DI04006071: Railway, Harbour & Tunnel Engineering

Lecture 3.21: Principle and Methods of Interlocking and Devices used for interlocking

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Introduction to Interlocking I

Interlocking is an arrangement of signal apparatus that prevents conflicting movements through an arrangement of tracks such as junctions or crossings. The signaling appliances and tracks are sometimes collectively referred to as an interlocking plant. Its primary purpose is to ensure that a train cannot be signaled to proceed unless the route is proven safe.

Key Points

- Ensures safety by preventing conflicting routes.
- Synchronizes signals, points, and level crossing gates.
- Fundamental to modern railway engineering and operations.

Basic Principles of Interlocking I

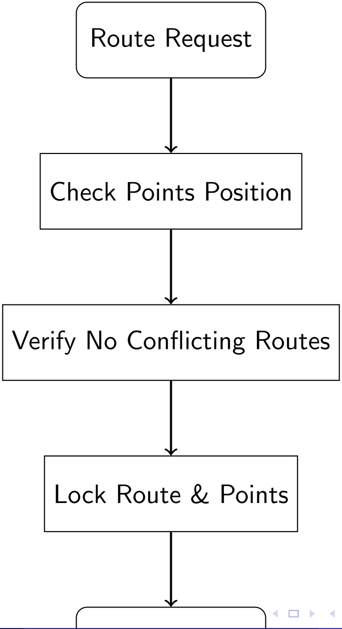
The fundamental principle of interlocking dictates that signals can only show a 'proceed' aspect when the route is fully set, points are locked in the correct position, and no conflicting routes are established. If any component of the route is disturbed, the signal must automatically revert to a 'danger' aspect.

Key Points

- Points must be correctly set and locked before signal clearance.
- Conflicting signals must be locked at 'danger'.
- Any failure in the system should result in a safe state (fail-safe).

Essential Interlocking Logic Flow I

Essential Interlocking Logic Flow II



Methods of Interlocking: Mechanical I

Mechanical interlocking relies on a system of levers, tappets, and locking bars to prevent conflicting movements. When a lever is moved to set a route, it mechanically blocks other levers that would set a conflicting route. This was the earliest form of interlocking and is highly robust but requires significant physical effort and space.

Key Points

- Utilizes physical locking mechanisms like catch handles and tappets.
- Key locking boxes and lever frames are central components.
- Limited by physical distance and requires extensive maintenance.

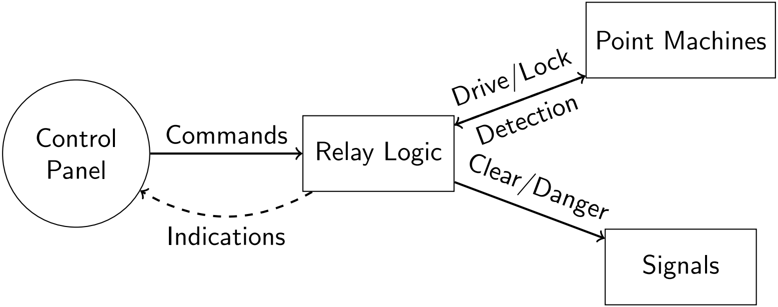
Methods of Interlocking: Relay Based I

Electrical interlocking uses relays and electrical circuits to achieve the interlocking logic. Electro-mechanical systems combine mechanical lever frames with electrical locks and circuit breakers. These systems allowed for operation over greater distances and reduced the physical labor required by signalmen.

Key Points

- Relay Interlocking (PI - Panel Interlocking and RRI - Route Relay Interlocking).
- Uses electromagnetic relays for safety logic.
- Faster route setting and operation compared to purely mechanical systems.

Component Relationship in Relay Interlocking I



Component Relationship in Relay Interlocking II

Key Points

- Separation of control (panel) and execution (field gear) via logic (relays).
- Continuous feedback loop for point detection and signal status.
- Fail-safe design ensures relays drop out (safe state) on power loss.

Methods of Interlocking: Solid State (Electronic) I

Solid State Interlocking (SSI) or Electronic Interlocking (EI) replaces physical relays with microprocessors and software to perform the interlocking logic. This modern approach offers high reliability, smaller footprint, and easier modifications. It uses redundancy (like 2-out-of-3 voting architecture) to ensure safety.

Key Points

- Microprocessor-based software logic.
- High availability through redundant hardware architectures.
- Easier to modify logic via software updates rather than rewiring.

Devices Used: Lever Frames and Tappets I

In mechanical systems, lever frames are the primary interface. Each lever operates a specific signal or point. Tappet locking is a common mechanical logic mechanism where movement of a lever slides a tappet (a steel bar) with notches. Dogs or wedges fall into these notches to lock conflicting levers mechanically.

Key Points

- Catch handle locking provides initial safety check.
- Tappets and locking dogs physically prevent dangerous combinations.
- Often housed in elevated signal cabins for visibility.

Comparison of Interlocking Methods I

Feature	Mechanical	Relay (PI/RRI)	Electronic (SSI/EI)
Logic Medium	Tappets & Bars	Electromagnetic Relays	Microprocessors & Software
Space Required	Very Large	Moderate	Very Small
Maintenance	High (Wear)	Medium (Calibration)	Low (Self-diagnostic)
Route Setting	Slow (Manual)	Fast	Very Fast
Flexibility	Rigid	Requires rewiring	High, software update

Key Points

- Progression from physical to software logic.
- Trade-offs between simplicity and scalability.
- Cost implications over the system lifecycle.

Devices Used: Point Machines and Track Circuits I

Point machines are electrically or electro-pneumatically operated devices that move railway points and lock them in position. Track circuits are electrical circuits utilizing the rails to detect the presence of a train in a specific block. Both are critical inputs to the interlocking system to verify route availability.

Key Points

- Point machines provide vital detection feedback to the interlocking.
- Track circuits ensure routes are not altered while occupied.
- Fail-safe operation: track circuit failure indicates block occupied.

Summary I

Interlocking is the cornerstone of railway safety, evolving from cumbersome mechanical lever frames to sophisticated, redundant electronic microprocessor systems. Regardless of the technology, the fundamental principle remains ensuring routes are set, locked, and clear of conflicts before a train is signaled to proceed.

Key Points

- Fundamental goal: Prevent conflicting train movements.
- Evolution: Mechanical $\{}rightarrow$ Relay $\{}rightarrow$ Electronic Interlocking.
- Key devices include lever frames, relays, point machines, and track circuits.