USING ANCILLARY SIGNAL DEVICES TO IMPROVE SAFETY AT RAIL/HIGHWAY GRADE CROSSING SIGNALS

Summary

This application note addresses how to improve safety regarding two potentially unsafe situations that may occur with railroad grade crossing warning devices (typically flashers and gates, hereinafter referred to as "signals").

The potentially unsafe situations are:

- Intentionally disabled grade crossing signals; and
- Loss of AC power to grade crossing signals.

Intentionally Disabled Grade Crossing Signals

Disabling malfunctioning signals at a rail/highway grade crossing occasionally becomes necessary until the malfunction can be resolved and the signals returned to normal service.

Standard procedure should be upon learning of a signal malfunction, to immediately issue an order to all train crews to stop and provide appropriate flagging protection to highway traffic before the train enters the crossing. The signals may then be disabled so that highway traffic can proceed unimpeded until the signal maintainer can resolve the problem with the malfunctioning signals.

Using "Jumper Wires" to Disable Signals

Jumper wires are often used to "jumper-out" or disable signals by temporarily connecting wires to certain terminals available within the signal system equipment enclosure. This should be done only by a trained signal maintainer as it is electrically complex, and it must be done correctly to avoid equipment damage or unsafe signal operation.

It is worth noting that FRA recently issued an advisory regarding the safe use of jumper wires, as there have been serious accidents caused by jumper wires inadvertently left in place after the stop and flagging order was removed.

Using a Disable Switch to Disable Signals

Another method of disabling the signals is via a "designed-in" disable switch. Because the signal maintainer may not be immediately available to safely resolve the signal malfunction, the disable switch enables personnel who do not know how to electrically "jumper-out" the crossing signals to easily disable the crossing and allow highway traffic to continue uninterrupted.

Some railroads and FRA frown on disable switches and their use because of the possibility that untrained personnel may disable the signals without issuing the necessary and accompanying flagging order.

Loss of AC Power to Signals at Rail/Highway Grade Crossings

The Power ON Indicator (POI)

Commercial 120VAC power is used by railroad signal battery chargers to charge backup batteries that supply power to operate the signals when AC power is unavailable. The batteries, if not recharged while operating the signal sytem, may become discharged within several hours (this time can vary greatly with different equipment and frequency of train traffic). Therefore, it is very important that AC power be restored before the batteries are depleted so that a signal activation failure will not occur when a train approaches and occupies the grade crossing.

Many signal installations have a Power ON Indicator (POI) mounted on the signal equipment enclosure such that a white indicator light is visible to the train crew as the train approaches the crossing. Train crews are instructed to observe if the POI is illuminated. If not, this indicates that 120VAC commercial power is off and they are to report this to the appropriate railroad personnel so that a maintainer can be dispatched to resolve the problem.

Because the train crew is often preoccupied with observing grade crossing highway traffic and determining if the signals and gates are working properly, a POI that is off may go unnoticed. If AC power is absent long enough, the backup batteries will eventually deplete and a signal activation failure will occur when a train approaches. This obviously could result in a collision between the train and a highway vehicle.

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Improving Safety with Ancillary Signal Devices

Because POI's are already in place at many grade crossing signal installations, the POI could be used to indicate when the crossing signal is disabled or when the AC power is off.

Making the POI More Noticeable When AC Power is Off

If we flash the POI at 45 flashes per minute (FPM) when AC power is absent and inform the train crew of what this means, we should greatly improve the chances the train crew or other railroad personnel will notice a POI that is is indicating that 120VAC power is off.

Getting Technical - Understanding How to Make This Happen

Summary of Typical Types of Signal Installations

There are primarily two approaches to the way signals are designed to operate:

1. AC Line Biased Design (see Table 1); and
2. DC Battery Biased Design (see Table 2).

Although tables 1 and 2 define the two predominant approaches to signal design, "hybrid" versions are occasionally used.

TABLE 1 - TYPE 1 SIGNAL POWER DISTRIBUTION - AC LINE BIASED

	EQUIPMENT REQUIRING POWER	POWER SOURCE			
		NORMAL	VOLTAGE[4]	BACKUP	VOLTAGE[4]
TRAIN DETECTION	GCP, MS, Audio Type Train Detection System[1]	DC BATTERY	13.6VDC	DC BATTERY	13.6VDC
	ACDC Track Driver/Ring-10[1,2]	AC COMMERCIAL POWER	120VAC	DC BATTERY	13.6VDC
	ACDC Track Driver/Ring-10[1,3]	DC BATTERY	13.6VDC	DC BATTERY	13.6VDC
WARNING	Flasher & Gate Signal Lamps	LIGHTING TRANSFORMER	12VAC	DC BATTERY	13.6VDC
	Gate Mechanisms	DC BATTERY	13.6VDC	DC BATTERY	13.6VDC
	Bell	DC BATTERY	13.6VDC	DC BATTERY	13.6VDC
SUPPORT	Power ON Indicator (POI)	LIGHTING TRANSFORMER	8VAC	OFF	0
	Battery Charger(s)	AC COMMERCIAL POWER	120VAC	OFF	0
	Crossing Logic (Relays or Solid-State)	DC BATTERY	13.6VDC	DC BATTERY	13.6VDC
	Lighting Transformer	AC COMMERCIAL POWER	120VAC	OFF	0

1. Only one type of train detection system can be used for a given track circuit
2. Uses 115VAC power when available, and uses DC Battery if 115VAC is unavailable.
3. Uses DC battery power only.
4. Typical.

TABLE 2 - TYPE 2 SIGNAL POWER DISTRIBUTION - DC BATTERY BIASED

	EQUIPMENT REQUIRING POWER	POWER SOURCE			
		NORMAL	VOLTAGE[4]	BACKUP	VOLTAGE[4]
TRAIN DETECTION	GCP, MS, Audio Type Train Detection System[1]	DC BATTERY	13.6VDC	DC BATTERY	13.6VDC
	ACDC Track Driver/Ring-10[1,2]	AC COMMERCIAL POWER	120VAC	DC BATTERY	13.6VDC
	ACDC Track Driver/Ring-10[1,3]	DC BATTERY	13.6VDC	DC BATTERY	13.6VDC
WARNING	Flasher & Gate Signal Lamps	DC BATTERY	13.6VDC	DC BATTERY	13.6VDC
	Gate Mechanisms	DC BATTERY	13.6VDC	DC BATTERY	13.6VDC
	Bell	DC BATTERY	13.6VDC	DC BATTERY	13.6VDC
SUPPORT	Power ON Indicator (POI)	DC BATTERY	8VDC	OFF	0
	Battery Charger(s)	AC COMMERCIAL POWER	120VAC	OFF	0
	Crossing Logic (Relays or Solid-State)	DC BATTERY	13.6VDC	DC BATTERY	13.6VDC
	Lighting Transformer	NOT PRESENT	-	NOT PRESENT	-

1. Only one type of train detection system can be used for a given track circuit
2. Uses 115VAC power when available, and uses DC Battery if 115VAC is unavailable.
3. Uses DC battery power only.
4. Typical.

Preference for one type of design over the other is sometimes based partly on the personal preference of the designer or specification writer and on the space available for backup batteries. AC Line biased designs usually require batteries that are not as bulky or expensive as DC Battery biased designs, but they do require a lighting transformer and a power off relay (POR) that the DC Battery type system does not.

Retrofitting Existing Installations

Because the design of existing signal installations have evolved over the years they are somewhat varied. This requires us to explore the various ways we may need to design the circuits to illuminate the POI in the manner we wish. We will cover the basics of the design – you likely will need to modify your design to accommodate your particular installation.

What Message do You Want to Convey?

We first must decide what message to convey to train crews and other railroad personnel.

There are basically three choices:

- Improved Power ON (or OFF) indications - Indicate when Commercial AC Power is unavailable;
- Improved Protection of the Crossing when signals are (intentionally) disabled; and
- Improved Power ON (or OFF) indications *and* protection of the crossing when the signals are (intentional-ly) disabled.

Using the Flashing Power ON Indicator to Indicate Loss of Commercial AC Power

The "improved" Power ON Indicator operates normally, that is, it is ON when 120VAC power is available, but flashes when 120VAC power is not available, rather than simply being OFF.

Figure 1.a shows an arrangement that will flash the POI when 120VAC power is unavailable. When AC power is available, the POI is ON continuously and is dimmed by using a lower voltage tap of about 8VAC from the lighting transformer. To adjust the level of dimming, simply choose a different tap on the lighting transformer. Either an incandescent or a LED lamp may be used; the t-FX flasher will drive either type of lamp load.

Installing a two-terminal flasher pack to flash the POI is fairly straightforward. It usually requires the addition of an off-the-shelf 3PDT (three-pole double-throw) relay to switch power for a low-voltage AC source to DC battery.

If your POR relay has three sets of unused contacts, you can omit the 3PDT relay shown in Figure 1.a diagram and substitute the K1A, K1B and the K1C contacts shown in the diagram for the equivalent POR contacts. If you don't have enough POR contacts, you must use the 3PDT relay to switch the POI between AC and DC.

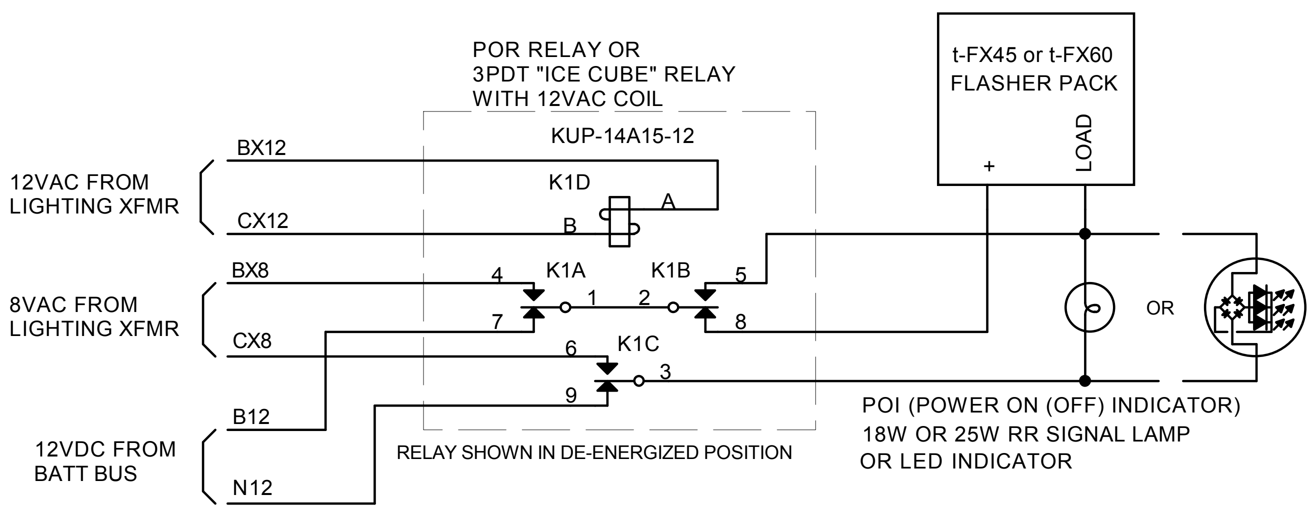

Figure 1.a Flashing POI - AC Line Biased Design Using AC Lighting Transformer

Referring to Fig. 1.a, we can see that the relay coil is connected to the 12VAC tap of the lighting transformer and as long as the lighting transformer is powered by 120VAC, its 12VAC tap output will keep the relay "picked" and the POI will illuminate continuously. Conversely, when 120VAC is absent, the relay will drop and the battery bus will furnish 12VDC to the t-FX flasher pack which will flash the POI.

Table 3 - Typical Current Draw for Various Crossing Signal Equipment

Equipment Description	Type of Equip.	Amps Req'd	Comment
PMD-1 or 2	Motion Detector	1.10	
GCP3000D2 (2-tracks)	Predictor	3.00	Includes recorder module
CXP-3	ACDC Track Circuit	3.50	Typical (half-load)
TD-4	ACDC Track Circuit	2.60	3 tracks in use 4 Ohm load each track
t-Boss7400-SP	ACDC Track Circuit	2.50	3 tracks in use 4 Ohm load each track
MS-585/590	Motion Detector	1.10	
HXP-3R (2-tracks)	Predictor	3.40	Includes recorder module
Relay - 500 Ohm	Control	0.03	Relay Coil Energized
POI - Incandescent	Warning Indicator	1.40	8V Continuous ON
POI - Incandescent	Warning Indicator	2.08	12V Continuous ON
POI - LED	Warning Indicator	0.51	12V Continuous ON
Gate Hold Clear	Gate Mech	0.04	

Figure 1.b shows how to connect the POI to flash when AC commercial power is absent when you don't have a POR (a power off relay is not used with DC Battery Biased Designs). Here we connect the 120VAC to the coil of a relay that connects 12VDC from the battery bus to the POI continuously if the relay is picked. When 120VAC is removed from the relay coil then the relay drops and 12VDC battery is applied to the t-Fx flasher pack and the POI flashes.

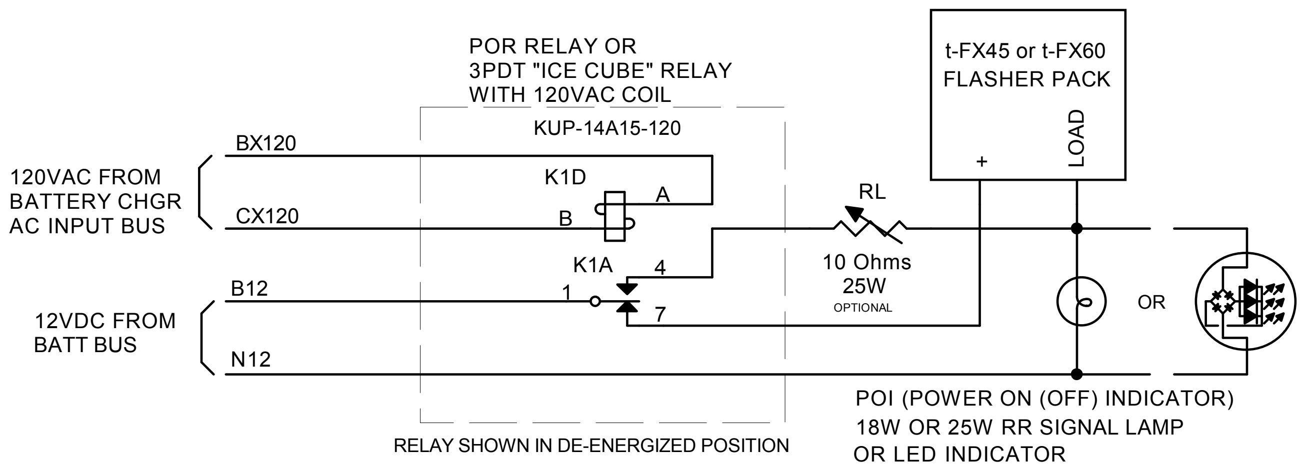

Figure 1.b Flashing POI - DC Battery Biased Design Using DC Battery Bus

If you are using an incandescent POI lamp you may want to insert a 10 Ohm resister as shown in Fig. 1.b to dim the lamp and extend its life. If you use an adjustable resistor you can adjust it to dim as much or as little as you like.

You may have noticed that the circuit in Fig. 1.b could also be used in place of the circuit in Fig. 1.a. The main difference is if you want to dim the POI when 120VAC power is available you must install the 10 Ohm current limiting resistor, RL, as shown in Fig. 1.b.

If you use a LED POI indicator and you want to dim it, a larger value resistor will be necessary. Usually an adjustable 50 Ohm resistor rated at 5 Watts will do nicely.

Added Battery Current Draw when the POI is Flashed

You may be concerned about the additional current draw from the batteries when the POI is flashed (and the batteries are not receiving a charge) and you would be justified having that concern. This is a judgement you must make regarding the overall safety of the crossing: Is it more important to conserve the batteries and rely on railroad personnel noticing the POI is OFF or is it more important to improve the chances the POI will be noticed by flashing it?

To help you answer this question, we have compiled some information about the current draw of various components within a typical crossing signal system. This is shown in Table 3, below.

The standby battery power draw for a non-activated crossing that uses a MS-585 or PMD-2 might typically be in the range of 2 Amps. If the flashing POI uses a 25W incandescent lamp its average power draw will be about 1 Amp. This will reduce the battery backup time by 50% which may be too much of a sacrifice.

However, if the POI uses a LED lamp its average power draw will be about 0.25 Amps. This reduces the battery backup time by only 13% which most likely is an acceptable trade-off.

If the batteries have high amp/hour ratings then it may not matter – the crossing may run for several days even with some train traffic *and* the POI flashing. Let's hope however, that before then someone has noticed and tended to the problem of no AC power!

Using a Strobed Indicator to Indicate when the Crossing is Intentionally Disabled

A flashing indicator is more noticeable than one that is merely ON or OFF, but a *strobed* indicator is even more effective at getting one's attention.

Flashing incandescent lamp performance is acceptable when its on duration is at least several times that of the combined filament warm-up and cool-down period. But when the length of the ON time is too short, its full brilliance is never reached. And if the OFF time is too short, it never becomes completely dark. Therefore, "strobing" isn't very effective with incandescent lamps.

LEDs reach full brilliance in microseconds, become dark nearly as quickly, and are very "attention getting" when briefly powered on and off several times successively. This is often referred to as "strobing" and is frequently used on law enforcement and emergency vehicles.

Because strobed LEDs are so effective at acquiring one's attention, it is quite logical to apply this technique to a railroad signal indicator to make sure it is noticed when remedial action is required to preserve the safety of the traveling public.

Some railroad/highway grade crossing signals are equipped with a disable switch that can be used to disable the signals when they are out-of-service. The Signal-Out-of-Service Indicator, or as we shall refer to it, the SOSI, is intended to alert and remind train crews that the signals are not functioning and that they will need to follow their railroad's rules for a stop and flag order before entering the crossing.

Figure 2.a shows how to implement a SOSI in conjunction with a disable switch using the t-Fx45s strobed flasher.

The disable switch is typically a 3PDT type. When in its NORM position it provides a connection between the train detection equipment (GCP, HXP, MS, etc.) and the XR relay. In the DISABLE position, it connects B12 and N12 to the XR relay which picks the relay and disables the crossing signals. The TEST position (optional) interrupts power

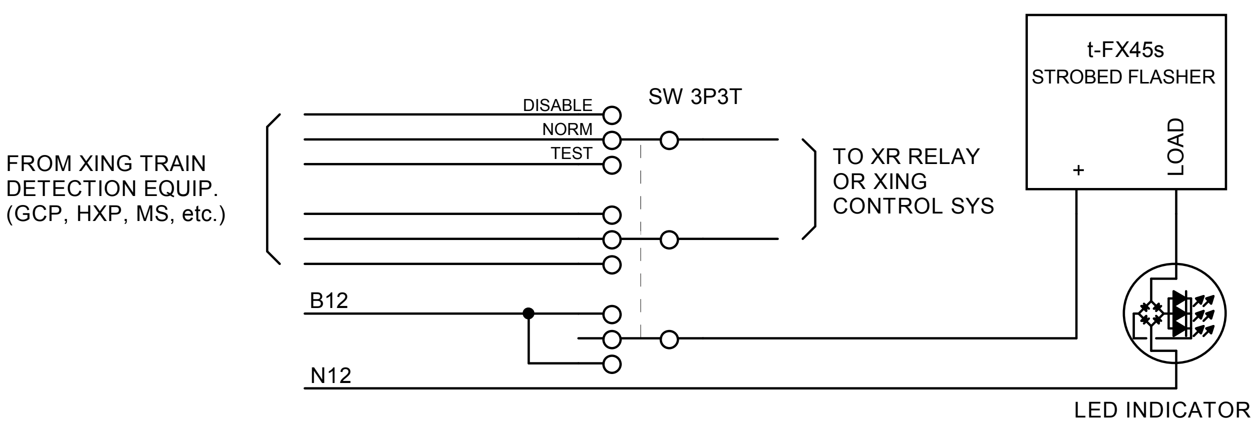

Figure 2.a Strobed Signal-Out-Of-Service Indicator (SOSI)

to the XR completely and provides an easy way to turn the signals ON continuously for test purposes. Both the DISABLE and TEST positions as wired in Fig. 2.a cause the SOSI to strobe/flash.

This circuit uses the t-Fx45s strobed flasher to strobe-flash a LED indicator. The t-Fx45s is a special version of the t-Fx45 flasher that turns on for about 30 milliseconds followed by an off period of about 60 milliseconds. This on-off sequence is repeated four times every 1.33 seconds or 45 times per minute.

For installations that don't have a disable switch, the SOSI may be installed using a single-pole single-throw switch to turn on the SOSI when the crossing is "jumpered."

We have intentionally omitted the connection details of the crossing disable switch because of the many varied ways it may be connected and the various versions of switches that could be used for this purpose. We strongly recommend that the design modifications required to add a disable switch be undertaken only by a qualified signal engineer.

Combining the POI and SOSI Functions to Use a Single Indicator

To combine the POI and SOSI functions to use a single LED indicator is but a simple step from either of the two previous described applications. The schematic to do this is shown below in Figure 2.b. Although the circuit is slightly more complex, its functionality has doubled.

Only a LED type indicator should be used when it is strobed for the reasons we explained in the previous section: "Using a Strobed Indicator to Indicate when the Crossing is Intentionally Disabled." Here we've included both a standard t-Fx45 flasher and a t-Fx45s strobed flasher to provide the ability to convey three different messages to railroad personnel about the status of the railroad/highway grade crossing signal system:

1. The signals are operating normally (POI/SOSI is ON continuously);
2. AC commercial power is OFF and a the system needs attention (POI/SOSI is FLASHING); and
3. The signals are intentionally disabled and the train crew must stop and flag the crossing before entering the crossing (POI/SOSI is STROBED).

Referring to the wiring schematic, notice that to give priority to the SOSI indication over the POI indication, the disable switch denies power to the standard t-Fx45 flasher when it is in the DISABLE and TEST positions. Thus the POI/SOSI strobes when the signals are disabled or tested and flashes when 120VAC commercial power is unavailable only when the disable switch is in the NORM position.

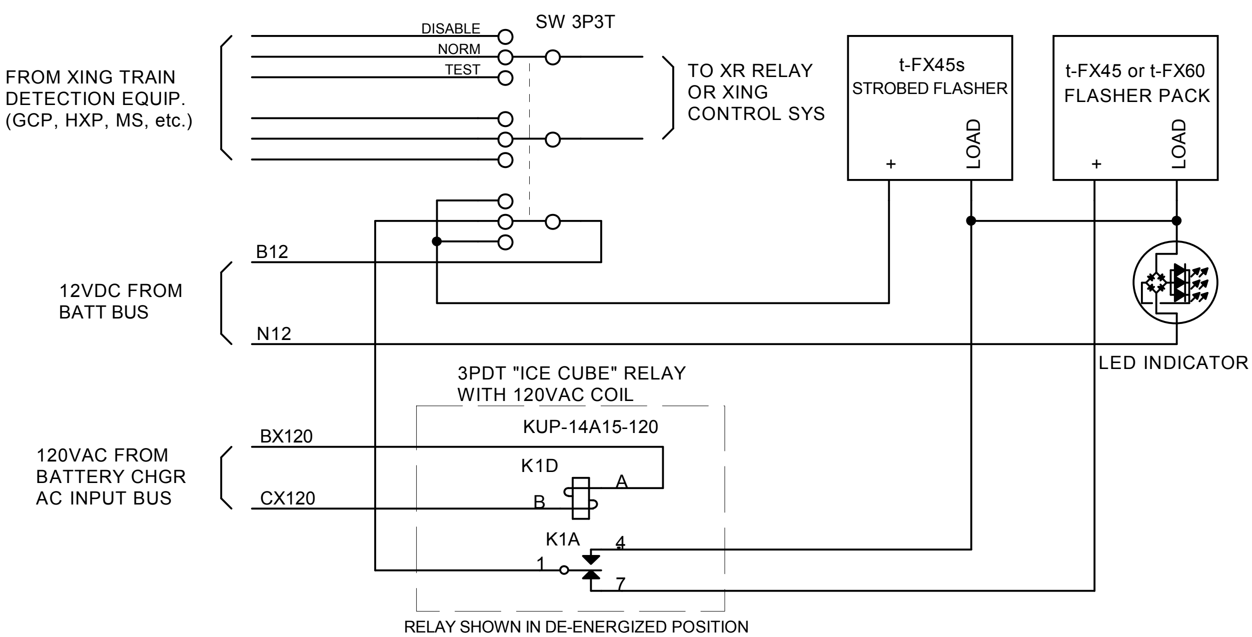

Figure 2.b Combined POI and SOSI Indicators

Giving priority to the SOSI function is usually preferred over the POI function simply because of the immediate safety needs of protecting a non-functional crossing when a train needs to occupy the crossing.

Wrapping Up

We've attempted to provide sufficient information to enable you, as a signal engineer or experienced signal maintainer, to be able to improve the safety of the rail/highway grade crossings where you choose to do so without "breaking the bank."

The drawings supplied in this application note are intended to serve only as guidelines and should be supplemented with good wiring practices that include terminal blocks where appropriate, neatly arranged wire runs, and of course, wire markings according to your railroad's signal wiring standards or wire markings that are consistent with those used in the particular signal installation you're modifying.

Without exception, you should make or modify drawings before you start to actually remove and connect wires. Never start any such project without a good and well documented plan – to do differently will almost certainly not turn out well.

And again, without exception, you should fully test every aspect of your installation to make certain everything is working correctly and safely.

Suggested Parts and Possible Sources

Table 4 lists of some of the essential components you will need to complete the modifications or installations described in this application note. Additional sources other than those listed exist for most of the components.

Table 4 - Essential Components Used in Wiring Schematics

Fig. 1.a	Fig. 1.b	Fig. 2.a	Fig. 2.b	Description	Mfg. P/N	Mfg.	Source	Alternate Source
x				Relay, 3PDT, 12VAC Coil, 5A	KUP-14A15-12	TE Connectivity	Mouser Electronics	Digi-Key Electronics
	x		x	Relay, 3PDT, 120VAC Coil, 5A	KUP-14A15-120	TE Connectivity	Mouser Electronics	Digi-Key Electronics
		x	x	Switch, 3P3T, 30.5 mm Heavy-Duty Watertight/Oiltight	102T50 Series	Eaton-Cutler Hammer	Newark Electronics	Allied Electronics
x	x		x	Flasher Pack, 2-Terminal, 45 or 60 FPM	T-FX45 or T-FX60	Genesis Technologies	Genesis Technologies	Invensys/Seimens
		x	x	Strobe/Flasher Pack, 2-Terminal 45 FPM	T-FX45S	Genesis Technologies	Genesis Technologies	
x	x	x	x	POI Indicator (order white LED lamp separatly - L&W)	2A1067-3X	L&W Industries	L&W Industries	
x	x	x	x	POI Indicator Guard Housing (recommended)	2A1760	L&W Industries	L&W Industries	

DIY Kits Available from Genesis

Genesis will soon have several kits of all the necessary components to implement the addition of a flashing POI or a strobed-flasher POI. Please call or email us for details and pricing.

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