Testing and Tuning a Helical Wound Magnetic Loop – Sept 30, 2014

Mike, KI6OID, and several others have been constructing a helical wound magnetic loop for 40 meters to serve as a portable antenna in several situations. The loop is an octagon 39 inches across. It is tuned using a high voltage capacitor opposite the feed point. The antenna is matched to 50 ohm coax using a gamma match. A an early photo of the antenna is shown below.

On Tuesday morning Mike KI6OID, Bob WB6ZAA, Dean KK6BIO, and Brian K0DTJ met at Mikes home to resolve some problems with the antenna. In earlier testing a good match was found with the gamma match and then lost.

Troubleshooting

Using a grid dip oscillator and an antenna analyzer neither could find a point of resonance of the loop. All connections in the loop appeared to be good including the internal connections in the capacitor. We decided to isolate the capacitor and measure its value. Measuring the capacitance of the loop by itself gave a value of ~550 pF, far too large. There was a 100 pF disk ceramic capacitor in parallel with the large variable and that was disconnected. An appropriate value was measured for the variable by iteslf, 30-150 pF. The disc ceramic showed a very low resistance across it. It had been blown probably by overvoltage during previous testing. A resonant frequency of about 8.1 MHz was measured using the fully meshed large variable capacitor.

Repair and tuning

It was clear that additional capacitance was needed to achieve resonance in the 40 meter band so a smaller ceramic disc capacitor was added across the large variable. We were able to get the loop adjusted to resonance at about 7.181 MHz but with a very poor match to the 50 ohm coax. The feed point impedance with the gamma match tap in its original position about 8 inches from the feed point was in the mid-teens of ohms for the real component and a fairly high inductive reactance for the imaginary part. As we moved the gamma tap outward from the feed point the resistance increased and the reactance decreased indicating we were moving in the correct direction. The best match was found about 18 inches along the circumference of the loop from the feed point. We made minor adjustments of the tuning by bending the gamma wire closer or farther from the loop element. Final tuning resulted in a SWR of about 1.5:1 at the resonant frequency and a 2:1 SWR bandwidth of about 200 Khz. That should have been a clue of things to come.

Re-repair and tuning

To handle more than a few watts of power, it was clear the small disc ceramic capacitor needed to be replaced. Mike located and obtained a 100 pF 5 KV “door knob” capacitor from another local ham. It was quickly installed in place of the small disc cap but when we checked the SWR it was off the map again ~10:1. Why?

We measured the small disc capacitor and found it to be about 81 pF, close enough to the marked value. But it was noticed that the parallel equivalent resistance was only about 3500 ohms, much lower than it should have been. The door knob capacitor was also measured and found to have a capacitance of 103 pF with a parallel equivalent resistance unmeasurably high (infinite). The thinking is that the low 'Q' of the small disc capacitor in the circuit of the loop changed the impedance distribution around the entire loop causing the need for moving the gamma tap out so far. With the high quality door knob capacitor in the circuit the loop had to be retuned.

With the gamma tap at about 18 inches from the feed point the impedance at the feed was in the low high teens for a resistive component and fairly high capacitive reactance, indicating the need to move the gamma tap inward towards the feed point. The optimum point was found about 10 inches out from the feed point and the final tuning was tweaked by bending the gamma wire slightly. An SWR of 1.1:1 was achieved at the resonant frequency with a 2:1 SWR bandwidth of about 20 Khz – much more appropriate for a high Q loop!

Conclusions

The helical wound loop as designed and built can be tuned to a desired frequency in the 40 meter band and matched to 50 ohm coax feedline. This process does take a bit of trial and error and fussing.

The availability of good test equipment is critical both to troubleshooting and tuning. A grid dip meter is handy to get the loop resonant near the desired frequency. An antenna analyzer or impedance bridge with the capability to measure real and imaginary components of impedance at frequency is necessary to find damaged or poor quality components. An analyzer which plots SWR and impedance vs frequency is handy in the tuning process.

If it is intended to have this type of antenna field-deployable, it will be necessary to provide adequate test/tuning gear and comprehensive instructions in order to ensure success.

Thanks! It was a fun day and I learned a lot.

Brian, K0DTJ