



**NTSB** National Transportation Safety Board

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*Office of Railroad, Pipeline and  
Hazardous Materials Safety*

# Loss of Train Detection

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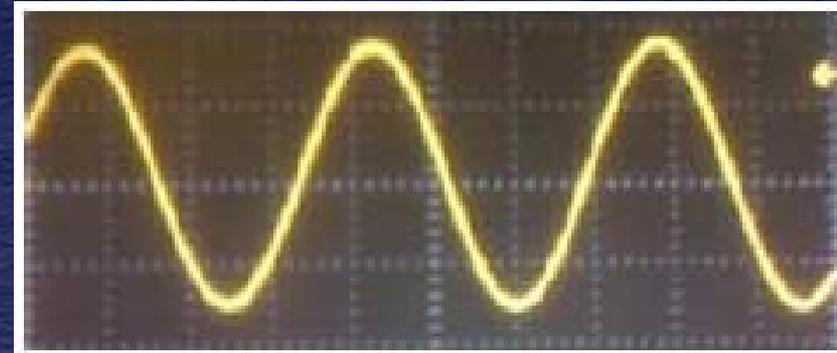
Signal & Train Control Investigation

# Events Preceding Accident

- Collision occurred on track circuit 304
- Receiver impedance bond replaced on December 12, 2007
- Transmitter impedance bond replaced on June 17, 2009
  - Transmitter power increased
  - Circuit began to lose train detection
- GRS track circuit modules scheduled to be replaced



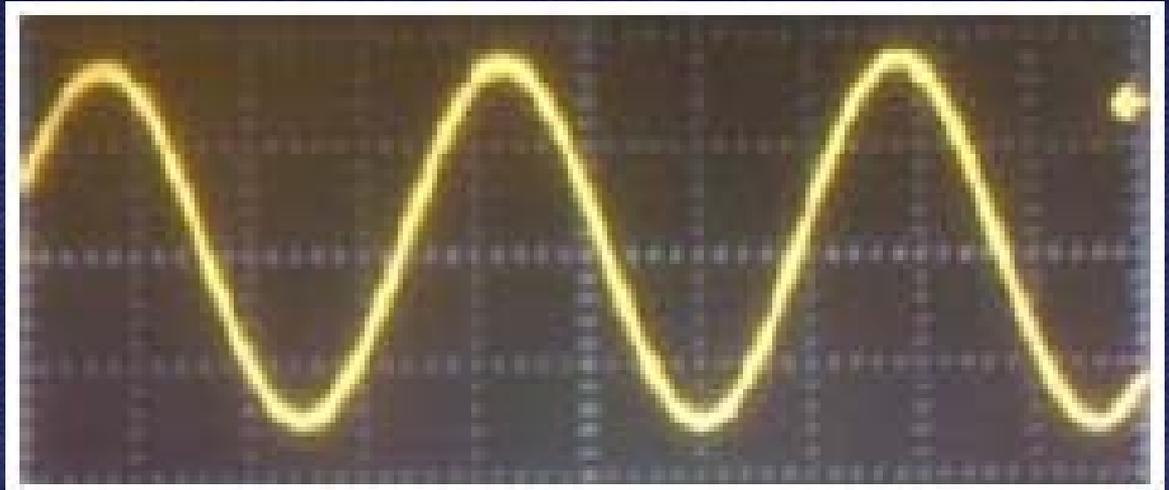
# GRS Track Circuit Modules



Valid track circuit signal

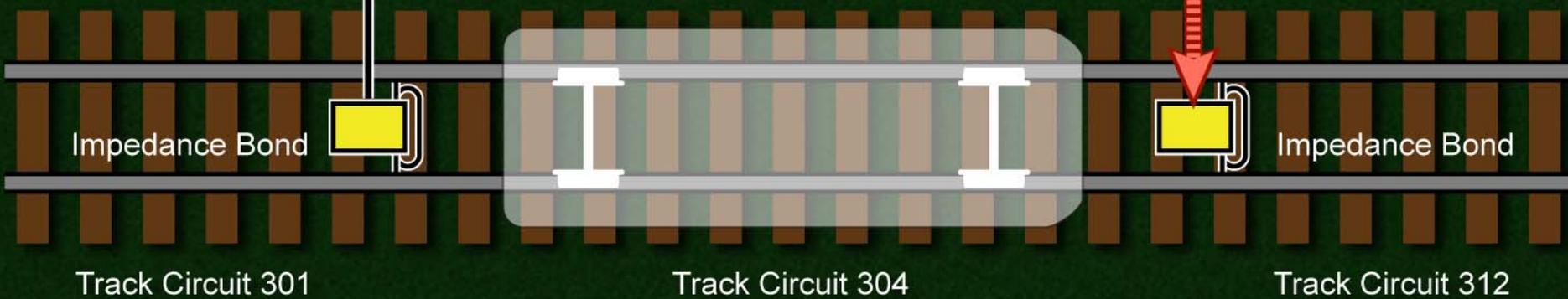
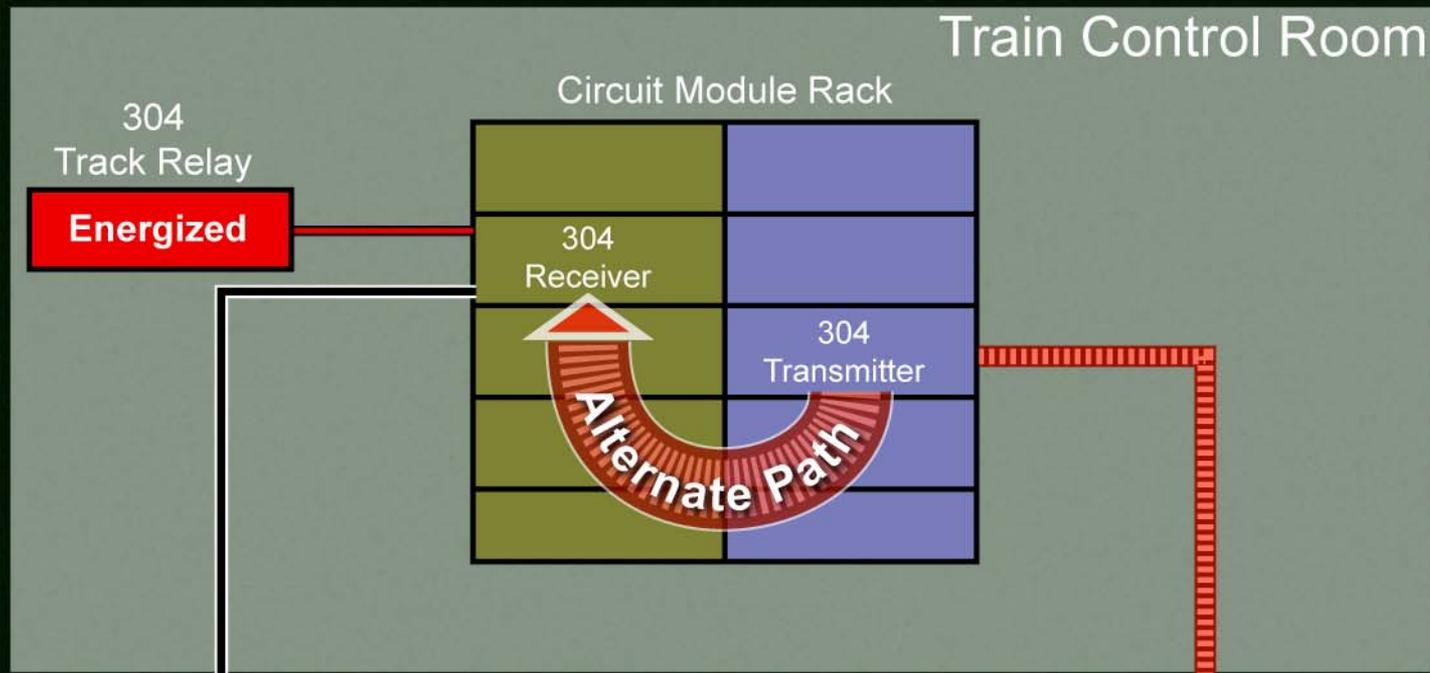
# Track Circuit Signal

Valid track circuit signal



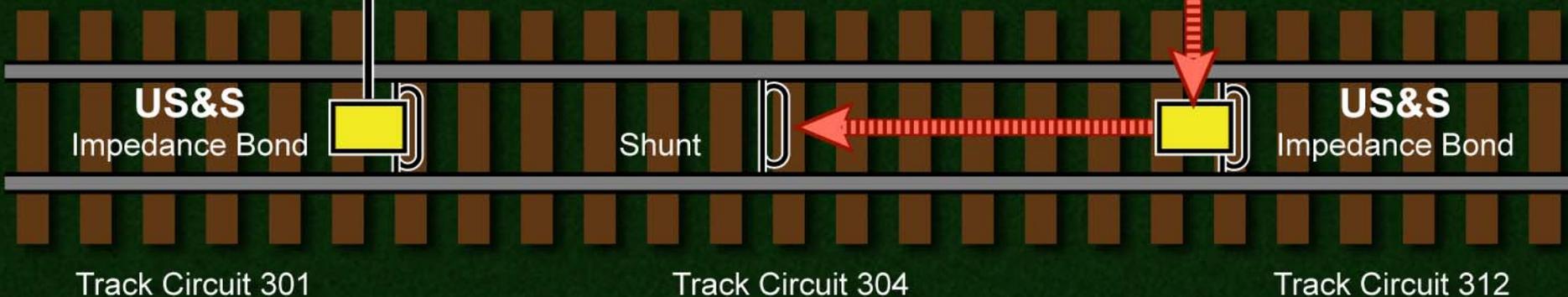
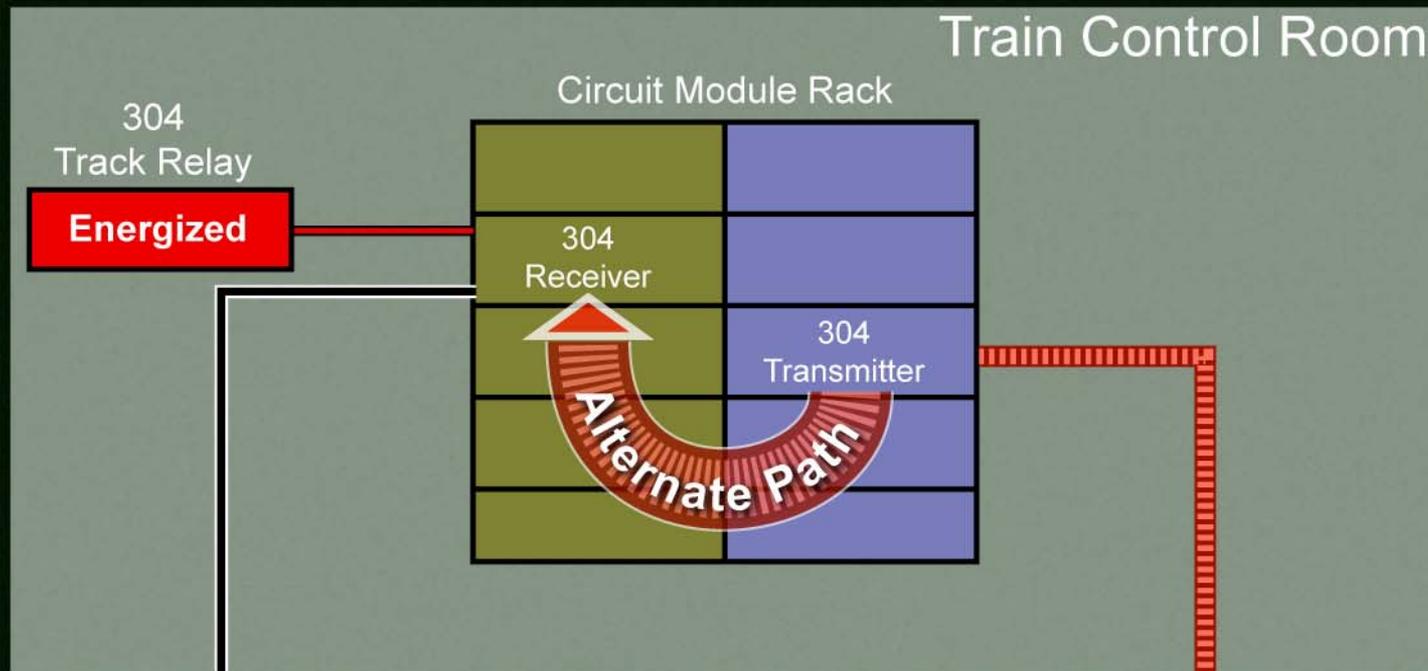
Track circuit signal with parasitic oscillation

# Loss of Train Detection



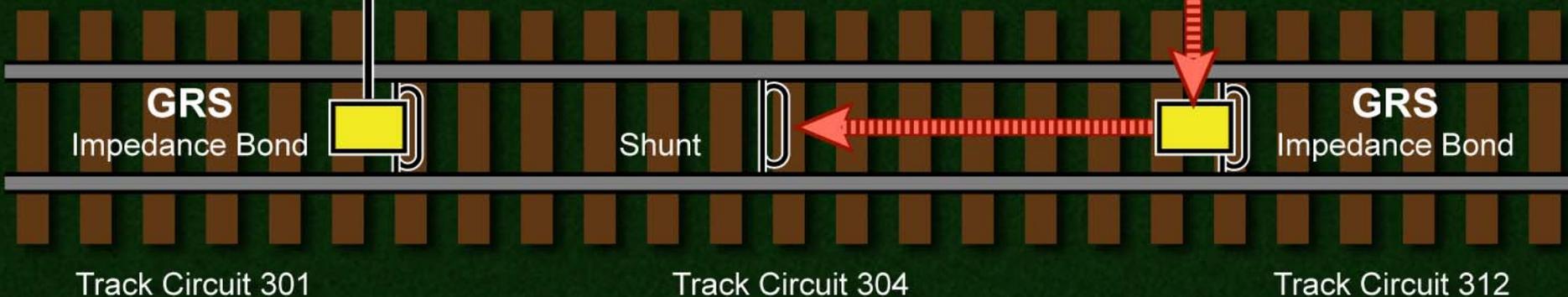
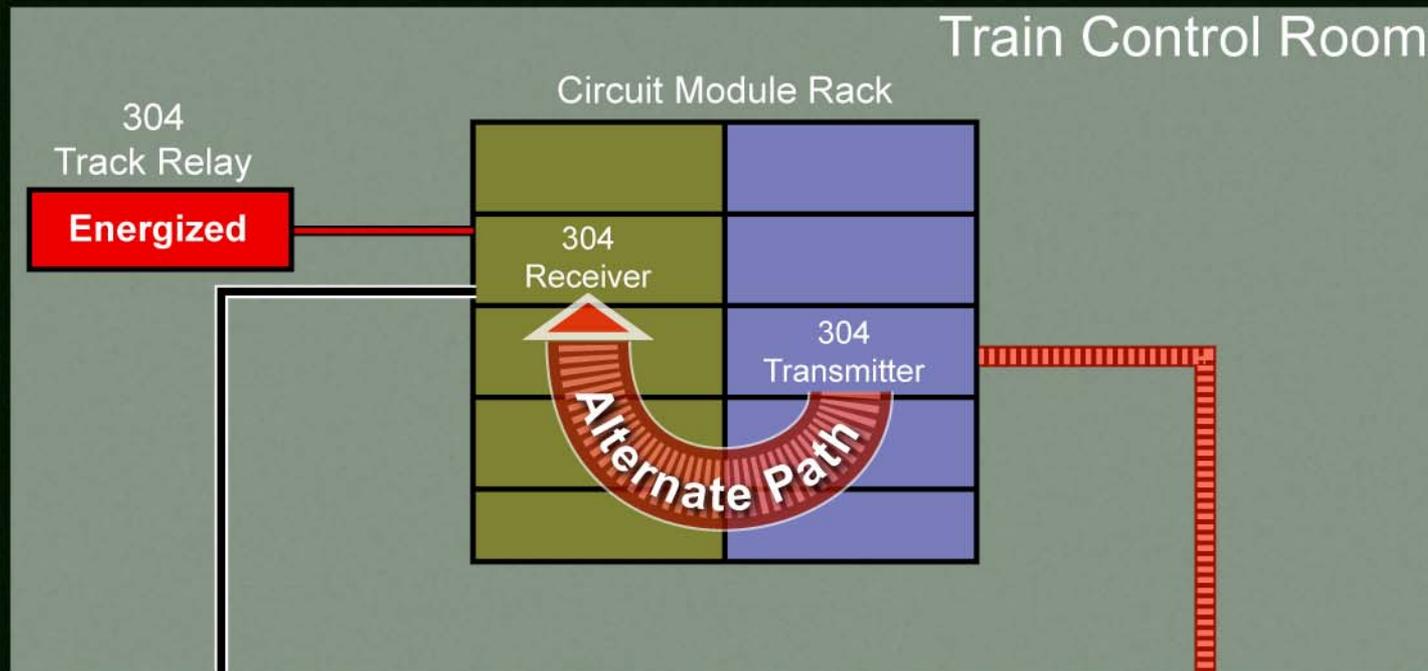
# Module Malfunction

- GRS modules exhibit parasitic oscillation with US&S impedance bonds



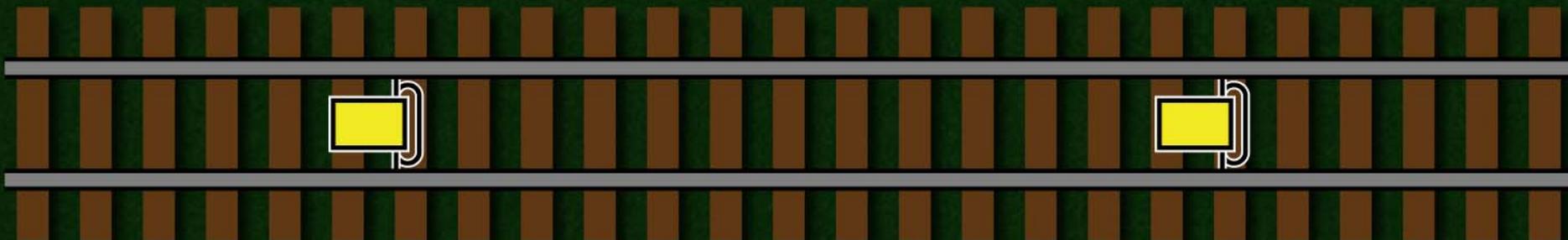
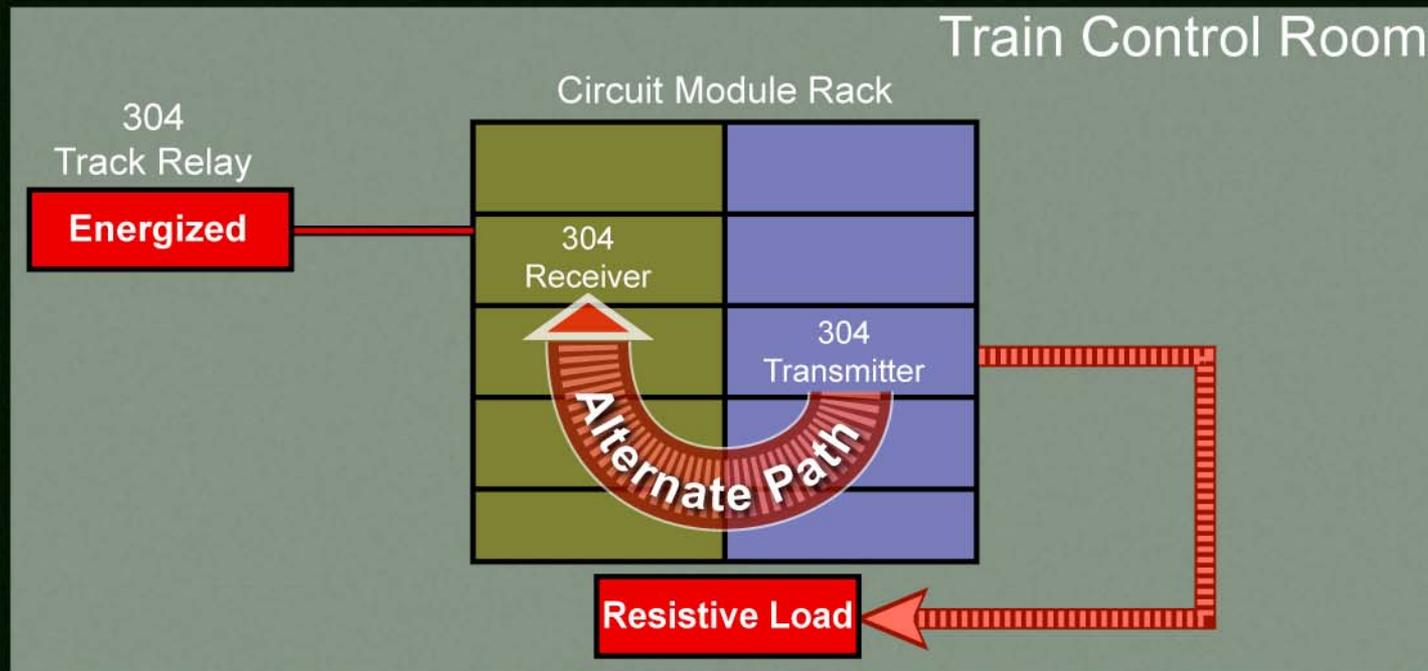
# Module Malfunction

- GRS modules exhibit parasitic oscillation with GRS impedance bonds



# Module Malfunction

- GRS modules exhibit parasitic oscillation with resistive load



Track Circuit 301

Track Circuit 304

Track Circuit 312

# GRS Module Malfunction

- Parasitic oscillation exhibited with
  - US&S impedance bonds
  - GRS impedance bonds
  - Simulated resistive load
- Parasitic oscillation generated in GRS track circuit modules regardless of brand of impedance bond

# Postaccident Developments

- WMATA developed T-163 test procedure to find parasitic oscillation
- All circuits with parasitic oscillation consist entirely of GRS components
  - 208 track circuits found with parasitic oscillation in the transmitter module
  - 82 track circuits with parasitic oscillation in the transmitter and receiver module
- Circuits with parasitic oscillation remain in service today



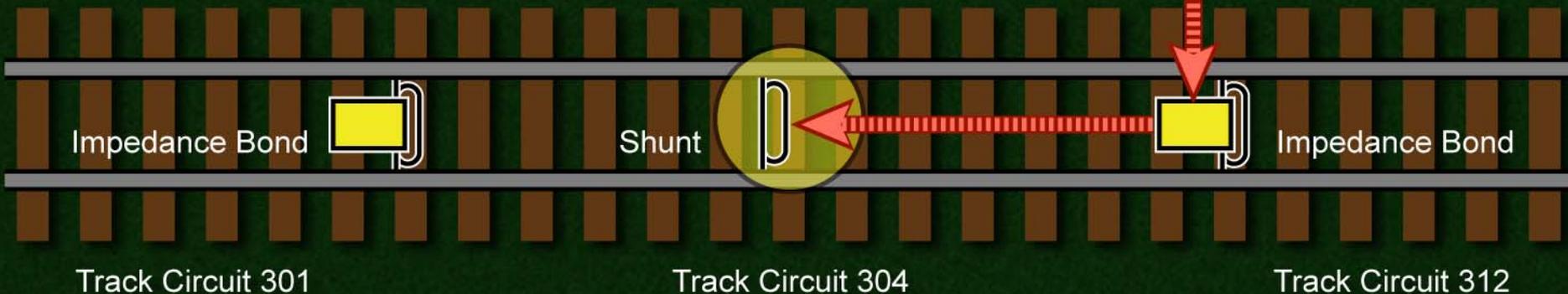
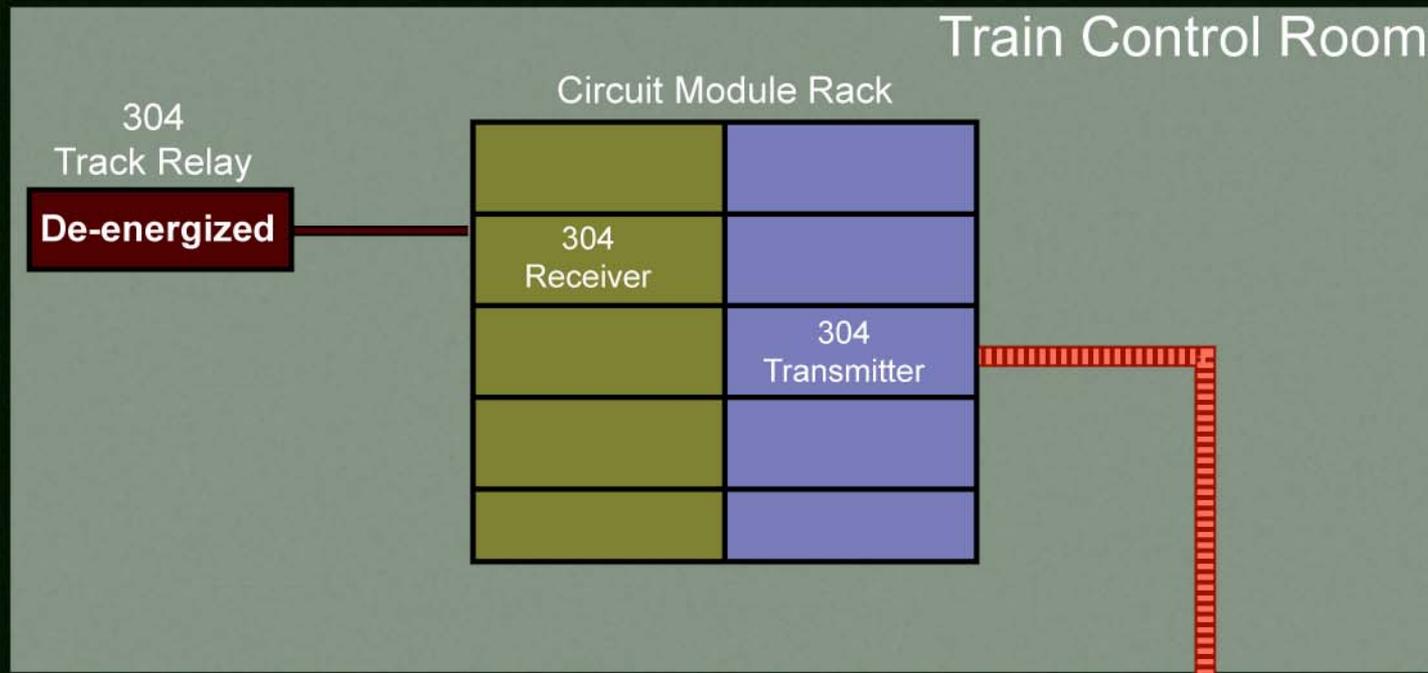
# GRS Track Circuit Maintenance

- Based on manufacturer's guidance
  - Ensures transmitter and receiver modules operate at reasonable power and sensitivity levels
  - Did not specify testing capable of identifying spurious signals

# 2005 Rosslyn Incident

- Rosslyn experienced loss of train detection similar to Fort Totten
- Investigated by WMATA with Alstom assistance
- Two procedures developed as a result of Rosslyn investigation
  - Loss-of-shunt software tool
  - Enhanced track circuit verification procedure to include middle shunt test

# Shunt Test of Track Circuit



# Track Circuit Verification

- During the investigation, accident track circuit consistently failed to detect a shunt placed in the middle
- If proper procedures had been used after impedance bond replacement it would have failed and track circuit not placed in service

# Safety Critical Systems

- Signal and train control systems use fail-safe design principles
- Single-point failures should not result in an unsafe condition
- Safe state includes:
  - Stopping trains
  - Restrictive signal
  - Speed limit imposed

# Fail Safe Design

- WMATA train control system is designed as a fail-safe system
- Failure modes must be identified and addressed in design and maintenance
- Investigation found that loss of train detection can be caused by
  - Parasitic oscillation
  - Rail or cable fault conditions
- GRS modules lacked a comprehensive maintenance plan



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