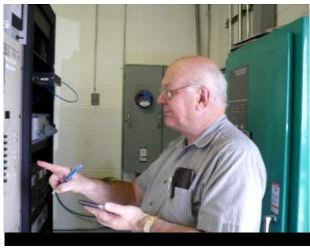

The

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From the Transmitter Site

Using Your MoM to Make Your Monitor Points Disappear

By Ed Trombley

[September 2010] As one of the biggest changes in AM directional applications since the "Approved Sam-pling System," the FCC approval of the Method of Moments modeling excited many stations who wanted a simpler way to design, build, and prove directional arrays. As Ed Trombley notes, this procedure is also of use with existing directional stations, saving many hours of visits to various monitor points.

Many of of us have fond memories of our favorite AM Monitor Points and the directional arrays that generated them.

Others of our broadcast engineering profession would be quite happy never to be burdened with an AM array, and the need to ensure the monitor points are within limits, ever again.

VISITING INTERESTING PLACES

AM monitor points, by luck of the draw, can find themselves located in some unusual settings. One monitor point I have visited is inside the local, locked and guarded toxic waste dump. You can go into the site easily enough, but afterward you might be afraid to wear your shoes into your house for the next two weeks.

Another array has the monitor point 150 feet inside the local state run bed and breakfast where all the guests wear blaze-orange and answer to an inmate number. The monitor point was there first, but 25 years later the State could care less.

One of my favorite monitor points is on the "heading of 160° True North, a Point located at the Greenville Airport, near the East end of the main east-west runway, just East of the large numerals in the center of the runway." The airport manager is a neat guy who reminded us, "When you hear that buzzing sound, it's time to duck and run!"

If you are not so fortunate, you may find yourself in the back alley of some decayed industrial city. You can tell when you are getting back into the better parts of town, because the junk cars in residential front yards are right-side up.

WHEN MoM WILL NOT HELP

Some combinations of tower heights and sample transformers are not allowed under the new method.

Check your current FCC license for the electrical heights of your towers. For example, towers that are 120 to 190 electrical degrees cannot use sample transformers. Historically, under certain conditions towers being driven with high reactance loads have fooled the sample transformer into returning an inaccurate measurement.

Anyone who has an AM tower near 145 degrees, it is that physical dimension where the resistance and reactance goes postal. They have discovered that RF goes in then plasma, smoke, and fire will attack anything that gets too close. Arrays with towers taller than 120 degrees but shorter than 190 degrees must use sample loops.

Additionally sample loops can only be used on towers with identical width and cross section. Unequal heights are okay but the towers must have identical width and cross section where the loops are located. Also, when using sample loops on tall towers, relocation of the loops may be required to place them at required current nodes.

WHAT IS NOT ACCEPTABLE FOR PROOFING BY MoM

To summarize the situations where MoM will not solve problems, here is sort of an anti-check list:

- Towers that are shunt fed of any type.
- Sectionalized towers or towers that have top de-tuning skirts to electrically shorten the tower.
- Tall towers between 120 and 190 degrees electrical length using sample transformers. Conversion to sample loops is required.
- Towers with different cross section that use sample loops.
- Ground systems where any part is elevated above ground or drastically shortened to fit property lines.
- Arrays with unequal sample lines.

DESIGN AND MONITOR POINTS CHALLENGES

Granted, moving a monitor point usually is an easy modification of a directional array but the distance of the move is sometimes very limited. The funny thing is, if you wait long enough and maybe are not keeping up on your array maintenance, something or someone eventually will make one of your monitor points totally useless.

On the other hand, it has become possible to eliminate some monitor points using the new Method of Moments (MoM) array modeling. Of course, there are several design requirements that need to be achieved for MoM to be useful; how the original array designer put your array together will often determine if your array is suitable for operation under the MOM proof methods. (Some arrays, because of the way they were constructed, are not eligible for proofing under the MoM rules. Examples include arrays using a shunt or skirt-fed tower, or an array with an elevated ground system.)

Keep in mind that your historic (older that dirt) array may have been designed by a talented guy using a slide rule and trig - log tables. Many of these pioneering array designers would take a “seat of the pants” guess how best to drive the array. Unfortunately, every now and again we find an array where that best guess method delivered the worst possible driving point combination.

Old arrays with four towers in line on any frequency seem to be "ugly" more often than average.

Almost always a challenging type of array

Arrays that were built using minimum land, short-element spacing, and minimum height towers approach design limits with low driving impedances and inherited stability problems.

If you have been blessed with an array that has stability problems re-proofing your array using the MoM method most likely will not stabilize the array. To achieve stability, array modeling, a new pattern and a new drive system will most likely be required.

Of special note are those arrays that have been tweaked to let out a null, that may have been modified to better cover populations that grew in the nulls, or that have had their ground conductivities measured and played with to net a power increase. These arrays may be bad choices for proofing under MoM because the new proof method does not use measurements to establish real world ground conductivities. (If your array has had a null expanded going to the new proof method may pull that null back down and restrict coverage.)

Another consideration is that whatever the array modeling gives you is what you are stuck with - making a change in pattern would require going back to "Go" and starting over. Meeting with a consulting engineer who understands the MoM proof methods is very important and will help give you a better idea if there is anything to lose by re-proofing your array using the MoM Rules.

APPLYING MOM MODELING TO EXISTING AM DIRECTIONAL ARRAYS

The FCC released the Method of Moments proof Rules in FCC-08-228 and later released a clarification in DA-09-2340, dated October 29, 2009. Let us run down the requirements published in the clarification and see how your array fares on the way to being proofed without monitor points.

The towers in the array must be series fed. Towers that are series fed with top loading can be accurately modeled and are allowed. The ground system must be a conventional ground system as described in FCC Part 73.189 (b)(4).

The Sample System is a major player. Under the new proof requirements it is developed into a calibrated precision system.

Do not assume that because you ordered equal electrical length lines from the factory that they will measure correctly after they are installed and buried. Sample lines must be made of phase-stabilized coax with a hard outer jacket and field trimmed to equal electrical length ± 1.0 degree using a network analyzer. Also the sample lines must measure equal impedance ± 2 Ohms.

If the lines fail the impedance test, there is no recovery other than replacement.

Additionally, if the array uses sample transformers they must be calibrated to each other and must meet manufacturer's specifications, which will change with the model of transformer used. Again, the network analyzer is employed for testing and calibration. If a sample transformer is found to be out of tolerance it can easily be replaced. Obviously, these spare transformers must be capable of matching the other transformers in your system.

While it has been our experience that transformers do not fail slowly - they are either good or way out of calibration - lightning can damage one in an instant. Thus it is a good idea to keep a spare sample transformer or two on the shelf. Losing the calibration of the sample system may require an early recertification trip by your consulting engineer.

POST CONSTRUCTION DOCUMENTATION

All new directional arrays being proofed under the MoM Rules are required to have a post-construction survey conducted by a licensed surveyor.

A sealed drawing of the array is required to be submitted with the proof data; the drawing must show all tower locations post-construction are within 1.5 electrical degrees as designed in any direction. Also the drawing must show that the heading of the array is within 1.0 degree based on true North. Errors built into the array are additive from the reference tower. If the survey shows too much error, the array will require that a new AM-301 application for construction permit be filed to reflect the as-built array.

For existing arrays the post-construction survey is not required as long as the array is keeping its theoretical design numbers. If the pattern is changed then it becomes a new construction on an old platform and the post-construction survey is again required.

WHERE *IS* THAT TOWER?

Here is a simple word of caution about designing a new pattern on an existing array: Today, we have GPS that is good down to a few centimeters. However, many old arrays were built using more primitive survey methods.

In the old days it was just before midnight when a surveyor aimed his transit at the North Star. Then there was a correction for true North - and a 50% chance it got corrected in right direction. Stakes were set, and surveyor came back in the daylight. The mechanical compass rose on the surveyor's all-brass transit set the final heading of the array. The distance between the towers was then measured with a steel tape and again stakes were set.

There were plenty of opportunities for error. If you are considering a new pattern on an old array you better do that post-construction survey *first* and get the headaches out of the way. The pattern, phasor design, and cost all change when you discover that a tower is not located where you thought it was!

Even with modern measurement toys we still run into tower riggers who have never built an AM array. Not everyone understands the importance of crossing the strings and landing the pin on center. Errors happen causing the concrete form and base insulator to end up three feet West of center. Your beautiful array then erodes into a miserable unintentional dog-leg.

FILING THE APPLICATION

The last consideration in putting together an application based on MoM is the required filing fees.

- If you are taking your existing array and keeping the existing pattern but re-proofing it with MoM mod-eling, the FCC tags you with a New License Fee of $615.00 plus an AM Directional Antenna Fee of $705.00 per application.

- If a decision was made to modify the pattern and operate with new theoretical parameters, then there will be a Minor Change 301AM filing fee of $940.00 added to the New License and Directional antenna fees.

- If you are starting with a new array for a new city or you modified your old array to the point that it be-comes a Major Change, the FCC 301AM filing fee is $3,740.00, plus you will pay the New License fee and the Directional Antenna fee if you chose to proof your new array using new MoM procedure.

- There may also be some attorney fees getting your proof in the front door at the Media Bureau. The Proof application and report is a paper-only filing and is not yet accepted in electronic form.

All of these fees add up to a good portion of the cost of an old fashion partial proof. If all your array needs is a monitor point moved it may still be less expensive to do that by the tried and true method. If your array has bigger problems, then a re-proof with array modeling may cure some past headaches.

MAINTENANCE UNDER MoM

As you can imagine, eliminating monitor points re-directs your maintenance efforts a bit. For instance, the precision of the sampling system under the MoM rules is required to be checked every two years.

Basically this requires re-measuring the sample lines and checking the calibration of the sampling trans-formers. These measurements are easily conducted with a network analyzer and minor down time of the array. The calibration of the phase monitor is also important and it should meet factory requirements. Consideration should be given to up grading to one of the new digital phase monitors.

GETTING MORE COMFORTABLE WITH THE PROCEDURE

As of the time of this writing we have several arrays successfully licensed using the new Method of Moments Rules. This small success is hardly enough to make us experts but enough experience to give us an interested feel for the method and its results. The more we play with the modeling aspect the more surprised we are with the accuracy of the results.

We have completed one of each of the three types of array modeling. One project was a new build, another was a re-proof of an existing license and a third was a new pattern on an existing array. Nationwide, 75 arrays have been licensed and numerous applications are pending a grant, all filed using the Method of Moments Rules.

MONITOR POINTS THAT ARE NOT

Now about those monitor points. If you have an existing array, your old monitor points will become reference points. If you are building a new array, your consulting engineer will pick new reference points on the null radials. There is no requirement to ever measure any of these reference points.

I am guessing that there were some old school engineers at the FCC who just could not let go of the concept of an array without some way to measure signal level with a field meter. I am also guessing that, as the art of MoM develops, the reference point requirements will be dropped.

So for the time being your old monitor points still hang around, but the requirement to visit and measure them goes away. Then again after 20 years of standing in Mrs. Smith's back yard you may not want to stop. You know she has apple pie ready just in case guest stop by.

OUR FIELD EXPERIENCE

Our granted re-proof application was conducted on WCHB in Taylor, Michigan. That was the 50 kW daytime into four towers and 15 kW nighttime into 10 towers that our office, Munn-Reese, built and proofed back in the summer of 1999.

Charlie Nettleman, Don Baad and I spent months on that nighttime array building and proofing it. The array had aged some and the land around it was being developed. It was time for the monitor points to be tucked back in-pattern. The owners, under the wise direction of Bill Bommarito, the chief engineer, made the choice to re-license the array using the new Method of Moments Rules.

Rick Grzebik from our office calibrated the sample system and obtained base impedance measurements for the day / night arrays, then both arrays were modeled and new array operating parameters derived.

The arrays were then adjusted to the new operating values and re-licensed. When the license application was granted, the requirement to timely measure 14 monitor points, six on the daytime and eight on the nighttime, was removed from the license.

HOW MODELING WORKS

The modeling of an array in mini-NEC is an interesting process that easily becomes repetitively frustrating. However, as you get better at it, the results come faster and easier.

First, base impedance measurements from the array are obtained with a network analyzer. The array is then modeled in the mini-NEC software. Shunt and series loads are added in the model for such things as the capacitance of the base insulator, the reactance of the copper tubing from ATU bowl insulator to tower leg, the obstruction lighting chokes, the static drains chokes and the iso-coupliers for STL or FM feedlines.

During this part of the game, a good calculator that can do complex math is a must.

The modeled array is then slowly adjusted until the calculated base impedance matches the real world measured base impedances taken out in the field. The operating parameters for phase and ratio for each tower in the mini-NEC model are then applied to the real array.

With the array operating on the mini-NEC derived values for phase and ratio a few passes around the tower bases are made to check the ATU matches back to the 50 Ohm transmission lines. As corrections are made to the T-networks the array must hold the derived values for phase and ratio for each tower.

Once the satisfactory match to the 50 Ohm transmission line is obtained and the array parameters are correct the tuning process is done.

ANOTHER FIELD EXPERIENCE

Here is another example of how array modeling produced favorable results.

A client contacted us for help with a newly purchased 5 kW, four-tower box array. This array was in dire need of a rebuild - it was so far out of line that the transmitter kept dropping out at any power level over 1000 Watts. I was sent to the array with the objective of finding what needed to be repaired and if possible get the array to run at full power.

The first step was to get the station set up on the non-directional tower with the other towers floating. Next, I measured the impedance of the non-directional tower. We found several bad caps in the ATU's, two bad sample lines and one bad feedline. Replacing the flamed caps was easy enough, but this was more than your average pile of trouble.

I took tower #4 with the bad feedline and pulled the ATU output jack to float it, then went back to the phasor pulled the jack on the buss that fed the power divider for tower #4. We made one pass around the other three towers with an OIB-3 and set the ATU matches arbitrarily to 50 Ohms with little reactance.

Then I went back to the phasor and set the Common Point impedance to 50 Ohms J zero. We now had a well-matched, three-tower dog-leg. The transmitter liked it and would make full power into the phasor.

At this point it should be intuitively obvious to the most casual observer that I had no clue where the RF was going - and with two bad sample lines, one coming from the reference tower itself, neither did the phase monitor!

We set the power level to keep the monitor points under the maximum limits and filed for operation under an STA with "all parameters at variance." Even with the array operating in this wounded condition we could run more power than Non-DA and still keep the monitor points under limits. With the STA on file they ran with it in this "ugly" mode.

DOING A MODELING MAKEOVER

Nine months later all the feedlines and sample lines were replaced and it was time to go back and attempt to put the pattern back on the numbers.

The station had also sprung for a new PI digital antenna monitor. Using the measurement data obtained from the NDA tower we made the assumption that the other towers were equal. The array was modeled with what little data we had.

Using the derived driving points for the four towers Don Baad worked backwards with data off the array schematic. Knowing the required phase shift in each network and the calculated mini-NEC tower drive impedance the reactance values for the arms of the T-networks were calculated. Then Don's infamous HP calculator method was used on each leg to determine how many active turns were needed in each coil to make the T-networks correct.

Armed with this active turn data on a yellow pad - and a good amount of skepticism - I returned to the array.

The array was restored to four active towers and the suggested active turn data from the yellow pad was employed at each T-network. The phasor was dialed back to the last set of recorded counter dial data found in a ten-year-old maintenance log. Low power was applied to the array and common point set to a usable match. The array came up with three towers ready to play.

SOMETIMES THERE IS SOMETHING ELSE GOING ON

The reference tower is like your get-out-of-jail-free card it will always be zero and 100 on the monitor. But, in this case even the matches back to the feedlines were better than normal for an array that had been turned inside out. The other two towers were about 5 degrees out and 10% off the proper ratio values. The matches back to the feedlines were also very good.

The pre-power up coil setting had worked on three towers but not on Tower #1. Tower #1 was not even close, not even in the game (it seemed like it was about half way to North Dakota). The other towers moved easily with adjustment of the phasor, but not Tower #1. Only changes at the tower base worked.

After two hours of slapping Tower #1 around, I got it to a point where the phasor finally started to play. For some reason the modeling and HP pre-settings had failed to work at Tower #1, while at the same time worked very well on the others. Eventually all the towers were returned to licensed operating values and the monitor points easily measured in with headroom to spare.

Later we found that Tower #1 had a pair of shorted insulators in one of the top guy wires. Not shorted so that it was top loaded but it was affected by the interaction of the guy wire. The damaged insulators were most likely exploded by lightning. They were very hard to see that high up without binoculars.

What happened was that Tower #1 was being pulled away from its natural impedance by the interaction of the long guy wire section near the top of the tower. That was why Tower #1 did not match the mini-NEC model, and the ATU active turn pre-setting was also inaccurate for the conditions the tower was attempting to operate in.

Needless to say, Don and I were very impressed that even with the shorted insulators, the modeled towers played so close to the real world array. It made the tune up a whole lot easier.

PROGRESS HAS COME TO AM

The art of AM broadcast directional array design has advanced steadily since that first array appeared in Florida around 1932.

Back in the early days of building and proofing, the engineers did not have many of the tools we take for granted. Harold Munn and Virgil Royer from our office stated that in the early days the Rule of Thumb for the time estimated to build and tune up an array was a month for two towers and two weeks for each additional tower added to the array.

In many cases, the array was constructed and the clips were set to the center of each adjustable coil, then the tune up process started. An accurate RF thermocouple meter, a General Radio impedance bridge, a precision 50 Ohm resistor and a slide rule were the field engineer’s best friends. Without the luxury of an operating impedance bridge, loads presented back to the feedlines had to be reverse engineered by working the T-network equations backwards. It was a time consuming trial and error process.

I have a copy of an early 1939 four-tower array proof where the phase monitor was a precision two input oscilloscope, two equal length coax lines were connected to two sample loops. One loop was attached to the reference tower and the other loop was walked between the other three towers in the array as needed. The early process makes a 30-year-old beat-up, button-mashing, relay-sticking, hit-it-twice-to-get-the-phase-number AM-19 look super user-friendly.

As the computer tools developed, so did the understanding that certain combinations should be avoided as inefficient. Random-spaced, dog-leg arrays became easier after computer calculated patterns sped up the number crunching. The operating impedance bridge and now, network analyzers have added to the speed and accuracy of the design of complicated arrays.

It seems that array modeling attached to real world data is the next logical progression in modern directional array art. Today, it would be foolish for any station owner considering a new directional array build out, to do anything but a MoM proof. In fact, the new array should be designed with the

MoM proof as part the finished product. The reduced field time of doing the MoM proof offers substantial cost saving over the old tried-and-true method.

One question still remains unanswered. How will the field engineer ever return home with an interesting tale to tell if he never leaves the transmitter site in search of actual field data? Just think of the fun stories we will lose: stories of being chased by livestock, questioned by police or falling into a water filled ditch.

On the other hand …

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