IP-189

Technical Description

INTEGRATED TRAIN CONTROL SYSTEM
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</tbody>
</table>
1. INTRODUCTION .................................................................................................................................................4
  1.1 OVERVIEW .......................................................................................................................................................4
2. SYSTEM DESCRIPTION ...........................................................................................................................................5
  2.1 COMPUTER CONTROLLED BRAKE (CCBII®) .................................................................................................5
  2.2 ELECTRONICALLY CONTROLLED PNEUMATIC TRAIN BRAKE (EP-60®) ......................................................8
  2.3 INTEGRATED EP-60®, CCB II® AND WIREDP™ TRAIN CONTROL ..............................................................10
3. COMPONENT DESCRIPTIONS .............................................................................................................................15
  3.1 MAN MACHINE INTERFACE ............................................................................................................................15
    3.1.1 Locomotive Cab Display Module (LCDM) .................................................................................................15
    3.1.2 Operator Interface Unit (OIU) ...................................................................................................................16
    3.1.3 Electronic Brake Valve (EBV) ..................................................................................................................17
    3.1.4 Electronic Brake Controller (EBC) ...........................................................................................................18
  3.2 CONTROL EQUIPMENT ....................................................................................................................................19
    3.2.1 Integrated Processing Module (IPM) ...........................................................................................................19
    3.2.2 Trainline Communications Controller (TCC) ............................................................................................20
    3.2.3 Trainline Power Supply (TPS) ..................................................................................................................22
    3.2.4 Relay Interface Module (RIM) ..................................................................................................................24
    3.2.5 Trainline Interface Module (TIM) .............................................................................................................24
    3.2.6 Electro-Pneumatic Control Unit (EPCU) ....................................................................................................25
  3.3 CABLING AND JUNCTION BOXES ....................................................................................................................27
    3.3.1 Junction Box with Identification Module ..................................................................................................27
    3.3.2 Trainline Cables and Connectors .............................................................................................................27
1. INTRODUCTION

1.1 Overview

This document describes the Computer Controlled Electronic Air Brake System (CCBII®), the
cable-based Electronically Controlled Pneumatic Brake (EP-60®) and Distributed Power
Systems (WireDP™).

The EP-60® and CCB II® systems are available as individual stand-alone systems providing
immediate performance and informational benefits. Each product, as a stand-alone element of
the railroad operation, provides immediate benefits by way of higher performance, real time
active diagnostics and lower life cycle costs.

The EP-60® and CCB II® systems are also available as an integrated system. When
integrated the system provides dual modes of operation, conventional pneumatic mode and
ECP mode. In conventional pneumatic mode, the CCBII® system is the sole control of the
train and the local locomotive brake controls. When in ECP mode, the EP-60® and CCBII®
systems form an integrated control package to control the train and locomotive brake controls
all through a single brake controller.

Additionally, the EP-60® and CCB II® integrated system is available integrated with
WireDP™. When integrated with WireDP™, the benefits of the individual technologies are
multiplied. NYAB’s integrated system is built upon the cable-based Intra-Train
Communications (ITC) Network, providing a gateway to deliver a wealth of information and
performance benefits. The integration of these products together creates a train control
system with synergistic value beyond the capability of any product alone.
2. SYSTEM DESCRIPTION

2.1 Computer Controlled Brake (CCBII®)

The CCB II® brake control system is a network-based, 26L compatible, electro-pneumatic air brake system designed for main line freight and passenger locomotives. CCB II® utilizes a line-replaceable unit (LRU) design approach based on a distributed architecture. Each LRU module contains embedded self-diagnostic capabilities. CCB II® incorporates a number of redundant functions, and has the unique ability to identify, reconfigure, and back-up key components in the event of failure. The following block diagram depicts the CCB II® architecture.

The CCB II® system consists of three primary components. They are the Electronic Brake Valve (EBV), the Integrated Processor Module (IPM) and the Electro-Pneumatic Control Unit (EPCU). The EBV provides the man-machine interface to the automatic (train) and independent (locomotive) brake controls. The IPM is the brake system’s central computer. The IPM manages the electronic interfaces between the brake system and the Locomotive Engineer's display, other locomotive on-board sub-systems (i.e. alerter, cab signal, etc.) and general locomotive inputs and outputs. The EPCU includes eight LRUs, which manage the locomotive pneumatic interfaces, including the locomotive’s brake cylinders, brake pipe, independent application and release pipe, and actuating pipe.
The CCB II® design incorporates the Echelon® LonWorks network technology to interconnect each LRU. These LRUs are in a constant state of communication with one another, actively controlling a number of functions.

The CCB II® system provides the following benefits:

- Compatible With Existing 26L Brake Control Systems
- Provides Flexibility To Changing Customer Needs
- LRU Design Provides Improved Maintainability (Self Contained Modules)
- Simplified Installation (Reduced Size & Modular Design), Reducing Installation Time
- Provides “Clean Cab” Design Capability (Reduction In Cab Clutter And Improved Cab Ergonomics)
- Provides the Platform to Transition from a Pneumatic Based to an Electronic Based Brake Control System
- Real-Time Locomotive Status Feedback
- Run-Time Diagnostics
- Down Loading Capabilities To Provide Diagnostics & Event-Driven Data
- Each LRU Contains Self-Diagnostics Embedded within It’s Control Node
CCB II® Electronic Air Brake Architecture
2.2 Electronically Controlled Pneumatic Train Brake (EP-60®)

EP-60® is an electro-pneumatic train brake control system, operating on a cable based communications network. The EP-60® system consists of locomotive equipment, car braking equipment, an end-of-train device (EOT), and a power/communications distribution system. The locomotive equipment includes a Trainline Power Supply (TPS) and a Head-End-Unit (HEU). The HEU consists of a Trainline Communications Controller (TCC), Brake Controller and a display. The car equipment consists of the Car Control Device (CCD). Each locomotive and car also include an Identification Module (IDM) to retain pertinent vehicle specific information. Additionally, the Auxiliary End-Of Train Device (AED) provides the EOT function for ECP brake. The following block diagram depicts the EP-60® system architecture.

The locomotive HEU communicates with each CCD via the Intra Train Communications (ITC) Network. The AED provides termination of the communication line and transmits an end-of-train message back to the HEU to establish trainline integrity. Trainline power and communications are transmitted on a single set of wires. The trainline communications network is based upon the Echelon Corporation’s LonWorks® network technology.

In ECP operation, brake pipe is not modulated for train brake control. The locomotive HEU interprets the Locomotive Engineer’s actions and provides braking commands to each car via the ITC network. This network is also used for reporting car exceptions, status information, and diagnostics. The display provides train control status information.
The EP-60® system provides the following benefits:

- Shorter Stopping Distance
- Reduced Air Consumption
- Improved Train Handling
- Reduction Of In-Train Forces
- Reduction Of Undesired Emergencies
- Constant Brake Pipe (Reservoir) Charging
- Simultaneous And Instantaneous Brake Control Throughout The Train
- Graduated Brake Application & Release Capability
- Proportional Brake Control
- Variable Load Braking
- Real-Time Train Status Feedback
- Run-Time Diagnostics
- Down Loading Capabilities To Provide Diagnostics & Event-Driven Data
- Automatic Train Consist Identification & Sequencing
2.3 Integrated EP-60®, CCB II® and WireDP™ Train Control

Integrated Train Control (ITC) is achieved through the integration of the EP-60®, CCB II® and WireDP™ systems.

The EP-60® system provides the platform for building a complete integrated train control and information system. EP-60® provides intelligent train braking as the initial building block to achieve “Integrated Train Control”. Most importantly, EP-60® provides the communication platform for all “Integrated Train Control” applications. The following features of the EP-60® system provide valued benefits to be built upon for additional levels of system integration.

- Intra-Train Communications Network – The ITC network provides the communications path for the addition of WireDP™.

- Intelligent Car Level Braking - This provides the basis for improved braking performance with the addition of real-time feedback of car operating conditions and better train handling.

- Automatic Train Consist Identification – EP-60® establishes the train consist database which contains information on each car and locomotive, such as, vehicle identification number, vehicle length, vehicle weight and other parameters. This information is also provided to WireDP™.

- Vehicle Sequencing and Orientation – EP-60® also establishes the sequence and orientation of each vehicle in the train. This information is provided to the WireDP™ system to automate the set-up process.

Integration of CCB II® with the EP-60® system provides single handle control of the ECP trainline and pneumatic brake pipe via the CCB II® electronic brake valve. The integrated package also combines the system feedback, set-up functions and diagnostic. Additionally, the CCB II® interprets the ECP trainline brake command to locally control the locomotive brake cylinder pressure. By combining the EP-60® system with a CCB II® conventional brake control system, a locomotive can be fitted for “Dual Mode” ECP and conventional pneumatic trainline brake control.

In conventional pneumatic mode, the CCBII® system is the sole control of the train and the local locomotive brake controls. The CCBII® system controls the pneumatic brake pipe, brake cylinder pressure and brake cylinder equalizing pipe. Additionally, the CCBII® system provides the necessary electrical circuitry to interface with the local locomotive controls for power cutoff for penalty and dynamic brake interlock.
When in ECP mode, the EP-60® and CCBII® systems form an integrated control package to control the train and locomotive brake controls all through a single brake controller. The EP-60® / CCBII® Integrated System has the EP-60® and CCBII® Systems share functional responsibilities. The CCBII® system handles all high level brake control inputs and local brake control outputs to the locomotive, as well as, charging the brake pipe and handling any locomotive application specific requirement. The EP-60® System handles the core ECP trainline control functionality as specified by the AAR. In ECP mode, the CCB II® system is fully functional, providing automatic handle and independent handle positions to the EP-60® Head End Unit (HEU), while continuously charging the brake pipe.

Summarizing, by integrating CCB II® with EP-60®, the following benefits are provided:

- The shared integration of the Man-Machine Interface minimizes operational brake control differences in regard to ECP mode and conventional pneumatic mode unitizing a common brake valve controller for train and locomotive braking.
- The EP-60® and CCB II® Systems share common locomotive inputs and outputs, which eliminates dual wiring and piping installation requirements.
- Locomotive brake cylinder control is provided without additional control valves for ECP equipped lead locomotives and trail locomotives.
- Eliminates unnecessary pneumatic brake pipe reductions for penalty brake applications when in ECP mode.

The addition of WireDP with EP-60® and CCB II® provides the added benefit of controlling remote locomotives via the ITC network.

When in WDP mode, the WireDP™ system forms an integrated control package to control remote locomotive throttle, dynamic brake, locomotive air brake controls, etc. from the lead locomotive. New York Air Brake and GETS Global Signaling have teamed to develop the AAR compliant WireDP™ system. The WireDP™ integrated system has WDP software within the Trainline Communications Controller (TCC) and LOCOTROL® software within the Integrated Processor Module (IPM) systems share functional responsibilities. The WireDP™ system manages distributed power functions related to locomotive set-up, linking, mode control, interface to the propulsion controls, data logging and operator interface as well as remote locomotive air brake control.
The EP-60® and WireDP™ system utilizes the Echelon PLT-22 transceiver to communicate from the lead controller to the trailing cars and remote locomotives via the ITC Network. An FTT-10A communications link from the EP-60® system to the Integrated Processor Module (IPM) provides the integration path to link both the EP-60® / CCB II® systems and the EP-60® / WireDP™ systems. The EP-60® link to the CCB II® system handles the local locomotive air brake control functions. The TCC link to the LOCOTROL® system handles the distributed power functions. The WireDP™ interface to the Locomotive Propulsion Control Computer is provided through a direct communication interface or through discrete I/O to the MU Trainlines.

By integrating WireDP™ with EP-60® and CCB II®, a fully integrated platform for complete train control is now established with control and information transfer capability at each car and locomotive.

Summarizing, by integrating WireDP™ with EP-60® and CCB II®, the following additional benefits are provided.

- Minimized installation requirements through reduction of hardware
- Utilization of the EP-60® as the controller and gateway of the ITC Network
- Utilizes the established brake control features provided by the EP-60® & CCB II®
- System complexity is reduced due to a more robust captive communications network, utilizing the already established ITC/ECP trainline management capability.
- Establish a train wide communication network to each locomotive & rail car for control and information.
Integrated Locomotive System Architecture
Integrated EP-60®, CCB II® and WireDP™ Train Control
3. COMPONENT DESCRIPTIONS

3.1 MAN MACHINE INTERFACE

The Locomotive Cab Display Module (LCDM) is available to display information to the train operator. Alternatively, the locomotive’s display (IFC / FIRE / ICE etc…) can be interfaced with the integrated system.

An Operator Interface Unit (OIU) is also available to display information to the train operator. The OIU is typically only used on stand-alone EP-60® applications.

Operator control of the train brakes is achieved using the CCBII® Electronic Brake Valve (EBV). For stand-alone EP-60® an Electronic Brake Controller (EBC) is available.

3.1.1 Locomotive Cab Display Module (LCDM)

The Locomotive Cab Display Module (LCDM) is the prime operator device for the system(s). It is designed as a panel mount for installation on the locomotive driver’s console. It consists of a single rugged, sunlight-readable 10.4” screen with eight function keys housed with a self-contained 14” x 9” enclosure. For CCBII®, the LCDM is used for Air Brake Set-Up, Air Brake Diagnostic Logs, and System status and alarm display. The screen displays real-time system pressure values. For EP-60® the LCDM provides the ECP system set-up functions, display the operating and event related status, and system related alarms. For WireDP™, the LCDM is used for system linking, system testing, system status and alarm display, train and remote mode selection, independent traction and brake control, and various locomotive functions.
3.1.2 Operator Interface Unit (OIU)

The Operator Interface Unit (OIU) has typically been used on stand-alone EP-60® applications. It provides the interface to the train operator. It is designed with use of a bracket for mounting. It consists of a main operating screen, 3-digit brake command display, four (4) function keys, a trainline power indicator, alarm status light, an EOT status light, audible/visual brake fault alarm indicator, and bright / dim function keys. For EP-60® the OIU provides the ECP system set-up functions, display the operating and event related status, and system related alarms. The OIU interfaces with the Trainline Communications Controller for power and communications.
3.1.3 **Electronic Brake Valve (EBV)**

The Electronic Brake Valve (EBV) provides the operator interface for controlling the train brakes on the CCB II® and on the integrated systems. It is available in either a desktop or vertical style. The EBV contains handles for operation of the Automatic and Independent brakes. Depressing a button or lifting a lever on the desktop style’s independent brake lever will command the release of an automatic brake application by activating the “bail-off”. This is accomplished by depressing the vertical style’s independent brake lever. The EBV is connected to the distributed LON network and communicates with the five “intelligent” modules of the Electro-Pneumatic Control Unit (EPCU) in real-time.

The Automatic brake handle has the following positions RELEASE, MIN (minimum service), FS (full service), SUP (suppression), CS (continuous service) and EMER (emergency). There is a detent in the MIN, FS, SUP, and CS positions. The EBV contains a cam-actuated pneumatic valve, which will create a pneumatic emergency when the automatic handle is moved to EMERGENCY, regardless of the presence of locomotive or battery power.

The independent handle is continuous from RELEASE to FULL.
3.1.4 Electronic Brake Controller (EBC)

The Electronic Brake Controller (EBC) provides the operator interface for controlling the ECP train brakes on stand-alone EP-60® applications. It is available in a desktop style and in vertical style. The desktop mounted EBC also includes a mounting panel with 4 holes that can be used in the event that any console switches need to be relocated on the desktop. The EBC contains a single handle for applying and releasing the ECP train brakes. The EBC interfaces to the Trainline Communications Controller for power and communications.

The EBC handle has the following positions REL (full release), MIN (minimum service), FS (full service) and EMER (emergency). There is a detent in the MIN and FS positions. Graduated apply and release is controlled between MIN and FS positions. The EBC does not have any pneumatic functions.

The photograph (below left) shows a BNSF EMD SD60M application of the EBC mounted on the desktop and is to the left of the propulsion controller.

The photograph (below right) shows a QCM ALCO application of the EBC mounted vertically and is to the right of the conventional brake valve.
3.2 CONTROL EQUIPMENT

3.2.1 Integrated Processing Module (IPM)

The IPM Module is used on the CCBII®, and on the CCBII® / EP-60® / WireDP™ integrated system(s). The IPM Module contains the system electronics, processor, relay driver circuits, and I/O boards that interface with the LCDM, RIM module, EBV module, EPCU module, Trainline Communications Controller, the Locomotive Propulsion Control Computer or the Trainline Interface Module (TIM). The IPM is based on the existing LOCOTROL® LSI processor module. The IPM is the central processor for the LOCOTROL® DP system. The LOCOTROL® DP software programming and maintenance logger functions are contained in this module. The module controls overall system operation and is the heart of the LOCOTROL® DP system.

There are 9 LED indicators on the front of each IPM, which provide operational feedback of the system. There is also a portable test unit (PTU) connector interface on the front of the IPM. This can be used for accessing a data logger function for troubleshooting or downloading new software. The IPM module meets the mechanical requirements of the LSI specification. The IPM Module size is four MCU as defined by the LSI specification.

![Diagram of IPM Module](image-url)
3.2.2 Trainline Communications Controller (TCC)

The Trainline Communications Controller (TCC) provides the interface between the lead locomotive and the rest of the train for controlling car braking, and for reporting train status and diagnostic information. The primary function of the TCC is network management of the ECP trainline communication system.

The TCC has eight connectors on the front face of the unit that are used to interface with the locomotive and the EP-60® system. The types of connections available are indicated above and described below.

Connector C1: This connector provides both an RS-232 asynchronous serial communication link and a LON FTT10 network communication link. These are used for connecting to a laptop computer Portable Test Unit (PTU). The PTU is connected to the RS-232 for accessing and downloading various log files. These log files provide ECP operational data and events. The RS-232 is also used for downloading software to the TCC’s single board computer. The PTU is connected to the LON for downloading software to the TCC’s remaining components.

Connector C2: This connector provides an Ethernet communication link and is used for EP-60® systems integrated with NYAB’s LEADER® (Locomotive Engineer Assist / Display and Event Recorder) system.

Connector C3: This connector provides a LON FTT10 network communication link and 24 VDC. This is used to supply power to and communicate with the EBC. On the integrated systems the LON is used to communicate with the IPM. This interface provides the Wire Distributed Power (WDP) functionality.
Connector C4; This connector provides a LON FTT10 network communication link and 24 VDC. This is used to supply power to and communicate with the OIU.

Connector C5; This connector provides an RS-422 synchronous HDLC serial communication link.

Connector C6; This connector provides a LON FTT10 network communication link and 24 VDC that is used for the locomotive IDM. It has a connection for the 8 AWG trainline cable used by the TCC to communicate with the ECP network. It also has connections to the 16 AWG locomotive trainline cable used by the TCC to detect head end trainline termination.

Connector C7; This connector provides an RS-422 synchronous HDLC serial communication link and an RS-232 asynchronous serial communication link. The RS-422 is used on integrated systems to communicate with the integrated locomotive computer (such as IFC, ICE or FIRE). The RS-232 provides ECP data for event recorder purposes. The RS-232 is used on systems that do not have an integrated locomotive computer or a “PLT22 ready” Event Recorder (an event recorder that is able to communicate on the ECP trainline network). Note that an event recorder must be properly configured for recording the ECP data that is provided on this RS-232 link. The preferred approach for an event recorder to obtain ECP data is for it to read the trainline, the AAR has developed the appropriate specifications for event recorders to do this.

Connector C8; This connector provides five outputs configured as normally open or closed, four digital inputs, and an analog input. It also receives locomotive battery voltage through this connector. On stand-alone EP-60® systems the digital inputs are used to obtain zero speed, to obtain 20 MPH or greater, to interface with the alert/over-speed system and to interface with the cab signal system if so equipped. On stand-alone EP-60® systems an output is used for the trainline power supply and an output is used for interfacing with the PCS (Power cut off) circuitry.
3.2.3 Trainline Power Supply (TPS)

The Trainline Power Supply (TPS) converts the locomotive battery voltage into 230 VDC trainline power for the ECP network and car equipment. The TPS is capable of supplying output power up to approximately 2500 watts. It also supplies 24 VDC to the trainline for use during train sequencing.

The TPS is controlled by a Trainline Power Controller (TPC) that is an integral part of the trainline power supply and is located within its enclosure. The TPC communicates on the trainline network and receives commands from the Trainline Communications Controller.

The TPS includes a means to detect the presence and polarity of trainline voltage. In the event of polarity mismatch the TPS corrects its output voltage polarity so that it can be used as an additional source of trainline power. The TPS is fully capable of load sharing with other trainline power supplies.

The TPS has three connectors and from left to right are labeled INPUT, AUX and OUTPUT.

The TPS uses its INPUT connector to receive locomotive battery voltage. It uses its OUTPUT connector to supply power to and communicate on the trainline. The AUX connector is used to

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**INPUT:** 74 VDC
Or 110 VDC
Locomotive input

**OUTPUT:** 230 / 24 VDC
ECP Trainline

**AUX:** Service Switch
To TCC

**Status LEDs:**
Power Supply
Fault Summary
230V
24V

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provide a means ("service switch") for the TCC to determine that both it and the TPS are located on the same locomotive.

The TPS(s) are polled by the TCC in order to determine their status. The TPS also has four LED's for local diagnostic information and from top to bottom are,

**POWER SUPPLY**
- GREEN if the TPS is functional and is supplying 230V output power
- GREEN (flashing) if the TPS is functional but not supplying 230V output
- OFF if the locomotive battery is low or if the TPS is non-functional

**FAULT SUMMARY**
- RED if a fault condition is active
- OFF if no faults are active

**230V**
- RED if trainline voltage is 100 VDC or higher
- RED (flashing) if trainline voltage is below 100 but greater or equal to 30
- OFF if trainline voltage is less than 30 VDC

**24V**
- RED if trainline voltage is below 30 but greater or equal to 12 VDC
- OFF if trainline voltage is less than 12 VDC **OR** equal to 30 and higher

The TPS does not require a fan as it is cooled by natural convection via its cooling fins, and therefore must be mounted in the orientation shown in the above photo.
3.2.4 Relay Interface Module (RIM)

The RIM module includes a LSI standard enclosure, which handles CCBII® inputs and outputs for local locomotive interlocks. The RIM may contain up to seven relay outputs, which are driven by the IPM low level drivers.

3.2.5 Trainline Interface Module (TIM)

The TIM module includes a LSI standard enclosure, which interfaces with the locomotive’s MU trainlines when they are being controlled directly in “non-LSI type” applications.
3.2.6 Electro-Pneumatic Control Unit (EPCU)

For the CCB II® systems, the EPCU contains the pneumatic valves, which control the locomotive pneumatic trainlines. These valves are functionally grouped and modularized into "line replaceable units" (LRU’s). Five of these LRU’s are “intelligent” and communicate via the network:

- The Equalizing Reservoir Control Portion (ERCP) provides brake pipe control pressure.
- The 16 Control Portion (16CP) provides brake cylinder control pressure.
- The Brake Pipe Control Portion (BPCP) contains the brake pipe relay and provides cut-in and cut-out of brake pipe as well as emergency activation.
- The 20 Control Portion (20CP) provides brake cylinder equalizing pipe pressure.
- The 13 Control Portion (13CP) provides bail off command pressure.
The EPCU also contains:

- The Brake Cylinder Control Portion (BCCP) which houses the brake cylinder relay.
- The Power Supply Junction Box (PSJB) which contains the EPCU power supply.
- The DB Triple Valve (DBTV) provides the pneumatic backup in the event of an electronics failure.
- The Dead Engine Regulator (DER), allows main reservoir to be charged from the brake pipe on a dead locomotive.
- Filters for main reservoir air as well as air to the independent control and bail-off control LRU’s. Air supply to the brake pipe relay is conditioned by a screen element.
3.3 CABLING AND JUNCTION BOXES

3.3.1 Junction Box with Identification Module

The ID module is located within the center junction box and connects to the TCC. The ID module provides locomotive specific information to the TCC including locomotive number, type, orientation and other pertinent parameters. In addition, the ID module contains circuitry, which is used for determining the order of the cars and locomotives in the train.

3.3.2 Trainline Cables and Connectors

Power and communication signals transmitted between the Head End Unit (HEU) and the CCD's are carried by a two conductor, #8 awg, cable which runs the length of the train. The trainline cable runs the length of the locomotive, and terminates at each end. The inter-car cables are also connected into each junction box so all cars and locomotives of a train can be connected together. These inter-car cables are designed so as to have only one way in which they can be connected and are the style approved by the Association of American Railroads.