Bob's TechTalk #38
by Bob Eckweiler, AF6C

New Coax Problems - NOT

New Coax Raises Measured VSWR

I received an email recently from Mike, a reader of TechTalk. He has a problem; but perhaps it would be best to let him explain it.

Mike's Letter:

Hi Bob,

My neighbor Carol, who is an electronic buff, follows the TechTalk column in the RF newsletter. She 's gotten me reading it too. We're both in the same class in high school. But, right now I am at my wit's end over a problem I encountered helping a senior ham with his antenna. And Carol's on vacation with her parents so I can't ask her.

When I started, I thought I'd be befriending an elder ham, Mr. Weldon, who lives near me. He has a reputation of being quite grumpy and I thought if I helped him he'd appreciate young hams more. Instead, I have managed to make him hate me; he's even threatening legal action. All this because I offered to help him replace the feedline on his ten meter antenna.

I was at Candee's, the local radio store in my town. Carl, who works behind the counter, told me Clarence Weldon was looking for someone to replace the feedline to one of his antennas. Carl said Mr. Weldon was in earlier and had bought some new PL-259 connectors and a 150' roll of LMR-400 coax.

On the way home I parked my bike in Mr. Weldon's drive and was walking up to the door when he came out and asked rather gruffly what I was doing on his property. I explained that I had talked to Carl and was willing to help him replace his coax.

He seemed to warm up some, and took me for a tour of his antennas and shack. His antennas consisted of an 80/40 meter trap dipole up about 80' between two tall telephone poles and fed with open-wire line - the ancient kind with the porcelain spacers and bare wires, and a ten meter beam on top of a 60' guyed Rohn tower. The tower looked old but seemed in good shape as did the guy wires. We then went into his shack. The equipment was old, but it seemed to have been good in its day. His receiver was a Collins 75A4. The transmitter was a Central Electronics 20A driving a home built linear amplifier that he said had six 6AG7 tubes in grounded grid running 120 watts. The linear was in a rack 6' high and looked like it belonged in Frankenstein's lab. He fired it up and a blue glow emanated from a plate glass window in the power supply section. He said they were 816 mercury-vapor rectifier tubes. The glow changed in brightness as he talked into the microphone. The glow was pretty, but those tubes could be replaced today with silicon diodes for a buck or two!

I didn't realize what happened next would cause such a problem. He keyed the transmitter, set the forward power on an old Heathkit AM-1 SWR bridge and flipped the switch to show the VSWR on ten meters at 1.1 : 1.

I asked him why he wanted to change the coax and he said because he had been using it since 1946 and it was war surplus then. He then ranted on the price of coax now-a-days. I promised to visit him Saturday and change his coax, weather permitting.

Saturday turned out to be a sunny day and I soon had the LMR-400 laid out alongside the old coax. I couldn't help noticing the old coax was so warn you couldn't make out the brand and that the outer insulation was brittle with the braid showing through in a few places. In one place the coax was nicked as if by a knife or hedge trimmer.

The trip up the tower was uneventful and the new coax was attached to a UHF connector on

the antenna that had held the old cable. I used tape covered with Coax Seal to waterproof the connector. The coax ran about 130 feet to a panel he had outside his house with heavy grounds on it and an old coaxial lightning arrestor. I terminated the 130' length there with a PL259, again well waterproofed, and made the remaining 20' feet into a jumper cable that ran from the lightning plate into the shack through a feed-thru hole.

It was past lunch when I finished and called Mr. Weldon who looked over my job while eating a sandwich. With nary a word of approval he led me to the front door and said I should get home. He never even said a thank you, and I was a bit miffed as I rode home.

When I got home my dad called me in and told me Mr. Weldon had called and was furious. I had ruined his station! I called him back and after a long rage he complained that his SWR had gone up to 1.5 : 1; and what had I done? I rushed back over, only to find him on the air with his local buddies on ten meters and they were reporting that his signal was one to two 'S' units stronger. Still he ranted to me about his high SWR.

I checked all the connections, even climbed the tower again, but everything looked fine. He finally kicked me out and said I owed him new coax and connectors because I must have ruined his new cable.

I'm at a loss. And my father is telling me that I should never have gotten involved. Do you have any idea of what the problem is?

Sincerely,

Mike

(Ham Call removed by request)

My Reply:

Hi Mike,

Sorry to hear of your difficulties with Mr. Weldon. I hope you used a safety belt when climbing his tower.

Actually, Mike there is no problem. What happened is exactly what I would have expected. The high losses at 30 MHz in the old cable were masking the true SWR making the SWR appear much lower that it really is.

Let's look at the performance of the new coax first. Time Microwave, the makers of LMR-400, give its loss at 0.7 dB per 100 feet. For the 150' length the loss is then about 1.05 dB or 21.48%. Say Mr. Weldon's output is right at 100 watts. His power at the antenna would then be 78.52 watts. In the shack the SWR now says 1.5 : 1 which is 4% reflected power relative to the 100 watts of forward power, or 4 watts. To get four watts reflected in the shack the antenna must be reflecting 5.09 watts. Thus at the antenna is 5.09 watts reflected and 78.52 watts forward power or about 6.5% reflected power. This give a true antenna SWR of 1.68 : 1.

From the age and condition of the old coax we can assume that it has a higher loss; but how high? Well, I did the calculations. Since the antenna SWR remained constant the loss in Mr. Weldon's old coax must have been 7.25 dB. This means, of his 100 original watts, only 18.84 watts was reaching the antenna. The antenna was reflecting 6.5% of that or 1.2 watts. when this reached the SWR meter in the shack it was attenuated to 0.23 watts.) 0.23 watts reflected with 100 watts forward the SWR meter would indicate an SWR of 1.1 : 1.

Also, since Mr. Waldon's radiated power has gone up over fourfold, that would account for his friends reporting an increase in signal strength of over an 'S' unit. Feel free to share this information with Waldon; I hope you to become friends.

Bob.

AF6C

PS The math is right from the ARRL Antenna Book. When Carol gets back she can help you review it! - ∑

Just at press time I got this reply from Mike:

Hi Bob,

I showed your email to Clarence. He studied it for a while and then told me he was getting out better than he had in years. It seems he understands that the new coax is working okay. He insisted I stay for lunch and chat. He told me all about operating in the old days, and asked me if I'd help him adjust his 10 meter beam. I told him about my friend and neighbor Carol and he told me to bring her along. It seems he worked for Carol's uncle for 35 years before he retired!

Mike

The Calculations:
For those who are interested in how I came up with the numbers, here is how they were calculated:

The loss in coax is a simple calculation. It is just the coax loss specification per 100 feet (at the frequency) times the actual length:

$$\text{dB loss} = \frac{0.7\ \text{dB}}{100\ \text{ft}} * 150\ \text{ft} = 1.05\ \text{dB}$$

To calculate the loss in the coax as a percentage first calculate the ratio of two powers:

$$\frac{P_2}{P_1} = 10^{\frac{\text{dB}}{10}}$$

$$\frac{P_2}{P_1} = 10^{\left(\frac{-1.05}{10}\right)} = 10^{(-0.105)} = 0.7852$$

Where P_2 is the power reaching the antenna and P_1 is the power at the transmitter.

Since the ratio of P_2/P_1 is less than one, it indicates a loss which we would expect. Now just convert the loss into a percentage.

$$\%\ \text{Loss} = \left(1 - \frac{P_2}{P_1}\right) * 100 = (1 - 0.7852) * 100 = 21.48\%$$

This is the power lost in the new coax.

When you put 100 watts into the antenna only about 78% gets to the antenna or:

$$P_2 = 0.7852 * P_1 = 0.7852 * 100\ \text{watts} = 78.52\ \text{watts}$$

At the ham station the SWR is 1.5 with the new coax. Relating a VSWR of 1.5 : 1 to a 4% reflected power is shown:

$$\frac{P_R}{P_F} = \left(\frac{SWR - 1}{SWR + 1}\right)^2 = \left(\frac{1.5 - 1}{1.5 + 1}\right)^2 = \left(\frac{0.5}{2.5}\right)^2 = 0.2^2 = 0.04 = 4\%$$

Where P_R is the reflected power and P_F is the forward power as measured at the SWR bridge.

Calculating reflected power at the antenna:

$$P_{R_{ANT}} = \frac{P_{R_{STA}}}{0.7852} = \frac{4}{0.7852} = 5.09$$

Where $P_{R_{ANT}}$ is the reflected power at the antenna and $P_{R_{STA}}$ is the measured power at the SWR meter.

The true % reflected power at the antenna is:

$$\%\ P_R = \frac{P_R}{P_F} * 100 = \frac{5.09}{78.52} * 100$$
$$= 6.5\%$$

And the true VSWR at the antenna can be calculated from the power reaching the antenna and the power reflected back right at the antenna:

$$SWR = \frac{1 + \sqrt{\frac{P_R}{P_F}}}{1 - \sqrt{\frac{P_R}{P_F}}} = \frac{1 + \sqrt{\frac{5.09}{78.52}}}{1 - \sqrt{\frac{5.09}{78.52}}}$$
$$= \frac{1 + \sqrt{0.06482}}{1 - \sqrt{0.06482}} = \frac{1.2546}{0.7454}$$
$$= 1.68 : 1$$

Calculating the losses in the older coax is a bit more difficult. The SWR at the transmitter measured by the SWR bridge is 1.1 :1. This amounts to 0.23 watts assuming the forward power is 100 watts:

$$\frac{P_R}{P_F} = \left(\frac{SWR - 1}{SWR + 1}\right)^2$$
$$= \left(\frac{1.1 - 1}{1.1 + 1}\right)^2 = \left(\frac{0.1}{2.1}\right)^2$$
$$= 0.0476^2 = 0.0023 = 0.23\%$$

$$P_R = P_F * 0.0023 = 100 * 0.0023$$
$$= 0.23 \text{ watts}$$

The simplest way to solve this type problem is to examine the loss along the path. Since 100 watts produces 0.23 reflected power along the full path this amounts to 26.383 dB.

$$\text{dB} = 10 \log\left(\frac{0.23}{100}\right) = 10 \log(0.0023)$$
$$= 10 * -2.6383 = -26.383 \text{ dB}$$

Next lets look at the antenna. Since changing the coax didn't change the SWR of the antenna at its terminals, we can calculate the loss at the antenna. This loss is really the radiated energy. What remains is the loss up and down the coax. Dividing by two give the loss one way:

$$\text{Coax loss} = \frac{(\text{Total loss} - \text{Ant loss})}{2}$$
$$= \frac{-26.383 \text{ dB} - (-11.882 \text{ dB})}{2}$$
$$= \frac{-14.501 \text{ dB}}{2} = -7.25 \text{ dB}$$

Now that the loss in the old coax is known, the power reaching the antenna can be calculated:

$$P_2 = 10^{\frac{\text{dB}}{10}} * P_1$$
$$P_2 = 10^{\left(\frac{-7.25}{10}\right)} * 100$$
$$= 10^{(-0.725)} * 100$$
$$= 18.84 \text{ watts}$$

As can the power being reflected by the antenna:

$$P_R = \left(\frac{SWR - 1}{SWR + 1}\right)^2 * P_F$$
$$= \left(\frac{1.68 - 1}{1.68 + 1}\right)^2 * 18.84$$
$$= 0.254^2 * 18.84 = 1.2 \text{ watts}$$

And so can the magnitude of the reflected power returning to the shack, which in the case of the old coax should be 0.23 watts of power

$$P_2 = 10^{(-0.725)} * 1.2$$
$$= 0.23 \text{ watts}$$

Finally we can calculate the% loss in the old coax:

$$\% \text{ Loss} = \left(1 - \frac{P_2}{P_1}\right) * 100$$
$$= \left(1 - \frac{18.84}{100}\right) * 100$$
$$= (1 - 0.1884) * 100$$
$$= 81.16\%$$

This is the % of power lost in the old coax.

73, from AF6C

This article is based on the TechTalk article that originally appeared in the March 2008 issue of RF, the newsletter of the Orange County Amateur Radio Club - W6ZE.