WIRING & GROUNDING PRACTICES

AS RELATED TO ACCESS CONTROL SYSTEMS

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10/11/93

Grounds are important to system reliability. The main electrical service entrance to a facility has a ground supplied that we will call "Service Ground". This is the only power ground that can be used to meet NEC. Confusion results here from references to power, signal, and lightning grounds, as being different grounds. Ultimately all grounds must connect to the Service Ground, but they will reach that point via different paths. Many commercial and industrial facilities use a Conduit ground and not a separate conductor run back to Service Ground.

Today's computers are especially sensitive to ground problems. A seperate ground wire MUST be run WITH the power wiring all the way back to the service ground WITHOUT ANY OTHER SYSTEM CONNECTIONS. This is called an "isolated ground" and requires an orange colored outlet.

Suppose a ground circuit had a 1 ohm resistance, and the equipment draws 20 amps. By OHM'S LAW we can see that a 20 volt difference of potential would exist. When the equipment is connected to a remote unit with a proper ground, that difference would already exist - enough to destroy some of the newer integrated circuits.

This problem is enhanced by the fact that many devices such as heaters and some fans induce a leakage current into the ground wire. These devices will often trip ground fault detectors by sending a noise spike down the ground lead. This same noise spike can cause problems with the highly sensitive integrated circuits we now utilize in security equipment. This is why the isolated ground circuits are not connected to any other ground circuit, but run directly to the Service Ground.

Many lightning suppression devices require a separate earth ground, most often this is also tied to the Service Ground. The manufacturers recommendations must be followed for these devices. Lightning will not travel around corners. The pulse of power is so fast that any inductance will appear as a high resistance path. When a wire is bent around a corner, or a loop made in a wire such as the loop in the wire at the building service entrance, a high impedance to the very fast lightning pulses is created. The lightning pulse will try to find a low impedance path to ground. Lightning suppression devices installed on the interior must be connected to the same ground connection as the cabinet with as short a connection as possible.

Many problems are related to ground loops. These are caused by difference in potential that exists between two connected points. Often the ground loop is also related to the noise induced into a conductor.

Shielding of conductors is both the solution and the culprit in many noise problems. Placing a shield around a wire or pair of wires prevents a magnetic field from crossing the wires and inducing an unwanted voltage. This resolves the problem with the unwanted exception that the shield is also a conductor that picks up induced noise from magnetic fields as well. A place for the voltage to drain off must be provided. This is done by connecting the shield to ground at the end of the wire run. When the shield is connected to ground at both ends, a current will flow if a difference of potential exists between the ground points.(Figure5)(refer to previous discussion of grounding)

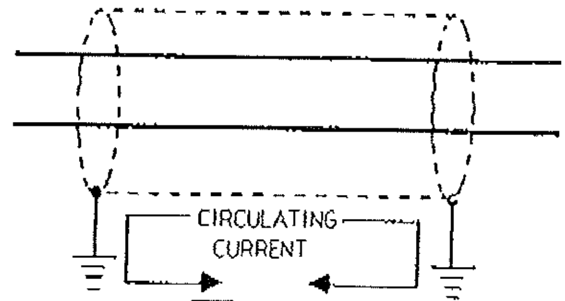

FIGURE 5

The current flow in the shield will induce a voltage into the enclosed wires, and the signal wires are noisy again. This may actually be worse than when we started because the grounds may have more noise than the wire we tried to shield the signal from initially. To defeat this problem, the shield is only grounded at one end, (Figure 6).

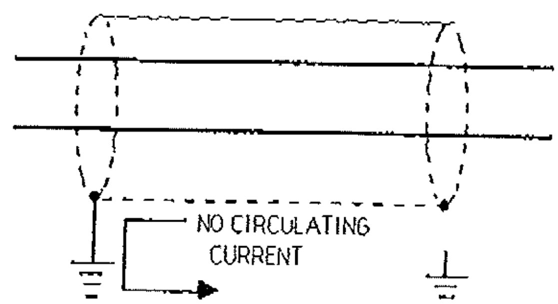

FIGURE 6

With no current flowing, no magnetic field is created, but a means to drain the voltage off the shield to ground is provided. For long runs with multiple connections, the shield is connected together at the connection points, but not grounded anywhere except at a single point at the beginning of the run. (Figure 7).

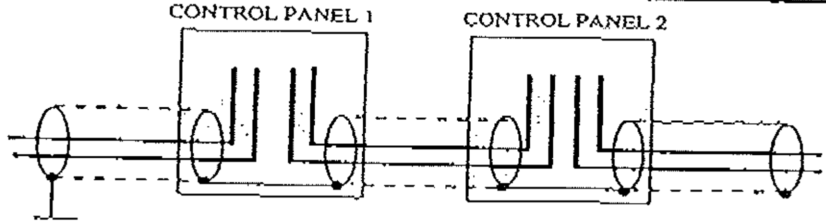

FIGURE 7

Almost all control devices utilized in the security industry today are comprised of integrated circuits. Controls that required thousands of components years ago are now contained on a single IC costing less than a dollar.

As the devices become smaller they operate at lower voltages and are much more susceptible to "noise" and damage by improper installation than the older devices.

Older systems were not sensitive to these problems so very little attention was paid to wiring. The newer systems require careful attention to the practices outlined by the NATIONAL ELECTRIC CODE (NEC, part 70).

For years the audio and instrumentation industries have adhered to these wiring practices to eliminate hum, ground loops and lightning. The security industry must now also make these wiring practices a way of life if they are to coexist with integrated circuits and microprocessor technology.

Let's review some of the basics of electrical circuits. When a current flows through a conductor a magnetic field is created (Figure 1). This field surrounds the conductor completely.

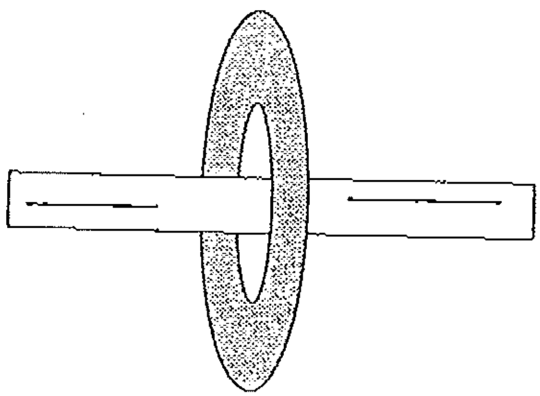

FIGURE 1

The extent of this field depends on how great the current through the conductor is. When a second wire is placed near the conductor, a voltage is induced in the wire as the magnetic lines of force cut through the wire. (Figure 2).

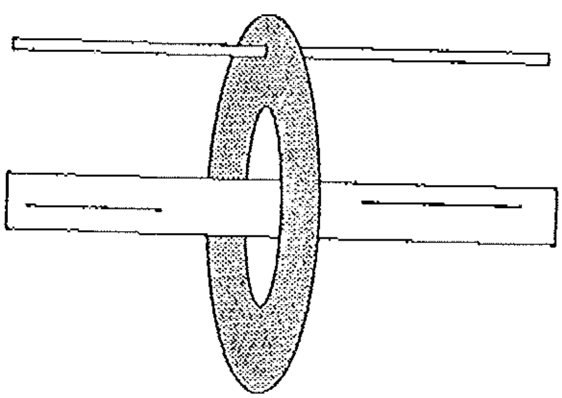

FIGURE 2

This is the basis for the design and operation of transformers. The closer the wires are to each other, the more lines of force are cut and the greater the induced voltage. However, if no current exists within the wire, no field is created no matter what the voltage is.

When two wires run close to another conductor that has noise on it, one wire is always closer to the noisy conductor than the other. No matter how hard you try, it would be impossible to get the same voltage induced in both wires.(Figure 3)

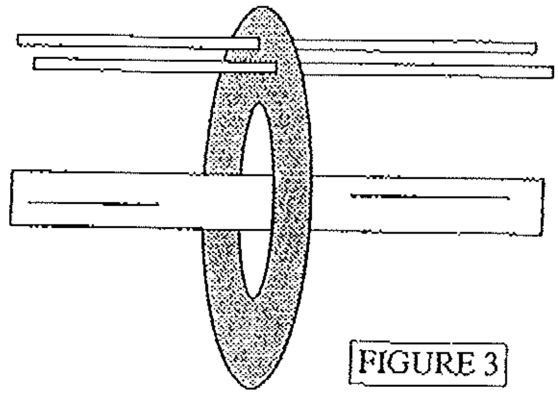

FIGURE 3

By twisting the conductors as a twisted pair, nearly the same voltage will be induced in both wires.(Figure 4)

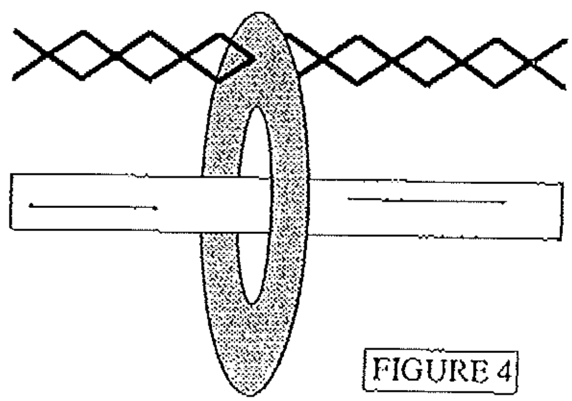

FIGURE 4

The voltage must be 180 degrees out of phase, that is if one is positive the other must be negative for a circuit to be formed and current to flow. When the induced voltage on both wires is of the same polarity, no current flows cancelling the noisy signal. This is called "Common Mode Rejection". Some circuits do this better than others. Unbalanced circuits (circuits with one side connected to ground) can set up a path for secondary current flow so they are not very effective. Balanced circuits float both wires above ground and are very effective for common mode rejection.

<u>It should be concluded from the above examples;</u>

1. Never run high voltage wiring to strikes or relays adjacent to low voltage wiring such as that to card readers, data communications cables, or alarm inputs.
2. Always use shielded cable for sensitive cable runs, and follow the rules concerning shields described herein.
3. Use twisted pairs for data cables whenever applicable.

With AC voltages the signal is changing from one polarity to the other, with current flowing in one direction and then reversing. Since the signal travels at a finite speed along the wire it is possible to have differing polarities on the same wire - this is called standing wave. This is the basis for specific lengths of wire being used as antennas for radio.

As a wire approaches a substantial portion of a wave length, this standing wave acts like an antenna and current can actually flow from the wire radiating the signal. This again could interfere with the signal on the shielded wires by inducing the noise into them. A wire cut to these specific lengths, even a ground lead, may act as an antenna receiving the signal or noise and causing problems.

For long cable runs, an alternate method is to terminate the shield at one end only, however, terminate at each control point and do not connect the shields through. This breaks up the standing wave and reduces the antenna effect. (Figure 8).

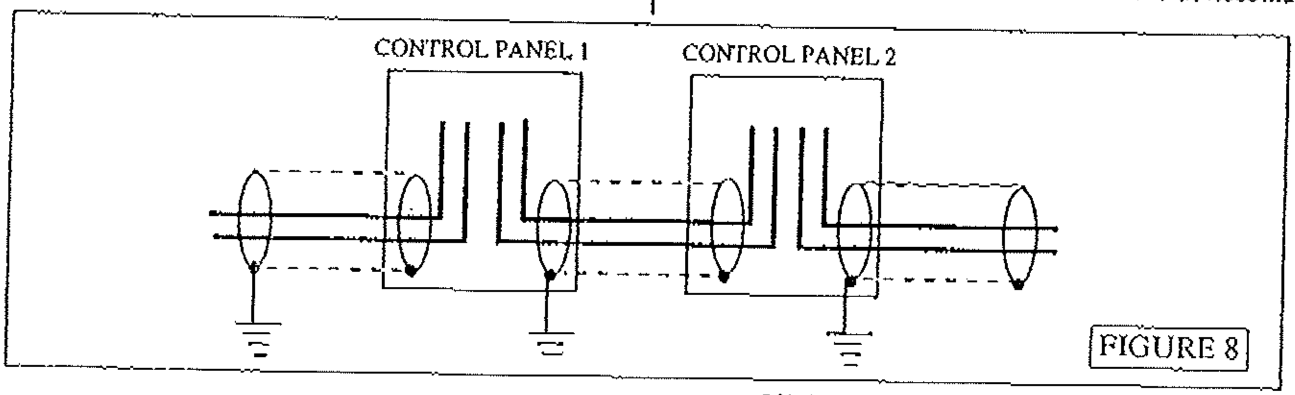

FIGURE 8

Again no current path is provided and a voltage drain is provided so the difference in potential is unimportant. This is the recommended procedure for shielding from RF signals

Many of the problems encountered in access control seem to relate to the controlled devices such as relays, solenoids, door strikes, etc. These are all inductive devices. They work very much like an auto ignition system. (Figure 9).

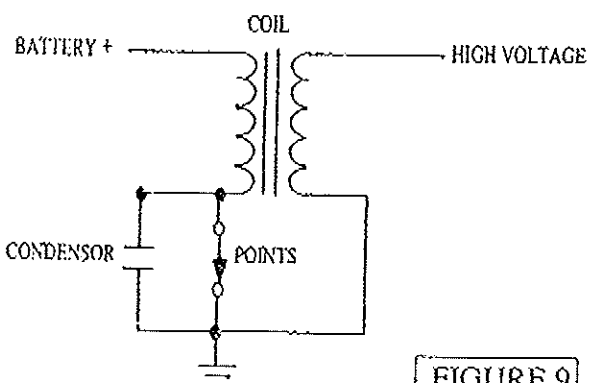

FIGURE 9

When the voltage is removed from the coil by the points opening, the field collapses on the coil generating a counter magnetic force (CMF) and current flows in the opposite direction. The capacitor across the points enhance the effect by requiring a fairly large current to charge up. Together the components induce a voltage that is several thousand volts, even though the applied voltage is only 12 volts in most cases.

Relays, door strikes, and electro-magnetic locks are all inductors and all cause the same kind of effect as the auto ignition system previously described. On release of current from the coil, a large inductive spike is sent back to the system - the wiring acts as the capacitor. Besides the CMF spike causing possible circuit malfunction, it also causes an arc at the contacts of the controlling relay shortening the contact life. A common practice is to add a reverse biased diode across the inductor to act as a short circuit to the CMF. It is extremely important this diode be installed at the controlled device in order to bleed the field prior to it's traveling through the wiring to the control panel. (FIGURE 10)

The reverse diode is used of course for DC type devices only. For AC devices an MOV (Metal Oxide Varistor) with a rating of approximately 25 % greater than the applied voltage will sometimes work. In some cases AC devices may

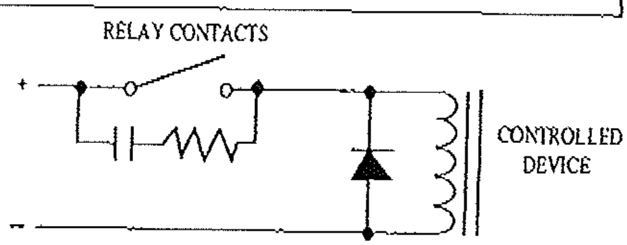

FIGURE 10

be converted to DC by the addition of a rectifier and then a reverse diode installed as indicated.

Notice in Figure 10 the resistor and capacitor network across the relay contacts. This is commonly called a "snubber". It's purpose is to add a time constant releasing the voltage slowly and reducing the effect of CMF. The capacitor should be a disc type with a voltage rating four times the applied voltage and a value of .05 to .2 mfd. The resistor should be between 39 and 100 ohms - 1/2 watt. The manufacturer of the equipment may install the snubber during manufacture.

An understanding of noise problems and adherance to good installation and grounding practices will result in fewer installation problems, fewer service calls, and much more reliable performance.