Appendix B

Reducing Electrical Noise

Noise-related difficulties can range in severity from minor positioning errors to damaged equipment from runaway loads crashing blindly through limit switches. In microprocessor-controlled equipment such as the APEX615n, the processor constantly retrieves instructions from memory in a controlled sequence. If an electrical disturbance occurs, it may cause the processor to misinterpret an instruction or access the wrong data. This can be catastrophic to the program and force you to reset the processor.

Sources of Noise

Being invisible, electrical noise can be very mysterious, but it invariably comes from the following sources:

- Power line noise
- Externally conducted noise
- Transmitted noise
- Ground loops

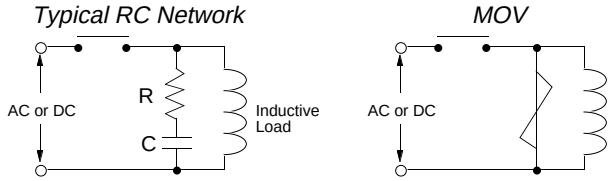
The following electrical devices are notorious for generating unwanted electrical noise conditions:

- Coil-driven devices: conducted and power line noise
- SCR-fired heaters: transmitted and power line noise
- Valves, motors & motor drives: transmitted and power line noise
- Welders (electric): transmitted and power line noise

Power Line Noise

Power line noise is usually easy to resolve due to the wide availability of line filtering equipment for the industry. Only the most severe situations call for an isolation transformer. Line filtering equipment is required when other devices connected to the local power line are switching large amounts of current, especially if the switching occurs at a high frequency.

Any device having coils is likely to disrupt the power line when it is switched off. Surge suppressers, such as metal oxide varistors (MOVs) are capable of limiting this type of electrical noise. A series resistor/capacitor (RC) network across the coil is also effective (resistance: 500 to 1,000 Ω; capacitance: 0.1 to 0.2 μF). Coil-driven devices (inductive loads) include relays, solenoids, contactors, clutches, brakes, and motor starters.



Internal Switching Noise

This noise directly relates to the high *dv/dt* from the internal switching of the IGBT power block of the APEX615n's drive. This high *dv/dt* creates a large earth ground *di/dt* through the motor case. This may cause the ground to jump if a solid earth connection is not present. Depending on how the drive and other equipment are connected to the earth ground, users may experience voltage spikes on I/O lines. Systems involving data acquisition from low level analog and digital signals are most vulnerable.

The best method to limit the *dv/dt* is to add a filter between the drive output and the motor. This reduces the *dv/dt* and decreases the *di/dt* a great deal. These filters have been installed by Compumotor in several applications with good results. Another method that can be used to reduce noise is to install AC line input filters. Compumotor has found from our own testing that properly installed AC line filters, on the drive as well as the controller, reduce noise on both analog and digital inputs and outputs.

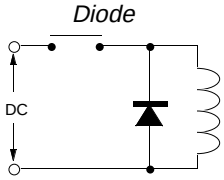
Compumotor has located a series of suitable AC line filters and motor output filters that can be purchased for use in applications as needed. These filters are manufactured by the SCHAFFNER Co. and may be purchased by contacting the manufacturer or the stocking distributor listed at the end of this appendix. The suitable motor output filters are listed below. The suggested AC line filters are listed in the "Filtering the AC mains supply" section of Appendix E of this document.

	Manufacturer	**Part Number**
APEX6151	Schaffner Co.	FN 510-8/29
APEX6152	Schaffner Co.	FN 510-8/29
APEX6154	Schaffner Co.	FN 510-16/29

Externally Conducted Noise

Externally-conducted noise is similar to power line noise, but the disturbances are created on signal and ground wires that are connected to the APEX615n. This kind of noise can get into logic circuit ground or into the processor power supply and scramble the program. The problem here is that control equipment often shares a common DC ground wire that may be connected to several devices, such as a DC power supply, programmable controller, remote switches, etc. When a noisy device such as a relay or solenoid is attached to the DC ground, it may cause disturbances within the APEX615n.

To solve a noise problem caused by DC mechanical relays and solenoids, you can connect a diode backwards across the coil to clamp the induced voltage *kick* that the coil will produce. The diode should be rated at 4 times the coil voltage and 10 times the coil current. Using solid state relays is another way to eliminate this problem.



Multiple devices on the same circuit should be grounded together at a single point.

Furthermore, power supplies and programmable controllers often have DC common tied to Earth (AC power ground). As a rule, it is preferable to have the APEX615n Iso GND floating with respect to Earth. This prevents noisy equipment that is grounded to Earth from sending noise into the APEX615n. When floating the signal ground is not possible, you should make the Earth ground connection at only one point.

In many cases, optical isolation may be required to completely eliminate electrical contact between the APEX615n and a noisy environment. Solid state relays provide this type of isolation.

Transmitted Noise

Transmitted noise is picked up by external connections to the APEX615n, and in severe cases can attack the APEX615n when there are no external connections. The APEX615n's sheet metal enclosure will typically shield the electronics from this, but openings in the enclosure for connections and front panel controls may *leak*.

When high current contacts open, they draw an arc, producing a burst of broad spectrum radio frequency noise that can be picked up on a limit switch or other wiring. High-current and high-voltage wires have an electrical field around them and may induce noise on signal wiring, especially when they are tied in the same wiring bundle or conduit.

When this kind of problem occurs, you should consider shielding signal cables or isolating the signals. A proper shield surrounds the signal wires to intercept electrical fields, but this shield must be tied to Earth to drain the induced voltages. At the very least, wires should be run in twisted pairs to limit straight line antenna effects.

Installing the APEX615n in a NEMA enclosure ensures protection from this kind of noise, unless noise-producing equipment is also mounted inside the enclosure. Connections external to the enclosure must be shielded.

Even the worst noise problems in environments near 600 amp welders and 25kW transmitters have been solved using enclosures, conduit, optical isolation, and single-point ground techniques.

Ground Loops

Ground Loops are the most mysterious noise problems. They seem to occur most often in systems where a control computer is using RS-232C communication. Symptoms like garbled transmissions and intermittent operation are typical.

The problem occurs in systems where multiple Earth ground connections exist, particularly when these connections are far apart.

Ground Loops—Noise Scenario

Suppose an APEX615n is controlling a motor, and the limit switches use an external power supply. The APEX615n is controlled by a computer in another room. If the power supply Common is connected to Earth, the potential exists for ground loop problems. This is because most computers have their RS-232C signal common tied to Earth. The loop starts at the APEX615n system limit switch ground, goes to Earth through the drive, and on to Earth at the computer. From there, the loop returns to the APEX615n system through RS-232C signal ground. If a voltage potential exists between drive Earth and remote computer Earth, ground current will flow through the RS-232C ground, creating unpredictable results.

The way to test for and ultimately eliminate a ground loop is to lift or *cheat* Earth ground connections in the system until the symptoms disappear.

Defeating Noise

The best time to handle electrical noise problems is before they occur. When a motion system is in the design process, the designer should consider the following set of guidelines for system wiring (in order of importance):

1. Put surge suppression components on all electrical coils: Resistor/capacitor filters, MOVs, Zener and clamping diodes.
2. Shield all remote connections, use twisted pairs. Shields should be tied to Earth at one end.
3. Put all microelectronic components in an enclosure. Keep noisy devices outside. Watch internal temperature.
4. Ground signal common wiring at one point. Float this ground from Earth if possible.
5. Tie all mechanical grounds to Earth at one point. Run chassis and motor grounds to the frame, and the frame to Earth.
6. Isolate remote signals. Solid state relays or opto isolators are recommended.
7. Filter the power line. Use common RF filters, and use an isolation transformer for worst case.
8. Filter the lines between the drive output and the motor.

A noise problem must be identified before it can be solved. The obvious way to approach a problem situation is to eliminate potential noise sources until the symptoms disappear, as in the case of ground loops. When this is not practical, use the above guidelines to *shotgun* the installation.

References

Information about the equipment referred to may be obtained by calling the numbers listed below.

- Corcom line filters, (214) 386-5515
- Opto-22 optically isolated relays, (408) 496-6611
- Crydom optically isolated relays, (415) 463-2250
- Potter Brumfield optically isolated relays, (812) 386-1000
- Teal power line isolation filters, (800) 888-8325

SCHAFFNER EMC, Inc.
12 Hughes St.
Suite D-106
Irvine, CA 91718-1901

Phone: 714-457-9400
Fax: 714-457-9510

SCHAFFNER EMC, Inc.
9B Fadem Road
Springfield, NJ 07081

Phone: 201-379-7778
Fax: 201-379-1151

Kam Electronics (Stocking Distributor)
400 Boren Ave. North
Seattle, WA 98109

Phone: 206-382-1300
Fax: 206-382-0186