DA Proofs and the FCC 302-AM

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Abstract

Following construction, setup and adjustment of a directional array, the FCC requires the permittee to prove that the array is functioning properly before program test authority and a license will be issued. This section deals not with the directional proof-of-performance measurements themselves, but rather the requirements for the proof-of-performance documentation needed to satisfy the FCC. The various elements will be discussed in the order that they are created, not necessarily the order that they will be in when the final document is assembled.

1.01 ND Measurement Analysis [DAPROOF]

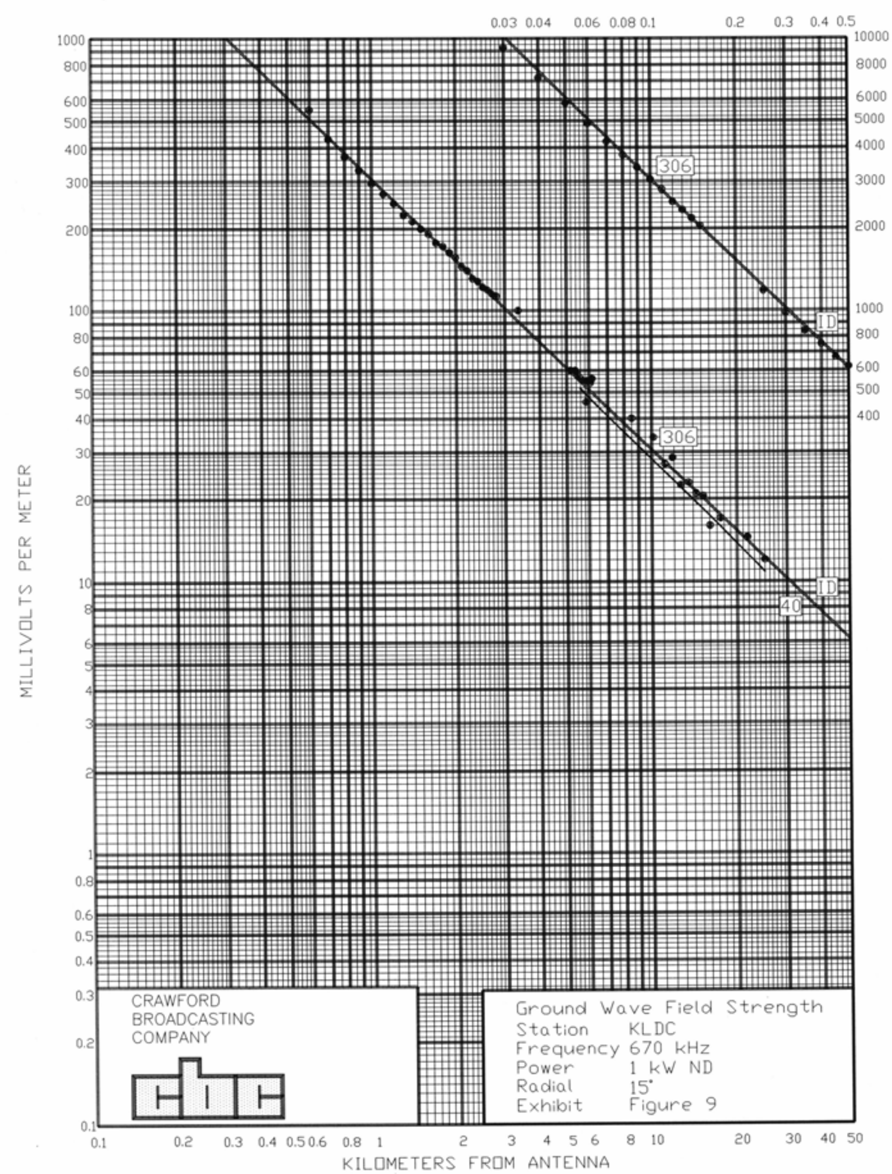
The first step in directional antenna proof-of-performance measurement data analysis is determination of the non-directional inverse distance field (IDF) on each radial. This is done by plotting field strength versus distance on log-log field strength graph paper and performing graphical analysis. It is this analysis that is most often open to interpretation by the FCC. The resulting ND IDF on each radial is used as a multiplier for all DA measurements. As a result, these values have a significant effect on the rest of the proof. For that reason, it is wise to collect as much close-in (inside 3 km) ND data as possible. The more data, the easier it is to analyze and harder to dispute the results.

Once all the points are plotted on log-log graph paper, the inverse-distance line is adjusted up and down the page for a best fit to the data points. A good starting place is the average of E x D of the measurements. With the best fit determined for the inverse distance line, the 1 km value is noted and that established the ND IDF for that radial. An example of a non-directional field strength graph is shown on page 2.

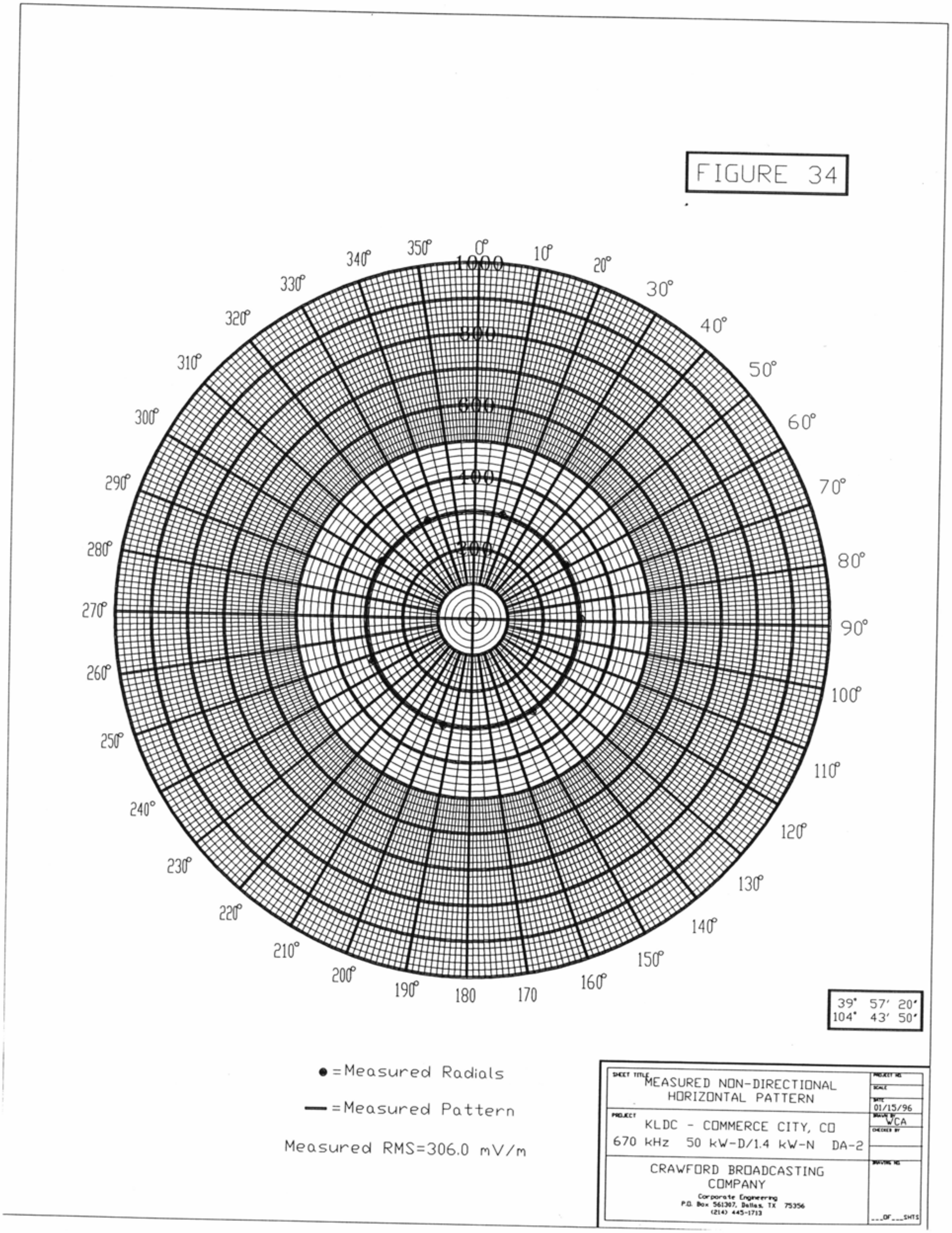
It is also necessary to establish the measured ground conductivity at this point. This is also determined by graphical analysis of the measured data. With the ND IDF established for the radial, various conductivities are tried for best fit to the measured data. A good starting point is the conductivity value for the site as determined from the M3 ground conductivity map. When the best fit is determined, the conductivity curve is drawn onto the field strength graph coincident with the measurement points that support the selection of that particular curve. In some cases, it will appear that one set of points on the graph fits one conductivity curve while other points fit a different curve better. This indicates a conductivity change or “break.” In such cases, a portion of each appropriate conductivity curve is drawn coincident with the supporting measurement points.

Once the points, IDF line and conductivity curve(s) have been plotted on the field strength graph, the graph should be labeled accordingly. Note call letters, frequency, power, azimuth of the measurement radial and exhibit number in the title box on the graph. Label the inverse distance line with the measured IDF value, and label the conductivity curve(s) with the conductivity value.

This process should be repeated for all the radials on which non-directional field strength measurements have been made. With all the ND inverse distance fields established, the ND RMS must be measured. First, a polar graph should be created showing the non-directional radiation pattern. Plot a point on the polar graph showing the measured IDF on each radial. Label the graph with all the pertinent data. Use a polar planimeter to measure the area of the measured ND pattern. Take the square root of the area and multiply by the graph scale to get the RMS. Label the graph with the ND RMS value. An example of such a graph is shown on page 3.



ND Field Strength Graph



Non-Directional Polar Graph

2.0 DA Measurement Analysis:

The next step in the process is analysis of the directional measurements for each pattern. This consists of taking the ratio of DA to ND field strengths at each measurement point, then finding the arithmetic or logarithmic average of all the ratios on the radial and multiplying by the ND IDF for the radial. This yields the value of the directional IDF for the radial.

Because the decision is global to the proof, the decision whether to use the log or arithmetic average bears some consideration. The log average will yield a lower directional IDF, which is useful if the measured pattern will be close to the standard pattern value in any direction. The other side of that coin is that if the measured RMS is low and might possibly be less than the FCC-specified minimum of 85% of the standard pattern RMS, using log averages could put the measured RMS below the minimum. It may be necessary to try it both ways to determine which average to use. Whatever the case, if the log average is used on one radial, it must be used on all.

Once the directional IDF has been determined for all the radials, directional field strength graphs must be produced in the same manner as the ND field strength graphs. Plot the field strength versus distance for each measurement point, draw the directional IDF line, then draw the conductivity curve(s). The conductivity curves for each directional graph must be the same values and spans as on the ND field strength graph. Label each graph as appropriate.

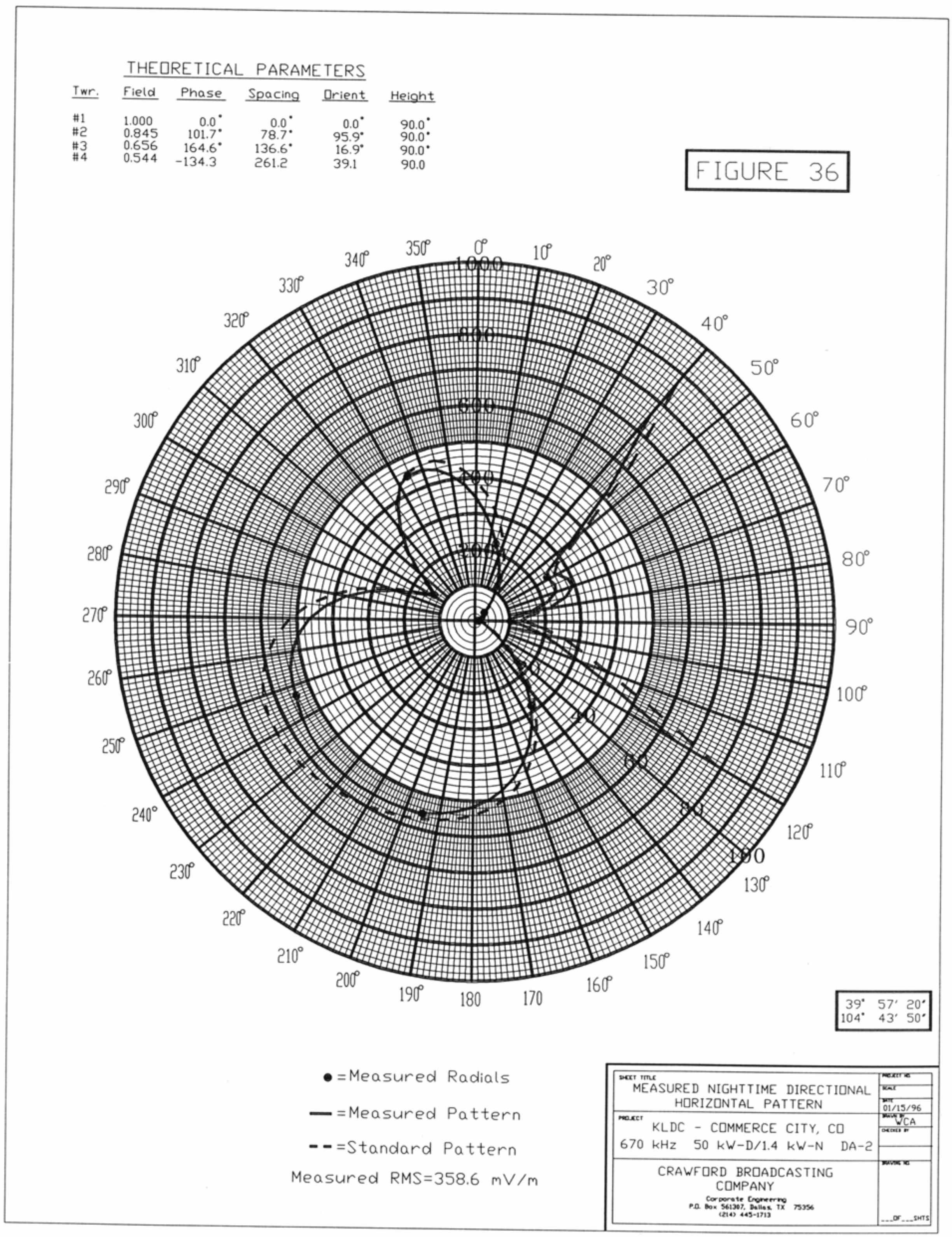
With the directional IDF established and the field strength graphs prepared, a polar graph of the measured directional pattern must be prepared. This graph should show both the standard pattern and the measured pattern. A point should be plotted for each measured radial. Label the graph as appropriate. Use a polar planimeter to measure the area of the measured directional pattern. Take the square root of the area and multiply by the graph scale to get the RMS. Label the graph with the directional RMS value. Make sure that the measured RMS is at least 85% of the standard pattern RMS. An example of such a graph is shown on page 5.

The directional measurement analysis, field strength graphing and plot of the measured pattern must be repeated for each pattern (i.e. DA-D, DA-N, etc.).

Construction permits for AM directional facilities require that a monitoring point be selected on specified radials, usually pattern minima. Each monitoring point (MP) must be located between one and four miles from the center of the array and must be coincident with a measurement point used in the proof. MPs should be located in easily-accessible areas (such as beside roadways) and should be readily described and easily identifiable. Keeping these criteria in mind, select a monitoring point on each of the specified radials. You can calculate the maximum field strength at each MP by the following formula:

$$FS_{MAX} = \frac{FS_{DA} FS_{CP}}{IDF}$$

where: FS_{MAX} *is the maximum field strength for the MP*
FS_{DA} *is the directional field strength measured at the point*
FS_{CP} *is the construction permit maximum field strength for the radial*
IDF is the measured directional inverse distance field for the radial



Directional Polar Graph

3.0 Tabulation

For each radial, a tabulation of field strength measurements must be produced. Each tabulation must include for each measurement point the point number, distance, date, time, field strength and DA/ND ratio. Any point designated as a monitoring point should be so labeled.

A single tabulation can be used for ND and multiple DA modes of operation. The log or arithmetic average of the DA/ND ratio for each directional mode must be shown. Spreadsheet programs such as Lotus and Excel are particularly well suited to creating the tabulations. In addition to formatting the data in each column, the ratios and averages can be automatically calculated and displayed. This is particularly useful when deciding which points to use and which to discard, as the effect on the overall radial average can quickly be seen.

A tabulation of all the measured fields must also be produced. This tabulation must include radial azimuth and ND measured field, then for each directional mode the average ratio DA/ND, DA measured field and DA standard pattern.

4.0 MP Descriptions, Photos and Map

For each monitoring point, complete directions from the antenna site to the point must be provided along with a description of the point. Directions should be written so as to be easily followed in an automobile, using odometer distances and permanent landmarks wherever possible. Geographic coordinates as determined by GPS should also be included if available.

A photo must also be provided of each monitoring point. The photo should show the FIM being held by a person or mounted on a tripod with the antenna oriented toward the station. Keep in mind that the best MP photos show some permanent, identifiable object in the foreground or background that will make location of the point easy.

A map showing all the monitoring points must be produced. This map should show the transmitter site and all the roads referenced in the written MP directions. Each MP should be clearly labeled with MP number and radial azimuth.

5.0 Measurement Location Maps

Topographic maps showing each of the measurement locations must be provided. These topo maps can be reduced to 8½ x 11, but they must be reasonably clear reproductions. On each map, the radial(s) on which measurements were made must be drawn with all measurement points clearly marked and numbered. The point numbering must match the numbering in the tabulations. Points designated as monitoring points should be marked as such. Each map must be labeled with the exhibit number, and the radial line should be labeled with its azimuth on both ends. The *central* map (the one which has all the radials and the transmitter site shown) should generally not be reduced from its original size. There is too much information on this map to reduce and maintain clarity.

6.0 Engineering Statement

While it is not specifically required, an engineering statement *should* be include with the directional proof-of-performance. It is here that you can answer in advance any questions that the FCC staff may have as they process the application. The engineering statement should contain the following information:

< Introduction, giving the purpose of the application and general background

< Engineering discussion, providing:

    < Description of the array
    < CP requirements
    < Adjustment procedure and results
    < Sampling system description
    < Ground system description
    < Measurement procedure, including a list of personnel and FIMs
    < Impedance measurement procedure and list of equipment used
    < Discussion of monitoring point selection

If there are any special conditions in the construction permit, a discussion of the special conditions and what measures were taken to comply with them should be included in the engineering statement. In short, anything that the FCC may ask about the application that is not otherwise covered in the proof exhibits or Form 302-AM should be included. Examples of this may include an intermod study is the site is collocated with or close to another AM station, or obstacles encountered while making measurements (such as a lake or terrain that made measurements impossible for a span of several miles on one or more radials).

7.0 FCC Form 302-AM

The actual FCC form has been simplified in recent years and is in actuality very easy to fill out. A copy of the engineering section of the current form is provided in the appendix.

In the case of a directional proof-of-performance, the 302-AM requests a *Station License*, not Direct Measurement of Power. Most of the blanks to be filled in are self-explanatory. They include callsign, CP file number, frequency, hours of operation, power for each mode of operation, and transmitter, studio and remote control location. There are yes/no questions regarding AM Stereo and the sampling system. The sampling system question requires an exhibit. If you have fully described the sampling system in the engineering statement, you can reference it here without creating an additional exhibit.

The next section is for operating constants for all modes of operation. These include common point current and resistance and reactance for each mode in addition to antenna monitor parameters for each mode. You must also list the make and model of the antenna monitor. Extra care should be taken here as these are the parameters that will become the licensed operating parameters. A missing or incorrect sign, decimal point in the wrong place or typographical error will cause grief down the road.

Information is required for each tower in the directional array, including type radiator, overall height above base, overall height above ground with and without lighting, and a description of top-loading/sectionalization if used. Again, you can simply reference the engineering statement if the top-loading/sectionalization was described there. One question that is *not* on the form that should be (and you will have to supply it later if you don’t take the initiative here) is antenna structure registration number (ASRN). The easiest way to address this is to simply type in the information on the form, for example: ASRNs: #1 - 1234567; #2 - 1234568; #3 - 1234569

Check boxes are provided to indicate series or shunt excitation. If a combination of these is used (i.e. one or more towers skirted, the rest insulated), check neither box and simply type in the information (e.g. #1, #3 series; #2 shunt. See Engineering Statement).

Geographic coordinates must be supplied, and these should match the center-of-array coordinates from the construction permit.

Questions are asked regarding other antennas (STL, RPU, etc.) mounted on array elements and their isolation circuits as well as the ground system. Both these should have been discussed in the engineering statement. That can be referenced here.

The last question on the form asks in what respect, if any, does the apparatus constructed herein differ from that described in the CP application. This is a loaded question because virtually anything you answer here will violate the terms of the CP. The best thing to do here is leave it blank.

8.0 Putting it All Together

With all the elements of the directional proof-of-performance and FCC Form 302-AM completed, the final step is putting it all together in an order that makes sense. Assemble the components in the following order:

1. Engineering Statement
2. FCC Form 302-AM
3. Tabulation of Field Strength Measurements
4. Plot of Field Strength Measurements (graphs)
5. Tabulation of Measured Inverse Distance Fields
6. Polar Plot of Non-Directional Pattern
7. Polar Plot(s) of Directional Pattern(s)
8. Monitoring Point Map
9. Monitoring Point Descriptions/Photos
10. Maps Showing Measurement Locations

Create a title page with a descriptive title for the application, callsign, community of license, licensee name and date. Create a table of contents to follow the title page.

When filing the proof with the FCC, supply an original and two copies. Place a copy in the public file, put a copy at the transmitter site, and of course keep a copy for yourself.

For the moment, the 302-AM cannot be filed electronically. That will in all likelihood change at some point in the near future. When that happens, you will have to add scanning and uploading of exhibits to the end of your project. Even with electronic filing, however, it would be advisable to also file a paper copy of the proof and application, complete with a full-size central topo map.