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YOU Can Build This VLF to HF Loop Receiving Antenna

Part 3 of 3.

Linearizing a nonlinear world: We would like the loop's tuned frequency to linearly track the coarse tuning control. If the loop tunes from 2.00 to 7.00 MHz, we would like the same number of degrees of revolution of the tuning knob to cover 2.00–3.00 MHz as it takes to cover 6.00–7.00 MHz.

I f we were using a mechanical variable capacitor, we would use one with plates cut for "straight line frequency." A varactor equivalent of these ingeniously shaped capacitor plates, unfortunately, isn't available. So, how do we approximate straight-line frequency tuning with potentiometer and a varactor diode?

The resonant frequency of an LC tuned circuit is given by:

$$f = \frac{1}{2\pi\sqrt{LC}} \quad [4]$$

where:
f is the frequency in Hertz
L is the inductance in henrys
C is the capacitance in farads

In the loop tuner, C consists of the capacitance of varactor diodes D1–D4, the turn-to-turn distributed capacitance of the loop windings, and strays. (We'll call both of these last two items together C_{stray}).

Equation 5 provides a good fit for the capacitance versus voltage relationship for the MVAM-109 diodes that I used over the range 0.5 volts through 10 volts:

$$C = 8.5 + 447.6e^{\frac{v-v_0}{k}} \quad [5]$$

where:
C is capacitance in pF
$v_0 = 1.24$
$k = 2.698$
v is the applied voltage, in volts

If we assume that L is in µH, C is in pF, and f is in MHz, and then substitute Equation [5] into [4], we get [6], the tuning frequency f in MHz as a function of tuning voltage v.

$$f_{MHz} = \frac{159.16}{\sqrt{L(C_{stray} + 8.5 + 447.6e^{\frac{v-v_0}{k}})}}$$

At first glance, equation [6] doesn't look particularly linear. However, it turns out that it isn't too far away from a straight-line relationship, as can be seen in the error plot.

To see if the linearity could be improved, I modeled the behavior of the circuit using an Excel® spreadsheet and experimented with various values of resistance between the wiper on R11 to +12 V or to ground, based upon the 3-turn air loop of 9.3 µH inductance. An excellent tutorial on using resistors to customize pot responses can be found at R.G. Keen's Web page "The Secret Life of Pots," [http://www. geofex.com/Article_Folders/potsecrets/potscret.htm].

A single 3.3k ohm resistor to ground from R11's wiper reduced the tuning error significantly.

Parts availability

A few of the parts may prove difficult to find:

• Varactor diodes D1–D4. I used Motorola MVAM-109 diodes, now unfortunately obsolete. The NTE-618 is a substitute and is carried by major parts houses such as Mouser Electronics, 1000 North Main Street Mansfield, TX 76063; 1-800-346-6873; [http://www.mouser.com]; part number 526-NTE618.

• BN 43-202 binocular core and FR-7 1/2-61 ferrite rod. I found these at Ocean State Electronics, 6 Industrial Drive, P.O. Box 1458, Westerly RI 02891; 401-596-3080; (fax) 401-596-3590; [http://www.oselectronics.com].

• Surplus loopstick. Ocean State Electronics lists an inexpensive 3-1/2-inch, 1/2-inch-diameter loopstick, part number LA-540. I purchased several of these some months ago and measured the inductance as 1140 µH with the supplied coil of approximately 105
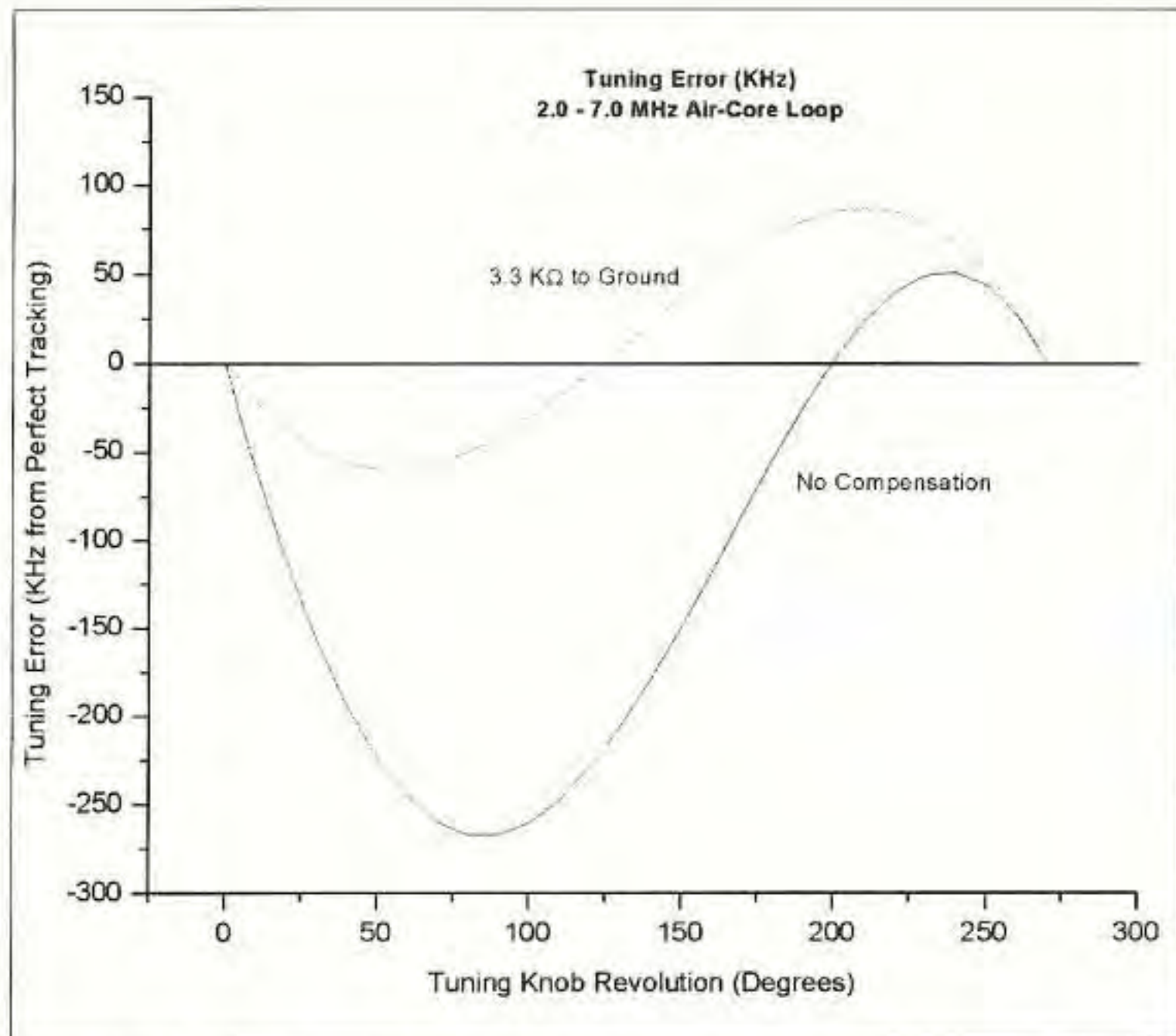
Fig. 10. Tuning error with and without compensation resistor.

turns. The approximate tuning range with the tuner is then 97 kHz to 765 kHz, using low and high modes. It would be possible, of course, to remove sufficient turns to move up resonance. (The LA-540 loopstick is not the one referred to in the text.)

• Q-Dope. Ocean State Electronics carries this product.

• Relay K1 is an Omron model G5V-2-H1 with a 12-volt coil. This relay plugs into a 14-pin DIP socket and has contacts optimized for switching low-level signals. Mouser's part number is 653-G5V-2-H1-DC12. Most major supply houses carry Omron relays.

• Printed circuit board. A printed circuit board is available for this project from Far Circuits, 18N640 Field Court, Dundee IL 60118; voice/fax 847-836-9148; [http://www.cl.ais.net/farcir/].

References

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