



Wellington Station Interlocking on the Orange Line © Alstom Transport

Track Circuits

NEW SIGNALING FOR BOSTON'S ORANGE METRO LINE

SEAMLESS INTEGRATION TO STATE-OF-THE-ART SYSTEMS

The Massachusetts Bay Transportation Authority (MBTA) decided to resignal the northern portion of the 30-year old Orange metro line to make it more reliable and to minimize service delays. In January 2003, Alstom was awarded a subcontract to supply new signaling and control systems for this project.

The scope entailed all final and interim designs, all materials, training, field testing and commissioning required for the complete replacement of the existing relay-based signaling system. Alstom provided 8 new control locations (7 bungalows and 1 Yard Tower room) complete with Vital Process Interlocking (VPI), AF Track Circuits and Non-vital Programmable Logic Control (PLC) with a fully functional state-of-the-art signal system. The new equipment was installed over seven miles of two and three track territory at five Interlockings and one Yard Tower.

This signal replacement project included the installation of new track circuits, switch machines, train stop devices, signal rooms and cabling throughout the project.

The installation of this new system has significantly improved system reliability and throughput while at the same time allowing for increased operational flexibility.

Alstom met the testing phase challenge whereby more than 50% had to be conducted with minimal interruptions to the operating system.

In This Section:

- Genrakode™ II and III
- Genrakode™ Code T
- Genrakode™ Test Unit
- Dual Code Audio Frequency Track Circuit
- WEE-Z® Impedance Bonds
- Receiver Coils
- Microseismic Railway Monitoring System (MRMS)

> Genrakode™ Track Circuit and Communication System

The latest generation of **Genrakode™** adds new features to the reliability, maintainability and value for which the product has become known. First developed in 1989, the Genrakode Track Circuit and Communications System is a family of microprocessor-based modules used for vital signal clearing and train detection, non-vital block indication, and non-vital initiation of signal tumble-down. Genrakode is a DC-coded, bidirectional system fully compatible with Electrocode™ IV.

The Genrakode main board, with Intelligent Diagnostics, a built-in Data Logger and point & click configuration, makes the Genrakode system a truly exceptional value.

This microprocessor-based system for train detection and cab signaling is ideal for all rail applications.

The flexible, cost-effective system allows for eliminating pole lines and relays and adding signaling to dark territory.



Genrakode™ II



Genrakode™ III

Ordering Information

For assistance in ordering Genrakode products, please go to the Alstom website for online configuration of Genrakode module ordering number or contact the Alstom Customer Service Center at 800-717-4477.

> Genrakode™ Track Circuit and Communication System

Maintainability

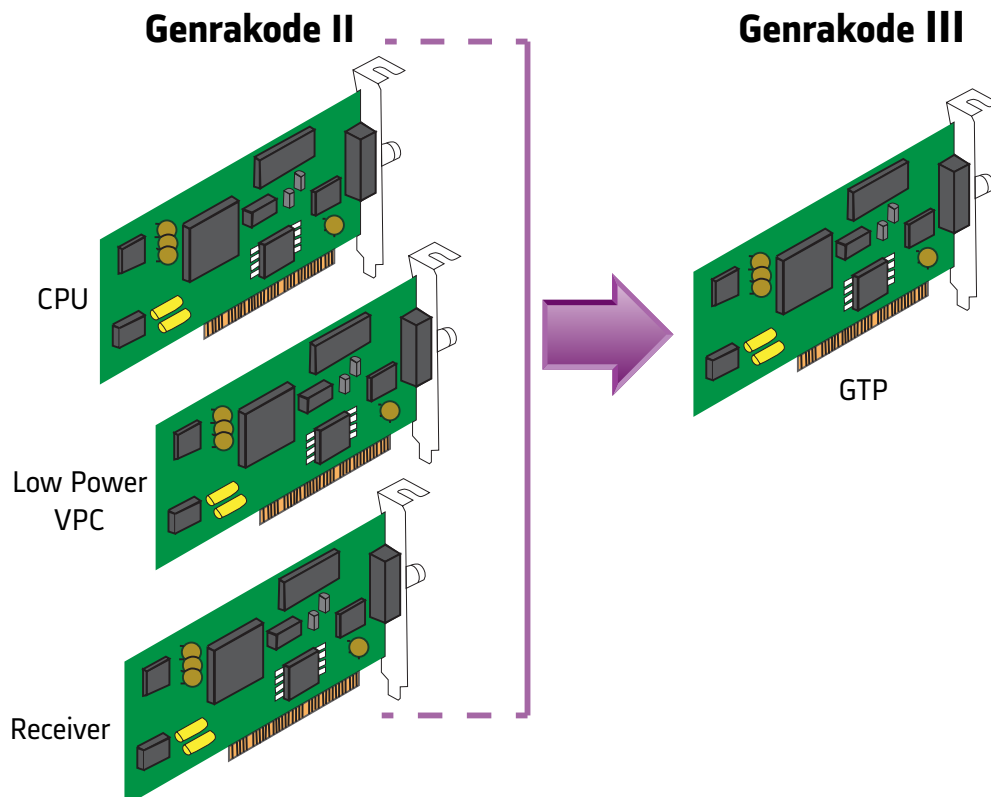
- > No periodic testing of receiver modules
- > Intelligent diagnostics
- > Code T provides advanced diagnostics
- > Simple design that is easy to maintain

Value

- > Huge cost savings by elimination of pole lines and relays
- > Flexible design that is compatible with all major track circuits and interlockings
- > Integrated data logger at no additional cost
- > User programmable



Genrakode™ II Modules being installed in a housing unit at the Rochester, NY facility



> Genrakode™ Track Circuit and Communication System

FEATURES

Cab Signaling

- > Three cab signal modules are available, each capable of driving the 5 standard cab signal rates: 75, 120, 180, 270, 420 PPM.
- > Carrier frequencies of 60 Hz, 100Hz, and 250 Hz are available

Remote Operation

- > Serial communications link at intermediate signal locations provides additional flexibility by permitting remote control of signals and codes

Enhanced CAA

- > Enhanced Computer Aided Application (CAA) package. Includes editing and printing features that accelerate the application process

Ground Fault Detection

- > Integrated within the Genrakode unit – no additional or external equipment needed
- > Has a field adjustable detection threshold
- > Is automatically cycle checked to verify proper operation
- > When combined with Code T, can remotely report the status of proper operation and ground fault status

Intelligent Diagnostics – Increases Availability

- > Intelligent diagnostics and built-in battery-backed data logger provides a time and date-stamped log of all external events as well as any internal fault.

Cable Integrity Check – Reduces Troubleshooting

- > Optional Cable integrity check provides additional security by detecting external cable failures.

Automatic Receiver Checking – Reduces Maintenance

- > Automatic receiver level checking lowers maintenance costs by eliminating the requirement for manual periodic verification.

Regulated Lamp Drive Voltage Maximizes Signal Bulb Life

- > The output voltage is regulated for both input voltage and lamp load current changes.
- > Therefore, signal lamps can be operated at a constant lamp voltage.

Isolated Logic Power Supply

- > Improves lightning and noise immunity.

Track to Line Board Simplifies Code Rerouting

- > Track-to-Line board simplifies application when applying Genrakode in dark territory with existing DC crossing circuits.

Serial Communication Eliminates Relay Interfaces

- > A serial communications link between Genrakode and VPI is available which reduces cost by eliminating relay interfaces and reducing the number of discrete wires required.

PC-Based Simulator

- > A full featured PC based Simulator is available to assist in the development and evaluation of the application programming.

Long Track Circuit length

- > Track circuits lengths of up to 29,000 feet are attainable (welded rail, 10 ohms DC ballast).



Genrakode™ II
Intermediate Module

Reliability

- > **No safety notice in over 20 years of operation**
- > **Mean Time Between Failure (MTBF) rating of 18.7 years**
- > **Over 78 million hours in field operation**
- > **Installed at over 35 customer properties around the world**
- > **Safety Assurance Logic (SAL) for fail-safe operation**

Cab Signal Module

Cab signaling is used in conjunction with the Control Point, Repeater, Switch Lock, and Intermediate Modules. The traditional 100Hz rate coded, or two-aspect ON/OFF cab signal system is implemented by overlaying the cab signaling onto the GENRAKODE track circuit. 60Hz and 250Hz carrier frequencies are also available.

Switch Lock Module

The Switch Lock Module supplies all functions necessary at a switch lock location including line circuit signal control, series track circuit lock release, siding timer release, switch lock magnet control and padlock contact direction.

Intermediate Module

The Intermediate Module supports two track circuits and signals for both directions. It is used at intermediate signal locations to transmit and decode line circuit information via the rails from adjacent modules. Since the module drives signal lamps and mechanisms directly and performs all lightout detection, no relays are required.

The Intermediate Module can directly drive up to six individual color light signal aspects or up to two searchlight mechanisms in each direction. Outputs are continuously checked for correct state and all lamps are checked to insure that filaments are intact. Optional cable integrity checking is also available.

Also featured are options which permit signals to be approach-lit or approach-lit only when AC power is lost. A dedicated input on the Auxiliary I/O Board may be used to approach-light the signal when AC power is lost, thus reducing the drain on the batteries. Auxiliary inputs are provided which allow the displayed aspect to be downgraded. These inputs are typically used for switch controllers, slide fences and other equipment.

Control Point Module

The Control Point Module supports up to two independent track circuits when interfacing with the interlocking relay logic at the location, via discreet inputs and outputs or up to 8 independent track circuits when interfacing directly to a VPI Interlocking Control System. It is used at end-of-block signal locations to initiate code transmission to other signal locations through the rails, decode signals from the rails, energize relay outputs reflecting the decoded line circuit information and optionally to generate cab signal rates.

Repeater Module

The Repeater Module is used at cut sections and is used to extend distances between signal locations. The codes transmitted from the repeater are re-generated, minimizing distortions and increasing system reliability.

> Genrakode™ III Track Circuit and Communication System



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The new and improved **Genrakode™ III** consists of 2-3 boards, plus a Track Interface Module for electrified territory – a much smaller form factor.

When Genrakode™ III units are installed as part of a Track Circuit system, they will operate autonomously, without direct user interaction. Therefore user interaction is limited to the following scenarios:

- > **Initial Configuration:** Each GTP board will be programmed with location specific application logic responsible for controlling the behavior of the vital I/O. This application is created using the GTP CAA.
- > **Maintenance and Field Configuration:** Genrakode™ III provides maintenance status indications to aid in maintenance as well as specific Event and Error Logging to assist in diagnosis of anomalies.

The Genrakode™ III system has a number of external interfaces:

- > **Two track interfaces (track clearing code transmit/receive, series overlay)**
- > **Four Cab outputs**
- > **Differential vital and non-vital I/O (Auxio board)**
- > **Configurable vital jumpers (Switchlock I/O) and non-vital switches (Auxio)**
- > **RS-232 Serial and USB Type B port for programming and terminal access**
- > **Front panel LEDs and mode switches**
- > **Configurable site and revision ID switches**

Ethernet Interface is in development and can be available to your system for more information on availability please call 1-800-717-4477

The Main Board in a Genrakode™ III is the GTP.

GTP Functions

- > **Vital Power Control:** The GTP board generates its own vital energy with which to drive its vital outputs. It also vitally arbitrates similar energies on all other boards within the Genrakode™ III chassis. In this way, vital power control (VPC) is centralized.
- > **Process Application Logic:** Behavior of the Genrakode™ III system is controlled by user-defined application logic. The Logic Controller (LGC) processes all user application logic in a vital manner. All system outputs states are commanded based on the states of the system inputs (vital and non-vital) and the user-defined application logic.
- > **Transmit and Receive Signal Clearing Codes:** The GTP board is capable of vitally transmitting and receiving Genrakode track clearing codes from two independent track circuits.
- > **Transmit Cab Signals:** The GTP board is capable of vitally transmitting two cab signals overlaid onto each of the two track circuits.
- > **Field Programmability:** Genrakode™ III applications and all vital system software are field programmable/updatable.
- > **iVPI Interoperability:** The GTP board provides a vital interface for iVPI to communicate vital I/O parameters. When the GTP board is inserted into an iVPI chassis, this communication occurs through a vital protocol using dual port RAM. In stand-alone mode, an Ethernet interface is being developed, most likely running Vital Serial over Ethernet (VSoE).
- > **User Interface:** The GTP board provides a serial interface for querying system state, viewing logs and other maintenance functions, and for programming all vital software components. It is accessible through standard RS-232 and Universal Serial Bus (USB).



Genrakode™ III
GTP Board



> Genrakode™ Code T

The Revolutionary Railroad Communication System from Alstom Expand your remote monitoring capabilities without expanding your budget with Genrakode and Genrakode Code T

Genrakode™ Code T provides an additional non-vital communications channel at no additional cost. Using the rails as the communications medium, non-vital communications can be received at the ends of the signaling block from all locations within the block. A unique location ID as well as a specific message identification allows the source of each message to be precisely pinpointed. By interlacing the non-vital messages with the existing vital train detection and vital signaling, remote monitoring eliminates the need for trenching cable or expensive radio communications systems.

Genrakode Code T potential uses include:

- > Monitoring of grade crossing health
- > Intrusion alarm reporting
- > Signal filament status
- > Status of commercial power

Benefits

Genrakode Code T applications can help simplify your maintenance activities, save you thousands of dollars and keep you in constant communication with your remote wayside locations.

Additional communication channel at no extra cost

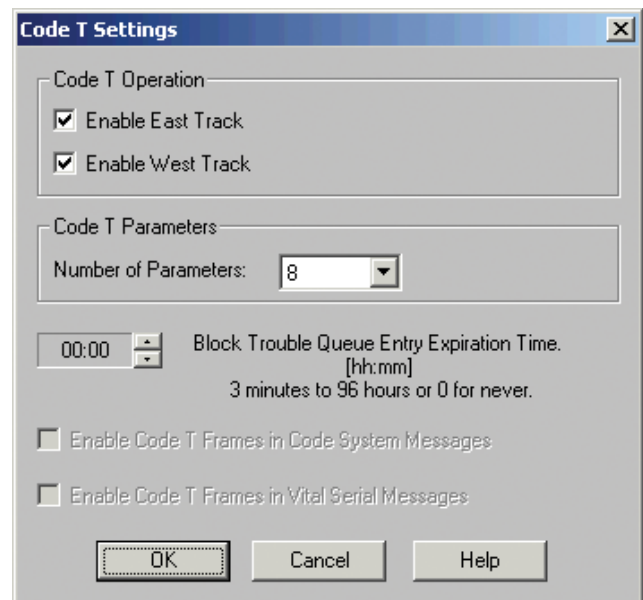
By combining traditional train detection and vital communications through the rail with a binary coding scheme, Genrakode now provides a secondary communication channel that can be used for any non-vital signaling need.

Save cost by reducing the size of your battery system

Simply use Code T to monitor the status of the commercial AC power that keeps your batteries fully charged. As soon as power is lost, you can be notified giving you ample time to avoid failure due to discharged batteries.

Remotely monitor the status of your grade crossing equipment

Use Code T to extract critical health information that can be reported back to a central location or dispatching office.



Code T GUI

Ordering Information

For assistance in ordering a Genrakode II system or Genrakode Code T, please go to the Alstom website for online configuration of Genrakode module ordering number or contact Alstom Customer Service Center at 800-717-4477.

FEATURES

- > **Rugged design – housed in a protective case and operates from -20° to +70° Celsius**
- > **Portable – lightweight and easy to transport**
- > **Easy to use – user-friendly, intuitive console**
- > **Wide power voltage range (9 to 16 VDC)**
- > **RS-232 communications port for connection to terminal or computer**
- > **Flash upgradability of software**
- > **Configuration settings are stored in non-volatile memory**



Genrakode Test Unit

The **Genrakode™ Test Unit** was engineered with three primary design goals in mind: portability, functionality, and upgradability.

The test unit is compatible with all existing Genrakode and Genrakode-compatible systems to date, including various competitors' products. The unit is capable of receiving DC track codes 1 through 9 and also features for possible future codes. AC codes 1 through 8, 28, 32, 42, 43, 48, and 72 are also supported.

The test unit features two simultaneously operating channels: East and West. While both channels are independent from each other, certain settings must remain the same between the two channels. Specifically, the AC/DC mode selection, the Code 5 type, and the DC Normal vs. Transit rate selection must be the same for both transmit and receive on both channels.

The right side of the unit is essentially a mirror of the left side: Both sides feature a two digit 14-segment display and Code 5 LED that indicate the code currently being received, if any. Additionally, both sides contain a code select rotary switch, a Code T transmit enable switch, a Code 5/6 transmit switch, and a transmit enable switch.

The test unit also features over-voltage, current, and thermal protection. For example, accidental connection of the track leads to a 12 volt DC battery source will not damage the device. Connecting the power connection or track leads backwards (i.e. negative to positive and vice versa) will also not result in damage to the unit. While the device contains numerous such protections, the maximum voltage that may be applied to any part of the device without causing damage is 16 VDC.

Ordering Information

Description	Ordering #	Price
Genrakode Test Unit	20182-119-01	\$ 3,362.00

> Dual Code Audio Frequency Track Circuit



AF Track Circuit being tested at the Rochester, NY facility

FEATURES

Immune to Electrical Noise

- > From chopper-controlled vehicles
- > From foreign current interference
- > Four frequencies/track for maximum security

No Insulated Joints Required

- > Savings in track maintenance
- > Ideal for welded rail

Easy to Maintain

- > Solid-state electronic components
- > Plug-in printed circuit boards
- > Equipment for a number of circuits can be centrally housed

High Capacity

- > For cab signaling and speed control or for automatic train operation
- > Two-way data exchange between wayside and train

The Alstom Signaling Inc. **Dual Code High-Frequency Track Circuit** reliably operates in the presence of electrical noise generated by chopper-controlled vehicles. The track circuit is ideally suited for use on continuous welded rail, where insulated joints are neither desired nor required. Combining solid-state devices with proven vital circuit relays, this track circuit eliminates the need for insulated joints, protects against interference from foreign current picked up in the rails, increases track circuit versatility, and provides a simple

and proven method of transmitting function commands to the train for cab signals and speed control or for complete automatic operation. Track circuit lengths of up to 1,800 feet can be obtained, with suitable ballast conditions. A unique feature of the dual code high-frequency track circuit is the flexibility afforded by the "building block" concept. This allows the basic track circuit to be upgraded with more features added to accommodate stages of expanding facilities.

> Dual Code Audio Frequency Track Circuit

The **Dual Code High-Frequency Track Circuit** equipment consists of WEE-Z® bonds, a solid state transmitter and receiver, and a track relay. With the exception of the WEE-Z bond, this equipment can be housed in a central equipment room or in a wayside case. The WEE-Z bond couples information between the rails and the electronic wayside equipment (via a single twisted-pair line circuit), defines block limits, and confines pertinent frequencies to the applicable track circuits. The transmitter and receiver consist of printed circuit boards which plug into a rack-mounted cabinet located near the associated track relays. The transmitter supplies, and the

receiver responds to, the high-frequency signals in the rails, which provide track occupancy detection and automatic train protection commands. Up to eight frequencies are available for track occupancy detection. One or two additional frequencies can be used to transmit cab signal and/or speed control information, depending on the amount of information required. The WEE-Z bond traction current return can be connected to a traction return feeder, to a substation, or to a bond on an adjacent track. For more detail on WEE-Z bonds, see the following page.

System Operation

Train Detection

The track is divided into blocks, with each block checked for occupancy by high-frequency track circuits. Except at interlockings, there are no insulated joints for block separation. The bonds also inject into the track speed commands that are picked up by the train. WEE-Z bonds are located at the ends of each track circuit, with one circuit usually in each block but two or more circuits in longer blocks. Except at interlockings, a particular bond serves as a track circuit boundary, the transmitter coupling for one circuit and the receiver coupling for the next downstream track circuit. An ATP transmitter at the leaving end of the track circuit feeds high-frequency energy to the track, using the WEE-Z bond as a coupling transformer. Acting as a receiver, a bond at the entering end of the circuit energizes a track relay if the signal from the transmitter is not shunted by the axles of a train. The transmitter and receiver associated with one particular track circuit are tuned to the same frequency.

Automatic Speed Commands

The high-frequency track circuit equipment is the communication channel between the wayside and train for the ATP speed limit commands. In addition, the WEE-Z bonds and rails are the transmission mediums for the train to wayside communications (TWC) system. The ATP speed command channel has a frequency separate from the train detection and TWC frequencies. When a train is detected in a circuit, a speed command generated by the wayside track transmitter at the leaving end of the circuit is transmitted through the rails to the train to control its speed.

Interlockings

At interlockings, special track circuits and insulated joints permit safe operation of opposing traffic moves. The system allows propulsion return currents to flow unimpeded through the rails, while blocking train and track signals and permitting cab signals to reach only the desired train.

Ordering Information

For assistance in ordering a Dual Code High-Frequency Track Circuit, please contact the Alstom Customer Service Center at 1-800-717-4477.

> WEE-Z® Impedance Bonds



WEE-Z Impedance Bond installed at customer location

They are also used for:

- > Cross-bonding between tracks
- > A connector for a negative return
- > Coupling the track circuit transmitter and receiver to the rails
- > Coupling cab signal energy to the rails
- > Inhibiting the transmission of other frequencies along the rail
- > Coupling bi-directional Train-to-Wayside Communication (TWC) through the rails

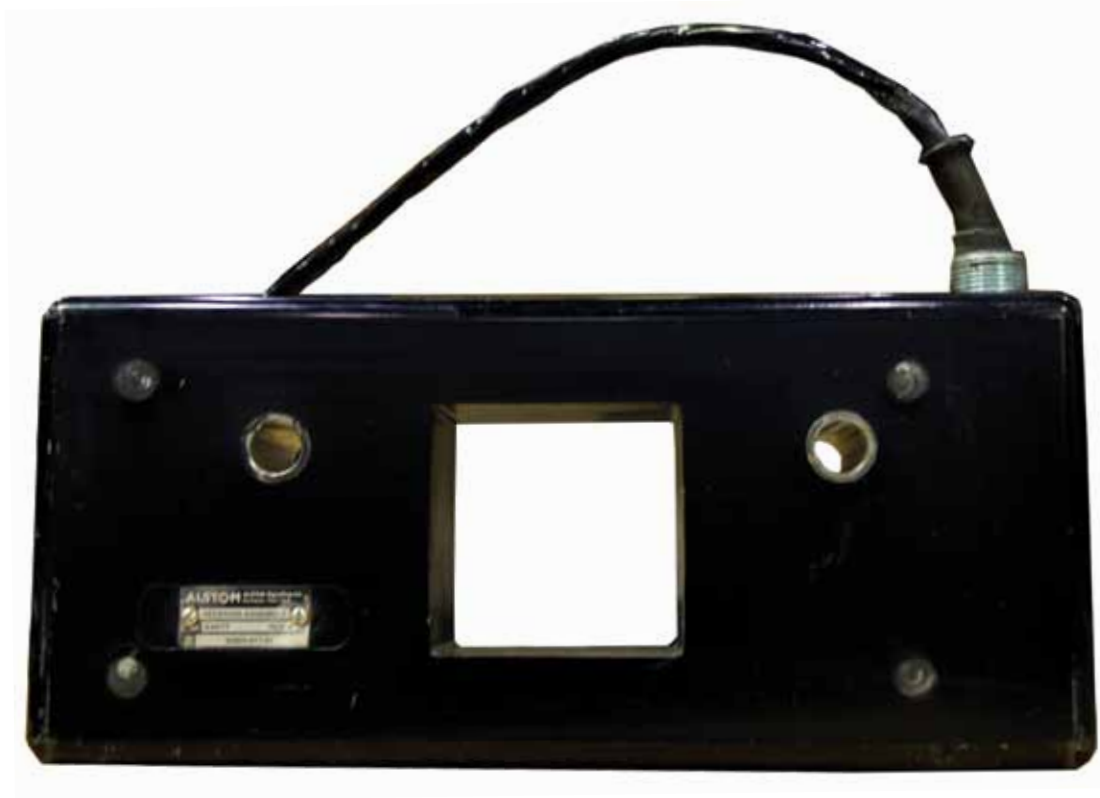
“WEE-Z Impedance Bonds are designed for rapid transit audio frequency (AF) track circuits. They are used to terminate each end of an AF Track Circuit having different frequencies. The bonds are tuned to a respective frequency using capacitors mounted on circuitry inside the bond. WEE-Z bonds provide a low resistance for equalizing the propulsion current in the rails. Alstom WEE-Z bonds are also qualified as water tight and submersible up to four atmospheres (100 foot depth). The high capacity 4,000 Amp/Rail bond is ideal for customers who operate long, high performance trains with short headways.”

WEE-Z bonds are configured for:

- > Short-range track circuits less than 1,000 feet (304.8m)
- > Long-range track circuits up to 1,800 feet (548.6m)
- > With or without Train-to-Wayside Communications
- > Receive/Receive function only

Ordering Information

Description	Amps	Ordering #	Price
WEE-Z Bond Complete	2,800 amp/rail	30859-008-XX	\$ 5,700.00
WEE-Z Bond Complete	2,800 amp/rail	30859-009-XX	\$ 5,700.00
WEE-Z Bond Complete	2,800 amp/rail	30859-010-XX	\$ 5,700.00
WEE-Z Bond Complete	4,000 amp/rail	30859-011-XX	\$ 7,995.00
WEE-Z Bond Complete	4,000 amp/rail	30859-012-XX	\$ 7,995.00



Typical Cab Signaling Receiver Coil

Receiver coils are used for 100 Hz cab signaling systems – both continuous and coded. They are mounted underneath the front of the locomotive above the rails. The encapsulated coils inductively couple 100 Hz signals from the rails to the

onboard vehicle signaling equipment. Integrated into the coil assembly is a test coil used to verify ATC operation during daily departure testing. During this testing the locomotive cannot be powered and the brake must be applied.

Ordering Information

Description	Ordering #	Price
Receiver Coil Complete - RH	52100-010-05	\$ 1,895.00
Receiver Coil Complete - LH	52100-010-06	\$ 1,895.00

> Microseismic Railway Monitoring System (MRMS)



Alstom's MRMS detects and reports against dangerous incursions and derailments

FEATURES

- > **Self-contained system**
- > **Automatic reset**
- > **Interfaces with existing signaling system**
- > **Remote monitoring and alarming**
- > **Local monitoring and data logging**
- > **Operates 24/7 in all weather conditions**
- > **Specific mode of failure detection**
- > **Communication via Ethernet**

Alstom's Micro-Seismic Railway Monitoring System (MRMS) is a new innovative solution that augments existing railway technology; is a reliable, accurate and cost-effective solution to detect rock slides, collisions with bridges and elevated structures, derailments on parallel tracks, and other conditions.

MRMS uses seismic sensors and digital signal processing to monitor ground motion and detect potential unsafe events; automatically generating an alarm output that can interface with existing signaling systems to allow the system to respond appropriately. MRMS automatically resets to reduce train delays and lower operating and maintenance costs.

Its simple configuration setup, local data monitoring and logging gives MRMS the power and flexibility to detect potential hazards while limiting false activations.

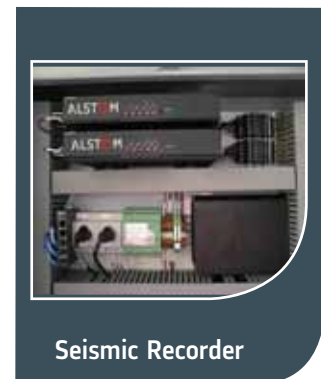
MAJOR COMPONENTS



Seismic Sensor

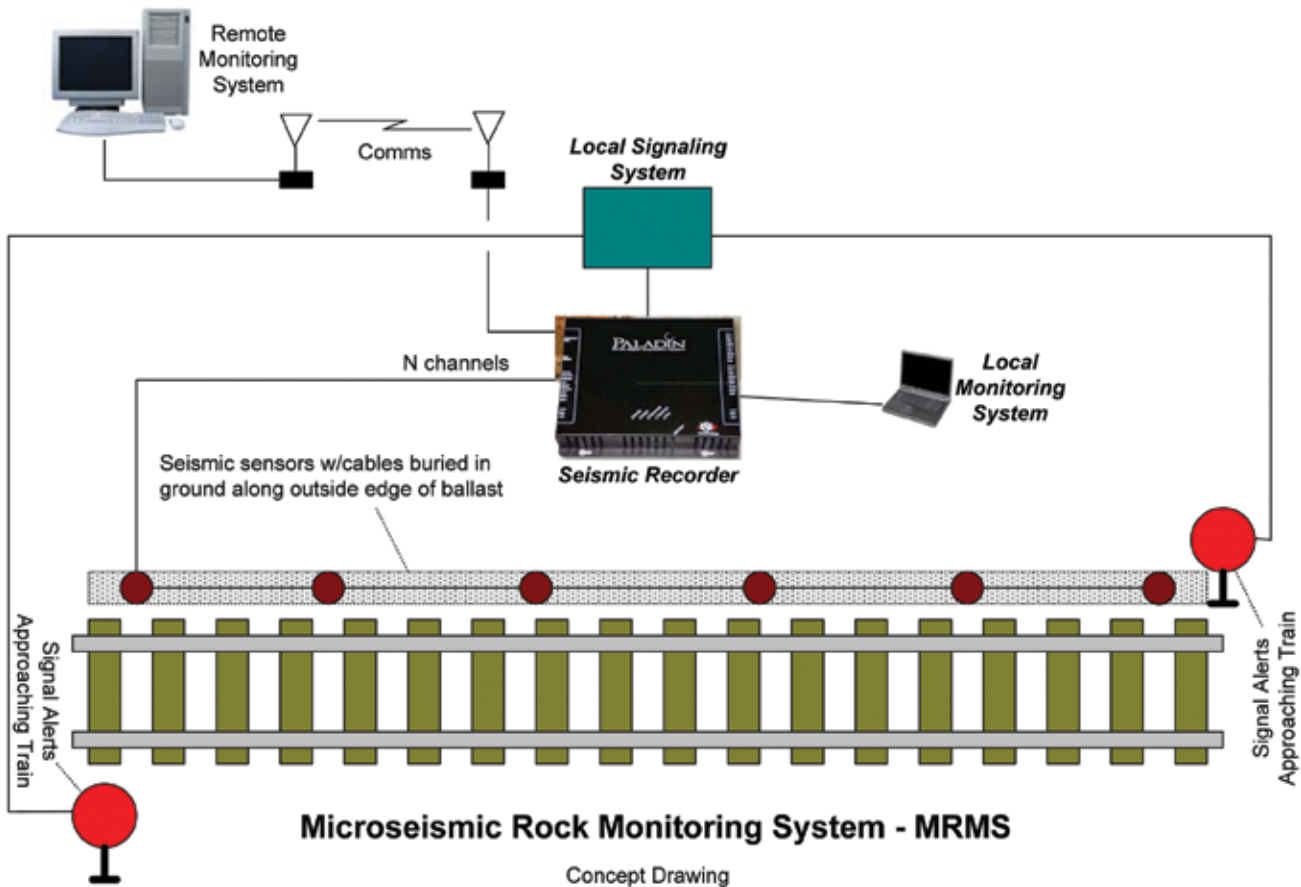


Local Signaling System



Seismic Recorder

> Microseismic Railway Monitoring System (MRMS)



BENEFITS

- > Ease of installation
- > No change to existing signal system
- > Reduces train delays and false alarms thus increasing velocity
- > Potential significant operating cost reductions
- > Records data for later analysis
- > Significant reduction to maintenance requirements
- > Improved worker safety

Ordering Information

For assistance in ordering or to obtain more information on MRMS, please contact the Alstom Customer Service Center at 1-800-717-4477.