antennas

BY KENT BRITAIN,* WA5VJB

More on Ground Radials plus Log Periodics

This month the column might be used as evidence of ADD (attention deficit disorder) in this columnist, but we are going to be visiting a variety of topics.

The letter in the last column about ground radials brought up a whole new batch of comments and questions. First was the concept of a 1/4-wave radial. A 1/4-wave radial is a lot harder to determine than some of our readers seem to think. As an example, let's start with a 1/4-wave radial at 7.1 MHz. Seems simple enough. At 7.1 MHz a radio wave is 299,792,458 meters/sec., or 7,100,000 cycles/sec., or 42.224 meters.

At this point I wish to apologize to any long-time readers. I hate taking math to this level and think anyone who published that their antenna elements should be measured to .0001 inch needs to have his or her scientific calculator taken away and whacked firmly over the head with a pocket slide rule! I had planned to get out there with my TDR (time domain reflectometer) and actually measure some ground radials, but I wimped out in the freezing weather. Heck, the dielectric constant of water changes from Er = 80 to Er = 9 when it freezes. How about that for an excuse?

So does my 1/4-wave radial or antenna element need to be 42.224/4, or 10.55 meters long? No! A thin wire has inductance, and this inductance along even a straight wire slows down the wave. This slowing down, or velocity factor of the wire, varies with the gauge of the wire, but is about 95%. If you have ever tried to work out the classic equation for a half-wave dipole using your high school physics book, that 468/MHz equation doesn't quite work out. That 95% fudge factor is already calculated in, and even the 468 is just an approximation.

The classic formula will get you close, but again, the gauge of the wire, insulation on the wire, and mounting height will change the final frequency. That's why we have SWR meters and can tweak the antenna for our favorite frequency.

However, now back to our 10.55-meter long, 1/4-wave radial at 7.1 MHz.

At this point I want to apologize for the diagrams. The only program I had that would do a good job of looking at a buried radial as a transmission line is written in DOS and thinks it is outputting to a dot matrix printer.

Fig. 1 shows a network analyzer response for an elevated radial 10.55 meters long and 2 feet off the ground. It is a tuned radial with a nice resonance at 7.1 MHz.

In fig. 2, the radial is lying on top of the ground. Can you imagine a section of coax using dirt as the center insulator as shown in fig. 3? What are the conductivity, dielectric constant, and loss tangent of this coax separator? Also, the electrical properties of dirt vary wildly across the U.S. and even vary with the seasons. The dielectric properties of the dirt has changed the velocity factor of the wire from .95 to about .80, and the resonant frequency of the radial is now down near 6 MHz just by lowering the wire to the ground. Also note the width of the low SWR curve—quite a lot of bandwidth.

Here's why the idea of resonant buried radials really doesn't matter! In fig. 4, the radial is buried two inches underground. Now the velocity factor of this very dirty transmission line is about .6 and the same 10.55-meter radial is now sort of reso-

*1626 Vineyard, Grand Prairie, TX 75052
e-mail: <wa5vjb@cq-amateur-radio.com>

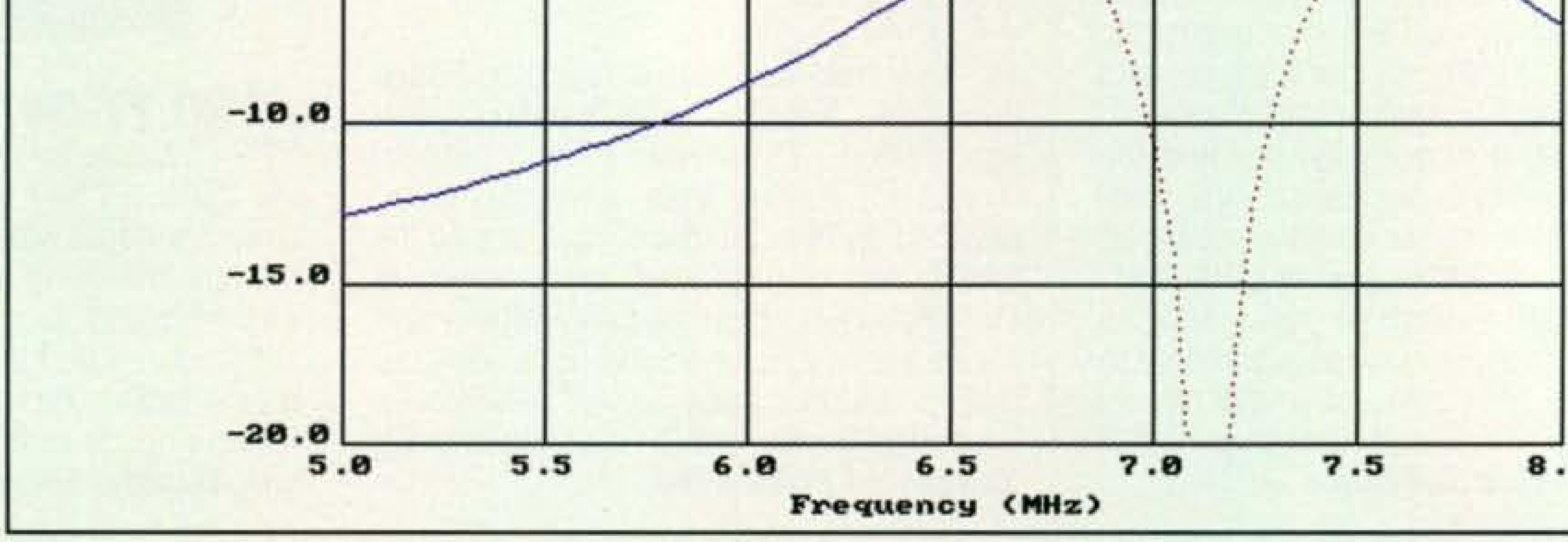

Fig. 1– Tuned radial response (for an elevated radial).

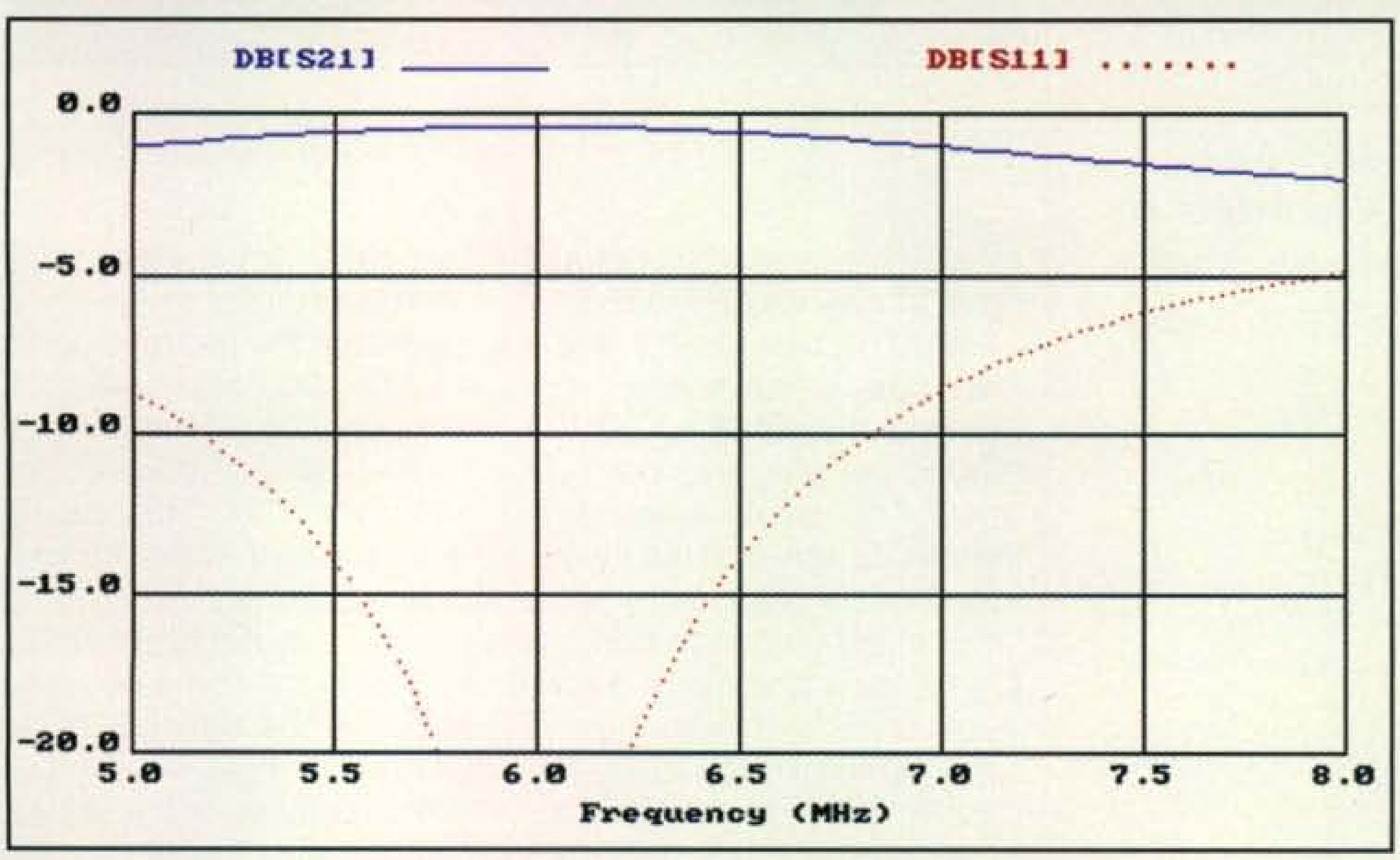

Fig. 2– Response of a ground radial on the dirt.

nant at 5 MHz. However, look at the resonance curve; there really just isn't any.

The radial is so lossy that it has no chance to build up a resonance. Like putting your 2-meter antenna at the end of 500 feet of RG-58, it always has a good SWR no matter what you do to the antenna.

In the AM broadcast community, I have never heard the idea of resonant earth radials ever mentioned or tested for. At one AM station I worked for, we did have some water sprinklers out there and had been known to turn on the water until the antenna current meter came up to full power.

A modest number of buried radials close to 1/4-wave on the lowest band you plan to work will also work fine on all the higher bands. More radials are better, longer is better, but their exact length is not important.

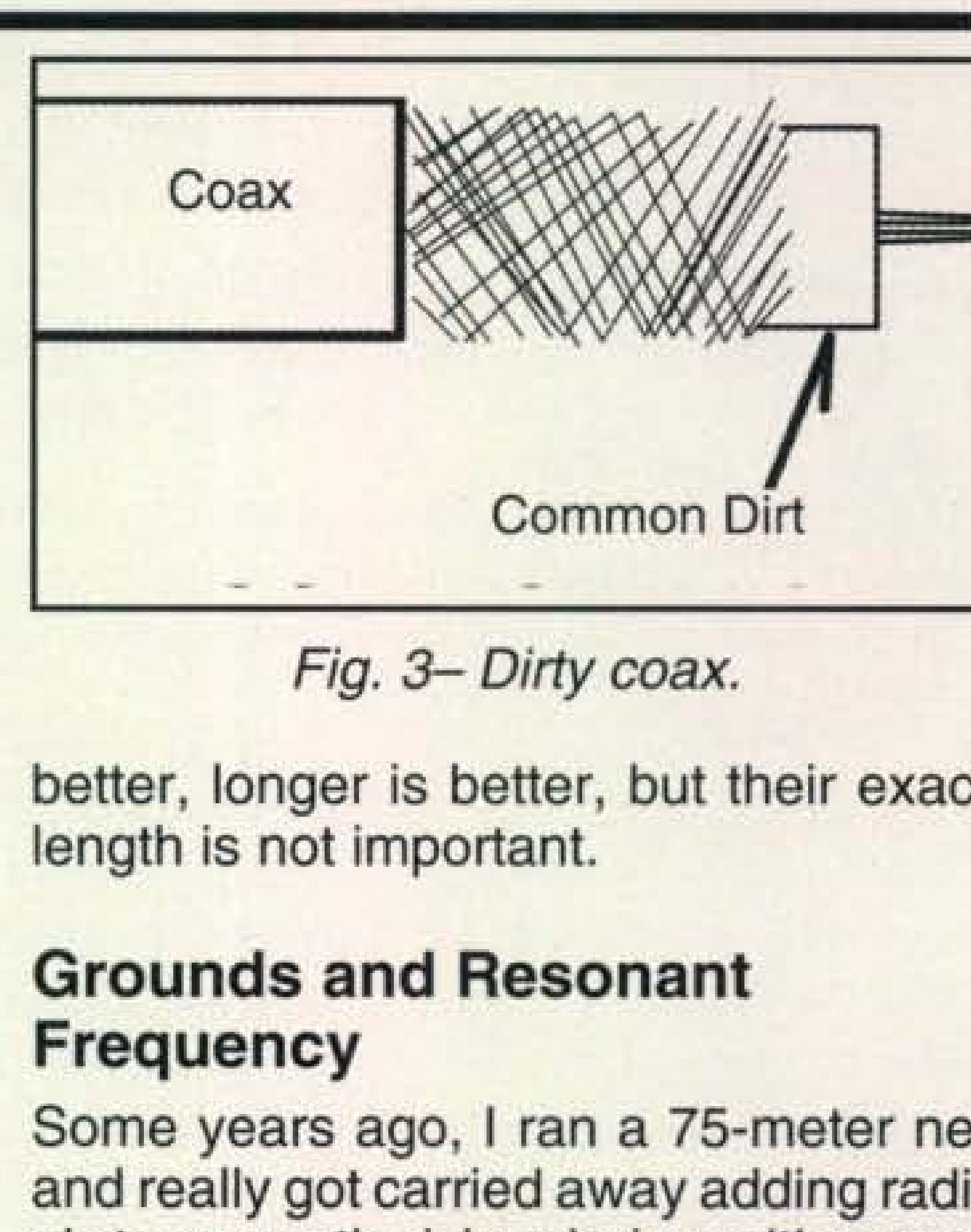

Fig. 3– Dirty coax.

Grounds and Resonant Frequency

Some years ago, I ran a 75-meter net and really got carried away adding radials to my vertical. I ended up with somewhere between 300 and 400 radials out there. Most were short, but at least two were 200 feet long. As I added more ground radials, I noticed that the SWR dip of the vertical would move down in frequency several kHz. Have others seen this as well?

Metallic Ions

As ground wires age in the soil, there are two factors at work. First is the metallic ion migration from the wire into the soil as shown in fig. 5. Over a period of years this migration improves the conductivity of the soil. At the same time, though, oxides form on the wire, reducing the conductivity between the wire and the soil. Most of my ground radials are insulated. Insulated wire works just fine.

There is a lot of capacitance between the wire and the soil, so RF-wise, the wires all are grounded. I do believe in having a few non-insulated wires just to give the vertical a good DC ground for static and lightning issues.

Log Periodics and the 4-meter Band in Europe

I got a pretty good deal last week on a used 90–1500 MHz log-periodic antenna ... and a whole bunch of material for more columns.

With a log periodic, and a Yagi for that matter, the phase of the RF current reverses in each element as shown in fig. 6. It's not exactly 180 degrees, but close. How well this current and its phase are controlled in the elements is how modern computer programs can calculate gain and patterns. Adjusting these factors is how the gain or pattern of an antenna can be optimized.

In the antenna books, the connections between log-periodic elements often are drawn as shown in fig. 7 to make this phase reversal between elements very clear. While the back elements were correctly assembled on my "good deal" antenna, the front elements are shown in photo A. To put it politely, this antenna had never worked above 400 MHz or so. Well, it has "worked," but more as a bent coat hanger than a beam antenna. I mention this because I have seen this assembly mistake several times before. For log periodics, the elements have to alternate phase, like the one in photo B.

Photo A– "Good deal" log-periodic elements.

Photo B– Properly phased log-periodic elements.

While on the subject, with log periodics the center booms are a parallel transmission line, much like 300-ohm twin lead, but typically with a 100–120-ohm impedance. In this case, if the log periodic was being used at 146 MHz, the lower frequency elements between 200 MHz and 1500 MHz would look capacitive and the elements would bring the boom/transmission line down from 120 ohms to 50 ohms.

Now, my plan is to add a few elements to the back of this log periodic and move it down to 70 MHz for some possible 4-meter *F*-layer openings to Europe as the sunspot cycle picks up. Using my 2EØVAA call, I have worked 4 meters in the UK, but 2EØVAA/W5 on 70.1 MHz might raise a few eyebrows at the FCC—then again, maybe not. There is a big push to allow "unused" TV channels to become data services. These are known as "white spaces." Depending on how the FCC rules are written, it may be possible for hams to share TV Channel 4 in areas that do not have a TV Channel 4. This would be very similar to our shared use of the 902-, 2400-, and 5800-MHz bands with RFID, WiFi, and other data services.

I was involved in some early tests putting TV antennas inside laptop computers to pick up HDTV, and the results were very poor. The computers were jamming the TV signals, *but they pass FCC testing*! FCC compliance testing says that the emissions from the device will not unduly interfere

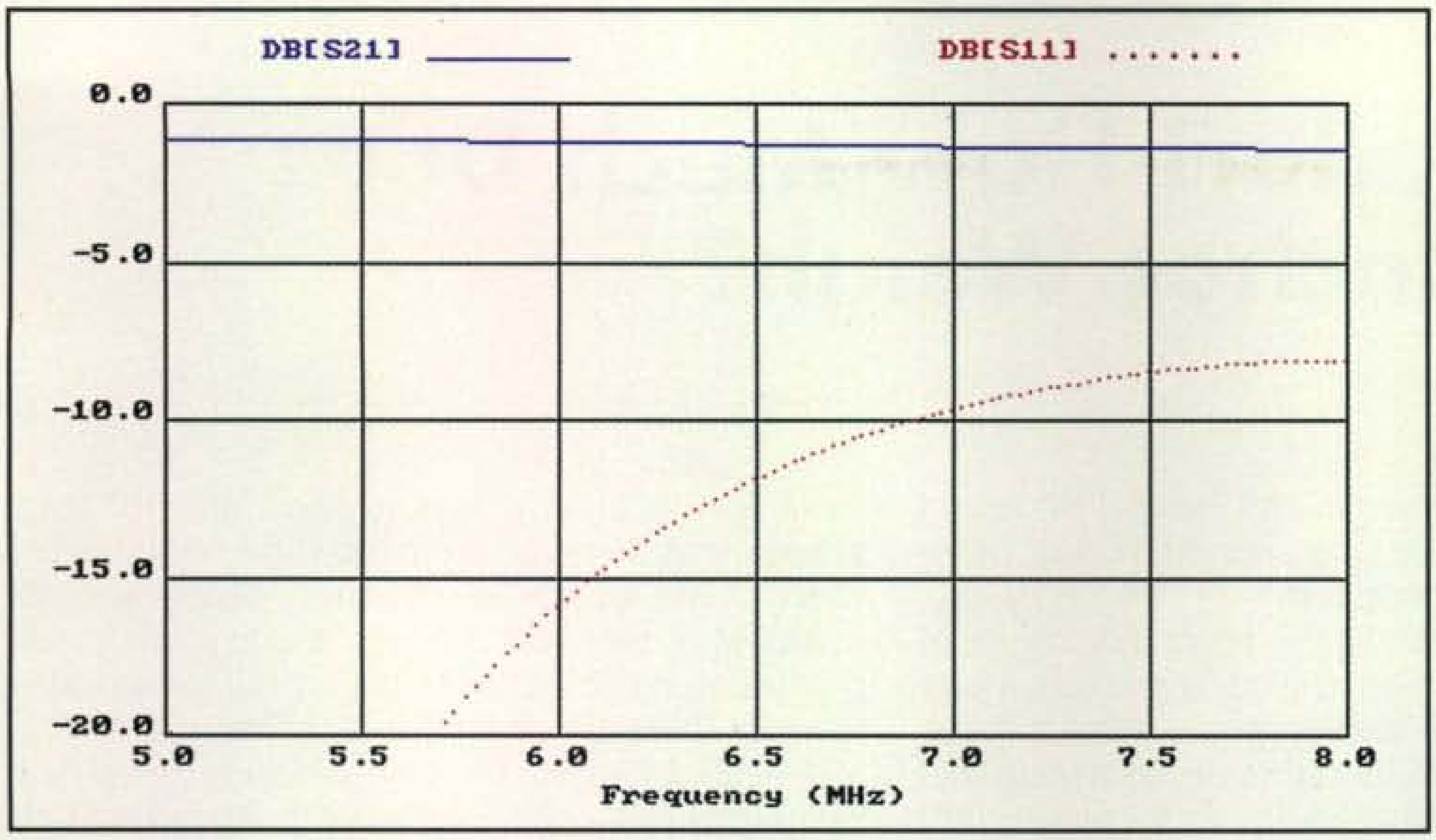

Fig. 4– Response of a buried ground radial.

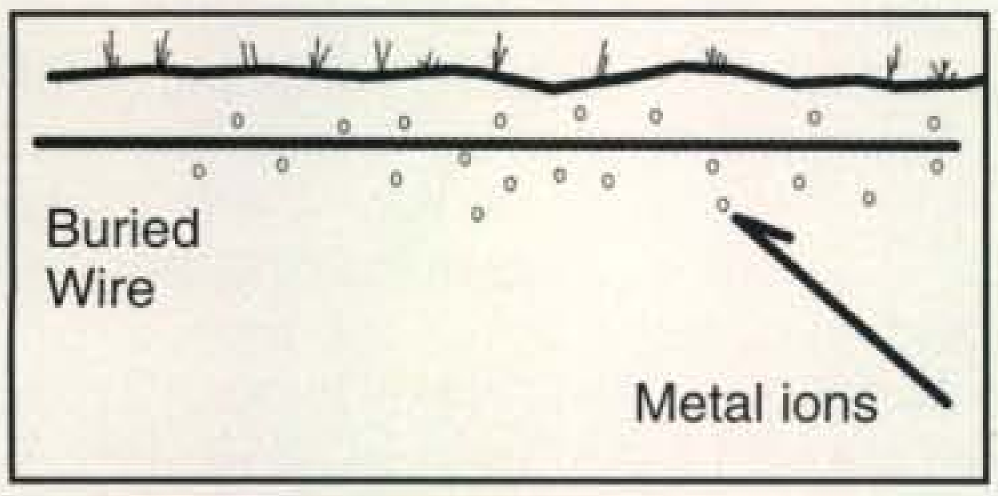

Fig. 5– Metallic-ion migration.

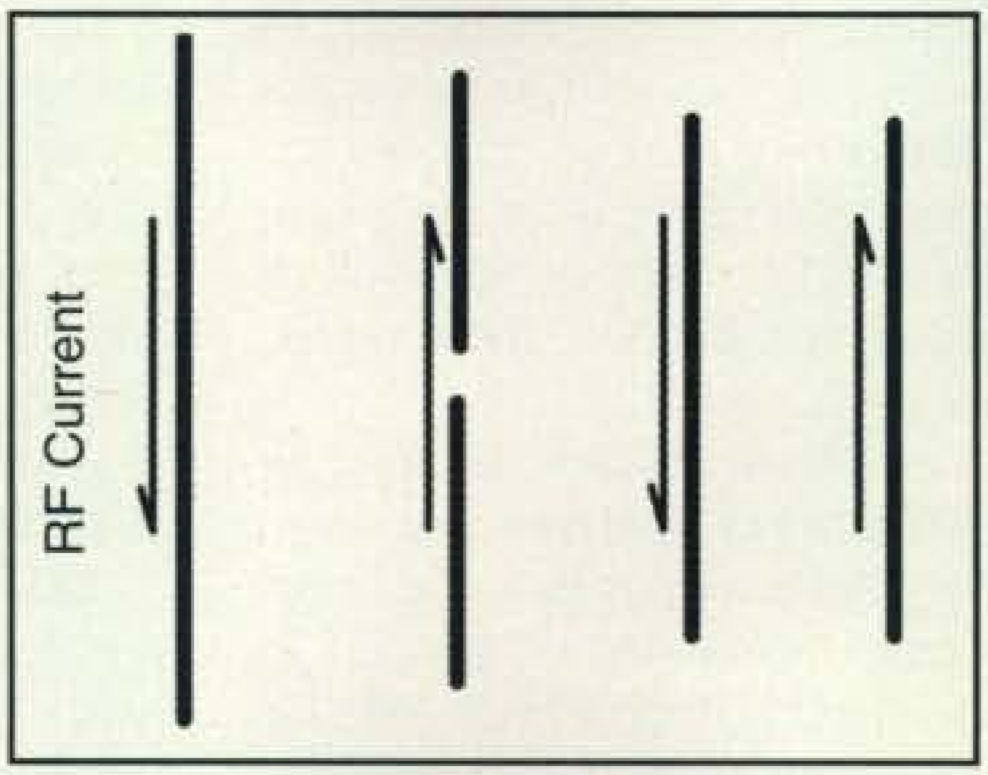

Fig. 6– Current phase-reversal in log periodic and Yagi elements.

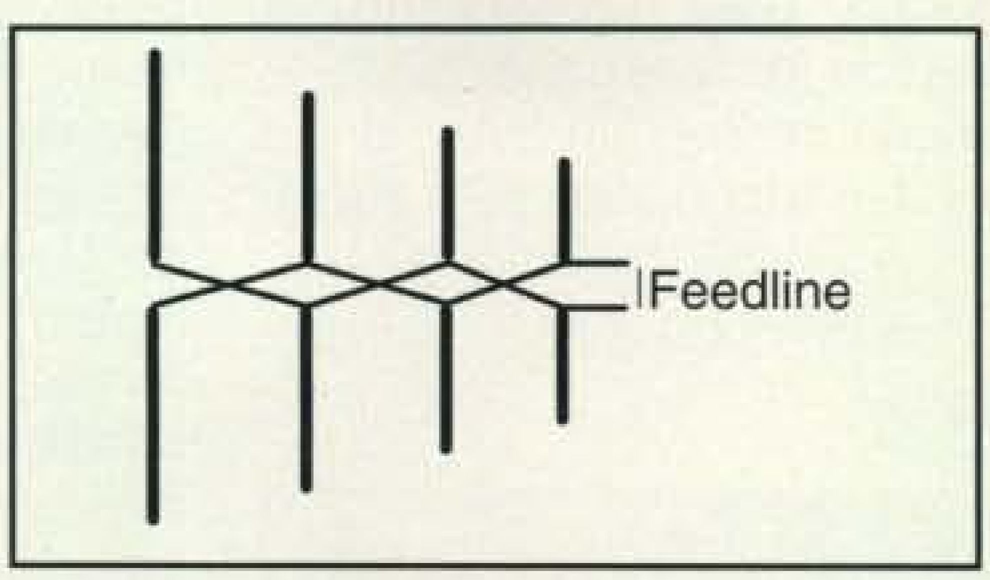

Fig. 7– Log-periodic elements.

with a TV set 3 meters away. The problem is very different when the TV antenna is inside the computer.

You have lots of clock oscillators with spurs all over the place. However, the big culprit is the RAM memory, with billions and billions of little capacitors that are constantly being refreshed. The result is broadband white noise from 400 MHz to 1000 MHz.

In short, the laptop computers can't tell if there is a TV transmitter on that frequency or not. It looks like users will have to use a geographical lookup table with their white-space data services.

Back to the Mailbag…

From Everett, we received a question about using an ohmmeter to find water in coax.

Yes, pure water is an insulator that does not conduct electricity, but it is very difficult to find water that pure in the world. Any time water comes in contact with air, it picks up a little bit of CO^2. Now you have a weak solution of carbonic acid that will conduct electricity. If you have a coaxial cable with a solid extruded insulation, such as RG-8 or RG-58, there is very little conductivity between the shield and the center conductor, even when wet. The weak link is at the connectors, which is where the water can get between two metallic conductors. That weak solution of acid will show conductivity with an ohmmeter.

As always we welcome your questions and topic suggestions. Just drop a snail mail to my QRZ.com address or an e-mail to <wa5vjb@cq-amateur-radio.com>. As for that loading-coil suggestion from California, it looks like we will need to wait until room-temperature superconducting wire is available. For other antenna articles and projects you are welcome to visit <www.wa5vjb.com>.

73, Kent, WA5VJB