Tech Notes- Ohms Law “the rules are the rules”! Understanding the rules will help insure you “follow the law”. “OHMS LAW”

By John Dignan

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The importance of understanding “OHMS LAW”, the rules of electrical circuits, becomes a real factor when you look at all the electronics installed on today’s hi-tech planters and other machines and the electrical demands required.

A few years ago I was presented with an opportunity to equip the first 80 foot John Deere corn planter in this part of the country with a clutch control system. The planter had Deere electric clutches installed. I had Trimble tools on all the customers other machines. First thing I did was examine the planter to see what I was getting myself into.

Any system out there requires a reliable supply of power capable of delivering typically 12.5 to 13.5 volts. I knew each Deere clutch needed about .5AMPS at 12 VOLTS to work properly. The power source was the tractor batteries, some 60 to 80 feet away.

With .5 amps needed by each clutch and there are 32 clutches, I knew we needed 16 amps at the planter, just to run the clutches. “THAT TAKES BIG WIRES” for both plus and minus connections and I knew there weren’t any in the current wiring configuration of the planter.

I told the customer, I didn’t think it would work as wired and opted out of the job. When it didn’t work, the dealer updated the wiring using larger wires.

Today, the manufacturers have learned their lesson about power, “WATTS”, and are putting generators on the planter to insure good power is available.

It’s worth learning the basic rules of electricity called “OHMS LAW” to insure when you’re installing new systems or in the field doing maintenance you’ll recognize potential problems. Believe me the *law it the law*!

Units of the basic electric circuit

In an electric circuit, there are three factors that determine the operation of the circuit and they all interact as the circuit changes. The unit of electrical pressure is expressed as VOLTS. Current flowing in the circuit is expressed in AMPS and the resistance to current flow is represented in OHMS.

Power is expressed in WATTS and is the result of Volts X Amps.

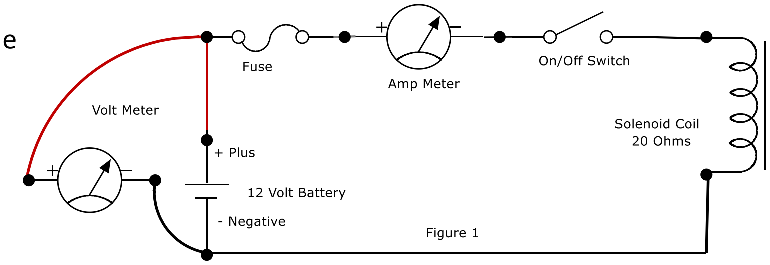
In the circuits we as Field Techs see in the field, the voltage is typically between 12V and 13.6 volts. The wires and fusing must be sized to allow for the current to be drawn, “AMPS”, in the circuit we’re building.

Ohms Law says: $Volts = Amps X Ohms$

then: $$Amps = \frac{Volts}{Ohms}$$

The circuit in figure one includes a battery, a fuse, an on/off switch and a coil. This could be an electric clutch or a valve for liquid control and others. A voltmeter is hooked in parallel with the battery and an Ammeter is installed in series with the overall circuit.

Until the switch is closed nothing happens in the circuit. The voltmeter reads 12 volts and the ammeter reads “0” zero.

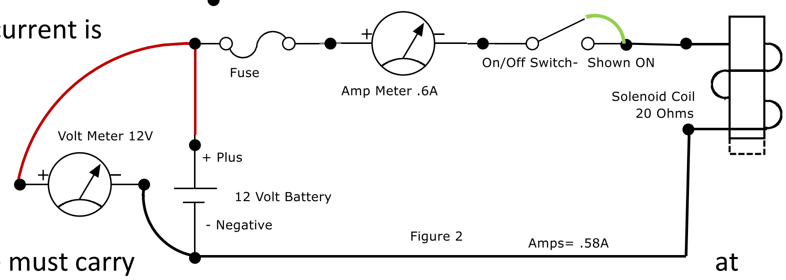


When the switch is closed, figure 2, current begins to flow.

The solenoid coil has a resistance of 20 ohms. The circuit current is calculated using Ohms Law knowing the voltage is 12Volts and the resistance is 20 ohms.

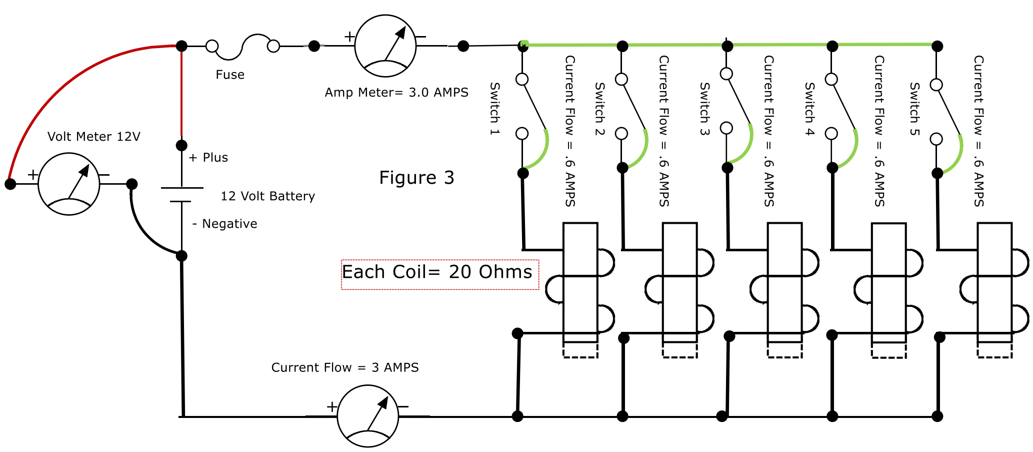
$$Amps = \frac{Volts}{Ohms} \qquad \frac{12}{20} = .6amps$$

A “one amp” fuse might be recommended.

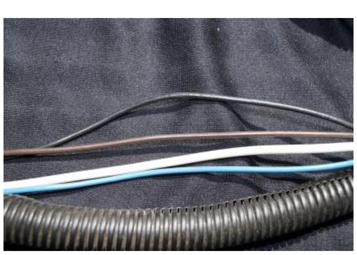


Both the plus and minus connections at the solenoid valve must carry at a minimum of .6 amps.

The circuit shown in figure 3 is an expansion of the previous circuit. Now we have 5 solenoids, maybe clutches. Each clutch circuit needs .6 amps. Current flow in the total circuit is 3 amps. .6 amps per circuit times 5 circuits= 3 amps



Notice in the Figure 3 circuit that each solenoid is controlled by a switch. Each solenoid is drawing .6 amps. The negative connection to the battery must be able to carry the total circuit current of 3 amps. This is called the “Common” connection for all 5 solenoid and carries the total circuit current.



A wires size or gauge determines its ability to carry the necessary current. The common wire in many cases must be larger than “signal” wires turning on each solenoid valve. The pictured RAVEN 440 cable has the boom control wires, black, brown and blue as 18 gauge wire where the common, white is a 12 gauge.

Wires actually add resistance to the circuit and add voltage drop across the wire. This could mean in longer wire runs you might only have 10 volts available to run the devices. In a circuit with 24 solenoid valves, each drawing .6 amps the common wire would need to carry 14.4 amps.

Figure 4 shows a possible solution to the need for a large common connection.

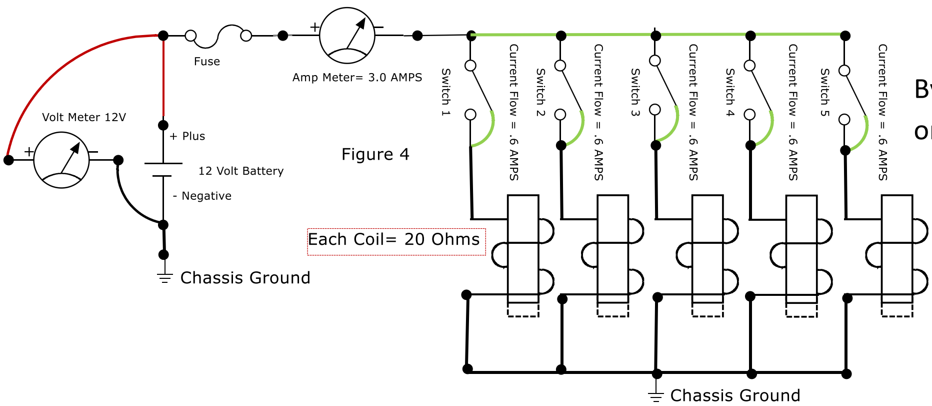


Figure 4

By using the vehicle or implement "chassis" or frame for the negative connection the need for a large common wire can be eliminated.

Many times today big planters and other tools have telescopic parts. These may have plastic slides installed which make the frame parts move smoothly, but break the electrical connection, "Chassis Ground". Make sure you're aware of any issues.

Wire Sizing

What size wire to use in an installation can be a tough question to answer. Many times as Field Techs we use, "whatever we've got". Try to carry different sizes for various job needs. I found a "wire size calculator" at wirebarn.com that is real good!

The user can enter the supply voltage, 13.8, and the wire length, 60 feet, and the acceptable voltage drop percentage, 5 percent, then enter the required current and watch the recommendations. The calculator indicates, "Size Okay" by checking the box, right of the wire size.

Spend some time plugging in different scenarios to become comfortable with sizing wire for the job.

Wire Size Calculator

Voltage	13.8 Volts	
Amperage	5	Enter Maximum Circuit Amperage
Wire Length	60	Enter Total Wire Length in Feet
Percent Drop	5% Drop	

Wire Table

Wire Gauge	Metric	End Voltage	Max Length	Size OK
22 Gauge	0.65mm/0.33mm²	8.9580	8.55	☐
20 Gauge	0.81mm/0.51mm²	10.7550	13.60	☐
18Gauge	1.0mm/0.82mm²	11.8845	21.61	☐
16 Gauge	1.3mm/1.3mm²	12.5952	34.36	☐
14 Gauge	1.6mm/2.1mm²	13.0425	54.65	☐
12 Gauge	2.1mm/3.3mm²	13.3236	86.90	☑
10 Gauge	2.6mm/5.3mm²	13.5003	138.15	☑
8 Gauge	3.3mm/8.4mm²	13.6115	219.68	☑
6 Gauge	4.1mm/13.3mm²	13.6815	349.28	☑
4 Gauge	5.2mm/21.2mm²	13.7255	555.33	☑
2 Gauge	6.5mm/33.6mm²	13.7531	882.92	☑
1 Gauge	7.4mm/42.4mm²	13.7628	1113.80	☑
0 Gauge (1/0)	8.3mm/53.4mm²	13.7705	1404.29	☑
00 Gauge (2/0)	9.3mm/67.4mm²	13.7766	1770.82	☑

Calculate | Reset | Sample

Wire Size Calculator

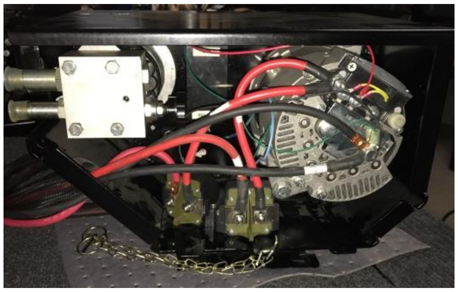
Voltage	13.8 Volts	
Amperage	15	Enter Maximum Circuit Amperage
Wire Length	60	Enter Total Wire Length in Feet
Percent Drop	5% Drop	

Wire Table

Wire Gauge	Metric	End Voltage	Max Length	Size OK
22 Gauge	0.65mm/0.33mm²	0.0000	2.85	☐
20 Gauge	0.81mm/0.51mm²	4.6650	4.53	☐
18Gauge	1.0mm/0.82mm²	8.0535	7.20	☐
16 Gauge	1.3mm/1.3mm²	10.1856	11.45	☐
14 Gauge	1.6mm/2.1mm²	11.5275	18.22	☐
12 Gauge	2.1mm/3.3mm²	12.3708	28.97	☐
10 Gauge	2.6mm/5.3mm²	12.9010	46.05	☐
8 Gauge	3.3mm/8.4mm²	13.2346	73.23	☑
6 Gauge	4.1mm/13.3mm²	13.4444	116.43	☑
4 Gauge	5.2mm/21.2mm²	13.5764	185.11	☑
2 Gauge	6.5mm/33.6mm²	13.6593	294.31	☑
1 Gauge	7.4mm/42.4mm²	13.6885	371.27	☑
0 Gauge (1/0)	8.3mm/53.4mm²	13.7116	468.10	☑
00 Gauge (2/0)	9.3mm/67.4mm²	13.7299	590.27	☑

Calculate | Reset | Sample

Moving the Power Source



One real good way to eliminate the need for large power wires is to move the power source from the tractor to the implement. Kinze Manufacturing along with others have moved the power source to the implement by installing a hydraulic driven generator on the planter. Kinze is also using 24volts as the power source which effectively cuts the current flow requirement in half versus a 12 volt circuit allowing for smaller wires to be used.

Corrosion adds Resistance

Just as too long and too small of wires can cause voltage drop, so can corrosion in the circuit. When connectors are covered with corrosive material, resistance is introduced into the circuit. That resistance causes voltage drop and results in trouble. The best fix is to eliminate it. Clean and protect the connectors and broken wires or replace them.

Corrosion as a Conductor

That corrosive material is also conductive which means it will allow current to flow. Conduction between pins allows for low current connections to be made within the connector. This can send all kinds of signals to control circuits connected to them. Connectors must be cleaned or replaced.

Watts represents "power required"

The solenoid valve shown in the photo indicates it is a 12 volt coil that needs 7 watts of power.

$$Watts = Volts X Amps$$

So- $Amps = \frac{Watts}{Volts}$

The solenoid valve in the photo is labeled showing it will consume 7 watts of power with 12 volts applied.

$Amps = \frac{7}{12}$ $\qquad$ $Amps = .5833$

I hope you've found this Tech Notes column covering basic Ohms Law has been helpful. Please send feedback and suggestions for columns to me at johnd@agtester.com. I'll look forward to hearing from you!

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