Telephony 101 – Voltage, Currents, and Resistance November 1, 2012

Hello All,

Welcome to Telephony 101. Please send any questions about the reading assignments directly to me (use Reply, not Reply All). 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 the questions and answers. By sending questions directly to me, rather than to everyone, we will avoid unnecessary clutter on the List.

Please read the Introduction (pp. 8-10) as this will give some background and describe the scope of the book. This should be easy reading.

Next read the first page of the Appendix (p. 217) and the first two sections on the next page (p. 218). Then read the first page of Chapter 1 (p. 11) and stop there. For those of you who are not familiar with the basic elements of electricity and magnetism (i.e., electromagnetism), this may be the hardest part of the book. So please take your time and make sure you understand the following.

I like to think of an electric current as water flowing through a pipe or a garden hose. In an electric current, there is something actually moving through the wire, and that something is electrons. They are little particles that carry an electric charge, but we don't have to think about any of those details. Just imagine this water-like stuff flowing through a wire, and this flowing stuff can do useful things.

If this current is flowing steadily in one direction, it is called direct current (dc). For reasons that will become clear later, an electric current sometimes flows a little bit in one direction and then reverses, flowing a little bit back in the other direction. It continues to flow back and forth without any net progress in one direction, but it can still do useful things. This back-and-forth flow is called alternating current (ac).

The magnitude of an electric current is measured in amperes. It's sort of like gallons of water per minute. Put a meter in the wire and you can measure it. Measuring dc is easy to imagine because the meter just measures how much current flows by. But measuring ac is quite different. If you put a dc meter in the line, it would see a little plus (+) current followed by a little minus (-) current and on average you would get zero. Therefore, an ac meter actually multiplies the current by itself (i.e., takes the square, thus getting rid of the minus signs) and averages the result (then it takes the square root). You don't have to remember any of these details. Just remember, when using a meter, to put the meter on the dc setting when measuring dc and on the ac setting when measuring ac.

Just like water in a pipe, it takes some pressure or force to make current flow in a wire. That force is called a voltage and is usually provided by a battery or a generator. The voltage is measured in volts, and as with current a dc voltage is easy to imagine. An ac volt meter, like an ac current meter (ammeter), works with the square of the actual voltage. As with ac currents, it is not necessary to keep these details in mind for our purposes.

In summary, for our purposes we can just think of a current (ac or dc) as water flowing through a pipe and a voltage (ac or dc) as the pressure that causes the current to flow.

Because of its nature, electric currents always have to flow in circles or circuits. A battery works like a pump and pushes the current out one terminal, and the current flows back into the other battery terminal. If there is something in the circuit that impedes current flow, like a light bulb, less current will flow. The amount of impedance to current flow is measured in ohms. There are several telephone components that impede the flow of current, and the simplest one is a resistor. A resistor affects direct current (dc) and alternating current (ac) the same way.

I want to emphasize that we are not going to do any significant calculations in Telephony 101, but it is helpful to write a few equations to understand basic concepts. Bear with me as this is not difficult. Here are the symbols we are going to use.

I = current (amperes, dc or ac)

V = voltage (volts, dc or ac)

Z = impedance (ohms)

R = resistance (ohms)

The following three empirical observations were made by 19^{th} Century physicists and provide us with almost everything we need to know to understand how telephones work.

<u>Oersted's observation</u>

Current moving through a wire produces a magnetic field around the wire.

<u>Faraday's and Henry's observations</u>

A changing (not steady) magnetic field will generate a voltage in a nearby wire. Think of waving a horseshoe magnet over a wire.

<u>Ohm's observation (Ohm's Law)</u>

V = RI (i.e., voltage equals resistance times current). You can think about this in several ways. For example, if the resistance is constant and you increase the voltage, the current will increase. Or if the voltage is constant and you increase the resistance, the current will diminish.

That's it. If you can keep these three observations in mind, we are ready to understand how telephones work. Please send any questions directly to me, and you will see my answers in another e-mail on the TCI List Server before we move on to the next reading assignment.

Ralph

Telephony 101 – Voltage, Currents, and Resistance November 4, 2012

Hello All,

I received very few questions and comments this time, and they are summarized below.

One person commented that the wiring color code is puzzling. In telephones, the green wire is positive L1(+) and the red wire is minus L2(-) whereas in non-telephone applications the green wire is usually ground and the red wire is live (+). It is true and confusing, and I'm sorry but I don't have any insights on this situation. If someone reading this has further information about the origin of these color codes, perhaps they can post something on the TCI List Server for all to see.

Another person asked what's the difference between impedance and resistance, since they are both measured in ohms. Impedance is a more general term. Resistors, condensers (i.e., capacitors), and coils all impede the flow of current. Resistors are characterized by their resistance, condensers by their capacitance, and coils by their inductance. The impedance of a resistor is equal to its resistance, so for resistors impedance and resistance are the same. Ideal condensers and coils don't have resistance (real ones have some), so their impedance to current flow is something else. We will get to that later.

Finally, there was a request for some instruction for using a multimeter. We may get to that later, but for now just look at Fig. 21-1, which is a very common analog multimeter. For our purposes, the two probes would always be plugged in to the two terminals on the bottom left (-COM and +V-Ω-A). If you want to measure resistance of part of a telephone circuit, make sure it is not hooked up to the line and any batteries are disconnected. Then place the probes across the part of the circuit or component of interest. Many of our measurements will have low values, so turn the dial to RX1, which measures down to 1 ohm. It won't hurt the meter if it is set to RX1 and the resistance is very high. Look on the OHMS scale on the top to read the value. Similarly for voltage, but with the phone connected to the line and batteries connected, turn the dial to the right setting (often 5 on the DC V scale). For voltage measurements, it will damage the meter if the voltage is greater than the setting (5 volts in this example). So it is good to start on a higher setting and work down. Then look carefully for the right dial markings for reading. Just study the meter for awhile and it should become clear how to use it.

If you have any follow-up questions, send them directly to me. We will move on to the next reading assignment, which I will post soon.

Ralph