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FCC Class II Permissive Change Application

For The

IntegraTR
VHF RADIO MODEM

FCC ID: NP44018450

Rev 0

TABLE OF CONTENTS

NAME OF TEST: Transmitter Occupied Bandwidth

RULE PART NUMBER: 2.201, 2.202, 2.1033 (c)(14), 2.1049 (h), 2.1041;90.203(j)(3)
IC: RSS-Gen 4.6.1

Necessary Bandwidth Measurement

This radio modem uses digital modulation signals, passing through a linear 8th 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 = ±4.99 kHz
Modulator signal bit rate 19200 bps,

Bn=16300 Hz
The corresponding emission designator prefix for necessary bandwidth = 16K3

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Table 1 - Measurements results for the INTEGRATR unit , 9600 bps BT.3 and 19200 bps BT.3 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	
19200	4.99	16.3	16K3F1D

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Spectrum Efficiency (90.203 (j)(3)) requirement: 4800 bits per second per 6.25 kHz of channel bandwidth.
19200bps=4*4800bps Meets Efficiency Standard for 25.0 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

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

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.

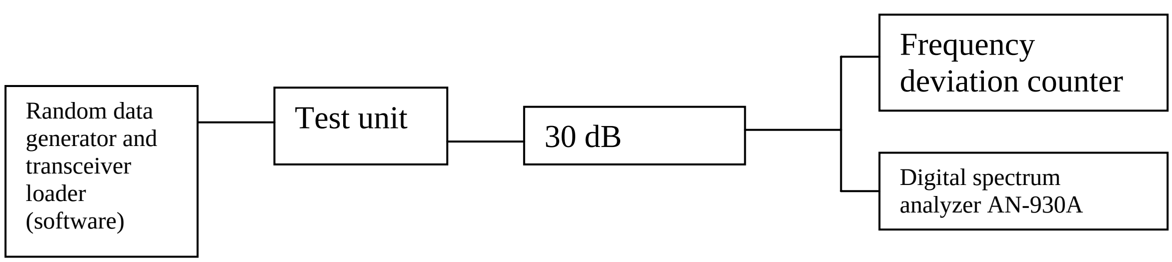
Standard calculation precision is all that is required. The main error factor being the y display resolution is covering calculation precision.

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.

NAME OF TEST: Transmitter Occupied Bandwidth for Emission Designators **16K3F1D**

RULE PART NUMBER: 2.202, 90.209 (b)(5), 90.210(d), 2.1049 (c) (1)

MINIMUM STANDARDS: Mask B
Sidebands and Spurious [Rule 90.210 (b), P = 5 Watts]
Authorized Bandwidth = 20 kHz [Rule 90.209(b) (5)]
From Fo to 50% of Authorized BW Removed from Fo, down 0 dB.
From 50% to 100% removed, at least 25 dB.
From 100% to 250% removed, at least 35 dB.
Greater than 250% remove, at least 43 + $10\log_{10}(P)$ dB.

Fo to 10 kHz Attenuation = 0 dB
10 kHz to 20 kHz, Attenuation = 25 dB minimum
20 kHz to 50 kHz, Attenuation = 35 dB minimum
> 50 kHz, Attenuation = 50 dB minimum (5 watts)
> 50 kHz, Attenuation = 43 dB minimum (1 watt)

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

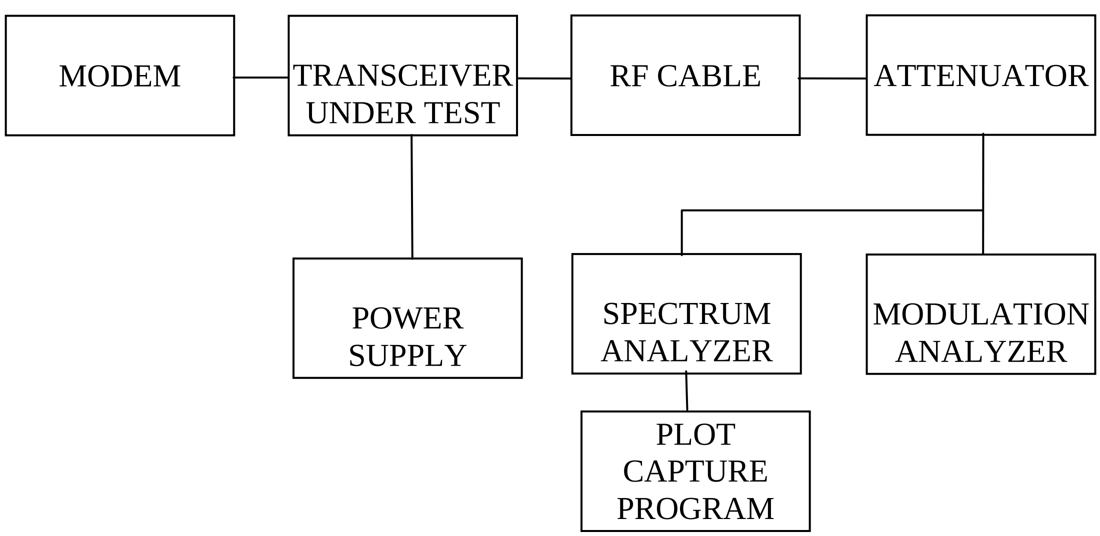
TEST RESULTS: Meets minimum standards (see data on following page)

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 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:

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.

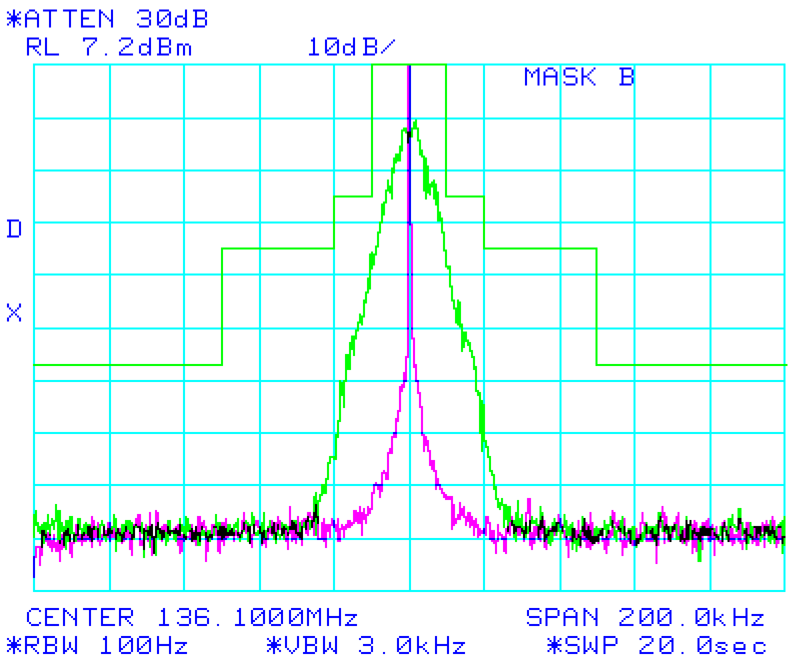
NECESSARY BANDWIDTH (Bn) CALCULATION

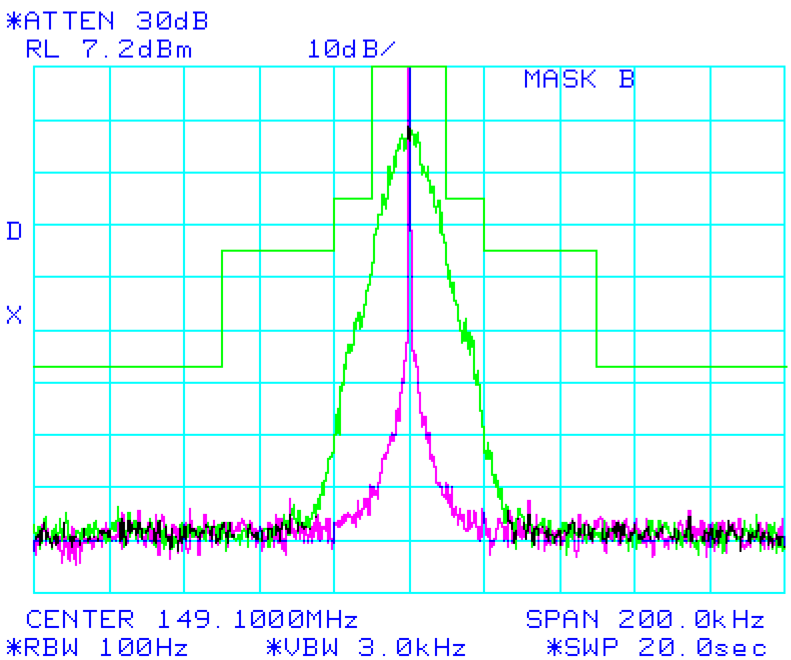
See page 15 for Emission Designator determination.

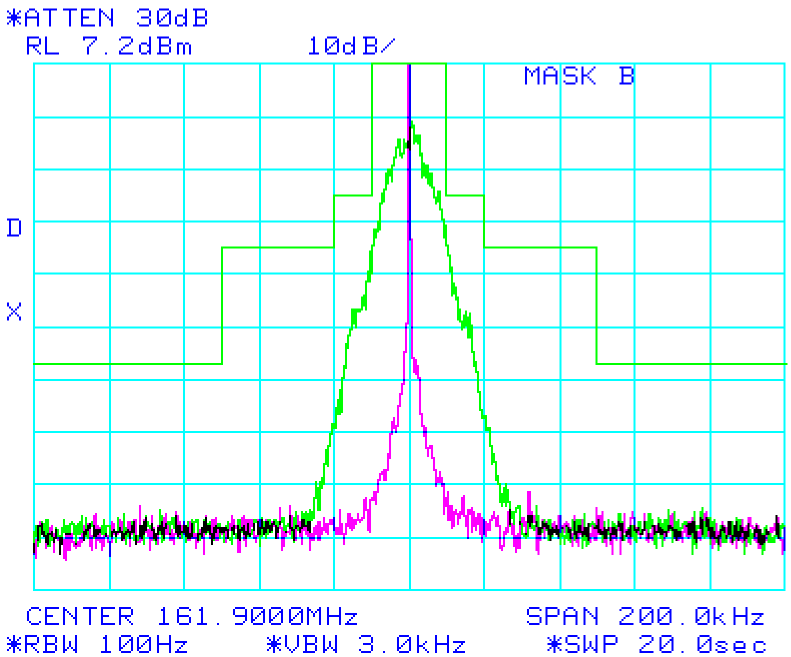
The corresponding emission designator prefix for necessary bandwidth = **16K3**

TEST DATA: Refer to the following graphs:

MASK: B for 5W
SPECTRUM FOR EMISSION **16K3F1D**
OUTPUT POWER: 5 Watts
19200 bps
PEAK DEVIATION = 4990 Hz
SPAN = 200 kHz



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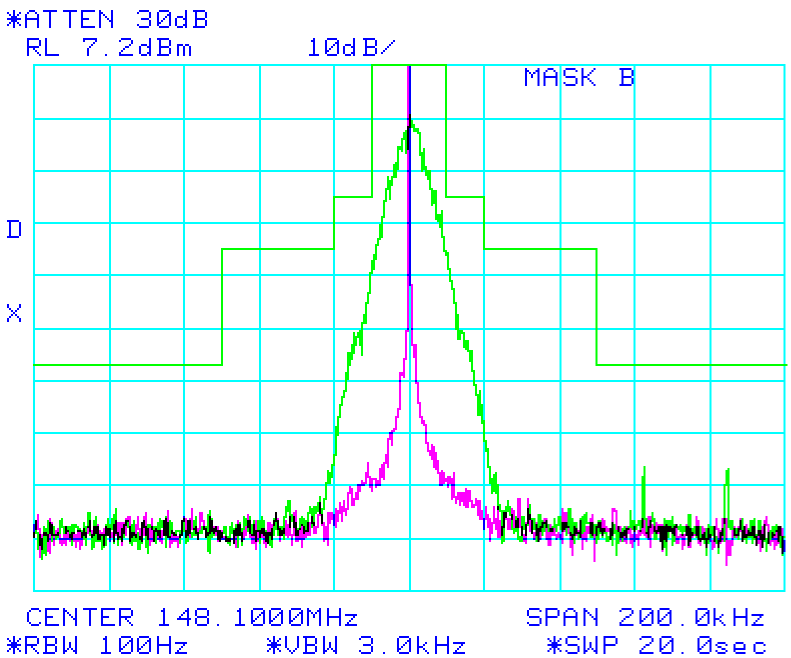
RL 7.2dBm
10dB/
MASK B
D
X
CENTER 161.9000MHz
SPAN 200.0kHz
*RBW 100Hz
*VBW 3.0kHz
*SWP 20.0sec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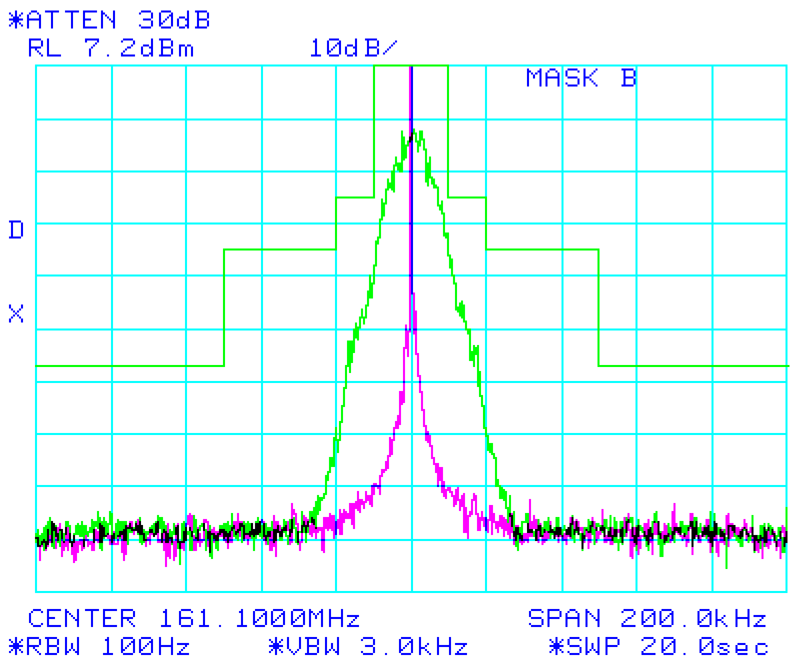
*SWP 20.0sec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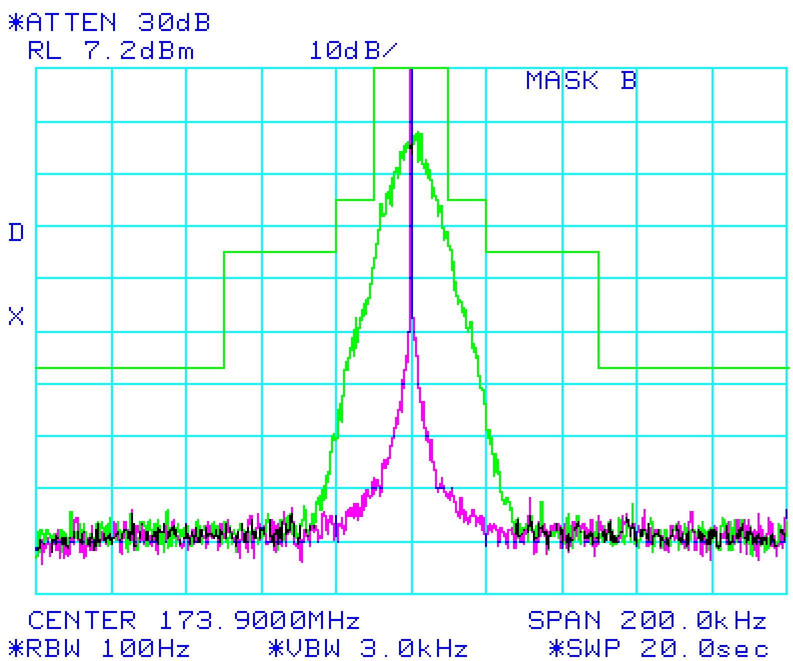
*SWP 20.0sec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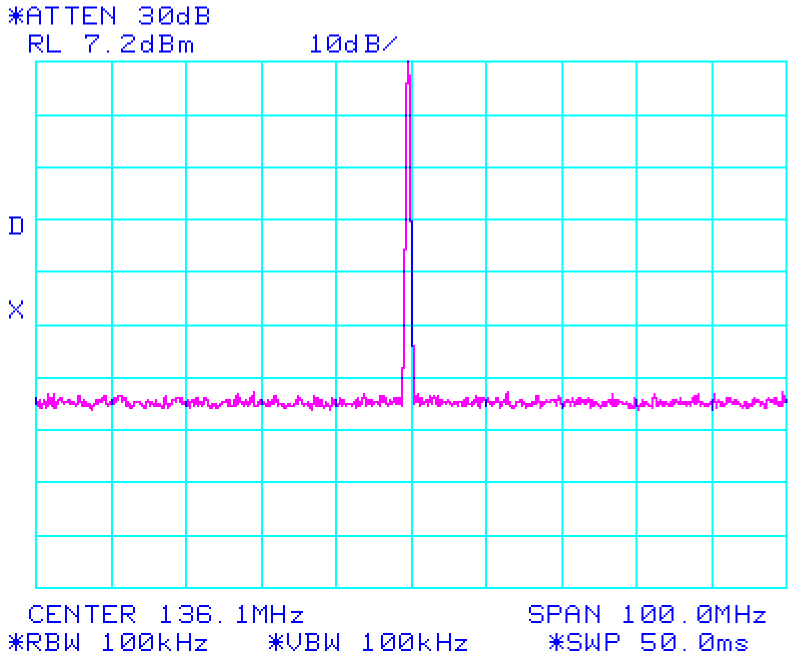
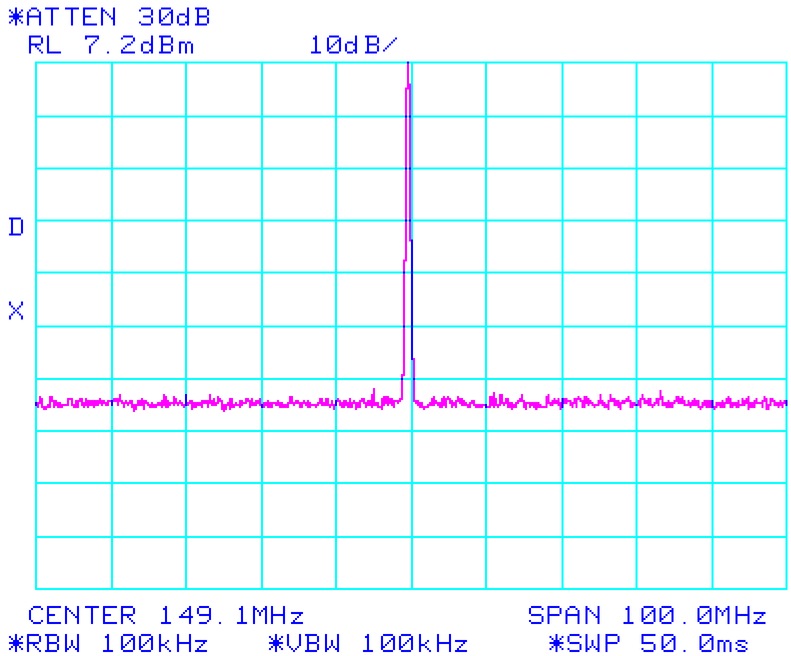
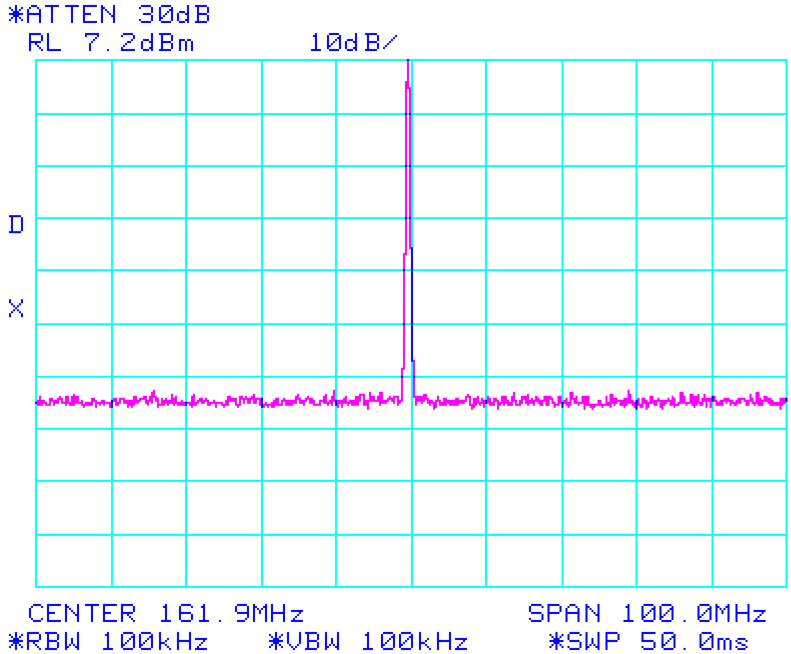
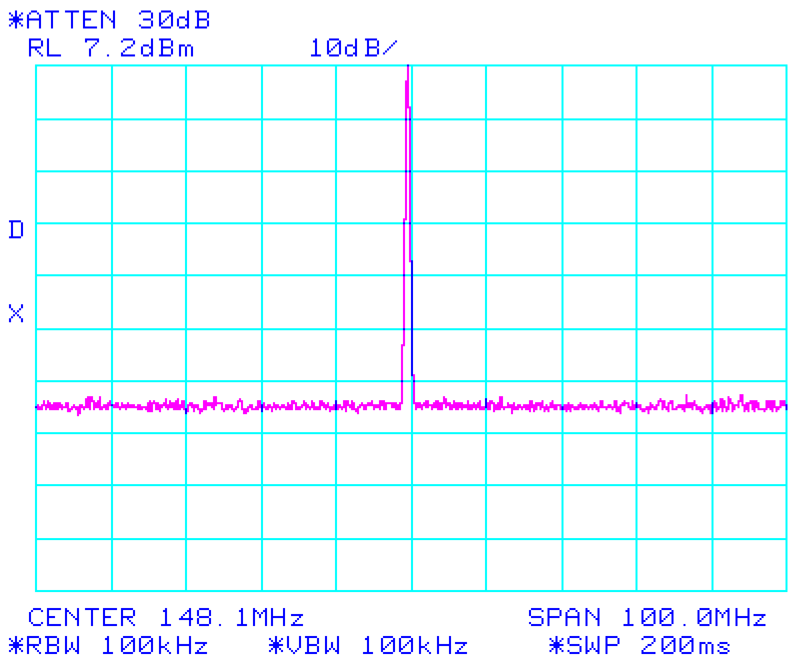
RL 7.2dBm
10dB/
MASK B
D
X
CENTER 173.9000MHz
SPAN 200.0kHz
*RBW 100Hz
*VBW 3.0kHz
*SWP 20.0sec

WIDE SPAN = 100 MHz
OUTPUT POWER: 5 Watts






*ATTEN 30dB
RL 7.2dBm 10dB/
D
X
CENTER 161.9MHz SPAN 100.0MHz
*RBW 100kHz *VBW 100kHz *SWP 50.0ms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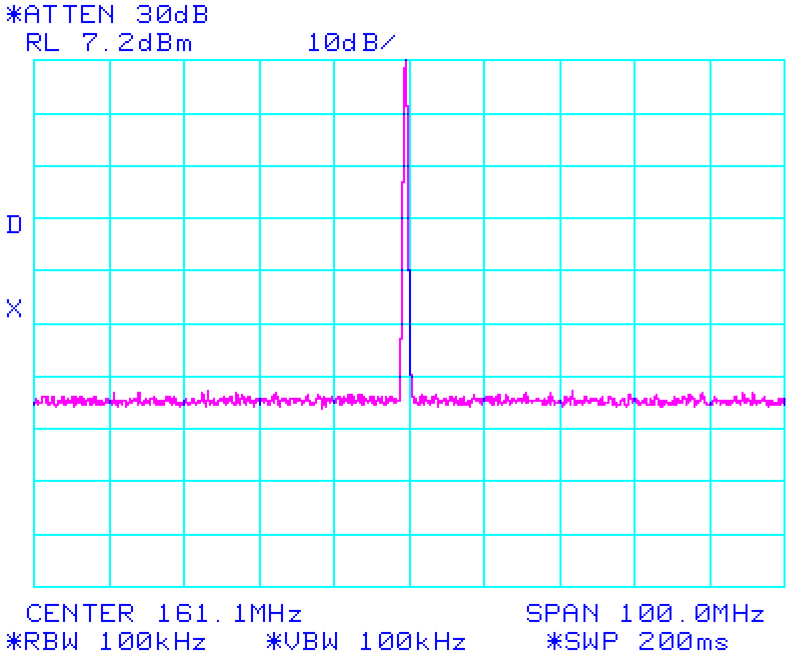
D
X
CENTER 148.1MHz SPAN 100.0MHz
*RBW 100kHz *VBW 100kHz *SWP 200ms


*ATTEN 30dB
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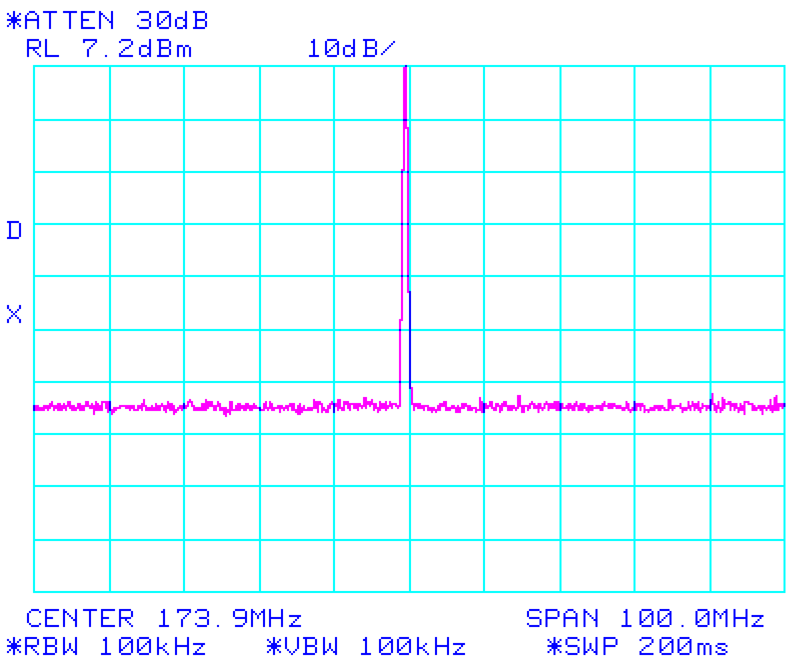
10dB/
D
X
CENTER 161.1MHz
SPAN 100.0MHz
*RBW 100kHz
*VBW 100kHz
*SWP 200ms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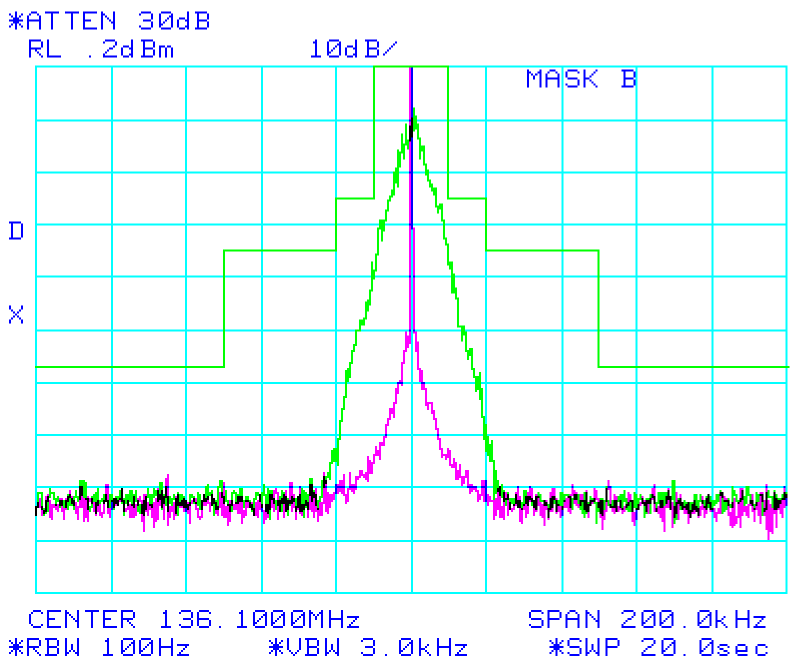
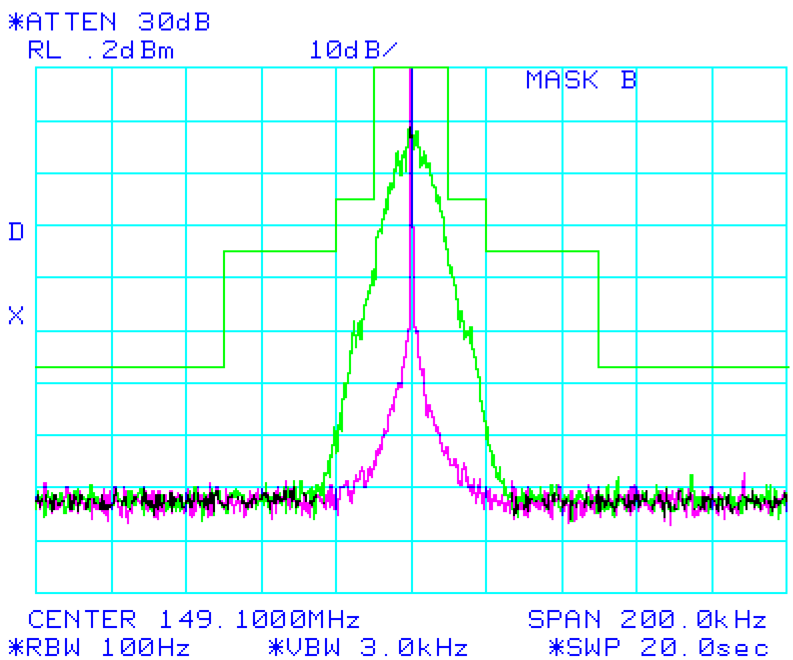
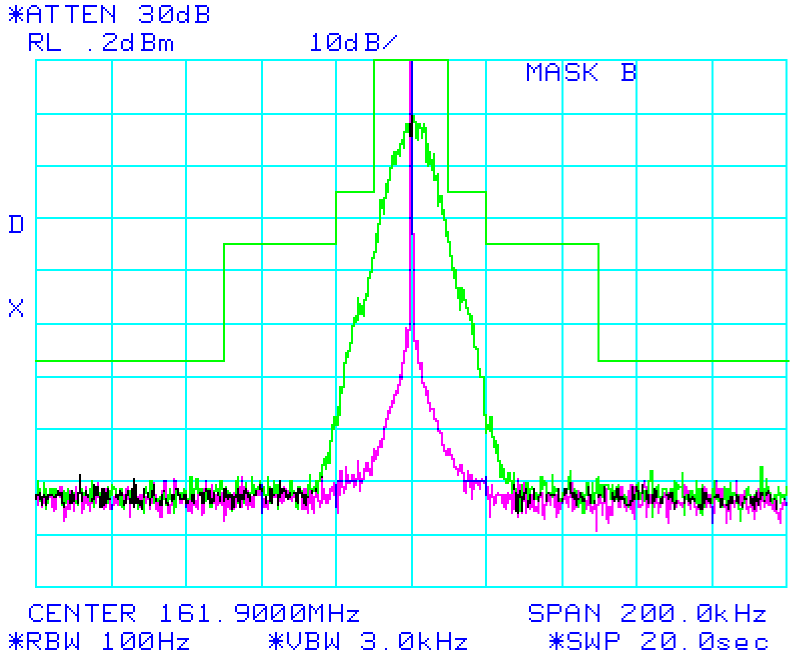
10dB/
D
X
CENTER 173.9MHz
SPAN 100.0MHz
*RBW 100kHz
*VBW 100kHz
*SWP 200ms

MASK: B for 1W
SPECTRUM FOR EMISSION **16K3F1D**
OUTPUT POWER: 1 Watts
19200 bps
PEAK DEVIATION = 4990 Hz
SPAN = 200 kHz






*ATTEN 30dB
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10dB/
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SPAN 200.0kHz
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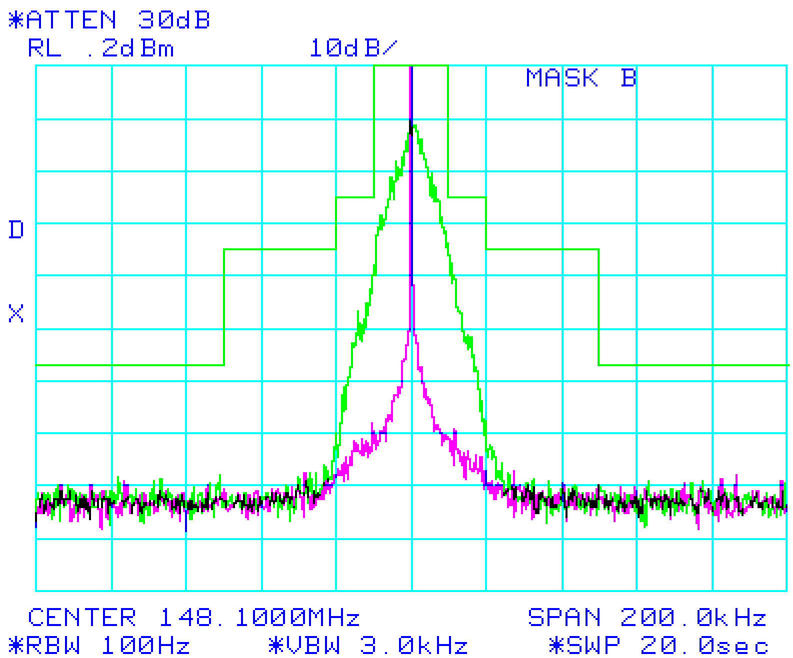
*SWP 20.0sec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RL .2dBm
10dB/
MASK B
D
X
CENTER 148.1000MHz
SPAN 200.0kHz
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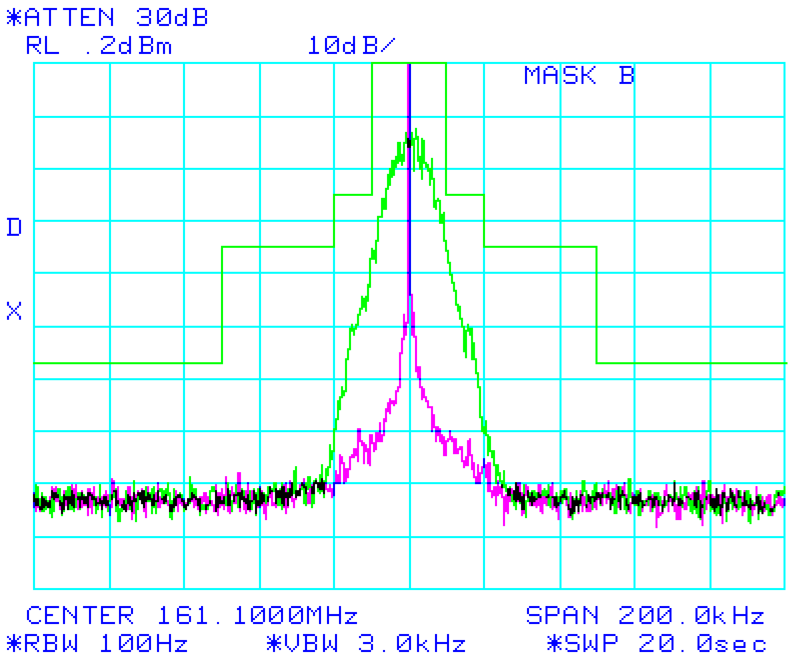
*VBW 3.0kHz
*SWP 20.0sec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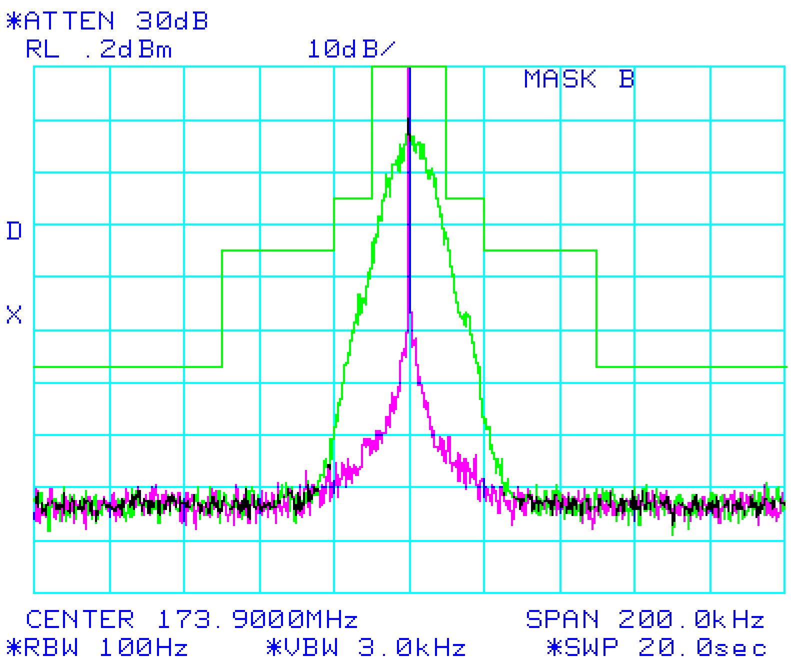
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X
CENTER 173.9000MHz
SPAN 200.0kHz
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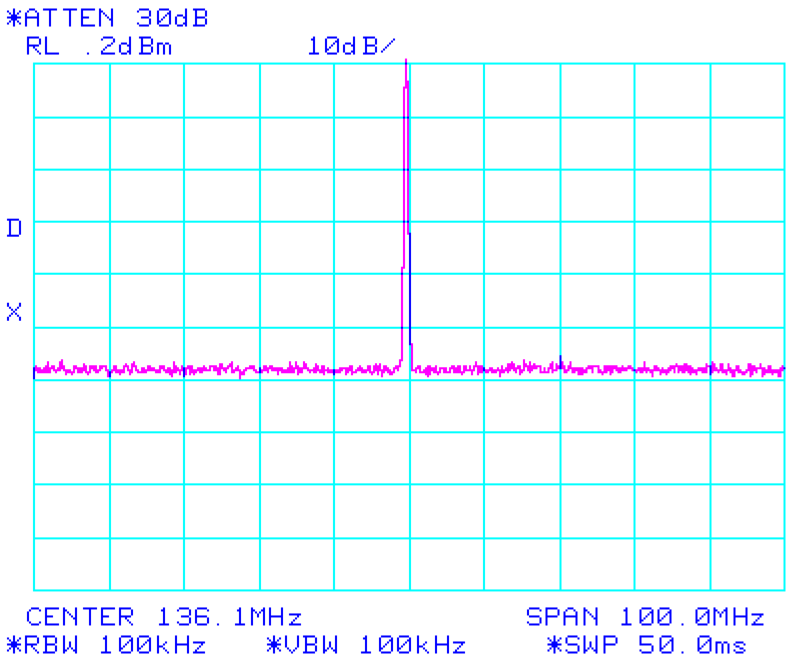
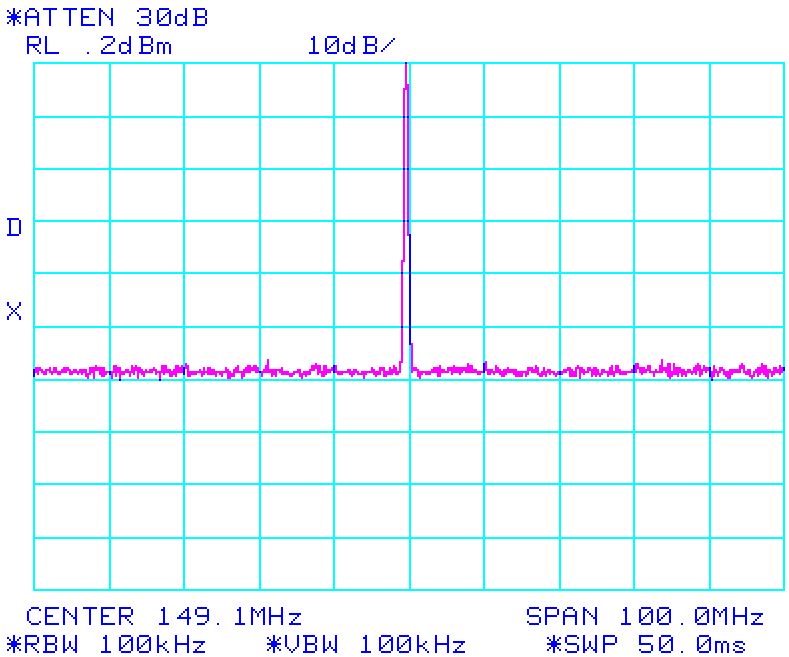
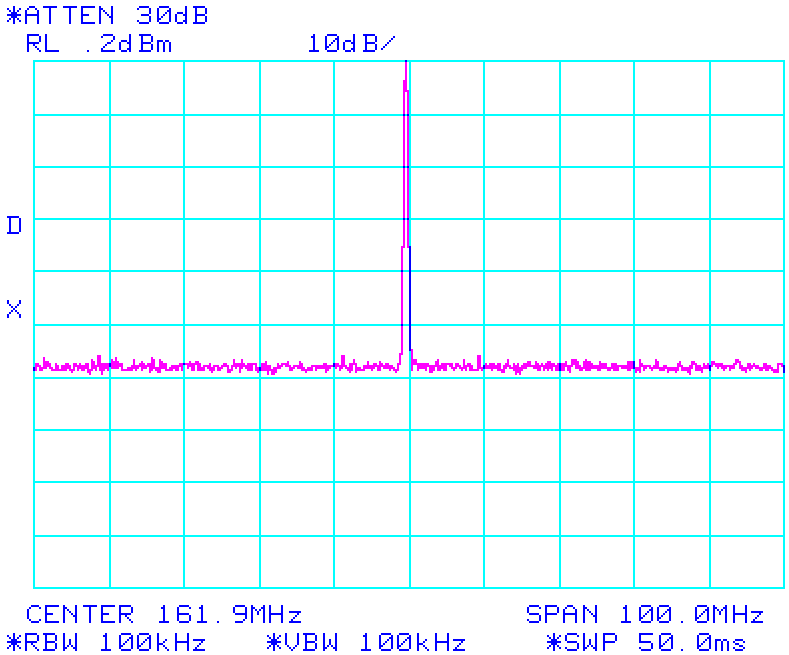
*VBW 3.0kHz
*SWP 20.0sec

WIDE SPAN = 100 MHz
OUTPUT POWER: 1 Watt



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*RBW 100kHz
*VBW 100kHz
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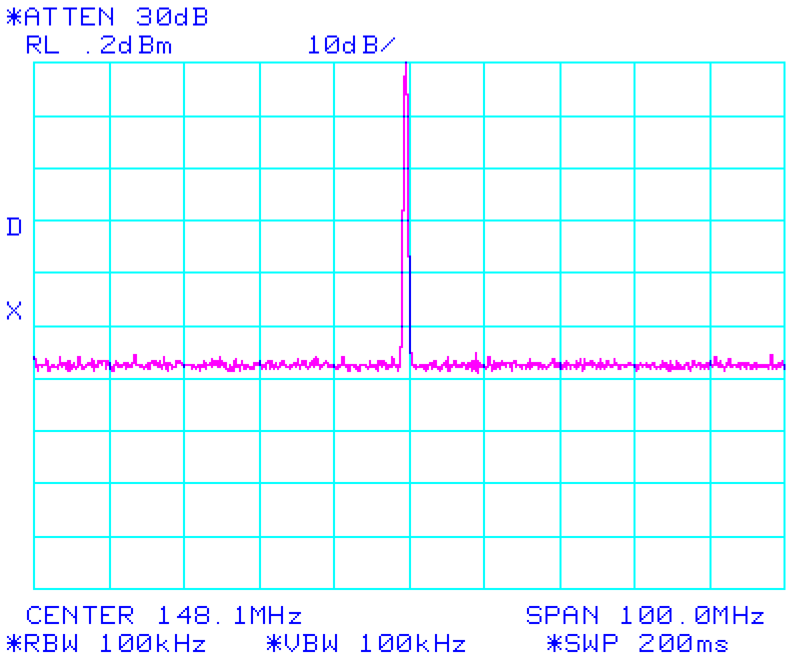
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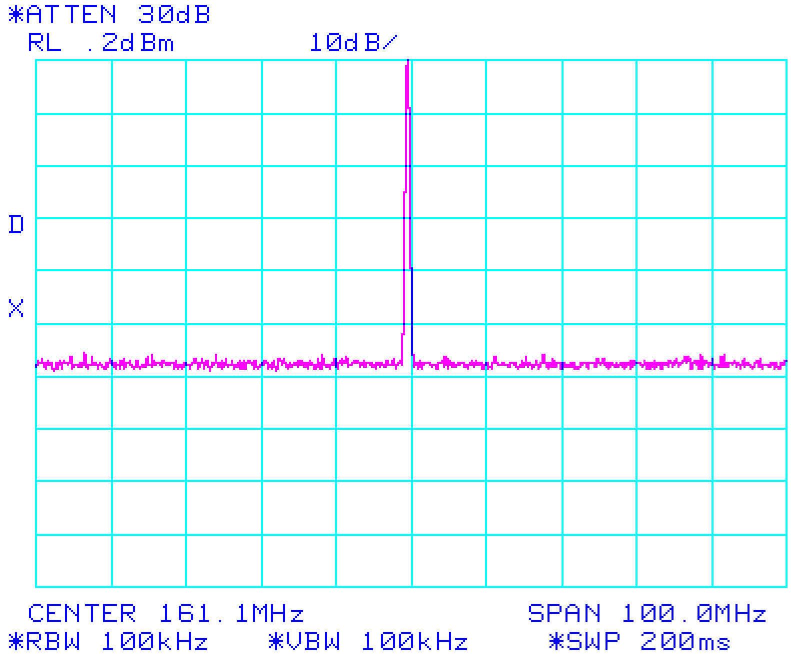
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*VBW 100kHz
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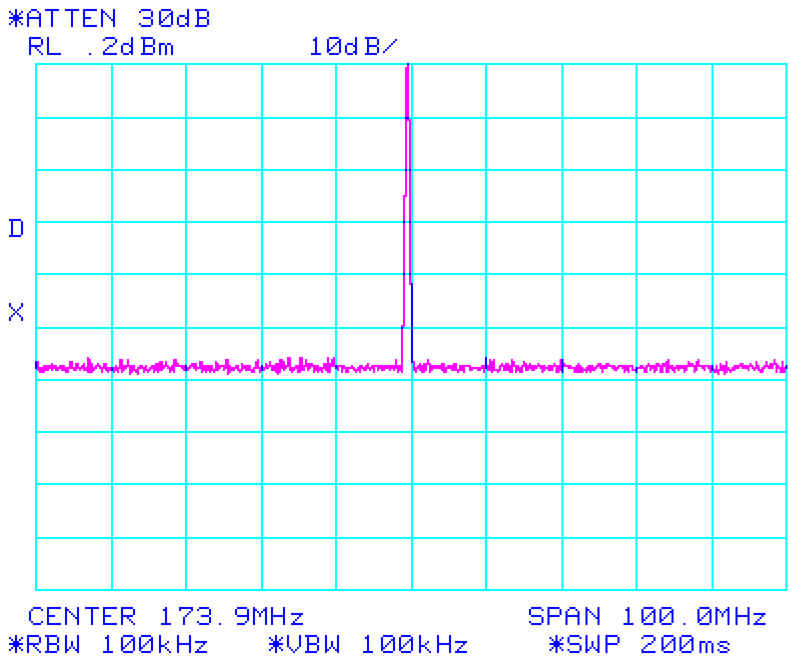
*ATTEN 30dB
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10dB/
D
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CENTER 173.9MHz
SPAN 100.0MHz
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*VBW 100kHz
*SWP 200ms

Equipment Calibration Information

Equipment	Serial Number	Cal Date	Cal Due
HP 8563E Spectrum Analyzer	3221A00149	4/15/2010	4/15/2012
Agilent E8257D Signal Generator	MY44320507	4/20/2010	4/20/2012
HP 8901A Modulation Analyzer	2950A05551	4/12/2010	4/12/2012
HP 437B Power Meter	3125U13882	4/12/2010	4/12/2012

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