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Presentation 1 of 3

Wiring for Signals

Part 1: Wiring

Part 2: Signals

Part 3: CATS
Presentation 2 of 3
Wiring for Signals

Part 1: Wiring

Part 2: Signals

Part 3: CATS
Outline

Wiring for Signals

- Introduction
- Planning – questions to ask and answer
- DCC – a 5 minute primer
- Occupancy detection – gaps and detectors
- Turnouts – control and feedback
- Signals – lights and semaphores
- A reference design
Planning
Wiring for Signals

What do I want?
Planning

Wiring for Signals

How much interaction?

Railfan

Operations
Planning

Wiring for Signals

Shout and Go

Operation scheme?

Mother, May I?

TT&TO

CTC

TWC/DTC

The Colorado & Southern Railway Company

TRACK WARRANT

NO______________________DATE______ 20____

TO______________________AT____________________

1. □ TRACK WARRANT NO______________________ IS VOID.
2. □ PROCEED FROM______________________TO______________________ON TRACK.
3. □ PROCEED FROM______________________TO______________________ON TRACK.
4. □ WORK BETWEEN______________________AND______________________ON TRACK.
5. □ NOT IN EFFECT UNTIL______________________M.
6. □ THIS AUTHORITY EXPIRES AT______________________M.
7. □ NOT IN EFFECT UNTIL AFTER ARRIVAL OF______________________AT______________________
8. □ HOLD MAIN TRACK AT LAST NAMED POINT.
9. □ DO NOT FOLLOW UNITS AHEAD OF______________________.
10. □ CLEAR TRACK AT LAST NAMED POINT.
11. □ BEYOND AND MAKE ALL MOVEMENTS AT RESTRICTED SPEED. LIMITS OCCUPIED BY TRAIN OR ENGINE.
12. □ BEYOND AND MAKE ALL MOVEMENTS AT RESTRICTED SPEED AND STOP SHORT OF MEN AND MACHINERY POOLING TRACK.
13. □ DO NOT EXCEED MPH BETWEEN______________________AND______________________.
14. □ DO NOT EXCEED MPH BETWEEN______________________AND______________________.
15. □ FLAG PROTECTION NOT REQUIRED AGAINST FOLLOWING TRAINS OR SAME TRACK.
16. □ TRACK BUREAUCY IN EFFECT
17. □ OTHER SPECIFIED INSTRUCTIONS______________________

OK______________________M DISPATCHER

RELAYED TO______________________COPYED BY______________________

LIMITS REGRETTED CLEAR AT______________________M BY______________________M.

(Mark “x” in each box instructed.)
Planning for CTC

Wiring for Signals

What kind of dispatcher panel?

GRS/US&S machine  Simulated machine  Modern

Photo: JMRI
Planning for CTC
Wiring for Signals

Local control?

Dispatcher lock

Field override

Photos: Pat Lana
What Kind of Signals?

<table>
<thead>
<tr>
<th>Signal Aspect</th>
<th>Name</th>
<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear</td>
<td>Proceed</td>
<td></td>
</tr>
<tr>
<td>Approach</td>
<td>Proceed prepared to stop before any part of train or engine passes the next signal. Trains exceeding 30 MPH must immediately reduce to that speed.</td>
<td></td>
</tr>
<tr>
<td>Approach Medium</td>
<td>Proceed. Speed passing next signal must not exceed 30 MPH.</td>
<td></td>
</tr>
<tr>
<td>Diverging Clear</td>
<td>Proceed on diverging route at prescribed speed through turnout.</td>
<td></td>
</tr>
<tr>
<td>Diverging Approach</td>
<td>Proceed on diverging route at prescribed speed through turnout prepared to stop before any part of train or engine passes the next signal. Trains exceeding 30 MPH must immediately reduce to that speed.</td>
<td></td>
</tr>
<tr>
<td>Diverging Clear Slow</td>
<td>Proceed on diverging route. Speed through turnout must not exceed 15 MPH.</td>
<td></td>
</tr>
<tr>
<td>Diverging Approach Slow</td>
<td>Proceed on diverging route prepared to stop before any part of train or engine passes the next signal. Speed through turnout must not exceed 15 MPH. Speed to next signal must not exceed 30 MPH.</td>
<td></td>
</tr>
<tr>
<td>Flashing</td>
<td>Stop and Proceed</td>
<td>Stop before any part of train or engine passes the signal then proceed at restricted speed, not exceeding 15 MPH prepared to stop at any obstruction, through the entire block.</td>
</tr>
<tr>
<td>Stop</td>
<td>Stop before any part of train or engine passes the signal.</td>
<td></td>
</tr>
</tbody>
</table>

Lights

Semaphores

Photos: Pat Lana

Aspects & indications
Planning

Wiring for Signals

What kind of switch machines?

Tortoise switch motor

Peco Code 55 turnout

Twin Coil

Servo – photo by Tam Valley Depot

Slow Motion – Photo by Pat Lana

Turnout Drive Mechanism
By Bob Frager
Planning
Wiring for Signals

How much computer dependence?
Planning

Wiring for Signals

What can you afford?
Planning
Wiring for Signals

Build?  Buy?
DCC Basics

Wiring for Signals
DCC Basics

Wiring for Signals

DCC Command Station

Throttle

Proprietary protocol

Decoder

Stationary Decoder

NMRA RP 9.x
DCC Basics

Wiring for Operations

DCC Command Station

Throttle

Proprietary Decoder

Decoder

Stationary Decoder

Proprietary protocol

NMRA RP 9.x
DCC Basics
Wiring for Operations

DCC Command Station

Proprietary Protocol

Throttle

Proprietary Decoder

Proprietary Decoder

Stationary Decoder

NMRA RP 9.x
DCC Basics

Wiring for Operations

DCC Command Station

Throttle

Adapter

Proprietary Decoder

Proprietary Decoder

Computer

Proprietary protocol

Decoder

Stationary Decoder

NMRA RP 9.x
DCC Basics
Wiring for Operations

DCC Command Station

Computer
Throttle
Proprietary Decoder
Proprietary Decoder

NMRA RP 9.x
DCC Basics
Wiring for Operations

DCC Command Station

Computer

Throttle Bus

Throttle

Adapter

Control Bus

Proprietary Decoder

Proprietary Decoder

Stationary Decoder

NMRA RP 9.x
DCC Basics
Wiring for Operations

Computer

Computer

Internet

Throttle

Adapter

Proprietary Decoder

Proprietary Decoder

DCC Command Station

Decoder

Stationary Decoder

NMRA RP 9.x
DCC Basics
Wiring for Operations

Computer

Internet

Computer

WiFi

Smart Phone

DCC Command Station

Throttle

Adapter

Proprietary Decoder

Proprietary Decoder

Decodex

Stationary Decoder

NMRA RP 9.x
NMRA Standards

Wiring for Signals

NMRA

- S-9.2.1, Subsection D: Accessory Digital Decoder Packet Format
  - Control a switch
  - Send an aspect to a signal

- S-9.7: Layout Command Control (aka OpenLcb, Layout Command Control, NMRA Net)
  - Adopted in 2015
  - Basic framework for providing vendors with guidance
  - Reference design uses CAN
  - LCS 9.10 (CMRlnet)
Control and Sensing

Wiring for Signals

Outputs (JMRI “turnouts”)

- signals
- switch machines
- block detectors
- turnout feedback
- electrical switches

Inputs (JMRI “sensors”)

COMPUTER
Prototype Equipment
Wiring for Signals

Automatic (Dual Control) Switch Machine
Exit Signal (Main)
Exit Signal (Siding)
Approach Signal
Field Equipment (Vital Logic)
Security Element (OS Section)

Wiring for Signals

Position Feedback

Switch Machine

A1

A2

Block Detection

B

C

Lock

Turnout Control

output

input
Kinds of Detectors

Wiring for Signals

“Point” Detector

“Area” Detector
“Point” Detectors

Wiring for Signals

Reliable

Unreliable

Trains must be longer than longest distance between detectors.
“Area” (Block) Detectors

Wiring for Signals

Reliable

Unreliable

Blocks must be longer than longest car
Block Occupancy Detection

Wiring for Signals

- Detection block gaps
- Wiring up occupancy detectors
- Power districts
Why Cut Gaps?

Wiring for Signals

Straight Route

Diverging Route

Uninsulated frogs and power routing points
Slide Switch

Wiring for Signals
Powered Frog

Wiring for Signals
Why Cut Gaps?
Wiring for Signals

Isolate shorts

Power Supply 1
Power Supply 2

Power distribution

Train location
Block Gaps – Simple Track

Wiring for Signals

- Put signals where trains should stop.
- Put gaps at signals.
- Do not put signals behind gaps
Block Gaps – Multiple Turnouts

Wiring for Signals

Ladder

Facing points
Block Gaps – Crossovers

Wiring for Signals
Block Gaps – Where to and Not to

Wiring for Signals
Block Detection

Wiring for Signals

Block Detector

Feedback

Track Power
Block Detection

Wiring for Signals

Feedback

Track Power

Block Detector

Detector Power
Power Shorts

Wiring for Signals
Power Districts

Wiring for Signals

Detector

Detector

Detector

Detector

Power Manager
Talking Points on Occupancy Detection

Wiring for Signals

- Put signals at block gaps
- A gap need not have a signal (short isolation, power distribution, affects)
- Isolate security elements, OS sections, plants
- Detection eats wires
- Power districts provide short protection
- Plan ahead – gaps are easy to cut. Feeders are easy to drop. Hooking up feeders is the difficulty.
Turnout Fundamentals

Wiring for Signals

- “Bending the iron”
- Providing position feedback
- Shared remote and local control
Bruce Chubb’s Taxonomy of Turnouts

<table>
<thead>
<tr>
<th>Manual</th>
<th>Automatic Electric Lock</th>
<th>Controlled Electric Lock</th>
<th>Dual Control</th>
<th>Power Operated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Control</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Dispatcher Control</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Field Unlock</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Dispatcher Unlock</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Switch Machine</td>
<td>No</td>
<td>Possible</td>
<td>Possible</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Typical Use
- Spur, Yard, Industry
- Spur, Branch off mainline
- Spur, Branch off CTC mainline
- CTC Control Point
- CTC Control Point
Manual Feedback for Position Light

Wiring for Signals

Rail B

Rail A

Rail B

Rail A

Rail B

Rail A
Manual Feedback to Decoder

Wiring for Signals

Rail A

Rail B

Rail B

Rail A

Rail A

Rail B

Rail B

Rail A

Rail A

Diverging

Straight
Electric Locks on Turnouts

Wiring for Signals

- Bad – a fouled turnout does not affect the protecting signal
- Good – Initiating unlocking turnout drops protecting signals
- Bad – Unlocking a turnout in front of an approaching train can be dangerous
- Good – “Running time”
- Bad – waiting for time to run out
- Good – Quick release zone
Controlling Switch Machines

Wiring for Signals

• Use conventional switch machines
  – Twin coils
  – Slow motion
  – Stall motors
  – Servos
  – Stepper motors

• Where to pull power from?
  – More wires?
  – Reduce power available for engines?
  – Trip detectors?

• Match stationary decoder to technology
Turnout Feedback Sources

Wiring for Signals

Sensor
Switch Motor
Stationary Decoder

Layout Bus

More Dependable
Connect a 10K-20K Ohm resistor between diverging route stock rail and frog.
Mechanical Turnout Feedback

Wiring for Signals

Exact

Sensor

Positive

Sensor

Sensor
Switch Command Sources

Wiring for Signals
Feedback via Command Listener

Wiring for Signals

Switch machine

Stationary decoder

Fascia push button

Adapter

Switch command

Computer

Cab
Feedback via Command Listener
Wiring for Signals
Feedback via Command Listener

Wiring for Signals

Switch machine

Stationary decoder

Fascia push button

Switch command

Adapter

Computer

Cab
Who Controls the Turnout?

Wiring for Signals

- Hand throw (Manual)
  - The field crew

- Unpowered
  - The field crew
  - Dispatcher may not be able to affect it, but grants permission to move it or unlocks it

- Powered – it depends
  - Normally the dispatcher
  - Procedure for transferring control from the dispatcher to the field crew
For Your Consideration

Wiring for Signals

- Does dispatcher have absolute control (i.e. unlock the turnout)?
- How does the crew know they have permission?
- Can the field override dispatcher?
- What steps does dispatcher do to transfer control or regain control?
- What steps does field crew do to receive control or relinquish control?
- How to convert the above to reality?
Example of Prototype of Dual Control
Wiring for Signals
Dispatcher Master Control (Locked)

Wiring for Signals

Example: Tam Valley Depot QuadLN
Dispacher Master Control (Unlocked)

Wiring for Signals

Switch machine

Lock
Unlock

Dispatcher control

Local control
Control by Request

Wiring for Signals

Switch machine

Stationary decoder

Fascia push button

Switch command (1095)

Switch request (10)

Adapter

Computer

Cab
Control by Override

Wiring for Signals

Switch machine

Stationary decoder

Fascia push button

Adapter

Feedback (77 open)

Computer

Opposite command (77 close)

Cab

(77 open)

(77 close)
**Wiring for Signals**

*Pat Lana’s Crandic*

**Turnout Drive Mechanism**

*By Bob Frager*

- **Red**: Locked, controlled by Dispatcher
- **Green**: Ready for manual use

*Peco Code 55 turnout*

*Tortoise switch motor*

*Wiring for Signals*
An Example – Pat Lana's Crandic

Wiring for Signals

Note:
1 EAO 51-237.025DZ Key 3PST Switch from Excess Solutions Part #ES2658 Terminals C3 and C4 not used.
An Example – Pat Lana's Crandic

Wiring for Signals

Fascia Key Switch

- A1
- A3
- B1
- B3

- A2
- B2
- B4

“Unlocked”

Fascia switch

DPDT rocker for local control

To 9-12VDC Power Supply

Tortoise driving Turnout

Digitrax SE8C

Dispatcher’s Computer

To 12-15VDC Power Supply

Fascia Bipolar LED Indicator

- Red = Locked, controlled by Dispatcher
- Green = Ready for manual use

Turnout Wiring  updated 05/28/2018
Wiring for Signals

Tortoise driving Turnout

Digitrax SE8C

Dispatcher’s Computer

To 12-15VDC Power Supply

Simple Key Switch

Fascia Push Button

+VE

SWx

An Example – John Parker’s BNSF Fall River Division

Updated 05/28/2018

John Parker’s BNSF Fall River Division

Wiring for Signals

Simple Key Switch

Fascia Push Button

+VE

SWx

Photo John Parker

Dispatcher’s Computer

To 12-15VDC Power Supply
An Example – Bruce Faulkner’s Shenandoah Division

Wiring for Signals

Tortoise driving Turnout

Digitrax SE8C

Dispatcher’s Computer

To 12-15VDC Power Supply

An Example – Bruce Faulkner’s Shenandoah Division

Wiring for Signals

Tortoise driving Turnout

Digitrax SE8C

Dispatcher’s Computer

To 12-15VDC Power Supply

Phono Plug

“Key”
Talking Points on Turnouts

Wiring for Signals

- Can use conventional technology
- Multiple feedback choices, certainty is proportional to cost
- The balance of remote control against local control can make a big difference in the “fun” of operations
- Plan before building
Signals

Wiring for Signals

• Lots of Choices
  – Semaphores
  – Multi-color lights
  – Searchlights

• Have to match driver electronics to technology

• We will look at some samples
Semaphores

Wiring for Signals
Wiring - Semaphores

Wiring for Signals

Semaphore Mechanism
By Bob Frager
At South Creston

Peco Code 55
N scale track

Semaphore Blade
Drive Wire

Linkage to Tortoise Switch Motors

Copyright Pat Lana

Semaphores (Scratch built)
Block Signals At Prairie Creek
Semaphore Considerations

Wiring for Signals

- Mostly a mechanical problem
  - How to translate large motion into small motion
  - How to make fine adjustments
  - How to hold fine adjustments
  - Fragile
  - Reliable pivot points
  - Threading wires

- Selection of machine (slow motion, stepper motor, servo)

- Digitrax SE8C and QuadLN support three positions
Lights

Wiring for Signals
Signal Lights

Wiring for Signals

• Choices, choices, choices
• Incandescent bulbs
• LEDs
  – Discrete color LEDs
  – Bi-color LEDS (H2 searchlights)
  – Tri-color LEDS (H2 searchlights)
  – Common anode/common cathode
• Match stationary decoder to technology
Which Control Discipline?

Wiring for Signals

- Automatic Block Signals (ABS)?
- Absolute Permissive Blocks (APB)?
- Centralized Traffic Control (CTC)?

(Descriptions in the next session.)
Talking Points on Signals

Wiring for Signals

• Very little mystery in wiring them
• Tend to be expensive
• Protect them from being knocked over
• Add a “wow” factor – bright and animated
• Can mix and match on the layout, but take care about mixing and matching the drive electronics
• Decide aspects and indications – what the signals are telling the crew – ahead of time
Reference Design for CTC

Wiring for Signals

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td>A1/A2</td>
<td>$40</td>
</tr>
<tr>
<td>Servo</td>
<td>$3</td>
</tr>
<tr>
<td>QuadLN</td>
<td>$15</td>
</tr>
<tr>
<td>BD4</td>
<td>$6</td>
</tr>
<tr>
<td>SE8C</td>
<td>$12</td>
</tr>
<tr>
<td>B</td>
<td>$30</td>
</tr>
<tr>
<td>C</td>
<td>$30</td>
</tr>
</tbody>
</table>

Total: $136
This clinic has been myopic in narrowly focusing on pieces of the layout.

Something is needed to tie the pieces together:

- The pieces have to “talk” to each other.
- The pieces have to “talk” to a central decision maker.
- The pieces have to “talk” to a collection of decision makers.

Where (how) does the human fit in?
References

Wiring for Signals


• Railroader’s C/MRI Applications Handbook, Volume 2 – Signaling Systems, Dr. Bruce Chubb, 2010

• “Understanding Signals”, Dr. Bruce Chubb, Railroad Model Craftsman, 14 parts, December, 2015 thru April, 2017

• “Absolute-Permissive Block Signals”, Jay S. Boggess, Model Railroading, January, 1992


• JMRI, jmri.org

End of the Line

Wiring for Signals