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FCC Part 80/90 Certification Application

FCC Form 731

For The

**Guardian 200
VHF RADIO MODEM**

FCC ID: NP4-5026-500

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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); 80.211 (f)

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 below.

Necessary Bandwidth Measurement:

Channel Spacing	12.5 kHz	12.5 kHz	25 kHz	25 kHz
Emission Type	10K2 F3D	10K2 F3E	15K3 F3D	15K3 F3E
Measured Peak Deviation	2.438 Hz	2.438 kHz	5.12 kHz	5.12 kHz
Measured 99% Occupied BW	10.2 kHz	10.2 kHz	15.3 kHz	15.3 kHz

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

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

and PSD (power spectral distribution) is

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

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 a digital spectrum analyzer.

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.

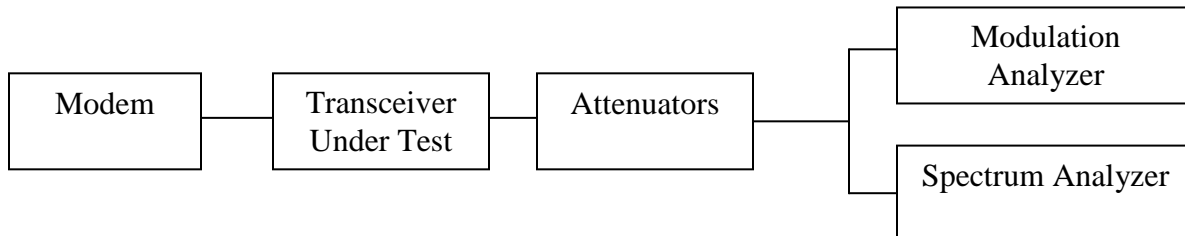
TEST EQUIPMENT:

50-Ohm Attenuator, Bird Electronics Model 25-A-MFN-20 (20dB, 25W)
50-Ohm Power Splitter, Mini Circuits Model ZFSC-3-4 (5.5dB IL at UHF)
Power Supply, Instek Model GPS-3303
Spectrum Analyzer, Hewlett Packard Model HP8563E
Modulation Analyzer, Hewlett Packard Model HP8901A

TEST SET-UP:

For the above requirements, the occupied bandwidth of a transmitter was measured using an Advantest Model R3162 using the following settings:

Occupied BW % Power: 99%
Trace: Max Hold A
RBW: 100 Hz (12.5 kHz channels)
RBW: 300 Hz (25 kHz channels)
VBW: 3 kHz
SPAN: 50 kHz (12.5 kHz channels)
SPAN: 150 kHz (25 kHz channels)



NAME OF TEST: Transmitter Occupied Bandwidth for Emission Designators
10K2F3D and **10K2F3E**

RULE PART NUMBER: FCC: 2.202, 90.209 (b)(5), 90.210(d), 2.1049 (c)(1); 80.211 (f)
Note: All data taken at 12 watts is to be applied to Part 80 only. Data taken at 2 watts is to be applied to Part 90 (217-220 MHz).

MINIMUM STANDARDS: **Mask D**
Sidebands and Spurious [Rule 90.210 (d), P = 12 Watts and P=1 Watt]
Authorized Bandwidth = 11.25 kHz [Rule 90.209(b) (5)]
From Fo to 5.625 kHz, down 0 dB.
Greater than 5.625 kHz to 12.5 kHz, down 7.27($f_d-2.88\text{kHz}$) dB.
Greater than 12.5 kHz, at least 50+10log₁₀(P) 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 = 60.8 dB at frequencies greater than 12.5 kHz @ 12 W
Attenuation = 50 dB at frequencies greater than 12.5 kHz @ 1 W

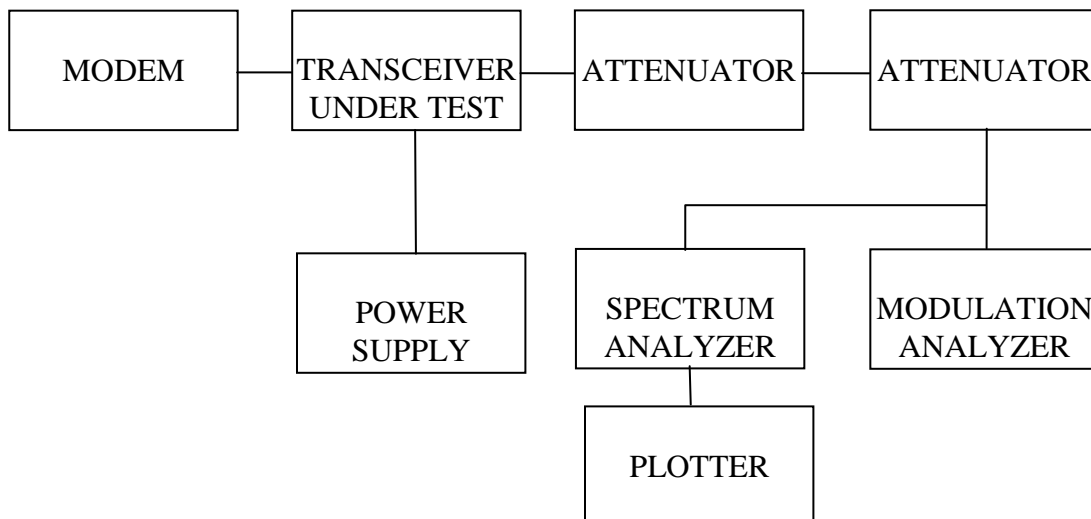
TEST RESULTS: Meets minimum standards (see data on following page)

TEST CONDITIONS: Standard Test Conditions, 25 C
RF Power Level = 1 Watt and 12 Watts
Voltage = 20VDC

TEST PROCEDURE: TIA/EIA – 603-C

TEST EQUIPMENT: 50-Ohm Attenuator, Bird Electronics 25-A-MFN-20 (20dB, 25W)
50-Ohm Power Splitter, Mini Circuits ZFSC-3-4 (5.5dB IL at UHF)
Power Supply, Instek Model GPS-3303
Spectrum Analyzer, Hewlett Packard Model HP8563E
Modulation Analyzer, Hewlett Packard Model HP8901A

TEST SET-UP:

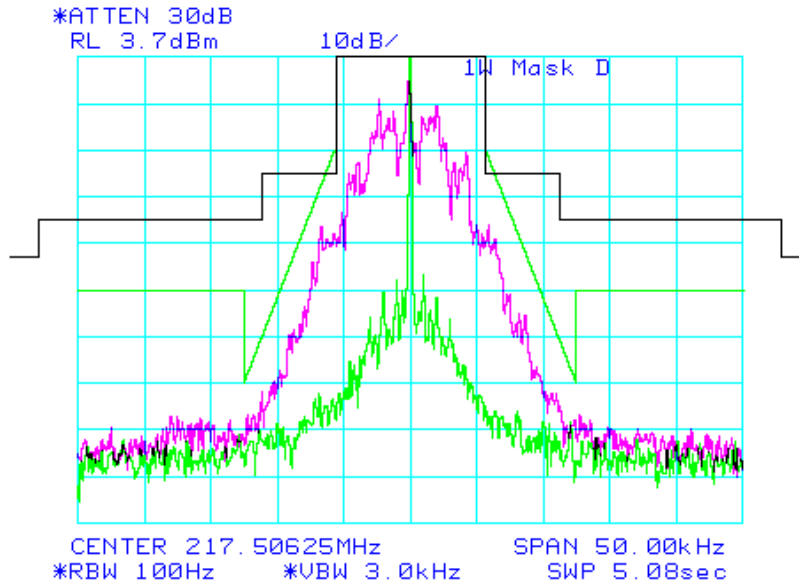


Mask: D, 1W
Output Power = 1 Watt

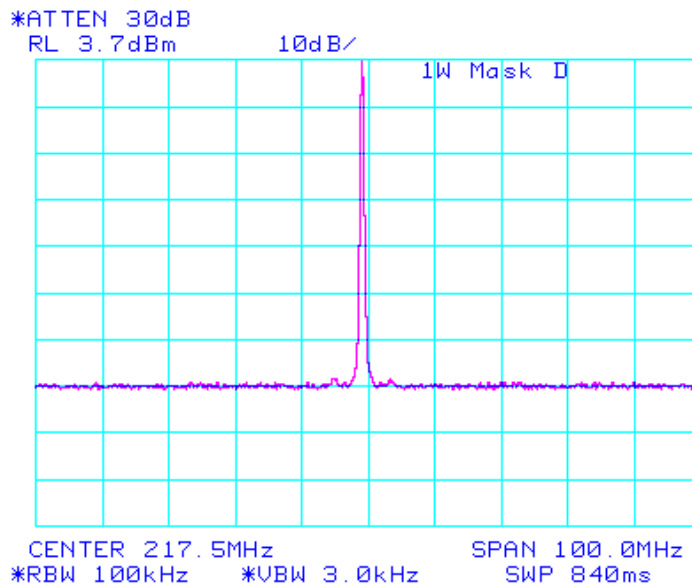
Spectrum for Emission: 10K2 F3D
Peak Deviation: 2.438 kHz

Mask B = Black Line
Mask D = Green Line

Narrow Span

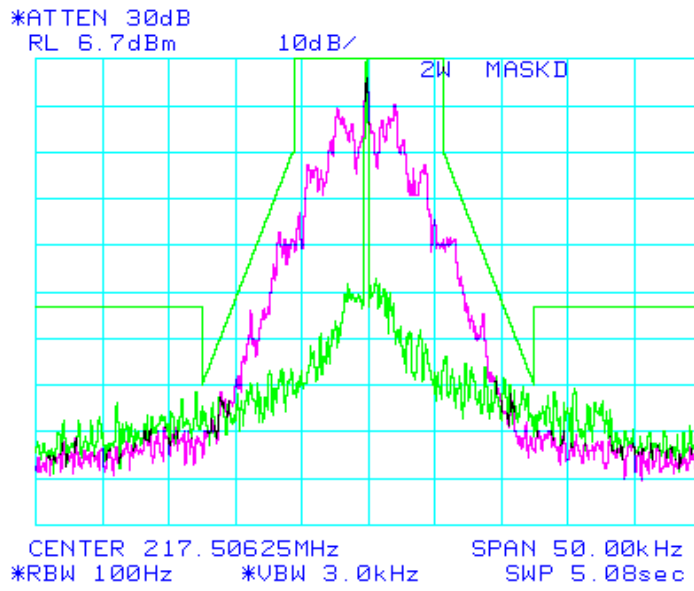


Wide Span



Output Power = 2 Watt
Applicable to Part 90 (217-220 MHz)

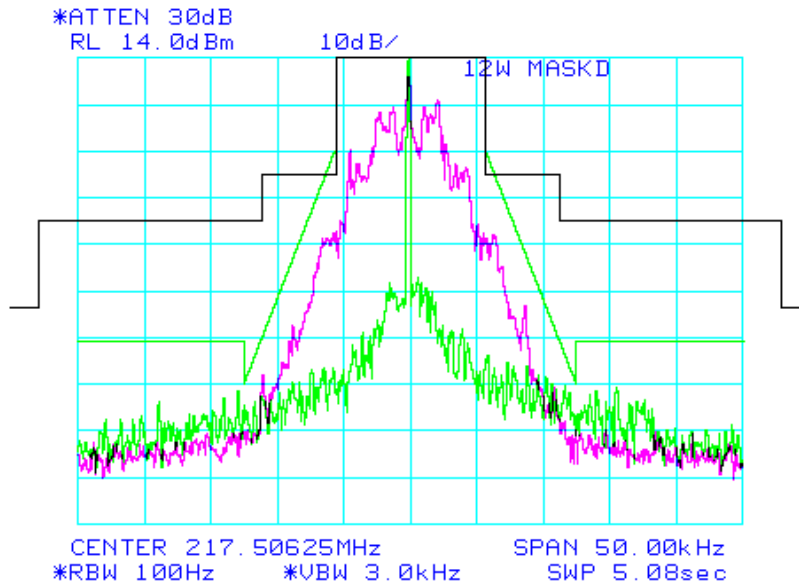
Mask D = Green Line



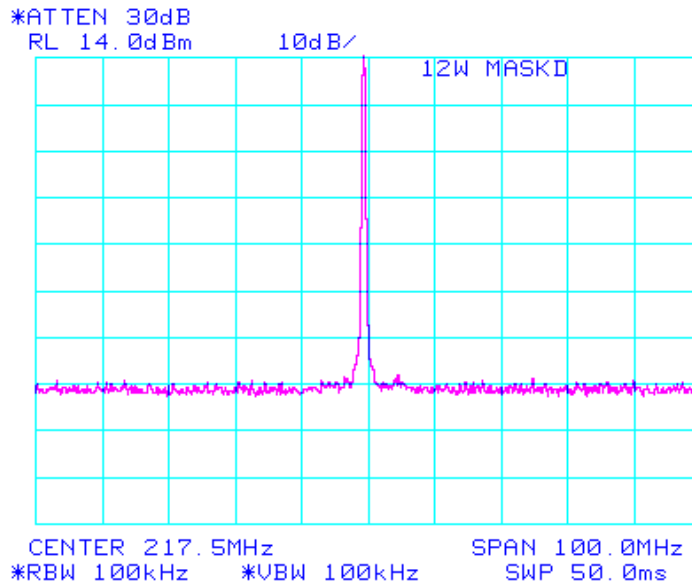
Output Power = 12 Watts
Applicable to Part 80 (216-220 MHz) only

Mask B = Black Line
Mask D = Green Line

Narrow Span



Wide Span

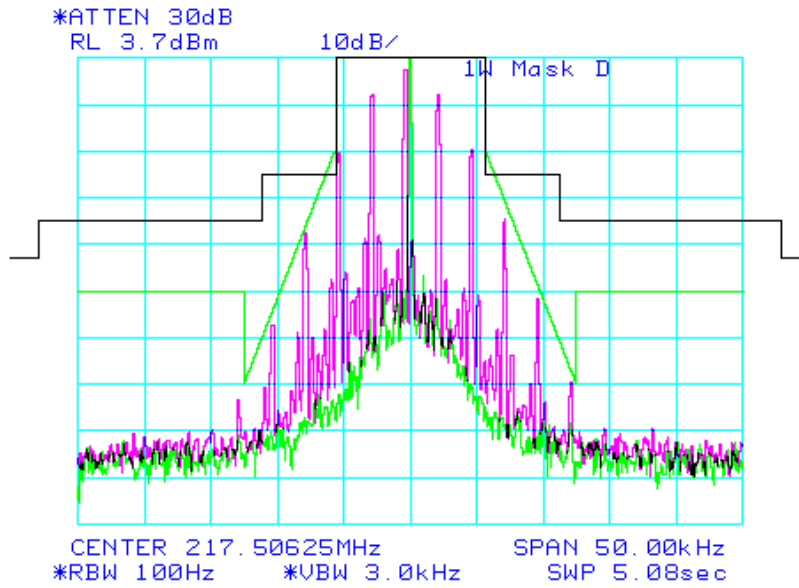


Mask: D, 1W
Output Power = 1 Watt

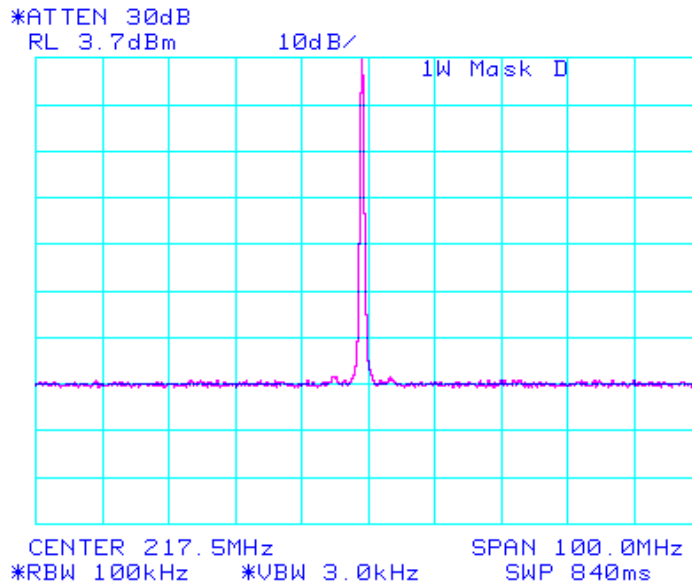
Spectrum for Emission: 10K2 F3E
Peak Deviation: 2.438 kHz

Mask B = Black Line
Mask D = Green Line

Narrow Span

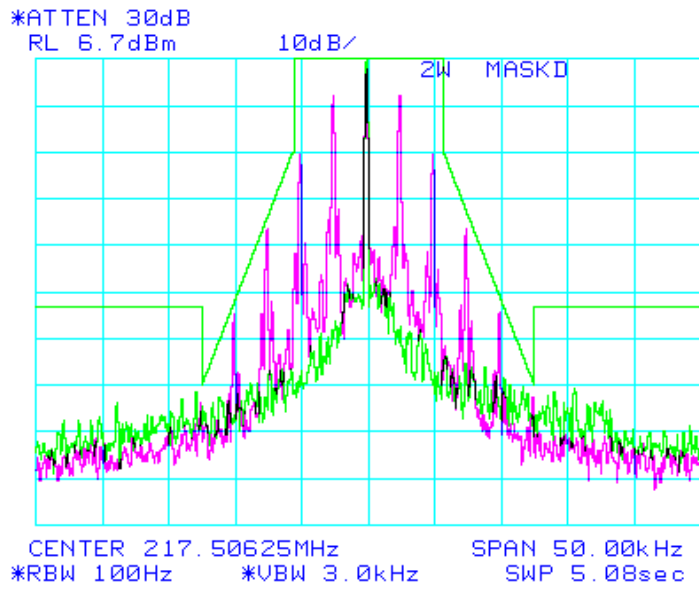


Wide Span



Output Power = 2 Watt
Applicable to Part 90 (217-220 MHz)

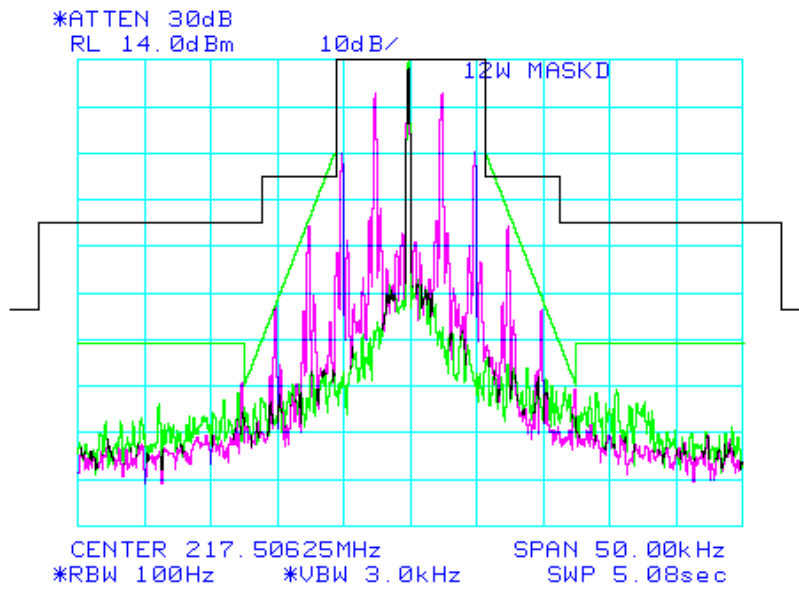
Mask D = Green Line



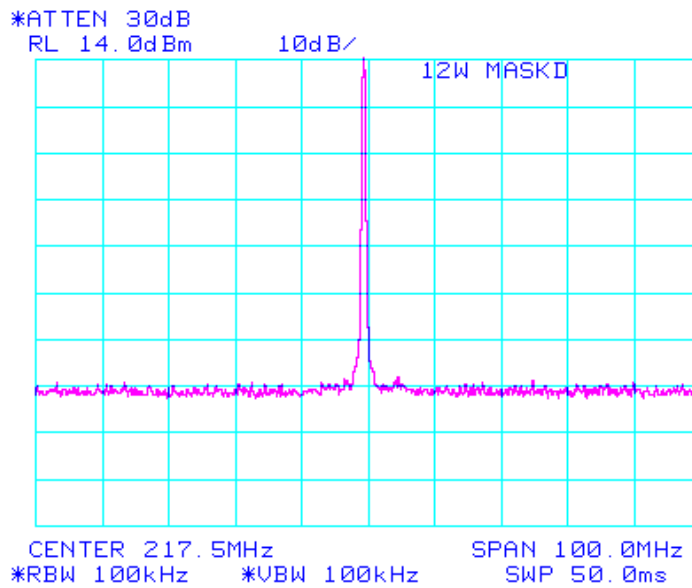
Output Power = 12 Watts
Applicable to Part 80 (216-220 MHz) only

Mask B = Black Line
Mask D = Green Line

Narrow Span



Wide Span



NAME OF TEST: Transmitter Occupied Bandwidth for Emission Designators **15K3F3D** and **15K3F3E**

RULE PART NUMBER: 2.202, 90.209 (b)(5), 90.210(c), 2.1049 (c)(1); 80.211 (f)
Note: All data taken at 12 watts is to be applied to Part 80 only. Data taken at 2 watts is to be applied to Part 90 (217-220 MHz).

MINIMUM STANDARDS: **Mask B**
Sidebands and Spurious [Rule 90.210 (b), P = 12 Watts and P=1 Watt]
Authorized Bandwidth = 20 kHz [Rule 90.209(b) (5)]
From Fo to 50 % of authorized BW, down 0 dB.
From 50 % to 100 % of authorized BW, down 25dB.
From 100 % to 250 % of authorized BW, down 35 dB
Greater than 250 % of authorized BW, $43 + 10\log_{10}(P)$

Attenuation = 0 dB at Fo to 10 kHz
Attenuation = 25 dB at 10 kHz to 20 kHz
Attenuation = 35 dB at 20 kHz to 50 kHz
Attenuation = 53.8 dB at frequencies greater than 50 kHz @ 12 W
Attenuation = 46 dB at frequencies greater than 50 kHz @ 2 W
Attenuation = 43 dB at frequencies greater than 50 kHz @ 1 W

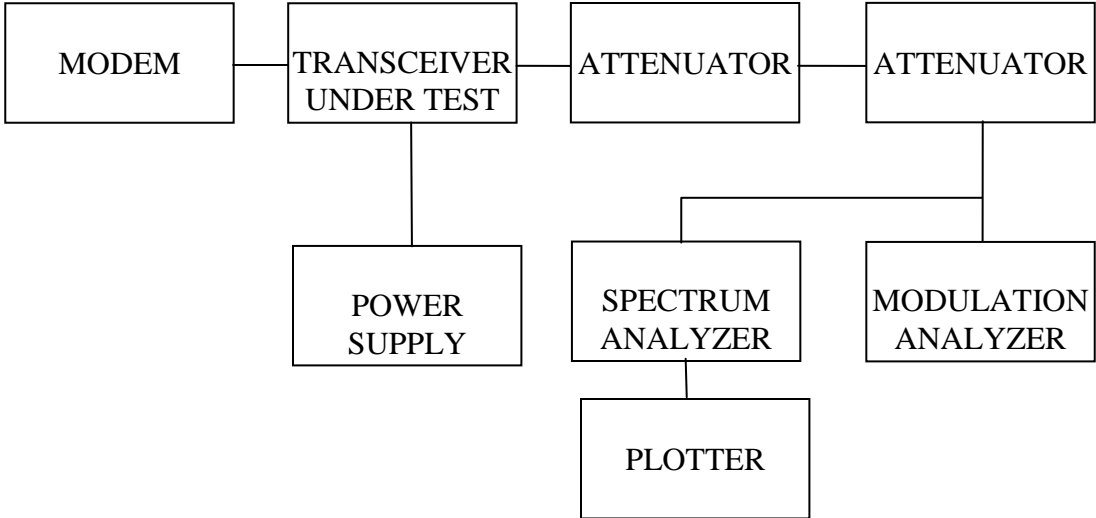
TEST RESULTS: Meets minimum standards (see data on following page)

TEST CONDITIONS: Standard Test Conditions, 25 C
RF Power Level = 1 Watt and 12 Watts
Voltage = 20VDC

TEST PROCEDURE: TIA/EIA – 603-C

TEST EQUIPMENT: 50-Ohm Attenuator, Bird Electronics 25-A-MFN-20 (20dB, 25W)
50-Ohm Power Splitter, Mini Circuits ZFSC-3-4 (5.5dB IL at UHF)
Power Supply, Instek Model GPS-3303
Spectrum Analyzer, Hewlett Packard Model HP8563E
Modulation Analyzer, Hewlett Packard Model HP8901A

TEST SET-UP:

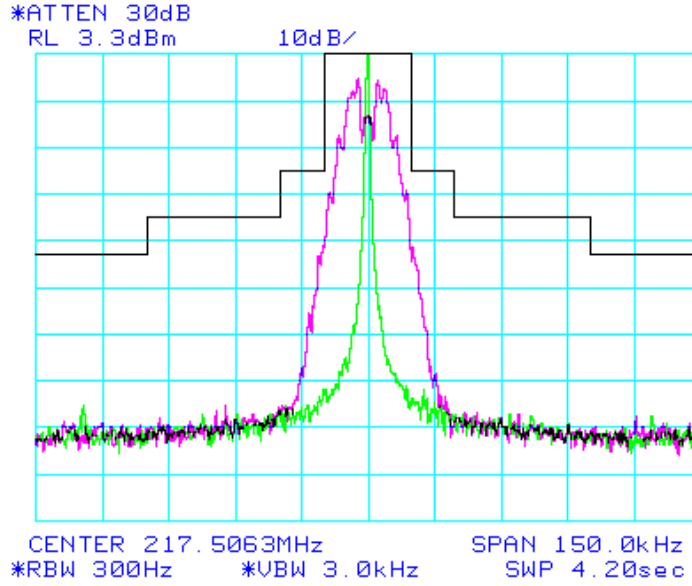


Mask: B, 1W
Output Power = 1 Watt

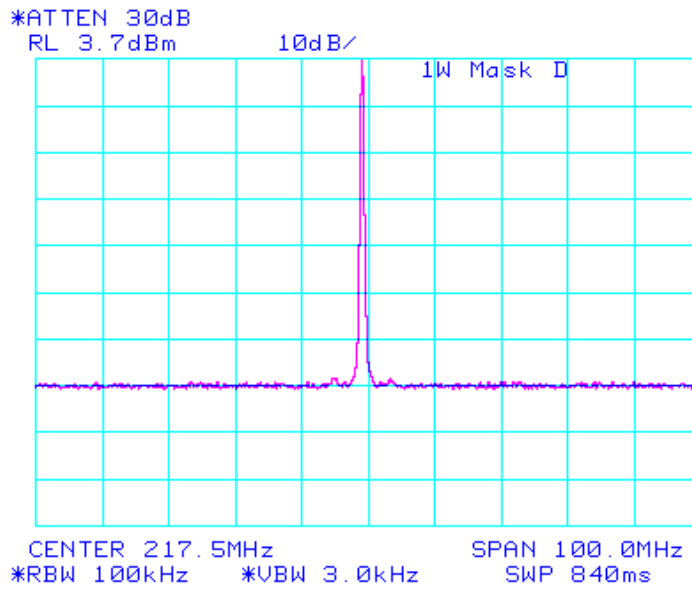
Spectrum for Emission: 15K3 F3D
Peak Deviation: 5.12 kHz

Mask B = Black Line

Narrow Span

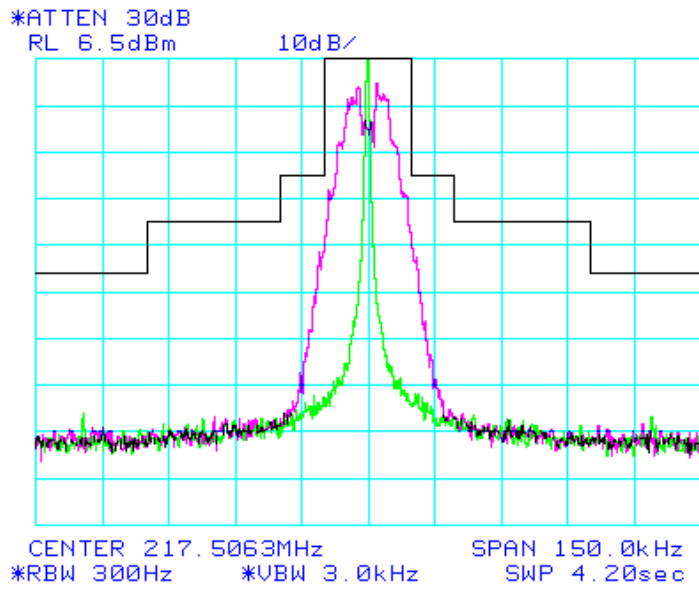


Wide Span



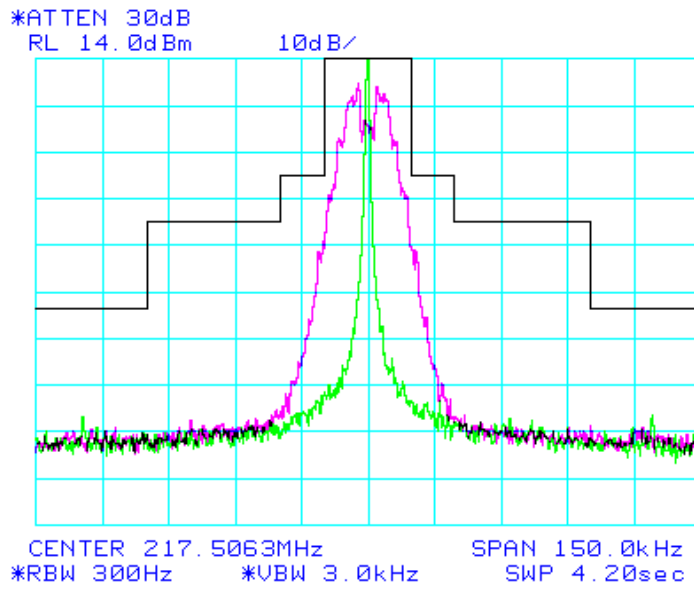
Output Power = 2 Watt
Applicable to Part 90 (217-220 MHz)

Mask B = Black Line

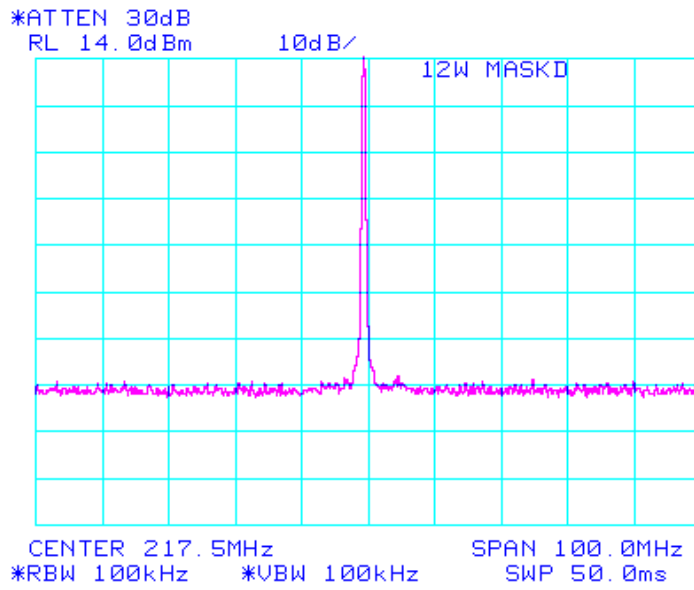


Output Power = 12 Watts
Applicable to Part 80 (216-220 MHz) only

Narrow Span



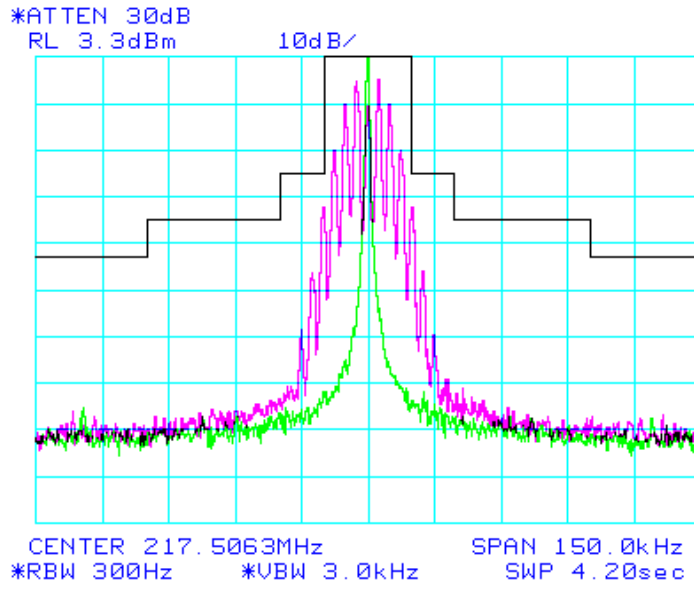
Wide Span



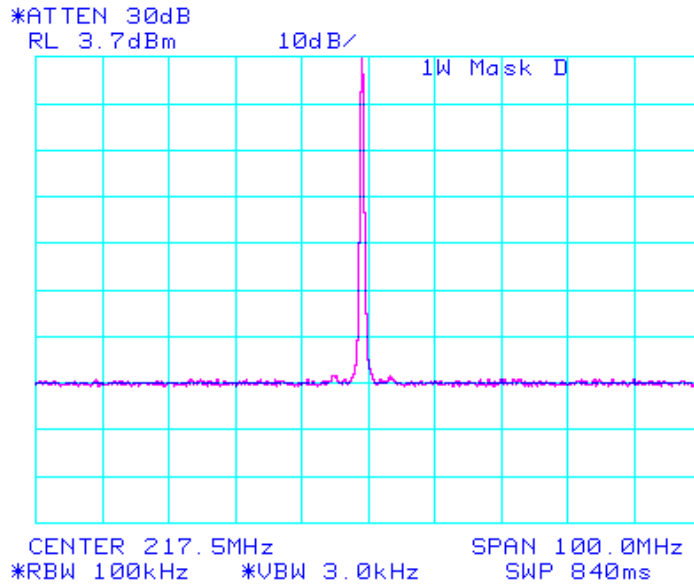
Mask: B, 1W
Output Power = 1 Watt

Spectrum for Emission: 15K3 F3E
Peak Deviation: 5.12 kHz

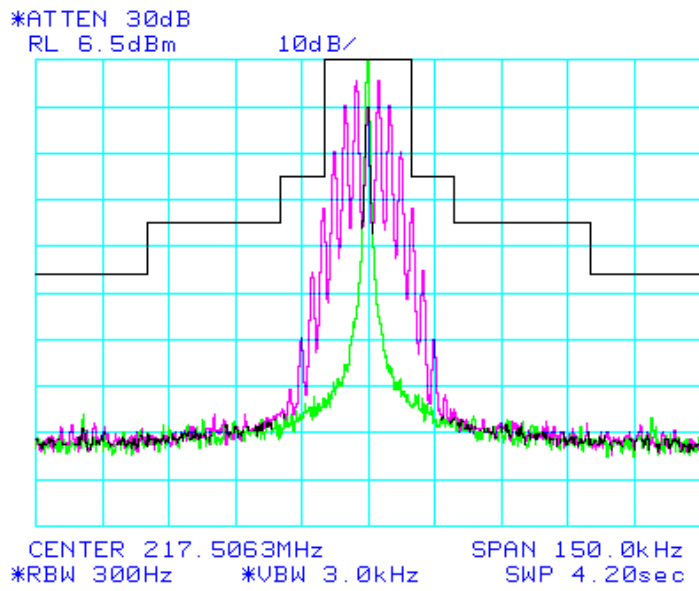
Narrow Span



Wide Span

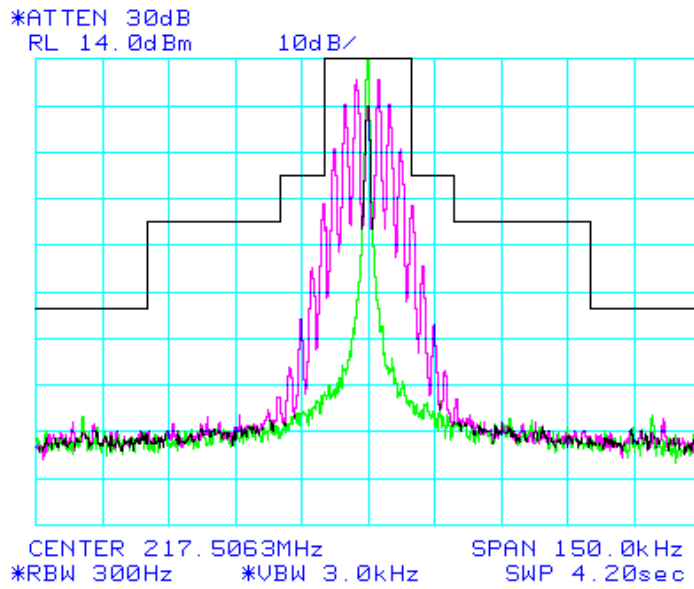


Output Power = 2 Watt
Applicable to Part 90 (217-220 MHz)

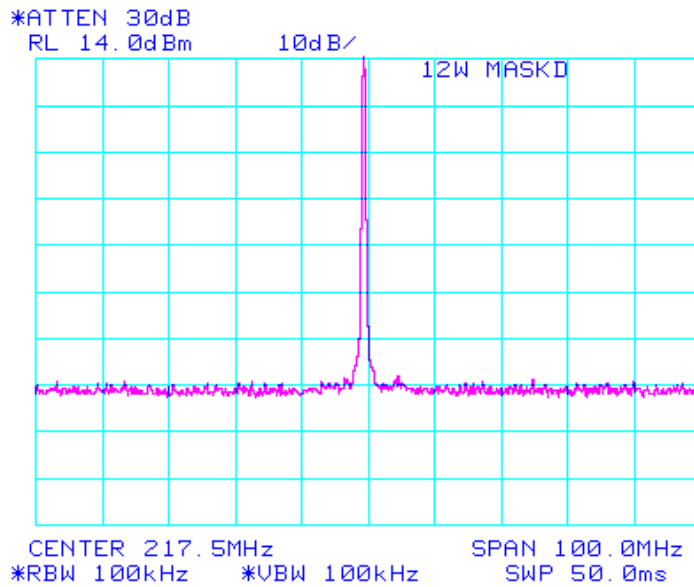


Output Power = 12 Watts
Applicable to Part 80 (216-220 MHz) only

Narrow Span



Wide Span



NAME OF TEST: Transmitter Occupied Bandwidth for Emission Designators **10K2F3D, 10K2F3E, 15K3F3D, 15K3F3E**

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

MINIMUM STANDARDS: **Mask F**
 Sidebands and Spurious [Rule 90.210 (c), P = 12 Watts and P=1 Watt]
 Authorized Bandwidth = 5 kHz [Rule 90.209(b) (5)]

From F_o to 2 kHz, down 0 dB.
 Greater than 2 kHz to 3.75 kHz, down $30 + 20(f_d - 2)$ dB.
 On any frequency beyond 3.75 kHz removed from the center of the authorized bandwidth f_d : At least $55 + 10 \log (P)$ dB.

The equipment under test will not function inside a single channel in the 220 to 222MHz band. Therefore the EUT was tested using aggregate combinations of channels as follows:

10K2F3D	4 contiguous channels
10K2F3E	4 contiguous channels
15K3F3D	6 contiguous channels
15K3F3E	6 contiguous channels

For emission designators 10K2F3D, 10K2F3E
 Attenuation = 0 dB at F_o to 9.5 kHz
 Attenuation = 30 dB at 9.5 kHz
 Attenuation = 55 dB at 10.75 kHz @ 1W
 Attenuation = 65 dB at 11.25 kHz @ 12W

For emission designator 15K3F3D, 15K3F3E
 Attenuation = 0 dB at F_o to 14.5 kHz
 Attenuation = 30 dB at 12 kHz
 Attenuation = 55 dB at 15.75 kHz @ 1W
 Attenuation = 65 dB at 16.25 kHz @ 12W

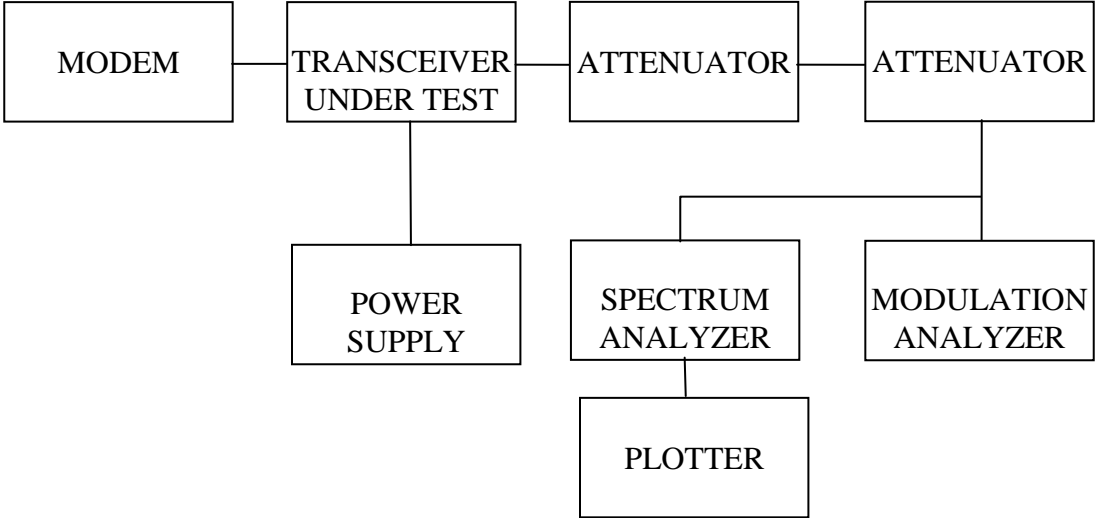
TEST RESULTS: Meets minimum standards (see data on following page)

TEST CONDITIONS: Standard Test Conditions, 25 C
 RF Power Level = 1 Watt and 12 Watts
 Voltage = 20VDC

TEST PROCEDURE: TIA/EIA – 603-C, 2.2.13, 3.2.11.2

TEST EQUIPMENT: 50-Ohm Attenuator, Bird Electronics Model 50-A-FFN-20 (20dB, 50W)
 50-Ohm Attenuator, Bird Electronics Model 10-A-MFN-10 (10dB, 10W)
 50-Ohm Attenuator, Pasternack Model PE7002-10 (10dB)
 DC Power Supply, Hewlett Packard Model 6653A
 Spectrum Analyzer, Hewlett Packard Model HP8563E
 Modulation Analyzer, Hewlett Packard Model HP8901B

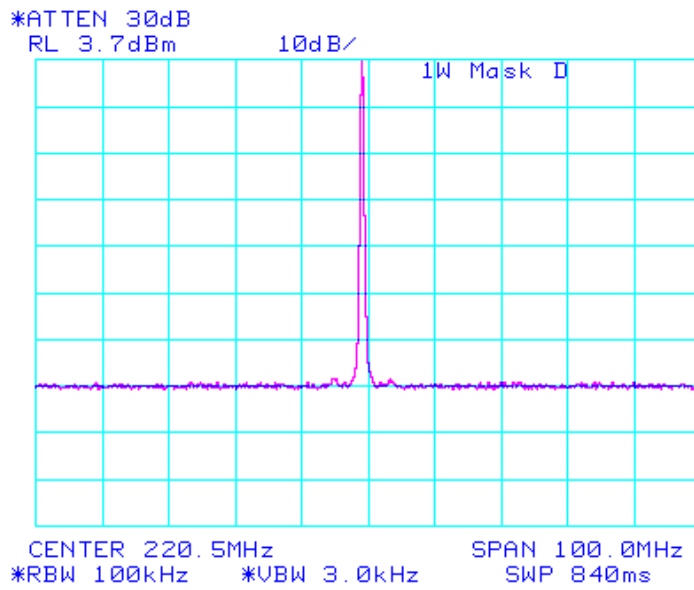
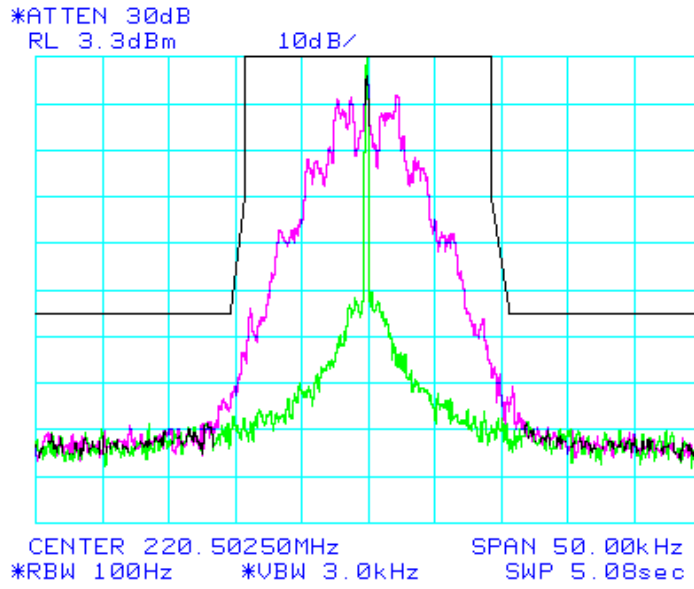
TEST SET-UP:



Mask: F (4 aggregate masks)
Output Power = 1 Watt

Spectrum for Emission: 10K2 F3D
Peak Deviation: 2.438 kHz

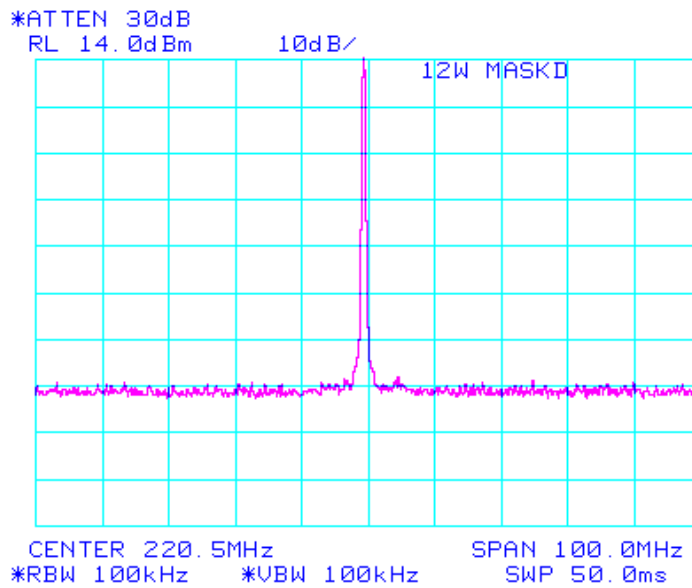
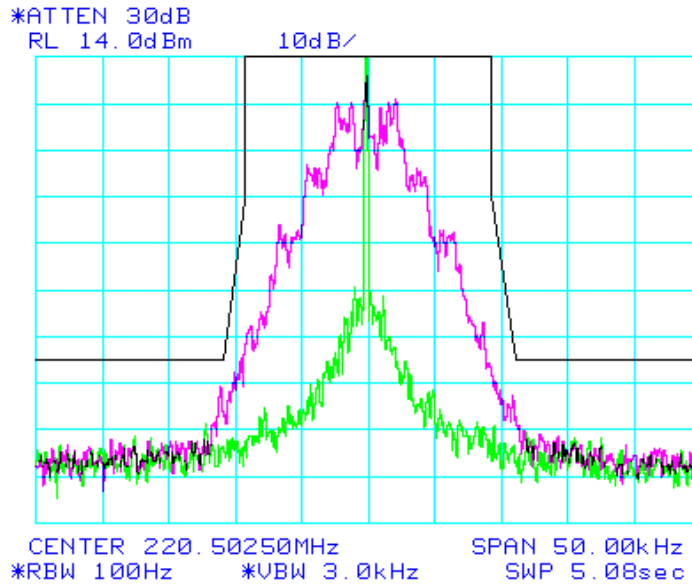
Mask F = Black Line



Mask: F (4 aggregate masks)
Output Power = 12 Watts

Spectrum for Emission: 10K2 F3D
Peak Deviation: 2.438 kHz

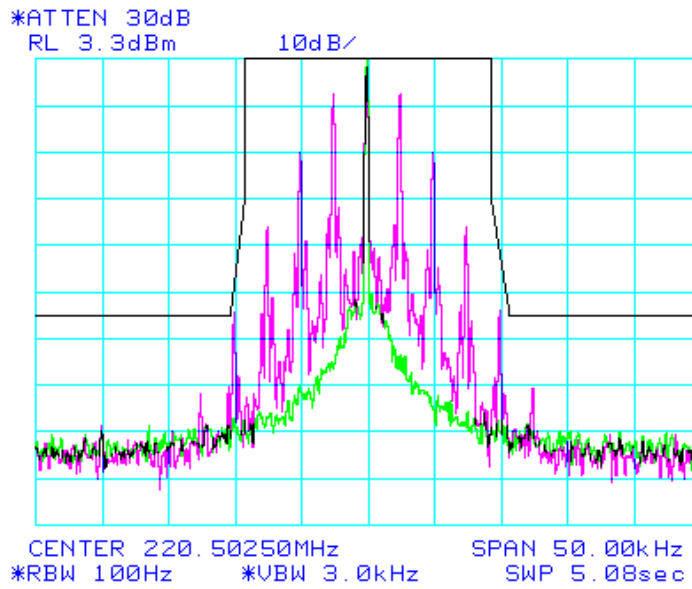
Mask F = Black Line



Mask: F (4 aggregate masks)
Output Power = 1 Watt

Spectrum for Emission: 10K2 F3E
Peak Deviation: 2.438 kHz

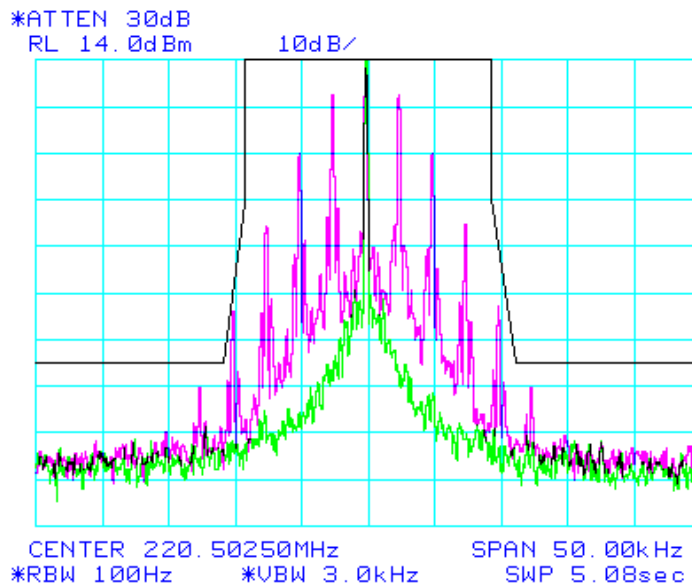
Mask F = Black Line



Mask: F (4 aggregate masks)
Output Power = 12 Watts

Spectrum for Emission: 10K2 F3E
Peak Deviation: 2.438 kHz

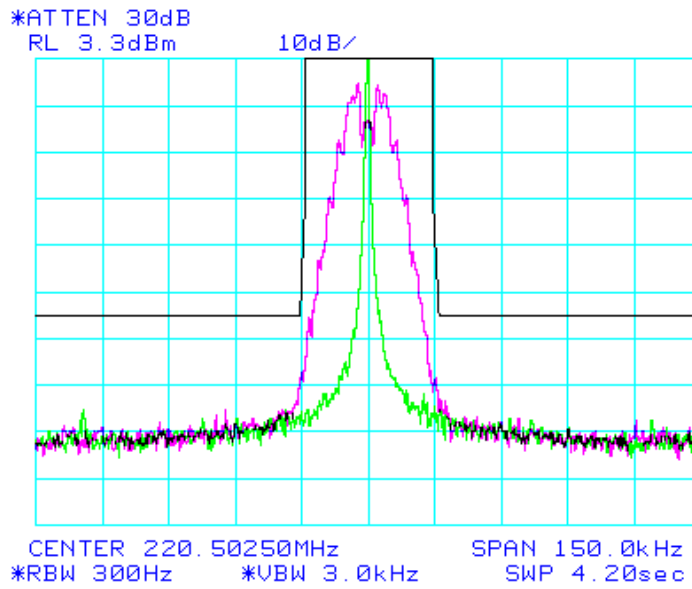
Mask F = Black Line



Mask: F (6 aggregate masks)
Output Power = 1 Watt

Spectrum for Emission: 15K3 F3D
Peak Deviation: 5.12 kHz

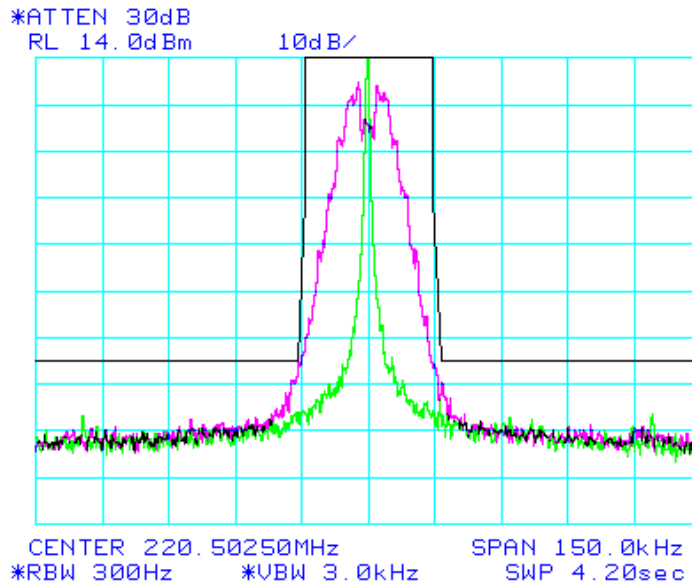
Mask F = Black Line



Mask: F (6 aggregate masks)
Output Power = 12 Watts

Spectrum for Emission: 15K3 F3D
Peak Deviation with Data: 5.12 kHz

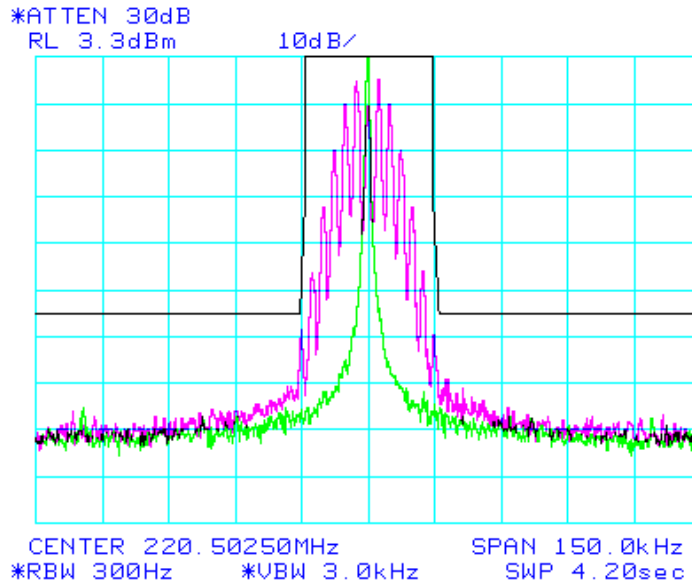
Mask F = Black Line



Mask: F (6 aggregate masks)
Output Power = 1 Watt

Spectrum for Emission: 15K3 F3E
Peak Deviation: 5.12 kHz

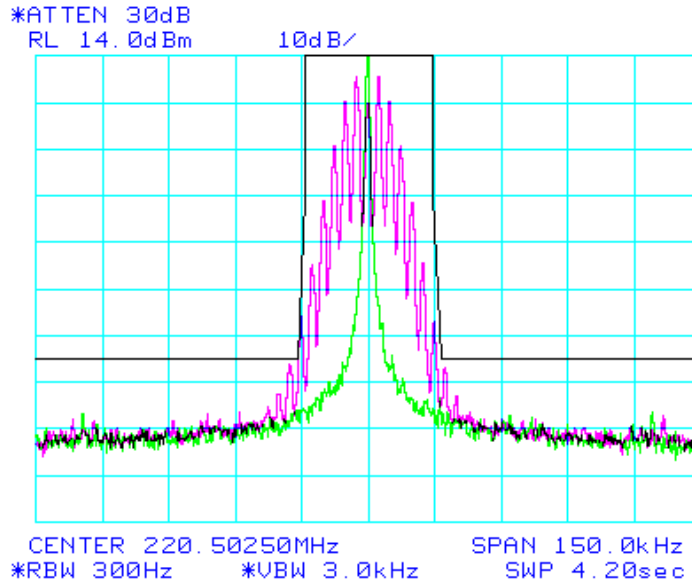
Mask F = Black Line



Mask: F (6 aggregate masks)
Output Power = 12 Watts

Spectrum for Emission: 15K3 F3E
Peak Deviation: 5.12 kHz

Mask F = Black Line



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
Advantest R3162	111000901	7/24/2009	7/24/2011
HP 437B Power Meter	3125U13882	4/12/2010	4/12/2012

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

Part 90.729

It is the responsibility of the professional installer to ensure that the Effective Radiated Power (ERP) does not exceed the limitations set forth by the FCC in the table listed below for transmitting on frequencies in the 220-221 MHz band.

ERP VS. ANTENNA HEIGHT TABLE

Antenna height above average terrain (HAAT), (Meters)	Effective Radiated power, (watts)
Up to 150	500
150 to 225	250
225 to 300	125
300 to 450	60
450 to 600	30
600 to 750	20
750 to 900	15
900 to 1050	10
Above 1050	5