Transmission Guide

by Ron Nott, DVP

The Elevated Radial System

For more than eight decades the buried ground radial system has been the standard for AM broadcast antennas. When the FCC came into existence during the 1930s, standards were established that are still in effect today.

However, during the last two decades, computer analysis has determined that the standard buried radial system of 90 or 120 wires may not be the best that can be built. In fact, NEC (Numerical Electromagnetic Computation) indicates that an elevated radial system of only four wires can do just as well or better.

The only problem is that a four-wire system may result in some scalloping resulting in a slightly four-leaf clover pattern. To resolve this, a six-wire elevated system can be utilized, which results in minimal scalloping and an essentially omni-directional pattern.

BUT DOES IT WORK?

Sometimes the experts belittle anecdotal experiences as if they were fiction. They say that you must perform extensive scientific measurements to validate a theory. But who is going to perform these measurements on AM radio, a technological relic in the eyes of many?

When an elevated radial system is installed for an AM broadcast station, the FCC often requires an antenna proof of performance because it deviates from the standard buried radial system described in the Rules. Such a proof for a non-directional station is simple and inexpensive. For directional antennas (DAs), the cost is the same as for a non-DA because it has to be done anyway.

While we have furnished a relatively small number of elevated radial systems, the antenna proof results have easily exceeded the FCC requirements. The point is that elevated radial systems have been proven to fully comply with FCC requirements for minimum field strength.

BURIED RADIALS

Ideally, radials should be laid directly on the surface because this would cause the least signal attenuation, but this is not practical. Radials must be buried for their own protection; otherwise they will be exposed to damage and theft.

Burying radial wires in the ground automatically introduces attenuation of the AM signal. It is caused by the dirt. The deeper the wires are buried, the greater the attenuation. Yet, even when they are buried, radials may be subject to pipeline or cable trenchers and farmers plows.

And do not forget, the velocity of propagation in a buried radial wire is determined by the relative permittivity (dielectric constant) of the soil and the burial depth. A quarter-wavelength buried radial is seldom, if ever, a quarter wave long as far as the RF is concerned. It is almost always longer than if it were in free space and its electrical length may vary with soil moisture.

DETERIORATION AND THEFT ISSUES

After they have been buried for many years, it is impossible to fully know the condition of a ground system. Are the radials corroded? Have they been cut by construction?

Buried radial systems are normally made of pure copper. During the last six months, the price of copper finished goods has approximately tripled. In addition to a big increase in the cost of a new or replacement system, your copper is much more attractive to copper thieves.

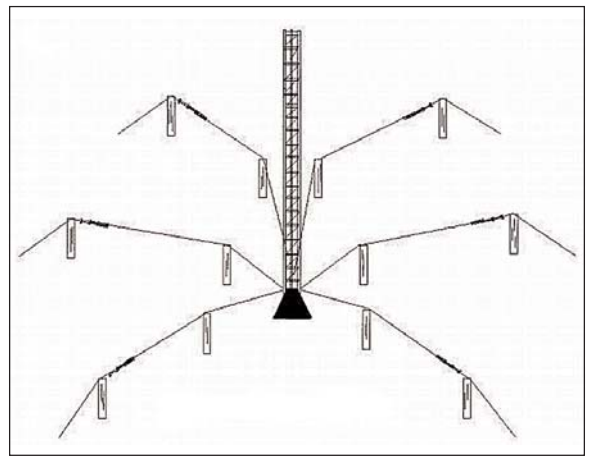
It is easy for the thieves. They come in the night and dig a hole near the base of your tower. They peel a few wires out of the ground, wrap them around the bumper of their vehicle and drive away. The wires peel out of the ground, the thieves coil them up and take them to the scrap dealer.

ELEVATED RADIAL SYSTEMS

A buried radial system is very labor intensive, not to mention the copper cost. An elevated radial system requires less labor and less in materials costs. Because it is up in the air, it is easily inspected at any time.

Imagine six wires equally spaced around your tower(s) tapering upward at about 30-degrees to posts about 12 to 15 feet above ground, then extending outward to another post or possibly two for a lower frequency station. The wires are attached to the ground rods at the base of the tower and by a ground strap to the ATU.

Beyond this ground connection, the wires must be insulated throughout their length. Each wire is slightly more than a quarter-wave long. A turnbuckle and tensioning spring provide adequate tension to support the wires. The posts may be steel or wood, but the wires must be insulated from them because considerable RF voltage develops at their outer ends. Back-guys may be needed at the outermost posts.



An Elevated Ground System

For strength, the wires are Copperweld, which, because they are made of steel with thin coating of copper have virtually no scrap value. And they are much less costly than pure copper wires. Pure copper wires would stretch under tension, but the Copperweld will not.

There are wires up in the air, but they are high enough to allow vehicle traffic under them. If necessary, elevated radials can go over buildings, which is better than routing wires around or under them.

You can inspect the system every time you visit your transmitter site and the wires are not surrounded by dirt that attenuates your signal.

There may be RFR concerns with high powered AM stations, but because the current is divided six ways, radiation is minimal from each wire and occurs mainly from the inner portion of the wires near the tower where the RF current is the greatest. There is normally high RF voltage at the ends of the radials, but they are up in the air where they are safe.

ELEVATED RADIALS WITH FOLDED UNIPOLES

These two technologies work extremely well together in that the radial wires are bonded to the tower legs at ground level. The continuity for the RF current is ideal. While most of the RF current in a folded unipole is in the skirt wires, there is also current in the tower legs that then flows into the elevated radial wires.

Alaska is hard on buried radial wires. Each winter there is frost heave, which means that the ground moves around. This movement of the soil can break radials. One station engineer told me that he had to install a new radial system every three to five years or his signal went to pot.

His 10 kW station coverage had deteriorated greatly, so we furnished a combination folded unipole antenna and elevated radial system. One problem was the possibility of snowmobilers being clotheslined by the elevated wires. Elevating the wire to about 10 feet above the deepest snow solved this. The end result was great. After installation, the station range was from 90 to 100 miles and more.

BUILDINGS AND PAVEMENT

Another story is about an old station on the west coast. As a result of the rainfall, the old tower had rusted away, so a new taller one was purchased in order to install an FM antenna. The old buried radial system had deteriorated, and because the station was located on a small college campus, one story dormitory buildings had been built as close as forty feet away from the tower.

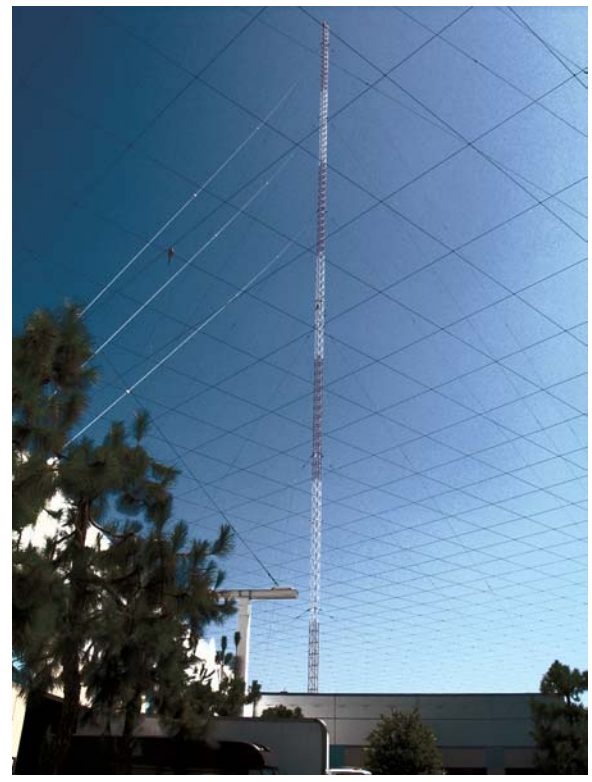
The station even had received an advisory from the FCC stating that they were not meeting the minimum field strength requirements, so they had problems.

The solution was to install a folded unipole antenna and elevated radials emanating out from the tower about 20 feet above ground. This completely solved the problems. The field strength requirement was now easily met and the signal gets out very well.

Nevertheless, because large trees cover the campus, I advised the engineer to prune their branches away from the elevated radials. When I spoke with him about two years later, he said that this was not necessary. Because the station is 10 kW, RF arcs from the wires just burn off the leaves and small branches. A breeze sways a branch near a wire and when it gets close enough, there is a zzzzt and the leaves and twigs just go away.

FLEXIBLE SOLUTIONS

An elevated radial system can solve many problems. If the transmitter site is in a swamp or lake, just elevate the wires above it. If the environment is not amenable to buried radials for other reasons (rocks, buildings, pavement, etc.), just go overhead with them.



This elevated system puts lots of overhead lines over an industrial park.

An elevated radial system is less expensive and performs equally to or better than a conventional buried system. Variations in pattern shape due to weather and season changes will be minimized. Plows and hooves are hard on buried copper wires. Now a farmer can grow crops or run livestock under the ground system.

Also, you can visually inspect the radial system any time. There is no more wondering about the condition of the buried wires, although a small fence may be required near the tower site to keep people away from the sloping portion of the wires.

Ron Nott operates Nott Ltd. in Farmington, NM, where he provides a wide array of tower systems and services. Contact Ron at ron@nottltd.com