Application Note

Broadcast Measurements with MS2720T Option 709

Spectrum Master™

The performance of AM and FM broadcast stations is regulated in the United States by the Federal Communications Commission (FCC) and in other countries by their own regulatory bodies. Part 73 of the FCC rules lays out many detailed rules that broadcasters must obey. In those rules there are several classes of stations that are defined primarily by the output power and the antenna configuration of a broadcast station. The performance parameters that must be measured are based, in part, on the class of the station – with the power output of the station being a fundamental determiner of some requirements.

In the United States both AM and FM broadcast stations are deploying a digital modulation format developed by iBiquity called HD (hybrid digital) or IBOC (in-band on-channel). The signals generated by IBOC equipped stations are required to meet the spectrum masks defined by Part 73. In addition, iBquity has a number of other requirements that require different masks and different spectrum analyzer settings.

Extremely good phase noise is required to make broadcast-proofing measurements. Only the MS2720T with Option 709 has adequate phase noise and dynamic range to make the measurement.

AM Broadcast Measurements

For AM stations, the classes are defined in paragraph 73.21 of the FCC rules.

Class	Time of Operation	Minimum Power	Maximum Power
Class A	unlimited	10 kW	50 kW
Class B	unlimited	250W	50 kW (or 10 kW in the 1605 to 1705 kHz band)
Class C	unlimited	250W	1 kW
Class D	daylight	250W with field strength >141 mV/m at 1 km	50 kW
Class D	nighttime		250W with field strength of <141 mV/m at 1 km

Table 1. AM Class Definitions.

There are some class C stations that are licensed to operate at 100 watts.

The field strength of an AM broadcast station is required to be within the 5 mV/meter contour for the entire community being served, and at night 80% of the of the community must be within that contour for stations operating from 535 kHz to 1605 kHz. For stations operating from 1605 to 1705 kHz at least 50% of the community must be within the 5 mV/meter contour. Class D stations are not required to meet this requirement at night.

Extremely good phase noise is required to make broadcast-proofing measurements. Only the MS2720T with Option 709 has adequate phase noise and dynamic range to make the measurement.

Paragraph 73.44 defines critical measurements that must be made on AM broadcast signals. Here is the wording of that paragraph:

§ 73.44 AM transmission system emission limitations.

(a) The emissions of stations in the AM service shall be attenuated in accordance with the requirements specified in paragraph (b) of this section. Emissions shall be measured using a properly operated and suitable swept frequency RF spectrum analyzer using a peak hold duration of 10 minutes, no video filtering, and a 300 Hz resolution bandwidth, except that a wider resolution bandwidth may be employed above 11.5 kHz to detect transient emissions. Alternatively, other specialized receivers or monitors with appropriate characteristics may be used to determine compliance with the provisions of this section, provided that any disputes over measurement accuracy are resolved in favor of measurements obtained by using a calibrated spectrum analyzer adjusted as set forth above.

(b) Emissions 10.2 kHz to 20 kHz removed from the carrier must be attenuated at least 25 dB below the unmodulated carrier level, emissions 20 kHz to 30 kHz removed from the carrier must be attenuated at least 35 dB below the unmodulated carrier level, emissions 30 kHz to 60 kHz removed from the carrier must be attenuated at least [5 + 1 dB/kHz] below the unmodulated carrier level, and emissions between 60 kHz and 75 kHz of the carrier frequency must be attenuated at least 65 dB below the unmodulated carrier level. Emissions removed by more than 75 kHz must be attenuated at least 43 + 10 Log (Power in watts) or 80 dB below the unmodulated carrier level, whichever is the lesser attenuation, except for transmitters having power less than 158 watts, where the attenuation must be at least 65 dB below carrier level.

c) Should harmful interference be caused to the reception of other broadcast or non-broadcast stations by out ofband emissions, the licensee may be directed to achieve a greater degree of attenuation than specified in paragraphs(a) and (b) of this section. emissions, the licensee may be directed to achieve a greater degree of attenuation than specified in paragraphs (a) and (b) of this section.

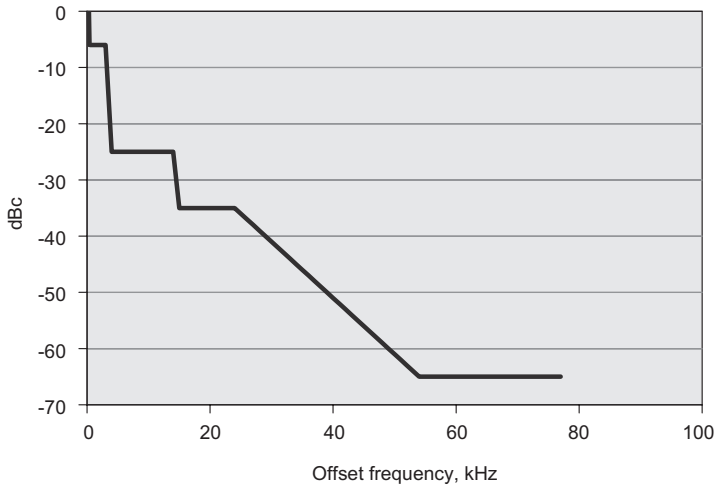
(d) Measurements to determine compliance with this section for transmitter type acceptance are to be made using signals sampled at the output terminals of the transmitter when operating into an artificial antenna of substantially zero reactance. Measurements made of the emissions of an operating station are to be made at ground level approximately 1 kilometer from the center of the antenna system. When a directional antenna is used, the carrier frequency reference field strength to be used in order of preference shall be:

(1) The measured non-directional field strength.

(2) The RMS field strength determined from the measured directional radiation pattern.

(3) The calculated expected field strength that would be radiated by a non-directional antenna at the station authorized power.

(e) Licensees of stations complying with the ANSI/EIA–549–1988, NRSC–1 AM Preemphasis/Deemphasis and Broadcast Transmission Bandwidth Specifications (NRSC–1), prior to June 30, 1990 or from the original commencement of operation will, until June 30, 1994, be considered to comply with paragraphs (a) and (b) of this section, absent any reason for the Commission to believe otherwise. Such stations are waived from having to make the periodic measurements required in § 73.1590(a)(6) until June 30, 1994. However, licensees must make measurements to determine compliance with paragraphs (a) and (b) of this section upon receipt of an Official Notice of Violation or a Notice of Apparent Liability alleging noncompliance with those provisions, or upon specific request by the Commission.



10.2 kHz to 20 kHz	–25 dBc
20 kHz to 30 kHz	–35 dBc
30 kHz to 60 kHz	–(5 + 1 dB/kHz)
60 kHz to 75 kHz	–65 dBc
> 75 kHz	–65 dBc

Figure 1. Spectrum Mask for AM stations running power levels <158 watts.

Every AM station that uses directional antennas is required to make field strength measurements at certain sampling point locations specified in the station's license. The rules are somewhat vague in that they say "as often as necessary to ensure that the field at those points does not exceed the values specified in the station authorization." For stations whose licenses don't specify sampling points, field strength measurements must be made every calendar quarter, at intervals not exceeding 120 days.

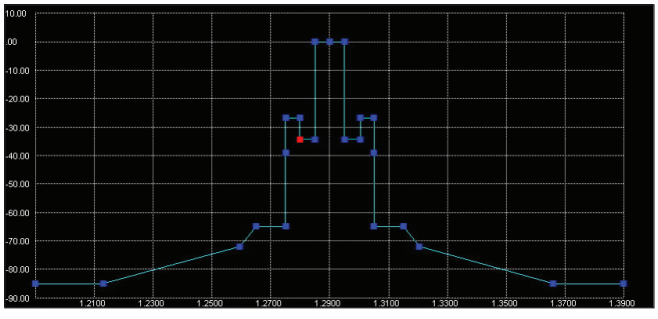
Theoretical calculations of the field strength of the proposed antenna system are submitted along with a license application. After the antenna is constructed, actual field strength measurements are required to confirm that the measured results, RMS, are within 85% of calculated results 1 km from the center of the antenna system. When a technician is making these measurements, the precise location of the measurement is required using, as a minimum, a GPS receiver augmented by photographs showing enough landmarks to determine the exact locations at which measurements are being made. (See paragraph 73.151.3 ii and iii.)

Interference calculations are made by measuring signals strengths from co-channel interferers and upper and lower adjacent channels (which the FCC calls "first adjacencies") then doing an RSS (root sum of the squares) calculation to determine the interference level. (See paragraph 73.182 (h.1 and h.2)

AM IBOC Measurements

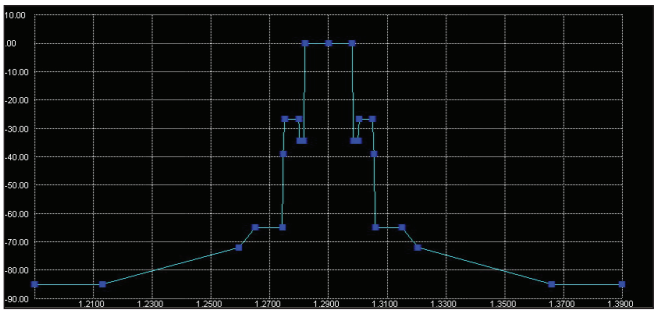
iBiquity Digital Corporation has defined two different measurement masks for AM IBOC measurements, one with a 5 kHz audio bandwidth and the other with an 8 kHz audio bandwidth. It appears that most stations are running according to the 5 kHz mask. The measurements are made by doing the average of at least 20 sweeps. This is significantly different than the 10-minute peak hold method that is used for compliance measurements of analog signals. However, an AM IBOC signal still must remain within the spectral mask defined by the FCC rules part 73 paragraph 44.

AM 5 kHz IBOC mask



0 to 5 kHz	0 dBc
5 kHz	–36.5 dBc
10 kHz	–36.5 dBc
10 kHz	–26.8 dBc
15 kHz	–26.8 dBc
15 kHz	–28 dBc
15.2 kHz	–28 dBc
15.2 kHz to 15.8 kHz	–39 – (f_{offset} -15.2)*43.3 dBc
15.8 kHz	–65 dBc
25 kHz	–65 dBc
25 to 30.5 kHz	–65 dBc – (f_{offset} -25)*1.273 dBc
30.5 KHz to 75 kHz	–72 (f_{offset} -30.5)*0.292 dBc
75 kHz	–85 dBc

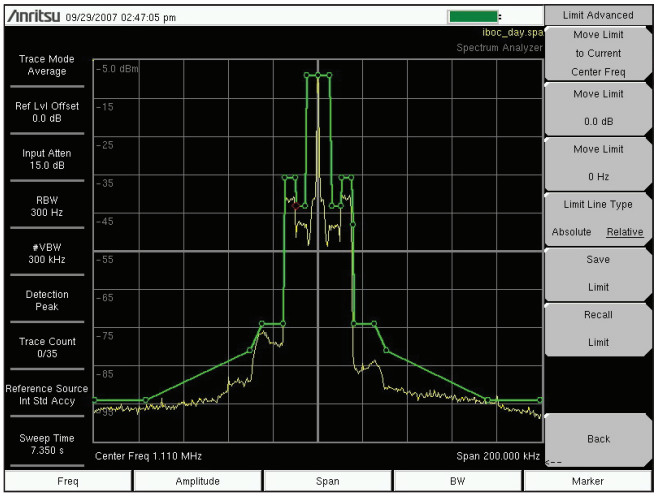
AM 8 kHz IBOC mask



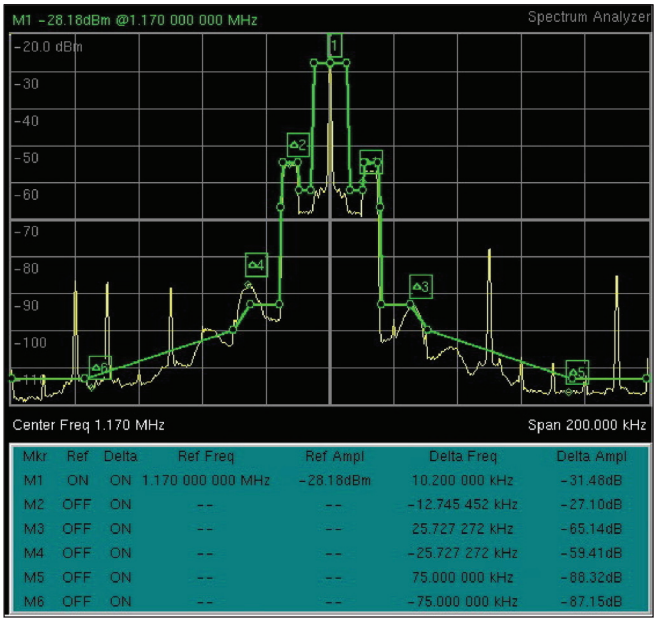
0 to 8 kHz	0 dBcc
8 kHz	–36.5 dBc
10 kHz	–36.5 dBc
10 kHz	–26.8 dBc
15 kHz	–26.8 dBc
15 kHz	–28 dBc
15.2 kHz	–28 dBc
15.2 kHz to 15.8 kHz	–39 – (f_{offset} -15.2)*43.3 dBc
15.8 kHz	–65 dBc
25 kHz	–65 dBc
25 to 30.5 kHz	–65 dBc – (f_{offset} -25)*1.273 dBc
30.5 KHz to 75 kHz	–72 (f_{offset} -30.5)*0.292 dBc
75 kHz	–85 dBc

AM IBOC measurement procedure

1. Connect an appropriate AM broadcast band antenna to the instrument.
2. Set the instrument center frequency to the center frequency of the station to be measured.
3. Set the span to 200 kHz.
4. Set the RBW to 300 Hz and the VBW to 3 MHz
5. Adjust the reference level to place the carrier level near the top of the screen.
6. Set the scale to 10 dB per division if it isn't already there.
7. Press <Shift> <Trace> <Trace A Operations> <Average -> A>.
8. Set the number of averages to 10 or greater. The instrument is fast enough that you can easily use an average value of 50.
9. Turn on markers to measure points on the signal by pressing <Marker> <More> <Marker 1 Reference ON> <Marker Style Tracking>.



AM IBOC signal measured at the transmitter's monitoring point.



AM IBOC signal measured over the air. There appears to be spectral re-growth indicated by delta markers 3 and 4.

RF Harmonic Measurements

RF harmonic measurements are required for all broadcast transmitters. The FCC rules require that harmonic levels be as low as “the state of the art permits.” To make these measurements properly requires measuring equipment whose internal harmonic generation mechanisms are better than that of the transmitter being tested. A prime mechanism for the generation of harmonics is a high signal level into the spectrum analyzer’s first mixer. This signal level is controlled by the use of sufficient attenuation, both inside the spectrum analyzer and externally if the signal level from the transmitter measurement point requires it. For MS2720T, the signal into the mixer needs to be less than -45 dBm to minimize nonlinearities that can increase harmonic generation.

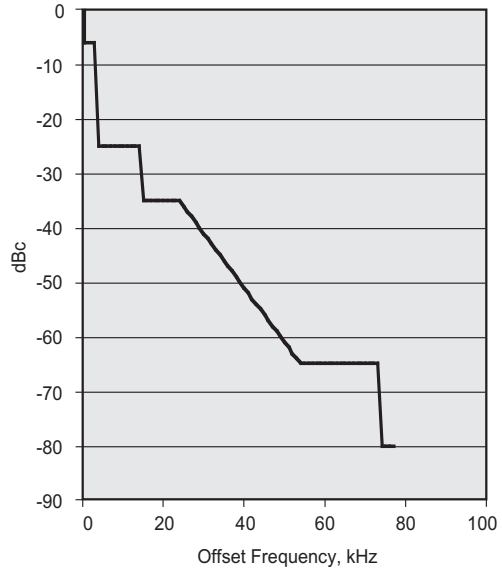
How to make an RF harmonic measurement:

1. Set the spectrum analyzer Start Frequency to place the fundamental frequency near the left edge of the display.
2. Set the Stop Frequency high enough to include at least the fifth harmonic.
3. Set the reference level to +20 dBm as a starting point.
4. Make sure attenuation is set to automatic for the start of the procedure. This step is to make sure there is sufficient attenuation to avoid overdriving the front end mixer. With these settings the input attenuator will be set to 40 dB.
5. Connect the spectrum analyzer to the transmitter’s test port.
6. Turn on a marker and place it on the fundamental.
7. Set the reference level to place the fundamental near the top of the screen.
8. Set the resolution bandwidth to 100 Hz.
9. Observe the displayed average noise level to be sure there is at least 86 dB signal to noise ratio to make the harmonic measurement. Decrease the resolution bandwidth if necessary to lower the noise floor.
10. Turn on other markers and place them on all visible harmonics. With the MS2720T, place all the markers on the fundamental and place delta markers on the various harmonics.
11. Note the amplitude of the fundamental and the second harmonic. Calculate or read the dB level of the second harmonic compared to the fundamental.
12. Press the Amplitude key, note the input attenuation level and increase it by 5 dB.
13. Determine if the second harmonic level has changed. If so, continue increasing attenuation in 5 dB steps until the difference between the fundamental and the second harmonic stabilizes. The intention here is to be sure the spectrum analyzer’s first mixer is not generating harmonics due to overdrive.
14. Measure all visible harmonics.
15. Compare the harmonic levels to the specifications of the broadcast transmitter plus the loss of any harmonic filters at the output of the transmitter. The specification for modern AM transmitters is for harmonics and spurious signals to be > 80 dB below the carrier level.
16. Save the measurements in the instrument.
17. Use Master Software Tools to save the measurements to a computer.
18. Print the measured results for the station log.

AM Noise Sideband Measurements

The requirements for this measurement are spelled out in 73.44(b), which reads:

> (b) Emissions 10.2 kHz to 20 kHz removed from the carrier must be attenuated at least 25 dB below the unmodulated carrier level, emissions 20 kHz to 30 kHz removed from the carrier must be attenuated at least 35 dB below the unmodulated carrier level, emissions 30 kHz to 60 kHz removed from the carrier must be attenuated at least [5 + 1 dB/kHz] below the unmodulated carrier level, and emissions between 60 kHz and 75 kHz of the carrier frequency must be attenuated at least 65 dB below the unmodulated carrier level. Emissions removed by more than 75 kHz must be attenuated at least 43 + 10 Log (Power in watts) or 80 dB below the unmodulated carrier level, whichever is the lesser attenuation, except for transmitters having power less than 158 watts, where the attenuation must be at least 65 dB below carrier level.



10.2 kHz to 20 kHz	–25 dBc
20 kHz to 30 kHz	–35 dBc
30 kHz to 60 kHz	–(5 + 1 dB/kHz)
60 kHz to 75 kHz	–65 dBc
> 75 kHz	–(43 + 10 log Pwatts) or 80 dB, whichever is less

Figure 2. Spectrum Mask for AM stations running power levels > 5000 watts.

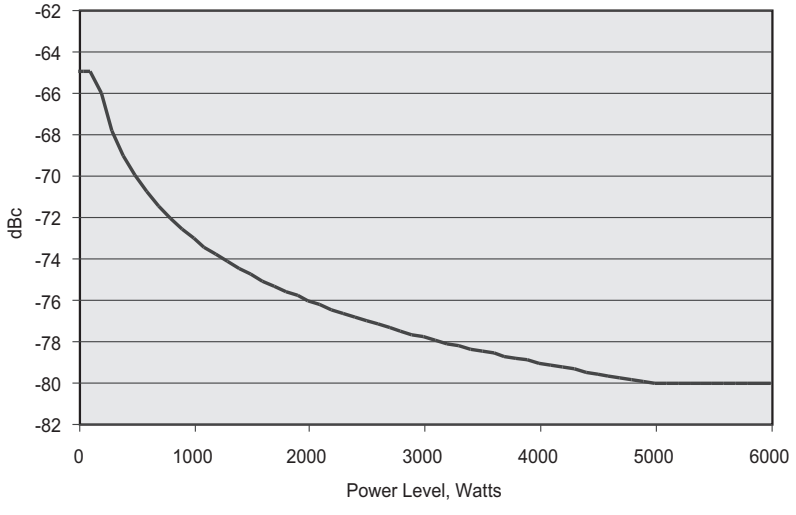
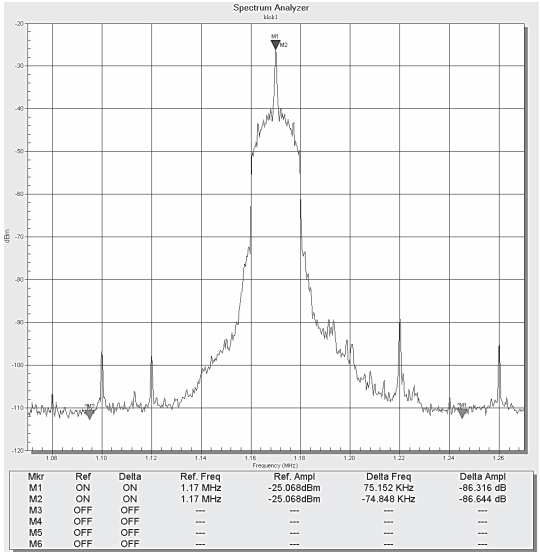


Figure 3. Allowed emission levels at offsets > 75 kHz.

At powers lower than 5000 watts, the requirements for suppression beyond 75 kHz are reduced as shown in Figure 3.

Here is how to make this measurement.

1. Set the center frequency to the carrier frequency to be measured.
2. Set the span to 200 kHz or greater.
3. Connect a suitable antenna and set the reference level to place the signal as near the top of the screen as possible.
4. Set the resolution bandwidth (RBW) to 300 Hz to meet the requirements of paragraph 73.44(a).
5. Set the video bandwidth to 3 MHz for the MS2720T.
6. Set the detector type to Peak.
7. Confirm that there is at least an 86 dB signal to noise ratio if measuring a station whose output power is greater than 5000 watts, or 72 dB if measuring a station whose power output is < 158 watts.
8. Set the Trace Mode to Max and let the measurement run for 10 minutes.
9. Save the measurment into the instrument's memory for later recall and printing to create documents for the station log.
10. Use the Master Software Tools trace editor on a PC to extract the stored trace from the instrument and save it on the computer.
11. Add markers to the signal to measure the carrier level and any points from 10.1 kHz to 75 kHz offset from the carrier to confirm compliance with the FCC rules as shown in Figure 4.



Mkr	Ref	Delta	Ref. Freq	Ref. Ampl	Delta Freq	Delta Ampl
M1	ON	ON	1.17 MHz	-25.068dBm	75.152 KHz	-86.316 dB
M2	ON	ON	1.17 MHz	-25.068dBm	-74.848 KHz	-86.644 dB
M3	OFF	OFF	---	---	---	---
M4	OFF	OFF	---	---	---	---
M5	OFF	OFF	---	---	---	---
M6	OFF	OFF	---	---	---	---

Figure 4. AM Broadcast Measurement with markers at ± 75 kHz.

AM Field Strength Measurements

For AM broadcast stations with directional antennas, the FCC requires frequent field strength measurements to assure continued compliance with license requirements. Basically these measurements need to be done with a calibrated antenna at known locations around the antenna system. The exact requirements for AM broadcast stations are detailed in paragraph 73.61 of the FCC rules.

§ 73.61 AM directional antenna field strength measurements.

(a) Each AM station using a directional antenna must make field strength measurements at the monitoring point locations specified in the instrument of authorization, as often as necessary to ensure that the field at those points does not exceed the values specified in the station authorization. Additionally, stations not having an approved sampling system must make the measurements once each calendar quarter at intervals not exceeding 120 days.

Measurement and record keeping requirements for field strength measurement are detailed in paragraph 73.151.

§ 73.151 Field strength measurements to establish performance of directional antennas.

(a) In addition to the information required by the license application form, the following showing must be submitted to establish, for each mode of directional operation, that the effective measured field strength (RMS) at 1 kilometer (km) is not less than 85 percent of the effective measured field strength (RMS) specified for the standard radiation pattern, or less than that specified in § 73.189(b) for the class of station involved, whichever is the higher value, and that the measured field strength at 1 km in any direction does not exceed the field shown in that direction on the standard radiation pattern for that mode of directional operation:

(1) A tabulation of inverse field strengths in the horizontal plane at 1 km, as determined from field strength measurements taken and analyzed in accordance with § 73.186, and a statement of the effective measured field strength (RMS). Measurements shall be made in the following directions:

(i) Those specified in the instrument of authorization.

(ii) In major lobes. Generally, one radial is sufficient to establish a major lobe; however, additional radials may be required.

(iii) Along additional radials to establish the shape of the pattern. In the case of a relatively simple directional antenna pattern, a total of six radials is sufficient. If two radials would be more than 90° _apart, then an additional radial must be specified within that arc. When more complicated patterns are involved, that is, patterns having several or sharp lobes or nulls, measurements shall be taken along as many as 12 radials to definitely establish the pattern(s). Pattern symmetry may be assumed for complex patterns which might otherwise require measurements on more than 12 radials.

(2) A tabulation of:

(i) The phase difference of the current in each element with respect to the reference element, and whether the current leads (+) or lags (-) the current in the reference element, as indicated by the station's antenna monitor.

(ii) The ratio of the amplitude of the radio frequency current in each element to the current in the reference element, as indicated on the station's antenna monitor.

(3) A monitoring point shall be established on each radial for which the construction permit specifies a limit. The following information shall be supplied for each monitoring point:

(i) Measured field strength.

(ii) An accurate and detailed description of each monitoring point. The description may include, but shall not be limited to, geographic coordinates determined with a Global Positioning System receiver.

(iii) Clear photographs taken with the field strength meter in its measuring position and with the camera so located that its field of view takes in as many pertinent landmarks as possible.

(b) For stations authorized to operate with simple directional antenna systems (e.g., two towers) in the 1605–1705 kHz band, the measurements to support pattern RMS compliance referred to in paragraphs (a)(1)(ii) and (a)(1)(iii) of this section are not required. In such cases, measured radials are required only in the direction of short-spaced allotments, or in directions specifically identified by the Commission.of Apparent Liability alleging noncompliance with those provisions, or upon specific request by the Commission.

FM Broadcast Measurements

In the United States, the FM broadcast channel assignments are from 88.1 MHz to 107.9 MHz. The FCC refers to these channels by number, with 88.1 MHz being channel 201 and 107.9 MHz being channel 300.

The FCC defines several classes of FM broadcast stations as shown in Table 2. HAAT is the Height Above Average Terrain for the antenna system. “Class contour” is the distance from the antenna for the field strength shown in the last column.

In the United States these are the class definitions:

Class	ERP	HAAT (meters)	Class contour (km)	Contour field strength dBµ
A	100 watts	100	28	60
B	50 kW	150	52	54 on channels 221 to 300
B1	25 kW	100	39	57 on channels 221 to 300
C	100 kW	600	92	60
C0	100 kW	450	83	60
C1	100 kW	299	72	60
C2	50 kW	150	52	60
C3	25 kW	100	39	60

Table 2. FM Class Definitions in the United States.

Table 3 shows the class definitions in Puerto Rico and the U.S. Virgin Islands. The class contours are somewhat complicated. See Part 73 paragraph 73.215 for a table of protected and interfering contour values.

There are treaty agreements with Canada and Mexico that somewhat complicate the class definitions shown in Table 2.

There are several measurements of FM broadcast transmitters mandated by the FCC that can be done with a spectrum analyzer.

Class	ERP	HAAT (meters)	Class contour (km)
A	6 kW	240	42
B1	25 kW	150	46
B	50 kW	472	78

Table 3. FM Class Definitions in Puerto Rico and the U.S. Virgin Islands.

Field Strength Measurements

The requirements for FM field strength measurements call for a mobile setup that can elevate the measurement antenna 9 meters in the air and then make a "mobile run" of at least 30 meters while continuously recording the field strength on a "strip chart recorder." Paragraph 73.314 gives all the details including what to do if a mobile run isn't possible at a particular location.

§ 73.314 Field strength measurements.

(a) Except as provided for in § 73.209, FM broadcast stations shall not be protected from any type of interference or propagation effect. Persons desiring to submit testimony, evidence or data to the Commission for the purpose of showing that the technical standards contained in this subpart do not properly reflect the levels of any given type of interference or propagation effect may do so only in appropriate rule making proceedings concerning the amendment of such technical standards. Persons making field strength measurements for formal submission to the Commission in rule making proceedings, or making such measurements upon the request of the Commission, shall follow the procedure for making and reporting such measurements outlined in paragraph (b) of this section. In instances where a showing of the measured level of a signal prevailing over a specific community is appropriate, the procedure for making and reporting field strength measurements for this purpose is set forth in paragraph (c) of this section.

(b) Collection of field strength data for propagation analysis.

(1) Preparation for measurements. (i) On large scale topographic maps, eight or more radials are drawn from the transmitter location to the maximum distance at which measurements are to be made, with the angles included between adjacent radials of approximately equal size. Radials should be oriented so as to traverse representative types of terrain. The specific number of radials and their orientation should be such as to accomplish this objective.

(ii) Each radial is marked, at a point exactly 16 kilometers from the transmitter and, at greater distances, at successive 3 kilometer intervals. Where measurements are to be conducted over extremely rugged terrain, shorter intervals may be used, but all such intervals must be of equal length. Accessible roads intersecting each radial as nearly as possible at each 3 kilometer marker are selected. These intersections are the points on the radial at which measurements are to be made, and are referred to subsequently as measuring locations. The elevation of each measuring location should approach the elevation at the corresponding 3 kilometer marker as nearly as possible.

(2) Measurement procedure. All measurements must be made utilizing a receiving antenna designed for reception of the horizontally polarized signal component, elevated 9 meters above the roadbed. At each measuring location, the following procedure must be used:

(i) The instrument calibration is checked.

(ii) The antenna is elevated to a height of 9 meters.

(iii) The receiving antenna is rotated to determine if the strongest signal is arriving from the direction of the transmitter.

(iv) The antenna is oriented so that the sector of its response pattern over which maximum gain is realized is in the direction of the transmitter.

(v) A mobile run of at least 30 meters is made, that is centered on the intersection of the radial and the road, and the measured field strength is continuously recorded on a chart recorder over the length of the run.

(vi) The actual measuring location is marked exactly on the topographic map, and a written record, keyed to the specific location, is made of all factors which may affect the recorded field, such as topography, height and types of vegetation, buildings, obstacles, weather, and other local features.

(vii) If, during the test conducted as described in paragraph (b)(2)(iii) of this section, the strongest signal is found to come from a direction other than from the transmitter, after the mobile run prescribed in paragraph (b)(2)(v) of this section is concluded, additional measurements must be made in a ''cluster'' of at least five fixed points. At each such point, the field strengths with the antenna oriented toward the transmitter, and with the antenna oriented so as to receive the strongest field, are measured and recorded. Generally, all points should be within 60 meters of the center point of the mobile run. (viii) If overhead obstacles preclude a mobile run of at least 30 meters, a ''cluster'' of five spot measurements may be made in lieu of this run. The first measurement in the cluster is identified. Generally, the locations for other measurements must be within 60 meters of the location of the first.

Here is how to make this measurement using the MS2720T.

1. Prior to going into the field, use the Antenna Editor in Master Software Tools to create a file that contains the antenna factors for the antenna that will be used for the measurement. Make sure the data for the antenna includes all frequencies at which you may want to make measurements. See Chapter 5 of the Master Software Tools User's Guide, for information on using the antenna editor.
2. Upload the antenna file into the instrument.
3. Extend the antenna to 9 meters in the air and connect it to the instrument.
4. Set the instrument center frequency to the carrier frequency of the signal to be measured.
5. Set the resolution bandwidth (RBW) to 300 kHz to be sure all of the signal's power is included in the measurement.
6. Set the video bandwidth (VBW) to 3 MHz.
7. Set the scale to 10 dB/division.
8. Set the reference level to place the signal about 5 dB from the top of the screen.
9. Set the scale to 3 dB/division. This should place the peak of the signal near the middle of the screen
10. Press Shift-Measure.
11. Press the Field Strength soft key.
12. Press the Antenna soft key and select your antenna from the list.
13. Press the On/Off soft key to begin making field strength measurements. The default measurement unit is dBm/meter, but may be changed if desired to dBV/meter, dBmV/meter, dBµV/meter, volts/meter or watts/meter. If you select one of the linear units, volts or watts, most likely the reference level and scale will need to be changed to center the signal vertically on screen.
14. Estimate the time required to make the 60 meter mobile run.
15. Press Shift-Sweep.
16. Press the Minimum Sweep Time soft key and set sufficient time to complete the 60 meter run.
17. Set sweep to "Single."
18. At the moment the mobile run begins, press the Manual Trigger soft key. This will start a new measurement sweep.
19. At the completion of the mobile run make sure sufficient time was allotted to complete the run while taking measurements.
20. Save the measurement by pressing Shift-File-Save/Recall-Save Measurement and name the file something that makes sense. The file name may be up to 40 characters long so a name such as the callsign of the station, the radial number and distance could be used as a file name.

FM Noise Sideband Measurements

§ 73.317 FM transmission system requirements.

(a) FM broadcast stations employing transmitters authorized after January 1, 1960, must maintain the bandwidth occupied by their emissions in accordance with the specification detailed below. FM broadcast stations employing transmitters installed or type accepted before January 1, 1960, must achieve the highest degree of compliance with these specifications practicable with their existing equipment. In either case, should harmful interference to other authorized stations occur, the licensee shall correct the problem promptly or cease operation.

(b) Any emission appearing on a frequency removed from the carrier by between 120 kHz and 240 kHz inclusive must be attenuated at least 25 dB below the level of the unmodulated carrier. Compliance with this requirement will be deemed to show the occupied bandwidth to be 240 kHz or less.

(c) Any emission appearing on a frequency removed from the carrier by more than 240 kHz and up to and including 600 kHz must be attenuated at least 35 dB below the level of the unmodulated carrier.

(d) Any emission appearing on a frequency removed from the carrier by more than 600 kHz must be attenuated at least $43 + 10 \text{ Log}_{10}$ (Power, in watts) dB below the level of the unmodulated carrier, or 80 dB, whichever is the lesser attenuation.

The spectral mask for a broadcast FM transmitter is shown in Figure 5. Measurement requirements for compliance with this mask are not spelled out to the degree they are for similar measurements on AM signals. The measurement shown in Figure 7, was done using a 300 Hz resolution bandwidth, a 3 MHz video bandwidth, peak detection and a 10 minute measurement time with max hold selected. This is the same as AM measurement specification.

The amount of required sideband attenuation above 600 kHz offset depends on the licensed carrier power level. The amount of suppression can be calculated as $43 + 10*\log_{10}$ (power in watts) or read from the graph in Figure 6.

Figure 7 shows an actual measurement made in the field of a broadcast FM transmitter. There are several other signals shown in the measurement, including one that is 78 dB down at 107.1 MHz which precludes measuring for regulatory compliance exactly at 600 kHz. Measurements at ± 700 kHz show –83 dBc.

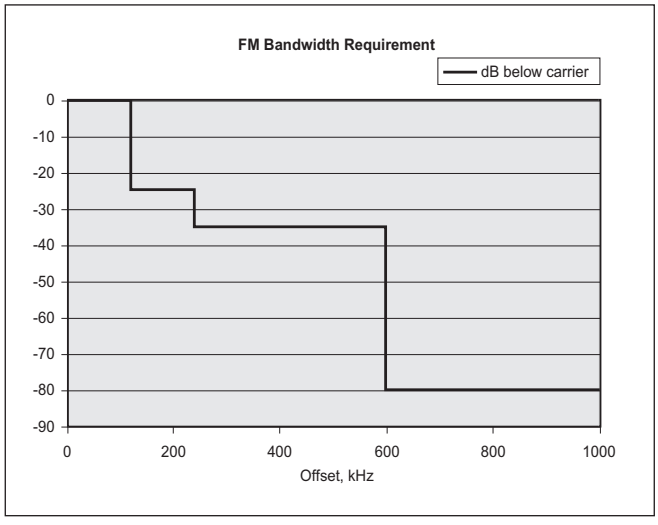


Figure 5. Sideband Attenuation Requirements for carrier levels > 5 kW.

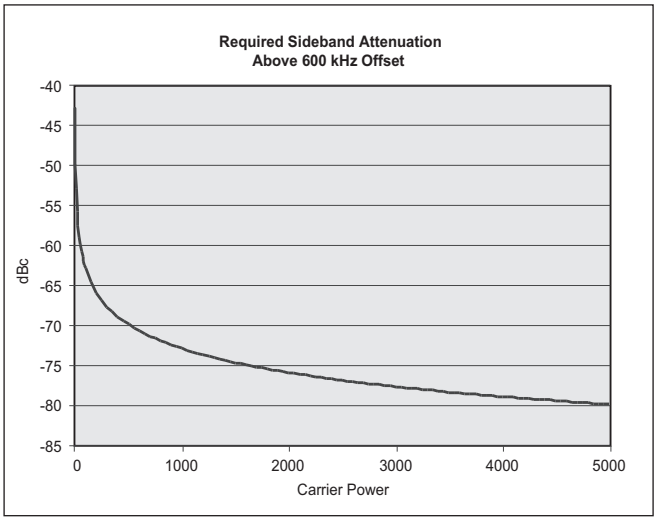


Figure 6. Sideband Attenuation Requirements for low power stations.

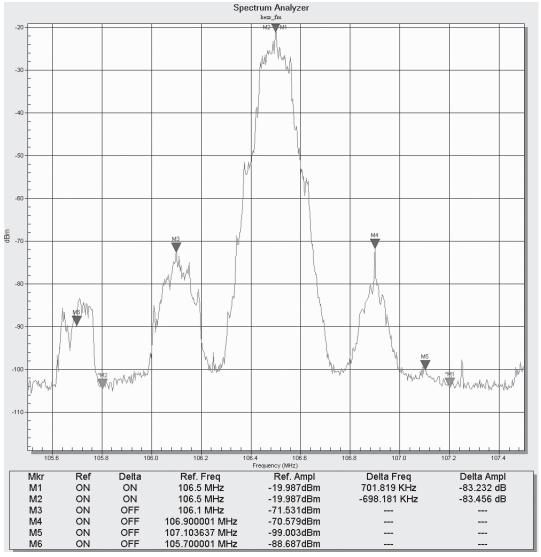


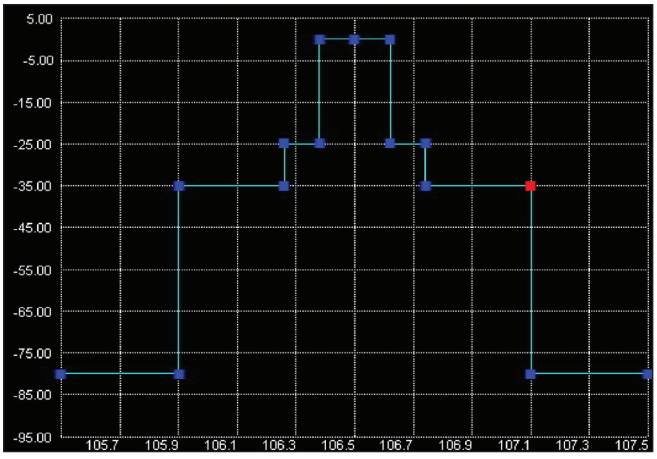
Figure 7. Measurement of Occupied Bandwidth on a broadcast FM signal.

FM IBOC Measurements

iBiquity Digital Corporation has defined a mask for measuring FM IBOC signals . The measurements are made by doing the average of at least 20 sweeps. This is significantly different than the 10-minute peak hold method that is used for compliance measurements of analog signals. However, an FM IBOC signal still must remain within the spectral mask defined by the FCC rules part 73 paragraph 44.

FM IBOC measurement procedure

1. Connect an appropriate FM broadcast band antenna to the instrument.
2. Set the instrument center frequency to the center frequency of the station to be measured.
3. Set the span to 600 kHz.
4. Set the RBW to 1 kHz and the VBW to 3 MHz
5. Adjust the reference level to place the carrier level near the top of the screen.
6. Set the scale to 10 dB per division if it isn't already there.
7. Press <Shift> <Trace> <Trace A Operations> <Average -> A>.
8. Set the number of averages to 20 or greater. The instrument is fast enough that you can easily use an average value of 50. The ibiquity standard calls for 10 seconds of averaging.
9. Turn on markers to measure points on the signal by pressing <Marker> <More> <Marker 1 Reference ON> <Marker Style Tracking>.



0 to 120 kHz	0 dBc
120 kHz	-25 dBc
240 kHz	-25 dBc
240 kHz	-35 dBc
600 kHz	-35 dBc
> 600 kHz	-80 dBc or –(43+10 log Pwatts) whichever is less

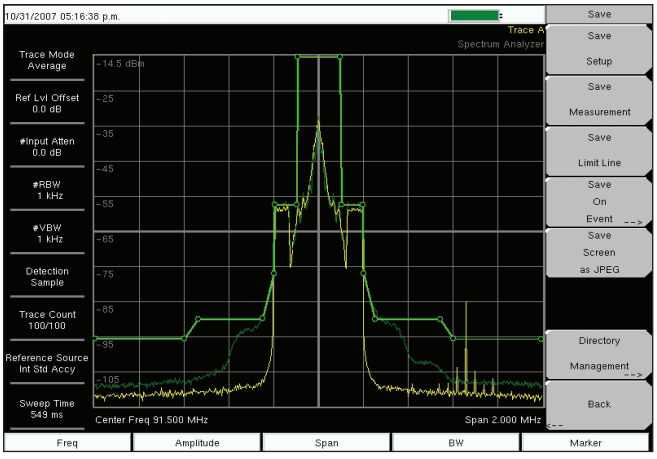


Figure 8. FM IBOC Signal Measured Over the Air with Mask.

Measuring Occupied Bandwidth

According to paragraph 73.317(b) the occupied bandwidth of an FM broadcast signal should be 240 kHz or less at the 25 dB down points. This measurement can be made directly with either the MS2720T occupied bandwidth smart (one-button) measurement.

Spectrum Master model MS2720T. Here is the basic procedure:

1. Center the signal to be measured on the screen.
2. Assure the signal to noise ratio is at least 35 dB.
3. Select peak detection.
4. Select max hold.
5. Select the occupied bandwidth measurement function.
6. Set the method to “dBc Down” and set the value to 25 dB.
7. Turn on the measurement and read occupied bandwidth. On the MS2720T the results will be similar to those shown in Figure 9.
8. To meet FCC requirements, the occupied bandwidth at the 25 dB down points should be less than 240 kHz.
9. Save measurements using names that make it easy to retrieve them later.

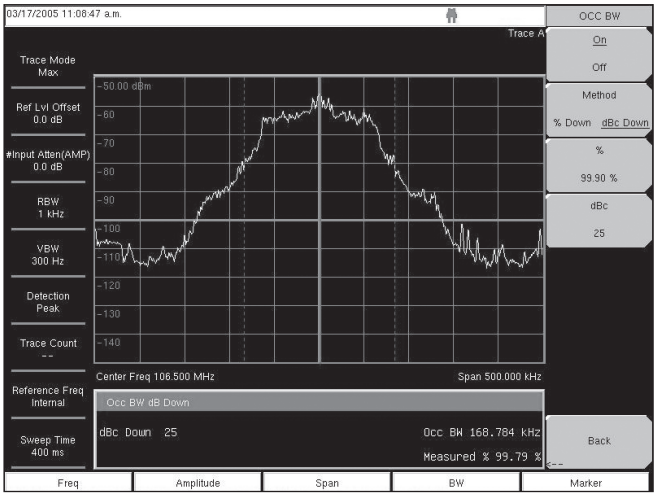


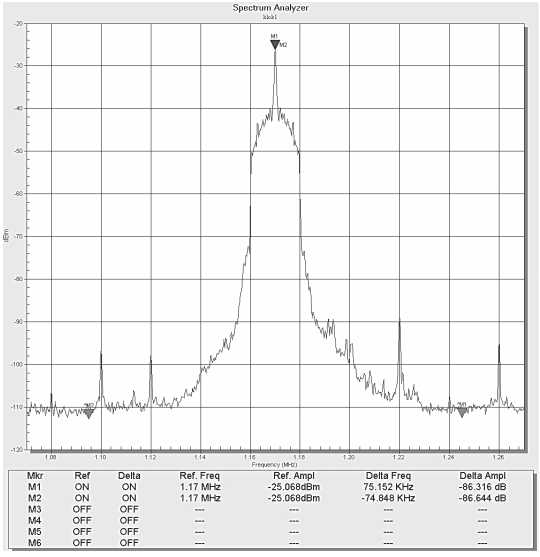
Figure 9. Measured results of a high powered FM broadcast transmitter.

Harmonic Measurements

The method of making Harmonic Measurements for FM transmitters is similar to that shown on page 5 for AM transmitters.

How to make an RF harmonic measurement:

1. Set the spectrum analyzer start frequency to place the fundamental frequency near the left edge of the display.
2. Set the stop frequency high enough to include at least the fifth harmonic.
3. Set the reference level to +20 dBm as a starting point.
4. Make sure attenuation is set to automatic for the start of the procedure. The intention of this step is to make sure there is sufficient attenuation to avoid overdriving the front end mixer. With these settings the input attenuator will be set to 40 dB.
5. Connect the spectrum analyzer to the transmitter’s test port. Note that using an antenna to make this measurement is not advisable unless the antenna characteristics are known and taken into account during the measurement.
6. Turn on a marker and place it on the fundamental.
7. Set the reference level to place the fundamental near the top of the screen.
8. Set the resolution bandwidth to 100 Hz.
9. Observe the displayed average noise level to be sure there is at least 86 dB signal to noise ratio to make the harmonic measurement. Decrease the resolution bandwidth if necessary to lower the noise floor.
10. Turn on other markers and place them on all visible harmonics. With the MS2720T use “Marker 1 Reference” and place marker 1 on the fundamental signal and place delta markers on the frequencies of harmonics.
11. Set the reference Marker Style to Fixed. This will keep marker 1 at the level of the carrier even when it is attenuated in the next step.
12. Insert a high pass filter at the input to the spectrum analyzer to suppress the fundamental. A 5KHP–120 filter from Microwave Filter Corporation will do nicely.
13. Set the reference level to -50 dBm, set the input attenuator to 0 dB and turn on the preamplifier to lower the noise floor.
14. Measure all visible harmonics.
15. Compare the harmonic levels to the specifications of the broadcast transmitter plus the loss of any harmonic filters at the output of the transmitter. The specification for modern FM transmitters is for harmonics and spurious signals to be > 70 dB below the carrier level.
16. Save the measurements using file names that will make it easy to retrieve the desired measurements at a later date



Measurement of a 50 kW AM Broadcast Station made without external filters.

Record Keeping

Since the FCC requires that records be kept, saving measurements in a computer and printing copies for filing with station records is a good way to satisfy this requirement. The MS2720T come comes with software that makes it easy to download measurements into a computer for storage and printing.

Conclusion

Broadcast measurements require attention to detail and consistent processes to assure accurate, repeatable results. Using handheld instruments to make measurements in the field can make the job less of a burden while getting results that meet regulatory requirements.

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11410-00370, Rev. D Printed in United States 2012-012