



Basics of Power Line Interference to Railroad Signal Systems

An Online Continuing Education Course for Engineers

Course Number: T-5013

Credit: 5 Hours / 5 PDH / 5 CPD

Basics of Power Line Interference to Railroad Signal Systems

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1. Recommended Prerequisite

It is highly recommended that anyone taking this course that is not familiar with railroad signal systems complete the prerequisite course, "Railroad Signal Systems Fundamentals" (Course Number: T-5011). Much of the material will be difficult to understand due to unfamiliar terminology and technology. In addition, it is essential that power system engineers have a basic understanding of the operation of railroad wayside and crossing systems if they are going to effectively find solutions for ElectroMagnetic Interference (EMI) problems or be able to design new lines that will not negatively impact nearby railroads.

2. Learning Objectives

This course teaches the following specific knowledge and skills:

- Susceptibility of sensitive train detection devices used for highway crossing protection to induced interference.
- Reasons for the Corridor Concept and how to make it work.
- What to keep in mind when proposing a power line encroachment to a railroad.
- Basic understanding of inductive interference from power lines to nearby railroads.
- Effect of variables such as length of parallel, phase current unbalance, distance, and current magnitude on induced rail voltages.
- Effect of track circuit unbalance due to shorted Insulated Joints (IJ's) or trains spanning IJ's.
- Effect of harmonic frequency interference.
- Effect of power line ground faults.
- Basics of power line design for minimizing EMI to nearby railroad facilities.
- Some techniques to mitigate EMI problems in existing power line encroachments.

3. Purpose of the Course

This course is designed to provide the basics of the effects of power line inductive interference that might compromise the safety or reliability of warning devices at public crossings or train signal systems.

Engineers at utilities that construct power lines or substations near railroad facilities should have a basic knowledge of railroad signal systems, their importance to the transportation industry, and their vulnerability to power line interference. This course is written with the power engineer in mind. However, anyone working in the railroad industry, from track maintenance to operating department executives should also have at least a basic knowledge of how such a vital component of their system can be impacted by invisible but powerful electromagnetic fields from power distribution systems.



Even though Railroads are an essential backbone to our economy, few outside the signal industry understand the intricate signal systems that protect and facilitate movement of trains and warn the public of approaching trains at highway crossings. Few university or trade school courses cover railroad signal design or even basics. The railroads, themselves, have some schools that provide training in maintenance and basic equipment and system testing for their own workers, but even they do not provide a good overview of railroad signal systems. Those who have even a basic understanding of both railroad signals and EMI are very rare.

Knowledgeable people in the signal industry who are experienced in EMI issues are rapidly disappearing. Most of the consultants in this field are at or above retirement age. They are trying to pass on their knowledge to a new generation, but it seems both the railroads and the utilities are being very short-sighted. There are a few consultants still working to create compatibility between railroads and power companies, but even if they are available, to assure meeting their best interests, both railroads and utilities need at least a few engineers with some overlapping knowledge in both disciplines who can oversee contractors and spot areas that might cause conflict that could delay or even cancel a major project.

Objectives of this course are:

- To provide a basic understanding of how Railroad signal systems work and the railroad signal environment so the power engineer can better communicate with railroad signal engineers.
- To point out some personnel safety problems that the railroad will be concerned about and what might be done to reassure signal engineers.
- To provide pointers on how to avoid costly pitfalls when working on right-of-way contracts with railroads.
- To provide basic information on the inductive coupling mechanism between power lines and the rails to help educate signal engineers about EMI and also as an aid to power engineers that have not had to deal with inductive interference to railroad signal systems. Even a power engineer that is knowledgeable about induction to communication lines might not understand the very different issues that will confront him when dealing with railroads.

- To discuss the vulnerabilities of signal systems to EMI and some possible revisions to make the system more robust.
- To talk about ground fault issues which are a threat to both railroad personnel and equipment. Due to lack of knowledge in this area, signal engineers tend to fear very short and rare but extremely severe ground faults as much as the problems caused by steady-state induction.
- To recommend possible power line design considerations to decrease induction to rail facilities.
- To offer some possible mitigation methods that might allow the safe and reliable sharing of a corridor.

4. Railroad Signal Basics

The signal systems used by railroads can be divided into two groups:

4.1 Wayside Signals

Wayside signals are for control and protection of trains. They are not generally used by anyone other than train operating personnel and dispatchers who control train operations.

Characteristics of Wayside Signals are that they:

- Are located alongside or over the track and aimed toward trains so train engineers can see them.
- Provide train engineers warning of track conditions.
- Protect against movement of other trains.
- Provide control information from dispatchers about speed and routing.



Sections of track between wayside signals are insulated from each other by insulated joints (IJ's). These sections of track, which can be over two miles long, are called **track circuits**. Wayside signals are controlled by energy flowing through the track circuit, generally less than 2 volts rail-to-rail. Often the energy is pulsed or coded to convey information through the rail from one signal to the next without using pole lines or cable. Trains are detected when they move into the track circuit and stop the communication between signals due to their axles shorting between the rails (shunting).

The track circuits used for wayside signals are quite robust and designed to resist 60 Hz interference. However, high levels of voltage can still cause the systems to fail or even be damaged. All railroad signal systems are designed according to "failsafe principles" that make an unsafe failure extremely unlikely. But, signals confused by interference will always go to

their most restrictive state, thereby causing expensive train delays. Both safety and reliability are essential to efficient train operation.

4.2 Crossing Signals

Crossing signals are for protection of the public that might be crossing railroad tracks on highways or pedestrian walkways. They are not generally used by those on or operating trains. However, train engineers and crews do observe the sidelights and gate operation of crossing signals for proper operation. Any anomalies such as burned out lights or slow gate operation are reported to the dispatcher who, in turn, reports problems to the signal maintenance department.



Characteristics of crossing signals are that they:

- Are located at highway crossings and aimed toward highway vehicles.
- Provide warning of approaching trains to vehicle drivers and pedestrians at locations where the tracks and highways meet at grade.
- Must be compatible with existing wayside signal systems that share the same tracks.

Like the wayside signals, crossing signals use voltage on the rails to detect trains. There are many types of equipment used to activate crossing warning devices (lights, gates, and bells), but their basic operation fits into four types:

4.2.1 Basic DC Track Circuit or "Style C" AC/DC Track Circuit.

These are the simplest detection circuits used for crossings. As shown below, current flows from a power source at one end of a track circuit to a detection device, commonly a relay at the other end. A resistor is placed in series with the power source to limit current when the track circuit is shunted. When an approaching train shunts the rails, the loss of current is detected and the warning devices are activated. The track circuits extend far enough that approaching trains are detected a minimum of 20 seconds before reaching the edge of the street or highway. Generally, these systems are as robust against interference as wayside signal track circuits.

