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FCC Part 90 Certification Application

FCC Form 731

For The

IntegraTR
UHF RADIO MODEM

FCC ID: NP44048551

Table of Contents

71.1 Transmitter Rated Power Output

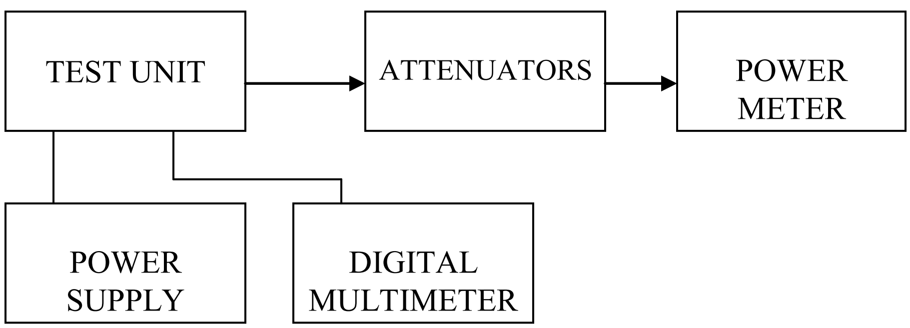
RULE PART NUMBER: 2.1046 (a) (c)

TEST RESULTS: See results below

TEST CONDITIONS: Standard Test Conditions

TEST EQUIPMENT: 50-Ohm Attenuator, Aeroflex/Weinschel 56-6-34 (6 dB / 250W)
Bird Elec. Corp. 50-A-FFN-20 (20 db / 50 Watt)
Power Supply, HP 6653A
Digital Multimeter, Instek GDM-8245
Power Meter, Model HP 437B

TEST SET-UP:



TEST RESULTS:

Frequency (MHz)	DC Voltage at Final (Vdc)	DC Current into Final (Adc)	DC Power into Final (W)	RF Power Output (W)
458.0	13.3	1.520	20.216	5.03

1.2 Transmitter Spurious and Harmonic Outputs

RULE PART NUMBER: 2.1051, 90.210 (d) and 90.210 (e)

MINIMUM STANDARDS:

(d) ***Emission Mask D****—12.5 kHz channel bandwidth equipment.* For transmitters designed to operate with a 12.5 kHz channel bandwidth, any emission must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows:

(1) On any frequency from the center of the authorized bandwidth f_0 to 5.625 kHz removed from f_0 : Zero dB.

(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5.625 kHz but no more than 12.5 kHz: At least 7.27(f_d −2.88 kHz) dB.

(3) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 12.5 kHz: At least 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.

Attenuation = 0 dB at Fo to 5.625 kHz
Attenuation = 20 dB at 5.625 kHz and 70 dB at 12.5 kHz
Attenuation = 57dB (50 dB for 1.0W) at >12.5 kHz

(e) ***Emission Mask E****—6.25 kHz or less channel bandwidth equipment.* For transmitters designed to operate with a 6.25 kHz or less bandwidth, any emission must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows:

(1) On any frequency from the center of the authorized bandwidth f_0 to 3.0 kHz removed from f_0 : Zero dB.

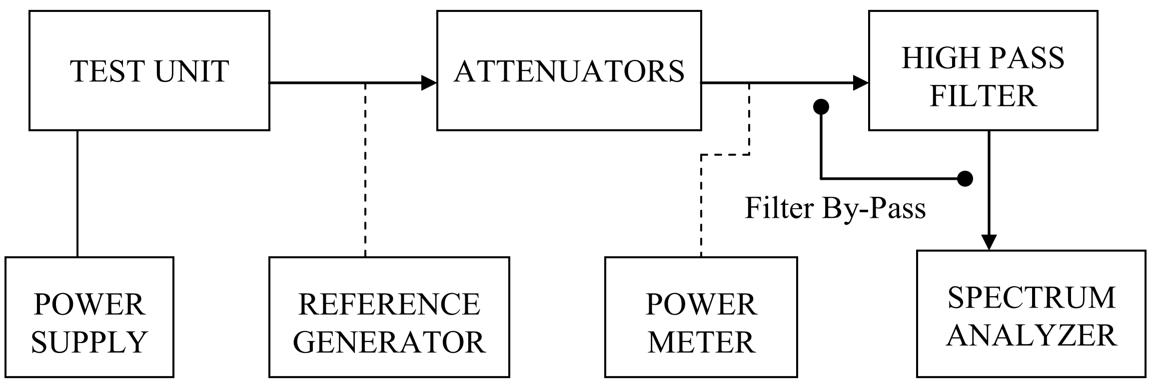
(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 3.0 kHz but no more than 4.6 kHz: At least 30 + 16.67(f_d −3 kHz) or 55 + 10 log (P) or 65 dB, whichever is the lesser attenuation.

(3) On any frequency removed from the center of the authorized bandwidth by more than 4.6 kHz: At least 55 + 10 log (P) or 65 dB, whichever is the lesser attenuation.

Attenuation = 0 dB at Fo to 3.0 kHz
Attenuation = 30 dB at 3.0 kHz and 57 dB at 4.6 kHz
Attenuation = 62 dB (55 dB @ 1 Watt) at > 4.6 kHz

TEST RESULTS:	Meets minimum standards (see data on following pages)
TEST CONDITIONS:	Standard Test Conditions, 25 C RF Voltage measured at antenna terminals
TEST PROCEDURE:	TIA/EIA – 603-C
TEST EQUIPMENT:	50-Ohm Attenuator, Aeroflex/Weinschel 56-6-34 (6 dB / 250W) Power Supply, HP 6653A Spectrum Analyzer, HP-8563E Reference Generator, Agilent E8257D High Pass Filter, Mini Circuits VHF-740, Fc = 740 MHz

TEST SET-UP:



MEASUREMENT PROCEDURE:

1. The transmitter carrier output frequencies are 440.100, 458.000 and 475.800. The reference oscillator frequency is 14.40 MHz. The DC voltage to the power amplifier is 13.3 Volts for 5 watts.
2. The carrier reference was established on the spectrum analyzer with the filter by-pass in place. Then the spectrum was scanned from DC to 2 Fc. Finally, the high pass filter was inserted to null the carrier fundamental and extend the range of the spectrum analyzer for harmonic measurements above 2 Fc.
3. At each spurious frequency, generation substitution was used to establish the true spurious level.
4. The spectrum was scanned to the 10^{th} harmonic of the highest internally generated frequency.

Tuned Frequency	440.100 MHz			Tuned Frequency	440.100 MHz	
Power (Watts)	5.00 Watts			Power (Watts)	1.00 Watt	
Power (dBm)	+37 dBm			Power (dBm)	+30 dBm	
Spec Limit	-62 dBc			Spec Limit	-55 dBc	
Worse Case	-98 dBc			Worse Case	-100 dBc	
Spurious	Relation to the Carrier	Relative to the Carrier		Spurious	Relation to the Carrier	Relative to the Carrier
Frequency (MHz)				Frequency (MHz)		
880.200	2Fo	-104.00		880.200	2Fo	-100.00
1320.300	3Fo	-110.00		1320.300	3Fo	-111.00
1760.400	4Fo	-101.00		1760.400	4Fo	-111.00
2200.500	5Fo	-118.00		2200.500	5Fo	-111.00
2640.600	6Fo	-115.00		2640.600	6Fo	-108.00
3080.700	7Fo	-114.00		3080.700	7Fo	-107.00
3520.800	8Fo	-109.00		3520.800	8Fo	-108.00
3960.900	9Fo	-112.00		3960.900	9Fo	-106.00
4401.000	10Fo	-98.00		4401.000	10Fo	-105.00

Tuned Frequency	458.000 MHz			Tuned Frequency	458.000 MHz	
Power (Watts)	5.00 Watts			Power (Watts)	1.00 Watt	
Power (dBm)	+37 dBm			Power (dBm)	+30 dBm	
Spec Limit	-62 dBc			Spec Limit	-55 dBc	
Worse Case	-96 dBc			Worse Case	-100 dBc	
Spurious	Relation to the Carrier	Relative to the Carrier		Spurious	Relation to the Carrier	Relative to the Carrier
Frequency (MHz)				Frequency (MHz)		
916.000	2Fo	-105.00		916.000	2Fo	-100.00
1374.000	3Fo	-106.00		1374.000	3Fo	-106.00
1832.000	4Fo	-96.00		1832.000	4Fo	-107.00
2290.000	5Fo	-117.00		2290.000	5Fo	-110.00
2748.000	6Fo	-118.00		2748.000	6Fo	-109.00
3206.000	7Fo	-106.00		3206.000	7Fo	-107.00
3664.000	8Fo	-114.00		3664.000	8Fo	-109.00
4122.000	9Fo	-111.00		4122.000	9Fo	-106.00
4580.000	10Fo	-107.00		4580.000	10Fo	-107.00

Tuned Frequency	475.800 MHz			Tuned Frequency	475.800 MHz	
Power (Watts)	5.00 Watts			Power (Watts)	1.00 Watt	
Power (dBm)	+37 dBm			Power (dBm)	+30 dBm	
Spec Limit	-62 dBc			Spec Limit	-55 dBc	
Worse Case	-93 dBc			Worse Case	-101 dBc	
Spurious	Relation to the Carrier	Relative to the Carrier		Spurious	Relation to the Carrier	Relative to the Carrier
Frequency (MHz)				Frequency (MHz)		
951.600	2Fo	-98.00		951.600	2Fo	-101.00
1427.400	3Fo	-111.00		1427.400	3Fo	-108.00
1903.200	4Fo	-99.00		1903.200	4Fo	-109.00
2379.000	5Fo	-111.00		2379.000	5Fo	-108.00
2854.800	6Fo	-113.00		2854.800	6Fo	-108.00
3330.600	7Fo	-116.00		3330.600	7Fo	-108.00
3806.400	8Fo	-117.00		3806.400	8Fo	-110.00
4282.200	9Fo	-93.00		4282.200	9Fo	-105.00
4758.000	10Fo	-98.00		4758.000	10Fo	-102.00

1.3 Transient Frequency Behaviour

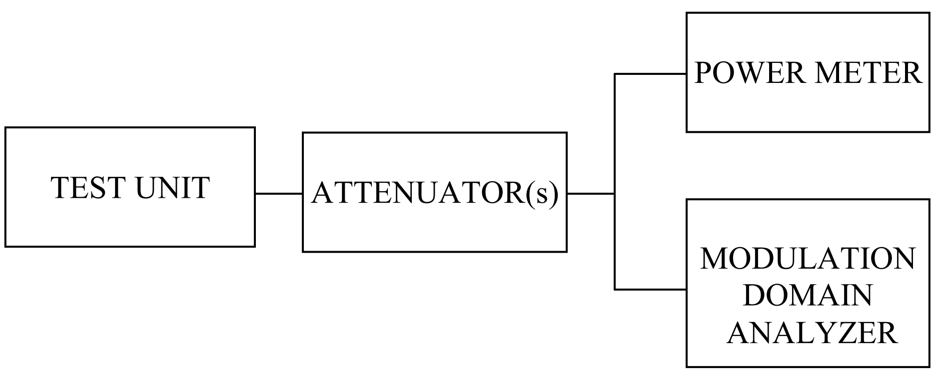
RULE PART NUMBER: 90.214

MINIMUM STANDARD: ±12.5 kHz channel (used worst case numbers from 440 to 476 MHz)

TIME INTERVAL	MAXIMUM FREQUENCY DIFFERENCE (kHz)	TIME (ms)
T1	±12.5	10
T2	±6.25	25
T3	±12.5	10

MINIMUM STANDARD: ±6.25 kHz channel (used worst case numbers from 440 to 476 MHz)

TIME INTERVAL	MAXIMUM FREQUENCY DIFFERENCE (kHz)	TIME (ms)
T1	±6.25	10
T2	±3.125	25
T3	±6.25	10



TEST RESULTS: Meets minimum standards, see data on following pages

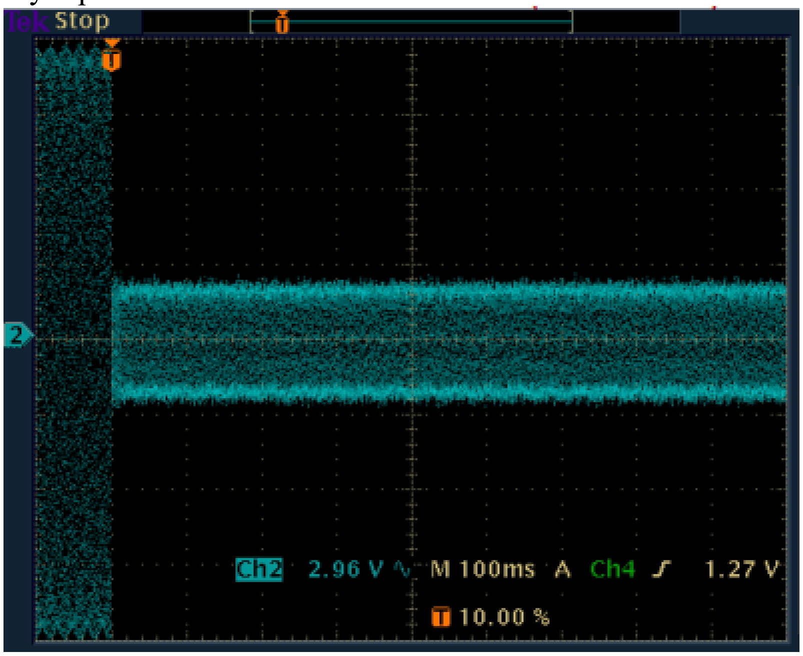
TEST CONDITIONS: RF Power Level = 5.0 Watts and 1.0 Watt
Standard Test Conditions, 25 C

TEST PROCEDURE: TIA/EIA – 603-C, Section 2.2.19.3

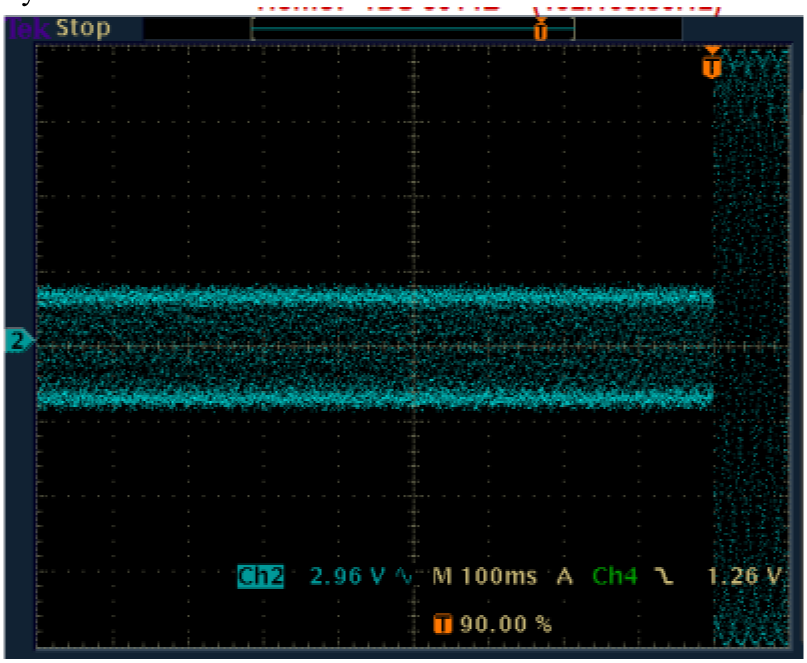
TEST EQUIPMENT: 50-Ohm Attenuator, Aeroflex Model 58-10-34 (10dB, 50W)
50-Ohm Attenuator, Mini-Circuits Model CAT-20 (20dB)
50-Ohm Attenuator, Mini-Circuits Model CAT-10 (10dB)
Power Supply, Agilent 6654A
Modulation Domain Analyzer, HP-53310A
Power Meter, Model HP 437B

Frequency : 440.100 MHz
Power: 5 W
12.5k

Key-Up

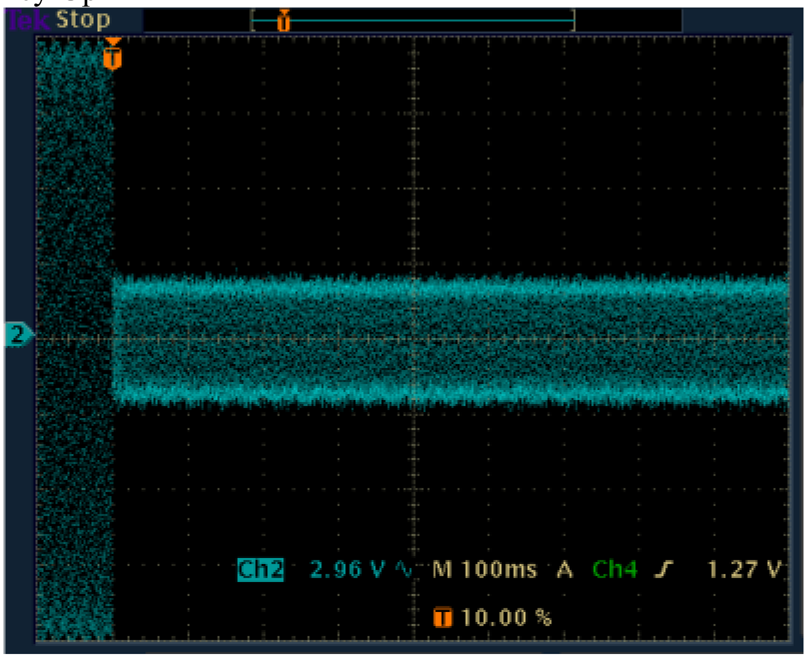


Key-Down



Frequency : 458.000 MHz
Power: 5 W
12.5k

Key-Up



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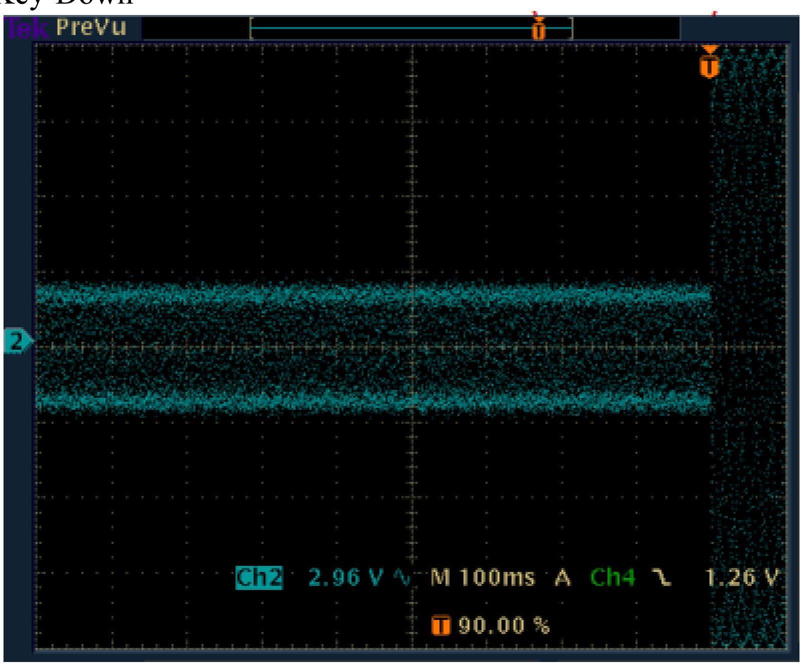
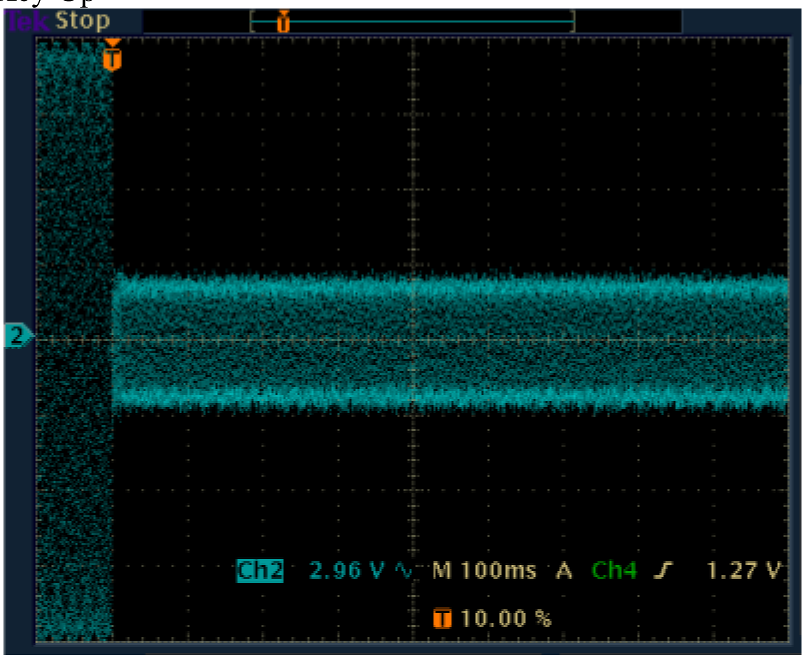


Frequency : 475.900 MHz
Power: 5 W
12.5k

Key-Up



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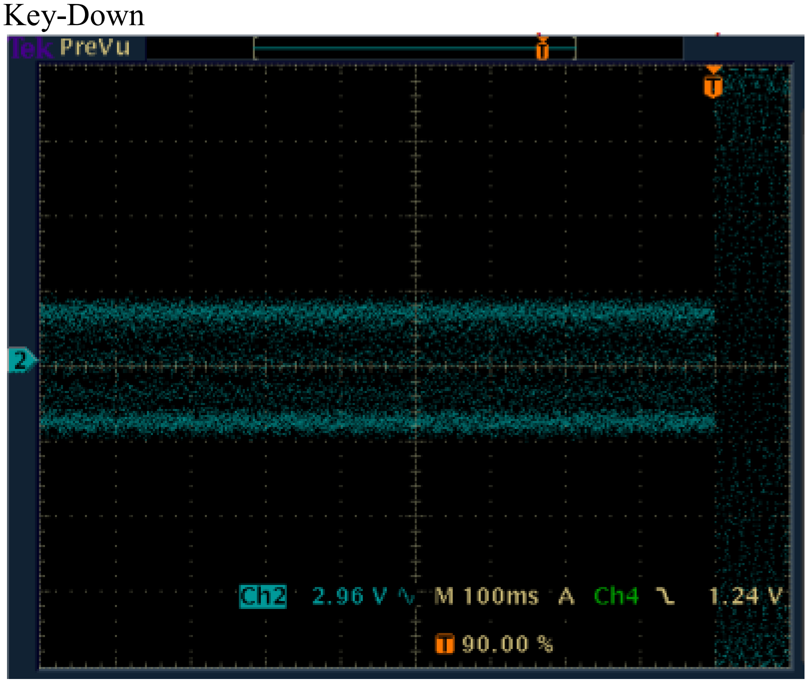
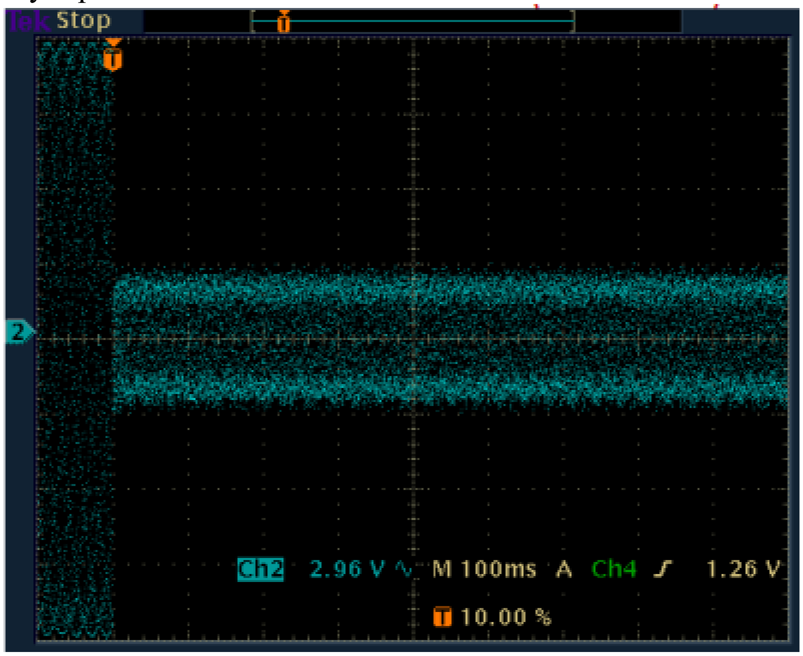


Frequency : 440.100 MHz
Power: 1 W
12.5k

Key-Up



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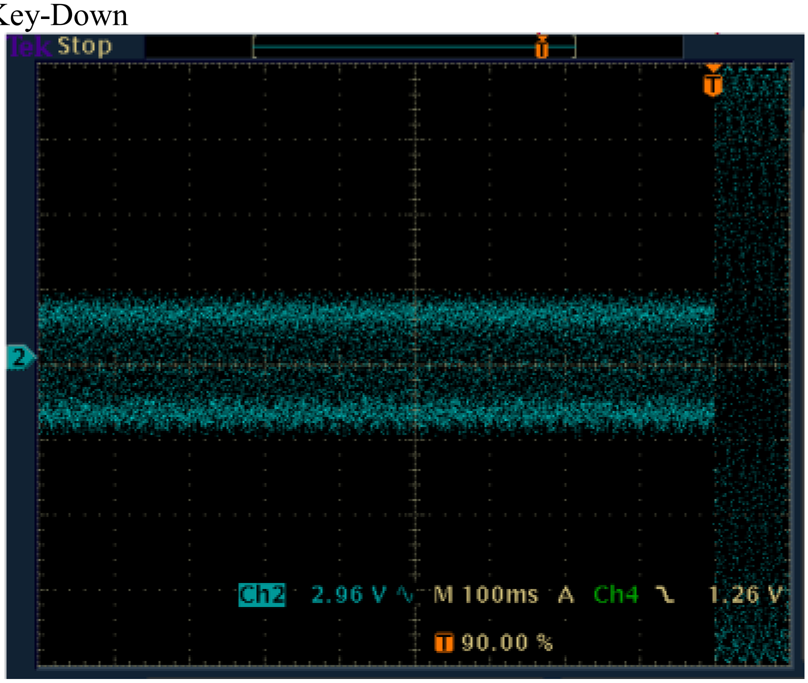
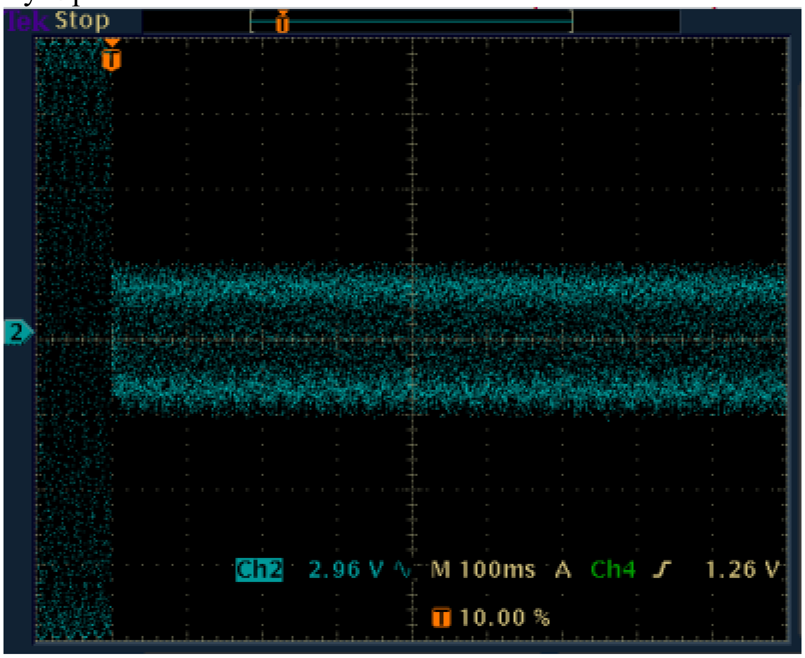


Frequency : 458.000 MHz
Power: 1 W
12.5k

Key-Up



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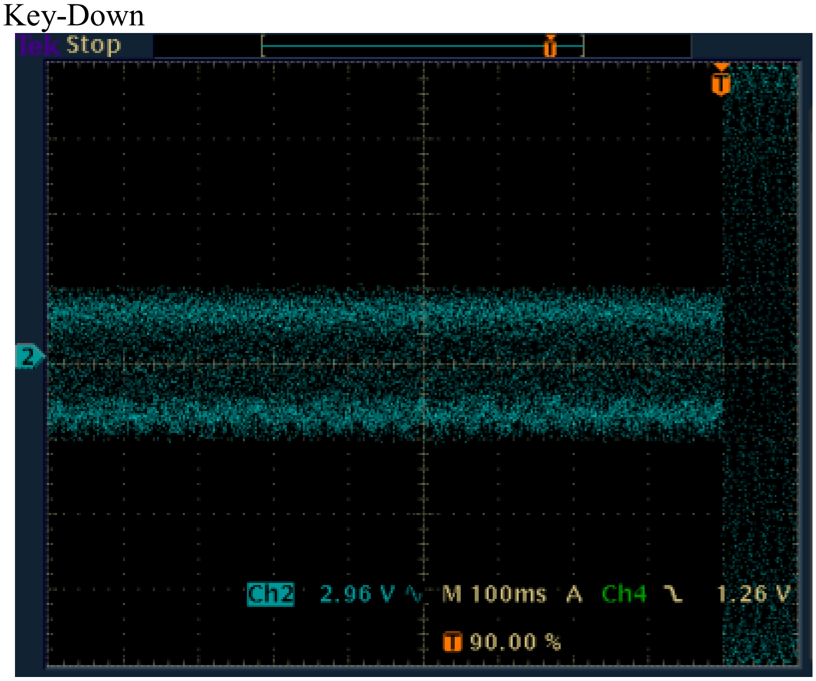
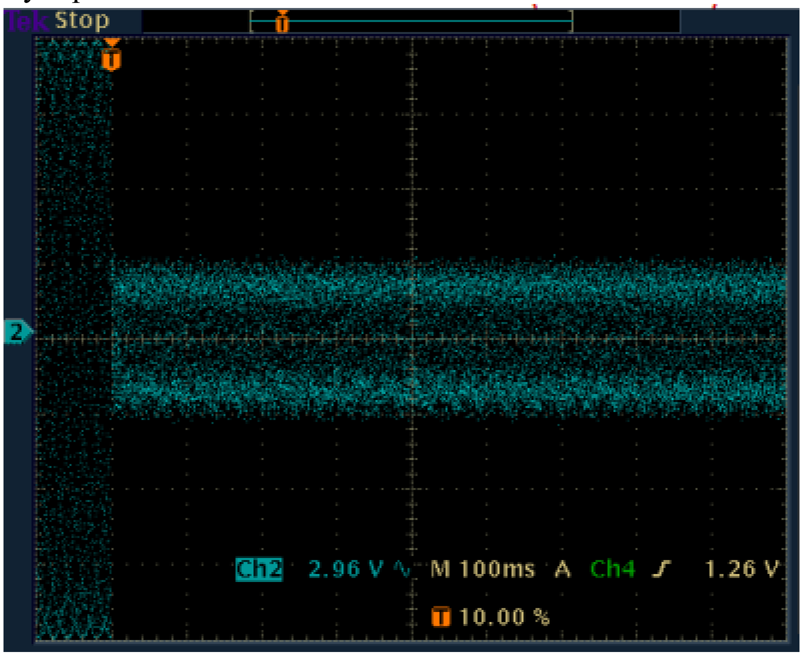


Frequency : 475.900 MHz
Power: 1 W
12.5k

Key-Up



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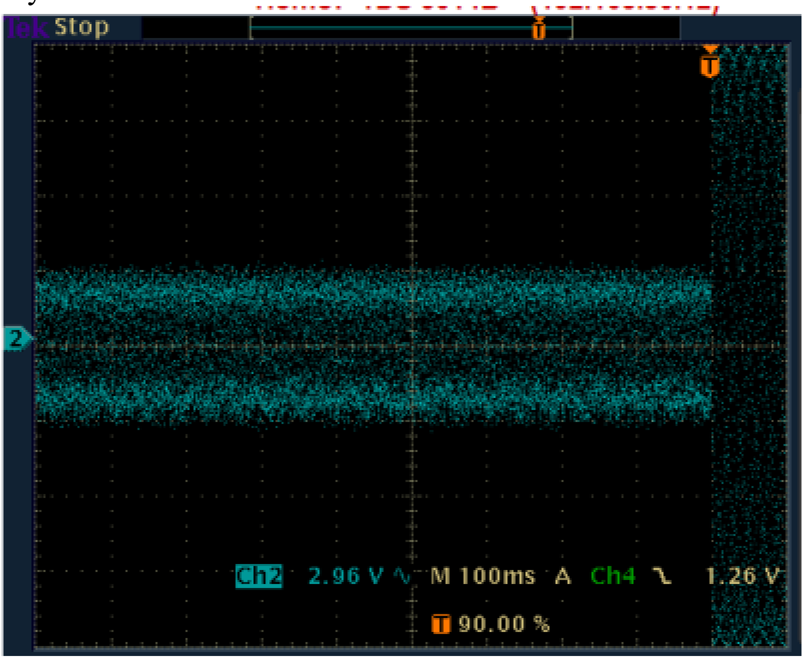
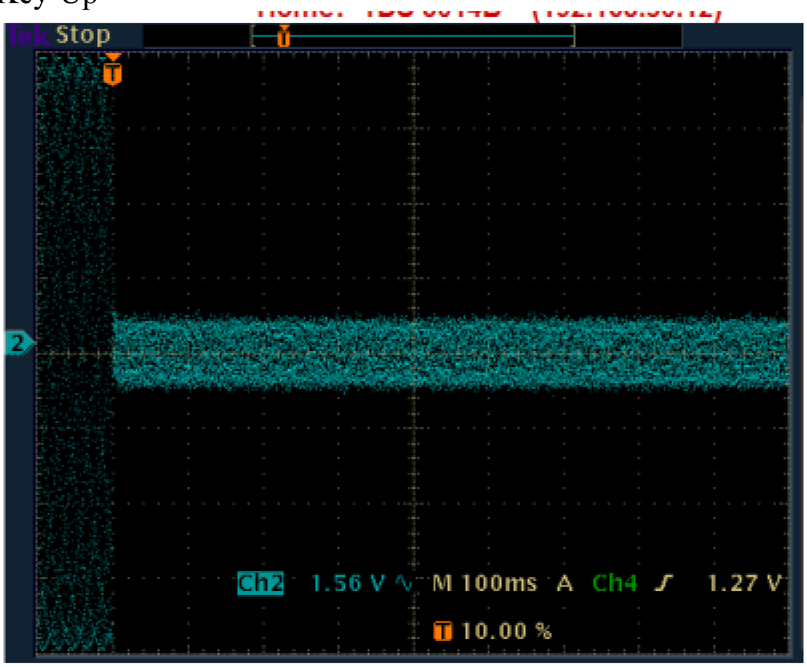


Frequency : 440.100 MHz
Power: 5 W
6.25k

Key-Up



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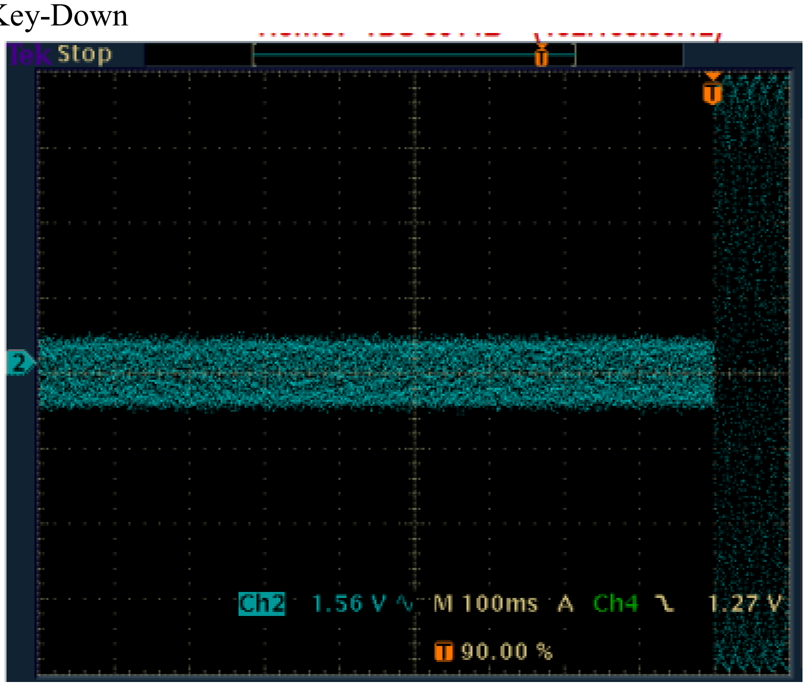
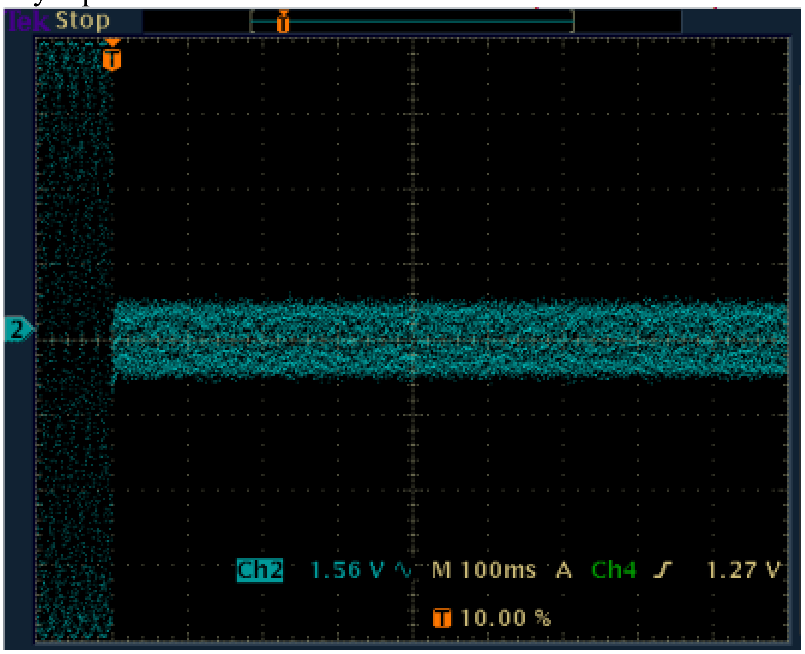
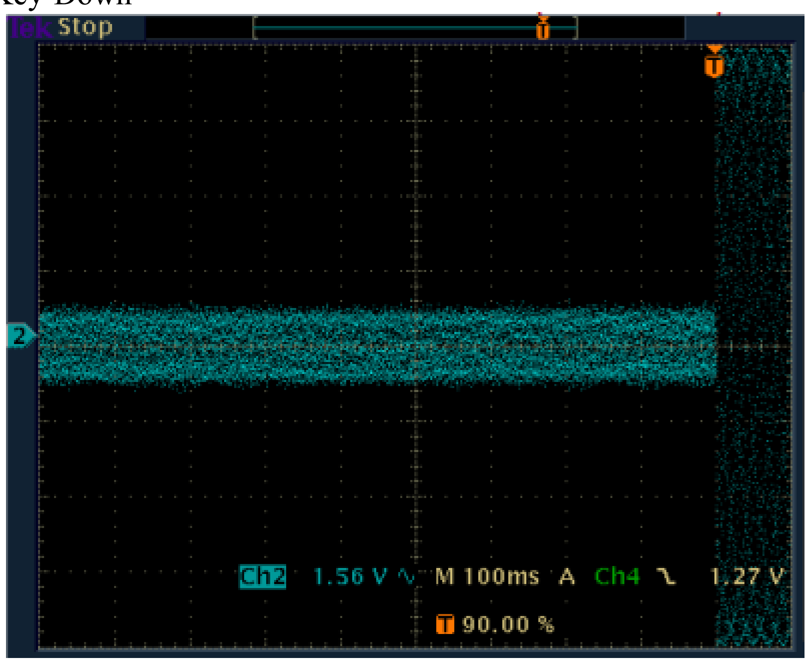


Frequency : 458.000 MHz
Power: 5 W
6.25k

Key-Up

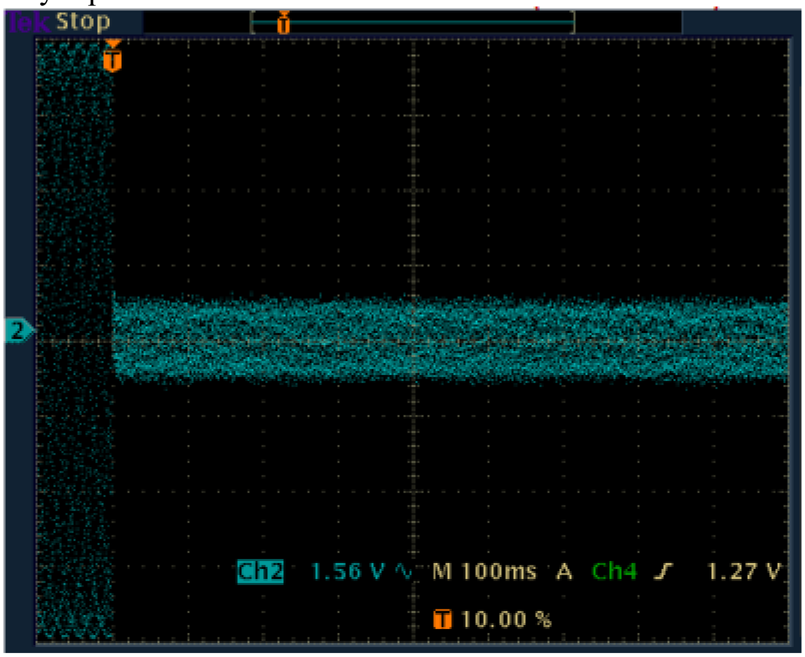


Key-Down



Frequency : 475.900 MHz
Power: 5 W
6.25k

Key-Up



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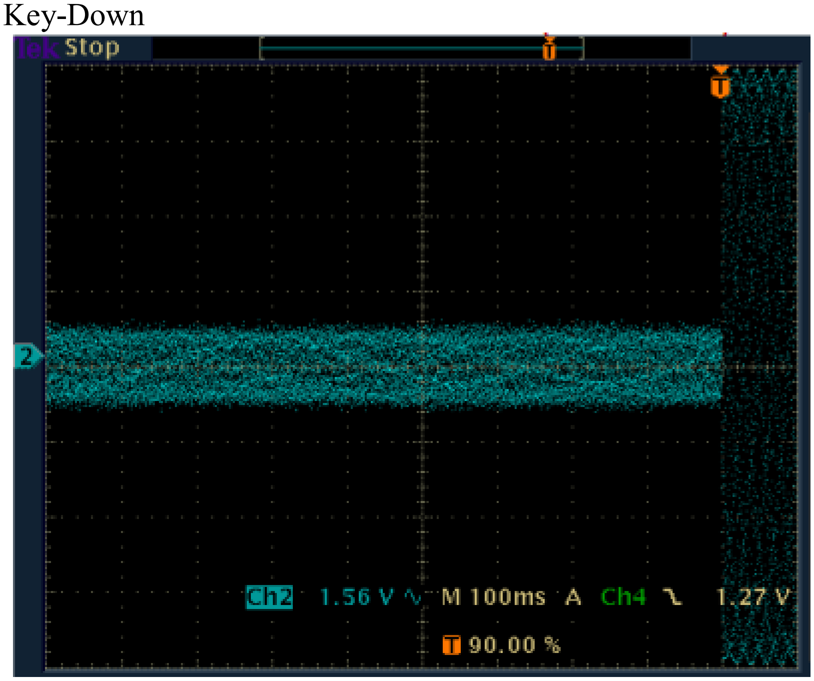
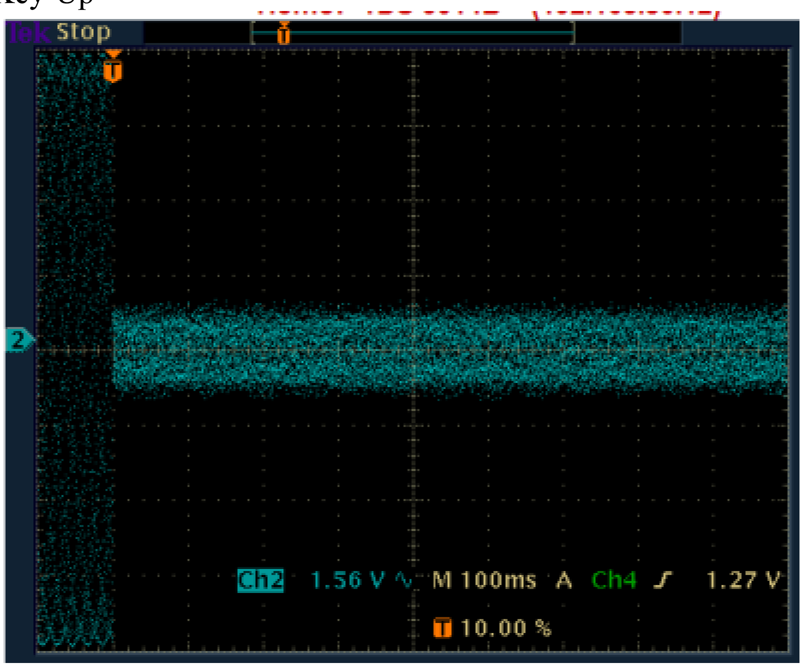


Frequency : 440.100 MHz
Power: 1 W
6.25k

Key-Up



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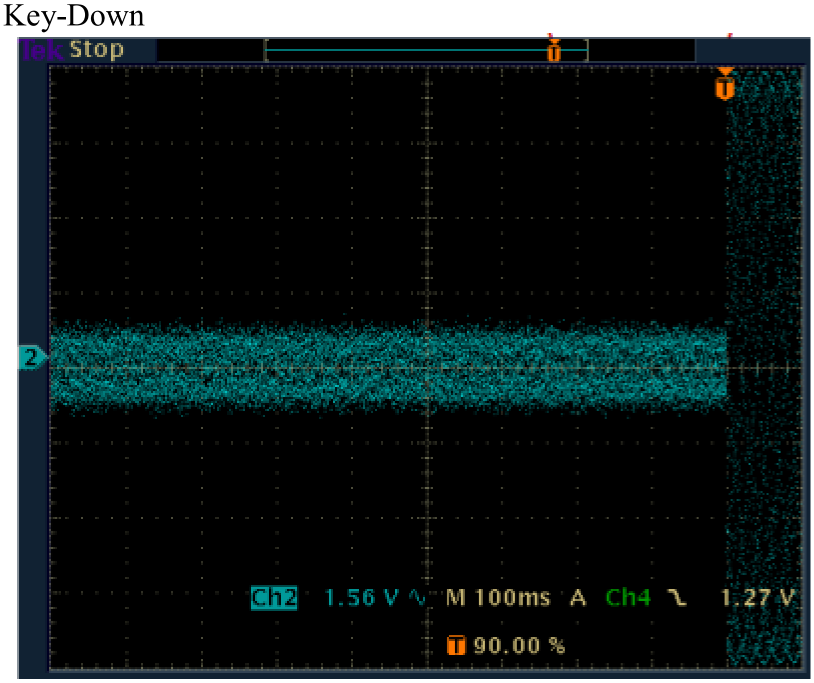
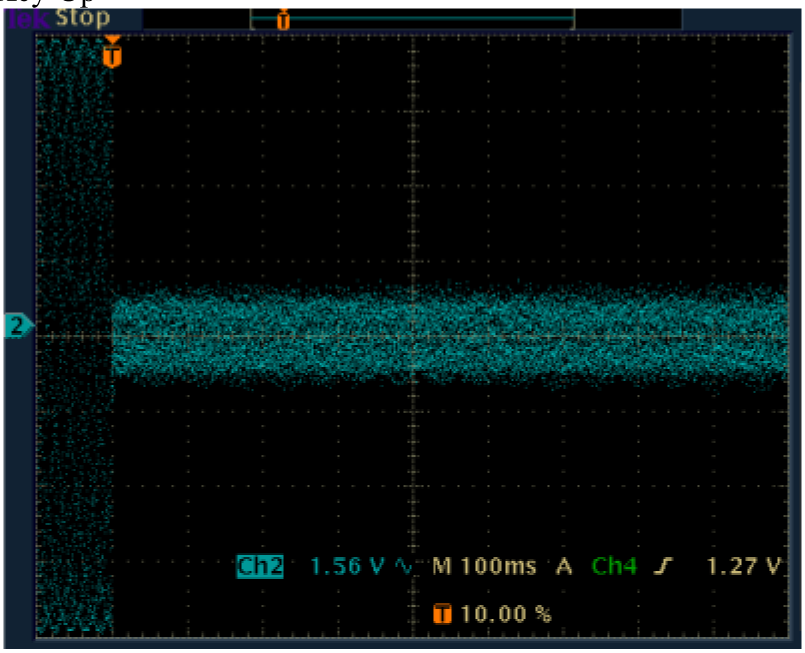


Frequency : 458.000 MHz
Power: 1 W
6.25k

Key-Up



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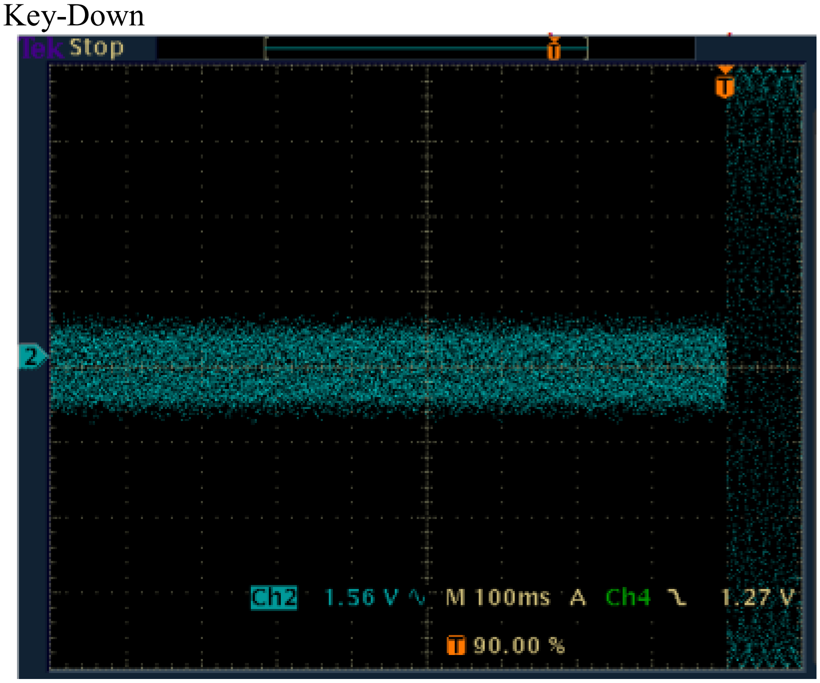
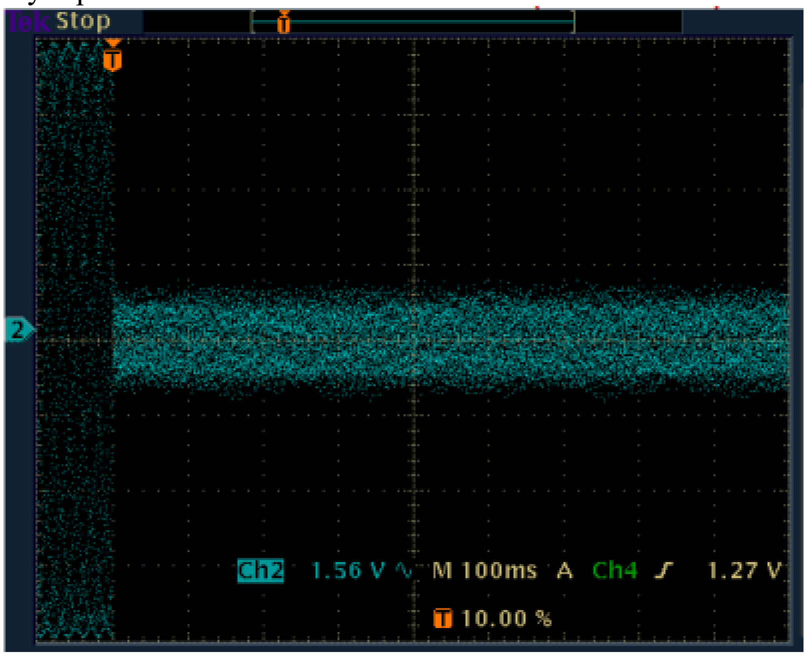


Frequency : 475.900 MHz
Power: 1 W
6.25k

Key-Up



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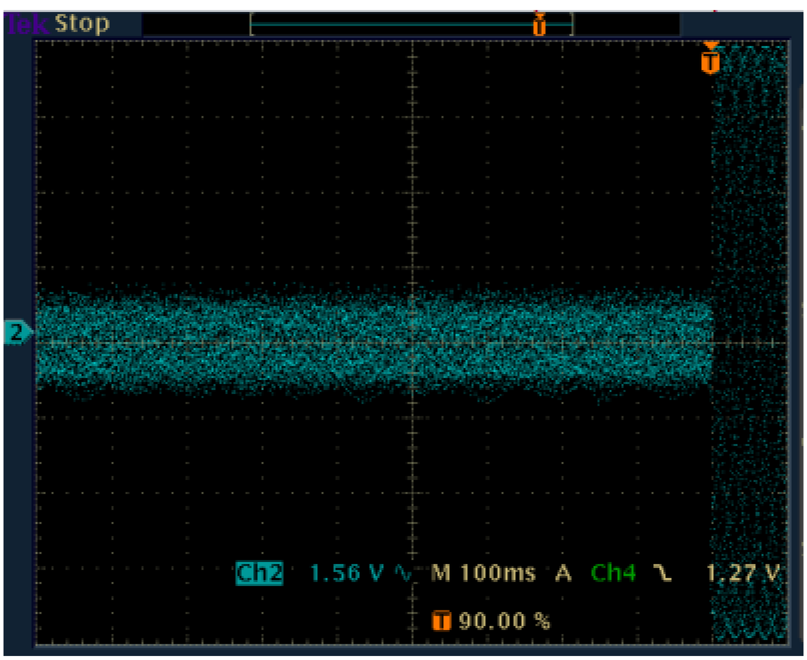


1.4 Frequency Stability with Variation in Supply Voltage

RULE PART NUMBER: 2.1055 (d)(1), 90.213 (a)

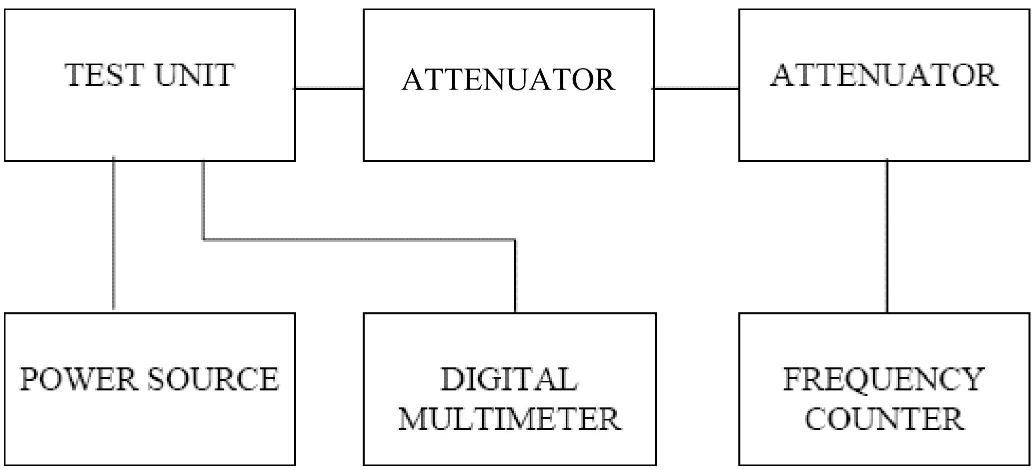
MINIMUM STANDARD: Shall not exceed ±0.50 ppm.

TEST RESULTS: Meets minimum standard, see data on following page

TEST CONDITIONS: Standard Test Conditions, 25 C

TEST EQUIPMENT: Frequency Counter, HP 8901A Modulation Analyzer
DC Power Supply, HP 6653A
Digital Voltmeter, Instek GDM-8245
50-Ohm Attenuator, AeroFlex/Weinschel 56-6-34 (6Db / 250W)
Bird Elec. Corp. 50-A-FFN-20 (20 db / 50 Watt)

TEST SET-UP:



TEST SET-UP

Channel Frequency: 458.2000 MHz
Tolerance Requirements: ±0.5ppm
Highest Variation: 0.06 ppm
Power Output: 5 Watts

Input Voltage (Vdc)	Frequency (MHz)	Frequency Error (Hz)	Frequency Error (ppm)
10	458.199990	-10	-0.02
13.3	458.199970	-30	-0.06
16	458.199960	-40	-0.09

1.5 Frequency Stability with Variation in Ambient Temperature

RULE PART NUMBER: 2.1055 (a) (b), 90.213 (a)

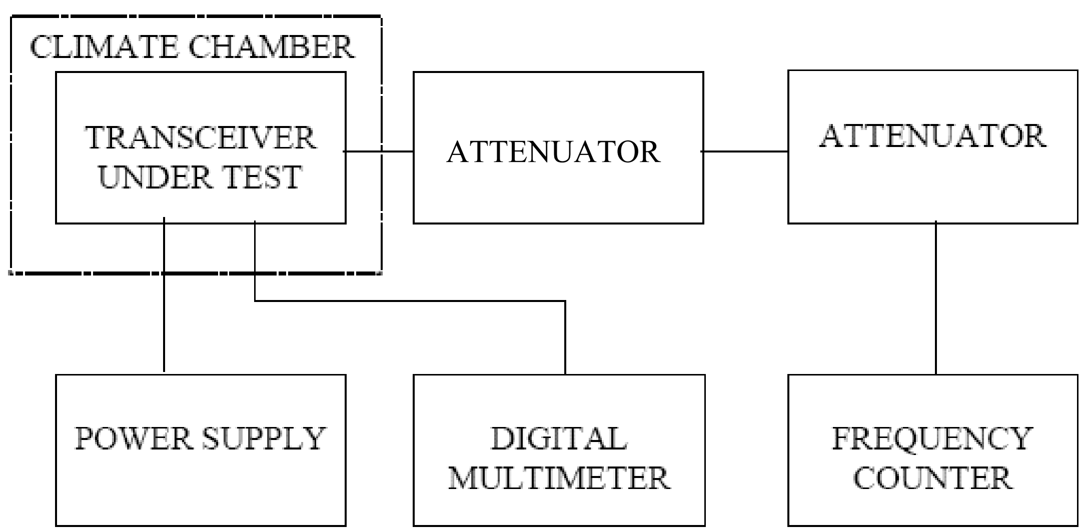
MINIMUM STANDARD: Shall not exceed ±0.50 ppm from test frequency

TEST RESULTS: Meets minimum standard, see data on following page

TEST CONDITIONS: Standard Test Conditions

TEST EQUIPMENT: Frequency Counter, 8901A Modulation Analyzer
DC Power Supply, HP 6653A
Digital Voltmeter, Instek GDM-8245
50-Ohm Attenuator, AeroFlex/Weinschel 56-6-34 (6dB,250W)
Bird Elec. Corp. 50-A-FFN-20 (20 db / 50 Watt)
Climate Chamber, Test Equity Half Cube Model 105

TEST SET-UP:



Channel Frequency: 458.200000 MHz
Voltage & Power Level: 13.3 Volts @ 5 Watts
Highest Variation: -0.22 ppm

Temperature (Deg C)	Measured Frequency (MHz)	Frequency Error (Hz)	Frequency Error (ppm)
-30	458.199899	-101	-0.22
-20	458.199936	-64	-0.14
-10	458.199986	-14	-0.03
0	458.200009	9	0.02
10	458.200009	9	0.02
20	458.200018	18	0.04
25	458.999922	-78	-0.17
30	458.200060	60	0.13
40	458.199986	-14	-0.03
50	458.199927	-73	-0.16
60	458.199899	-101	-0.22

Channel Frequency: 458.200000 MHz
Voltage & Power Level: 13.3 Volts @ 1.0 Watts
Highest Variation: -0.22 ppm

Temperature (Deg C)	Measured Frequency (MHz)	Frequency Error (Hz)	Frequency Error (ppm)
-30	458.199899	-101	-0.22
-20	458.199936	-64	-0.14
-10	458.199984	-14	-0.03
0	458.200009	9	0.02
10	458.200009	9	0.02
20	458.200018	18	0.04
25	458.999921	-79	-0.17
30	458.200060	60	0.13
40	458.199986	-14	-0.03
50	458.199927	-73	-0.16
60	458.199899	-101	-0.22

1.6 Transmitter Occupied Bandwidth Necessary Bandwidth

RULE PART NUMBER: 2.201, 2.202, 2.1033 (c)(14), 2.1049 (h), 2.1041; 90.203(j)(3)

Necessary Bandwidth Measurement

This radio modem uses digital modulation signals, passing through a linear 8^{th} order low-pass filter (Raise-Cosine alpha 1 approximation), to an FM transceiver. The necessary bandwidth calculation for this type of modulation (DRCMSK) is not covered by paragraphs (1), (2) or (3) from 2.202(c). Therefore, the approach outlined in (2.202(c)(4)) is applicable in this case.

The measurement explanations are provided in "Annex" (following pages)

Necessary Bandwidth Measurement:

Peak deviation = ±2.91 kHz
Modulator signal bit rate 9600 bps,

Bn=8800 Hz
The corresponding emission designator prefix for necessary bandwidth = 8K80

****
Table 1 - Measurements results for the INTEGRATR unit , 2400 bps, 4800 bps, 9600 bps and frequency deviations set to obtain specified values .

unit's software settings	measured data (kHz)		Emission designator
bit rate (data settings)	freq. dev	99% occupied BW	
2400	1.25	3.30	3K30
4800	0.92	3.40	3K40
9600	2.91	8.80	8K80

****

Also, Spectrum Efficiency (90.203 (j)(3)) requirement: 4800 bits per second per 6.25 kHz of channel bandwidth.
4800bps=1*4800bps so it is efficient for 6.25 kHz channel
9600bps=2*4800bps so it is efficient for 12.5 kHz channel

ANNEX

Theory of Measurement

The way to define the ***Occupied Bandwidth*** 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” (FCC 2.202), the mathematics are as follows:

$$0.005*TP=P_{(f1)}=\int_0^{f1} PSD_{(f)}df$$

$$0.995*TP=P_{(f2)}=\int_0^{f2} PSD_{(f)}df$$

$$OBW=f2-f1$$

where TP (total mean power) is

$$TP=\int_0^{+\infty} PSD_{(f)}df=(1/t)\int_{-\infty}^{+\infty} |z_{(t)}|^2dt$$

and PSD (power spectral distribution) is

$$PSD_{(f)}=|Z_{(f)}|^2+|Z_{(-f)}|^2 \qquad 0\leq f<4$$

and expresses the positive frequency representation of the transmitter output power for z(t) signal.

By applying these mathematics to the measurements, it is possible to measure the Occupied Bandwidth using the RF signal’s trace provided by a digital spectrum analyzer and processed further by computational methods.

The Occupied Bandwidth measurement is in two parts relatively independent of each other. The first gives the RF spectrum profile, and the second calculates the frequency limits and they result in the Occupied bandwidth. While the first involves RF measurement instrumentation, the second is strictly a computational part related to measured trace.

Getting an equally-sampled RF power spectrum profile requires a Digital Spectrum Analyzer. In addition to the instrument’s usual requirements, a special attention must be paid to the analyzer’s span (bandwidth to be investigated).

This bandwidth must be large enough to contain all the power spectral components created by the transmitter. The frequency step, where the samples are picked, is directly dependent on the span’s value.

Δf= span/number of points displayed

The frequency resolution will determine the measurement accuracy. So for greater accuracy, less bandwidth will give better values because of the constant number of points that can be displayed. Taking into account the purpose of transmitter, an acceptable balance can be set. For channel-limited transmitters all the power spectral components can be found in main channel and a number of adjacent channels, upper and lower, from the main channel. The relation between these two requirements, number of channels and accuracy, is depicted by:

$$a(\%) \cong (2*k*n/N)*100,$$

where a is desired accuracy, in percentage units, n is the number of channels in span, including main channel, N is displayed number of points and k= (authorized bandwidth) /channel bandwidth.
For usual spectrum analyzers N=500, k=0.8 (6) for 6.25kHz channel transmitters or k=0.9 (11.25/12.5) for 12.5kHz channel transmitters, so $a \cong n/2.5$ (%) can estimate the expected precision for measurement.

All other requirements for spectrum analyzer are the same as they are for mask compliance determination.

The second part has computational requirements related to the trace's values processing.

The following operations must be performed over the trace's (x,y) points:

1. convert y value in dBm (or the analyzer's display y units) units power sample
2. convert y value in W units power sample,
3. add to total power every power sample and get total power value (W units for total power)
4. set low level (0.5%*total power)
5. detect x1-sample which pass low level (convert f1 integrals to sample summing)
6. convert (x1-1)-sample value in frequency units (the x-sample is already in occupied bandwidth),
7. store first frequency correspondent to (x1-1)-sample
8. set up level (99.5%*total power)
9. detect x2-sample which pass up level (convert f2 integrals to sample summing)
10. convert (x2)-sample value in frequency units (the x-sample is now out of occupied bandwidth),
11. store second frequency correspondent to (x2)-sample
12. read the frequency difference , this is ***Occupied Bandwidth***, and display the result.

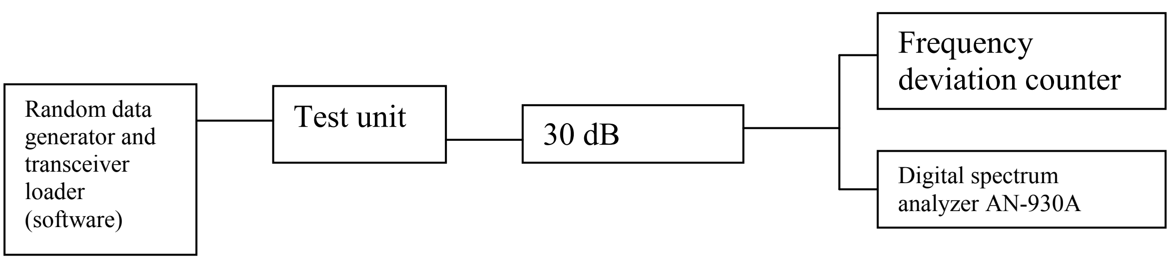
Standard calculation precision is all that is required. The main error factor being the y display resolution is covering calculation precision.

The absolute error for this measurement is -0/+2*)f. It is not possible to decrease span bandwidth under 2 channels bandwidth because this will affect the significance of result by cutting off the power's spectral distribution edges.

Measurement Set-Up

For the above requirements, the occupied bandwidth of a transmitter was measured using an HP 8563E Spectrum Analyzer. A spectrum analyzer having adequate macrofunction to perform computational part. The number of power spectrum samples (N) is 500. Because in test results frequency deviation was also a parameter, measurement instruments were completed with an IFR COM-120 B for frequency deviation determination.

The measurement set-up is:



The HP 8563E Spectrum Analyzer's parameters are adjusted as follow:
-total span is adjusted at 30 kHz for 6.25 kHz channel and 50 kHz for 12.5 kHz channel.

-RBW is set to 100 Hz, this is better than 1% of total span bandwidth.
-video filter is set to 100 Hz;
-all other parameter of the instrument are automatically adjusted to obtain calibrated measurements (sweep time 3.05s 6.25 kHz, 5.08s for 12.5 kHz).
-central frequency and reference level are adjusted to the unmodulated carrier frequency and level.

The HP 8563E Spectrum Analyzer's Occupied Bandwidth macrofunction input parameters are:

-central frequency, same as above, the unmodulated carrier frequency.
-channel spacing, 6.25 kHz or 12.5 kHz according to the signal,
-percentage of Occupied Bandwidth 99%.

The macro operations are:

-the trace is read;
-follow all the computational steps required.

Each sample is converted from dBm to mW and add to total power (tpow) variable. Then are computed the limits of 0.5% and 99.5% by using variable remaining percent (RemPer), and in same time are stored sample number where these two percentage meet. Then are assigned to the markers the correspondent frequencies of numbers.

- Occupied Bandwidth is then displayed as Delta mode marker (difference between markers).
-return to operational mode.

NOTE 1: The computational part could be performed on every device featured with data acquisition.
NOTE 2: An approximation of the occupied bandwidth calculation can be performed by measuring at the points at which the spectrum, measured with a spectrum analyzer of 100 Hz resolution bandwidth, is 25dB down relative to the unmodulated carrier reference level.

1.7 Transmitter Occupied Bandwidth Mask D - 8K80F1D

RULE PART NUMBER: 2.201, 2.202, 2.1033 (c)(14), 2.1041, 2.1049(h), 90.209 (b)(5), 90.210(d),

MINIMUM STANDARDS:

(d) ***Emission Mask D***—*12.5 kHz channel bandwidth equipment.* For transmitters designed to operate with a 12.5 kHz channel bandwidth, any emission must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows:

(1) On any frequency from the center of the authorized bandwidth f_0 to 5.625 kHz removed from f_0 : Zero dB.

(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5.625 kHz but no more than 12.5 kHz: At least 7.27(f_d −2.88 kHz) dB.

(3) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 12.5 kHz: At least 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.

(4) The reference level for showing compliance with the emission mask shall be established using a resolution bandwidth sufficiently wide (usually two to three times the channel bandwidth) to capture the true peak emission of the equipment under test. In order to show compliance with the emissions mask up to and including 50 kHz removed from the edge of the authorized bandwidth, adjust the resolution bandwidth to 100 Hz with the measuring instrument in a peak hold mode. A sufficient number of sweeps must be measured to insure that the emission profile is developed. If video filtering is used, its bandwidth must not be less than the instrument resolution bandwidth. For emissions beyond 50 kHz from the edge of the authorized bandwidth, see paragraph (m) of this section. If it can be shown that use of the above instrumentation settings do not accurately represent the true interference potential of the equipment under test, then an alternate procedure may be used provided prior Commission approval is obtained.

Attenuation = 0 dB at Fo to 5.625 kHz
Attenuation = 20 dB at 5.625 kHz and 70 dB at 12.5 kHz
Attenuation = 57dB (50 dB for 1.0W) at >12.5 kHz

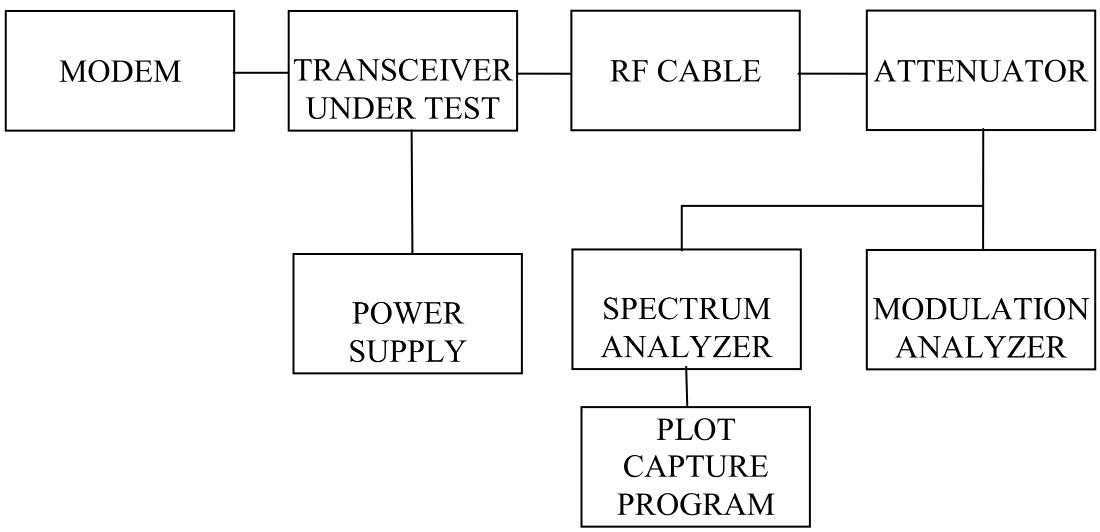
TEST RESULTS: Meets minimum standards (see data on following page)

TEST CONDITIONS: Standard Test Conditions, 25 C
RF Power Level = 1 Watt and 5 Watts
Voltage = 13.3VDC

TEST PROCEDURE: TIA/EIA – 603-C

TEST EQUIPMENT: 50-Ohm Attenuator, Bird Electronics 50-A-FFN-20 (20dB, 50W)
Power Supply, Agilent 6654A
Spectrum Analyzer, Hewlett Packard Model HP8563E
Modulation Analyzer, Hewlett Packard Model HP8901A

TEST SET-UP:



MODULATION SOURCE DESCRIPTION:

The digital modulation type used in the IntegraTR is DRCMSK (Differential Raised Cosine Minimum Shift Keying). A modem using such type of modulation is divided into three main functional units in a CPLD chip:

1. Scrambler:

The scrambler converts the data stream to a new data stream more suitable for FM transmission.
-It randomizes the data to avoid predictable patterns: 00000000, 111111111, 01010101, 00110011, etc.
-It keeps the power spectrum more compact by avoiding sequences like 01010101…
The scrambler is made with a serial shift register and 2 exclusive OR gates which implement the polynomial form X^7+X^5-1. For the receiver side, a similar circuit performs the descrambling function to decode the received scrambled data.

2. Differential encoder:

After data is scrambled, we encode the data with a differential encoder. The differential encoder XOR's the current input bit with the previous bit. The differential encoder is used to make the modem insensitive to audio polarity inversion of the FM radio system.

3. Waveshape generator:

The waveshape generator converts the processed data bits (scrambled and differentially encoded for DRCMSK) to the DRCMSK audio signal. This audio signal is passed through a low-pass filter before modulating the RF transmitter.

TRANSMISSION PREAMBLE:

Each data transmission begins by sending a 15 millisecond preamble of sinewave (101010...). This is to synchronize the digital phase locked loop of the receiver modem.

TEST PATTERN GENERATOR:

A 30 s test pattern sequence is generated by the test software when the "test data" button is clicked. The highest resulting modulating frequency is (baud rate)/2 Hz. The following pseudo random test pattern was used to modulate the transmitter:

###ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789\r\n,

In this pattern ### is replaced by the number of replays, \r is a carriage return and \n is a linefeed. The data is fed to the RS232 interface IC and processed as described above. The async-to-sync conversion, scrambler and differential encoder make the ABCDE... pattern appear random over the air.

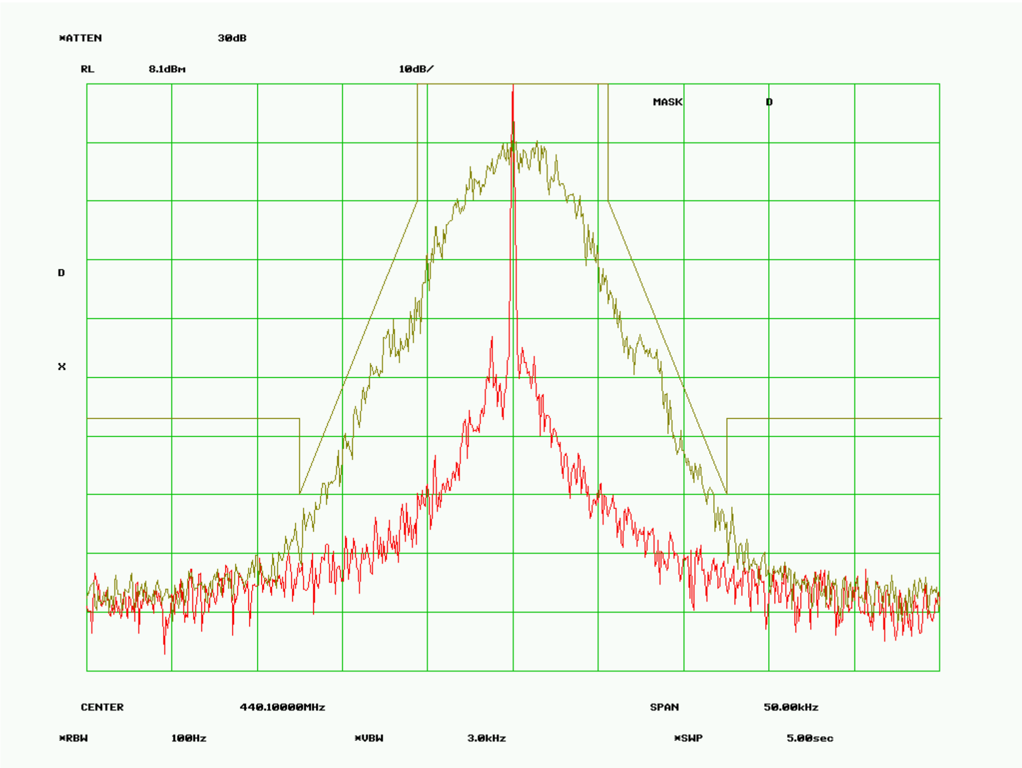
NECESSARY BANDWIDTH (Bn) CALCULATION

See page 15 for Emission Designator determination.

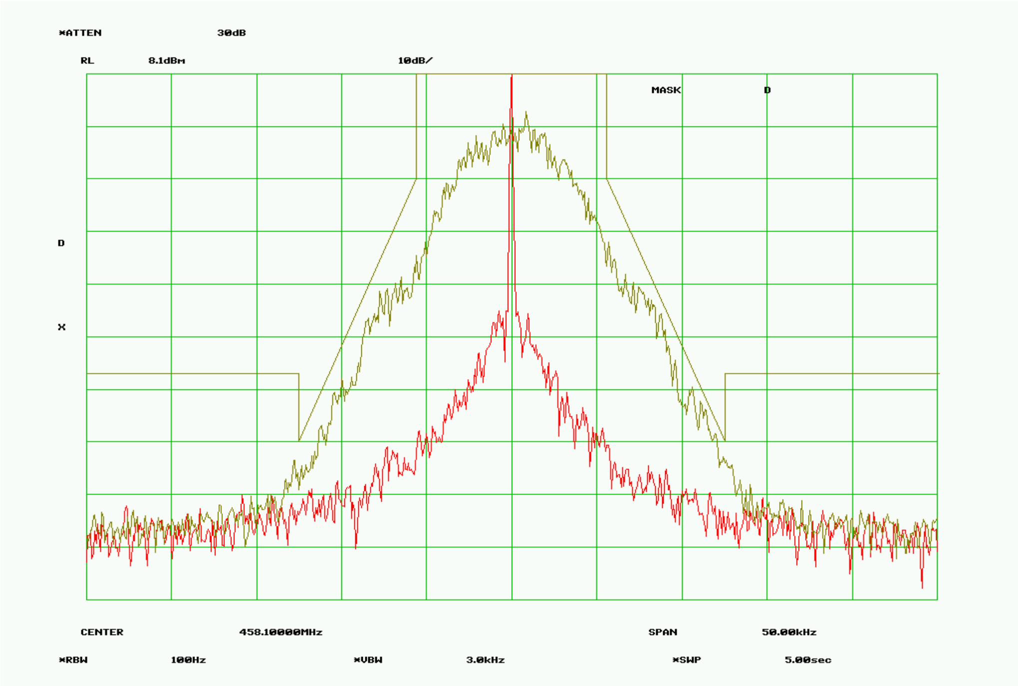
The corresponding emission designator prefix for necessary bandwidth = **8K80**

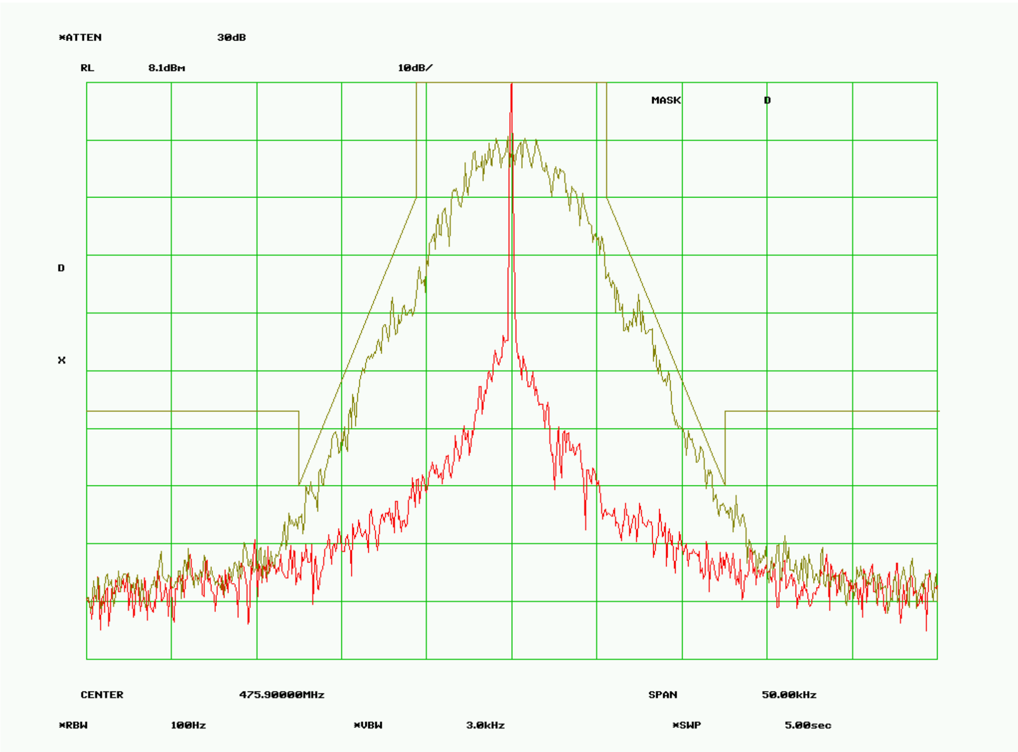
TEST DATA: Refer to the following graphs:

MASK D – 5.0 Watts - Span 50 kHz – RF Frequencies 440.100 MHz
SPECTRUM FOR EMISSION - **8K80F1D**
9600 bps
PEAK DEVIATION = 2910 Hz

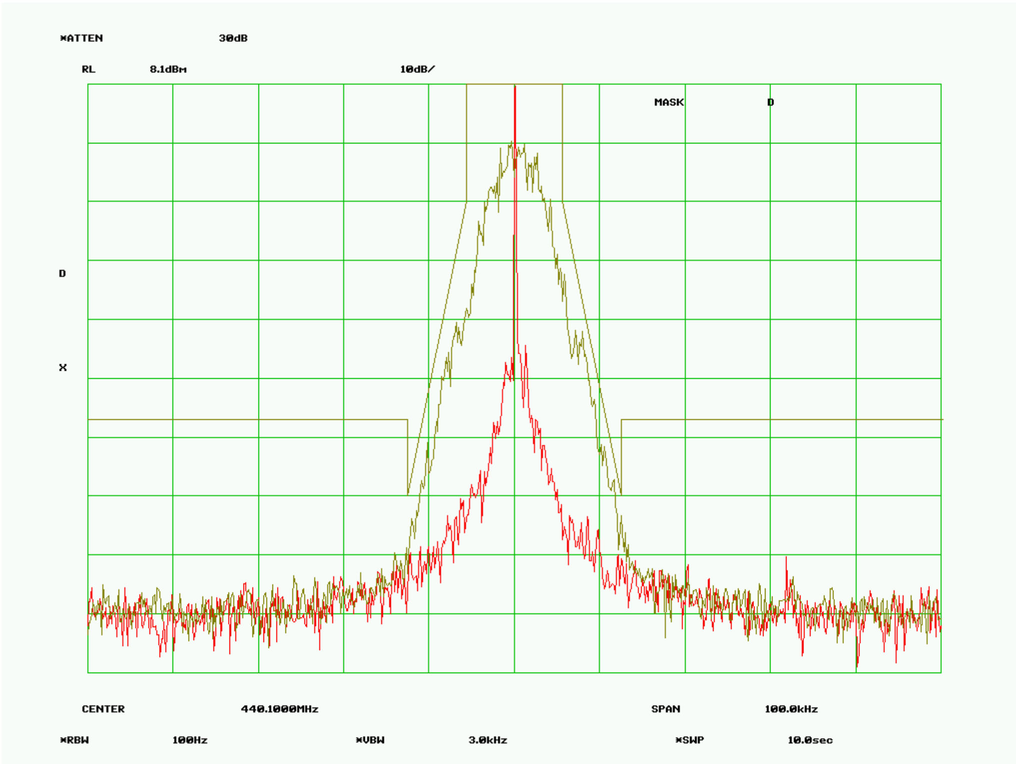


MASK D – 5.0 Watts - Span 50 kHz – RF Frequencies 458.100 and 475.900 MHz
SPECTRUM FOR EMISSION - **8K80F1D**
9600 bps
PEAK DEVIATION = 2910 Hz

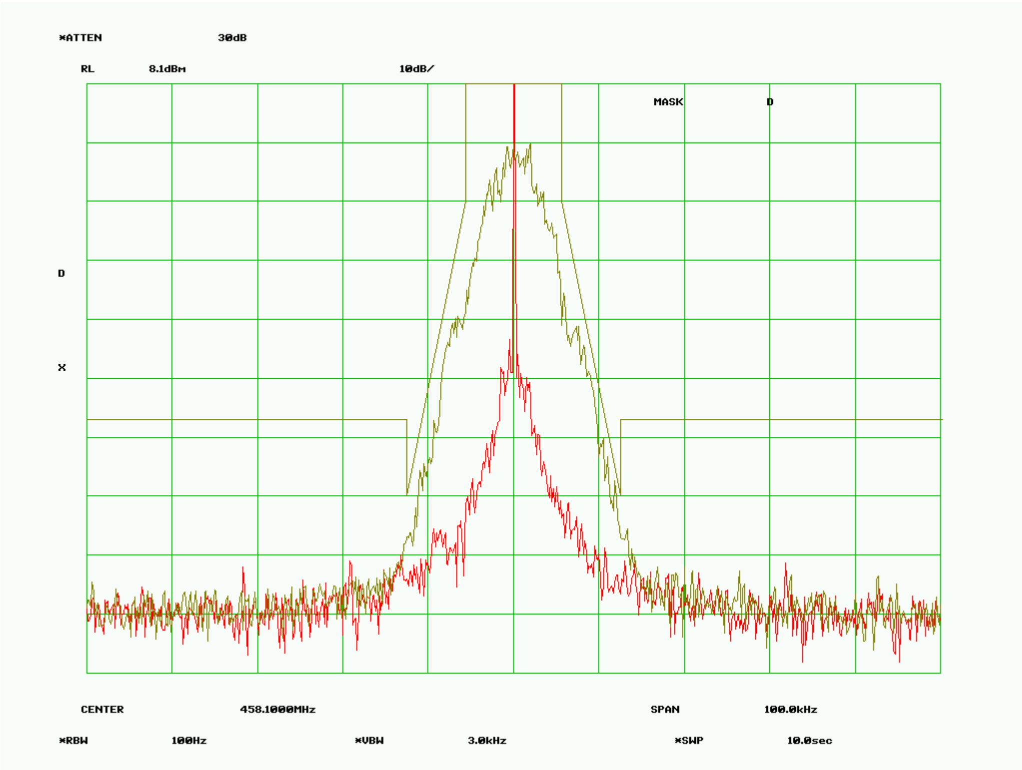


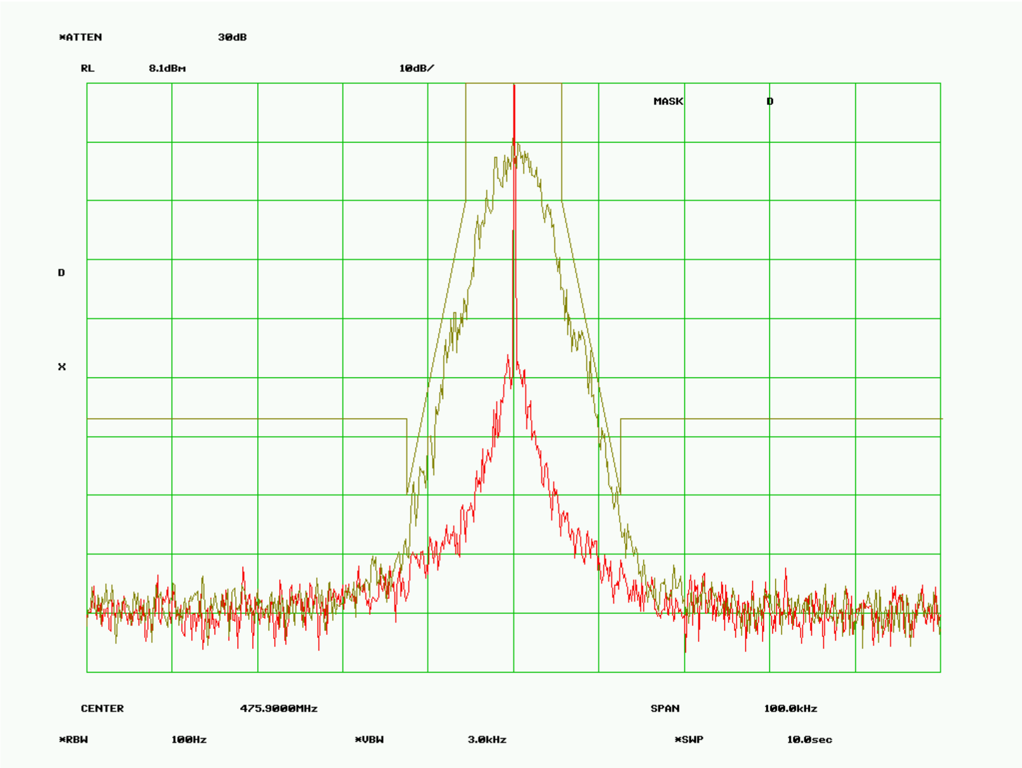


MASK D – 5.0 Watts - Span 100 kHz – RF Frequencies 440.100 MHz
SPECTRUM FOR EMISSION - **8K80F1D**
9600 bps
PEAK DEVIATION = 2910 Hz

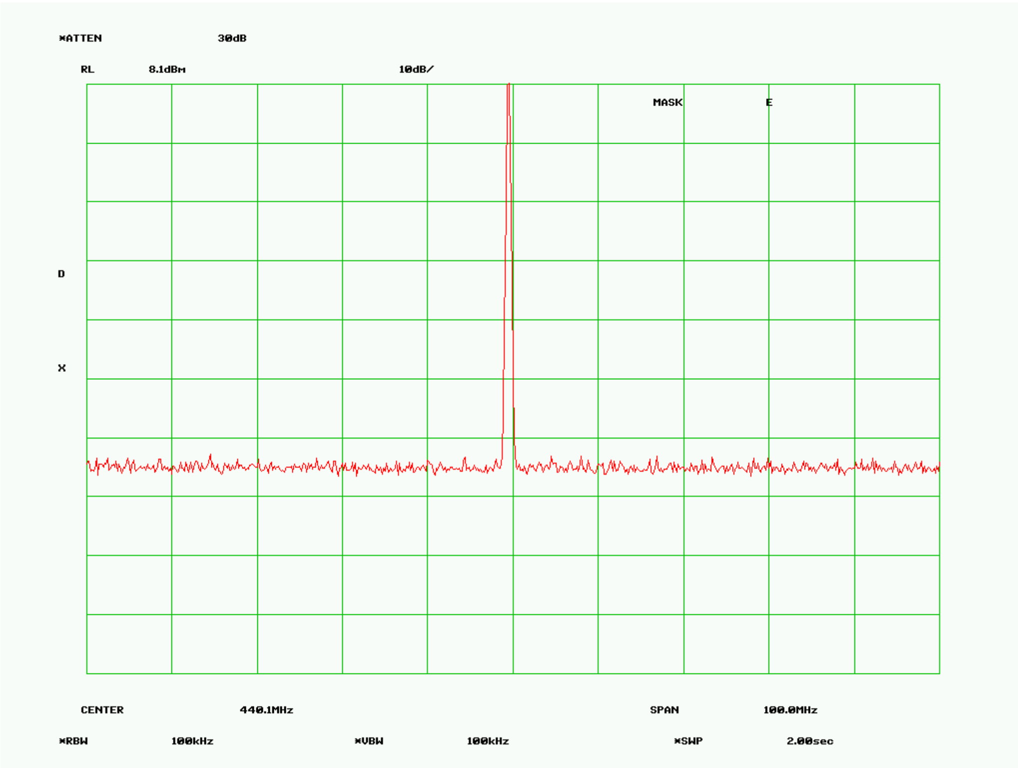


MASK D – 5.0 Watts - Span 100 kHz – RF Frequencies 458.100 and 475.900 MHz
SPECTRUM FOR EMISSION - **8K80F1D**
9600 bps
PEAK DEVIATION = 2910 Hz

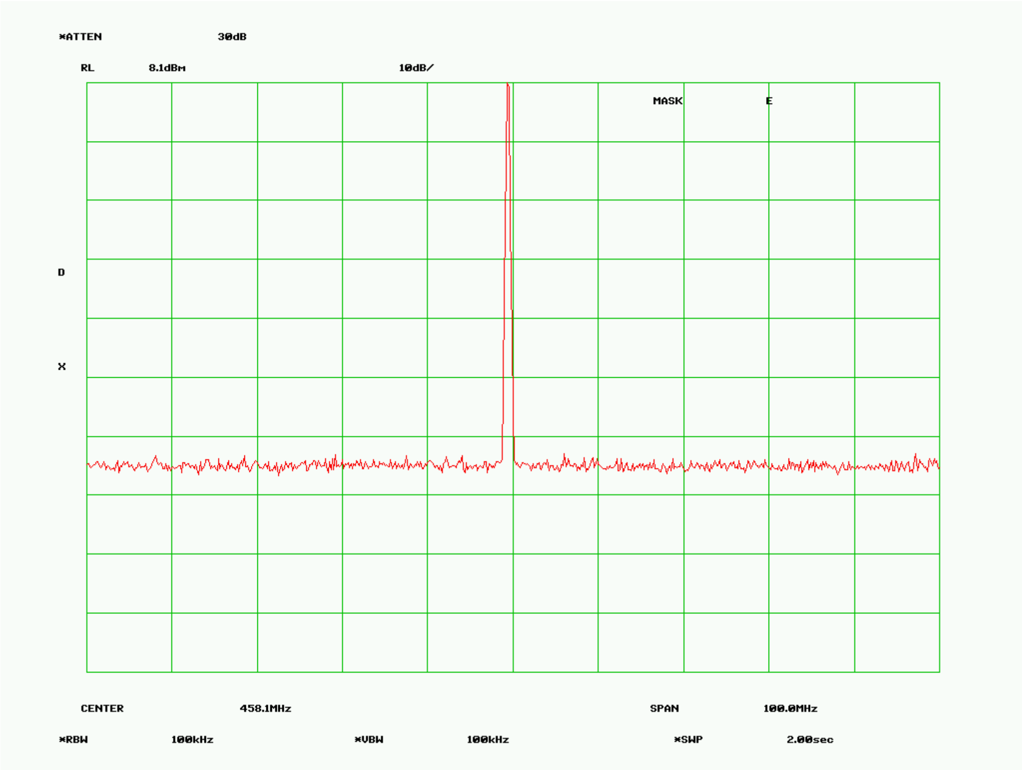


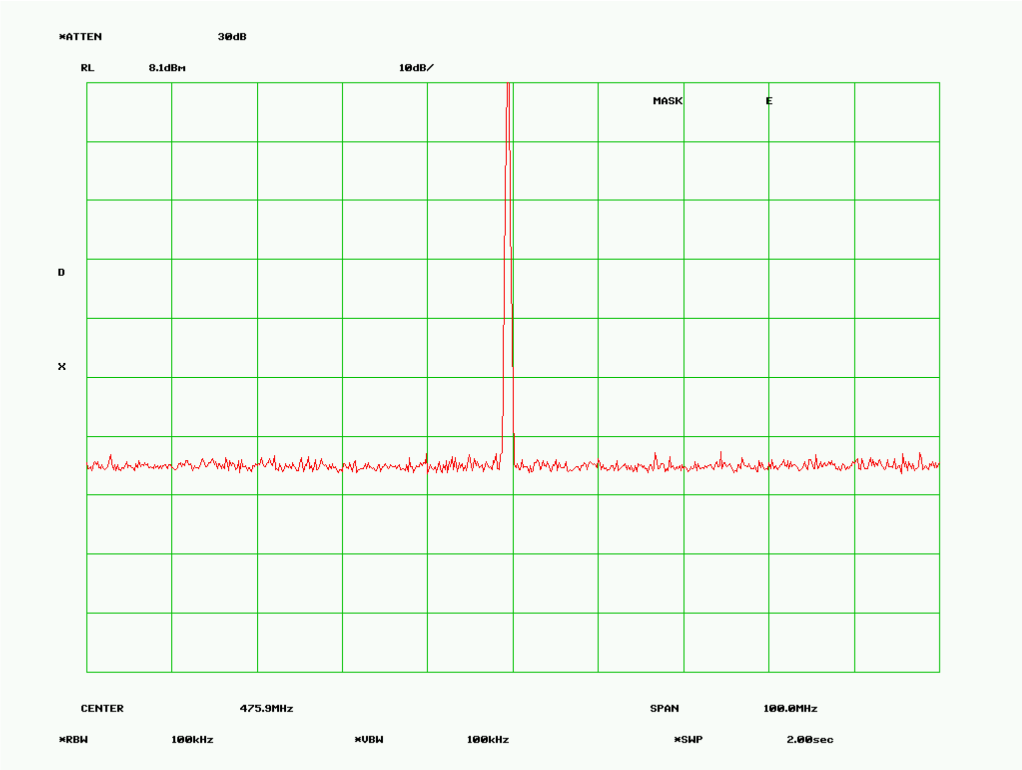


MASK D – 5.0 Watts - Span 100 MHz – RF Frequencies 440.100 MHz
SPECTRUM FOR EMISSION - **8K80F1D**
9600 bps
PEAK DEVIATION = 2910 Hz

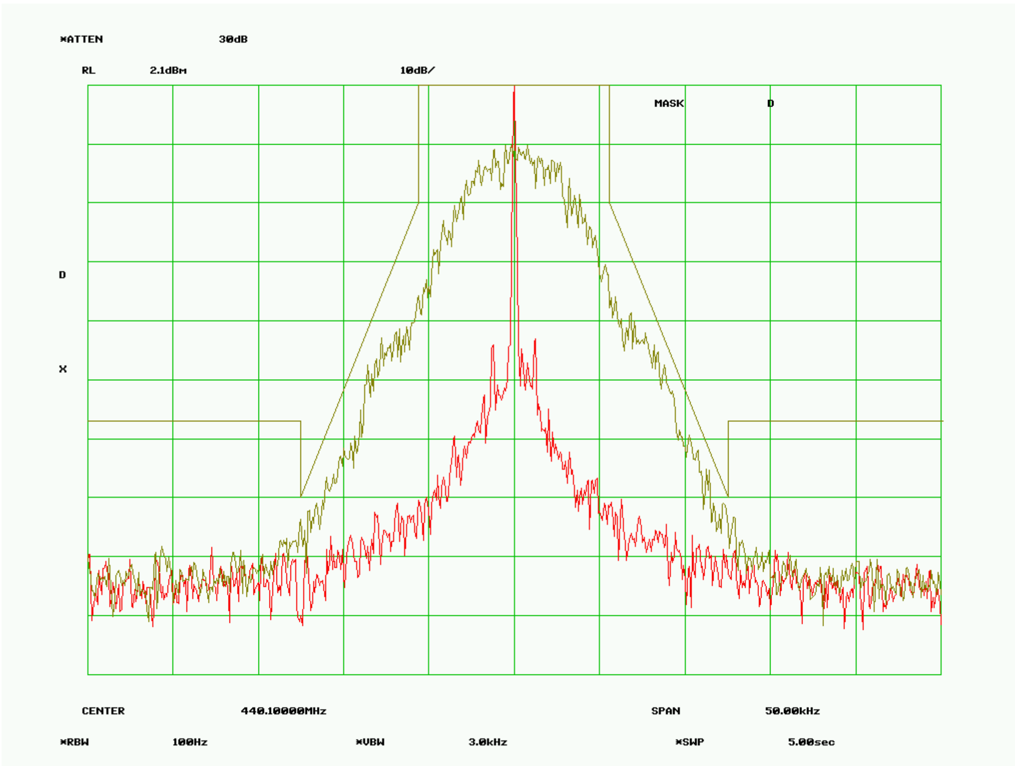


MASK D – 5.0 Watts - Span 100 MHz – RF Frequencies 458.100 and 475.900 MHz
SPECTRUM FOR EMISSION - **8K80F1D**
9600 bps
PEAK DEVIATION = 2910 Hz

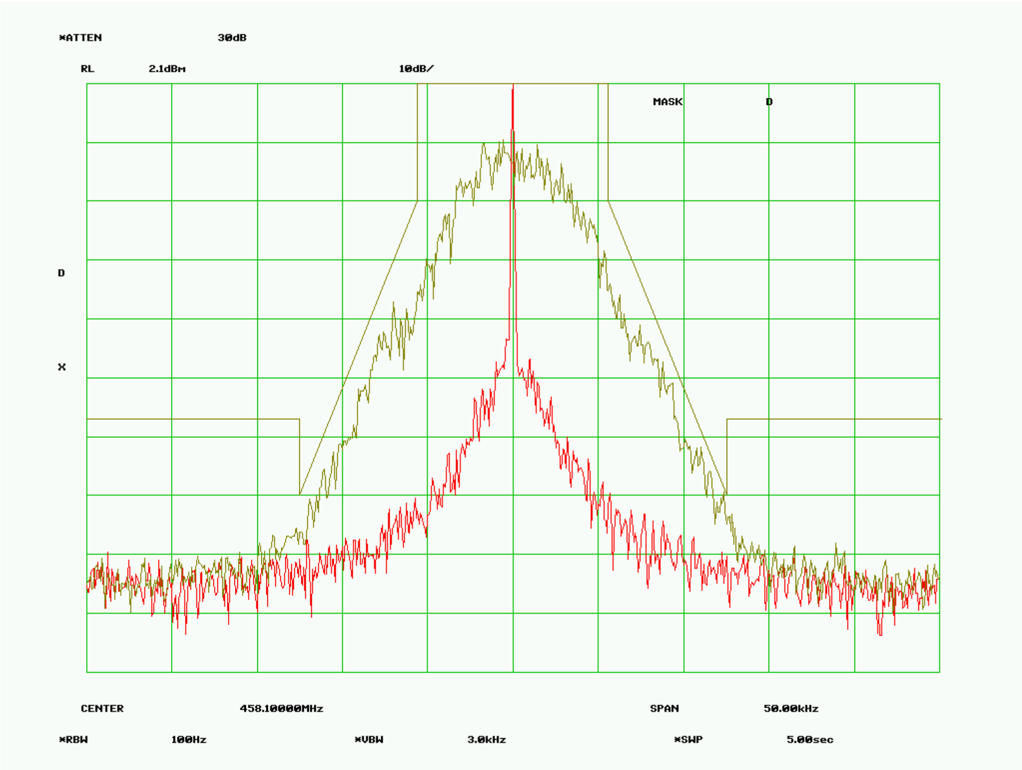


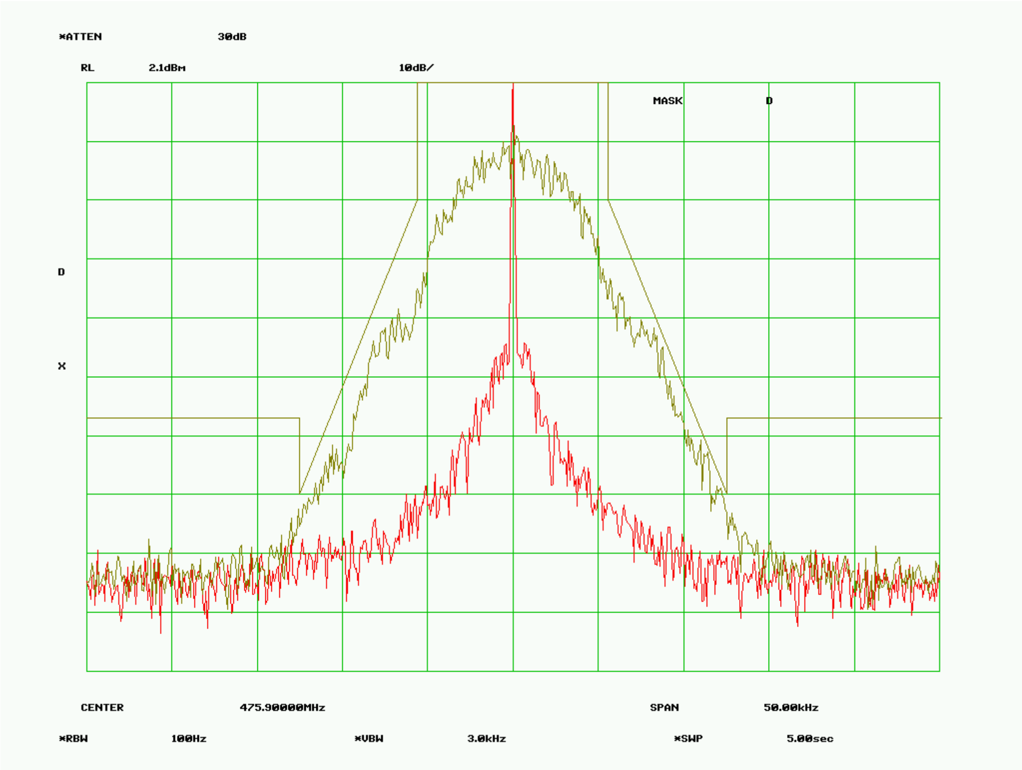


MASK D – 1.0 Watts - Span 50 kHz – RF Frequencies 440.100 MHz
SPECTRUM FOR EMISSION - **8K80F1D**
9600 bps
PEAK DEVIATION = 2910 Hz

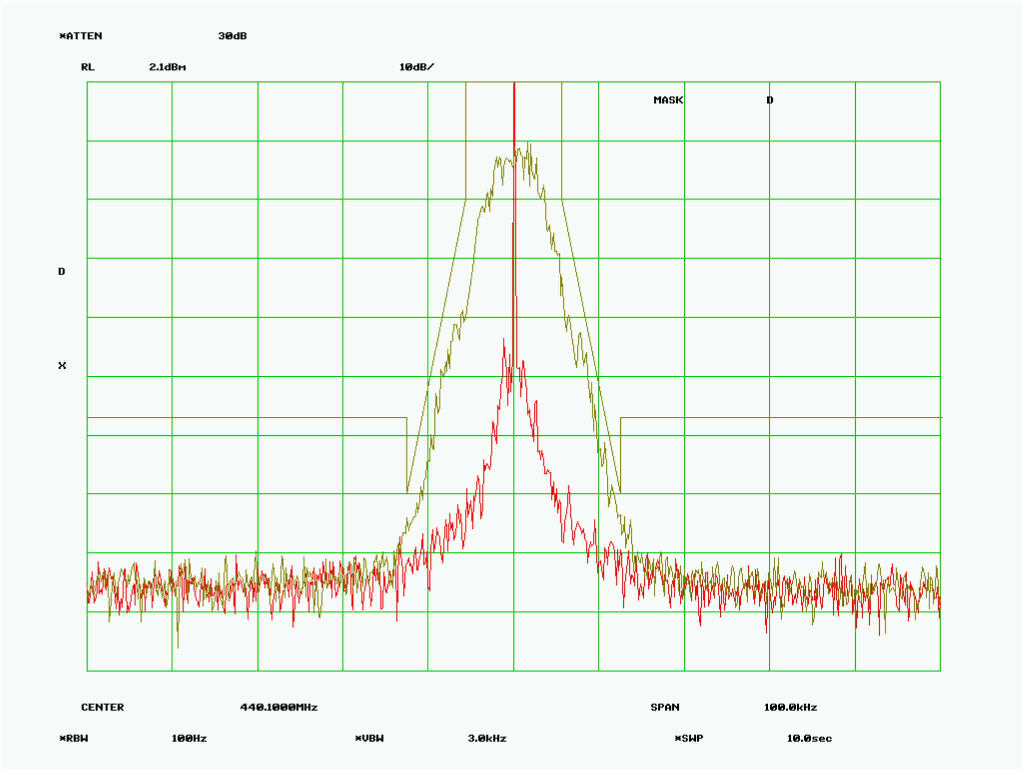


MASK D – 1.0 Watts - Span 50 kHz – RF Frequencies 458.100 and 475.900 MHz
SPECTRUM FOR EMISSION - **8K80F1D**
9600 bps
PEAK DEVIATION = 2910 Hz

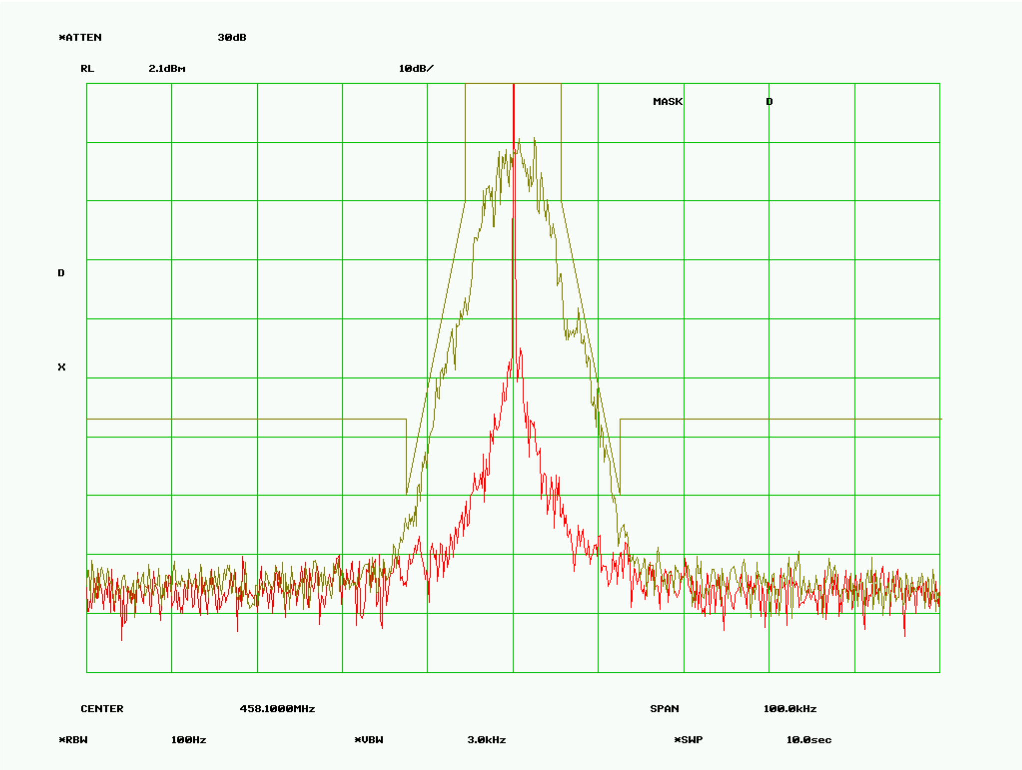


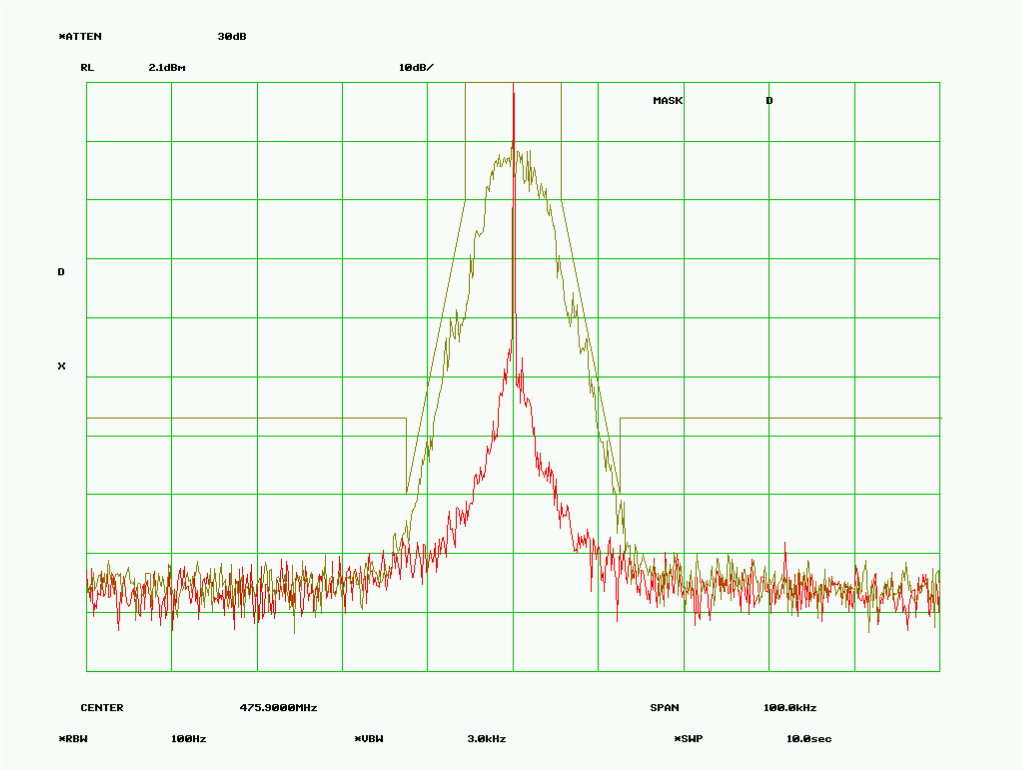


MASK D – 1.0 Watts - Span 100 kHz – RF Frequencies 440.100 MHz
SPECTRUM FOR EMISSION - **8K80F1D**
9600 bps
PEAK DEVIATION = 2910 Hz

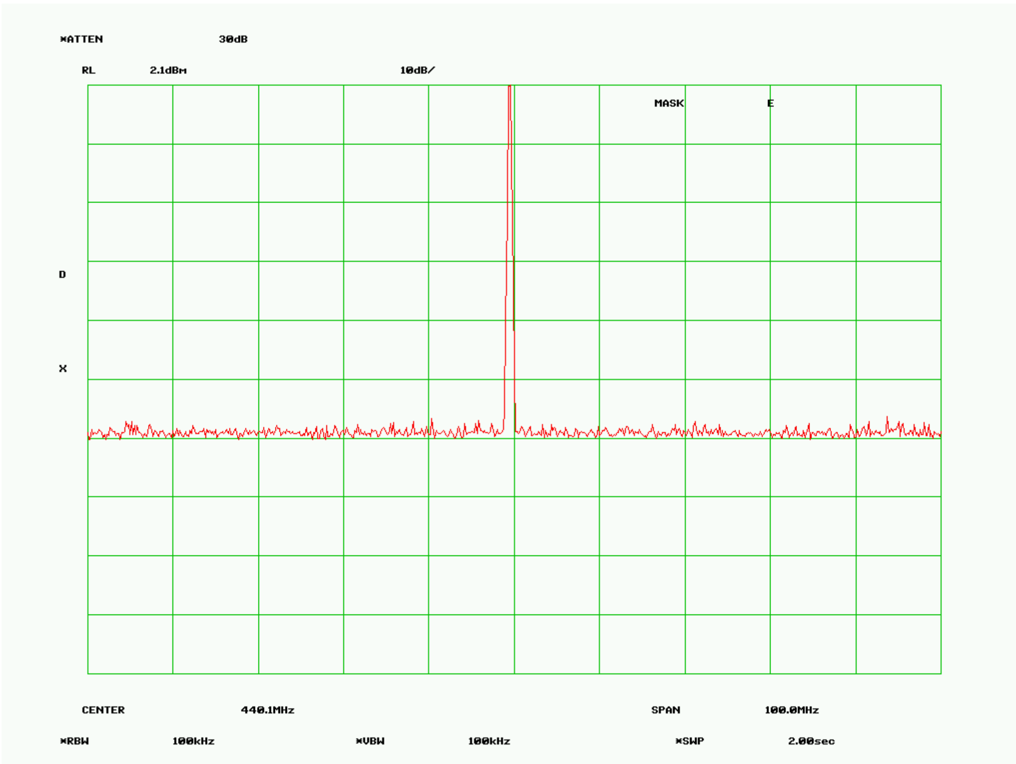


MASK D – 1.0 Watts - Span 100 kHz – RF Frequencies 458.100 and 475.900 MHz
SPECTRUM FOR EMISSION - **8K80F1D**
9600 bps
PEAK DEVIATION = 2910 Hz

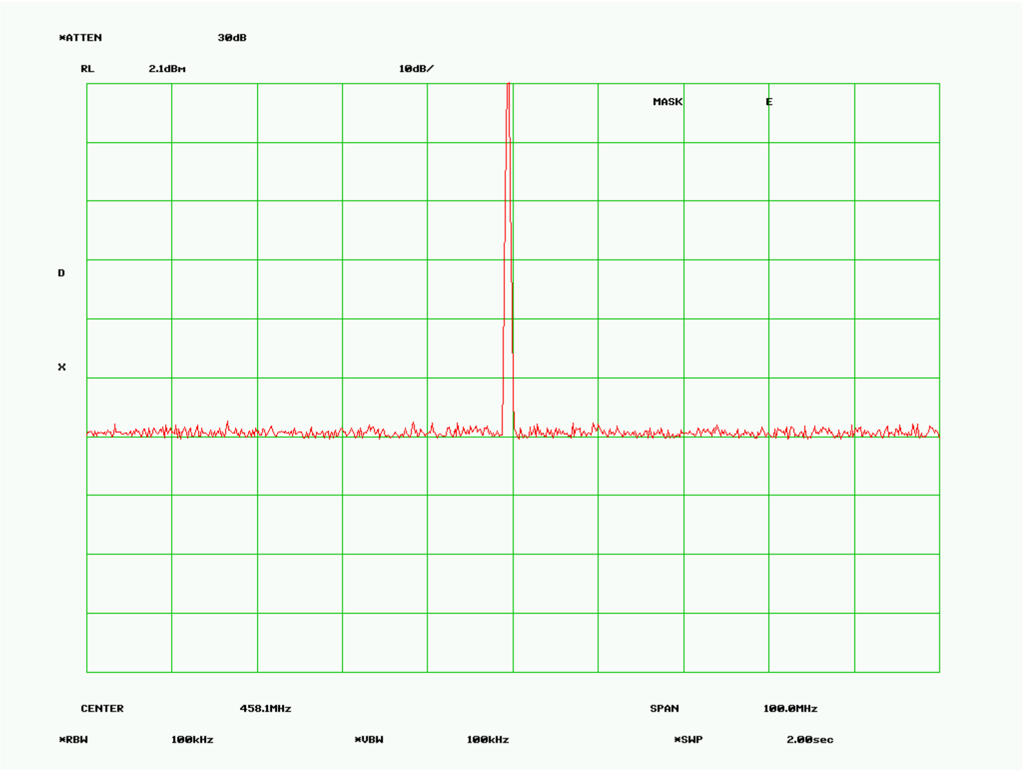


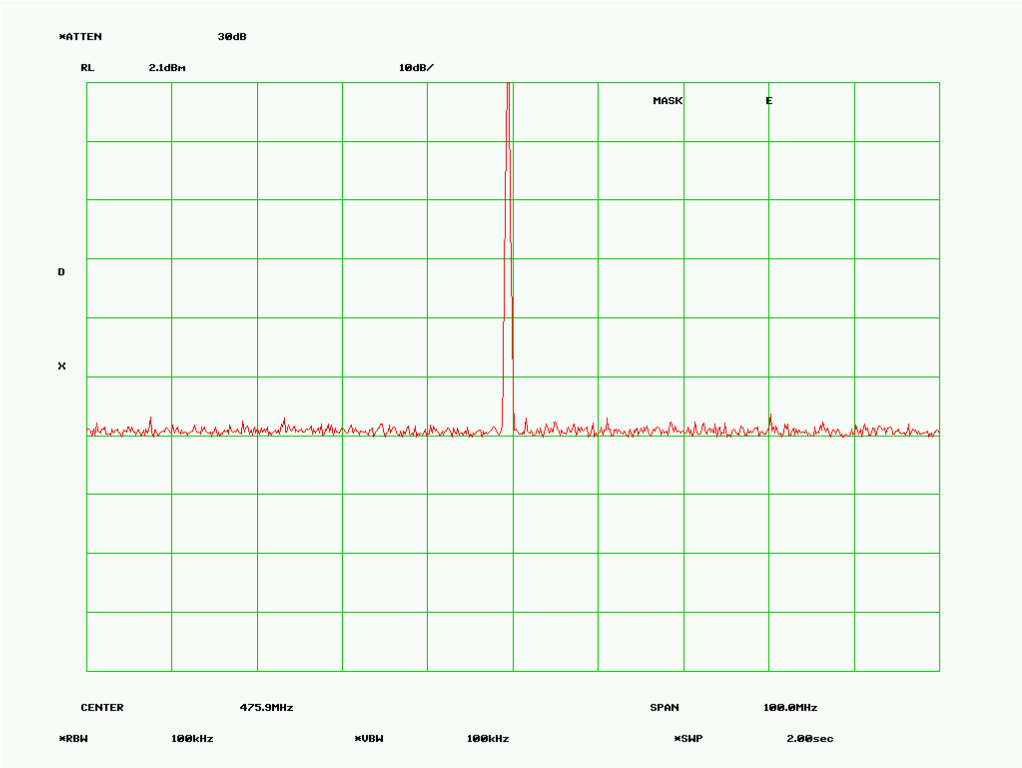


MASK D – 1.0 Watts - Span 100 MHz – RF Frequencies 440.100 MHz
SPECTRUM FOR EMISSION - **8K80F1D**
9600 bps
PEAK DEVIATION = 2910 Hz



MASK D – 1.0 Watts - Span 100 MHz – RF Frequencies 458.100 and 475.900 MHz
SPECTRUM FOR EMISSION - **8K80F1D**
9600 bps
PEAK DEVIATION = 2910 Hz





1.8 Transmitter Occupied Bandwidth Mask E - 3K30F1D

RULE PART NUMBER: 2.201, 2.202, 2.1033 (c)(14), 2.1041, 2.1049(h), 90.209(b)(5), 90.210 (e)

MINIMUM STANDARD:

(e) ***Emission Mask E***—*6.25 kHz or less channel bandwidth equipment.* For transmitters designed to operate with a 6.25 kHz or less bandwidth, any emission must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows:

(1) On any frequency from the center of the authorized bandwidth f_0 to 3.0 kHz removed from f_0 : Zero dB.

(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 3.0 kHz but no more than 4.6 kHz: At least 30 + 16.67(f_d −3 kHz) or 55 + 10 log (P) or 65 dB, whichever is the lesser attenuation.

(3) On any frequency removed from the center of the authorized bandwidth by more than 4.6 kHz: At least 55 + 10 log (P) or 65 dB, whichever is the lesser attenuation.

(4) The reference level for showing compliance with the emission mask shall be established using a resolution bandwidth sufficiently wide (usually two to three times the channel bandwidth) to capture the true peak emission of the equipment under test. In order to show compliance with the emissions mask up to and including 50 kHz removed from the edge of the authorized bandwidth, adjust the resolution bandwidth to 100 Hz with the measuring instrument in a peak hold mode. A sufficient number of sweeps must be measured to insure that the emission profile is developed. If video filtering is used, its bandwidth must not be less than the instrument resolution bandwidth. For emissions beyond 50 kHz from the edge of the authorized bandwidth, see paragraph (m) of this section. If it can be shown that use of the above instrumentation settings do not accurately represent the true interference potential of the equipment under test, then an alternate procedure may be used provided prior Commission approval is obtained.

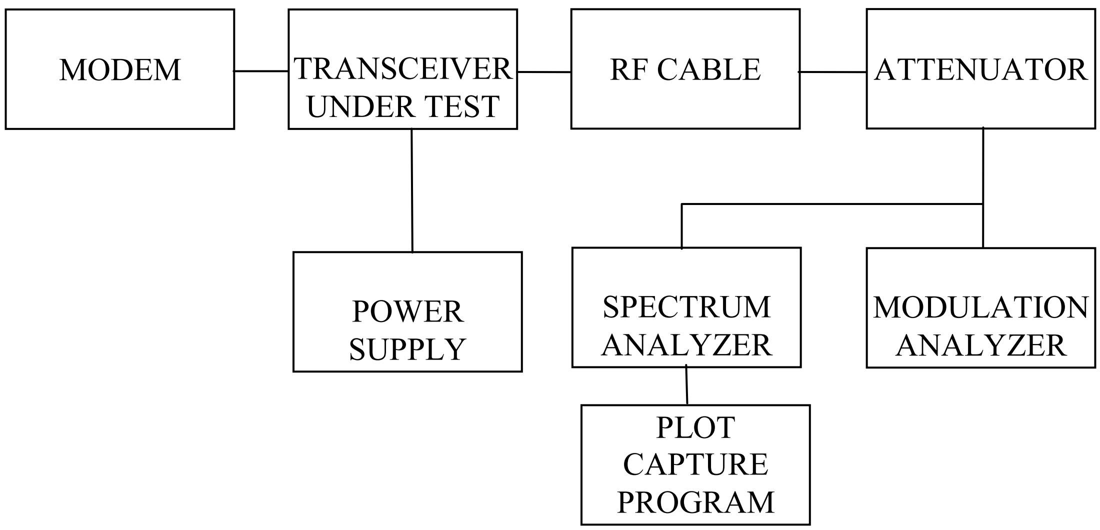
Attenuation = 0 dB at Fo to 3.0 kHz
Attenuation = 30 dB at 3.0 kHz and 57 dB at 4.6 kHz
Attenuation = 62 dB (55 dB @ 1 Watt) at > 4.6 kHz

TEST RESULTS: Meets minimum standard (see data on the following pages)

TEST CONDITIONS: Standard Test Conditions, 25 C

TEST EQUIPMENT:
50-Ohm Attenuator, Bird Electronics Model 50-A-FFN-20 (20dB, 50W)
50-Ohm Attenuator, Bird Electronics Model 25-A-MFN-6 (6dB, 25W)
DC Power Supply, Hewlett Packard Model 6653A
Spectrum Analyzer, Hewlett Packard Model HP8563E
Modulation Analyzer, Hewlett Packard Model HP8901A

TEST SET-UP:



MODULATION SOURCE DESCRIPTION:

The digital modulation type used in the IntegraTR is DRCMSK (Differential Raised Cosine Minimum Shift Keying). A modem using such type of modulation is divided into three main functional units in a CPLD chip:

4. Scrambler:
The scrambler converts the data stream to a new data stream more suitable for FM transmission.
-It randomizes the data to avoid predictable patterns: 00000000, 111111111, 01010101, 00110011, etc.
-It keeps the power spectrum more compact by avoiding sequences like 01010101…
The scrambler is made with a serial shift register and 2 exclusive OR gates which implement the polynomial form X^7+X^5-1. For the receiver side, a similar circuit performs the descrambling function to decode the received scrambled data.

5. Differential encoder:
After data is scrambled, we encode the data with a differential encoder. The differential encoder XOR's the current input bit with the previous bit. The differential encoder is used to make the modem insensitive to audio polarity inversion of the FM radio system.

6. Waveshape generator:
The waveshape generator converts the processed data bits (scrambled and differentially encoded for DRCMSK) to the DRCMSK audio signal. This audio signal is passed through a low-pass filter before modulating the RF transmitter.

TRANSMISSION PREAMBLE:

Each data transmission begins by sending a 15 millisecond preamble of sinewave (101010...). This is to synchronize the digital phase locked loop of the receiver modem.

TEST PATTERN GENERATOR:

A 30 s test pattern sequence is generated by the test software when the "test data" button is clicked. The highest resulting modulating frequency is (baud rate)/2 Hz. The following pseudo random test pattern was used to modulate the transmitter:

###ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789\r\n,

In this pattern ### is replaced by the number of replays, \r is a carriage return and \n is a linefeed. The data is fed to the RS232 interface IC and processed as described above. The async-to-sync conversion, scrambler and differential encoder make the ABCDE... pattern appear random over the air.

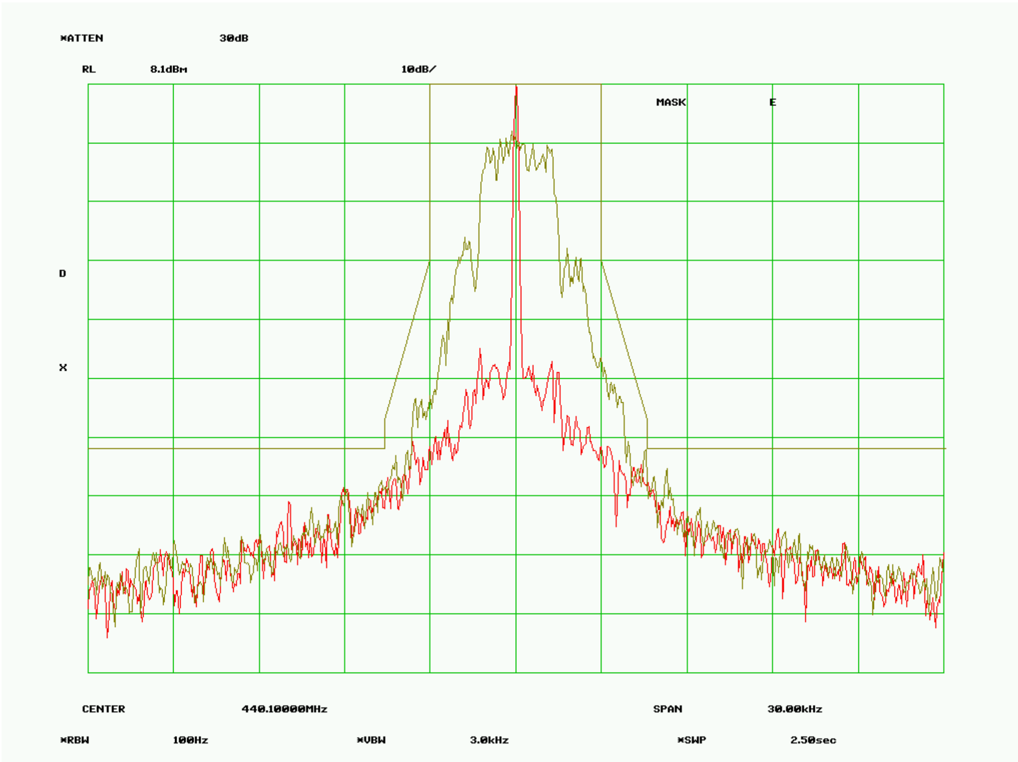
NECESSARY BANDWIDTH (Bn) CALCULATION

See page 15 for Emission Designator determination.

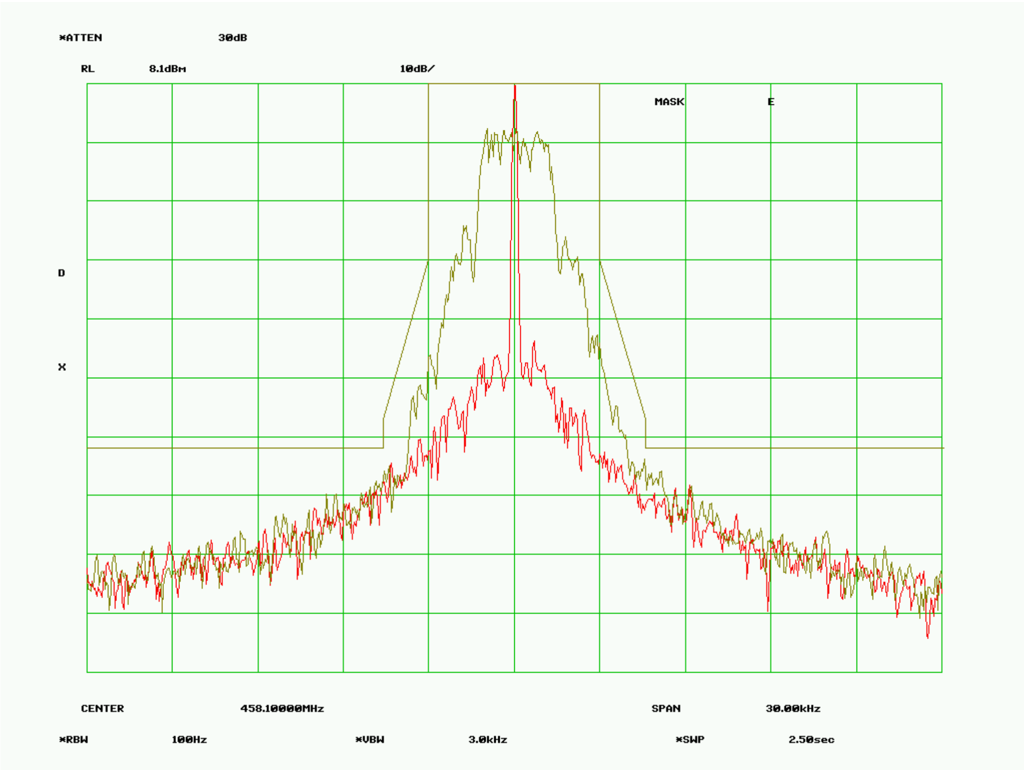
The corresponding emission designator prefix for necessary bandwidth = **8K08**

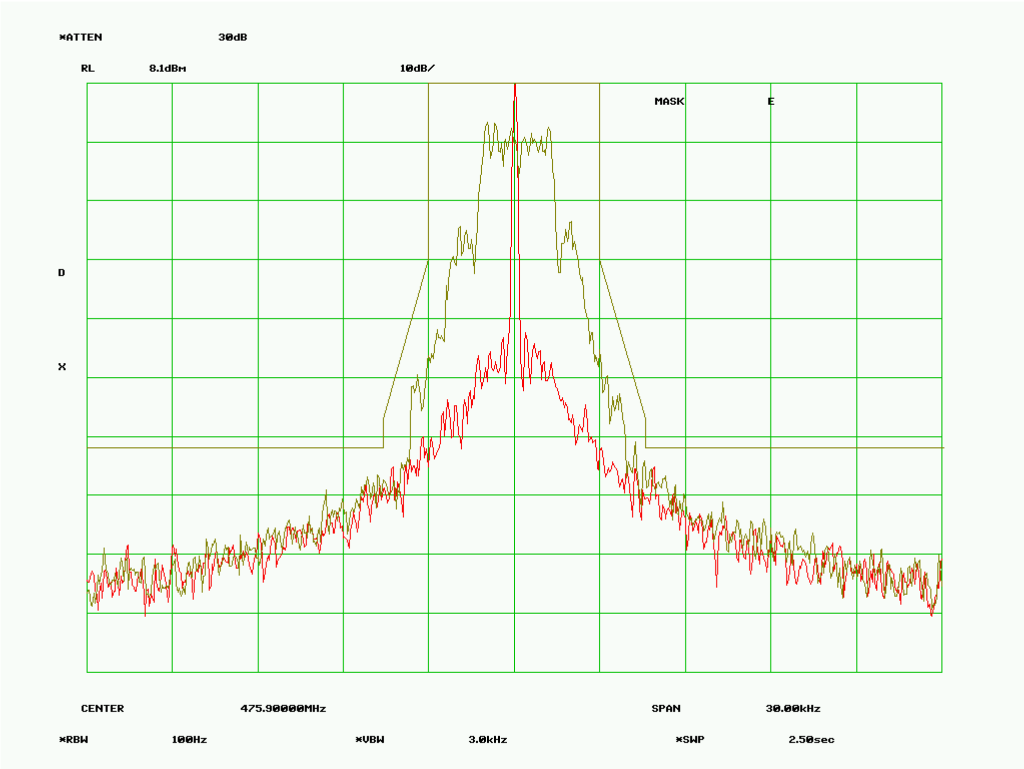
TEST DATA: Refer to the following graphs:

MASK E – 5.0 Watts - Span 30 kHz – RF Frequencies 440.100 MHz
SPECTRUM FOR EMISSION - **3K30F1D**
2400 bps
PEAK DEVIATION = 1250 Hz

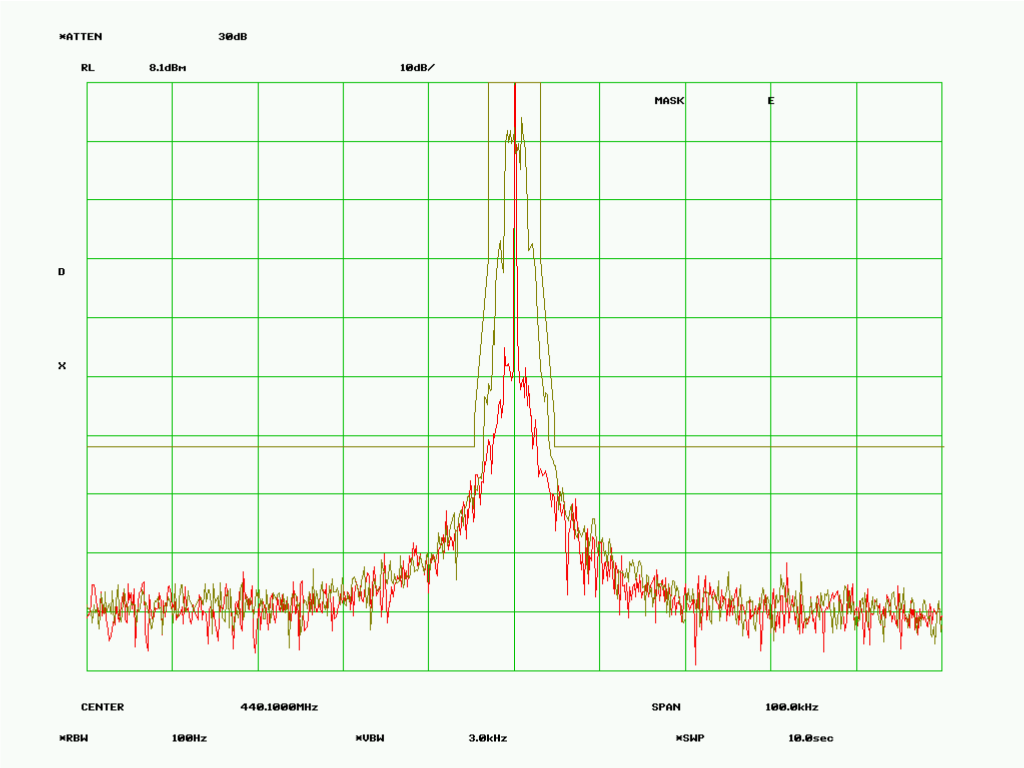


MASK E – 5.0 Watts - Span 30 kHz – RF Frequencies 458.100 and 475.900 MHz
SPECTRUM FOR EMISSION - **3K30F1D**
2400 bps
PEAK DEVIATION = 1250 Hz

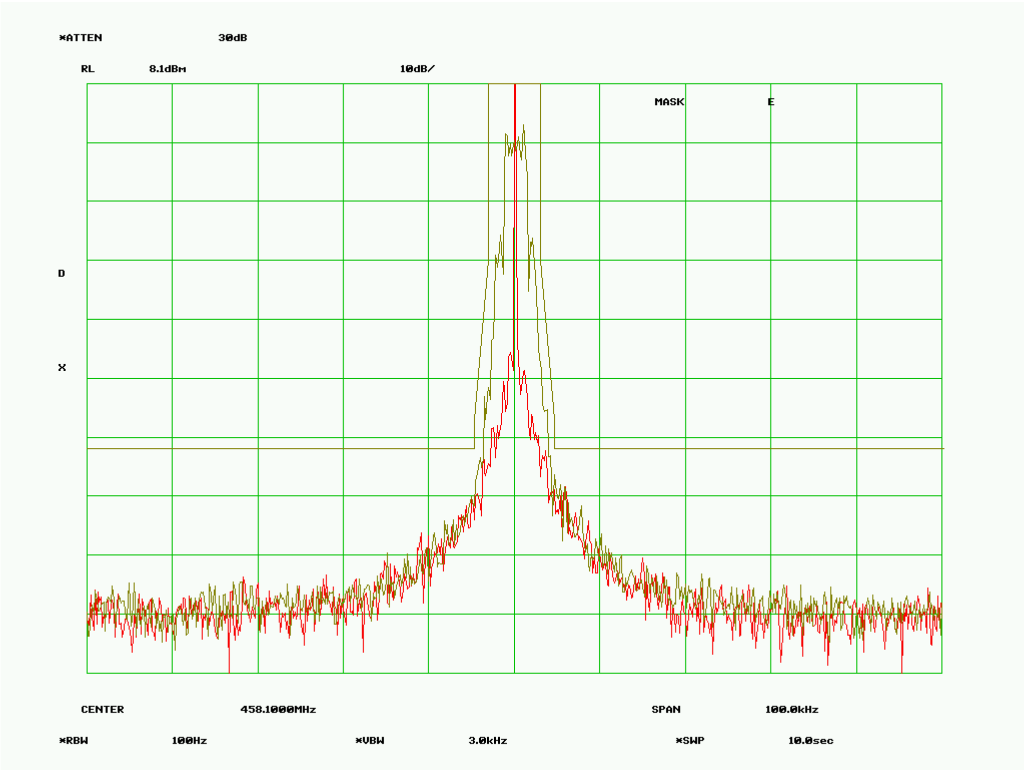


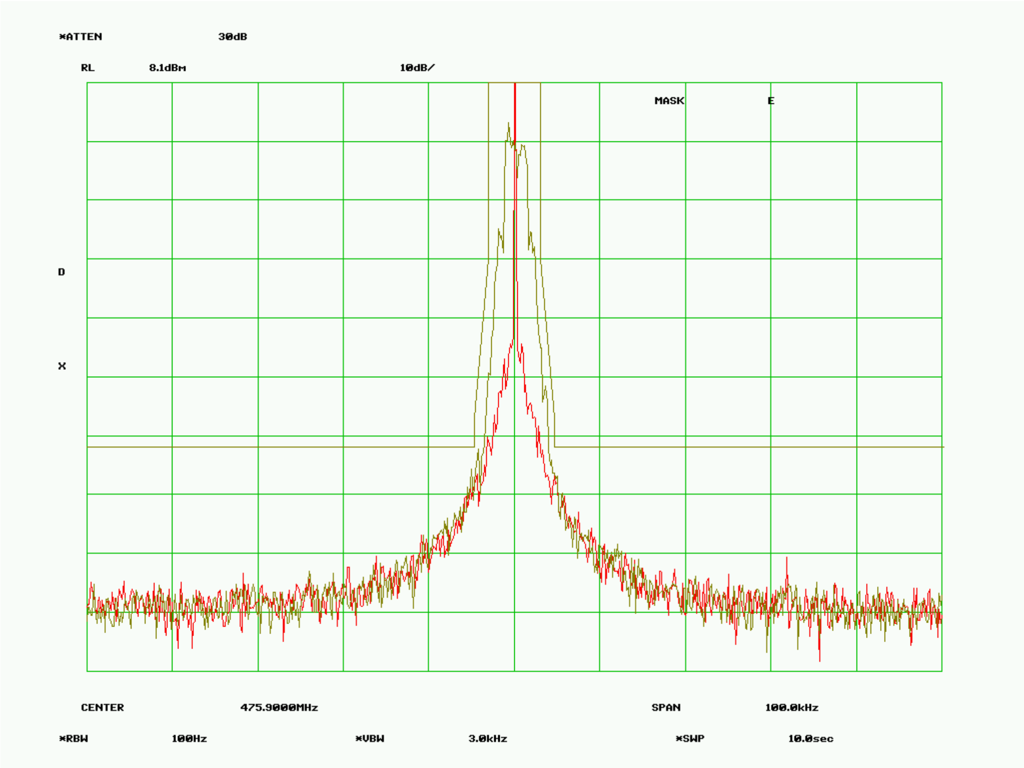


MASK E – 5.0 Watts - Span 100 kHz – RF Frequencies 440.100 MHz
SPECTRUM FOR EMISSION - **3K30F1D**
2400 bps
PEAK DEVIATION = 1250 Hz

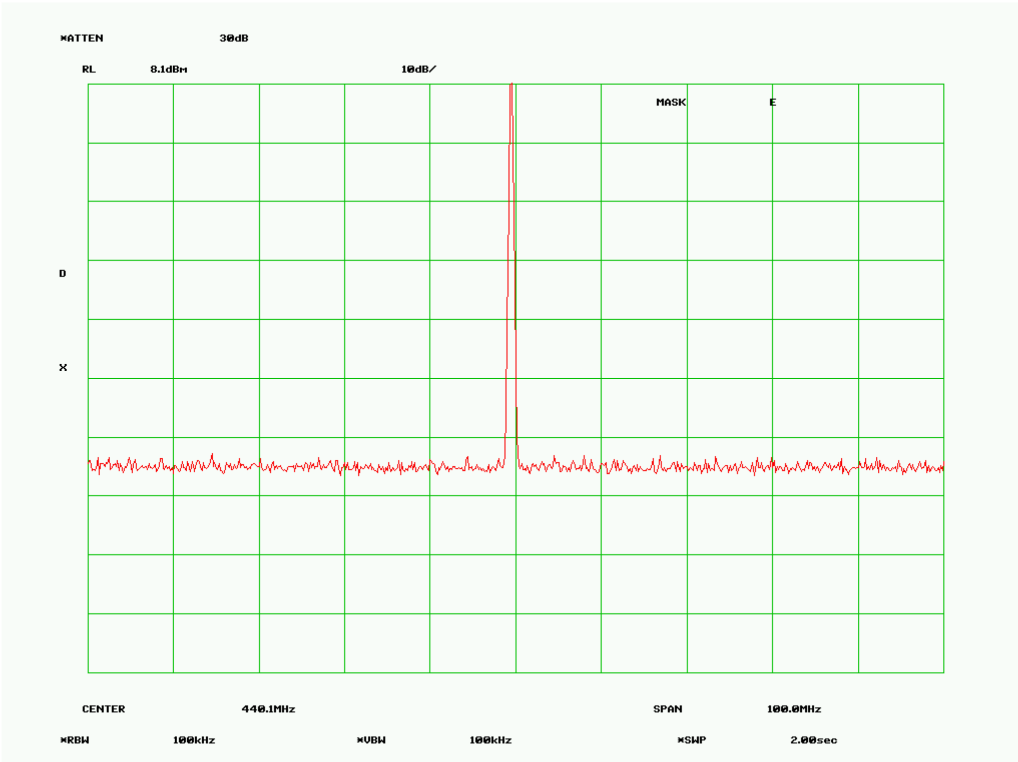


MASK E – 5.0 Watts - Span 100 kHz– RF Frequencies 458.100 and 475.900 MHz
SPECTRUM FOR EMISSION - **3K30F1D**
2400 bps
PEAK DEVIATION = 1250 Hz

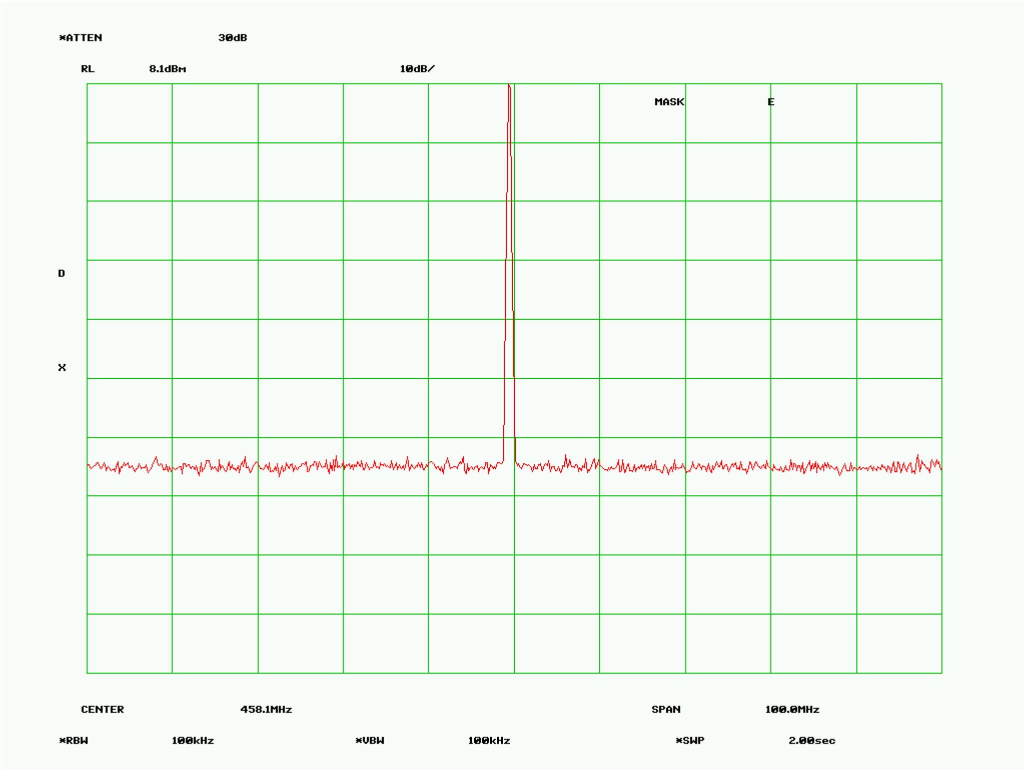


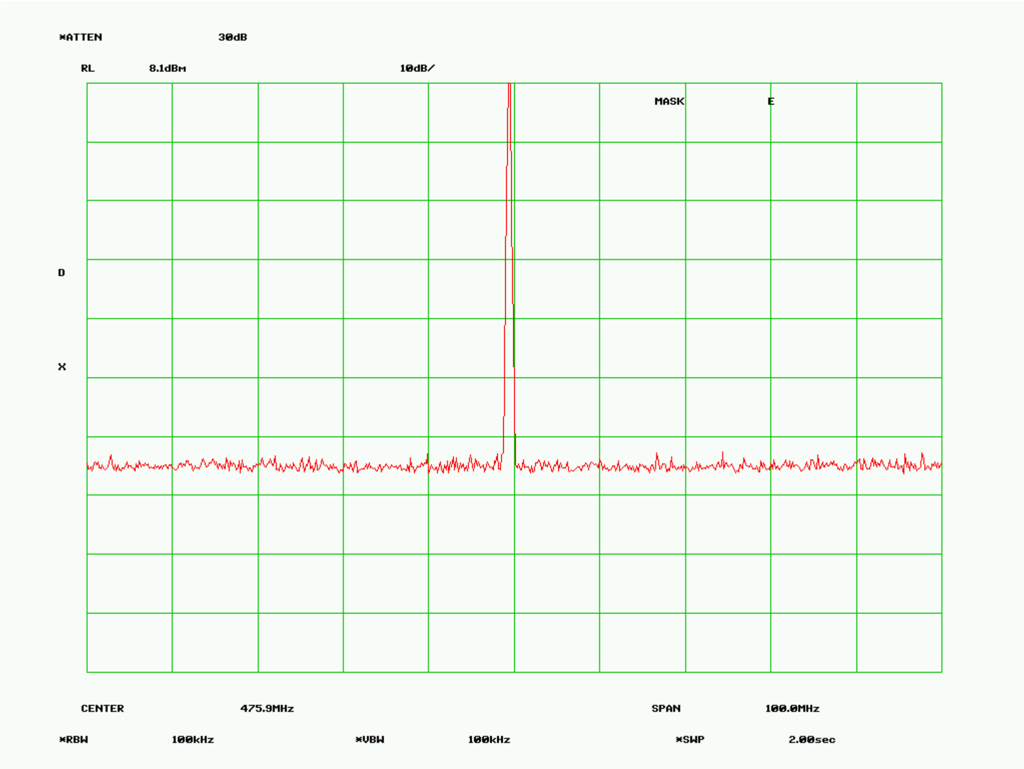


MASK E – 5.0 Watts - Span 100 MHz – RF Frequencies 440.100 MHz
SPECTRUM FOR EMISSION - **3K30F1D**
2400 bps
PEAK DEVIATION = 1250 Hz

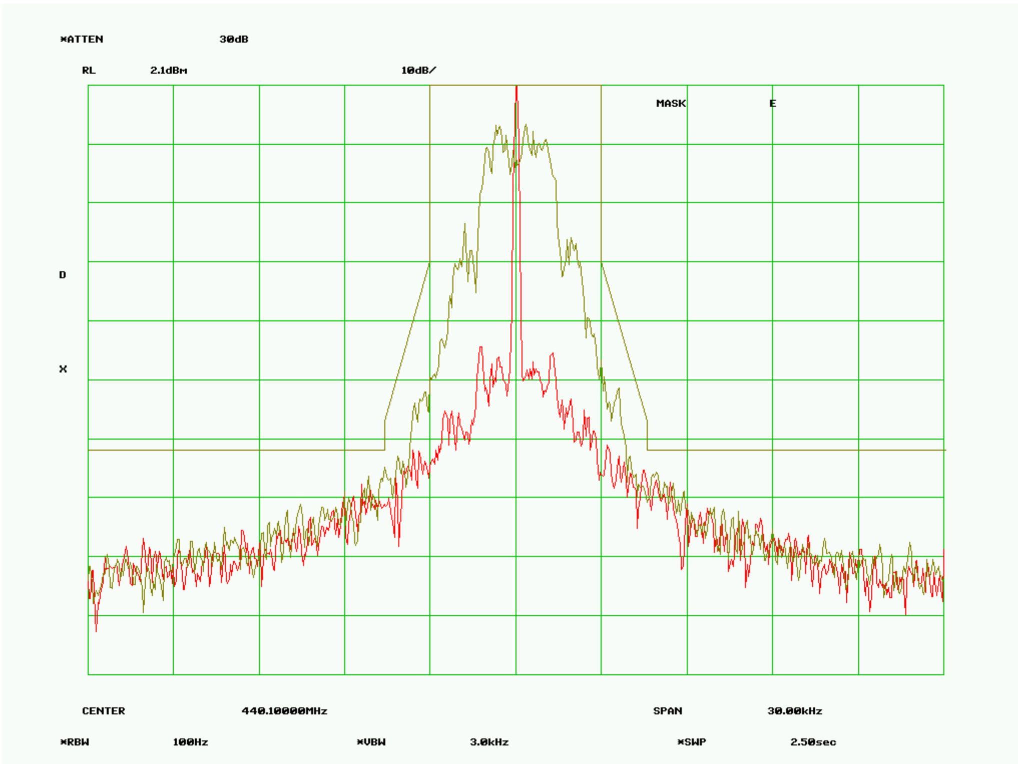


MASK E – 5.0 Watts - Span 100 MHz – RF Frequencies 458.100 and 475.900 MHz
SPECTRUM FOR EMISSION - **3K30F1D**
2400 bps
PEAK DEVIATION = 1250 Hz

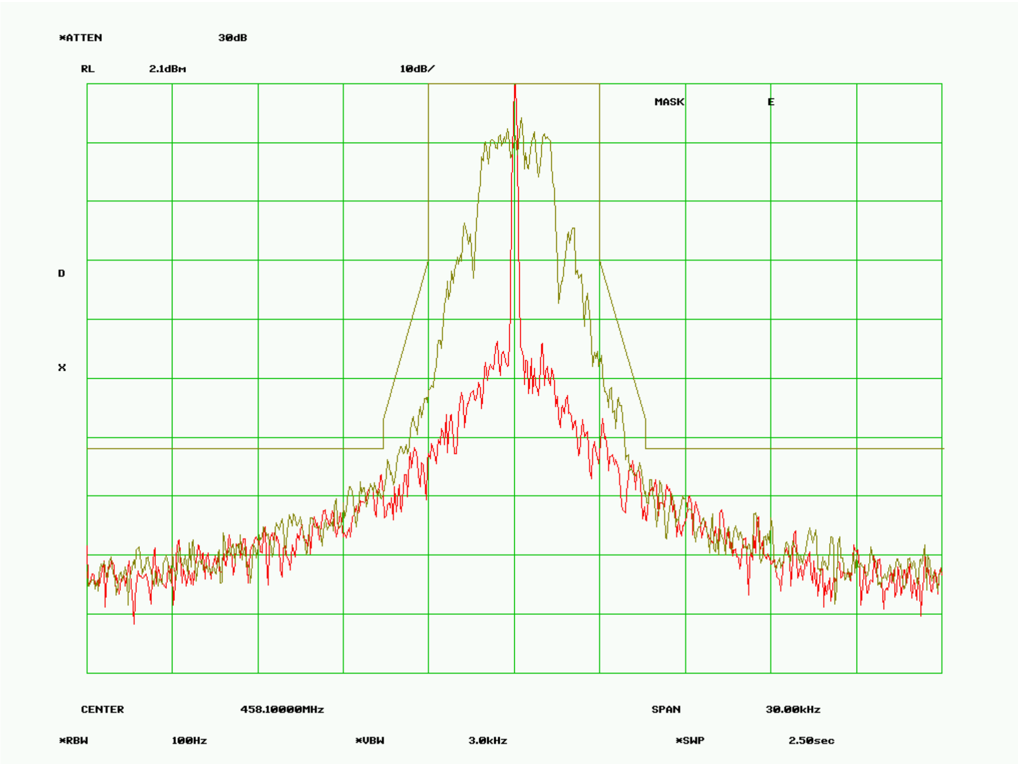


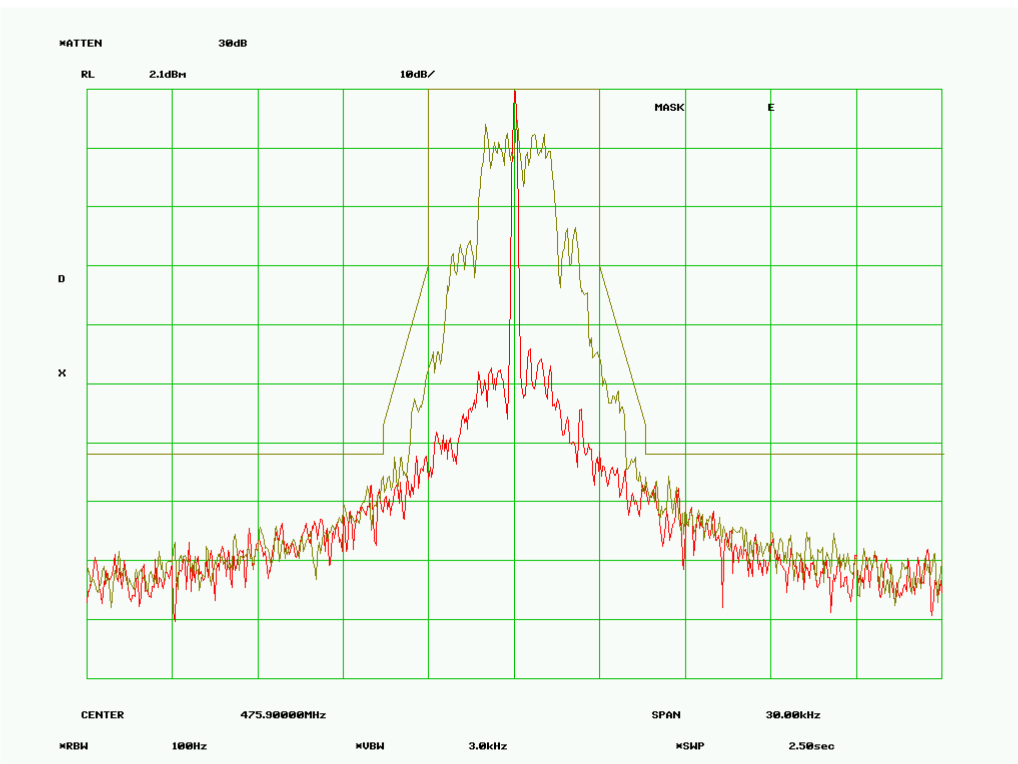


MASK E – 1.0 Watts - Span 30 kHz – RF Frequencies 440.100 MHz
SPECTRUM FOR EMISSION - **3K30F1D**
2400 bps
PEAK DEVIATION = 1250 Hz

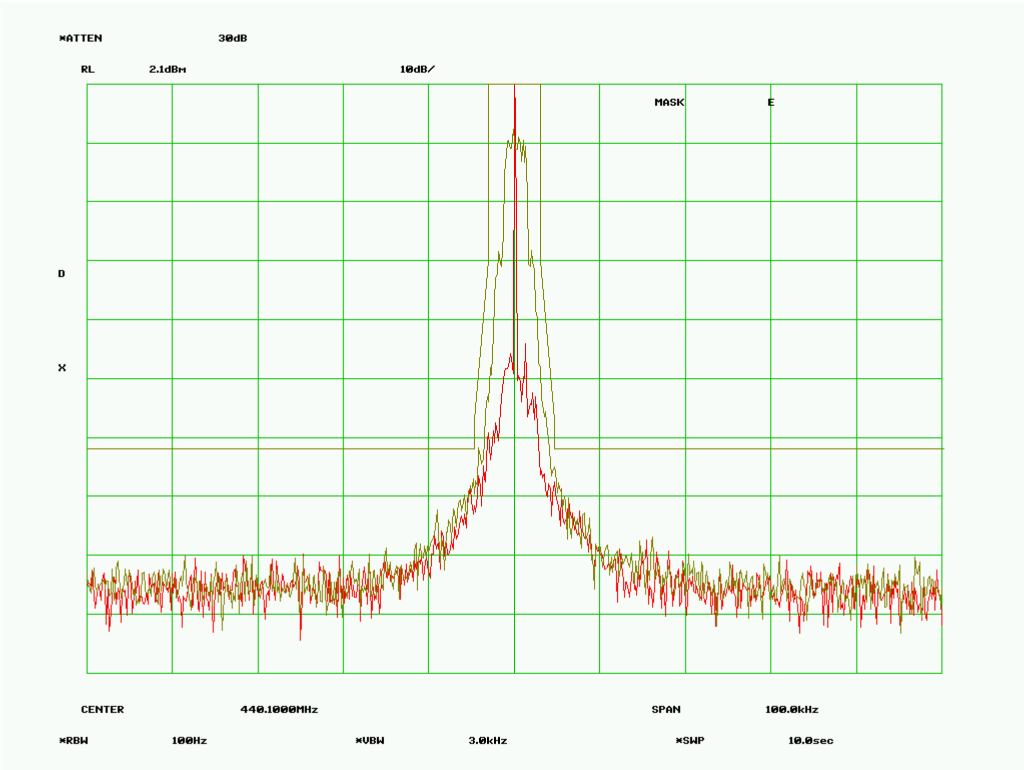


MASK E – 1.0 Watts - Span 30 kHz – RF Frequencies 458.100 and 475.900 MHz
SPECTRUM FOR EMISSION - **3K30F1D**
2400 bps
PEAK DEVIATION = 1250 Hz

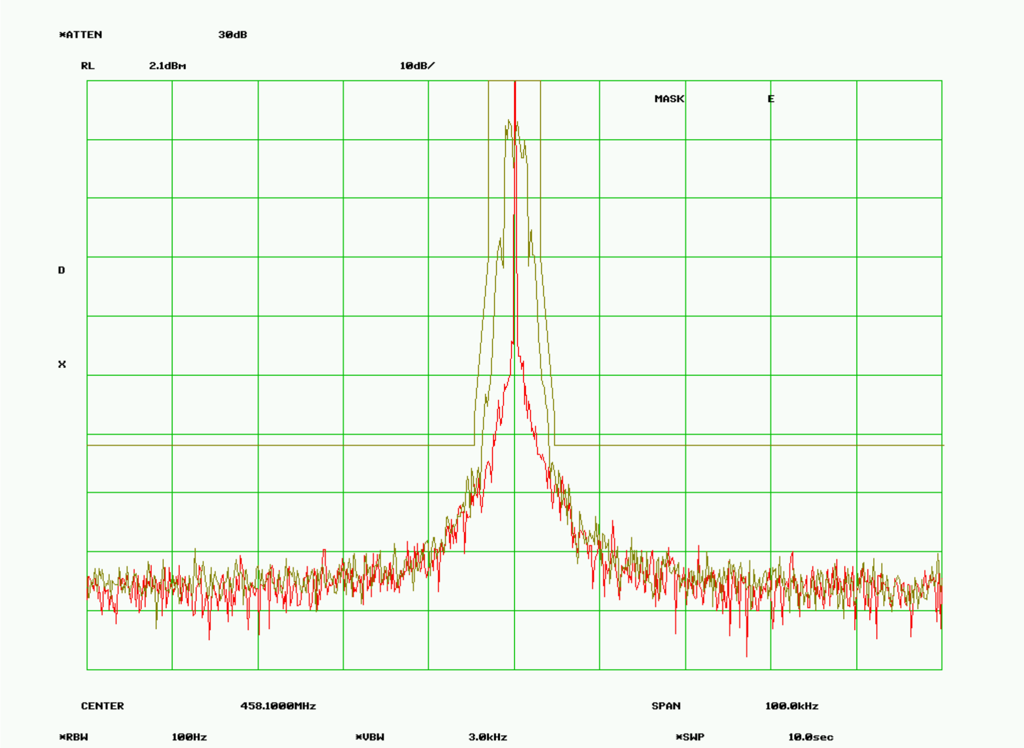


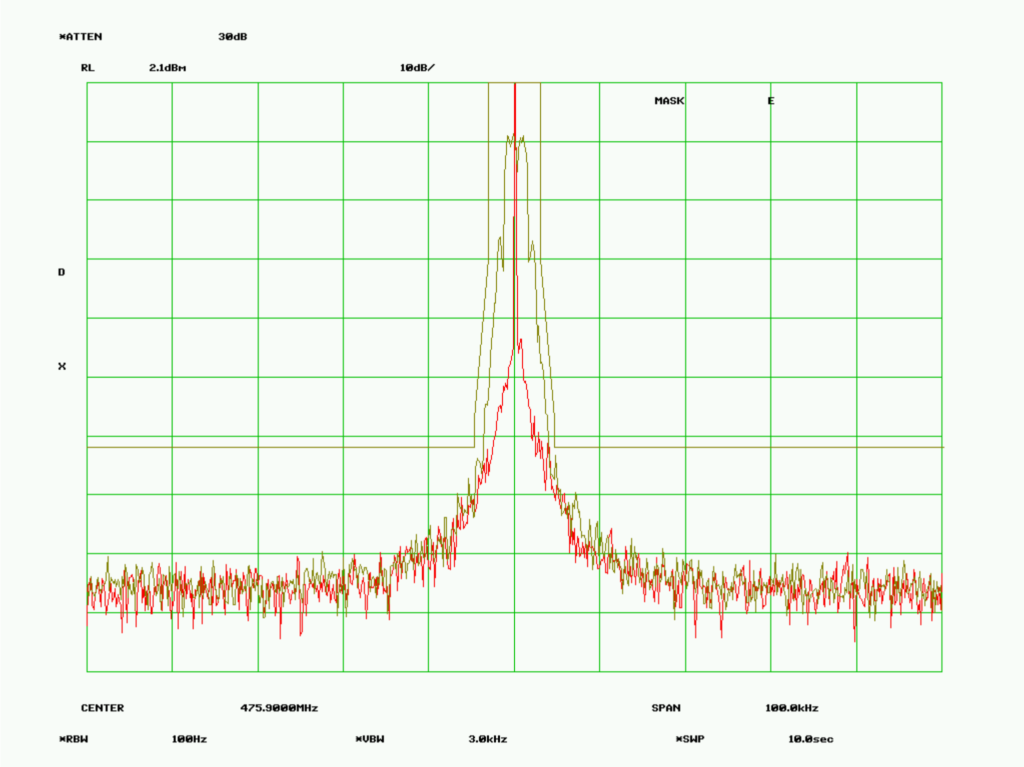


MASK E – 1.0 Watts - Span 100 kHz – RF Frequencies 440.100 MHz
SPECTRUM FOR EMISSION - **3K30F1D**
2400 bps
PEAK DEVIATION = 1250 Hz

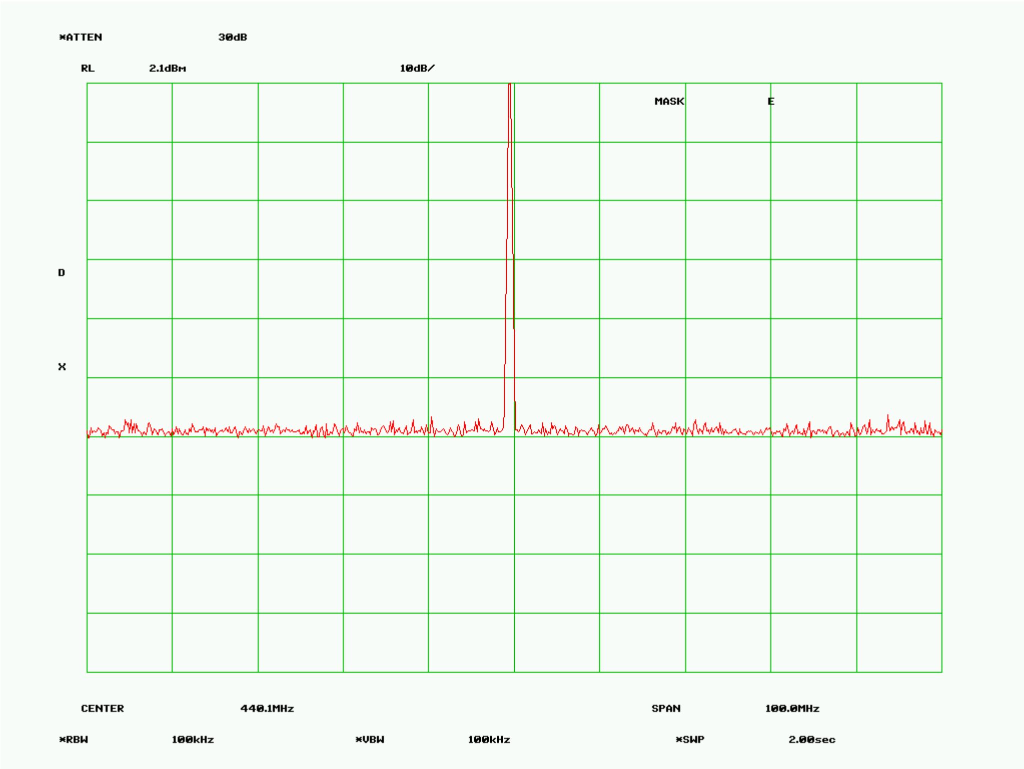


MASK E – 1.0 Watts - Span 100 kHz – RF Frequencies 458.100 and 475.900 MHz
SPECTRUM FOR EMISSION - **3K30F1D**
2400 bps
PEAK DEVIATION = 1250 Hz

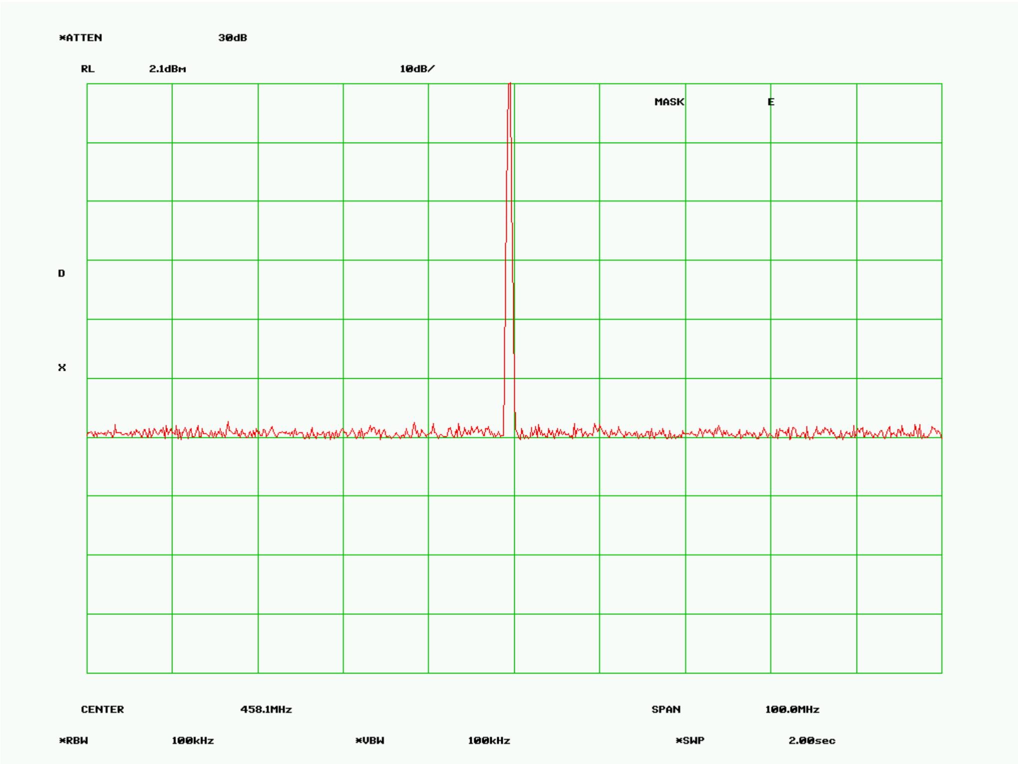


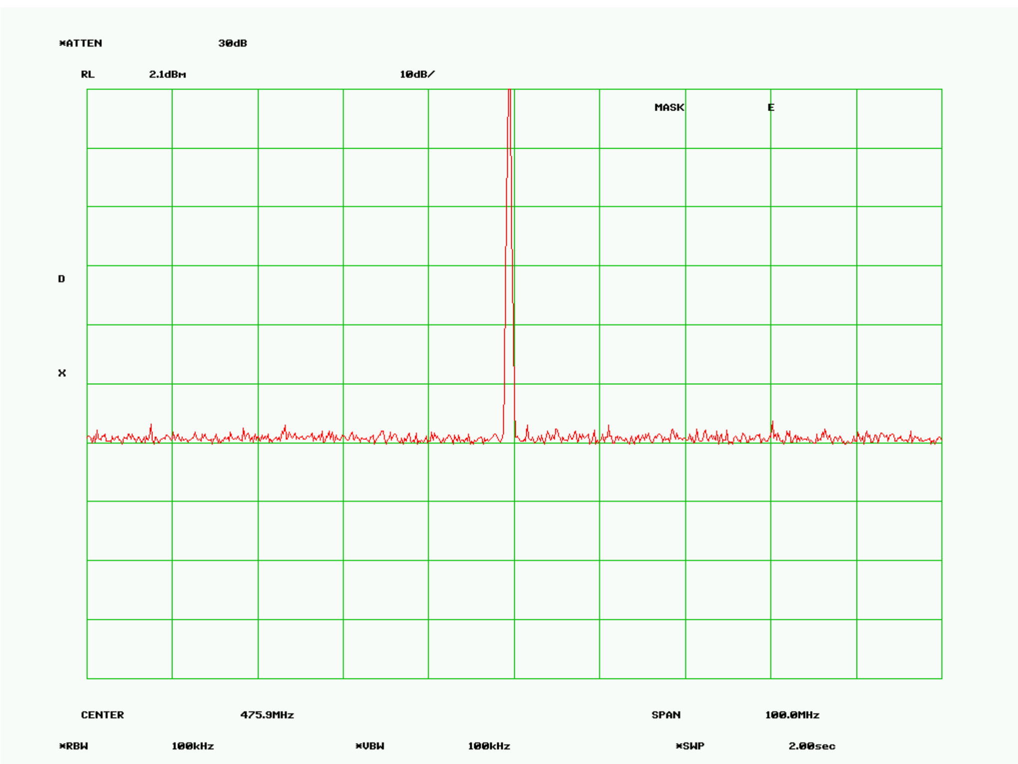


MASK E – 1.0 Watts - Span 100 MHz – RF Frequencies 440.100 MHz
SPECTRUM FOR EMISSION - **3K30F1D**
2400 bps
PEAK DEVIATION = 1250 Hz



MASK E – 1.0 Watts - Span 100 MHz – RF Frequencies 458.100 and 475.900 MHz
SPECTRUM FOR EMISSION - **3K30F1D**
2400 bps
PEAK DEVIATION = 1250 Hz





1.9 Transmitter Occupied Bandwidth Mask E - 3K40F1D

3K40F1D

RULE PART NUMBER: 2.201, 2.202, 2.1033 (c)(14), 2.1041, 2.1049(h), 90.209(b)(5), 90.210 (e)

MINIMUM STANDARD:

(e) ***Emission Mask E****—6.25 kHz or less channel bandwidth equipment.* For transmitters designed to operate with a 6.25 kHz or less bandwidth, any emission must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows:

(1) On any frequency from the center of the authorized bandwidth f_0 to 3.0 kHz removed from f_0 : Zero dB.

(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 3.0 kHz but no more than 4.6 kHz: At least 30 + 16.67(f_d −3 kHz) or 55 + 10 log (P) or 65 dB, whichever is the lesser attenuation.

(3) On any frequency removed from the center of the authorized bandwidth by more than 4.6 kHz: At least 55 + 10 log (P) or 65 dB, whichever is the lesser attenuation.

(4) The reference level for showing compliance with the emission mask shall be established using a resolution bandwidth sufficiently wide (usually two to three times the channel bandwidth) to capture the true peak emission of the equipment under test. In order to show compliance with the emissions mask up to and including 50 kHz removed from the edge of the authorized bandwidth, adjust the resolution bandwidth to 100 Hz with the measuring instrument in a peak hold mode. A sufficient number of sweeps must be measured to insure that the emission profile is developed. If video filtering is used, its bandwidth must not be less than the instrument resolution bandwidth. For emissions beyond 50 kHz from the edge of the authorized bandwidth, see paragraph (m) of this section. If it can be shown that use of the above instrumentation settings do not accurately represent the true interference potential of the equipment under test, then an alternate procedure may be used provided prior Commission approval is obtained.

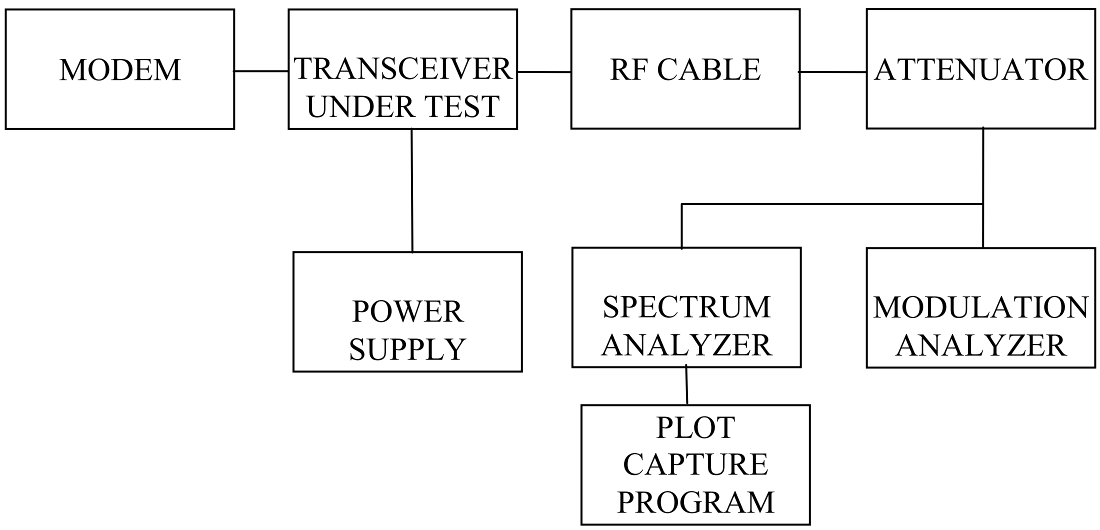
Attenuation = 0 dB at Fo to 3.0 kHz
Attenuation = 30 dB at 3.0 kHz and 57 dB at 4.6 kHz
Attenuation = 62 dB (55 dB @ 1 Watt) at > 4.6 kHz

TEST RESULTS: Meets minimum standard (see data on the following pages)

TEST CONDITIONS: Standard Test Conditions, 25 C

TEST EQUIPMENT:
50-Ohm Attenuator, Bird Electronics Model 50-A-FFN-20 (20dB, 50W)
50-Ohm Attenuator, Bird Electronics Model 25-A-MFN-6 (6dB, 25W)
DC Power Supply, Hewlett Packard Model 6653A
Spectrum Analyzer, Hewlett Packard Model HP8563E
Modulation Analyzer, Hewlett Packard Model HP8901A

TEST SET-UP:



MODULATION SOURCE DESCRIPTION:

The digital modulation type used in the IntegraTR is DRCMSK (Differential Raised Cosine Minimum Shift Keying). A modem using such type of modulation is divided into three main functional units in a CPLD chip:

7. Scrambler:
The scrambler converts the data stream to a new data stream more suitable for FM transmission.
-It randomizes the data to avoid predictable patterns: 00000000, 111111111, 01010101, 00110011, etc.
-It keeps the power spectrum more compact by avoiding sequences like 01010101…
The scrambler is made with a serial shift register and 2 exclusive OR gates which implement the polynomial form X^7+X^5-1. For the receiver side, a similar circuit performs the descrambling function to decode the received scrambled data.

8. Differential encoder:
After data is scrambled, we encode the data with a differential encoder. The differential encoder XOR's the current input bit with the previous bit. The differential encoder is used to make the modem insensitive to audio polarity inversion of the FM radio system.

9. Waveshape generator:
The waveshape generator converts the processed data bits (scrambled and differentially encoded for DRCMSK) to the DRCMSK audio signal. This audio signal is passed through a low-pass filter before modulating the RF transmitter.

TRANSMISSION PREAMBLE:

Each data transmission begins by sending a 15 millisecond preamble of sinewave (101010...). This is to synchronize the digital phase locked loop of the receiver modem.

TEST PATTERN GENERATOR:

A 30 s test pattern sequence is generated by the test software when the "test data" button is clicked. The highest resulting modulating frequency is (baud rate)/2 Hz. The following pseudo random test pattern was used to modulate the transmitter:

###ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789\r\n,

In this pattern ### is replaced by the number of replays, \r is a carriage return and \n is a linefeed. The data is fed to the RS232 interface IC and processed as described above. The async-to-sync conversion, scrambler and differential encoder make the ABCDE... pattern appear random over the air.

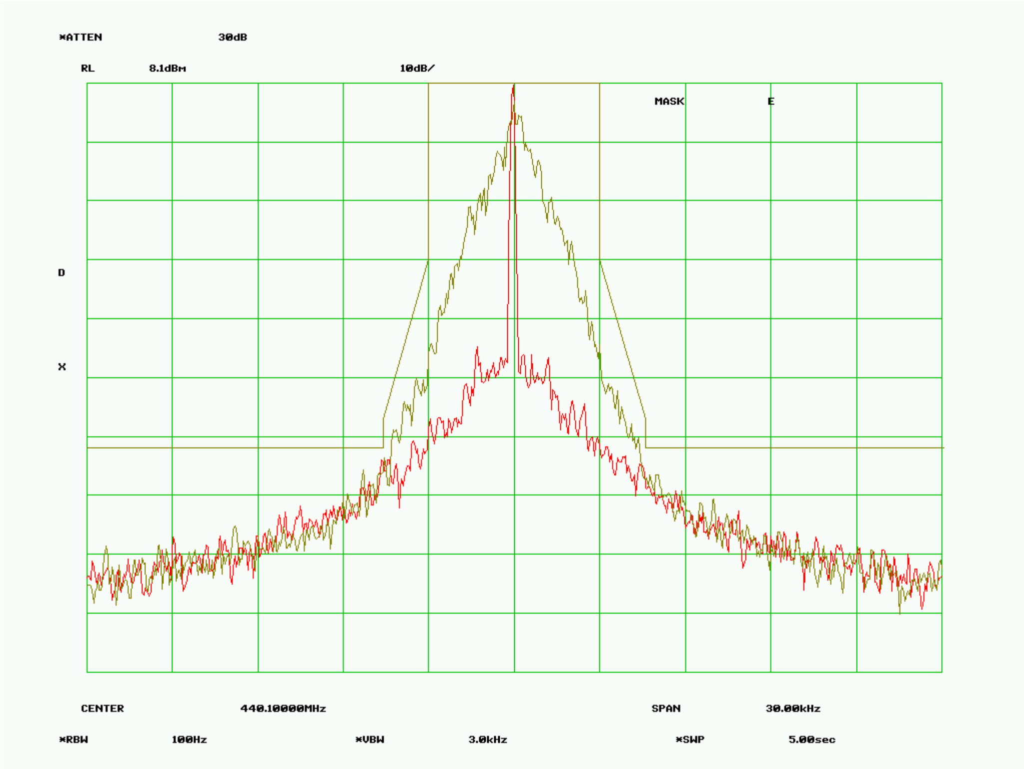
NECESSARY BANDWIDTH (Bn) CALCULATION

See page 15 for Emission Designator determination.

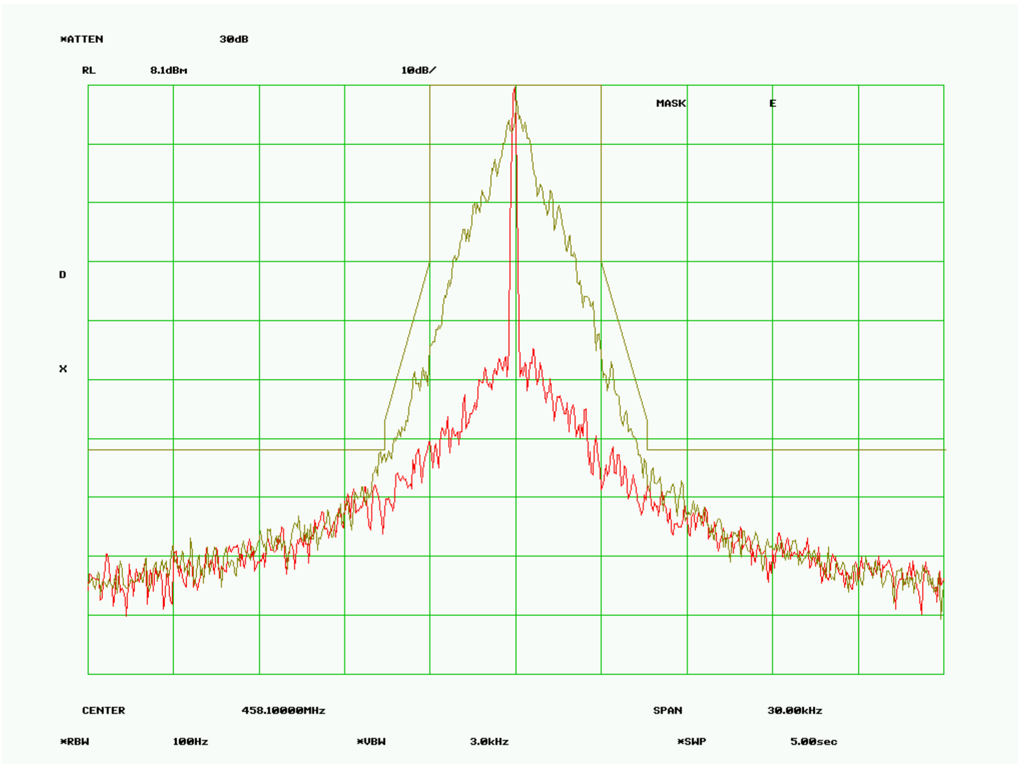
The corresponding emission designator prefix for necessary bandwidth = **8K08**

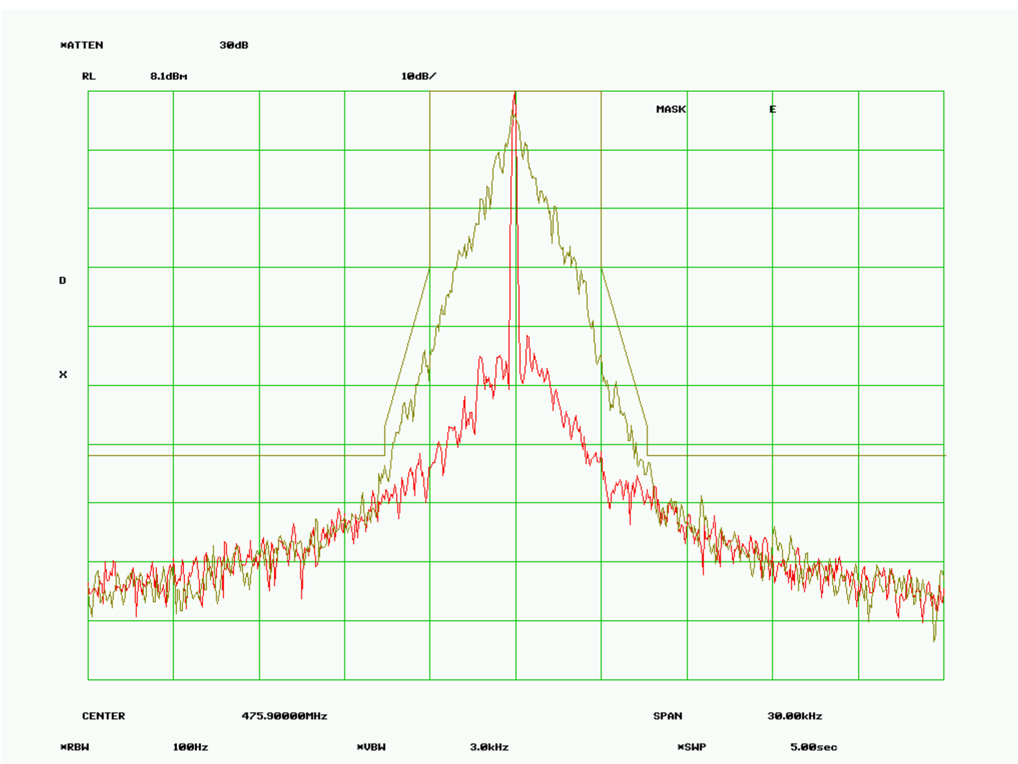
TEST DATA: Refer to the following graphs:

MASK E – 5.0 Watts - Span 30 kHz – RF Frequencies 440.100 MHz
SPECTRUM FOR EMISSION - **3K40F1D**
4800 bps
PEAK DEVIATION = 0.92 Hz

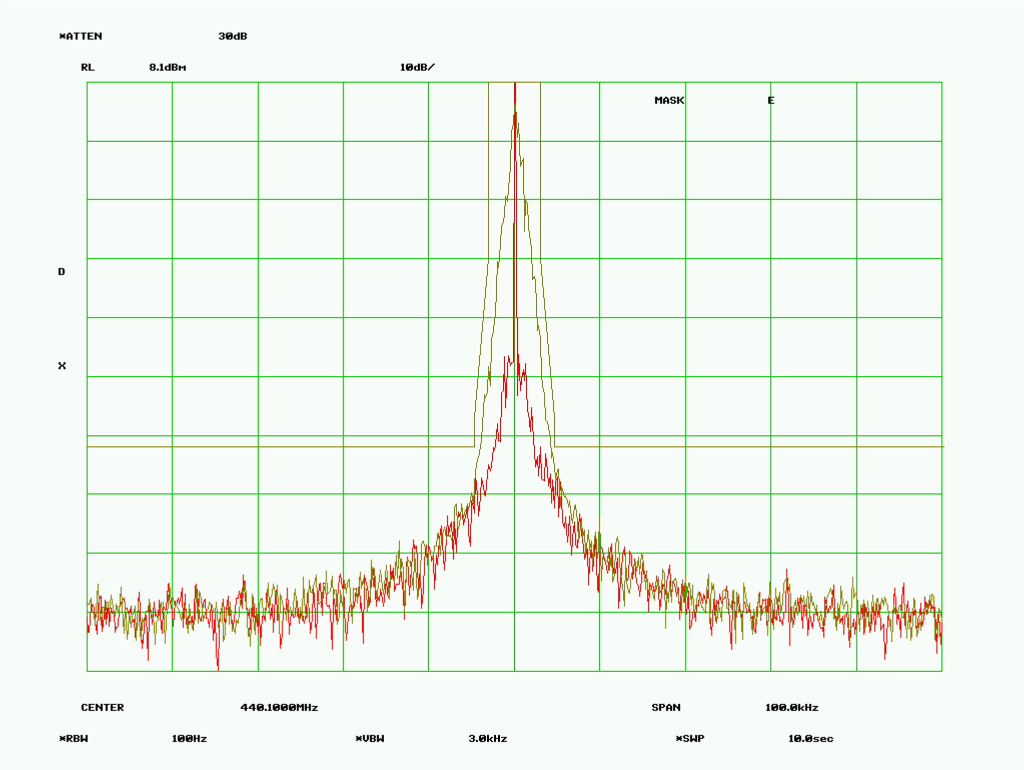


MASK E – 5.0 Watts - Span 30 kHz – RF Frequencies 458.100 and 475.900 MHz
SPECTRUM FOR EMISSION - **3K40F1D**
4800 bps
PEAK DEVIATION = 0.92 Hz

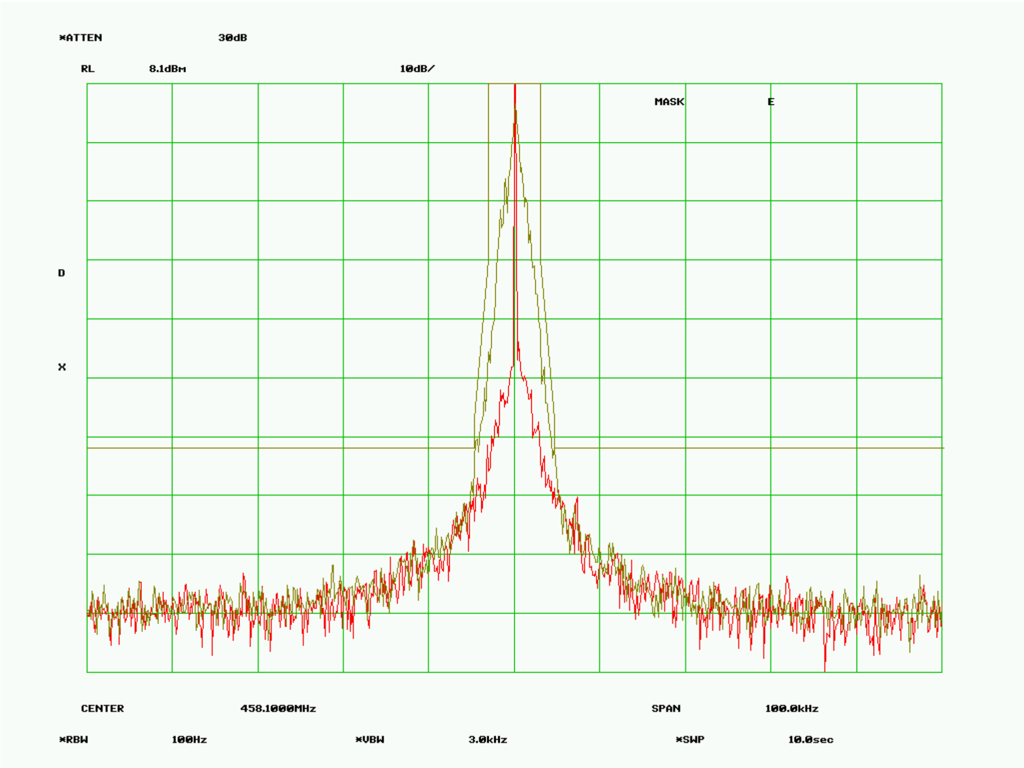


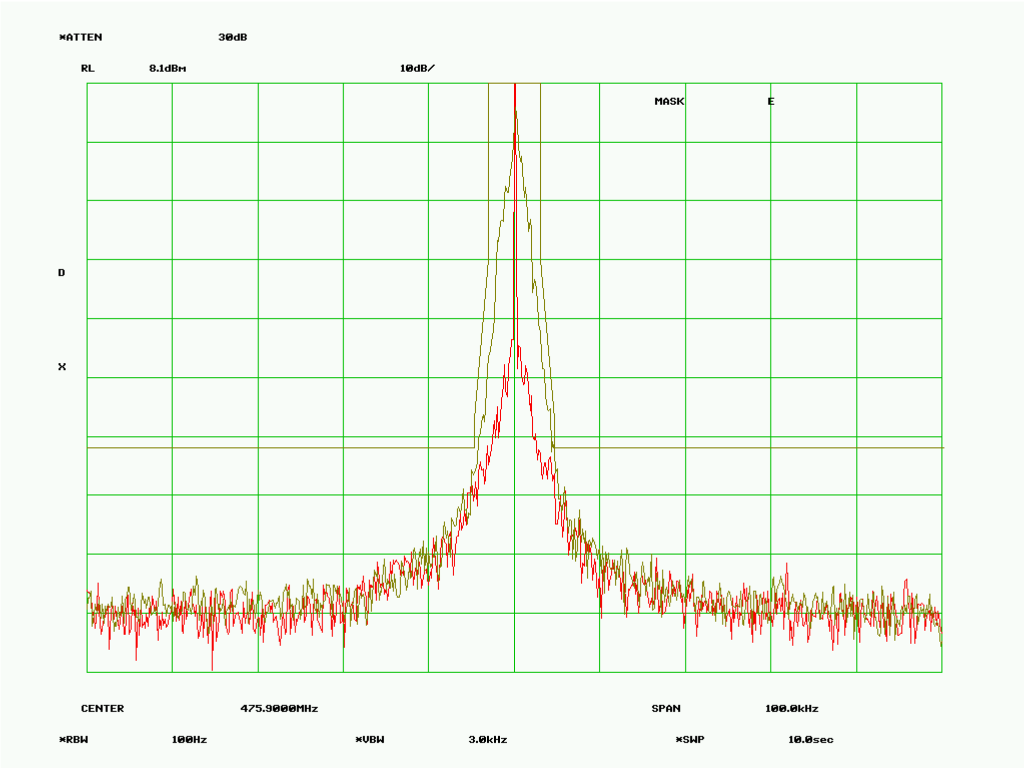


MASK E – 5.0 Watts - Span 100 kHz – RF Frequencies 440.100 MHz
SPECTRUM FOR EMISSION - **3K40F1D**
4800 bps
PEAK DEVIATION = 0.92 Hz

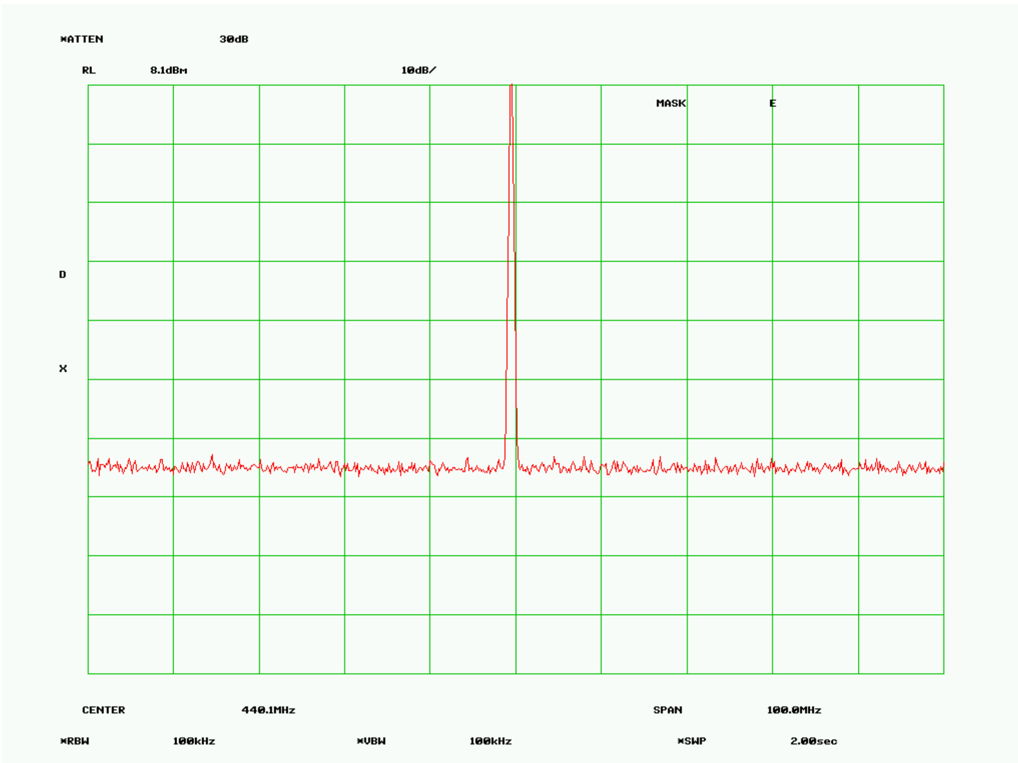


MASK E – 5.0 Watts - Span 100 kHz – RF Frequencies 458.100 and 475.900 MHz
SPECTRUM FOR EMISSION - **3K40F1D**
4800 bps
PEAK DEVIATION = 0.92 Hz

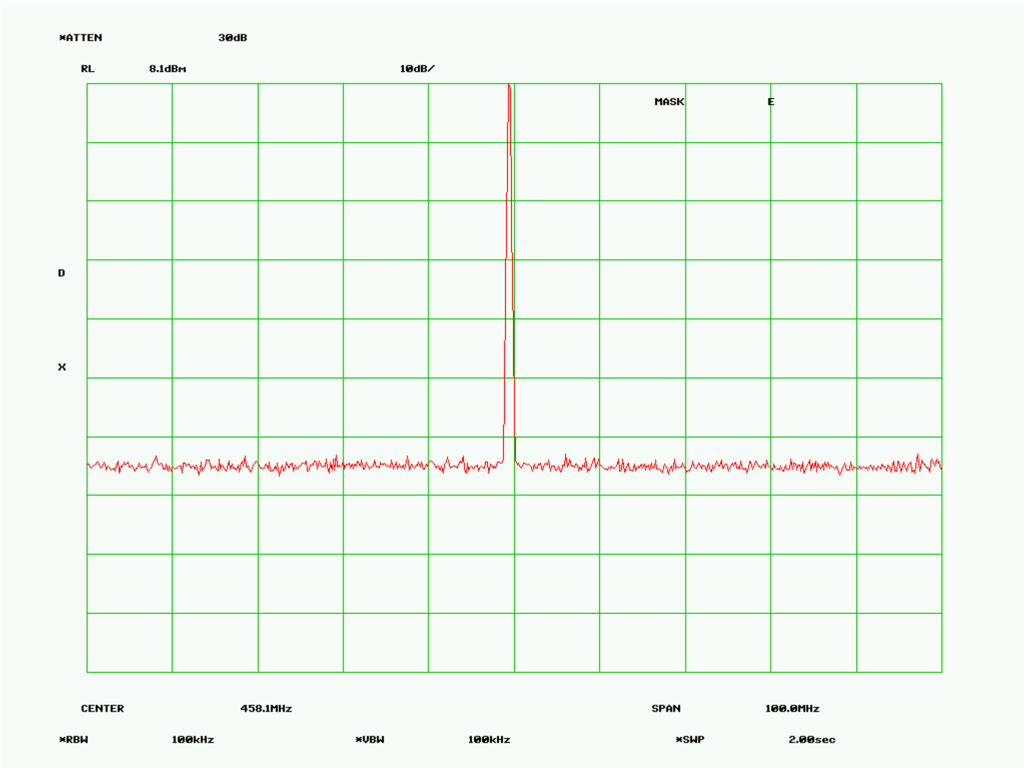


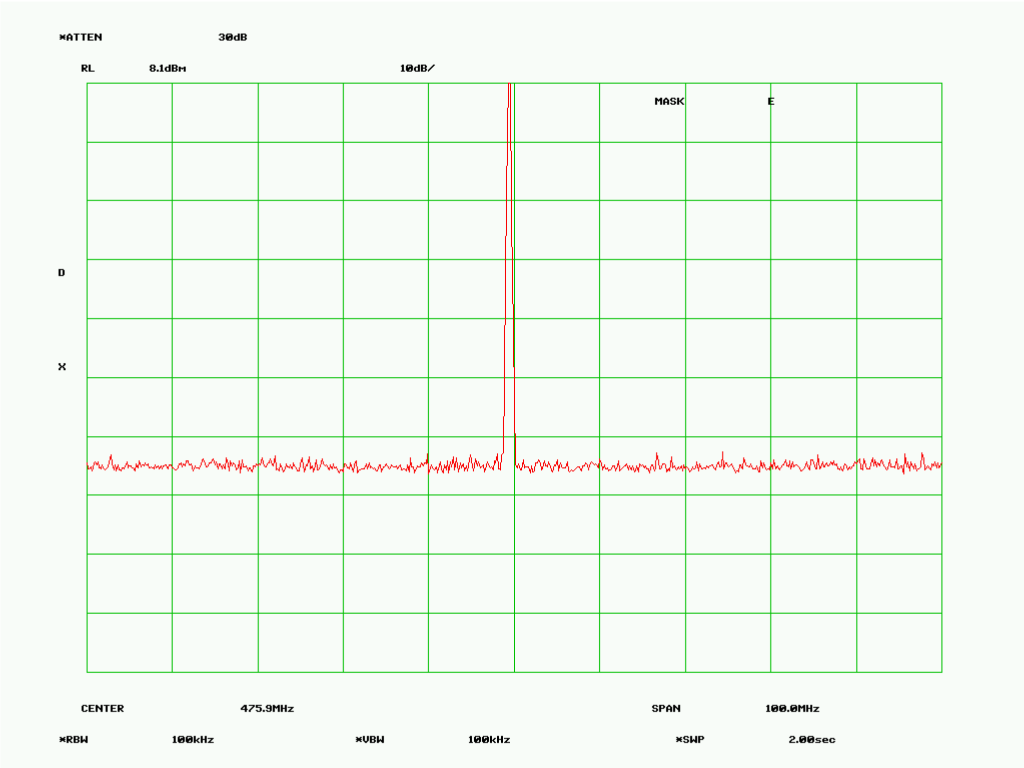


MASK E – 5.0 Watts - Span 100 MHz – RF Frequencies 440.100 MHz
SPECTRUM FOR EMISSION - **3K40F1D**
4800 bps
PEAK DEVIATION = 0.92 Hz

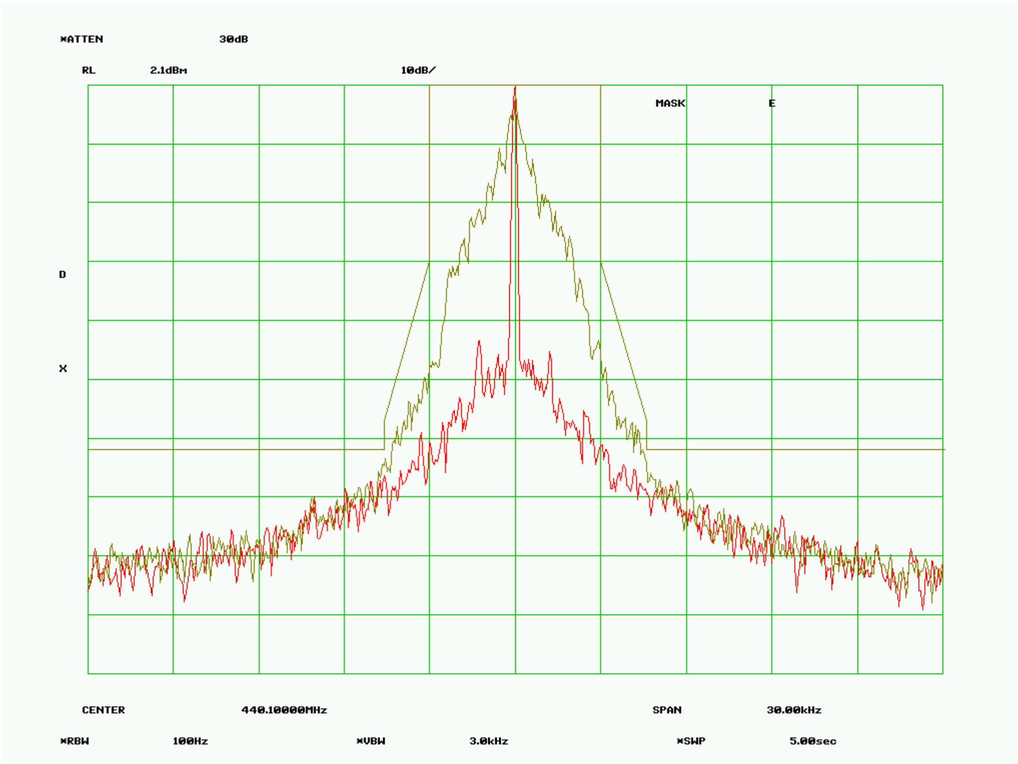


MASK E – 5.0 Watts - Span 100 MHz – RF Frequencies 458.100 and 475.900 MHz
SPECTRUM FOR EMISSION - **3K40F1D**
4800 bps
PEAK DEVIATION = 0.92 Hz

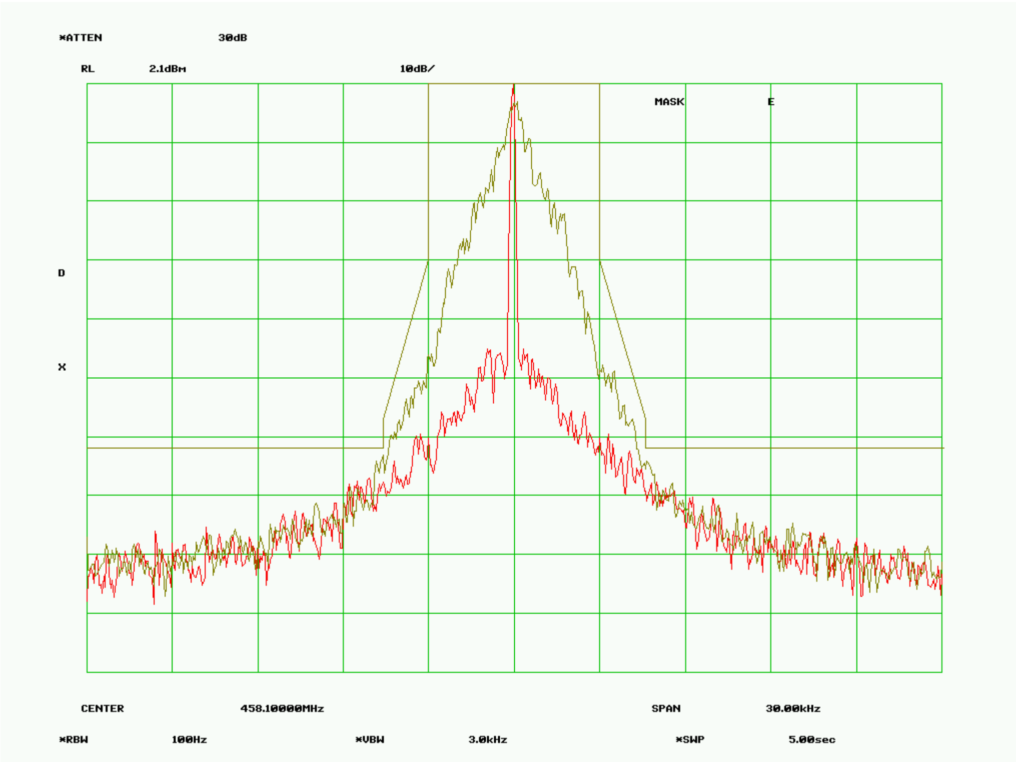


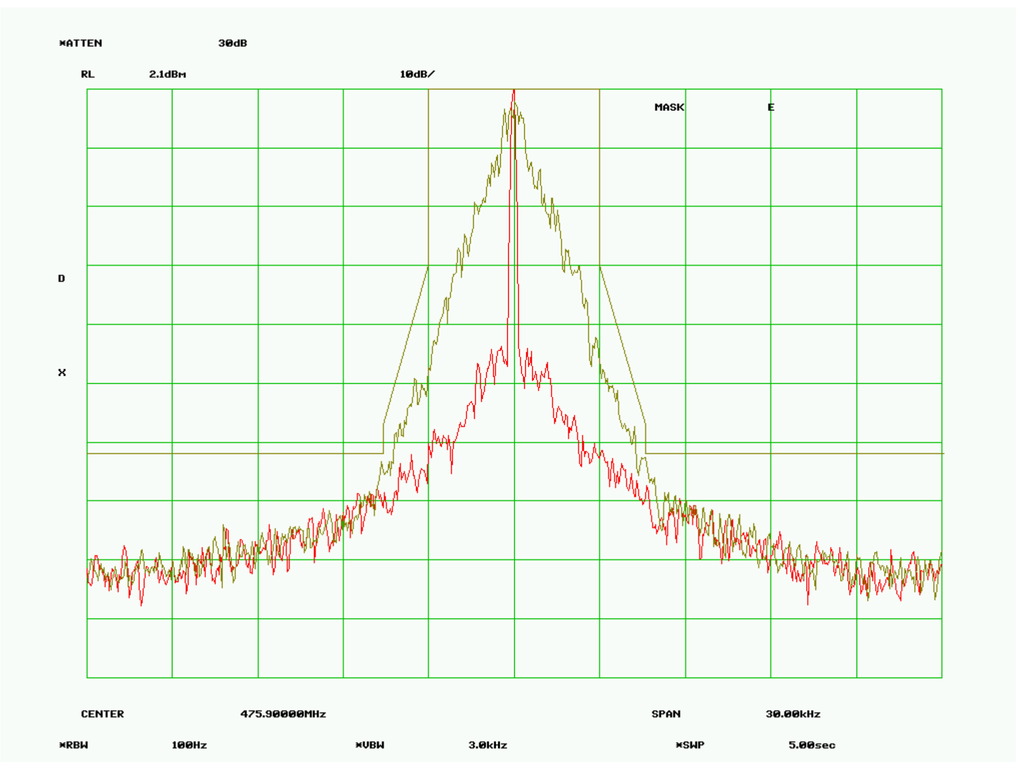


MASK E – 1.0 Watts - Span 30 kHz – RF Frequencies 440.100 MHz
SPECTRUM FOR EMISSION - **3K40F1D**
4800 bps
PEAK DEVIATION = 0.92 Hz

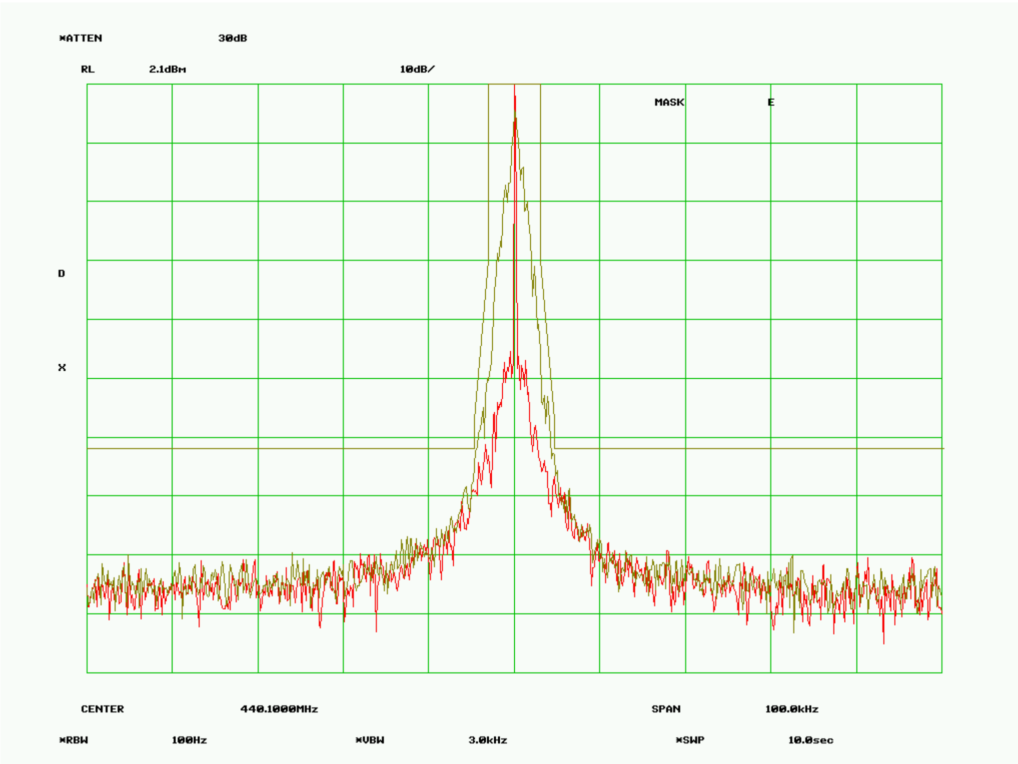


MASK E – 1.0 Watts - Span 30 kHz – RF Frequencies 458.100 and 475.900 MHz
SPECTRUM FOR EMISSION - **3K40F1D**
4800 bps
PEAK DEVIATION = 0.92 Hz





MASK E – 1.0 Watts - Span 100 kHz – RF Frequencies 440.100 MHz
SPECTRUM FOR EMISSION - **3K40F1D**
4800 bps
PEAK DEVIATION = 0.92 Hz



MASK E – 1.0 Watts - Span 100 kHz – RF Frequencies 458.100 and 475.900 MHz
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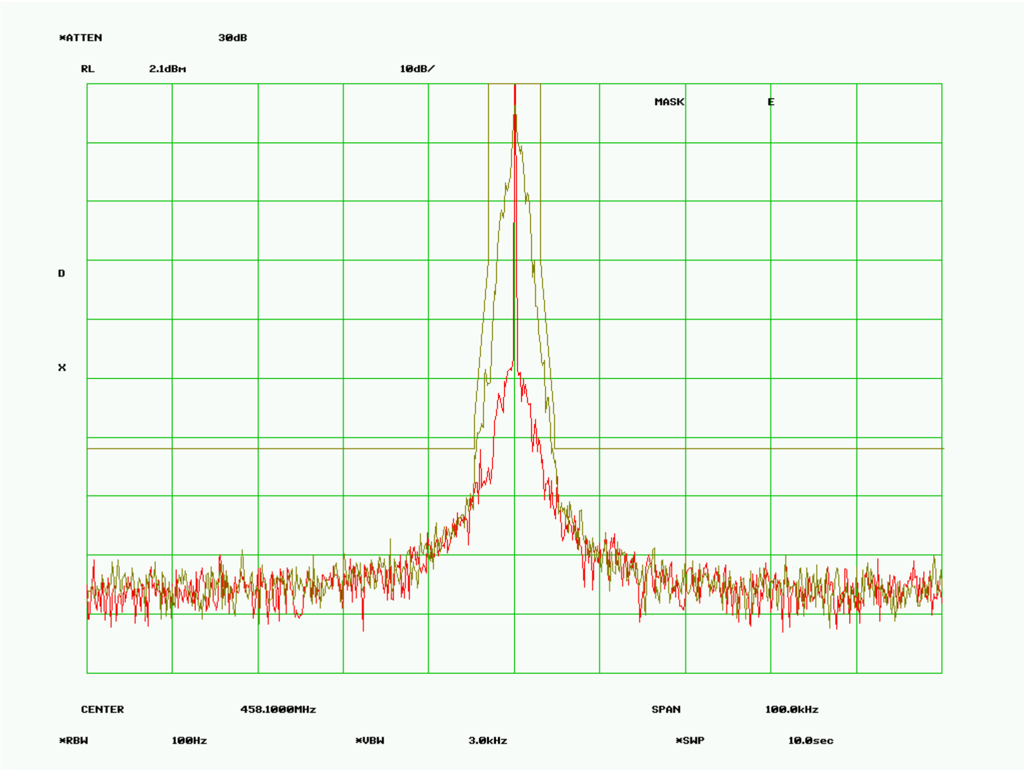

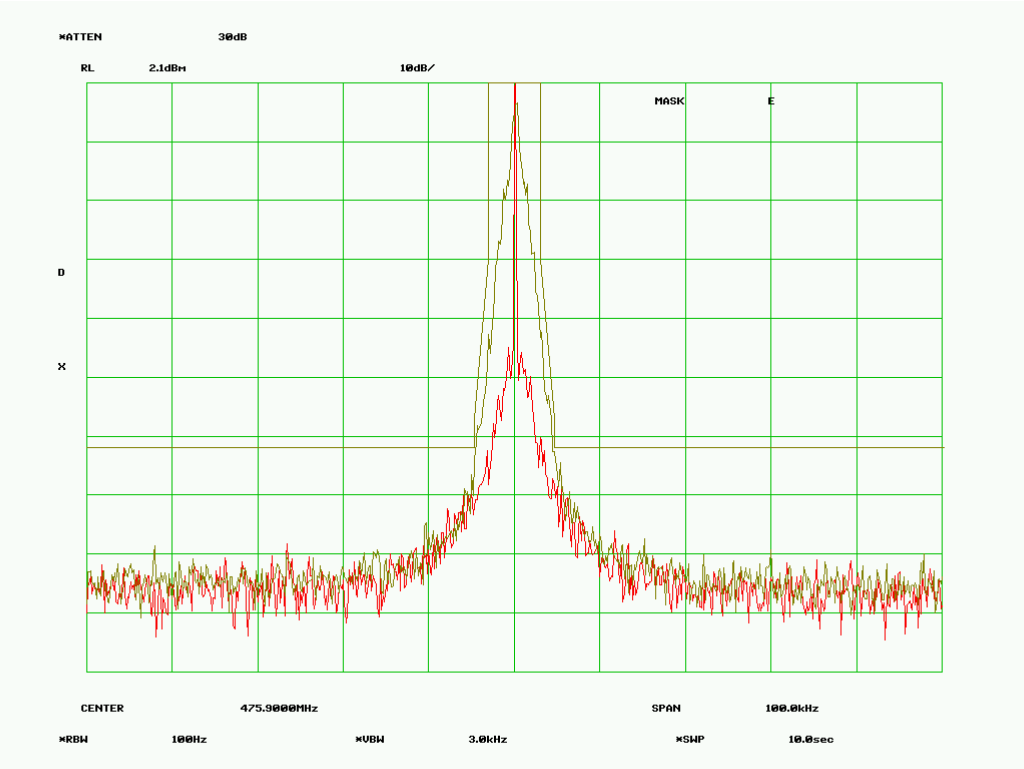

MASK E – 1.0 Watts - Span 100 MHz – RF Frequencies 440.100 MHz
SPECTRUM FOR EMISSION - **3K40F1D**
4800 bps
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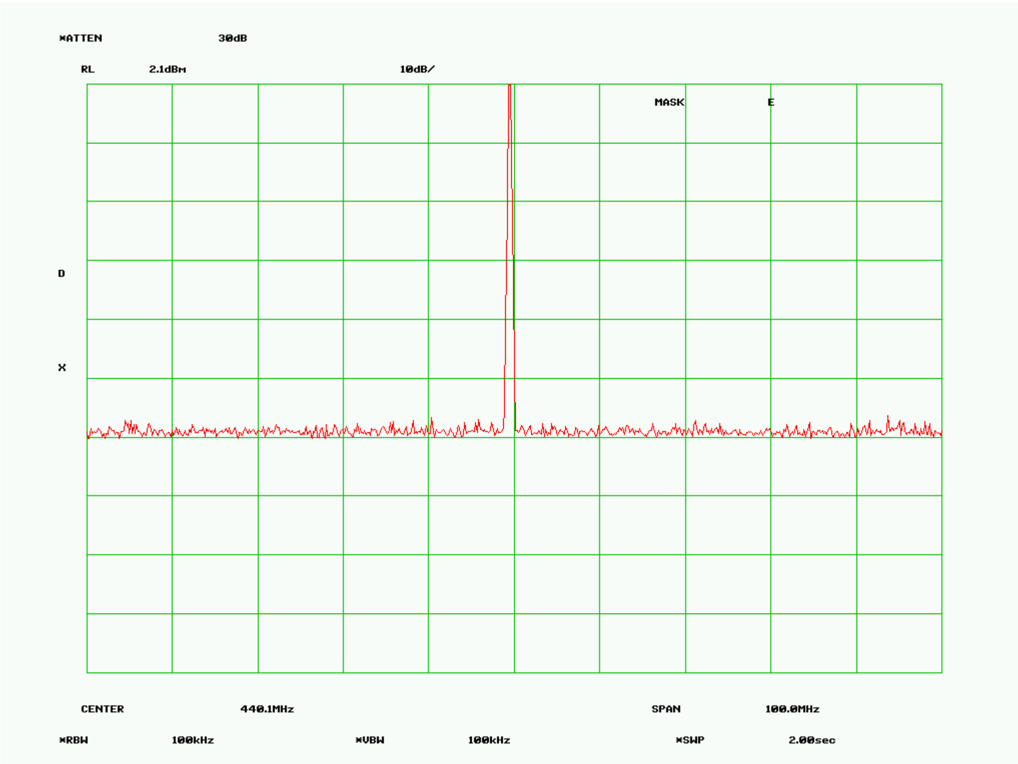

MASK E – 1.0 Watts - Span 100 MHz – RF Frequencies 458.100 and 475.900 MHz
SPECTRUM FOR EMISSION - **3K40F1D**
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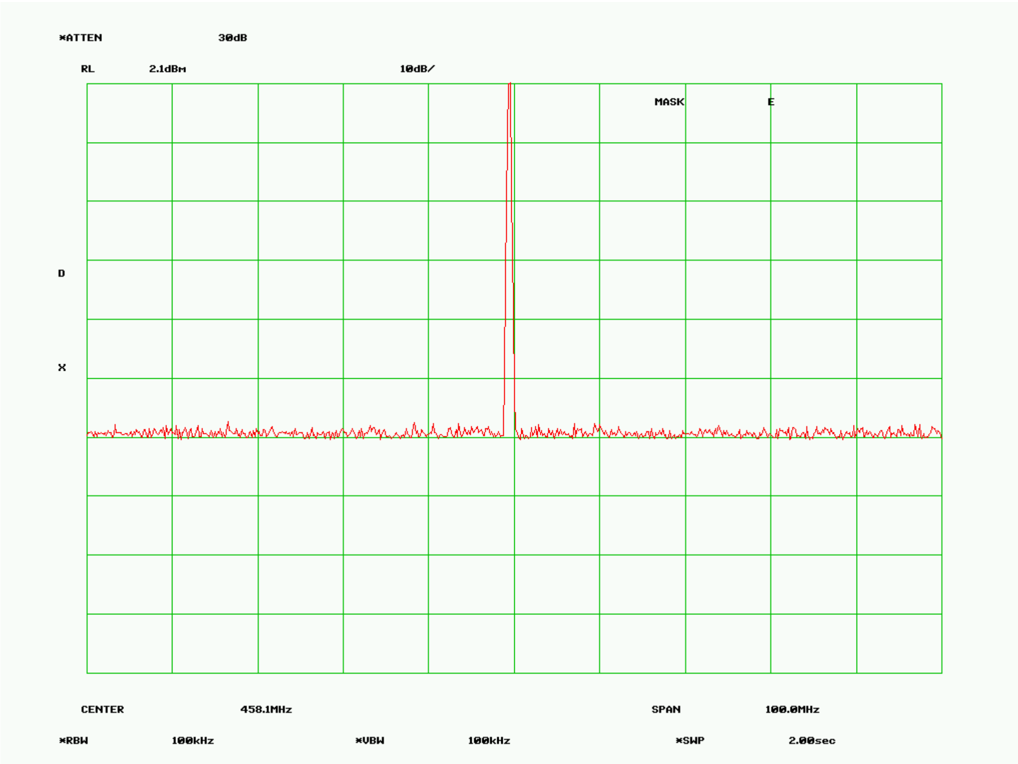

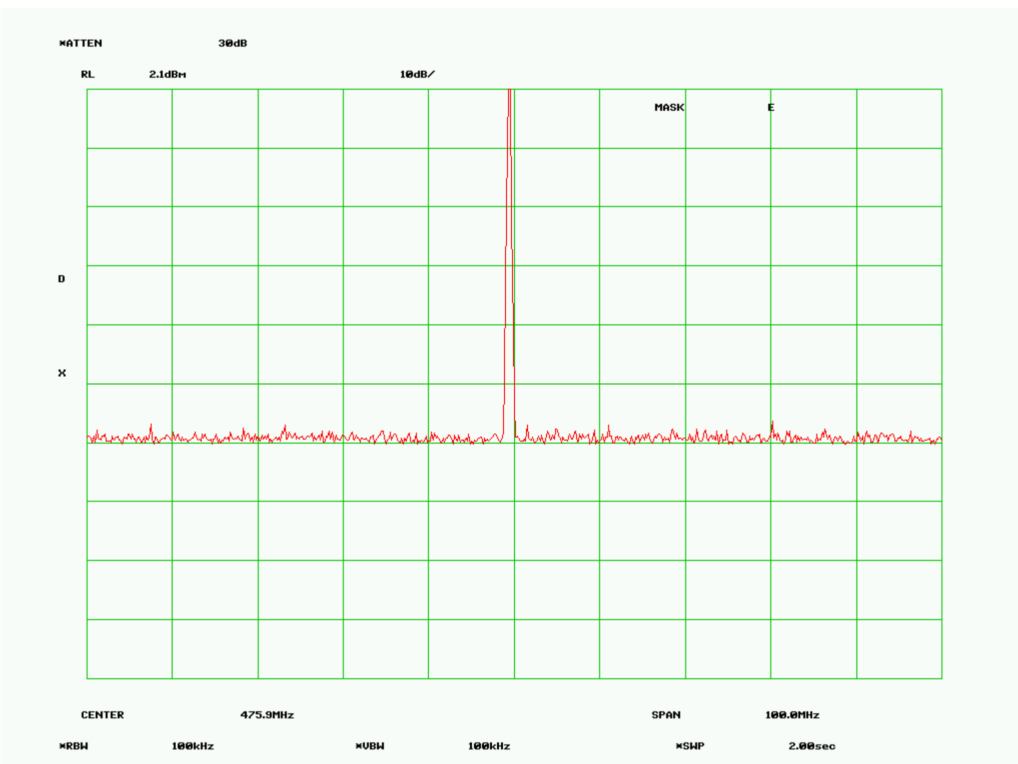

Equipment Calibration Information

Equipment	Serial Number	Cal Date	Cal Due
HP 8563E Spectrum Analyzer	3221A00149	4/23/2012	4/23/2013
Agilent E8257D Signal Generator	MY44320507	4/23/2012	4/23/2013
HP 8901A Modulation Analyzer	2950A05551	4/23/2012	4/23/2013
HP 437B Power Meter	3125U13882	4/23/2012	4/23/2013

Instruments have been calibrated using standards with accuracies traceable to NIST standards.