Tech Talk
With Bob Dolph

Technicians, Obey the Law!

Bob Dolph has served in various technical management and advisory positions in the security industry for 25 years. Bob currently is a training and products consultant for the security industry. He lives in Orlando, Fla.

BOB'S TIPS

- The current in a series circuit is the same through each device.
- The sum of all the voltage drops in a series circuit equals the voltage source.
- Small gauge, long cable runs can adversely affect high current loads in a series circuit.
- The "Power Wheel" diagram is a handy tech reference tool.

One of the most important basic laws of DC alarm circuits is Ohm's Law (E = IR). This law shows the relationship between resistance (R), current (I) and voltage (E) of an electrical device or a complete electrical circuit.

When reviewing the examples in this article, one should focus on the relationship between these values rather than memorizing fixed examples. In most examples, the resistance of a device will be constant, while the current and voltage will vary accordingly.

All Things Being Equal

As we all learned back in high school algebra, when you have an equation, if you increase/decrease one side of an equation, you must do the same proportionately to the other side of the equation. The equality of the equation must always be preserved.

Applying that principle to Ohm's Law, assuming the resistance is constant and the current going through a device is increased 10 percent, then the voltage measured (*voltage drop*) across the device will proportionately increase by 10 percent.

Notice that there has been no mention of any specific values and we have concentrated only on the relationship between current and voltage. This relationship will become more important as we look at the next law.

Behold the 'Power Wheel'

Before exploring the next important law and rules, let us look at the "Power Wheel" (*see Diagram 1*). These formulas are very handy when doing quick, on-the-spot field calculations. It is highly recommended that you make a few copies of this wheel diagram.

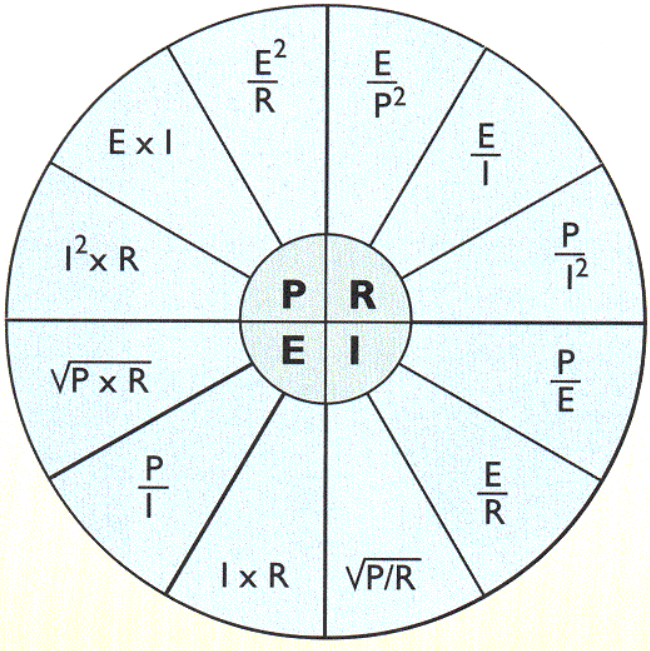
Take some clear packing tape and stick a copy on the back side of your digital meter, one on the inside of your toolbox cover and one on the inside cover of your license exam notebook. As we become more familiar with using Ohm's Law, it will become apparent that the Power Wheel formulas are variations of this law.

Setting the Siren Scenario

As an installation problem, let's say we want to install a DC alarm siren in an alarm system. In this application, the alarm siren must be installed at the front of the building, which is 500 feet from the alarm panel. We have heard that running alarm sirens a long distance can cause problems, but is this too long a distance or not? Let's see if these laws can help us estimate the problem before the installation.

We have selected a DC siren that draws 1.2A at 12V. The alarm control panel can support 1.5A, so it appears that we may be OK to go, or are we?

Diagram 1: 'Power Wheel' — A Quick Reference Tool



Each of these formulas spring from Ohm's Law of voltage, where (E)= current (I) X resistance (R). Clip this diagram and tape it somewhere handy for future reference.
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Laying Down Kirchoff's Law

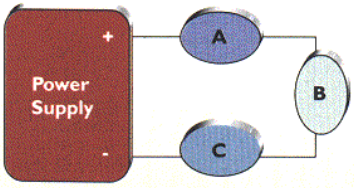
The next important law we need is Kirchoff's Voltage Law (KVL), which states that, in a series circuit (*see Diagram 2*), the total of all the component voltage drops must equal the voltage source. EB is the voltage drop across the siren. In the real world, the circuit wiring has a resistance that can vary depending on the length and thickness (gauge) of the conductor.

We will plan on using 16-gauge (AWG) wire, which has a resistance of 4 ohms (Ω) per 1,000 feet. The wire's voltage drops will be E_A and E_C. Applying KVL to our circuit, it would be $E_{PS} = E_T = E_A + E_B + E_C$

There are also a few other series circuit rules that go along with Kirchoff's Law. They are:

- All components in a series circuit share the same current. $I_T = I_A = I_B = I_C = \ldots$
- The total resistance in a series circuit equals the sum of individual resistances. $R_T = R_A + R_B + R_C$
- The voltage divider rule can be calculated as the voltage total times the ratio of component resistance to total resistance. $E_T = E_T \times (R_A/R_T) + E_T \times (R_B/R_T) + E_T \times (R_C/R_T)$.

Diagram 2: Basic DC Series Circuit



Circuit wiring has a resistance that can vary depending on the length and thickness (gauge) of the conductor.

Solving the Siren Situation

Now, we should have enough information to proceed. First, we need to find total current of the circuit. Using Ohm's Law and the Power Wheel, we see that $I_T = E_T/R_T$. We know that the total voltage supplied by the alarm panel is 12V, but we do not know the total resistance of the circuit. We must first estimate the operating resistance of the siren. Can we do this?

Yes, since we have the operating current of the siren at a particular voltage. Applying Ohm's Law, $R_B = E_B/I_B$ or R_B = 12 V/1.2 A = 10 Ω. Now, we take $R_T = R_A + R_B + R_C = 2 + 10 + 2 =$ 14Ω. Next, to find the total circuit current, or I_T, we plug in $I_T = E_T/R_T$ = 12/14 = 0.86 A. Using Ohm's Law, we can find the individual voltage drops of each 500-foot run of wire. $E_A = I_A \times R_A$ = 0.86 X 2 = 1.72 V.

To find if we will have enough voltage for the siren, we apply (KVL) with the divider rule. The results are $E_T = E_T (R_A/R_T) + E_T (R_B/R_T) + E_T (R_C/R_T)$, or 12 = 12(2/14) + 12(2/14) + 12(10/14) = 1.71 + 1.71 + 8.57 V. Another quick computational method would be $E_T = E_A + E_B + E_C$, or $E_C = E_T - E_A - E_B$ = 12 - 1.71 - 1.71 = 8.56 V.

A closer inspection of the siren manufacturer's specifications reveals that the siren will work down to 6V, so it appears that the application will work. The manufacturer may be able to advise if there will be any reduction in the sound level from the siren.

Taking It a Step Further

What would have happened if we had decided to use 20AWG wire in this application? The wire would have a DC resistance of 10 Ω per 1,000 feet. $R_T = 5 + 5 + 10 = 20$ Ω; $I_T = 12/20$ = 0.6A. $E_T = E_T (R_A/R_T) + E_T (R_B/R_T) + E_T (R_C/R_T) = 12(5/20) + 12(5/20) + 12(10/20) = 3 + 3 + 6$. The siren would have 6V, thereby leaving no operational margin. It appears that the 16 AWG wire is a better choice.

From the Floor: ASIS Philadelphia 2002

Do you make a Phillly cheese steak with cheese wiz or provolone? The cousine controversy continues. In Philadelphia, where I recently attended the American Society for Inustrial Security (ASIS) show, they serve it both ways.

Benjamin Franklin gives me some pointers.

Those who read my June "TechTalk" on ligning protection will be glad to know I was able to compare some notes with the expert, Ben Franklin (see photo), who greeted attendees at ASIS. He concures that good equipment grounding is the way to go. The following products especially caught my attention while roamiung the massive two-floor exhibit hall (NOTE: the $$ symbols signifies a potential new source of recurring monthly revenue [RMR]):

- Two new digital securty camera devices aht use memory card storage are the versatile MemoCam™ DVR from Crow (www.crowelec.com) and the battery operated, covert Snoop™ from Carol Products (www.carolproducts.com).
- The Suprex® is a supervised card reader extender from Cypress Computer Systems, Inc. (www.cypresscom.com). Now you can easily connect to a remote card reader with up to 10,000 feet of twisted-pair cable.
- The Linewatch ($$) give a phone circuit a numerical signature. If that number changes due to a phone tap, the product notifies the customer. This device from The Line Detective Co. (ww.linedetective.com) is simple to install and offers unique monitoring revenue.
- Interested in IP intercom systems? Try the GE-200 from Germany's Commend Inc. (www.commmendusa.com).
- The Observer III ($$) is a versatile wireless Internet camera/server from Colorado Video (www.colorado-video.com). It offers wireless Internet video monitoring RMR opportunities.