DI04006071: Railway, Harbour & Tunnel Engineering

Lecture 3.23: Principle and Methods of Interlocking and Devices used for interlocking (Part 3)

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Introduction to Modern Interlocking I

As train speeds and traffic density increased, mechanical interlocking became inadequate due to physical limitations and slower operation. Modern interlocking systems, specifically Route Relay Interlocking (RRI) and Solid State/Electronic Interlocking (EI), utilize electrical circuits and microprocessors to ensure safety, reduce human effort, and increase the efficiency of train operations.

Key Points

- Elimination of heavy mechanical lever frames.
- Centralized control of larger station yards.
- Faster route setting and signal clearance.
- Integration with automated train control systems.

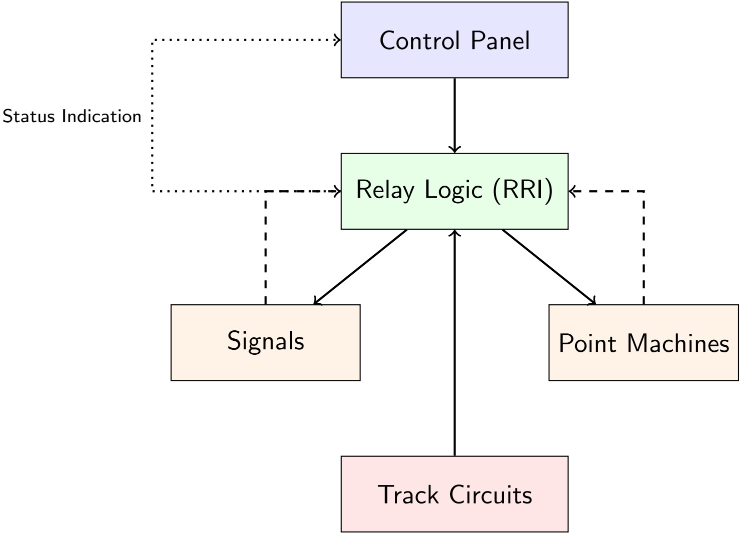
Route Relay Interlocking (RRI) I

Route Relay Interlocking (RRI) uses electromechanical relays to perform the interlocking logic. In RRI, the station master can set an entire route (points and signals) simply by pressing two buttons on a control panel: an entrance button and an exit button. The relay circuitry automatically verifies safety conditions, throws the necessary points, locks the route, and clears the signal.

Key Points

- Entrance-Exit (NX) principle of route setting.
- Uses fail-safe Q-series or plug-in type relays.
- Significant reduction in operation time compared to individual point operation.
- Route locking and sectional route release features.

Block Diagram of Relay Interlocking System I



Block Diagram of Relay Interlocking System II

Key Points

- Control panel sends commands to relay logic.
- Logic checks track circuits for occupancy.
- Outputs drive point machines and clear signals.
- Field devices provide continuous status feedback.

Electronic Interlocking (EI) / Solid State Interlocking (SSI) I

Electronic Interlocking (EI) replaces the bulky relays of RRI with microprocessor-based software logic. The interlocking rules are programmed into a central computer, which communicates with field modules that control the actual points and signals. EI provides self-diagnostics, data logging, and requires significantly less physical space while offering high reliability through redundant architectures (e.g., 2-out-of-2 or 2-out-of-3 configurations).

Key Points

- Software-based interlocking logic.
- Hardware redundancy ensures high availability and safety.
- Easier yard alterations by modifying software instead of rewiring relays.
- Comprehensive event logging for fault analysis.

Comparison of Interlocking Systems I

Feature	Mechanical	Relay (RRI)	Electro
Logic Element	Mechanical locking bed	Electro-mechanical Relays	Micropr ware
Space Required	Very large (cabin)	Moderate (relay room)	Minimal racks)
Route Alteration	Difficult (physical cutting)	Complex (rewiring)	Easy (s date)
Fault Finding	Visual inspection	Tracing circuits	Automa tics
Maintenance	High (lubrication, wear)	Medium (relay over-hauling)	Low (placeme

Comparison of Interlocking Systems II

Key Points

- EI offers the highest flexibility and lowest space requirements.
- RRI is highly reliable but requires substantial wiring.
- Mechanical interlocking is obsolete for new high-density yards.

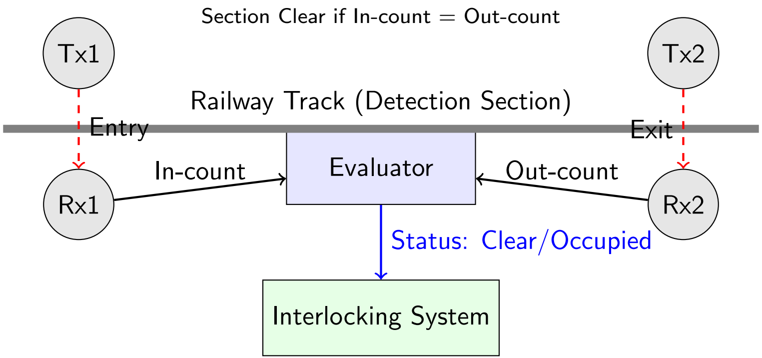
Electrical Point Machines I

An electrical point machine is a critical device in modern interlocking that physically moves the railway switch (points) from normal to reverse position, or vice-versa. It integrates an electric motor for operation, a locking mechanism to secure the point tongue rails against the stock rails, and internal detection contacts to continuously prove the position and locked state of the points to the interlocking system.

Key Points

- Combines throwing, locking, and detection in one housing.
- Operated typically by 110V DC or 3-phase AC motors.
- Equipped with crank handles for manual operation during power failure.
- Friction clutch protects motor from stalling if an obstruction exists.

Working Principle of Axle Counters I



Working Principle of Axle Counters II

Key Points

- Magnetic sensors mounted on track detect passing wheel flanges.
- Evaluator compares axles entering and leaving the block section.
- Immune to poor ballast resistance unlike track circuits.

Track Circuits and Block Instruments I

Track circuits are fundamental devices that detect the presence of a train on a specific section of track. In interlocking, a route cannot be set, and a signal cannot be cleared if the corresponding track circuit indicates occupancy. For station-to-station interlocking, block instruments are used. These devices electrically interlock the departure signal of one station with the block acceptance from the adjacent station.

Key Points

- Track circuits provide continuous, fail-safe train detection.
- DC and Audio Frequency (AFTC) track circuits are commonly used.
- Block instruments prevent two trains from entering the same block section.
- Both systems feed vital data directly into the RRI or EI logic.

Data Loggers and Fault Diagnostics I

Modern interlocking systems are equipped with Data Loggers (the 'black box' of railways). Data loggers continuously monitor the status of every relay, track circuit, point machine, and signal. They record the sequence of events with timestamping, which is crucial for incident analysis, preventive maintenance, and monitoring the reaction times of various interlocking devices.

Key Points

- Records all changes in digital inputs and outputs.
- Helps in post-incident investigation (e.g., Signal Passed at Danger - SPAD).
- Enables predictive maintenance by tracking relay operating times.
- Networked data loggers allow remote monitoring from centralized control centers.

Fail-Safe Principles in Devices I

The fundamental philosophy of all railway interlocking devices is the 'Fail-Safe' principle. This means that in the event of any component failure (e.g., wire break, power loss, component degradation), the system must naturally revert to a safe state. For example, if a signal lamp burns out or a relay coil loses power, the signal will default to its most restrictive aspect (red/danger), stopping the train.

Key Points

- Gravity-drop relays ensure contacts open on power loss.
- Closed-circuit principle: presence of current indicates safety.
- Hardware redundancy ensures no single point of failure can cause an unsafe output.
- Rigorous SIL-4 (Safety Integrity Level) certification for electronic devices.

Summary I

In this final part on interlocking, we transitioned from traditional mechanical systems to modern Relay and Electronic Interlocking. Devices like electrical point machines, axle counters, and track circuits serve as the sensory and muscular organs of the interlocking system. Governed by strict fail-safe principles, these advanced methods provide the reliability and speed necessary for contemporary high-density and high-speed railway networks.

Key Points

- RRI and EI offer faster, centralized route setting.
- EI provides higher flexibility, self-diagnostics, and lower footprint.
- Point machines, track circuits, and axle counters are key field devices.
- All modern interlocking relies on fail-safe and closed-circuit principles.