9. NOISE FIGURE

FCC Rules

Test Requirement(s):

§ 90.219 Use of signal boosters:

(e) (2) The noise figure of a signal booster must not exceed 9 dB in either direction.

Test Procedures:

The EUT was tested using Agilent Application Note 57-1,
'The direct noise measurement method"

1. GAIN measurement
EUT in the maximum gain of the repeater state.
The signal generator was connected to RF input port at a maximum level as determined by the spectrum analyzer was connected to RF output port depending on the circuitry being measured.
EUT GAIN = Output signal level – Input signal level
2. Output Noise level measurement
EUT in the maximum gain of the repeater state.
Without input signal.
Spectrum analyzer was connected to RF output port
Measured to Noise power.

NF=NP-G-BCF+PNAD
NF=NP-G-60+174
NF=NP-G+114

NF=Noise Figure(dB)
NP=Noise power(dBm/MHz)
G=Maximum gain
BCF=Bandwidth Correction Factor=10log(1 MHz/1 Hz)=60
PNAD=Noise Power Density=174 dBm/Hz

Test Results: The EUT complies with the requirements of this section.

Input Signal	Input Level (dBm)		Maximum Amp Gain	
	DL	UL	DL	UL
VHF(APCO25)	Without input signal		85	85
UHF(APCO25)			85	85
UHF(LMR450)			95	95

VHF Band

[APCO25] DL : Noise Figure = -38.416-85+114 = -9.416 dB

UHF Band

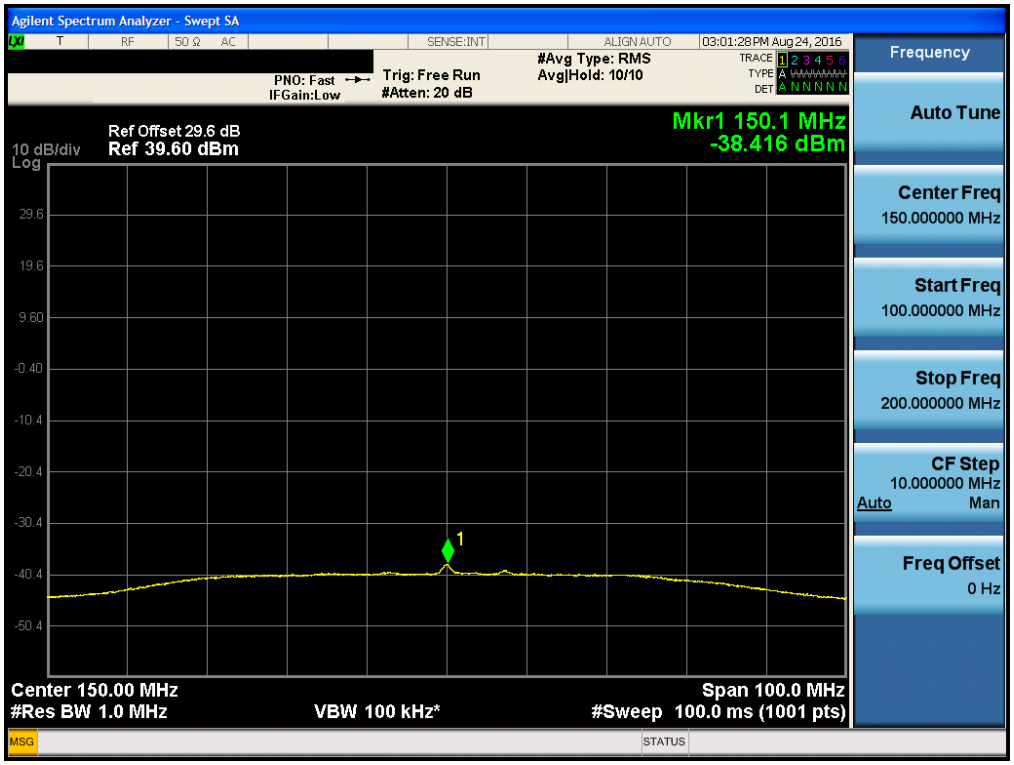
[APCO25] DL : Noise Figure = -30.337-85+114 = -1.337 dB

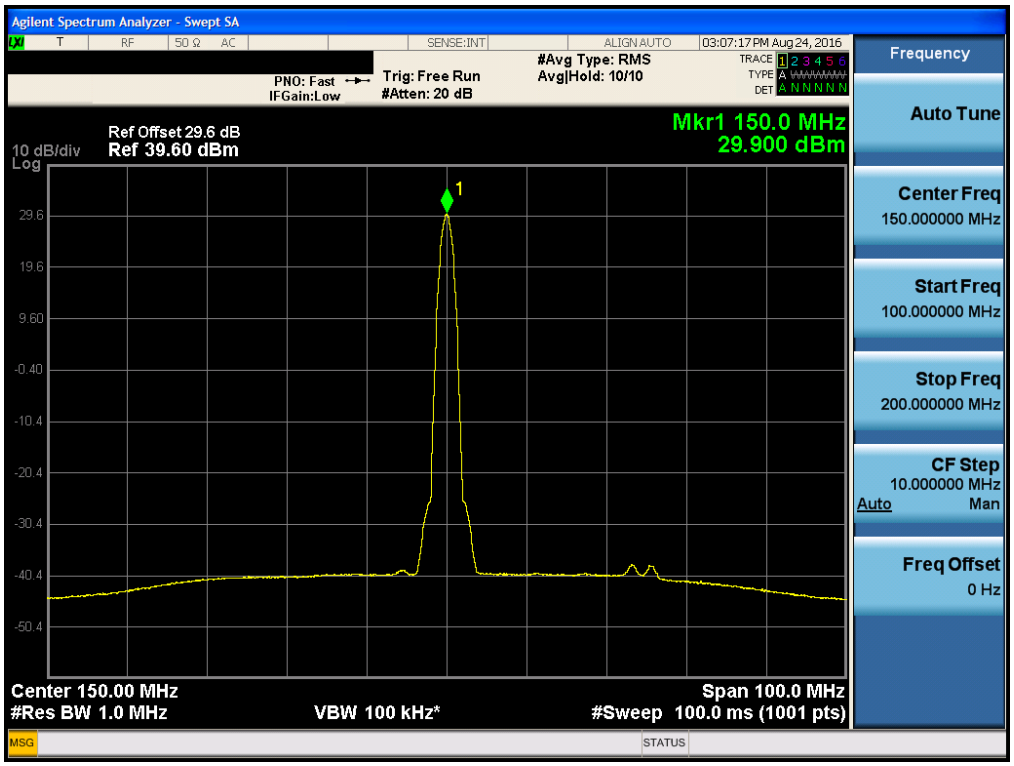
[LMR450] DL : Noise Figure = -26.082-95+114 = -7.082 dB

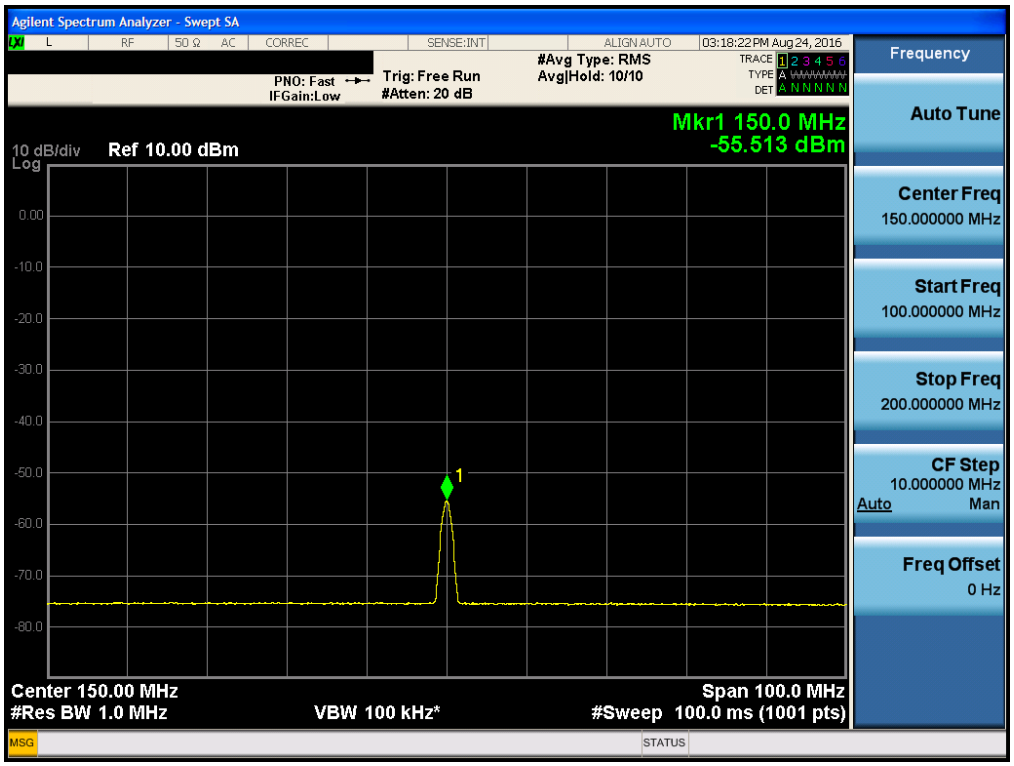
Plots of Noise power

VHF(APCO25)

[Downlink]



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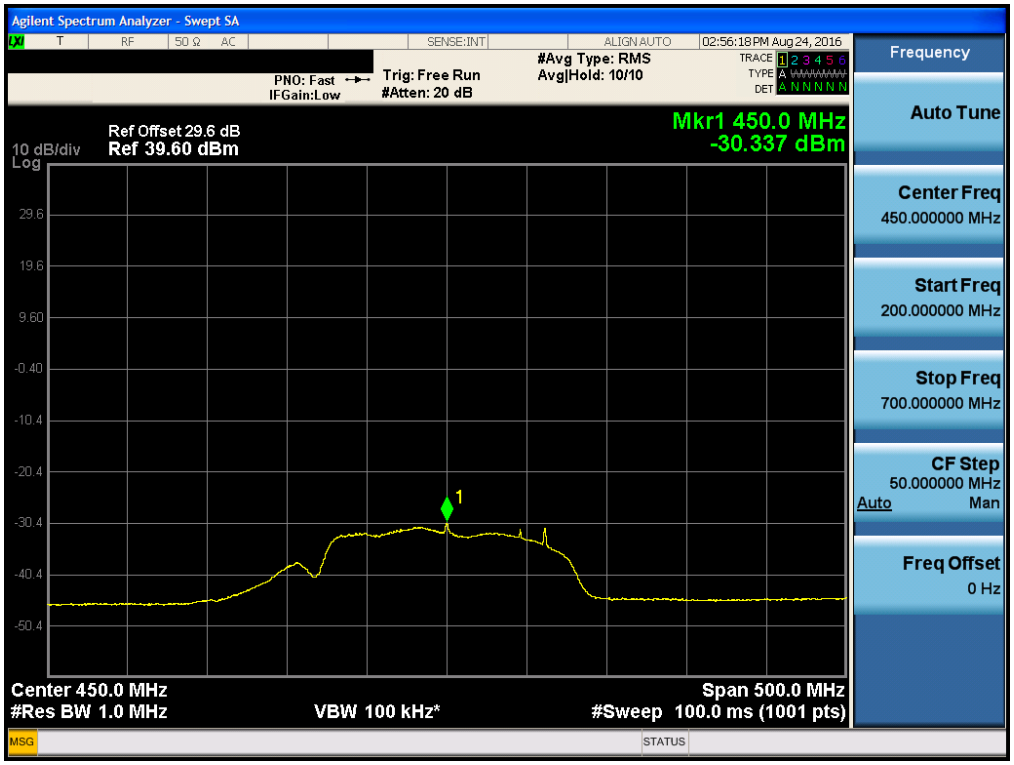
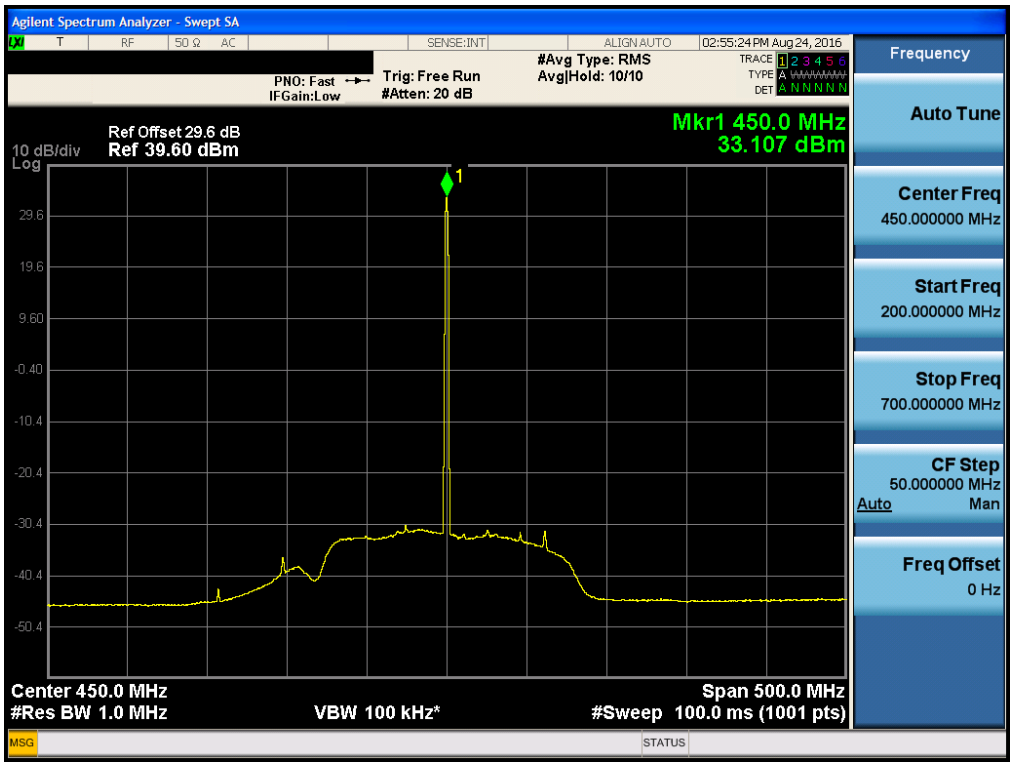
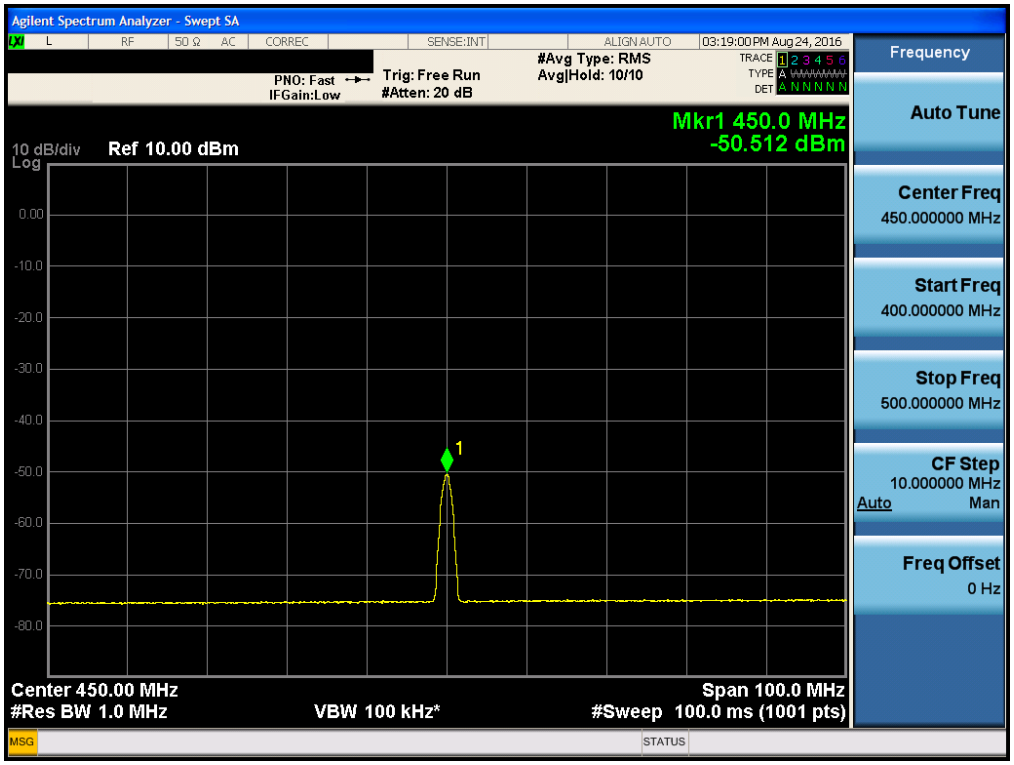
L
RF
50 Ω AC
CORREC
SENSE:INT
ALIGN AUTO
03:18:22 PM Aug 24, 2016
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 20 dB
#Avg Type: RMS
Avg|Hold: 10/10
TRACE 1 2 3 4 5 6
TYPE A
DET A N N N N N
Mkr1 150.0 MHz
-55.513 dBm
10 dB/div
Log
Ref 10.00 dBm
0.00
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
1
Center 150.00 MHz
#Res BW 1.0 MHz
VBW 100 kHz*
Span 100.0 MHz
#Sweep 100.0 ms (1001 pts)
MSG
STATUS
Frequency
Auto Tune
Center Freq
150.000000 MHz
Start Freq
100.000000 MHz
Stop Freq
200.000000 MHz
CF Step
10.000000 MHz
Auto
Man
Freq Offset
0 Hz

UHF(APCO25)

[Downlink]

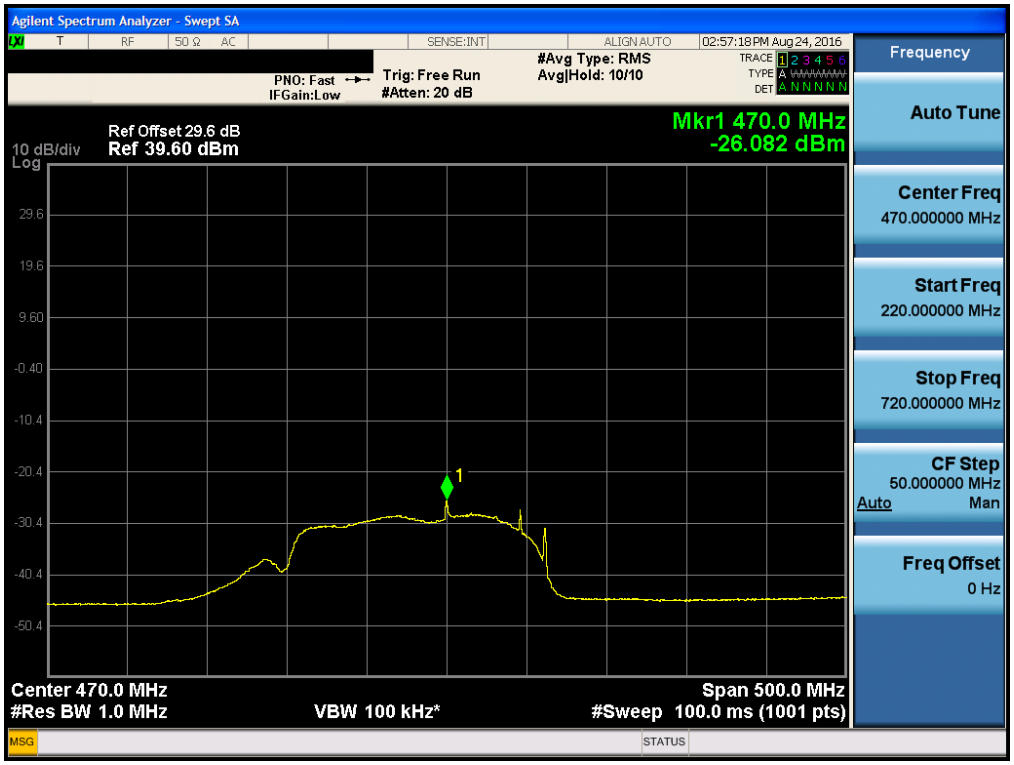


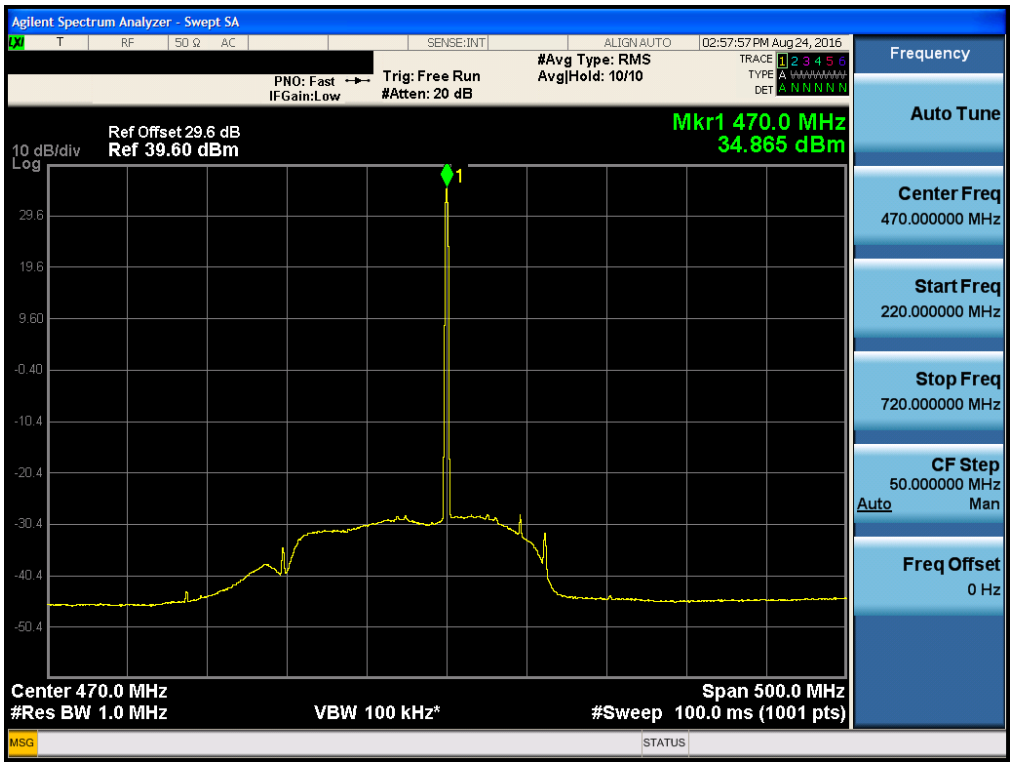


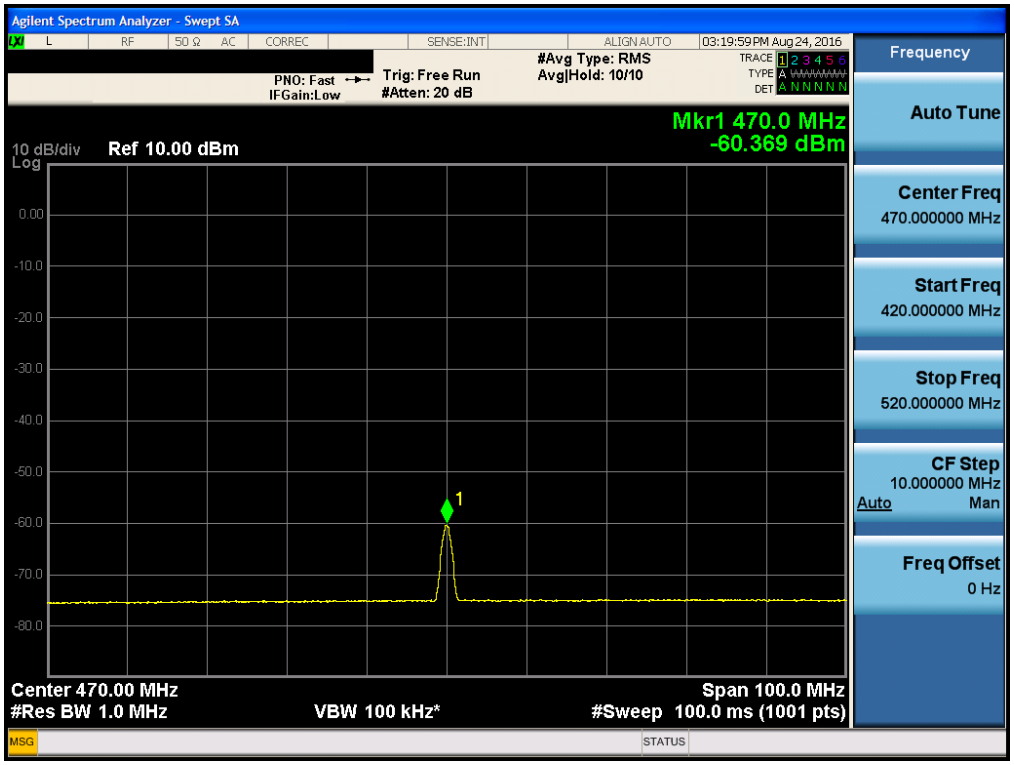

Agilent Spectrum Analyzer - Swept SA
L
RF
50 Ω AC
CORREC
SENSE:INT
ALIGN AUTO
03:19:00 PM Aug 24, 2016
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 20 dB
#Avg Type: RMS
Avg|Hold: 10/10
TRACE 1 2 3 4 5 6
TYPE A
DET A N N N N N
Mkr1 450.0 MHz
-50.512 dBm
10 dB/div
Log
Ref 10.00 dBm
0.00
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
1
Center 450.00 MHz
#Res BW 1.0 MHz
VBW 100 kHz*
Span 100.0 MHz
#Sweep 100.0 ms (1001 pts)
MSG
STATUS
Frequency
Auto Tune
Center Freq
450.000000 MHz
Start Freq
400.000000 MHz
Stop Freq
500.000000 MHz
CF Step
10.000000 MHz
Auto
Man
Freq Offset
0 Hz

UHF(LMR450)

[Downlink]



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RF
50 Ω AC
CORREC
SENSE:INT
ALIGN AUTO
03:19:59 PM Aug 24, 2016
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 20 dB
#Avg Type: RMS
Avg|Hold: 10/10
TRACE 1 2 3 4 5 6
TYPE A
DET A N N N N N
Mkr1 470.0 MHz
-60.369 dBm
10 dB/div
Log
Ref 10.00 dBm
0.00
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
1
Center 470.00 MHz
#Res BW 1.0 MHz
VBW 100 kHz*
Span 100.0 MHz
#Sweep 100.0 ms (1001 pts)
MSG
STATUS
Frequency
Auto Tune
Center Freq
470.000000 MHz
Start Freq
420.000000 MHz
Stop Freq
520.000000 MHz
CF Step
10.000000 MHz
Auto
Man
Freq Offset
0 Hz

10. EMISSION MASKS

FCC Rules

Test Requirement(s):

§ 90.210 Emission masks:

Except as indicated elsewhere in this part, transmitters used in the radio services governed by this part must comply with the emission masks outlined in this section. Unless otherwise stated, per paragraphs (d)(4), (e)(4), and (o) of this section, measurements of emission power can be expressed in either peak or average values provided that emission powers are expressed with the same parameters used to specify the unmodulated transmitter carrier power. For transmitters that do not produce a full power unmodulated carrier, reference to the unmodulated transmitter carrier power refers to the total power contained in the channel bandwidth. Unless indicated elsewhere in this part, the table in this section specifies the emission masks for equipment operating under this part.

APPLICABLE EMISSION MASKS

Frequency band (MHz)	Mask for equipment with audio low pass filter	Mask for equipment without audio low pass filter
Below 25[1]	A or B	A or C
25-50	B	C
72-76	B	C
150-174[2]	B, D, or E	C, D or E
150 paging only	B	C
220-222	F	F
421-512[2 5]	B, D, or E	C, D, or E
450 paging only	B	G
806-809/851-854	B	H
809-824/854-869[3 5]	B	G
896-901/935-940	I	J
902-928	K	K
929-930	B	G
4940-4990 MHz	L or M	L or M
5850-5925[4]		
All other bands	B	C

[2]Equipment designed to operate with a 25 kHz channel bandwidth must meet the requirements of Emission Mask B or C, as applicable. Equipment designed to operate with a 12.5 kHz channel bandwidth must meet the requirements of Emission Mask D, and equipment designed to operate with a 6.25 kHz channel bandwidth must meet the requirements of Emission Mask E.

(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 or three times the channel bandwidth) to capture the true peak emission of the equipment under test. In order to show compliance with the emission 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 (o) 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, an alternate procedure may be used provided prior Commission approval is obtained.

Test Procedures:

a) Connect a signal generator to the input of the EUT.

b) Configure the signal generator to transmit the appropriate test signal associated with the public safety emission designation (see Table 1).

c) Configure the signal level to be just below the AGC threshold (see results from 4.2).

d) Connect a spectrum analyzer to the output of the EUT using appropriate attenuation as necessary.

e) Set the spectrum analyzer center frequency to the nominal EUT channel center frequency. The span range for the spectrum analyzer shall be between 2 times to 5 times the EBW (or OBW).

f) The nominal resolution bandwidth (RBW) shall 300 Hz for 16K0F3E and 100 Hz for all other emissions types.
g) Set the reference level of the spectrum analyzer to accommodate the maximum input amplitude level.
h) Set spectrum analyzer detection mode to peak, and trace mode to max hold.
i) Allow the trace to fully stabilize.
j) Confirm that the signal is contained within the appropriate emissions mask.
k) Use the marker function to determine the maximum emission level and record the associated frequency as f0.
l) Capture the emissions mask plot for inclusion in the test report (output signal spectra).
m) Measure the EUT input signal power (signal generator output signal) directly from the signal generator using power measurement guidance provided in KDB Publication 971168 (input signal spectra).
n) Compare the spectral plot of the output signal (determined in step k), to the input signal (determined in step l) to affirm they are similar (in passband and rolloff characteristic features and relative spectral locations).
o) Repeat the procedure for both test signals with the input signal amplitude set 3 dB above the AGC threshold.
p) Repeat steps b) to n) for all authorized operational bands and emissions types (see applicable regulatory specifications, e.g., §90.210).
q) Include all accumulated spectral plots depicting EUT input signal and EUT output signal in the test report and note any observed dissimilarities.

Test Results: The EUT complies with the requirements of this section.

Input Signal	Input Level (dBm)		Maximum Amp Gain	
	DL	UL	DL	UL
VHF(APCO25)	-57	-61	85	85
UHF(APCO25)	-48	-58	85	85
UHF(LMR450)	-58	-68	95	95

Plots of Emission Mask

VHF(APCO25) DL

[138.5 MHz Downlink Emission Mask E]

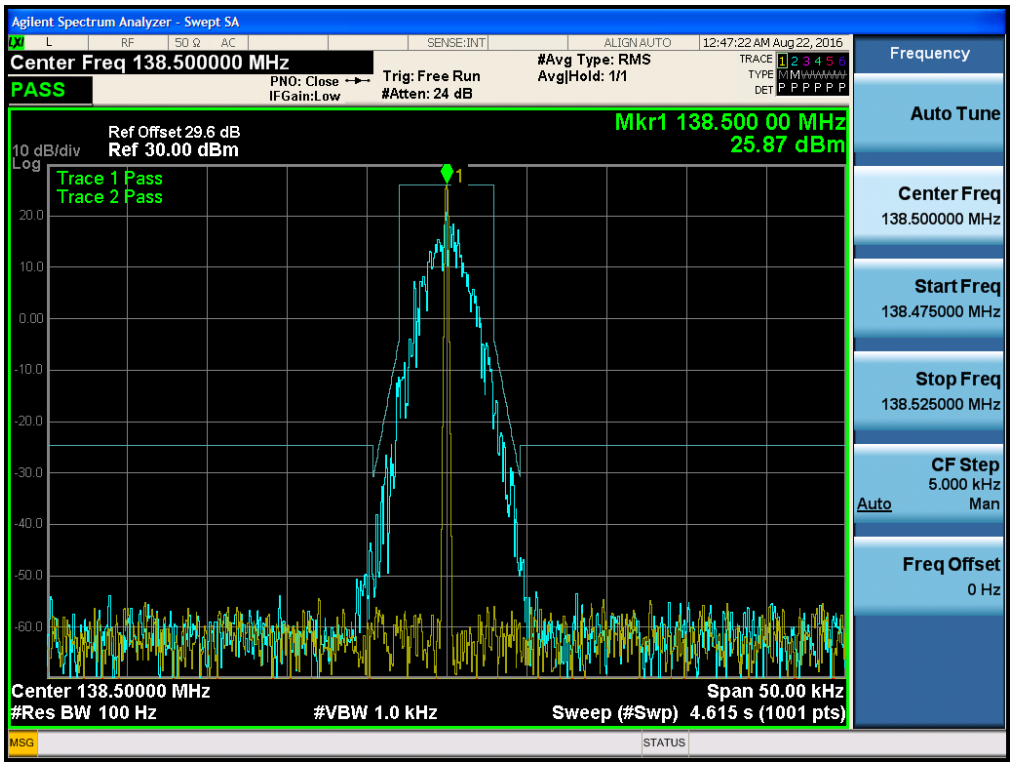
[150.5 MHz Downlink Emission Mask E]

[162.0 MHz Downlink Emission Mask E]

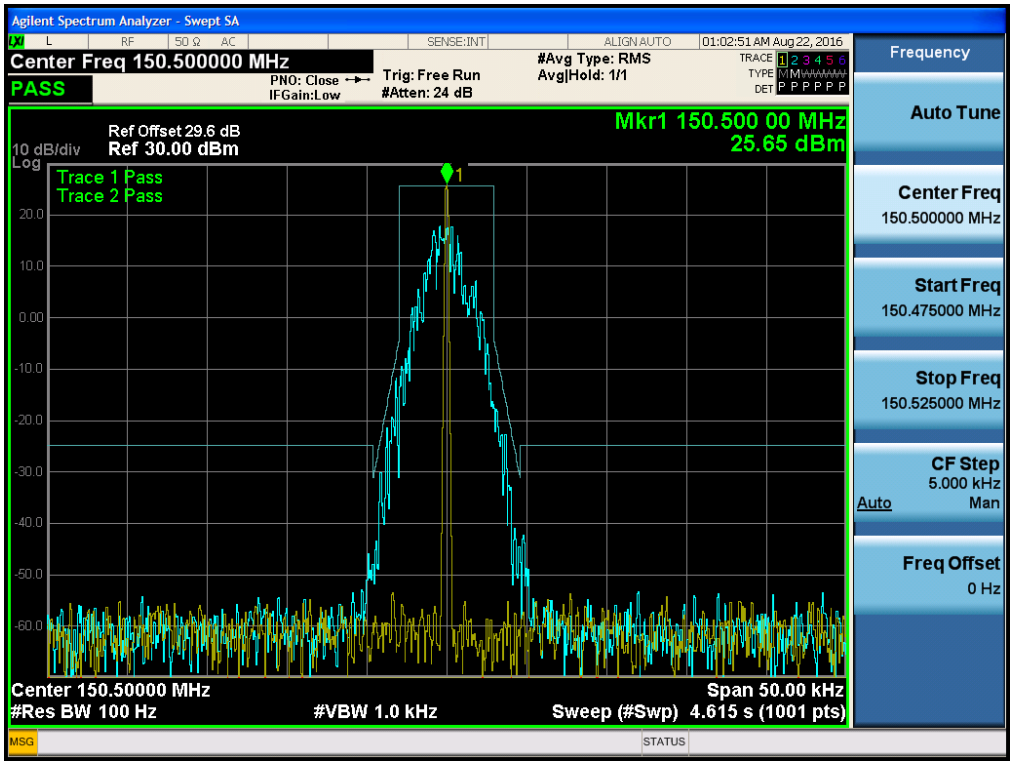
[173.5 MHz Downlink Emission Mask E]

VHF(APCO25) UL

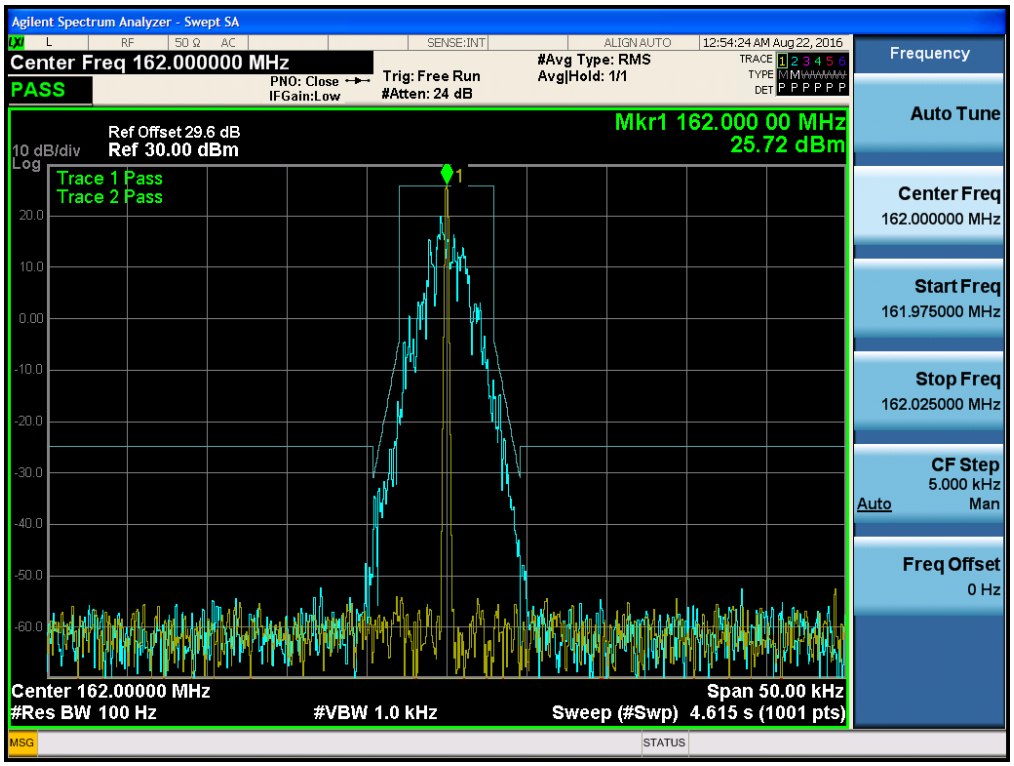
[138.5 MHz Uplink Emission Mask E]



[150.5 MHz Uplink Emission Mask E]



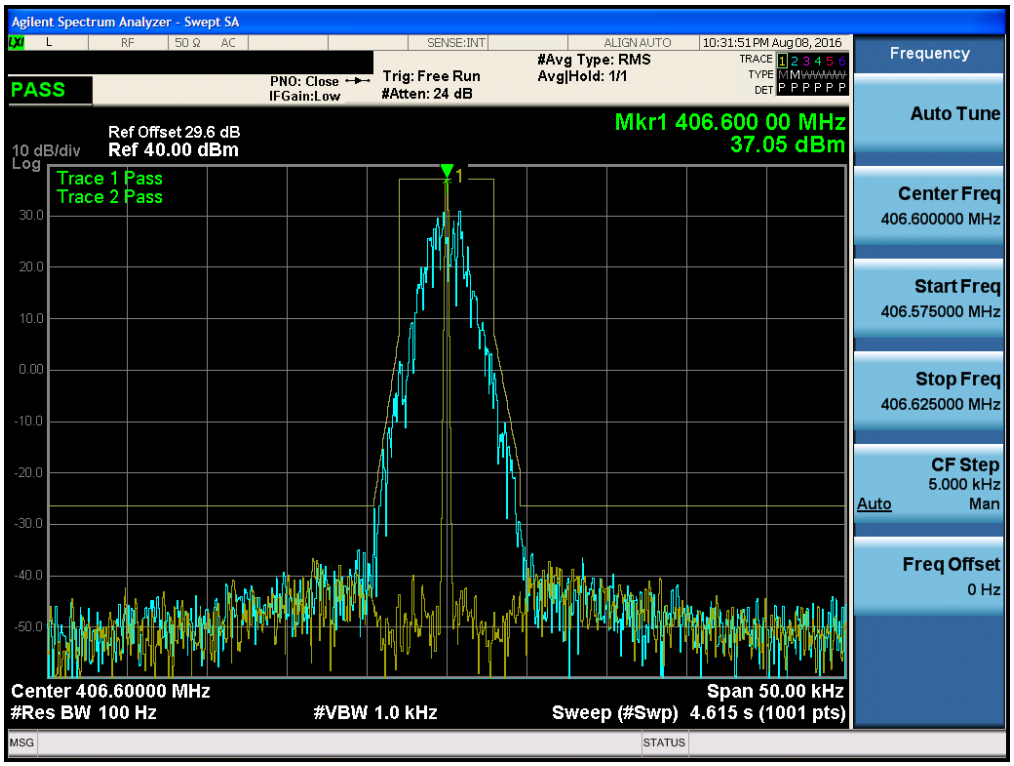
[162.0 MHz Uplink Emission Mask E]



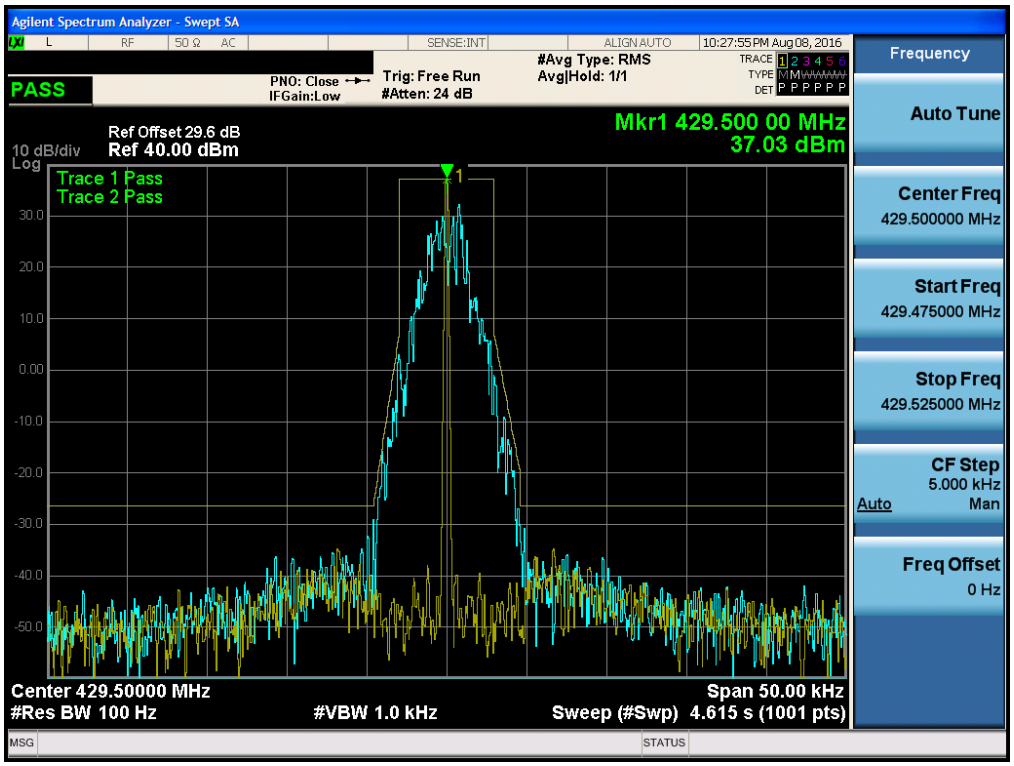
[173.5 MHz Uplink Emission Mask E]

UHF(APCO25) DL

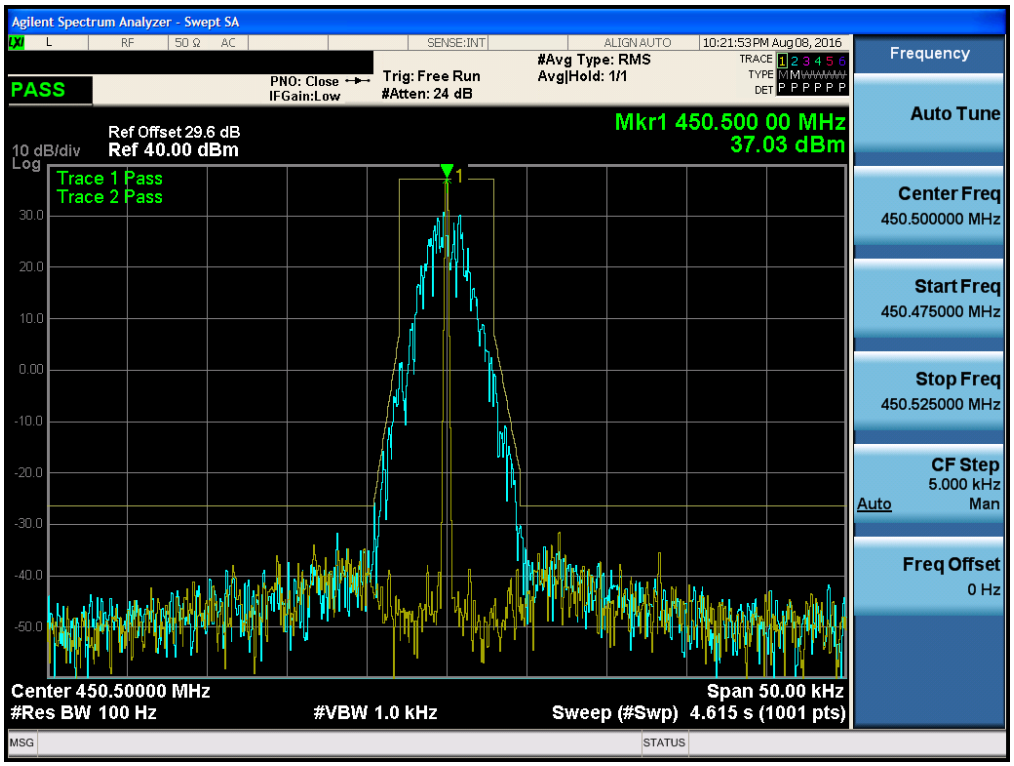
[406.6 MHz Downlink Emission Mask E]



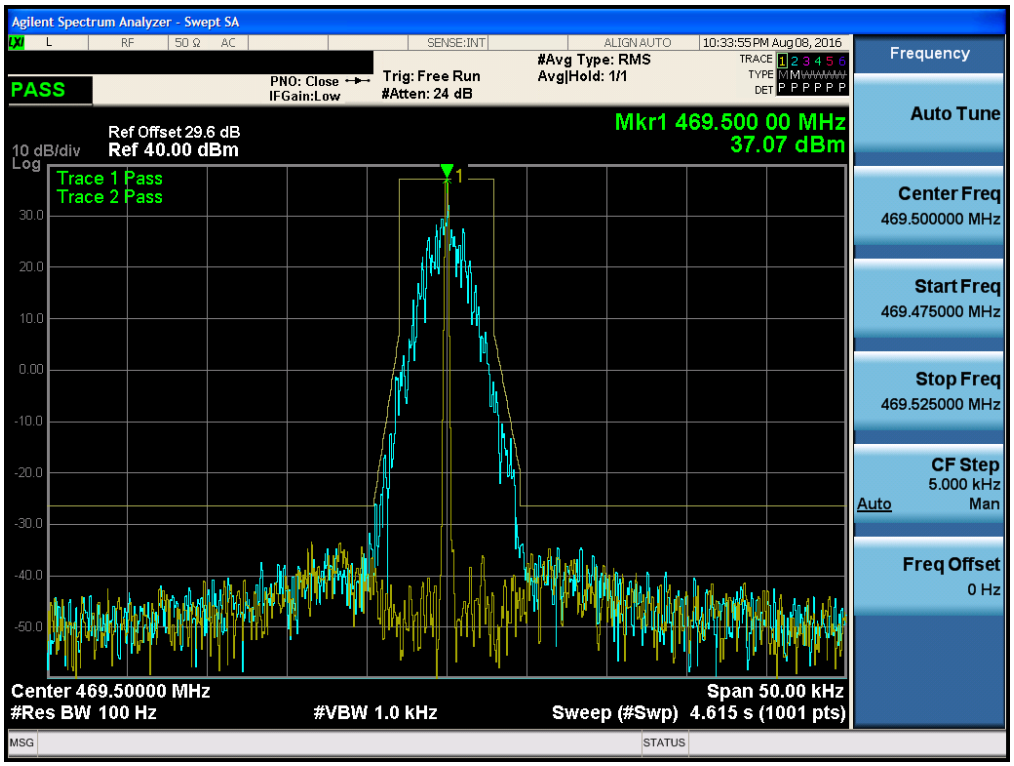
[429.5 MHz Downlink Emission Mask E]



[450.5 MHz Downlink Emission Mask E]



[469.5 MHz Downlink Emission Mask E]



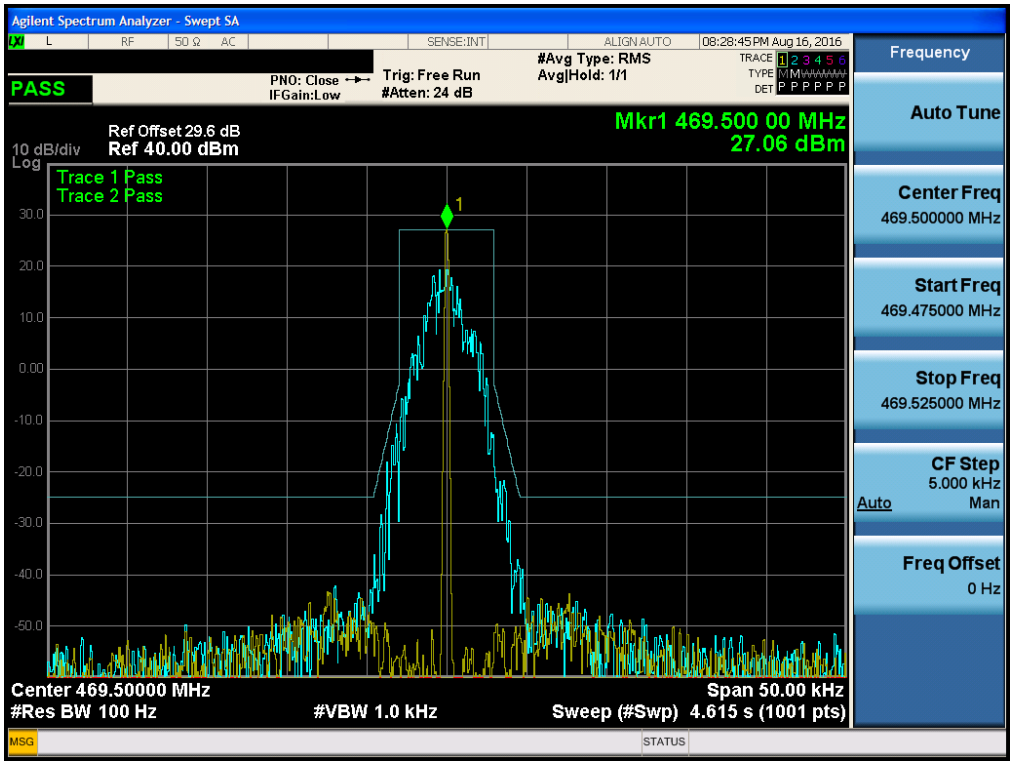
UHF(APCO25) UL

[406.6 MHz Uplink Emission Mask E]

[429.5 MHz Uplink Emission Mask E]

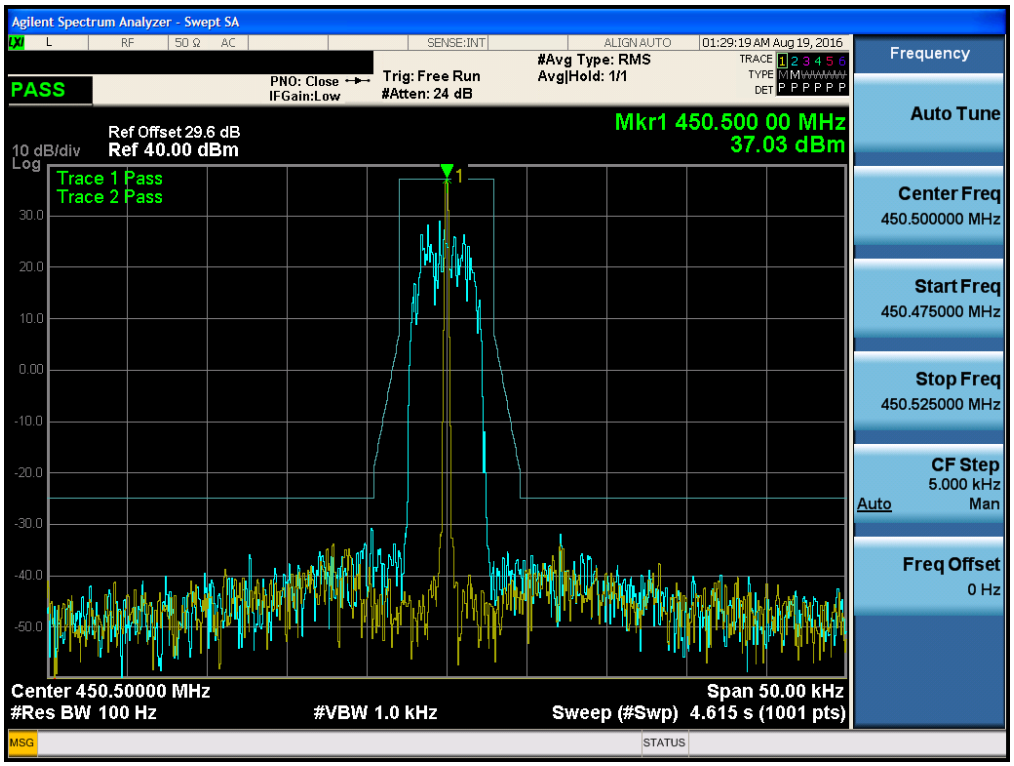
[450.5 MHz Uplink Emission Mask E]

[469.5 MHz Uplink Emission Mask E]

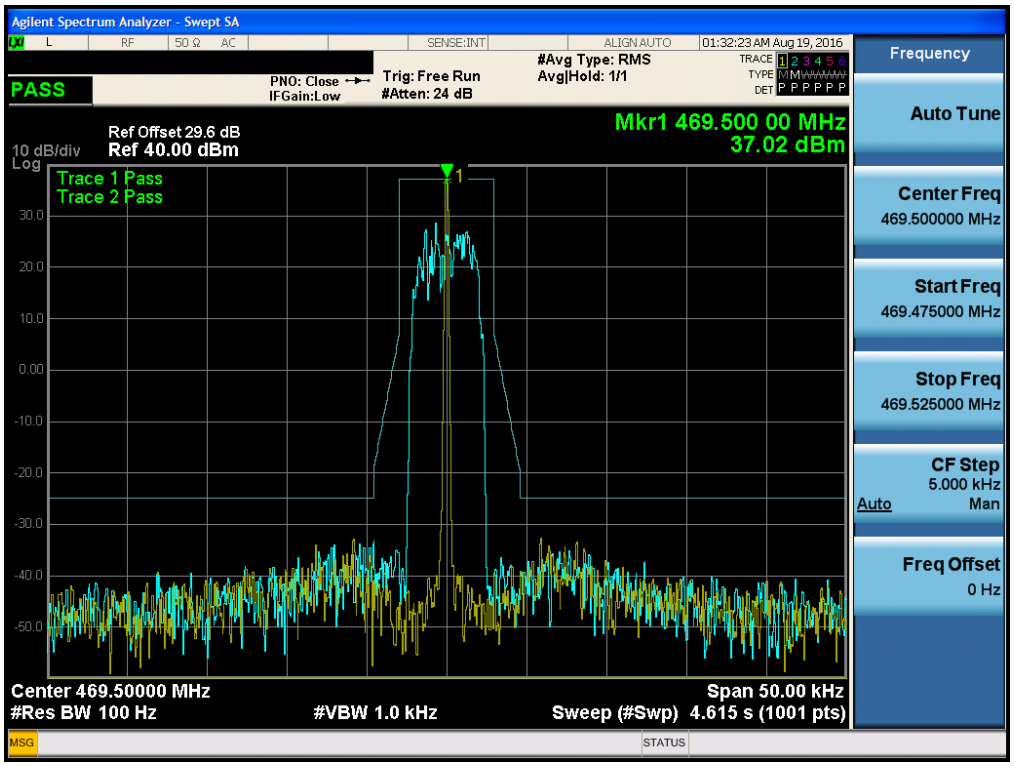


UHF(LMR450) DL

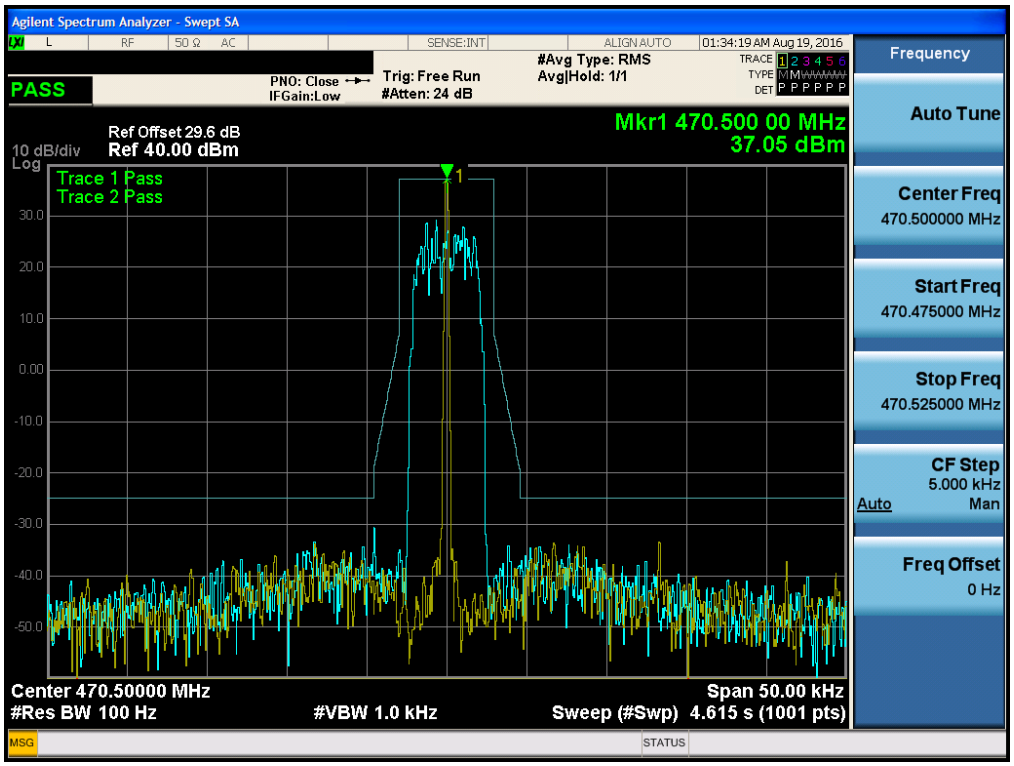
[450.5 MHz Downlink Emission Mask E]



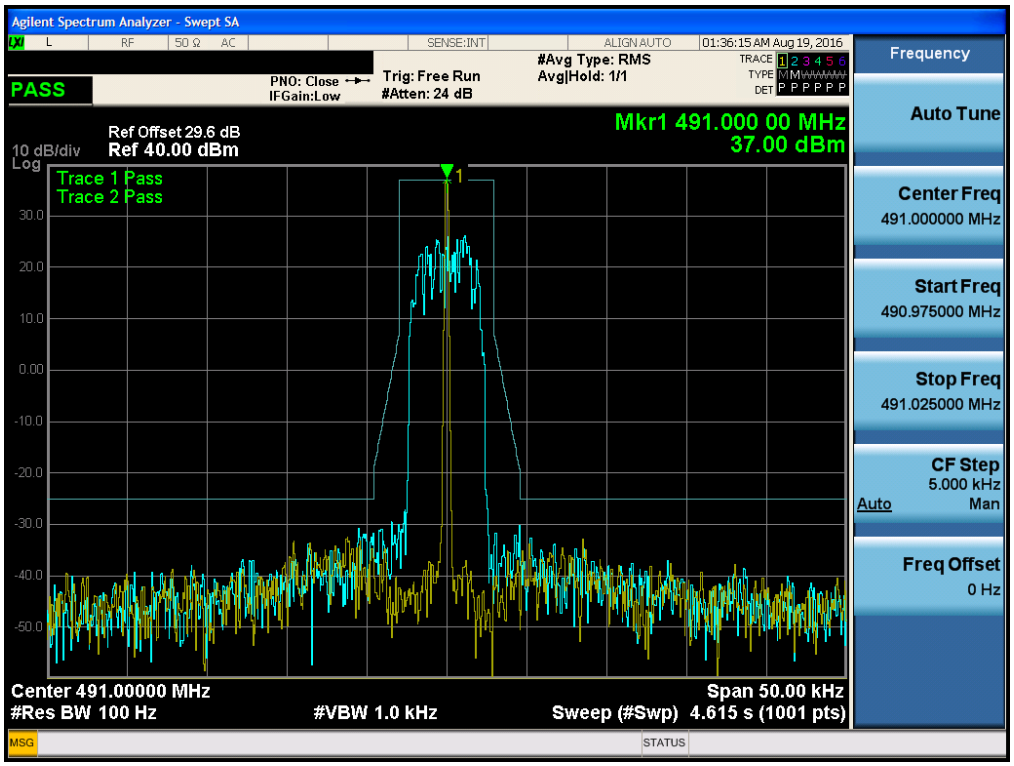
[469.5 MHz Downlink Emission Mask E]



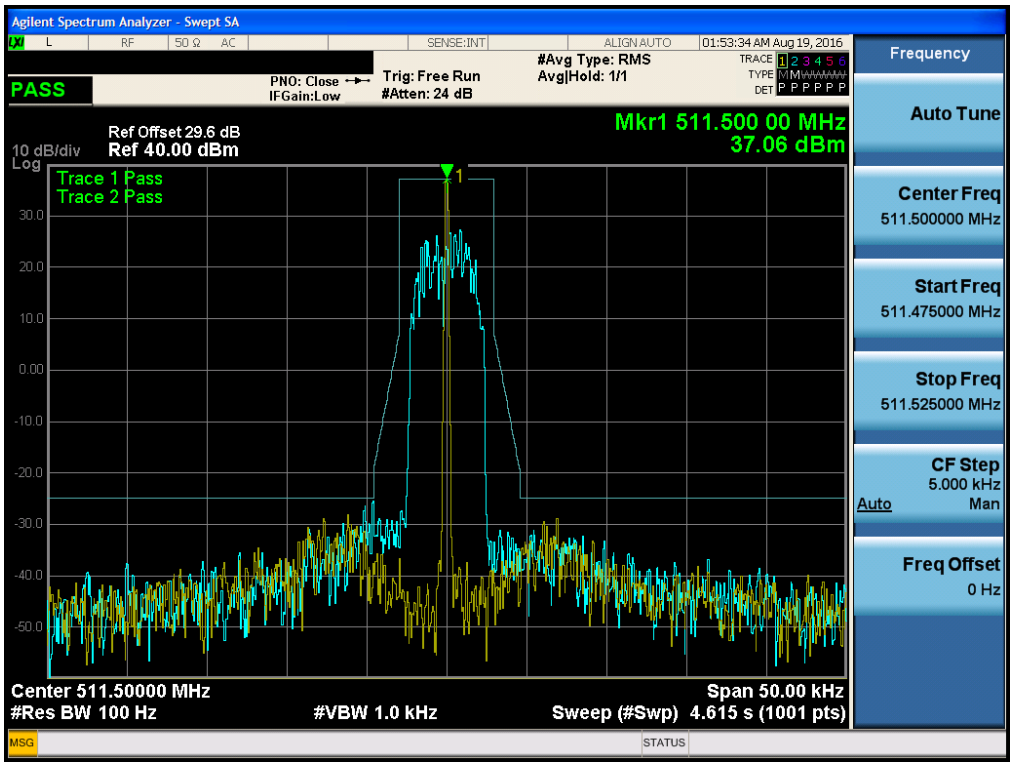
[470.5 MHz Downlink Emission Mask E]



[491.0 MHz Downlink Emission Mask E]

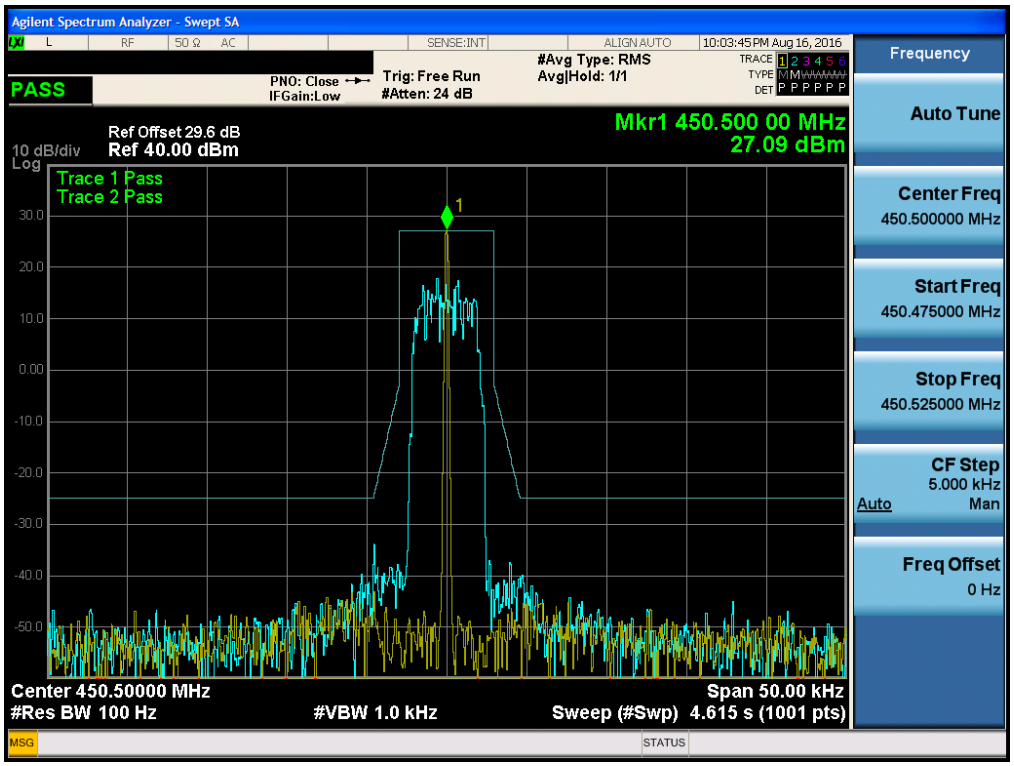


[511.5 MHz Downlink Emission Mask E]

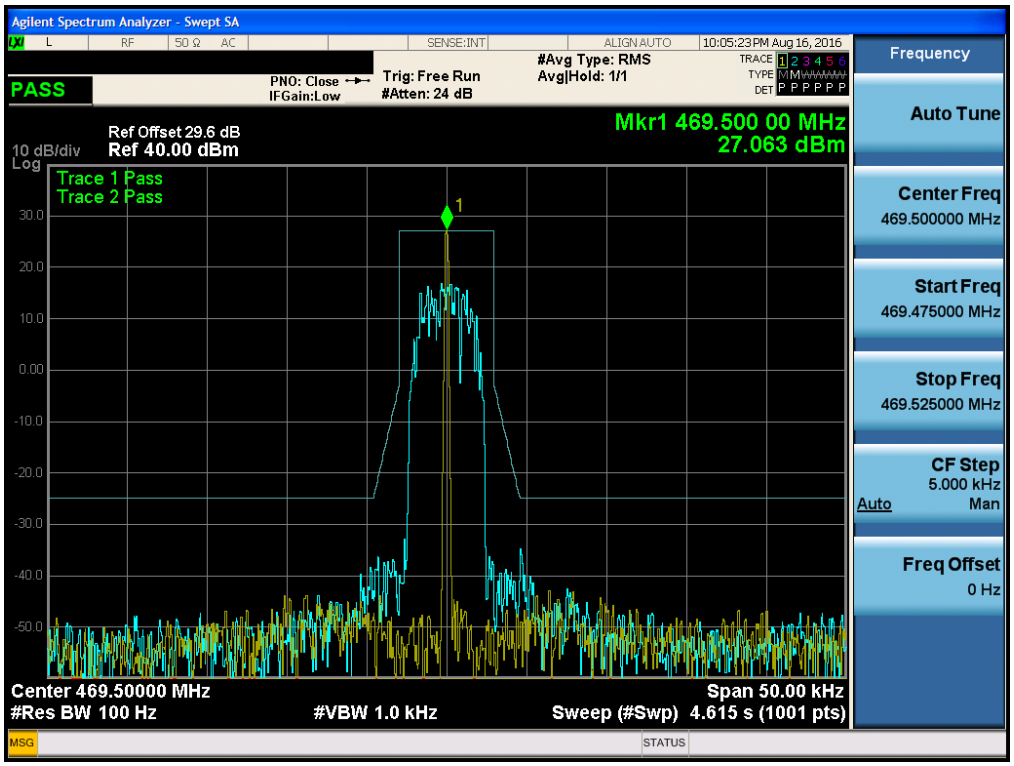


UHF(APCO25) UL

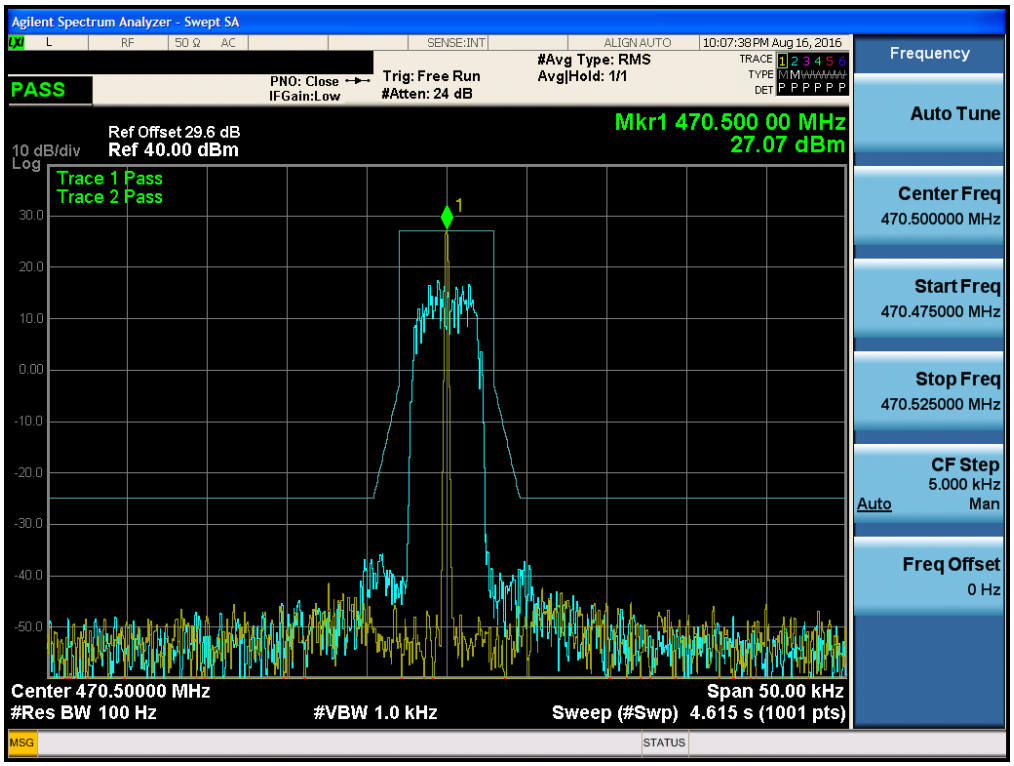
[450.5 MHz Uplink Emission Mask E]



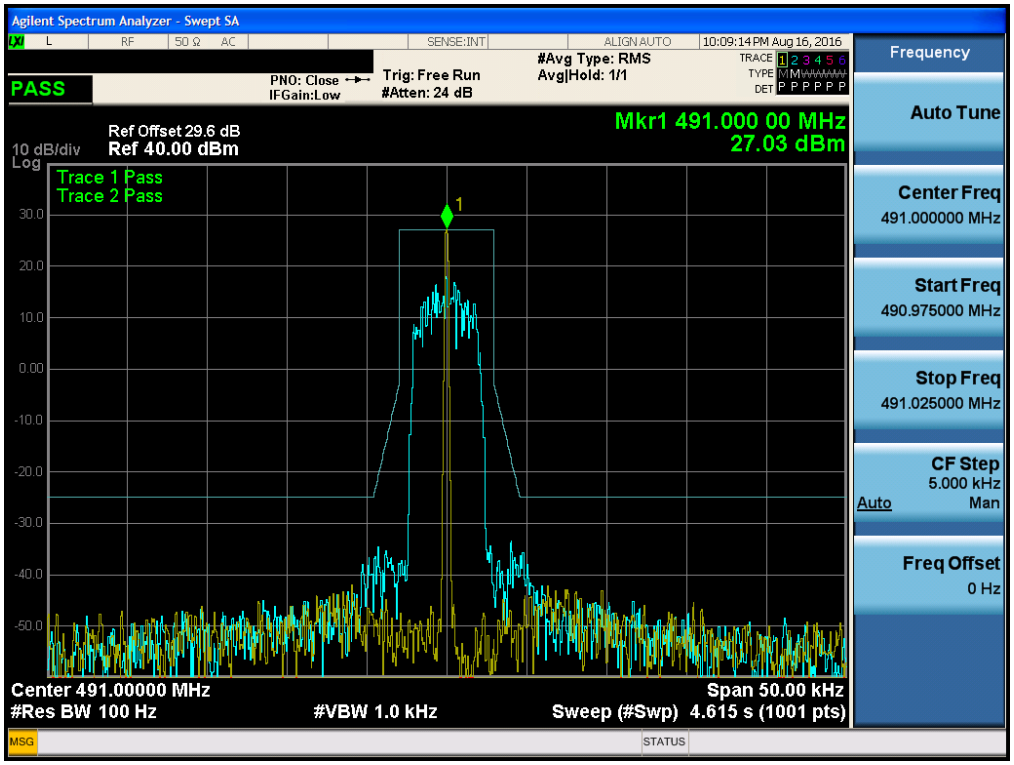
[469.5 MHz Uplink Emission Mask E]



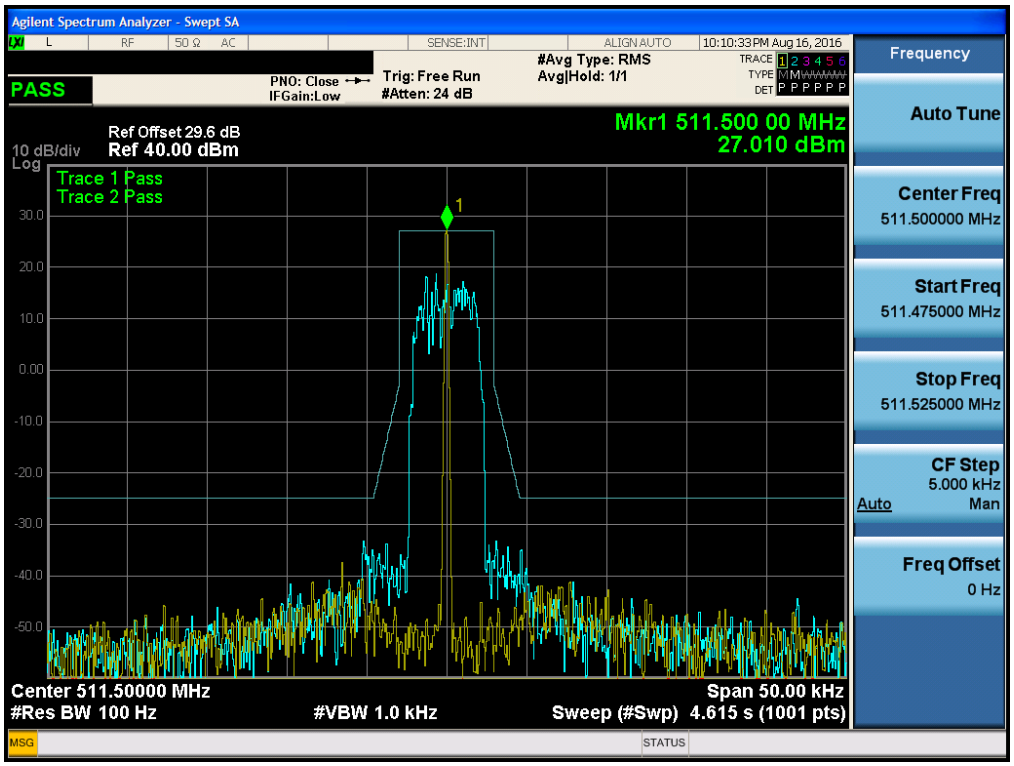
[470.5 MHz Uplink Emission Mask E]



[491.0 MHz Uplink Emission Mask E]



[511.5 MHz Uplink Emission Mask E]



11. SPURIOUS AND HARMONIC EMISSION AT ANTENNA TERMINAL

FCC Rules

Test Requirement(s):

§ 2.1051 Measurements required: Spurious emissions at antenna terminals:

The radio frequency voltage or powers generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent data shall show the magnitude of each harmonic and other spurious emission that can be detected when the equipment is operated under the conditions specified in § 2.1049 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.

§ 90.219 Use of signal booters.

(e) *Device Specifications.* In addition to the general rules for equipment certification in §90.203(a)(2) and part 2, subpart J of this chapter, a signal booster must also meet the rules in this paragraph.

(3) Spurious emissions from a signal booster must not exceed −13 dBm within any 100 kHz measurement bandwidth.

IC Rules

Test Requirement(s):

RSS-131

6.4 Spurious Emissions

Spurious emissions of zone enhancers and translators shall be suppressed as much as possible. Spurious emissions shall be attenuated below the rated power of the enhancer by at least:
43 + 10 Log10(Prated in watts), or 70 dB, whichever is less stringent.

Note: If the minimum standard is not met, check to see if the input signal generators have a high harmonic content.

Test Procedures:

RSS-131

4.4 Spurious Emissions

4.4.1 Multi-channel Enhancer

The spurious emissions of the equipment under test shall be measured using the two-tone method in section 4.3.1, with the two tones Po1 and Po2 set to the required levels.

Using a spectrum analyser with a resolution bandwidth set at 100 kHz, search for spurious emissions from 30 MHz to at least 5 times the highest RF passband frequency. The search may omit the band that contains the test tones and intermodulation products.

4.4.2 Single channel Enhancer

The enhancer shall be operated as described in section 4.3.2 during the search for spurious emissions.

Using a spectrum analyser with a resolution bandwidth set at 100 kHz, search for spurious emissions from 30 MHz to at least 5 times the highest RF passband frequency. The search may omit the band that contains the input signal.

Test Procedures: Measurements were in accordance with the test methods section 3.6 and 4.7 of KDB 935210 D05 v01r01.

3.6.1. General

Spurious emissions shall be measured using a single test signal sequentially tuned to the low, middle and high channels or frequencies within each authorized frequency band of operation.

Out-of-band/block emissions (including intermodulation products) shall be measured under each of the following two stimulus conditions:

a) two adjacent test signals sequentially tuned to the lower and upper frequency band/block edges;

b) a single test signal, sequentially tuned to the lowest and highest frequencies or channels within the frequency band/block under examination.

NOTE—Single channel boosters that cannot accommodate two simultaneous signals within the passband, can be excluded from the test stipulated in step a).

3.6.2. EUT out-of-band/block emissions conducted measurement

a) Connect a signal generator to the input of the EUT.

NOTE—If the signal generator is not capable of generating two modulated carriers simultaneously, then two discrete signal generators can be connected with an appropriate combining network to support the two-tone test.

b) Set the signal generator to produce two AWGN signals as previously described (e.g., 4.1 MHz OBW).

c) Set the center frequencies such that the AWGN signals occupy adjacent channels, as defined by industry standards such as 3GPP or 3GPP2, at the upper edge of the frequency band or block of interest.

d) Set the composite power levels such that the input signal is just below the AGC threshold (see 3.2), but not more than 0.5 dB below. The composite power can be measured using the procedures provided in KDB Publication 971168, but it will be necessary to expand the power integration bandwidth so as to include both of the transmit channels. Alternatively, the composite power can be measured using an average power meter as described in KDB Publication 971168.

e) Connect a spectrum analyzer to the output of the EUT using appropriate attenuation as necessary.
f) Set the RBW = reference bandwidth in the applicable rule section for the supported frequency band (typically 1 % of the emission bandwidth, 100 kHz, or 1 MHz)
g) Set the VBW = 3 × RBW.
h) Set the detector to power averaging (rms) detector.
i) Set the Sweep time = auto-couple.
j) Set the analyzer start frequency to the upper block edge frequency and the stop frequency to the upper block edge frequency plus 300 kHz or 3 MHz for frequencies below and above 1 GHz, respectively.
k) Trace average at least 100 traces in power averaging (i.e., rms) mode.
l) Use the marker function to find the maximum power level.
m) Capture the spectrum analyzer trace of the power level for inclusion in the test report.
n) Repeat the procedure with the composite input power level set to 3 dB above the AGC threshold.
o) Reset the input signals frequencies to the lower edge of the frequency block or band under examination.
p) Reset the spectrum analyzer start frequency to the lower block edge frequency minus 300 kHz, or 3 MHz (for frequencies below and above 1 GHz, respectively), and the stop frequency to the lower band or block edge frequency.
q) Repeat steps k) to n).
r) Repeat steps a) to q) with the signal generator configured for a single test signal tuned as close as possible to the block edges.
s) Repeat steps a) to r) with the narrowband test signal.
t) Repeat steps a) to s) for all authorized frequency bands or blocks used by the EUT.

3.6.3. EUT spurious emissions conducted measurement
a) Connect a signal generator to the input of the EUT.
b) Set the signal generator to produce the broadband test signal as previously described (e.g., 4.1 MHz OBW AWGN).
c) Set the center frequency of the test signal to the lowest available channel within the frequency band or block.
d) Set the EUT input power to a level that is just below the AGC threshold (see 3.2), but not more than 0.5 dB below.
e) Connect a spectrum analyzer to the output of the EUT using appropriate attenuation as necessary.
f) Set the RBW = reference bandwidth in the applicable rule section for the supported frequency band of operation (e.g., reference bandwidth is typically 100 kHz or 1 MHz).

g) Set the VBW ≥ 3 × RBW.

h) Set the Sweep time = auto-couple.

i) Set the analyzer start frequency to the lowest radio frequency signal generated in the equipment, without going below 9 kHz, and the stop frequency to the lower band/block edge frequency minus 100 kHz or 1 MHz, as specified in the applicable rule part.

NOTE—The number of measurement points in each sweep must be ≥ (2 × span/RBW) which may require that the measurement range defined by the start and stop frequencies be subdivided, depending on the available number of measurement points provided by the spectrum analyzer.

j) Select the power averaging (rms) detector function.

k) Trace average at least 10 traces in power averaging (i.e., rms) mode.

l) Use the peak marker function to identify the highest amplitude level over each measured frequency range. Record the frequency and amplitude and capture a plot for inclusion in the test report.

m) Reset the analyzer start frequency to the upper band/block edge frequency plus 100 kHz or 1 MHz, as specified in the applicable rule part, and the analyzer stop frequency to 10 times the highest frequency of the fundamental emission (see §2.1057). Note that the number of measurement points in each sweep must be ≥ (2 × span/RBW) which may require that the measurement range defined by the start and stop frequencies be subdivided, depending on the available number of measurement points provided by the spectrum analyzer.

n) Trace average at least 10 traces in power averaging (i.e., rms) mode.

o) Use the peak marker function to identify the highest amplitude level over each of the measured frequency ranges. Record the frequency and amplitude and capture a plot for inclusion in the test report and provide tabular data, if required.

p) Repeat the procedure with the input test signals tuned to a middle band/block frequency/channel and then a high band/block frequency/channel.

q) Repeat entire procedure with the narrowband test signal.

r) Repeat for all authorized frequency bands/blocks used by the EUT.

4.7.2 EUT out-of-band/block emissions conducted measurement

Intermodulation products shall be measured while applying two CW tones spaced in frequency ±12.5 kHz relative to the center frequency (f0) as determined from 4.4.

a) Connect a signal generator to the input of the EUT.

NOTE—If the signal generator is not capable of producing two independent modulated carriers simultaneously, then two discrete signal generators can be connected with an appropriate combining network to support the two-tone test.

b) Configure the two signal generators to produce CW tones on frequencies spaced at ±

12.5 kHz relative to f0 with amplitude levels set just below the AGC threshold (see 4.2).

c) Connect a spectrum analyzer to the EUT output.

d) Set the span to 100 kHz.

e) Set the resolution bandwidth to 300 Hz with a video bandwidth ≥ 3 × RBW.

f) Set the detector to power average (rms).

g) Place a marker on highest intermodulation product amplitude.

h) Capture the plot for inclusion in the test report.

i) Repeat the procedure with the composite input power level set to 3 dB above the AGC threshold.

j) Repeat steps b) to h) for all operational bands.

4.7.3 EUT spurious emissions conducted measurement

a) Connect a signal generator to the input of the EUT.

b) Configure the signal generator to produce a CW signal.

c) Set the frequency of the CW signal to the center channel of the pass band.

d) Set the output power level so that the resultant signal is just below the AGC threshold (see 4.2).

e) Connect a spectrum analyzer to the output of the EUT using appropriate attenuation as necessary.

f) Set the RBW to 100 kHz.

g) Set the VBW = 3 × RBW.

h) Set the Sweep time = auto-couple.

i) Set the detector to PEAK.

j) Set the analyzer start frequency to 30 MHz (or the lowest radio frequency signal generated in the equipment, without going below 9 kHz if the EUT has internal clock frequencies) and the stop frequency to 10 × the highest allowable frequency of the pass band.

k) Select MAX HOLD and use the marker peak function to find the highest emission(s) outside the pass band. (This could be either at a frequency lesser or greater than the pass band.)

l) Capture a plot for inclusion in the test report.

m) Repeat steps c) to l) for each authorized frequency band/block of operation.

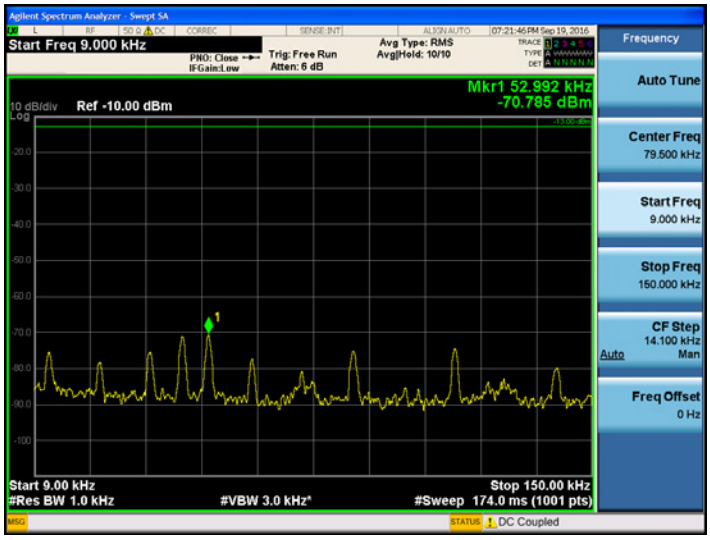
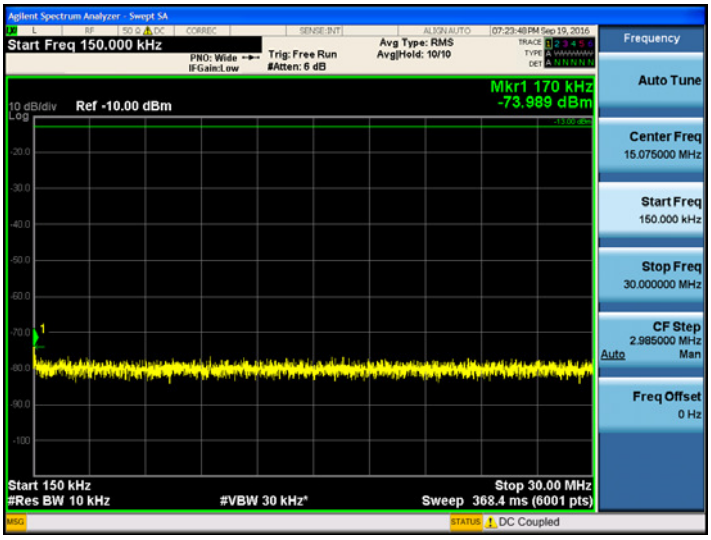
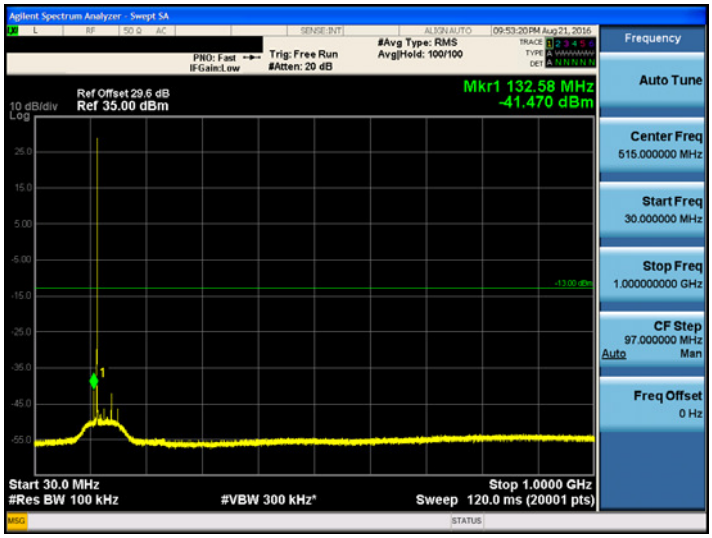
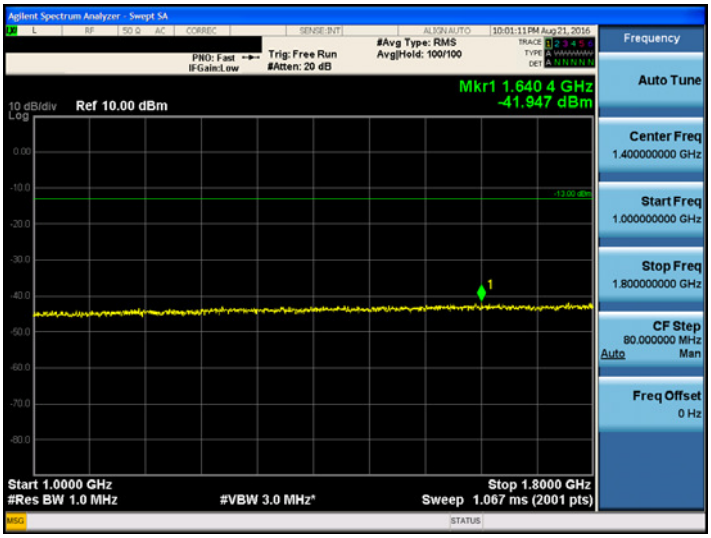
Test Results: The EUT complies with the requirements of this section. There were no Detectable Spurious emissions for this EUT.

Notes: In 9 KHz-150 KHz and 150 KHz-30 MHz bands, RBW was reduced to 1% and 10% of the reference bandwidth for measuring unwanted emission level(typically, 100KHz if the authorized frequency band is below 1GHz) and power was integrated. (1% = +20 dB, 10% = +10 dB)

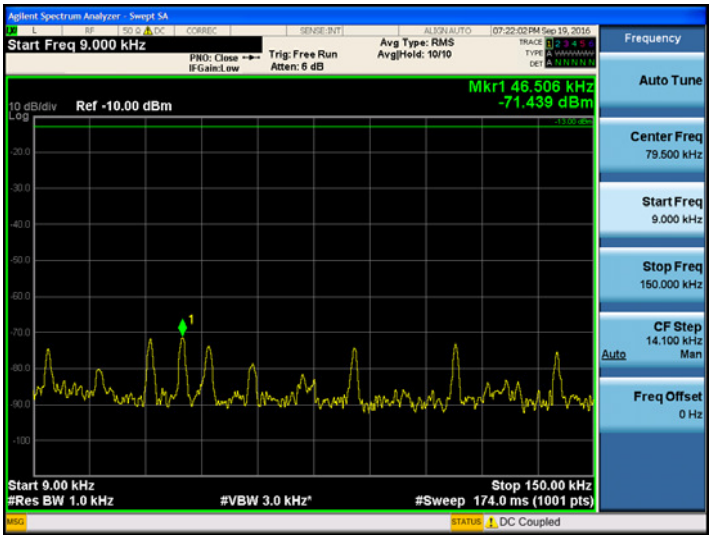
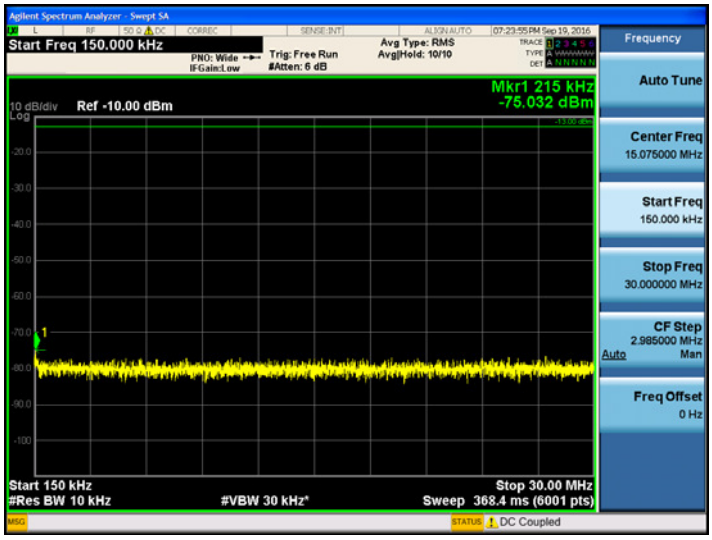
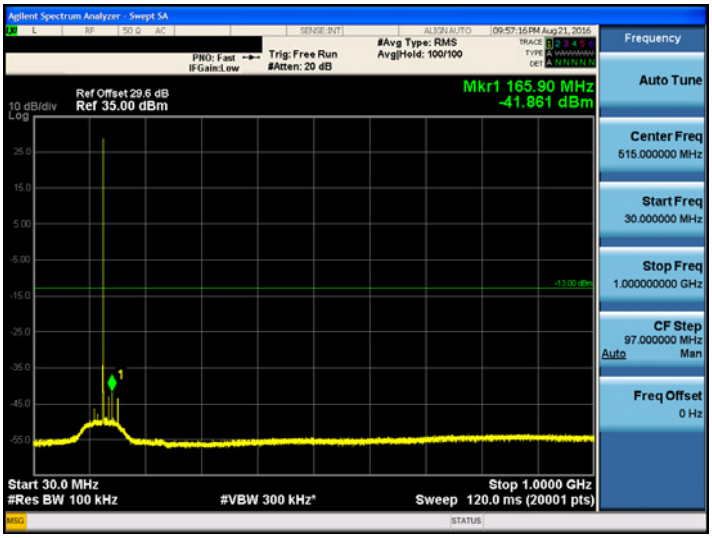
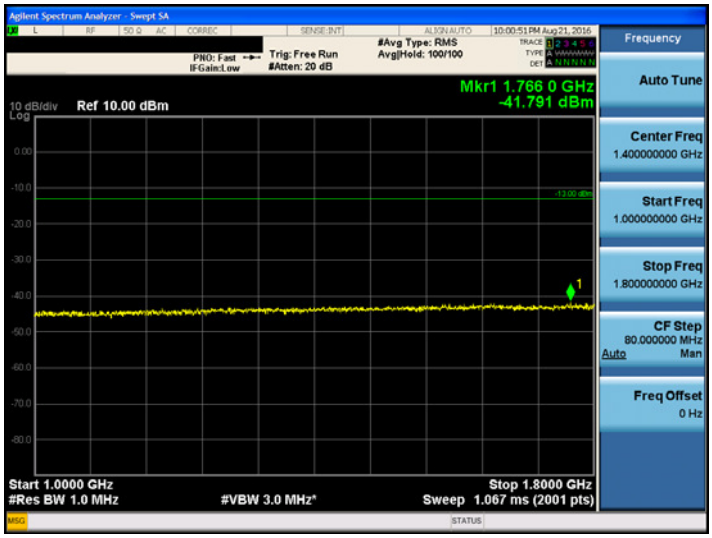
Single channel Enhancer Plots of Spurious Emission

VHF(APCO25)

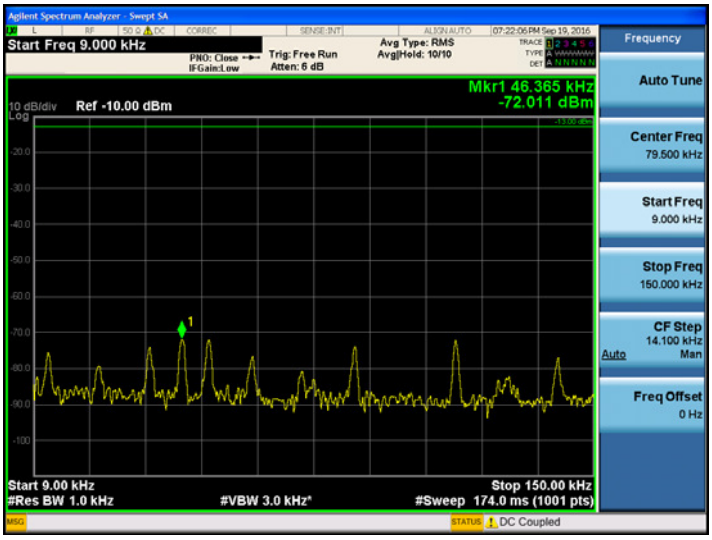
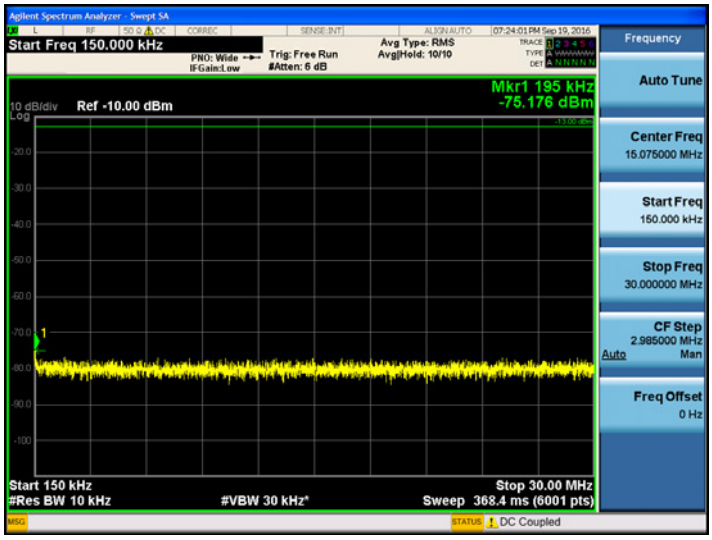
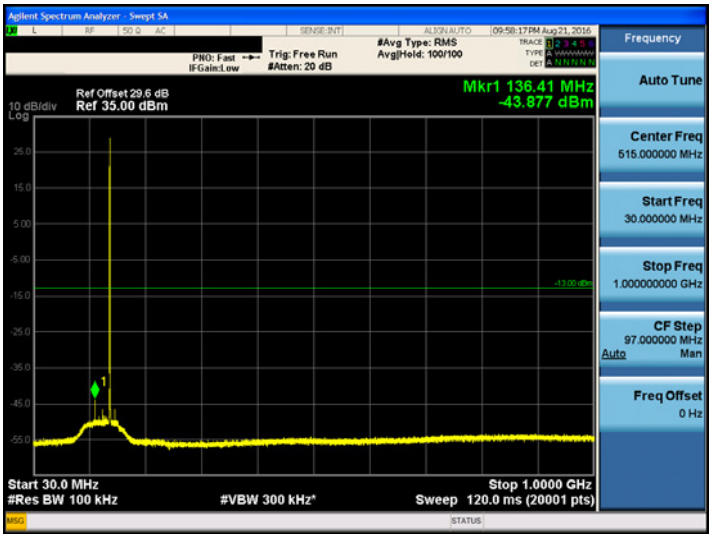
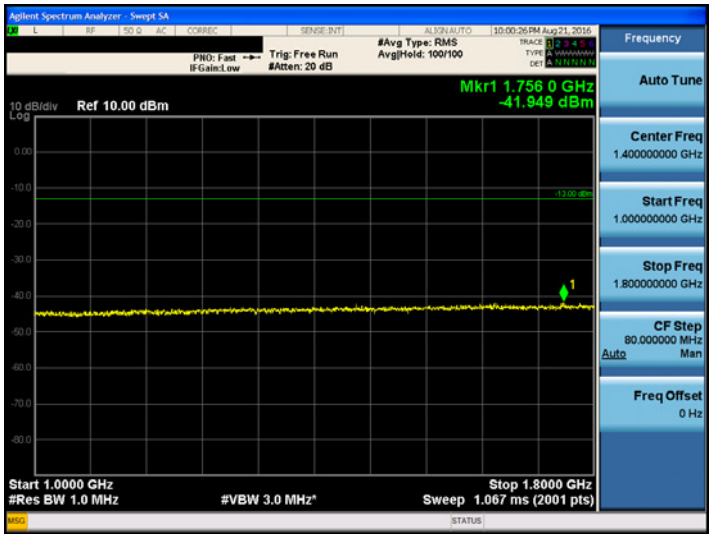
[Downlink_138.5 MHz]

9㎑ ~ 150㎑	150㎑ ~ 30㎒
	
30㎒ ~ 1㎓	**1 GHz ~ 1.8 GHz**
	

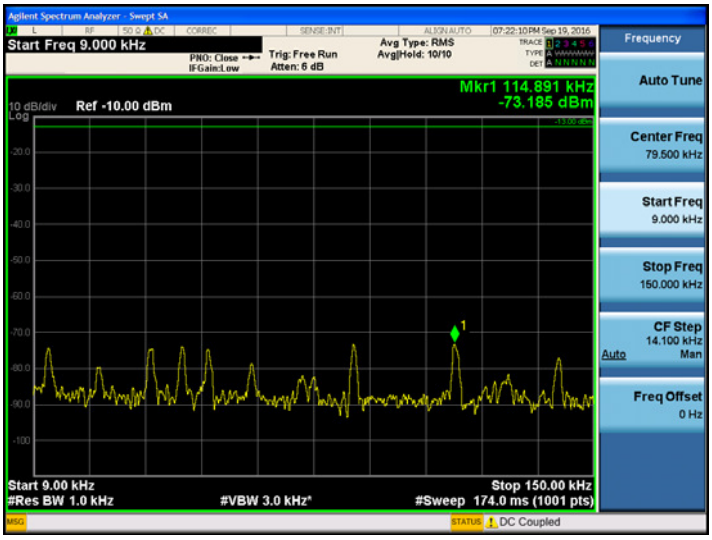
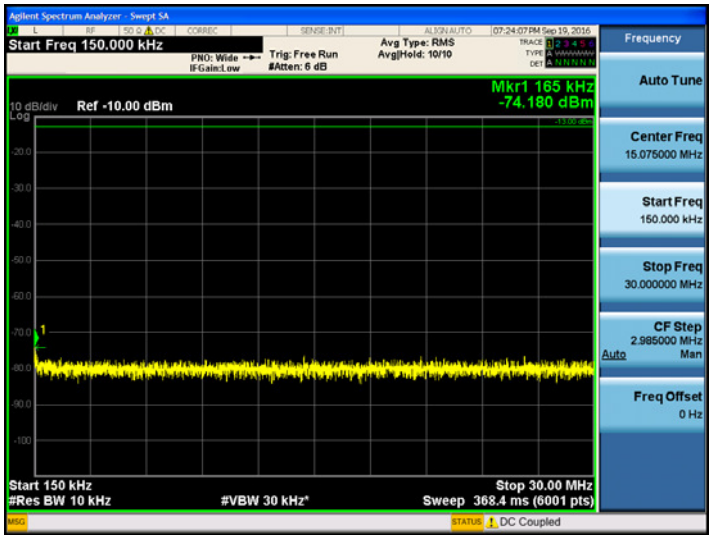
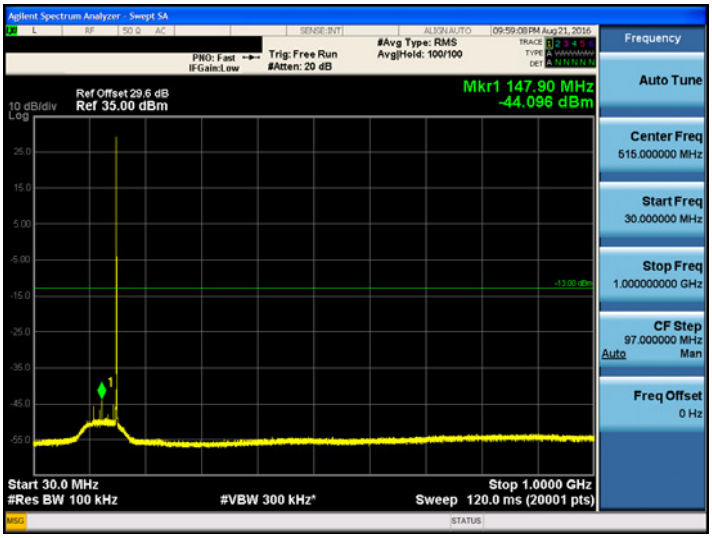
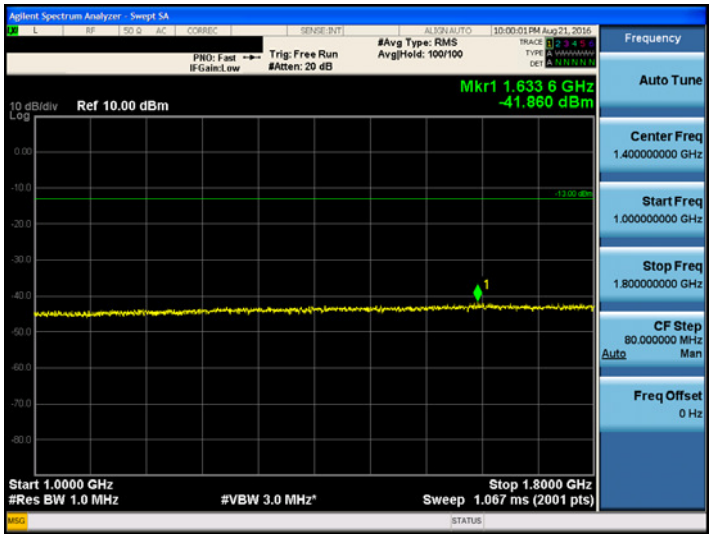
[Downlink_150.5 MHz]

9㎑ ~ 150㎑	150㎑ ~ 30㎒
	
30㎒ ~ 1㎓	**1 GHz ~ 1.8 GHz**
	

[Downlink_162.0 MHz]

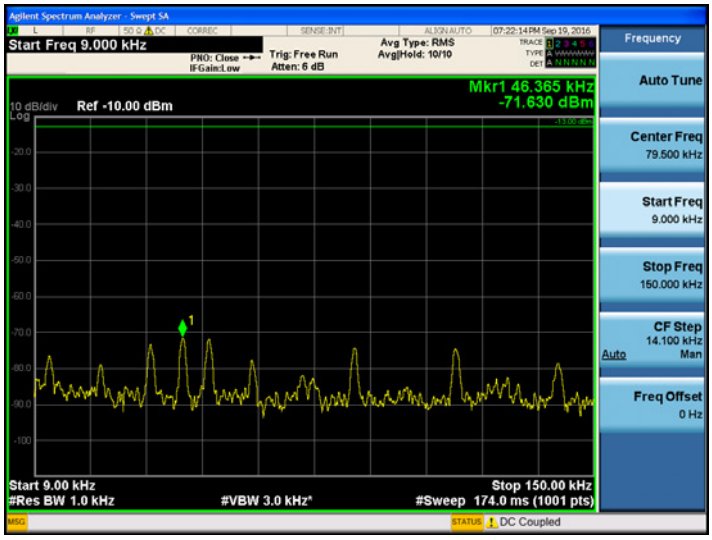
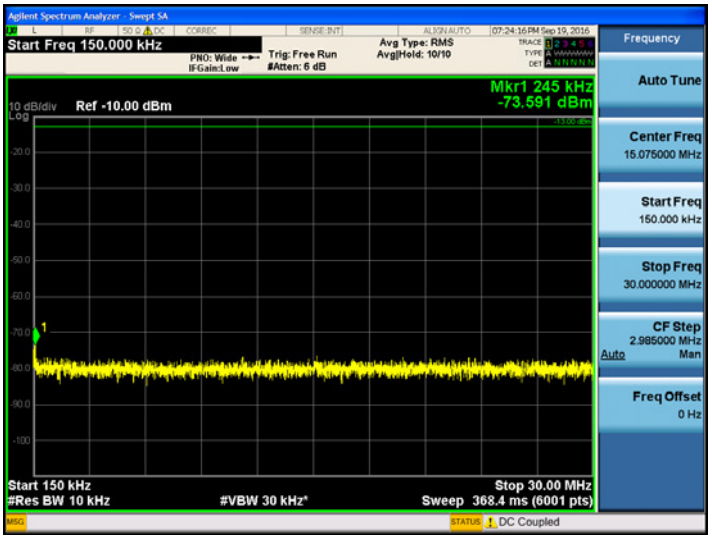
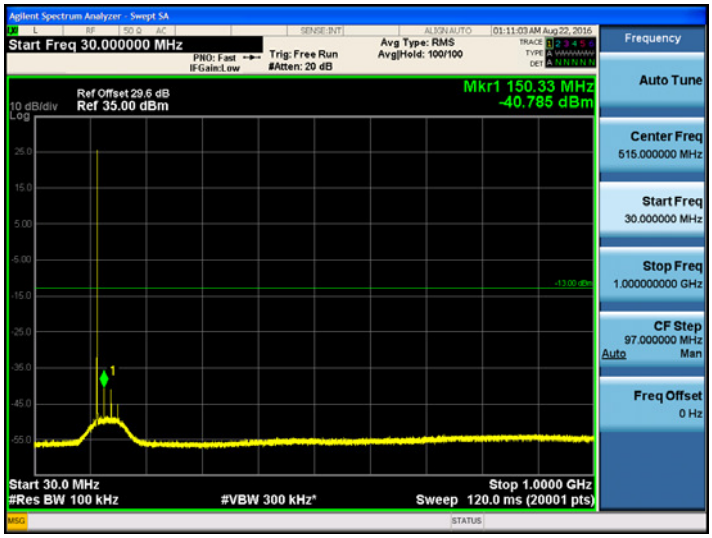
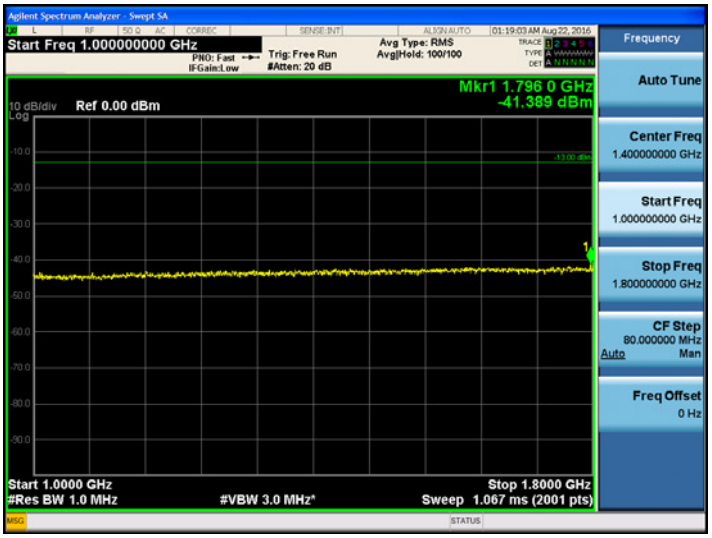
9㎑ ~ 150㎑	150㎑ ~ 30㎒
	
30㎒ ~ 1㎓	**1 GHz ~ 1.8 GHz**
	

[Downlink_173.5 MHz]

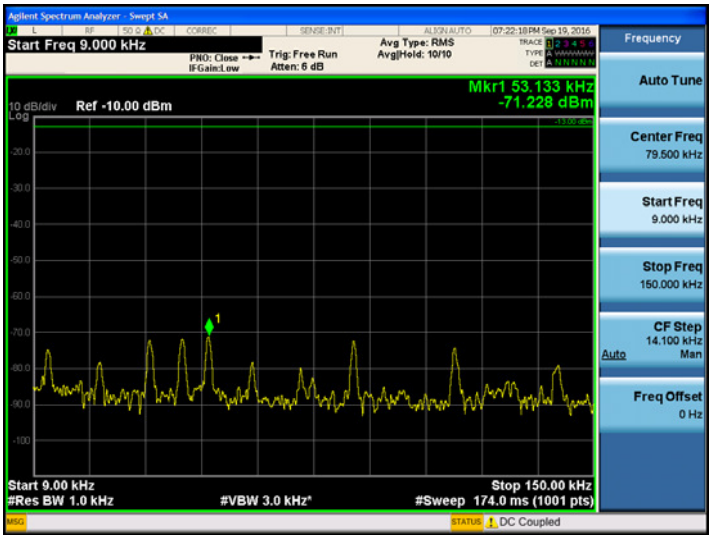
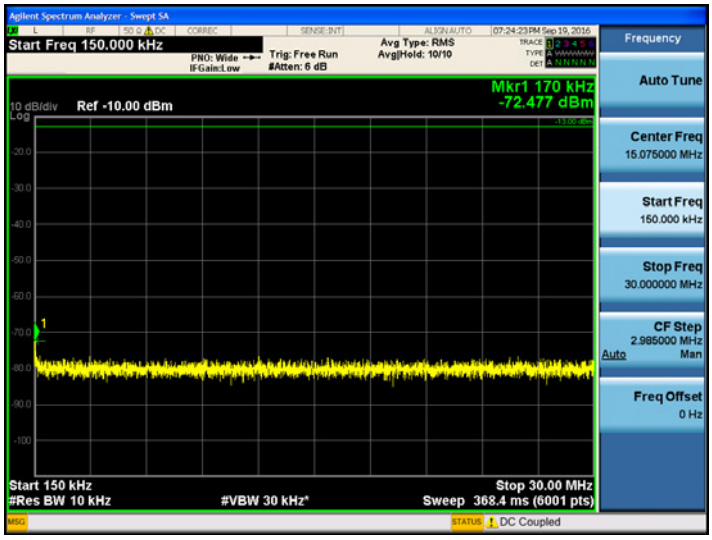
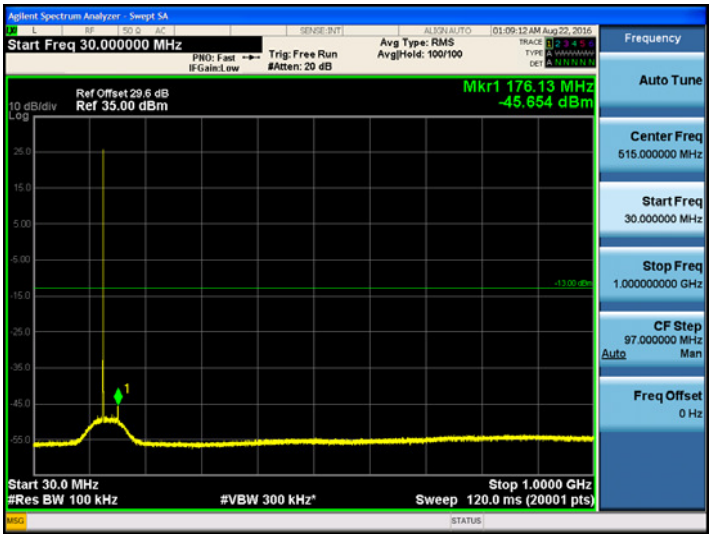
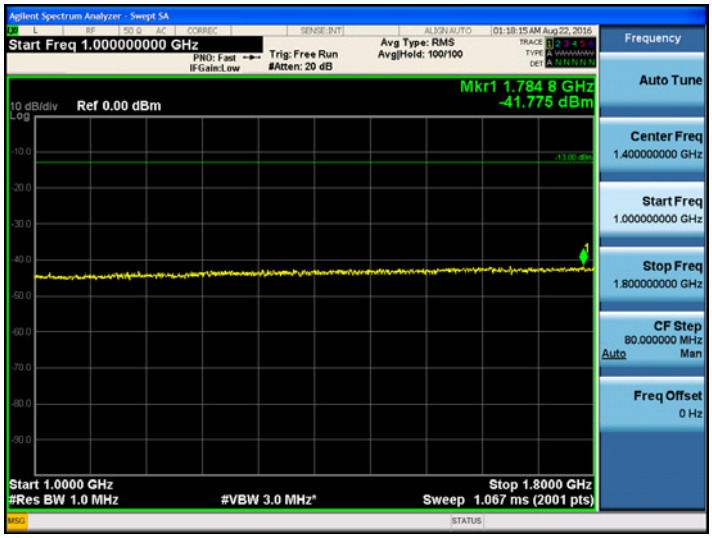
9㎑ ~ 150㎑	150㎑ ~ 30㎒
	
30㎒ ~ 1㎓	**1 GHz ~ 1.8 GHz**
	

VHF(APCO25)

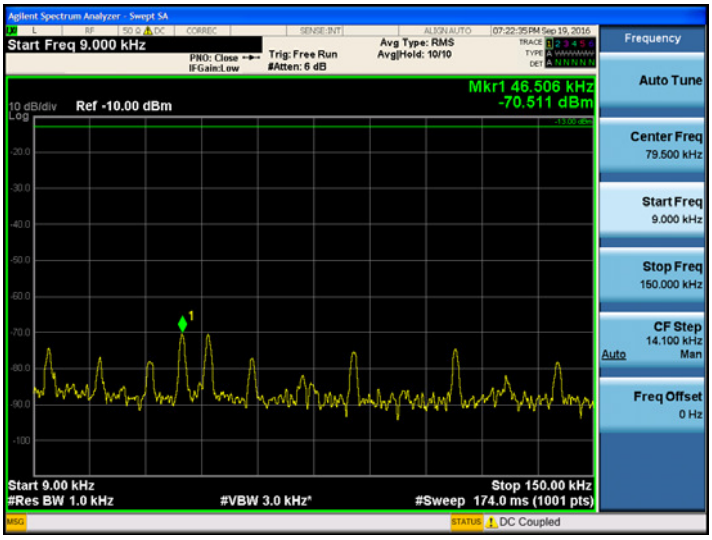
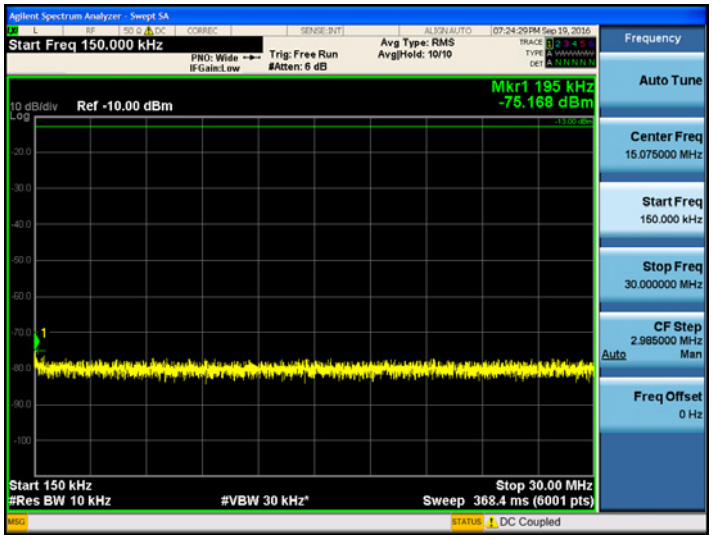
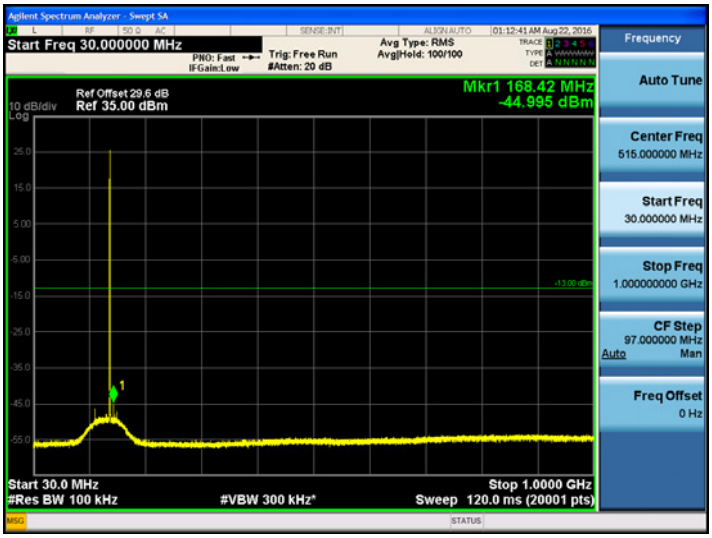
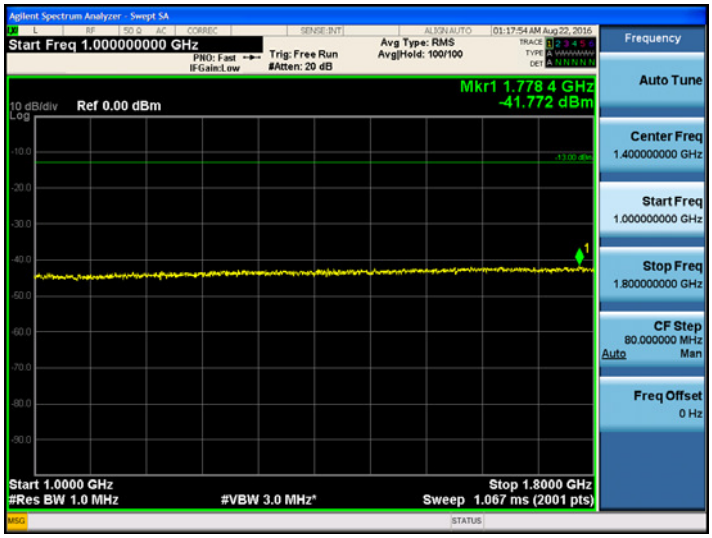
[Uplink_138.5 MHz]

9㎑ ~ 150㎑	150㎑ ~ 30㎒
	
30㎒ ~ 1㎓	**1 GHz ~ 1.8 GHz**
	

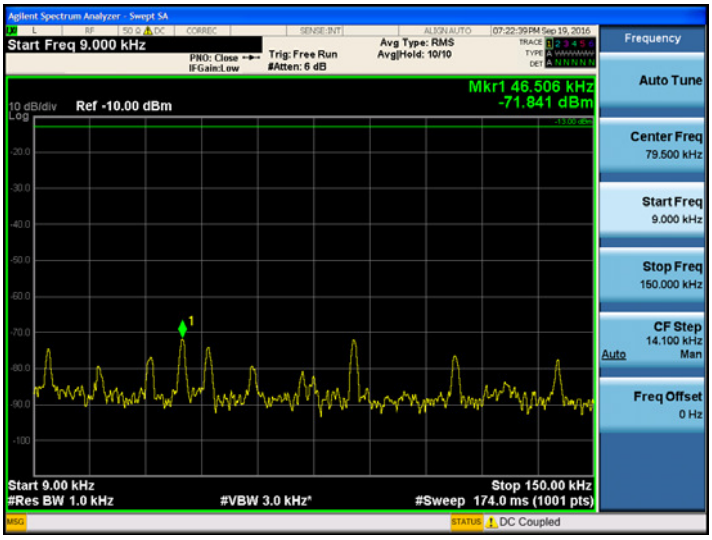
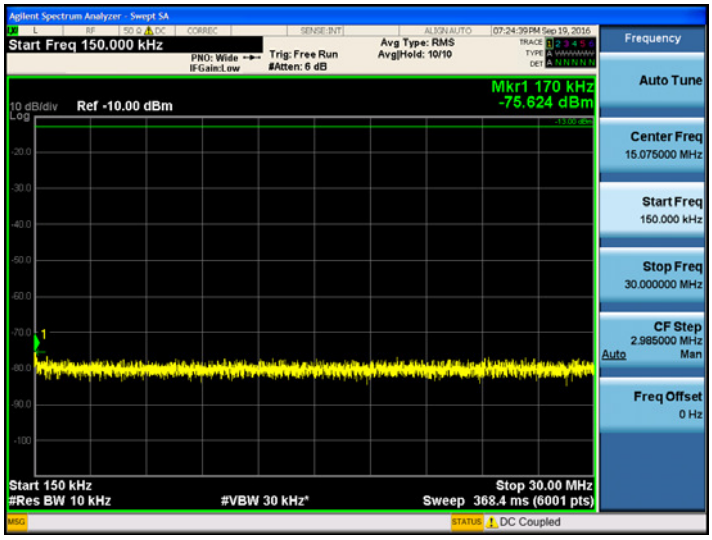
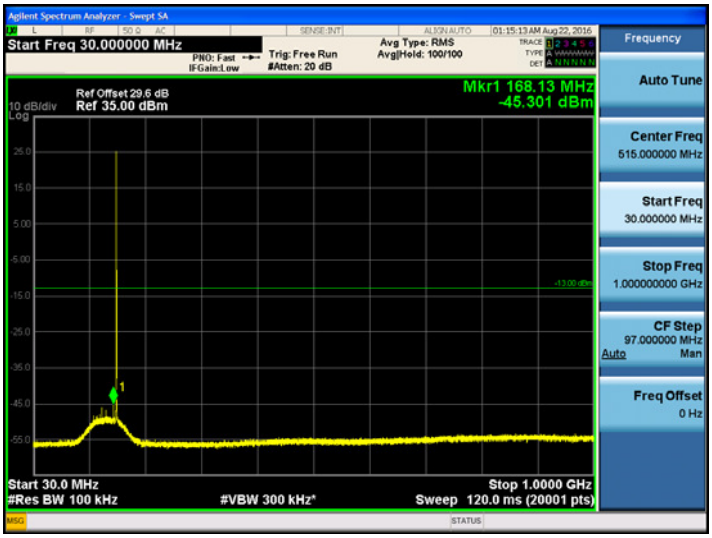
[Uplink_150.5 MHz]

9㎑ ~ 150㎑	150㎑ ~ 30㎒
	
30㎒ ~ 1㎓	**1 GHz ~ 1.8 GHz**
	

[Uplink_162.0 MHz]

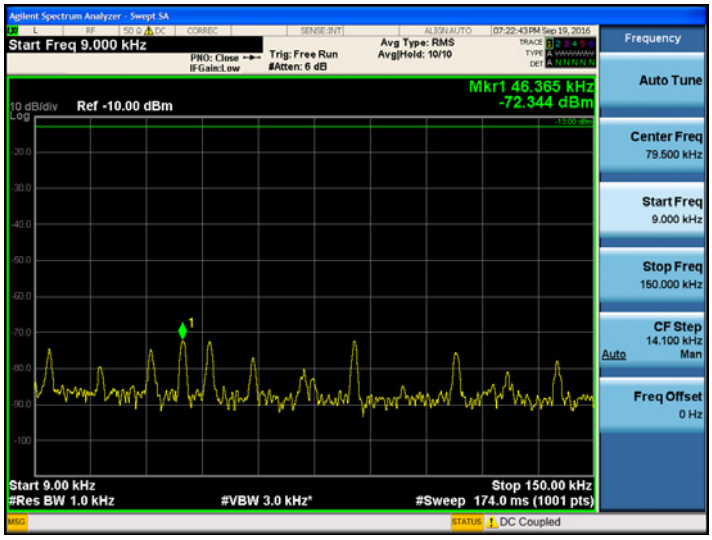
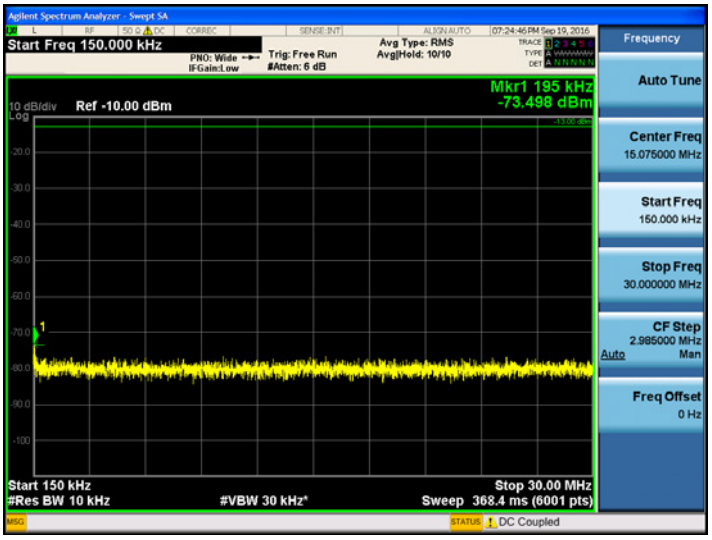
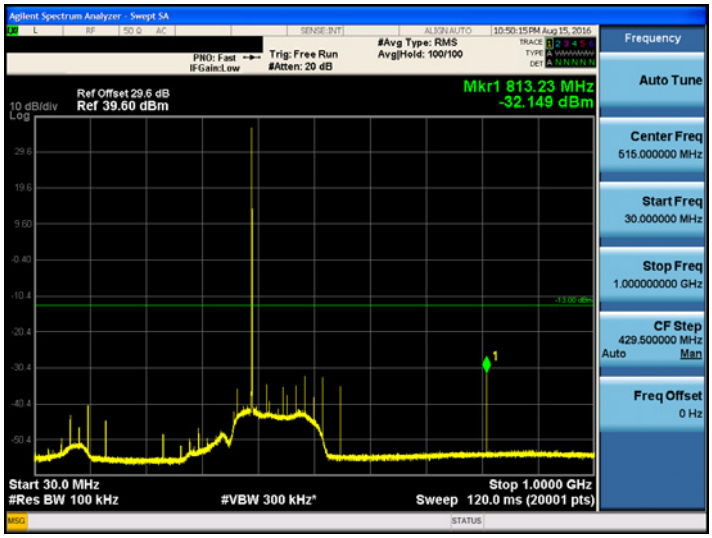
9㎑ ~ 150㎑	150㎑ ~ 30㎒
	
30㎒ ~ 1㎓	**1 GHz ~ 1.8 GHz**
	

[Uplink_173.5 MHz]

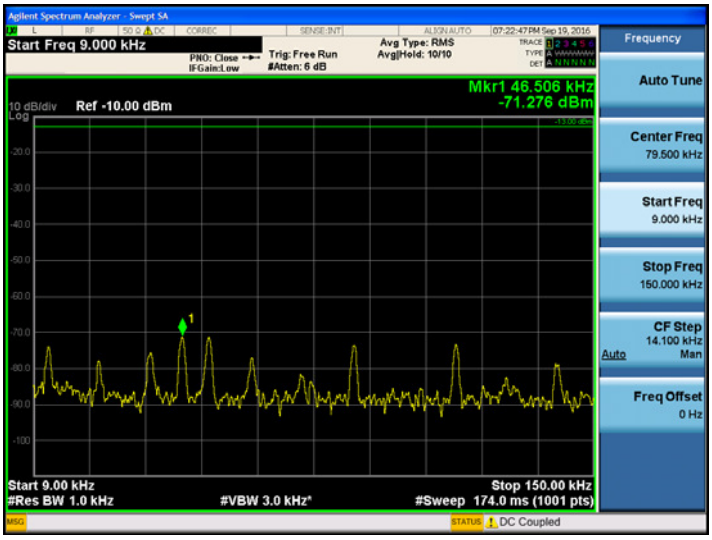
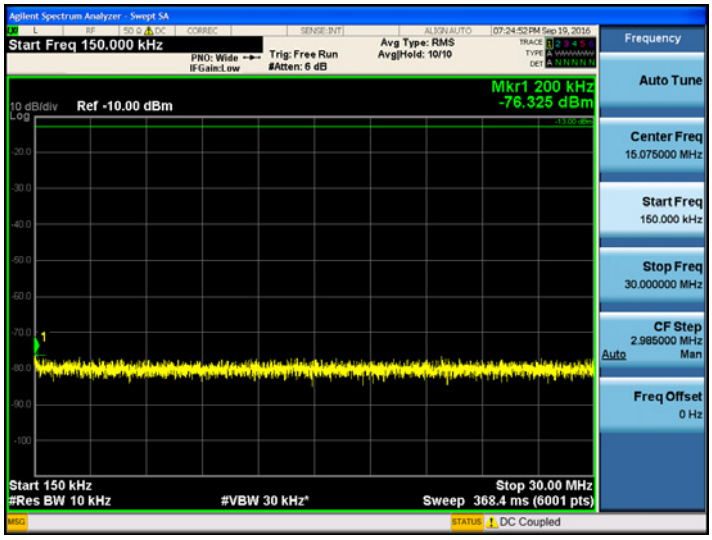
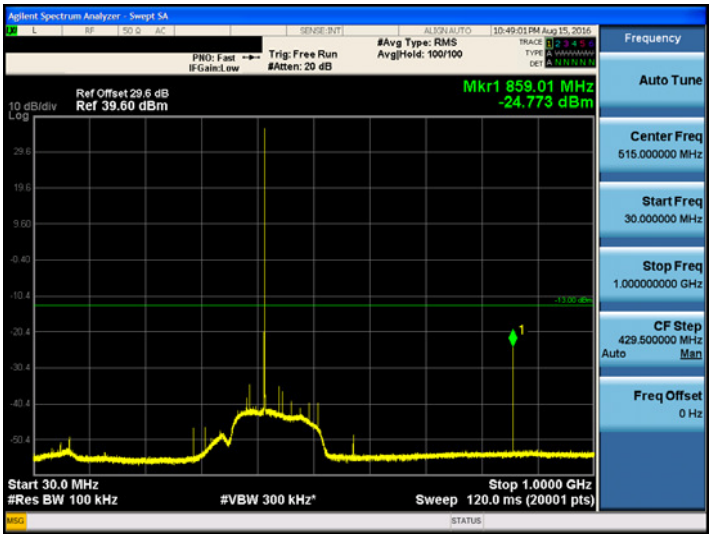
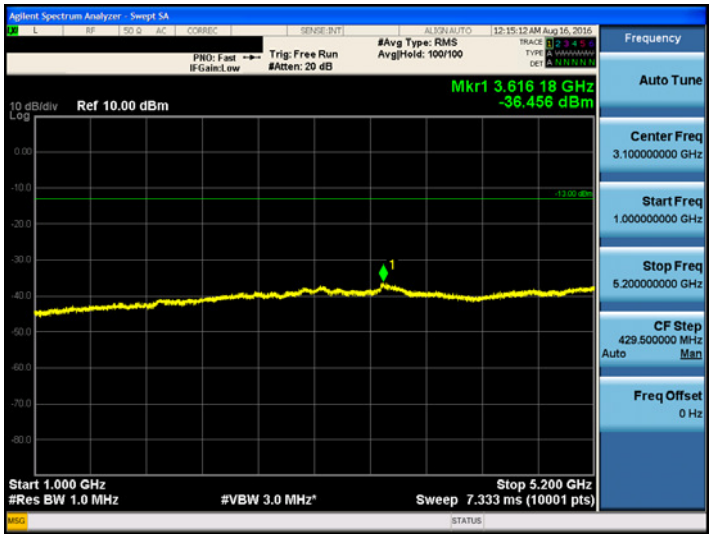
9㎑ ~ 150㎑	150㎑ ~ 30㎒
	
30㎒ ~ 1㎓	**1 GHz ~ 1.8 GHz**
	

UHF(APCO25)

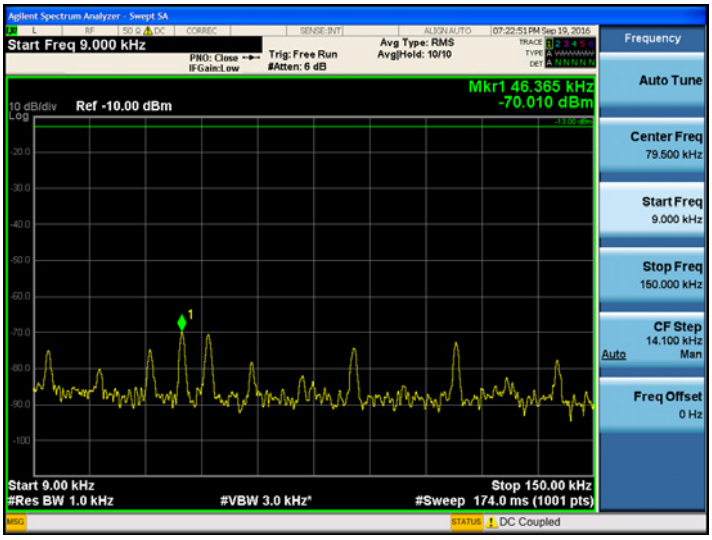
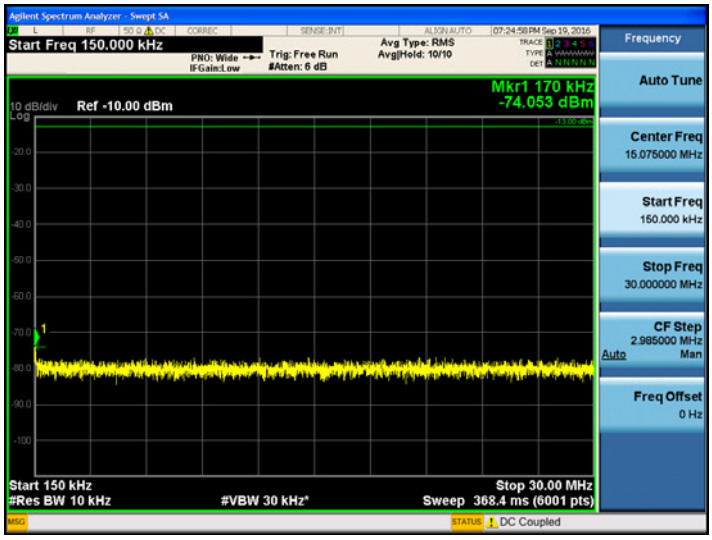
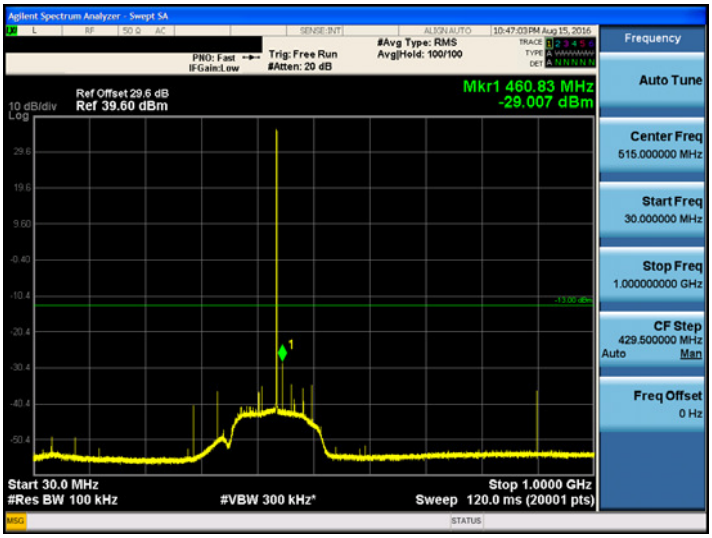
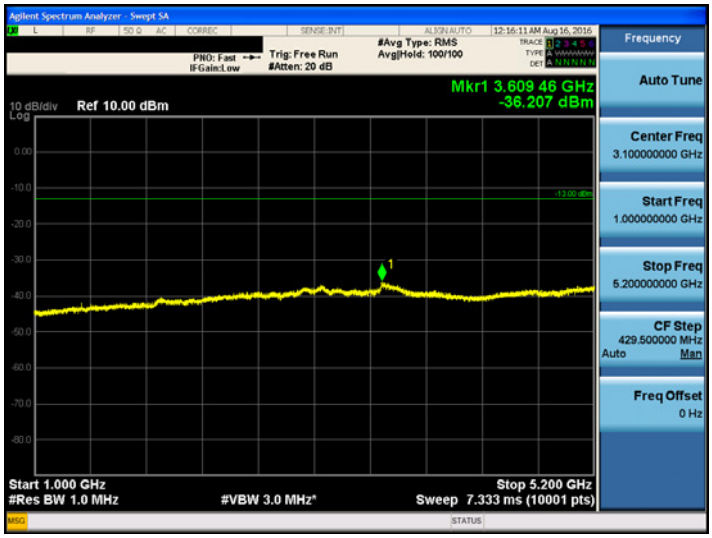
[Downlink_406.6 MHz]

9㎑ ~ 150㎑	150㎑ ~ 30㎒
	
30㎒ ~ 1㎓	**1 GHz ~ 5.2 GHz**
	

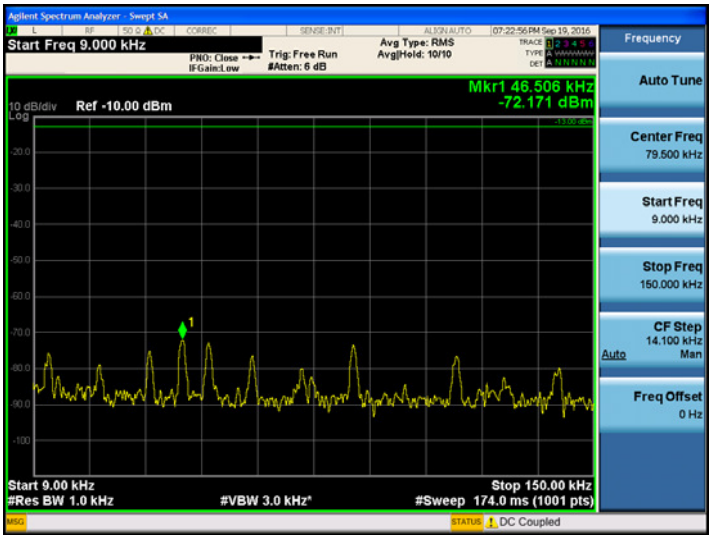
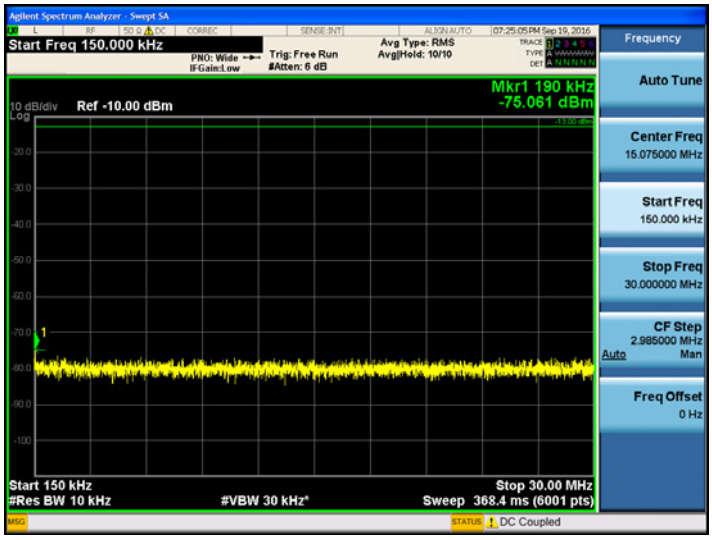
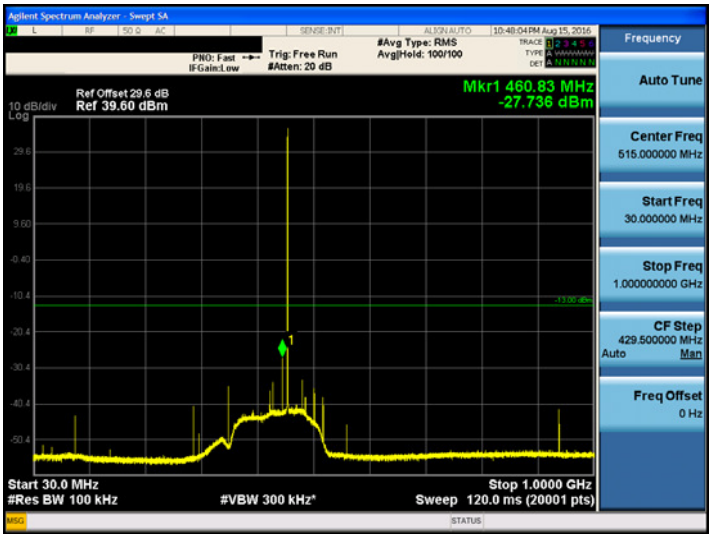
[Downlink_429.5 MHz]

9㎑ ~ 150㎑	150㎑ ~ 30㎒
	
30㎒ ~ 1㎓	**1 GHz ~ 5.2 GHz**
	

[Downlink_450.5 MHz]

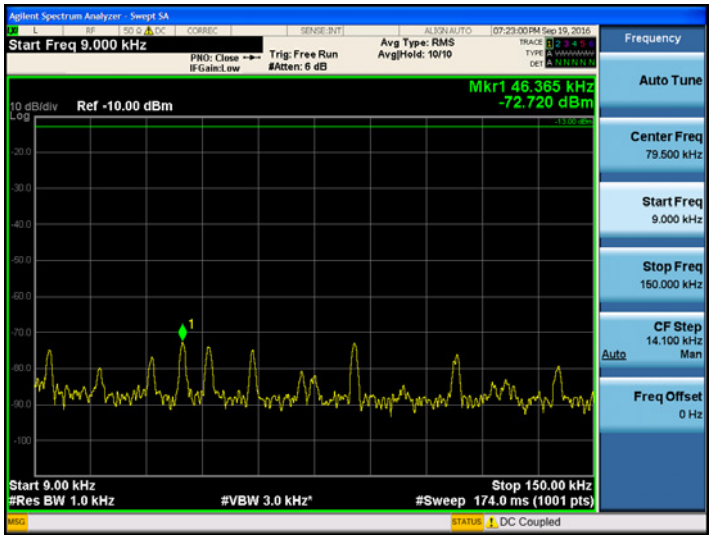
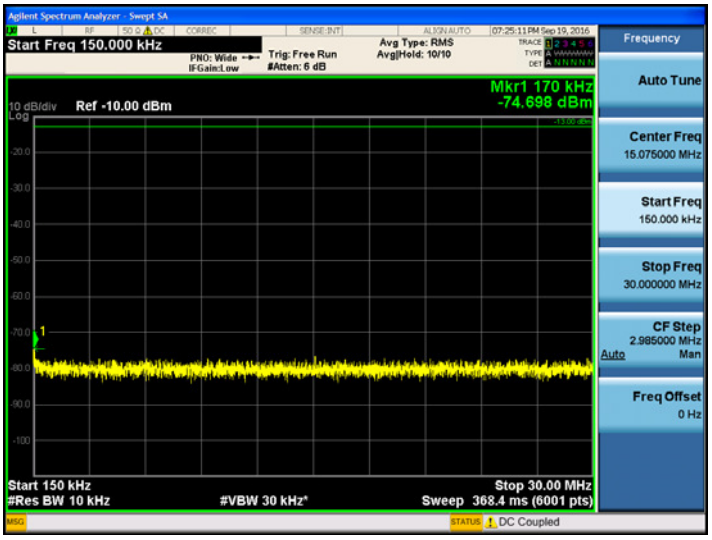
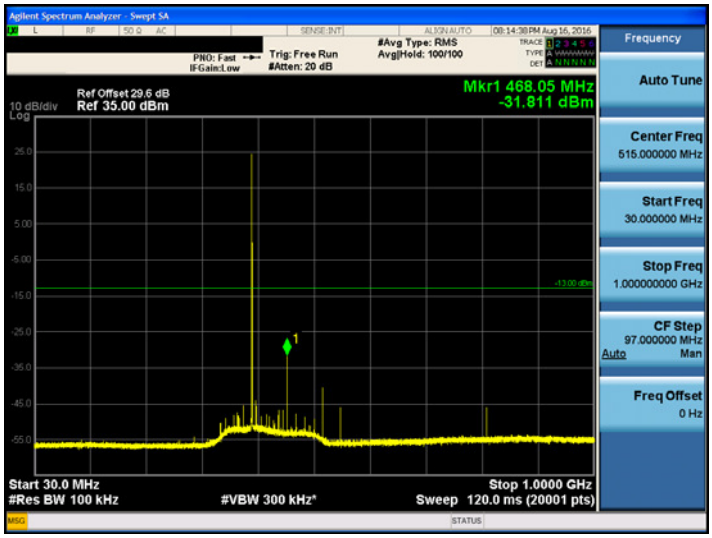
9㎑ ~ 150㎑	150㎑ ~ 30㎒
	
30㎒ ~ 1㎓	**1 GHz ~ 5.2 GHz**
	

[Downlink_469.5 MHz]

9㎑ ~ 150㎑	150㎑ ~ 30㎒
	
30㎒ ~ 1㎓	**1 GHz ~ 5.2 GHz**
	

UHF(APCO25)

[Uplink_406.6 MHz]

9㎑ ~ 150㎑	150㎑ ~ 30㎒
	
30㎒ ~ 1㎓	**1 GHz ~ 5.2 GHz**