Excerpt:

Daniels VT-4E150 @ 159 MHz
Temp: 14 degrees C
Humidity: 68 %
Pressure: 984 mBar
10/27/05, and 10/28/05

Limit -20 dBm

Frequency	Polarization	Height	Azimuth	Signal Generator	Cable Loss	Antenna Gain	EIRP	Margin
158.998	H	1.50	273	-40.6	16.5	2.1	-55.0	-35.0
227.998	V	1.70	360	-46.3	17.2	1.2	-62.3	-42.3
276.000	H	3.40	70	-34.8	17.9	1.4	-51.3	-31.3
300.000	V	1.30	254	-34.4	18.2	1.3	-51.3	-31.3
318.000	V	1.30	254	-21.4	18.4	1.4	-38.4	-18.4
347.999	H	1.47	62	-47.0	18.7	1.5	-64.2	-44.2
477.000	H	1.75	270	-18.8	20	1.2	-37.6	-17.6
635.998	V	2.04	150	-14.0	21.6	1.2	-34.4	-14.4
795.000	V	1.20	307	-45.0	22.9	0.6	-67.3	-47.3
954.000	H	1.32	348	-31.0	24.3	0.5	-54.8	-34.8
1113.000	H	1.00	0	-42.0	29.1	6.4	-64.7	-44.7
1272.997	H	1.50	325	-32.0	30.2	7.1	-55.1	-35.1
1431.001	H	2.00	360	-46.0	25.5	8.11	-63.4	-43.4
1589.996	V	2.00	360	-46.0	32.6	8.12	-70.5	-50.5

Radiated Spurious Emissions (ERP)
Model VT-4E150
TX Frequency = 159 MHz



10. Frequency Stability

Test Results: Complies
Standard: 47 CFR §2.1055
47 CFR §90.213
47 CFR §90.539

Test Procedure: TIA-603-C Sect 2.2.2

Notes:

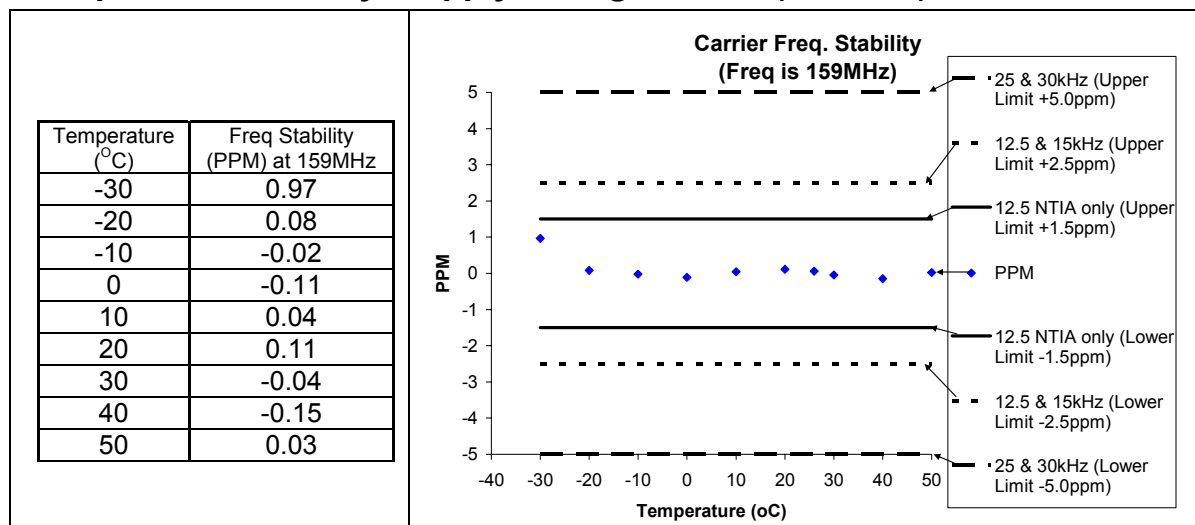
The center frequency is tested at each of the temperatures specified in the above test procedure. Once the chamber is within 1°C of the desired temperature, the environment chamber and the contents inside are given 20 minutes to acclimatize before the frequency is measured.

EUT Model #: VT-4E150
Serial Number: R&D 10011

Test Equipment: Radio Test Set Marconi 2955B (DE# 0962)
Temperature Chamber Thermotron 2800 (DE# 1341)
Variable Power Supply { Daniels RTTJ-2 (DE# 2857)
ICT2024-15A (DE# 2982)

Measurement Data: See the following table and graph:

Temperature Stability, Supply Voltage is STV (13.8 V_{DC})



Voltage Stability, Temperature at 20°C

Supply Voltage (V _{DC})	Freq Stability (PPM) at 159MHz
85%, 11.7V _{DC}	0.10
100%, 13.8V _{DC}	0.10
115%, 15.9V _{DC}	0.10

The limits for the Voltage Stability are the same as for Temperature Stability; the tightest limit, 12.5kHz NTIA only (±1.5ppm), is met.

11. Transient Frequency Response

Test Results: Complies
Standard: 47 CFR §90.214

Test Procedure: TIA-603-C Sect 2.2.19

Notes:

The transient response is measured at the center frequency, 159MHz at the maximum output power, 8W (39dBm).

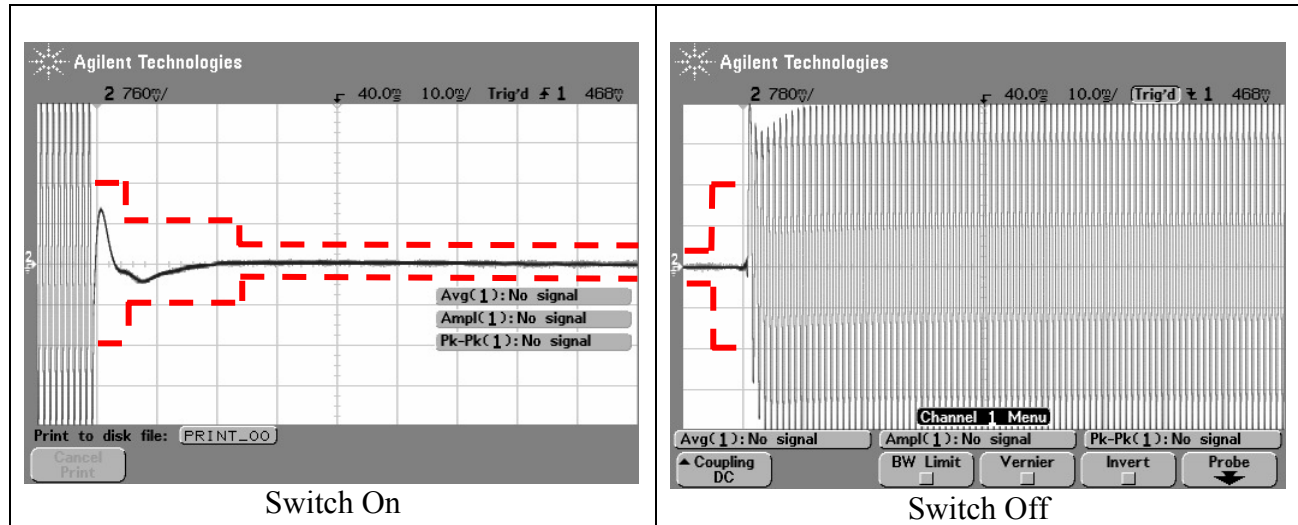
EUT Model #: VT-4E150
Serial Number: R&D 10011

Test Equipment:

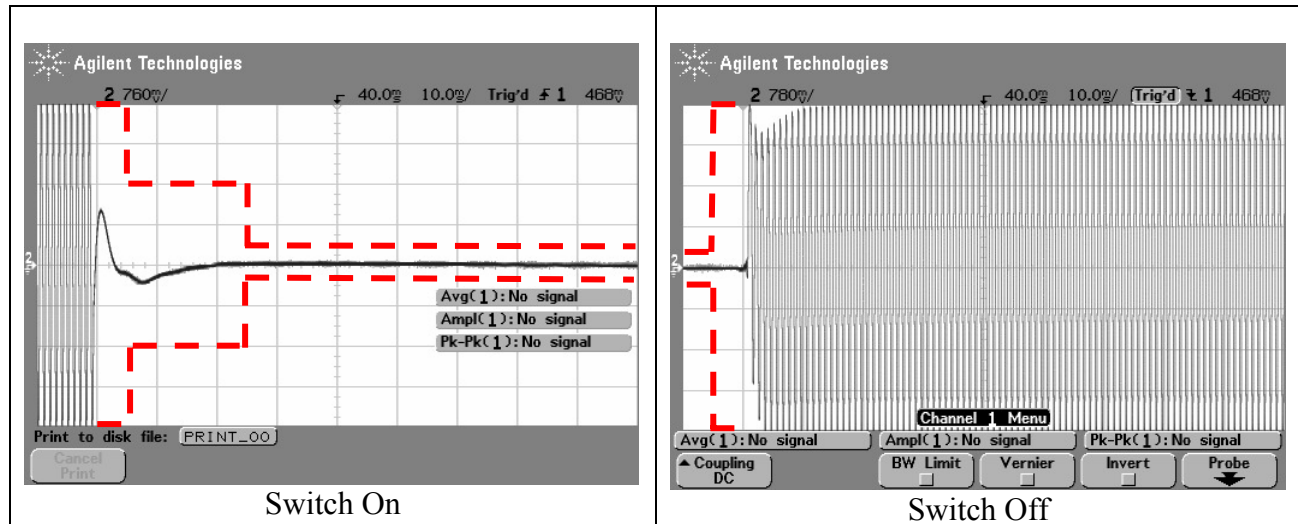
RF Signal Generator	IFR 2026B (DE# 1394)
Storage Oscilloscope	Agilent 54622D (DE# 1190)
Power Detector	DE RF Power Detector
Test Receiver	DE Test Receiver 21.4MHz IF DC
Combiner	Mini Circuits 15542
50 ohm load	} General Lab Equipment
Attenuators	

Measurement Data: See the following graphs:

Channel Spacing 12.5kHz, Center Frequency (159MHz)

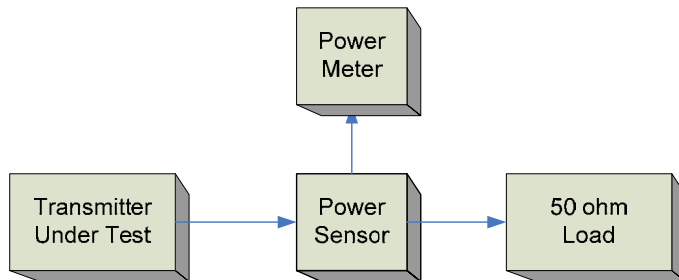


Channel Spacing 25kHz, Center Frequency (159MHz)

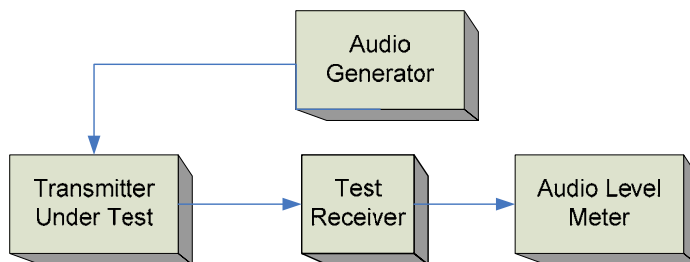


12. Block Diagrams

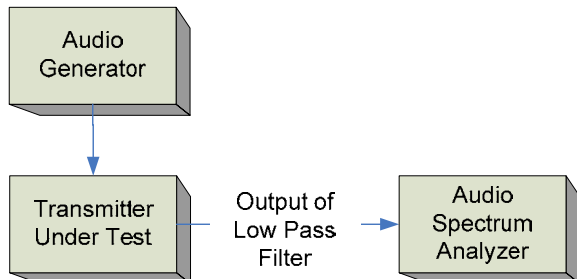
RF Power Output



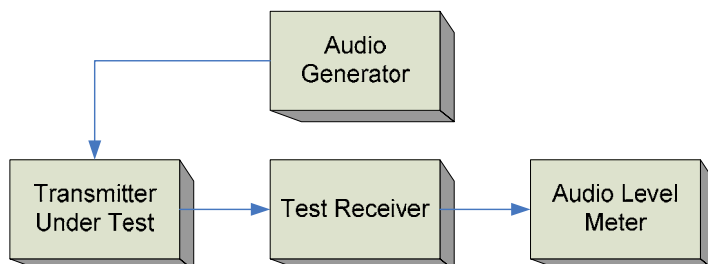
Audio Frequency Response



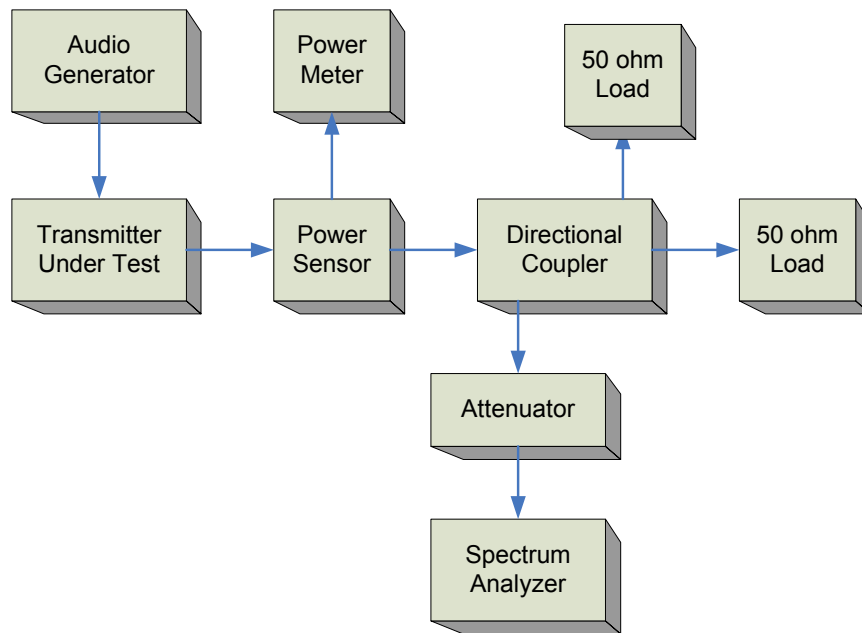
Audio Low Pass Filter Response



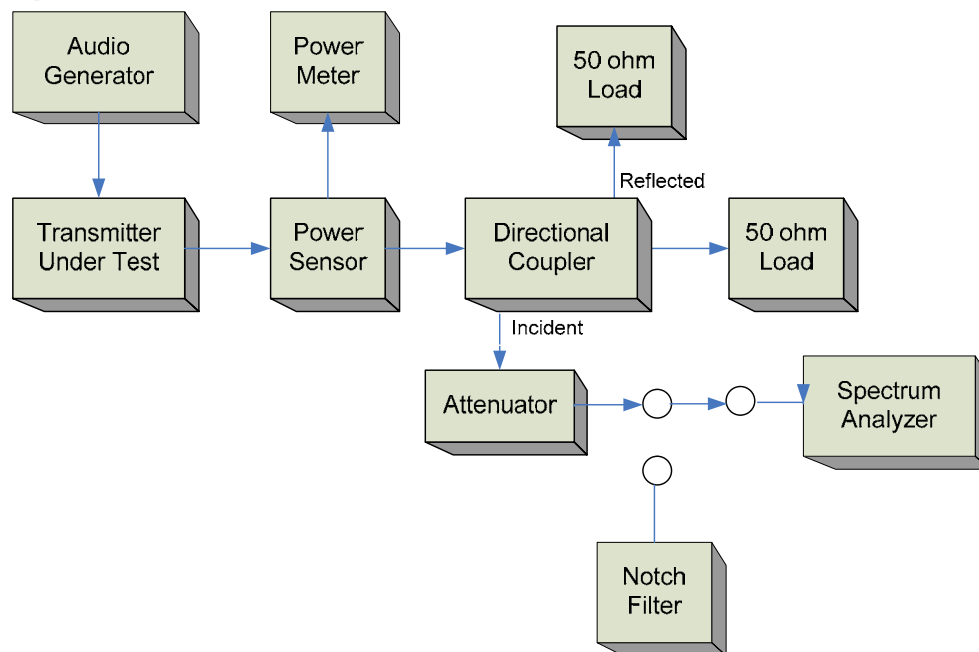
Modulation Limiting



Occupied Bandwidth (with audio low-pass filter installed)



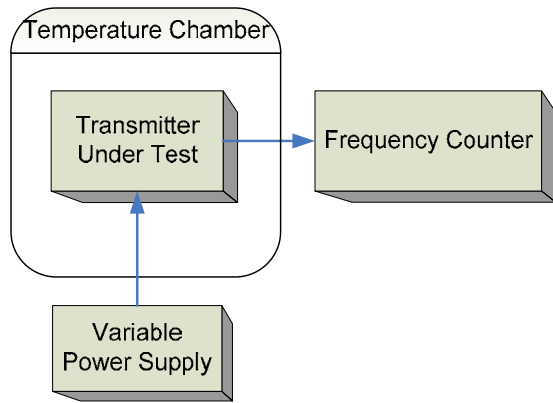
Spurious Emissions at Antenna Terminals



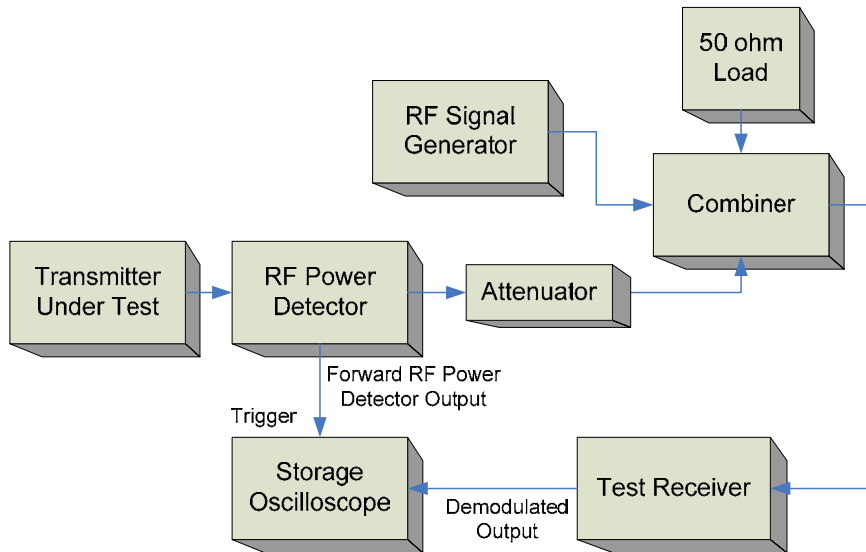
Field Strength of Spurious Emissions

See Appendix A: VT-4E150 VHF Transmitter – Field Strength of Spurious Emissions

Frequency Stability



Transient Frequency Response



13. Test Equipment List

Calibration Cycle	Equipment	Manufacturer	Model	DE Serial	Last Calibration	Next Calibration
1 Year	Radio Test Set	Rhode & Schwarz	CMS 54	1545	May 9, 2006	May 9, 2007
1 Year	Radio Test Set	IFR	2965A	1396	Mar 22, 2006	Mar 22, 2007
1 Year	Radio Test Set	Marconi	2955B	0962	Feb 12, 2006	Feb 12, 2007
1 Year	Radio Test Set	IFR	2975	1334	Aug 15, 2005	Aug 15, 2006
N/A	Test Receiver	Daniels Electronics	21.4MHz IF DC	N/A	N/A	N/A
1 Year	Multi Meter	Fluke	45	1720	Feb 25, 2006	Feb 25, 2007
1 Year	Spectrum Analyzer	Advantest	R3132	1717	May 4, 2006	May 4, 2007
2 Years	Spectrum Analyzer	Agilent	E4440A	1414	April 14, 2005	April 14, 2007
1 Year	Temperature Chamber	Thermotron	2800	1341	Mar 19, 2006	Mar 19, 2007
1 Year	Voltage Regulator	Daniels Electronics	RTTJ-2	2857	Mar 8, 2006	Mar 8, 2007
1 Year	Power Supply	Innovative Circuits	ICT2024-15A	2982	May 29, 2006	May 29, 2007
1 Year	RF Signal Generator	IFR	2026B	1394	Jul 13, 2005	Jul 13, 2006
2 Years	Storage Oscilloscope	Agilent	54622D	1190	Jun 17, 2005	Jun 17, 2006
N/A	Directional Coupler	HP	778D	N/A	N/A	N/A
N/A	Combiner	Mini Circuits	15542	N/A	N/A	N/A
N/A	Power Detector	Daniels Electronics	RF Power Detector	N/A	N/A	N/A