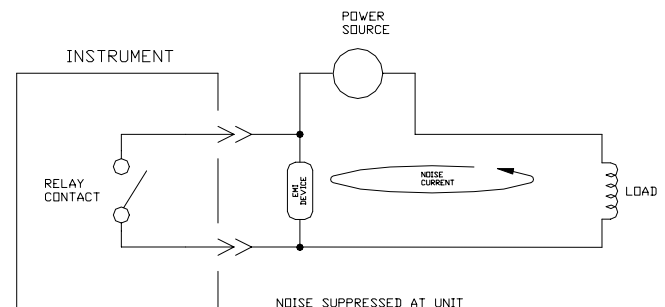
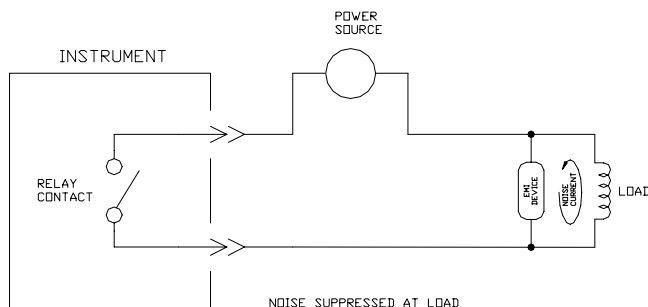


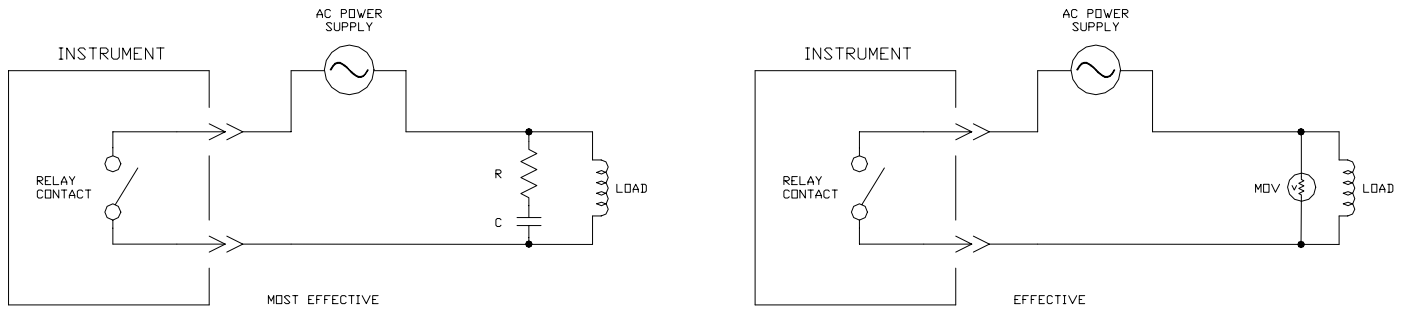
## EMI Installation Guidelines

Although Red Lion Controls Products are designed with a high degree of immunity to Electromagnetic Interference (EMI), proper installation and wiring methods must be followed to ensure compatibility in each application. The type of the electrical noise, source or coupling method into a unit may be different for various installations. A unit becomes more immune to EMI with fewer I/O connections. Cable length, routing, and shield termination are very important and can mean the difference between a successful or troublesome installation. Listed are some EMI guidelines for a successful installation in an industrial environment.

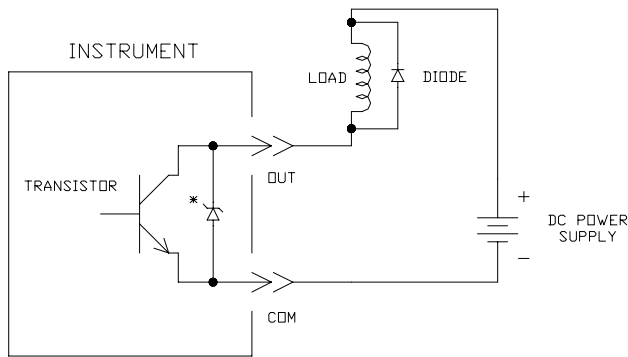
1. To reduce the chance of noise spikes entering the unit via the power lines, connections should be made to a clean source. Connecting to circuits that also power loads such as contactors, relays, motors, solenoids etc. should be avoided.
2. A unit should be mounted in a metal enclosure, which is properly connected to protective earth.
  - 2.a. Units that have a metal bezel should have the bezel connected to protective earth. This can be done by making sure the metal bezel makes proper contact to the panel cutout or connecting the bezel screw with a spade terminal and wire to protective earth.
3. Use shielded (screened) cables for all Signal and Control inputs. The shield (screen) pigtail connection should be made as short as possible. The connection point for the shield depends somewhat upon the application. Listed below are the recommended methods of connecting the shield, in order of their effectiveness.
  - 3.a. Connect the shield to earth ground (protective earth) at one end where the unit is mounted.
  - 3.b. Connect the shield to earth ground at both ends of the cable, usually when the noise source frequency is over 1 MHz.
  - 3.c. Connect the shield to common of the module and leave the other end of the shield unconnected and insulated from earth ground.
4. Never run Signal or Control cables in the same conduit or raceway with AC power lines, conductors feeding motors, solenoids, SCR controls, and heaters, etc. The cables should be run through metal conduit that is properly grounded. This is especially useful in applications where cable runs are long and portable two-way radios are used in close proximity or if the installation is near a commercial radio transmitter. Also, Signal or Control cables within an enclosure should be routed as far away as possible from contactors, control relays, transformers, and other noisy components.
5. Long cable runs are more susceptible to EMI pickup than short cable runs. Therefore, keep cable runs as short as possible.
6. In extremely high EMI environments, the use of external EMI suppression devices is effective. The following EMI suppression devices (or equivalent) are recommended:
  - 6.a. Ferrite Suppression Cores for signal and control cables:
    - Fair-Rite part number 0443167251 (Red Lion Controls part number FCOR0000)
    - TDK part number ZCAT3035-1330A
    - Steward part number 28B209-0A0
  - 6.b. Line Filters for input power cables:
    - Schaffner part number FN610-1/07 (Red Lion Controls part number LFIL0000)
    - Schaffner part number FN670-1.8/07
    - Corcom part number 1 VR3
7. To protect relay contacts that control inductive loads and to minimize radiated and conducted noise (EMI), some type of contact protection network is normally installed across the load, the contacts or both. The most effective location is across the load.



7.a. Using a snubber, which is a resistor-capacitor(RC) network or metal oxide varistor (MOV) across an AC inductive load is very effective at reducing EMI and increasing relay contact life.



7.b. If a DC inductive load (such as a DC relay coil) is controlled by a transistor switch, care must be taken not to exceed the breakdown voltage of the transistor when the load is switched. One of the most effective ways is to place a diode across the inductive load. Most RLC products with solid state outputs have internal zener diode protection. However external diode protection at the load is always a good design practice to limit EMI. Although the use of a snubber or varistor could be used.

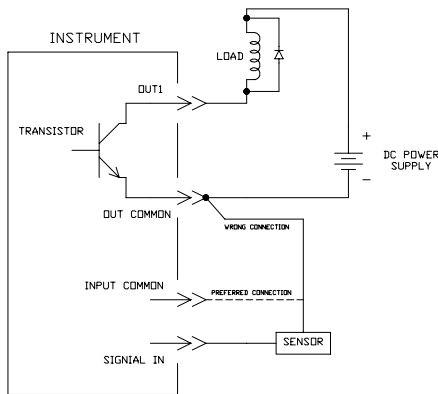


\* RLC Products with Internal Zener Diode Protection

Red Lion Controls part numbers: Snubber SNUB0000  
Varistor ILS11500 or ILS23000

Note: Reference manufacturer's instructions when installing any EMI suppression device.

8. Also care should be taken when connecting input and output devices to the instrument. When a separate input and output common is provided, they should not be mixed. Therefore a sensor common should NOT be connected to an output common. This would cause EMI on the sensitive input common, which could effect the instruments, operation.



## Understanding EMI Sources

The three most common sources of EMI problems in the field are Radio Frequency Interference (RFI), ElectroStatic Discharges (ESD) and Power and I/O Disturbances.

### Radio Frequency Interference (RFI)

RFI disturbances typically come from radio transmitters such as hand held VHF/UHF radios and cellular phones. Analog devices are particularly sensitive to RFI, which usually causes an erroneous reading and rarely causes permanent damage. Units operate normally when the RF field is removed. An RF field is defined in volts/meter and can be measured with a RF field intensity meter or predicted with this formula:

$$E = 5.5 \sqrt{P/d}$$

Where: E = field intensity in volts/meter

P = radiated power in watts

d = distance from antenna in meters

Example: For a 1 watt radio at 1 meter, the predicted field intensity is about 5 volts/meter.

A 10,000 watt radio station at 1 kilometer is about .55 volts/meter.

Therefore it can be seen that the small transmitter nearby is often a bigger threat than the distant transmitter. Typical solutions are the use of shielded cable, proper grounding of drain wire, and/or additional filtering on power and I/O cables, if necessary.

### Electro-Static Discharge (ESD)

ESD threats are usually caused by a rapid discharge from a human, although internal discharges due to mechanical movement are sometimes possible sources. ESD can cause problems from both direct (contact) and indirect (radiated) discharges. There have been cases of indirect discharges causing problems up to 20 feet away. Problems such as sensitive analog circuits that exhibit signal deviation, false unit resets and even memory failure are some of the problems that can occur. Also ESD can permanently damage circuits. At humidity levels below 10%, human ESD problems increase, while at humidity levels above 50 % they are much lower. The threshold of human feeling is about 2000 V, therefore if no ESD is felt the levels are fairly low. Most RLC products have plastic housings so there is usually no discharge to the bezel and therefore no problems. Units with metal bezels may require grounding of the bezel for discharge levels above 4 KV.

### Transients Power Lines

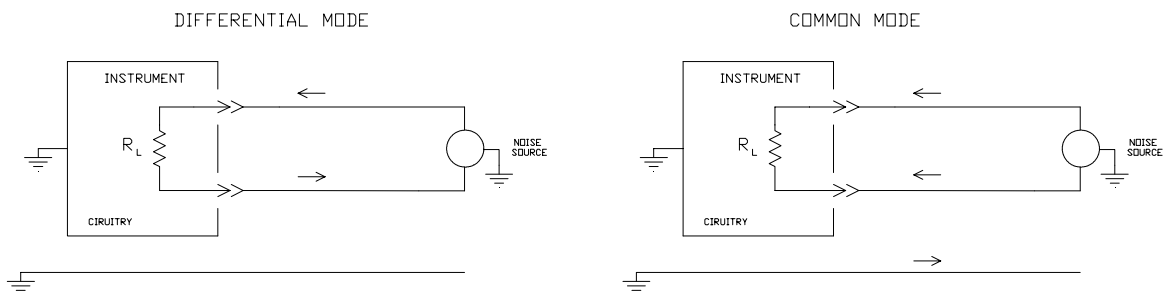
Power disturbances are normally caused by inductive load switching, power line distortion, RF transmitted over AC lines, thunderstorms and sometimes magnetic fields. I/O line threats are pretty much the same. Symptoms can be the same as ESD but permanent damage usually does not occur. The most common solutions for power disturbances are EMI line filters and for I/O cables is routing them in conduit with proper grounding of conduit. For RF transmitted problems clamp on ferrite cores will solve the problem and have the advantage of being easy to install. However they are not as effective as EMI filters and routing cables in conduit.

### Differential vs Common Mode

Differential mode refers to disturbances in which the noise voltage appears between the individual current-carrying conductors. The noise current flows in the same direction as the intended signal current. A corresponding differential noise voltage can be measured from wire to wire.

Common mode refers to disturbances in which the noise voltage appears between both current-carrying conductors and ground of protective earth. Common mode currents flow in phase with each other. A corresponding common noise voltage CANNOT be measured from wire to wire, but can be measured from wire to ground.

As a rule of thumb, differential mode disturbances are predominate at frequencies below 1 MHz, and common mode disturbances predominate at frequencies above 1 MHz.



## **Methods for Solving EMI Problems**

EMI (ElectroMagnetic Interference) problems can be some of the most difficult in the controls field to solve. Signals can come from anywhere, travel through strange and unknown paths, and cause unexplainable disruptions. Worse, problems may be only intermittent, making them still harder to find. Although it may seem like black magic, EMI control can be done. Hopefully the following troubleshooting guidelines will help you eliminate EMI problems.

### **Troubleshooting**

The first step is to diagnose the problem and gather data.

*What are the symptoms? Focus inside the unit.*

Is the unit resetting, like when power is first applied?

Are the programmable parameters changing or scrambled?

Do outputs turn on or off when they are not supposed to?

Do user inputs activate when they are not supposed to?

Counter: Is count value what it should be when counting stops or are there miscounts?

Rate: Is rate value changing erroneously?

Analog: Is the display value changing erroneously?

Serial: Are transmitted characters scrambled?

Does the unit lockup and require a power cycle to get it operating?

*What are some likely causes? Focus outside the unit.*

Is the environment severe, such as a factory floor or processing plant?

Is the environment less severe, such as a control room?

Where is the unit mounted?

For ESD, is it a low humidity environment?

Is power supplied to the unit on the same feed with other noisy systems?

Are hand held radios in use?

Are cellular phones in use?

Are relays, contactors or motors being switched in close proximity to the signal or control wiring?

Are relay, contactor or motor wiring in the same conduit or bundled with the signal or control wiring?

*Are there any constraints?*

Can unit location be changed?

Can unit be mounted in a grounded metal enclosure?

Can the type of cable be changed (i.e. use of shielded cable)?

Can the drain of the shielded cable be connected to protective earth at the instrument?

Can signal and control cables be run in separate conduit?

Can the cable routing be changed?

Can external EMI devices be installed?

Now that the data is gathered it must be diagnosed. A useful tool is the Source-Path-Receptor Model, which shows that any EMI problem has three elements; the source, the receptor and the path coupling them. All three must be present in order for a problem to occur. If you can eliminate any one element, the problem is solved.

SOURCE-PATH-RECEPTOR MODEL		
Any interference problem can be broken down into: The SOURCE of the interference The RECEPTOR of the interference The PATH coupling the source to the receptor		
SOURCES	PATHS	RECEPTOR
RF transmitters	Radiated: EM fields Crosstalk to cables	Red Lion
ESD	Conducted: Signal inputs Power inputs	Controls Products
Power Disturbances		
Lightning		

For example, if we know the unit resets when someone touches a front panel button, we can be pretty sure the source is ESD and the receptor is the reset circuit of the unit. However, when troubleshooting random EMI problems in the field, the element is usually the coupling path. It can be radiated, conducted or a combination of the two. Radiated coupling paths are often associated with cables which act as hidden antennas. Although coupling paths can be directly through the unit enclosure, usually the display window will be the path when the unit is panel mounted in a metal enclosure. Conducted coupling paths are often associated with the power, signal and ground interfaces. Keep in mind, electromagnetic interference coupling paths can be multiple, so until all the paths are dealt with, the EMI problem may still remain.

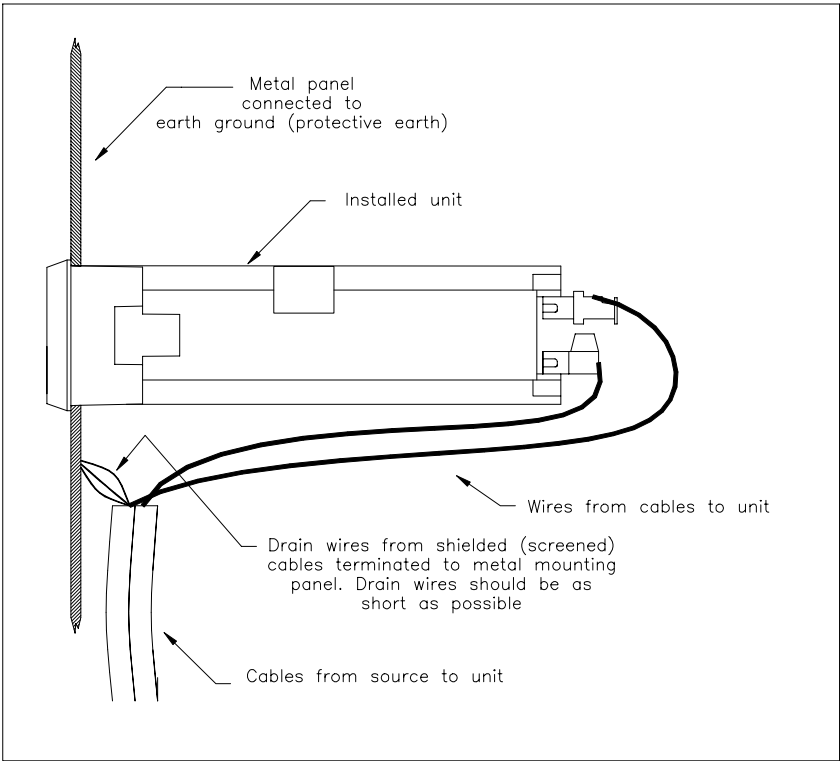
Here are some general guidelines for RF:

- Below 30 MHz the path is usually conducted.
- Above 30 MHz the path is usually radiated.
- Any length greater than about a 1/20 wavelength is a suspect antenna:
  - At 100 MHz this is about 6 in. (15 cm)
  - At 300 MHz this is about 2 in. (5 cm)
  - At 1 GHz this is about 3/4 in. (1.5 cm)

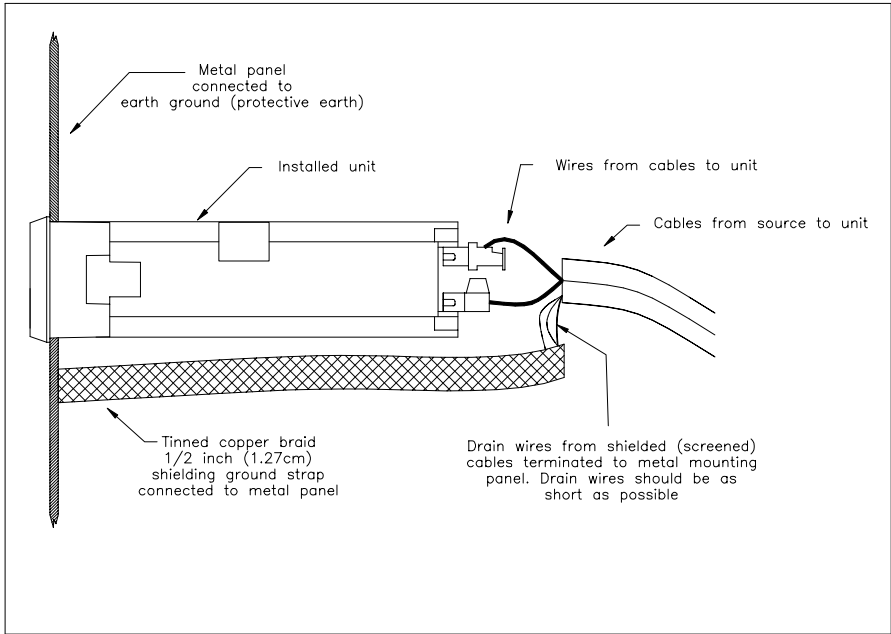
Therefore, even short cables and sometimes circuit wiring within the unit can act as hidden antennas.

**Shield Termination**

The drain wire termination for the shielded cable should be as short as possible. Shown below are two methods of termination that have been tested in RLC's EMC lab for a grounded open 19" panel rack. If the unit were mounted in a fully enclosed rack then the shield would be terminated as the cables entered the enclosure.



Good drain wire connection to grounded front panel as short as possible. Most RLC products tested in this manner.



Not as good when drain wire connection to grounded front panel via a long braided connection.

## **Low Voltage Directive**

The Low Voltage Directive (LVD) states that electrical equipment must comply with the harmonized safety standard that is relevant to the product.

To meet the requirements of the Low Voltage Directive, RLC products are evaluated for compliance to the harmonized safety standard EN61010-1 and IEC 1010-1.

Definitions- from EN61010-1 and IEC 1010-1

Installation Category (Overvoltage Category): Classification of parts of installation systems or circuits with standardized limits for transient overvoltages, dependent on the nominal line voltage to earth.

Installation Category (Overvoltage Category) I: Signal level, special equipment or parts of equipment, telecommunication, electronic etc., with smaller transient overvoltages than Installation Category (Overvoltage Category) II.

Installation Category (Overvoltage Category) II: Local level, appliances, portable equipment, etc., with smaller transient overvoltages than Installation Category (Overvoltage Category) III.

Installation Category (Overvoltage Category) III: Distribution level, fixed installation, with smaller transient overvoltages than Installation Category (Overvoltage Category) IV.

Installation Category (Overvoltage Category) IV: Primary supply level, overhead lines, cable systems etc. This category is not relevant to EN61010-1 and IEC 1010-1 standard.

Pollution: Any addition of foreign matter, solid, liquid or gaseous (ionized gases), that may produce a reduction of dielectric strength or surface resistivity.

Pollution Degree: For the purpose of evaluating clearances the following two degrees of pollution in the micro-environment are recognized for use with EN 61010-1 & IEC 1010-1.

Pollution Degree 1: No pollution or only dry, non-conductive pollution occurs. The pollution has no influence.

Pollution Degree 2: Normally only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected.

Operational Insulation: Needed for the correct operation of the equipment Note: Does not protect against electric shock. It may however, serve to minimize exposure to ignition and fire.

Basic Insulation: The failure of which could cause a risk of electric shock.

Supplementary Insulation: Independent insulation applied in addition to Basic Insulation in order to provide protection against electric shock in the event of a failure of Basic Insulation.

Double Insulation: Insulation comprising both Basic Insulation and Supplementary Insulation.

SELV or Class 2 circuit: Safety extra-low voltage (SELV) circuits shall exhibit voltages safe to touch both under normal operating conditions and after a single fault, such as breakdown of a layer of Basic Insulation or failure of a single component. The voltage between any two accessible parts, and between any accessible part and the equipment protective earthing terminal shall not exceed 30 V rms (42.4Vpeak), under normal operating conditions.

These standards require the product manufacturer to state the Installation Category and Pollution Degree of the equipment in the product installation manual. The evaluation of insulation clearance, creepage distances and dielectric strength requirements was based upon these installation category classifications of the unit.

Most RLC products are either intended for Installation Category (Overvoltage Category) I or II and normally Pollution Degree 2. Most panel mounted RLC units meet NEMA 4/IP65 or NEMA 4X/IP65 requirements for indoor use when properly installed.

To prevent electric shock the units must be mounted in the intended manner in an enclosure which provides the required barriers to accessible parts. In the determination of accessible parts, the operator during normal operation should not have access behind the panel in which the unit is installed. The caution labels used on the unit give adequate warning for the risk of electric shock at the rear of the unit. Double insulation is provided between the primary circuits and secondary SELV circuits.

Equipment temperature limits and protection against the spread of fire was verified by temperature tests and limited circuit classification testing. The enclosure material is a UL "Recognized Component" Plastics (UL Recognized Component Directory category QMFZ2) with a 94V-2 or better flammability rating. The printed circuit boards are UL "Recognized Component" Printed Wiring Board (UL Recognized Component Directory category ZPMV2) rated minimum 94V-0, 130°C.

Transformers have one of the following constructions:

UL "Recognized Component" Insulating Devices and Materials (UL Recognized Component Directory category NYYV2) rated at 105°C minimum for units with a switching power supply.

UL "Recognized Component" Electrical Insulating System (UL Recognized Component Directory category OBJY2) rated at Class 130 (B). When required the transformer has in each primary winding a UL "Recognized Component" Thermal Cutoff (UL Recognized Component Directory category XCMQ2) rated 130°C. The transformer meets IEC 742 construction requirements.

UL "Recognized Component" Class 2 Transformer (UL Recognized Component Directory category XOKV2) rated at least Class 130 (B) marked with company name or symbol, and system designation per UL Recognized Component Directory. Agency Recognized to UL 1950 or IEC 950, CSA and VDE.

References:

EDN-EMC Supplement Guide: 20 January, 1994

Noise reduction techniques in electronic systems, second edition; 1988