Telephony 101 – Receiver Specifications December 1, 2012

Hello All,

As always, please send any questions about the reading assignment directly to me at oldtimetelephones@goeaston.net. I will bundle questions if necessary, repeat the questions, and give answers in an e-mail to the TCI List Server before moving on to the next reading assignment. This way everyone will benefit from these questions and answers. By sending questions directly to me, we will avoid unnecessary clutter on the List Server. Previous reading assignments, notes, questions, and answers are available in the TCI Library at http://www.telephonecollectors.info/telephony-101/.

Please start reading at the top of p. 28 and finish Chapter 3 on p. 29. Also read the section called Coil on p. 219-220 in the Appendix – but don't read that section until after you read the following notes.

The acoustical properties or four Western Electric receivers are shown on a graph in a manner quite similar to that of the transmitter. In the case of the receivers, the test used a signal generator (common instrument in laboratories) to generate an electrical voltage of a constant value for all (well, many) of the frequencies in the range from zero to about 4,000 cycles per second. The receiver's sound was then measured with a sound-level meter that actually measured the pressure in the sound wave produced by the receiver. This pressure, relative to some reference pressure, was then plotted using the decibel method. The pronounced resonances that are seen in Fig. 305 are discussed in the book, so we'll move on to the electrical properties.

The electrical properties, as mentioned in the book, are a little complicated. Actually, more than a little, but I think we can handle the concepts without any mathematics.

For starters keep in mind that electrically a receiver is just a coil of wire – wire that has some resistance (not zero). If you put a dc ohmmeter (e.g., an old analog multimeter) across the terminals of a receiver, you will read the dc resistance of the coil wire. That's the value in column 2 in Table 3-1. You could also do this with a little circuit that has a small battery, an ammeter, and the receiver all connected together. Measure the voltage across the receiver with a voltmeter and measure the current with the ammeter. Use Ohm's law $V = RI$ (or equivalently $R = V/I$) and divide the voltage you just measured by the current you just measured and you will get the same value of resistance as measured with your old analog multimeter.

Now replace the small battery with a signal generator and set it to produce an ac voltage at 1,000 cycles per second. Throughout the book we will use 1,000 cycles per second as a typical frequency in the voice-frequency range. Make sure your ammeter and voltmeter can read small ac currents and voltages. Divide the measured ac voltage by the measured ac current and you get the impedance value shown in column 3 of Table 3-1. You see it's much larger than the dc resistance. Why is this, and what is the phase angle?

In both the dc case and the ac case, Oersted's observation tells us that the current (from the battery or the signal generator) will produce a magnetic field around the wire in the coil.

However, only in the ac case is this magnetic field changing – getting stronger and weaker along with the ac current, a thousand times a second. The Faraday-Henry observation tells us that this changing magnetic field will induce a voltage into nearby wire – and what's more nearby than the coil's own wire! In other words, the ac current produces a voltage in the coil that pushes back against the voltage of the signal generator and thus impedes the flow of current through the coil. Hence a coil resists (impedes) the flow of ac current much more than the wire's resistance alone.

The phase angle is not too hard to understand, but it takes a good imagination. Imagine one cycle of this ac current (and for now we're going to assume that the coil wire has zero resistance). Let's start the current from zero at the beginning of this cycle. It goes up to a maximum, back down through zero, on down to a minimum, and finally back up to zero. This all, of course, repeats a thousand times a second. When is the current changing most slowly? The answer is at its maximum and minimum values. You can see this by noting that just before its maximum, the current is increasing while just after its maximum, the current is decreasing. Therefore, at exactly its maximum (also at its minimum) the rate of change must be zero. Because a changing current produces a changing magnetic field which, in turn, produces a reverse voltage in the coil, this voltage is zero when the current is at its maximum because the magnetic field is not changing at that instant (rate of change is zero). Conversely, the coils voltage is maximum when the current is zero (but changing most rapidly).

So if we again imagine this one single cycle of ac current, we find that the ac voltage starts at its maximum value (when the current is zero), goes down to zero (when the current is at its maximum), continues down to a minimum voltage (when the current is zero), starts going back up to zero (when the current is minimum), and continues up to its maximum voltage (when the current is zero). If we consider a cycle to be composed of 360 degrees (that's what is done mathematically), then you see that the current is lagging the voltage by 90 degrees in a perfect coil (zero wire resistance). This is the phase angle. Because receivers have some resistance in their coil wires (not zero), their phase angles are a little less than 90 degrees as seen in column 4 of Table 3-1.

We are not going to do anything with phase angles in the remainder of the book, so you don't have to remember any of these details. Hopefully you will remember the concepts. What you need to remember for sure, though, is that a coil in any form (receiver, ringer, induction coil, retardation coil) will have a much higher impedance to ac current than to dc current. If you now read the Coil section in the Appendix, you will see the simple equations.

If there are any questions about the current reading assignment, we will deal with the questions before moving on to the next reading assignment.

Ralph