INTRODUCTION TO LCC

(LAYOUT COMMAND CONTROL FOR AUTOMATION")

CLINIC PRESENTED B Y

PAT FLEMING

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PRESENTATION: HTTPS://GITHUB.COM/PATFLEMING/NMRA/RAW/MAIN/INTRODUCTION TO LCC.ZIP

TCD NMRA MEDIA: HTTPS://WWW.YOUTUBE.COM/@TCDNMRAMEDIA3700/VIDEOS

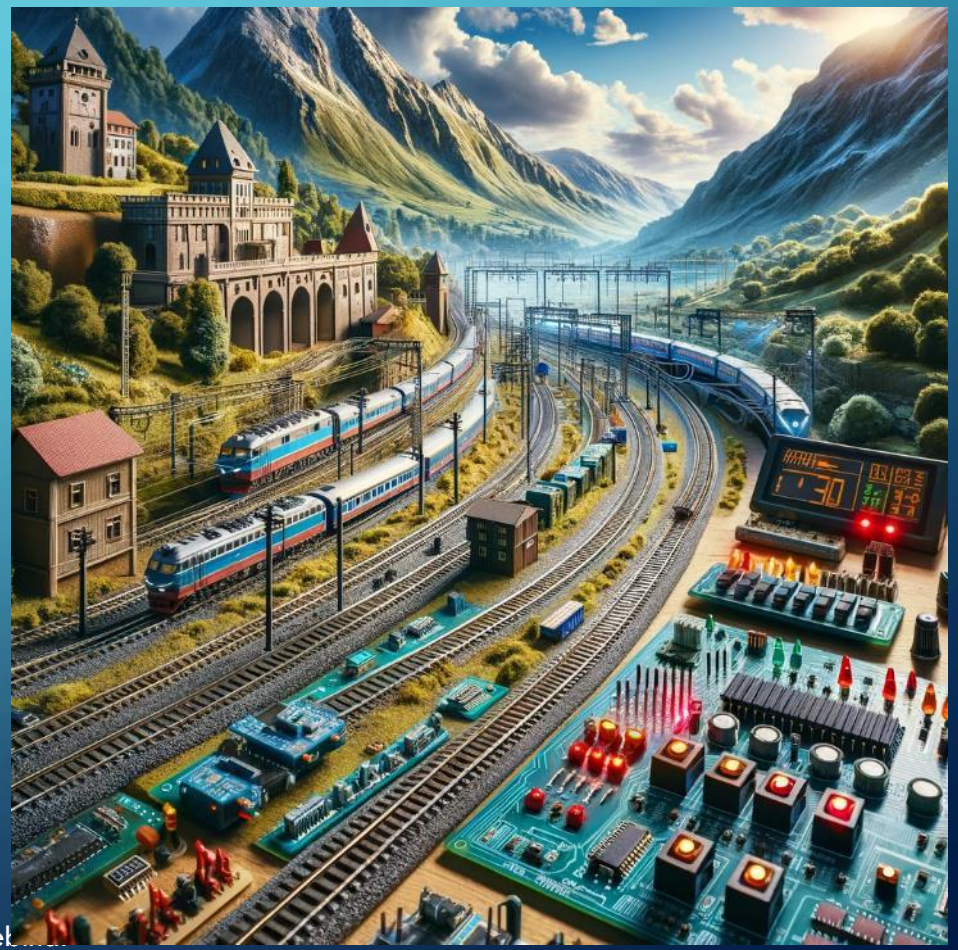
NOTE: FOR POWER POINT, USE SLIDE SHOW (FOR LINKS AND SLIDE ANIMATIONS)

AGENDA

- LCC Goal
- What is LCC
- LCC Considerations
- Utilizing LCC in Model Railroading
- Understanding LCC Vocabulary
- LCC Applications
- LCC Products
- LCC Educational Resources
- LCC Fusion Project (my open source DIY HW/SW project)

LCC GOAL

- The goal is to achieve a seamless, automated operation that can mimic real-world railway operations or run custom scenarios for hobbyists
- Integrating hardware and software components to control various aspects of the model railway, including:
  - Track switching
  - Signal lights
  - Train movements
  - More…



WHAT IS LCC

- **Universal Railroad Dialogue**: LCC serves as the universal protocol for communication between various elements of a railroad layout, including signals, turnouts, detection systems, lighting, and control panels.
- **Technology Integration**: It seamlessly integrates with modern technology, functioning across PCs and smartphones.
- **Comprehensive Control System**: LCC is the backbone of a comprehensive control system, connecting boosters, command stations, throttles, power management systems, and trains.
- **Manufacturer Independence**: LCC operates independently of Digital Command Control (DCC) systems and manufacturers, adhering to NMRA's open standards.
- **Upgradability**: Updating LCC nodes is straightforward and can be done through the internet or JMRI, ensuring your layout remains cutting-edge.
- **Event-Driven Protocol**: Communication within LCC is facilitated through a message-based protocol using Event IDs, which specify actions to be taken or report status changes, rather than altering the voltage on the wire.
    - For example, Event IDs can indicate the detection of a train in a block or the actuation of a turnout, providing immediate feedback on the status.
- **Autonomous Operation**: LCC allows for operations to be carried out without the need for a computer.
- **Defining LCC's Role**: It is important to note what LCC is not:
    - LCC does not serve as a substitute for DCC systems.
    - DCC is primarily used on the track for direct train control.
    - LCC operates beside the track, enhancing and potentially replacing DCC accessory decoders.

LCC CONSIDERATIONS

- **Creation and Evolution**: The NMRA OpenLCB group masterminded and refined the LCC standard, culminating in 2019.
- **Open Source Collaboration**: Implementations and illustrative examples of the LCC can be found on GitHub, under OpenMRN and OpenMRN-Lite Arduino projects.
- **Multi-Network Compatibility**: LCC stands as a versatile protocol compatible with Ethernet, Wi-Fi, Control Area Network (CAN), among other networks.
- **Interactive Control**: Enables two-way communication, facilitating features such as feedback on turnout motor positions and point settings.
- **Designed to Grow**: LCC is inherently scalable, accommodating larger layouts with a quick bus system and streamlined configuration management.
- **Freedom of Use**: Rooted in a license-free CAN network, it allows for unrestricted use and integration.
- **Universal Compatibility**: It supports a non-proprietary framework for hardware and software, ensuring wide-ranging interoperability.
- **Company Agnostic**: LCC's design is independent of any corporate affiliation, promoting widespread adoption and innovation.

UTILIZING LCC IN MODEL RAILROADING

Interactive Operation

- LCC enables the interconnectivity of layout components, such as linking buttons and switches to activate turnouts or illuminate LEDs.

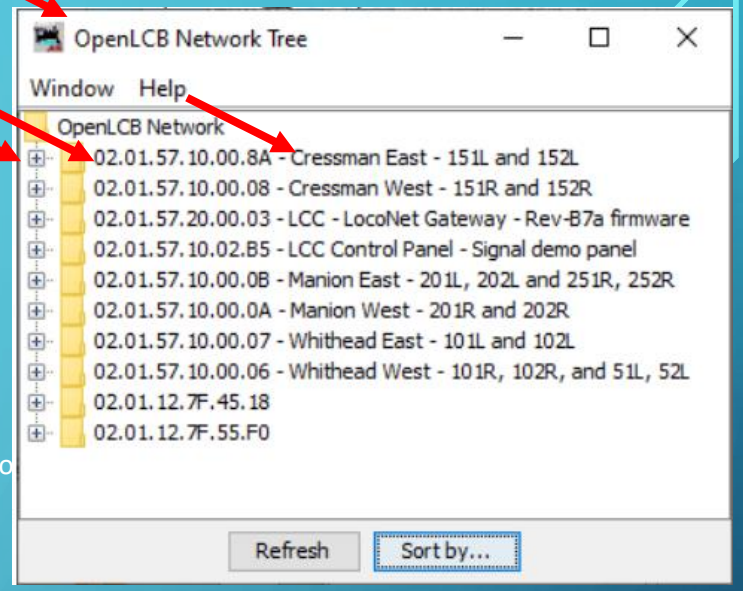
Automated Signaling

- LCC is instrumental in automating signal systems (known as ABS) by:
- Detecting train presence in blocks to adjust signal displays and align turnouts appropriately.
- Typically, this process begins with the establishment of block detection, followed by the configuration of signal aspects, and culminating in the application of conditional logic rules.

User Experience Insights

- Initial implementation of LCC may present a learning curve, but the investment of time and effort pays dividends in operational efficiency and control.

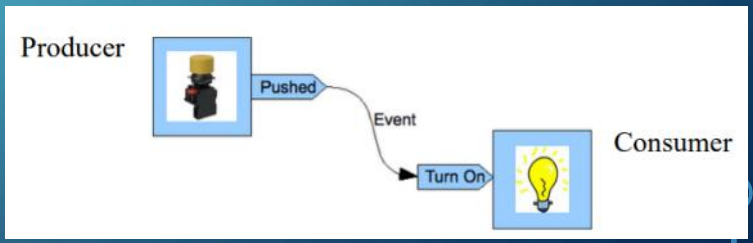
UNDERSTANDING LCC VOCABULARY



- **CAN Network (Control Area Network)**
  - A standard designed for robust vehicle communication.
  - Facilitates swift, precise message exchange over a pair of wires, typically within a network cable.
  - Employs these communication lines for interfacing LCC Nodes.
  - Note: LCC also has the capability to bridge connections over Wi-Fi.
- **LCC Configuration Tool**
  - A software application that orchestrates the management of CDI, like the JMRI Panel Pro or OpenLCB Configuration Too
  - It presents a visual map of all LCC Nodes within a network.
  - It's the interface through which the configuration of each Node's CDI is accessed and adjusted.
- **LCC Node**
  - Essentially, an LCC Node is a hardware entity that adopts the LCC protocol for network integration.
    - For instance, the RR-CirKits Tower LCC.
    - Equipped with a microprocessor, it runs the firmware that brings LCC functionality to life.
    - It's the hub for LCC communication, storing configurations, and managing LCC event handling.
  - In the OpenLCB vision, Nodes are designed to be self-sufficient, globally identifiable, and capable of peer-to-peer interaction.
- **LCC Node ID**
  - A distinctive 48-bit hexadecimal identifier for each LCC Node (e.g., 05.01.01.01.5C.60).
  - Every Node mandates a unique Node ID, which is utilized by its firmware.
  - The NMRA LCC assigns a unique set of Node IDs to ensure global uniqueness, akin to an ID assigned by Pat Fleming.
- **CDI – Configuration Description Information**:
  - This details the Node's functions and the configurable settings for connected devices.
  - It's designed to be stored within the Node for persistent reference.

UNDERSTANDING LCC VOCABULARY (CONT)

- **Events**
  - These are specific occurrences within a layout, like a button activation or a clock ticking.
  - The Node firmware, built on the LCC OpenMRN framework, manages these events.
  - Events enable communication among Nodes, even if they are from different producers.
- **Event ID**
  - This is a 64-bit code that gives each event a unique identity, displayed as a hexadecimal value (e.g., 05.01.01.01.5C.65.44.55).
  - They're handled through the Configuration Tool and can be reassigned as needed.
  - It’s important to note that often the same Event ID can be shared between producers and consumers, streamlining the action-response cycle.
- **Producer**
  - This is any device or Node that generates an Event ID when triggered,
  - such as a sensor detecting a train or a switch machine moving the points.



- **Consumer**
  - This is any device or Node that performs an action in response to an Event ID, like a signal changing its aspect or a turnout moving.

LCC APPLICATIONS

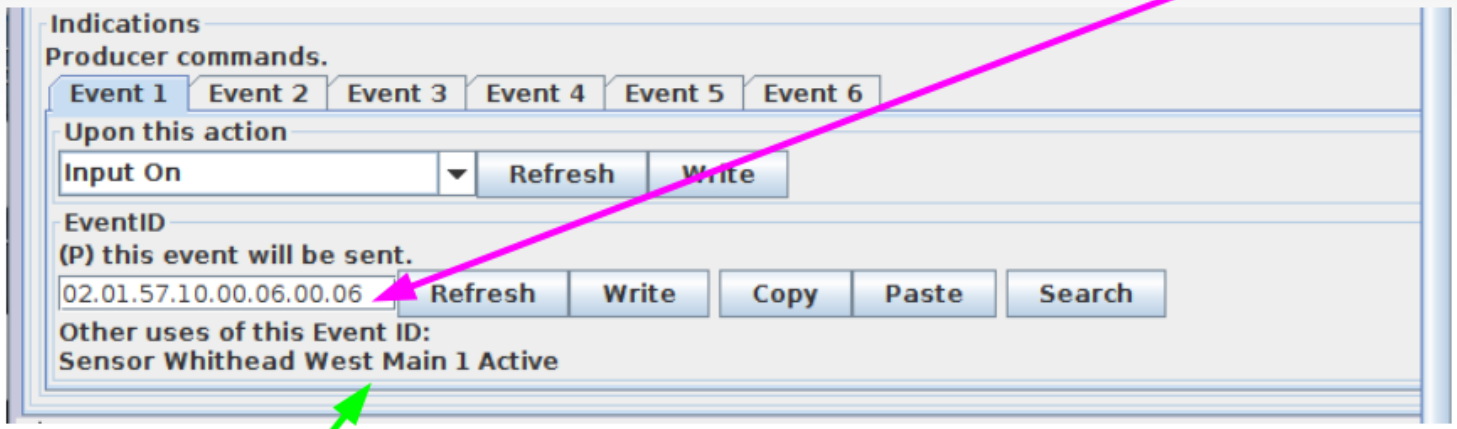
- **Automated Signal Control**: LCC facilitates sophisticated signaling systems that react to train movements, turnout positions, and other trackside conditions, enhancing realism on the layout.
- **Turnout and Switch Machine Operation**: Operators can control turnouts remotely using LCC, allowing for seamless routing of trains through complex track arrangements without manual intervention.
- **Block Detection and Reporting**: LCC can be used to monitor train occupancy on different sections of the layout, providing vital information for automated control and dispatching.
- **Layout Lighting and Effects**: With LCC, modelers can synchronize layout lighting, including streetlights and buildings, to simulate day/night cycles or to respond to train movements.
- **Integrated Scenery Elements**: LCC enables control over animated scenery elements such as crossing gates, barriers, and industrial automation, like moving cranes or loaders in a freight yard.
- **Distributed Power Control**: Manage and monitor the power distribution to various track sections, allowing for sectional shutdowns or power rerouting as needed.
- **Sound System Activation**: LCC can trigger sound effects tied to specific actions or locations on the layout, such as station announcements when a train arrives.
- **Scalable Layout Expansion**: As a layout grows, LCC allows for easy integration of new modules and control devices, maintaining consistent operation across all sections.
- **Cross-Platform Integration**: LCC's open standards allow for integration with different control systems and software, facilitating a mix-and-match approach to layout automation.
- **User Interface Customization**: LCC supports the development of custom user interfaces, such as handheld controllers or touch panels, tailored to the specific needs of the layout operator.
- **Troubleshooting and Diagnostics**: With bi-directional communication, LCC can provide feedback for diagnostic purposes, helping to quickly identify and resolve issues with trackside devices.
- **Modular Layouts**: LCC simplifies wiring and setup for modular layouts, making it easier to connect and disconnect sections while maintaining consistent control across the entire system.
- **Event-Driven Operations**: LCC allows for complex event-driven operations, where specific actions on the layout can trigger predefined sequences, enhancing the automation and interactivity of the model railroad.

CONFIGURATION EXAMPLE
BLOCK DETECTION (INPUT)

- Input (Produc[er) Events

Configuration – INPUT (BLOCK DE...

We now go to the Indications (Producers) for this line, and enable two events. The first (Event 1) will be sent when the Input is 'On' (goes low in our application) When we need to know if the block goes occupied, we will use this EventID.



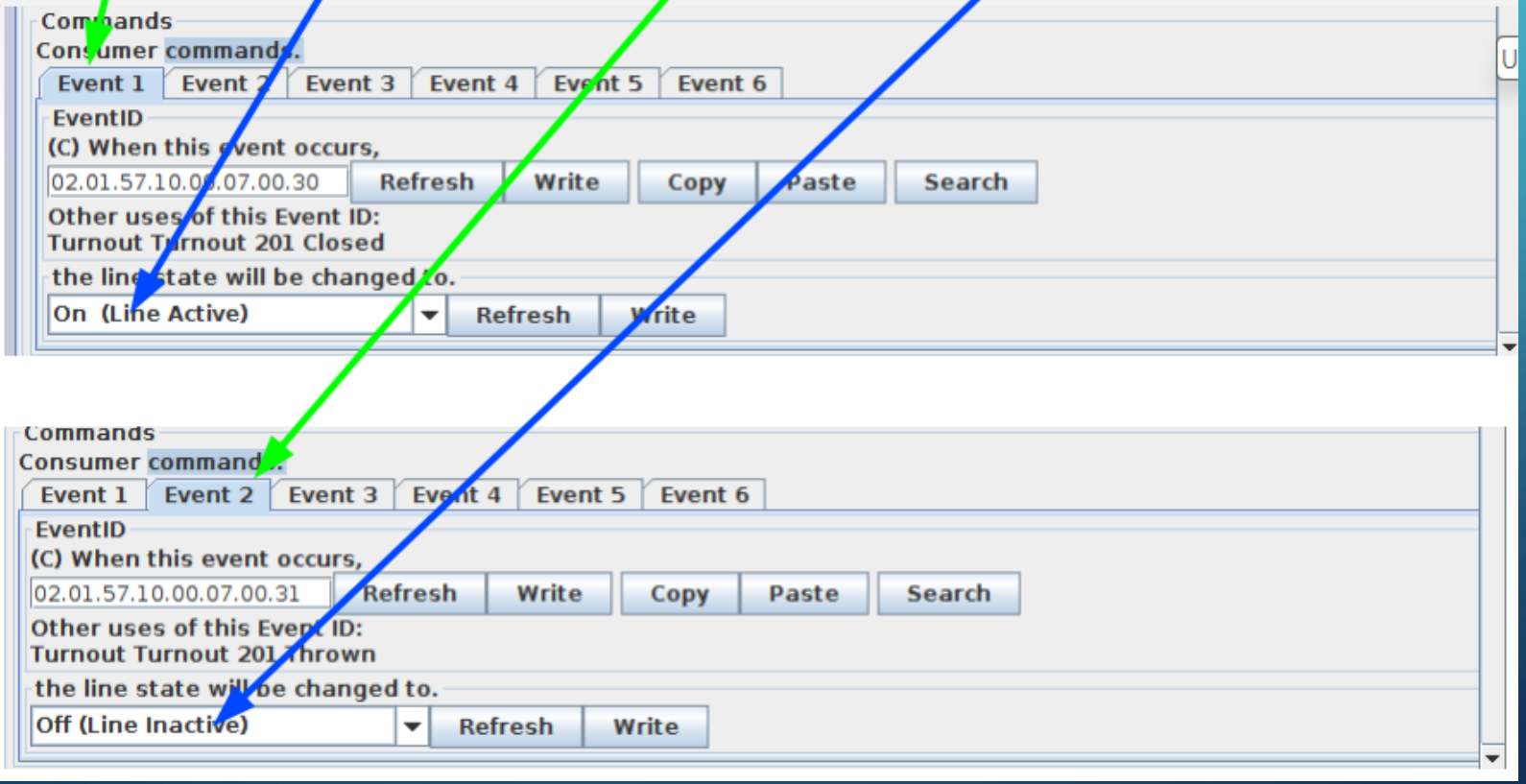
Event 2 will be set to 'Input Off'. Use 'Copy' and 'Paste' when you need to utilize the magic numbers (EventID) for these events. Its description 'Whithead West Main 1' Is noted here to remind you of its function. We can search on this name when we need to use this event in some logic. This information is known because I made a JMRI sensor that follows it. This is a JMRI feature available in the JMRI CDI tool.

Source: RR-Cirkits.com – Dick Bronson – Signaling Clinic Presentation

CONFIGURATION EXAMPLE
TURNOUT (OUTPUT)

- Output (Consumer) Events

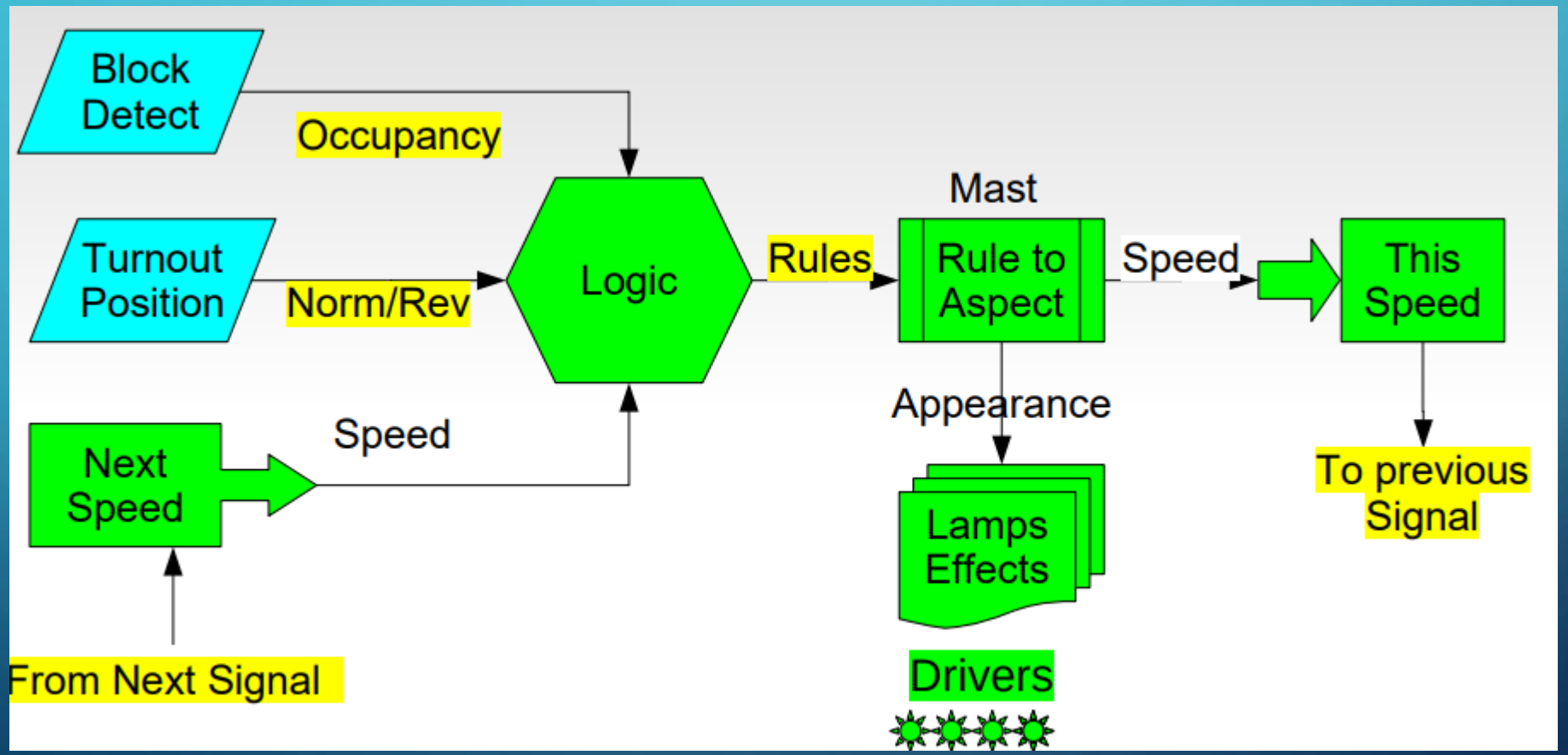
Event 1 will turn 'On' the line and event 2 will turn it 'Off'. Remember we alrea
specified that 'On' just sends a 100mS pulse, so our coils are safe.



Source: RR-Cirkits.com – Dick Bronson – Signaling Clinic Presentation

CONFIGURATION – SIGNAL LOGIC

- Signaling incorporates many of the LCC features and capabilities; detection, control, and logic
- Logic are conditionals (if-then-else like) to determine the appearance of a signal head
- For example: when the next block is occupied, set the Aspect to Stop (Red lamp)



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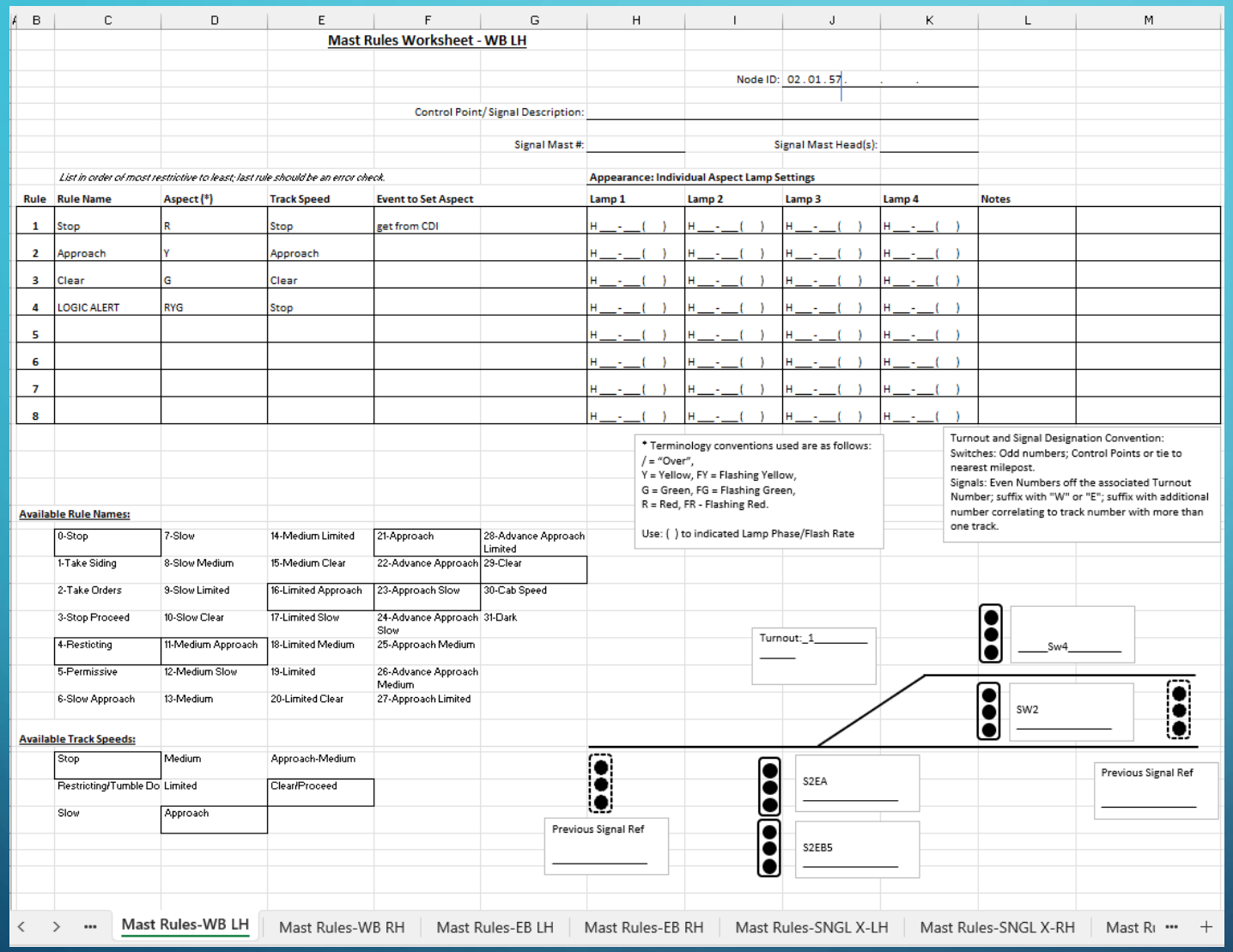
PLANNING FOR SIGNALS



Mast Rules Worksheet - WB LH

Node ID: 02 . 01 . 57 . . .

Control Point/Signal Description: _____

Signal Mast #: _____ Signal Mast Head(s): _____

List in order of most restrictive to least; last rule should be an error check.

Rule	Rule Name	Aspect (*)	Track Speed	Event to Set Aspect	Appearance: Individual Aspect Lamp Settings Lamp 1	Lamp 2	Lamp 3	Lamp 4	Notes	
1	Stop	R	Stop	get from CDI	H___-___( )	H___-___( )	H___-___( )	H___-___( )		
2	Approach	Y	Approach		H___-___( )	H___-___( )	H___-___( )	H___-___( )		
3	Clear	G	Clear		H___-___( )	H___-___( )	H___-___( )	H___-___( )		
4	LOGIC ALERT	RYG	Stop		H___-___( )	H___-___( )	H___-___( )	H___-___( )		
5					H___-___( )	H___-___( )	H___-___( )	H___-___( )		
6					H___-___( )	H___-___( )	H___-___( )	H___-___( )		
7					H___-___( )	H___-___( )	H___-___( )	H___-___( )		
8					H___-___( )	H___-___( )	H___-___( )	H___-___( )		

* Terminology conventions used are as follows:
/ = "Over",
Y = Yellow, FY = Flashing Yellow,
G = Green, FG = Flashing Green,
R = Red, FR - Flashing Red.

Use: ( ) to indicated Lamp Phase/Flash Rate

Turnout and Signal Designation Convention:
Switches: Odd numbers; Control Points or tie to nearest milepost.
Signals: Even Numbers off the associated Turnout Number; suffix with "W" or "E"; suffix with additional number correlating to track number with more than one track.

Available Rule Names:

0-Stop	7-Slow	14-Medium Limited	21-Approach	28-Advance Approach Limited
1-Take Siding	8-Slow Medium	15-Medium Clear	22-Advance Approach	29-Clear
2-Take Orders	9-Slow Limited	16-Limited Approach	23-Approach Slow	30-Cab Speed
3-Stop Proceed	10-Slow Clear	17-Limited Slow	24-Advance Approach Slow	31-Dark
4-Restricting	11-Medium Approach	18-Limited Medium	25-Approach Medium	
5-Permissive	12-Medium Slow	19-Limited	26-Advance Approach Medium	
6-Slow Approach	13-Medium	20-Limited Clear	27-Approach Limited	

Available Track Speeds:

Stop	Medium	Approach-Medium	
Restricting/Tumble Do	Limited	Clear/Proceed	
Slow	Approach		

Turnout:_1_____
_____

_____Sw4_____

SW2
_____

S2EA
_____

S2EB5
_____

Previous Signal Ref
_____

Previous Signal Ref
_____

Mast Rules-WB LH | Mast Rules-WB RH | Mast Rules-EB LH | Mast Rules-EB RH | Mast Rules-SNGL X-LH | Mast Rules-SNGL X-RH | Mast Ri

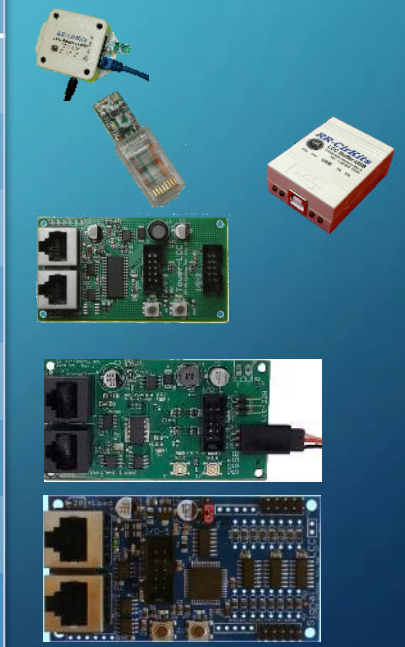
Source: The-LCC-Channel, Detlef Kurpanek

- TLC #13 video: https://www.youtube.com/watch?v=I5a-frZv0sg&list=PLaVRheJZ60pPkUZOzWV2GM_mgPnEiN4Vo&index=14
- File: https://gnwrwy.com/lcc-resources/"

PRODUCTS: RR-CIRKITS

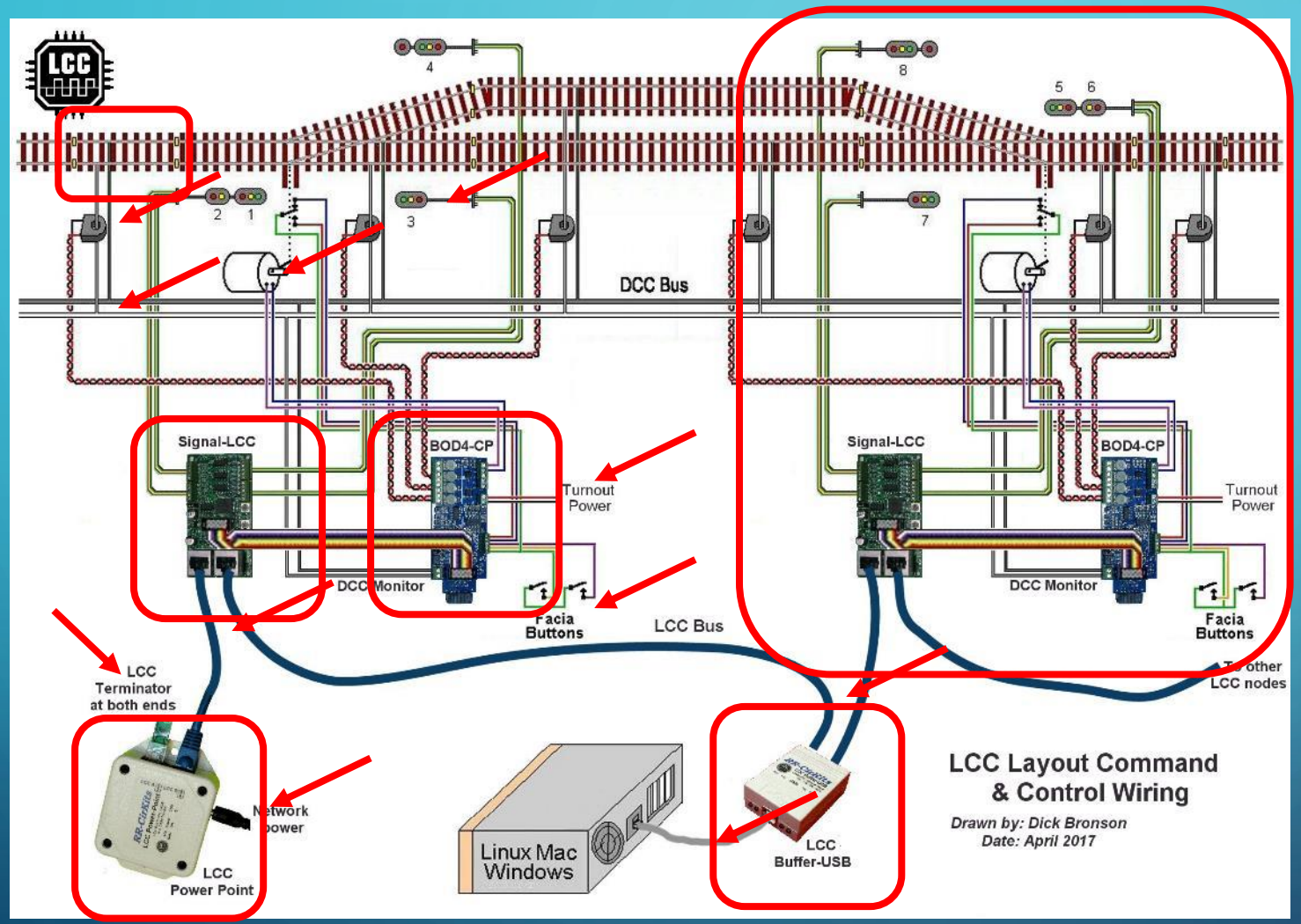
- RR-CirKits by Dick Bronson - https://www.rr-cirkits.com/
- Products: http://rrcirkits.com/description/index.html
  - Manuals: http://rrcirkits.com/manuals/

Product	Usage
LCC® Power-Point	Provides power to the Node and it's devices
LCC Terminator Pair	Terminates CAN bus (network), required at each end of network
LCC Buffer-USB	Connects CAN bus to a computer
LCC Start Kit	LCC Buffer-USB, Power-Point, 2 terminators, cables
Tower LCC	LCC Node with 16 Input/Output controls
Signal LCC-32H	LCC Node with 32 Signal head controller + 8 I/O controls
Signal LCC-P	LCC Node with 16 Led drivers + 8 line I/O controls
BOD4-CP	(4) Block Occupancy Detector + (2) Turnout driversBOD4-CP
And More…	



Source: http://rrcirkits.com/description/index.html

PRODUCTS: RR-CIRKITS (CONT)



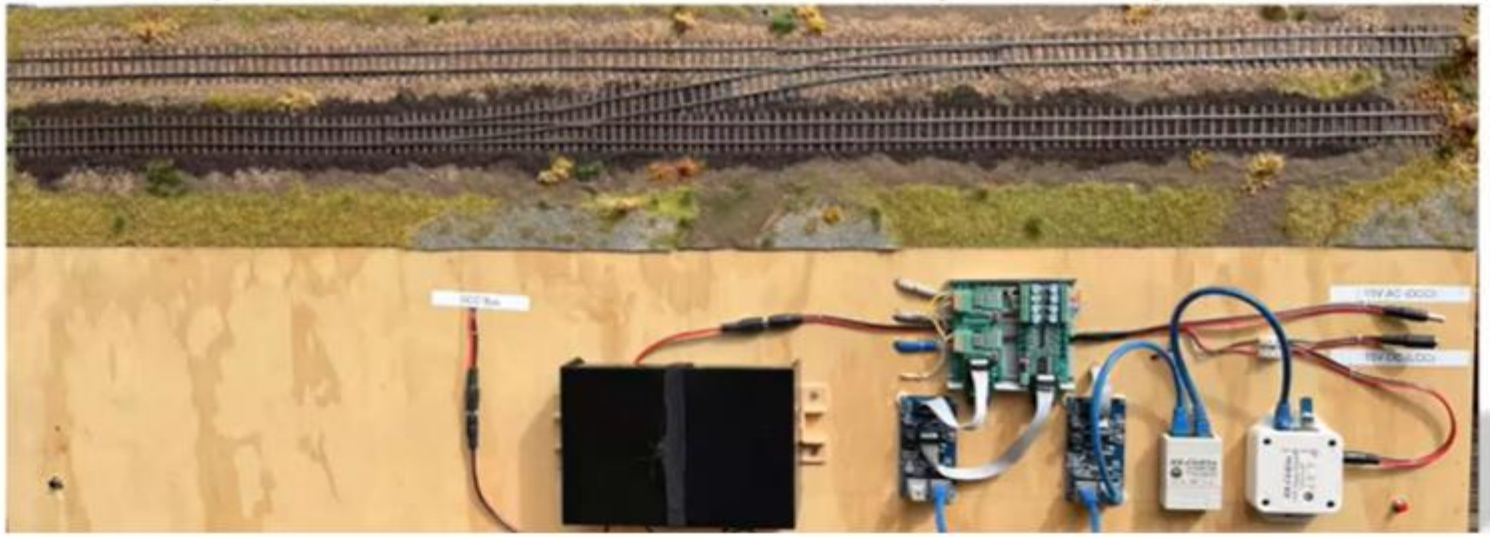
1. LCC Power Point (device)
   - DC Power
   - LCC Bus (CAN out cables)
2. LCC Terminators
3. LCC Buffer-USB (device)
   - Computer interface
   - LCC Bus (CAN in/out cables)
4. BOD4-CP (device)
   - Current Transformers (CT)
   - Track Blocks
   - DCC Bus
   - Turnout Motor
   - Turnout Power
   - Facia Buttons (controls turnout)
5. Signal-LCC (device)
   - Signal Heads
6. 2nd LCC Node and Devices

Source: https://www.rr-cirkits.com/wiring/

LCC LAYOUT DEMONSTRATION MODULES

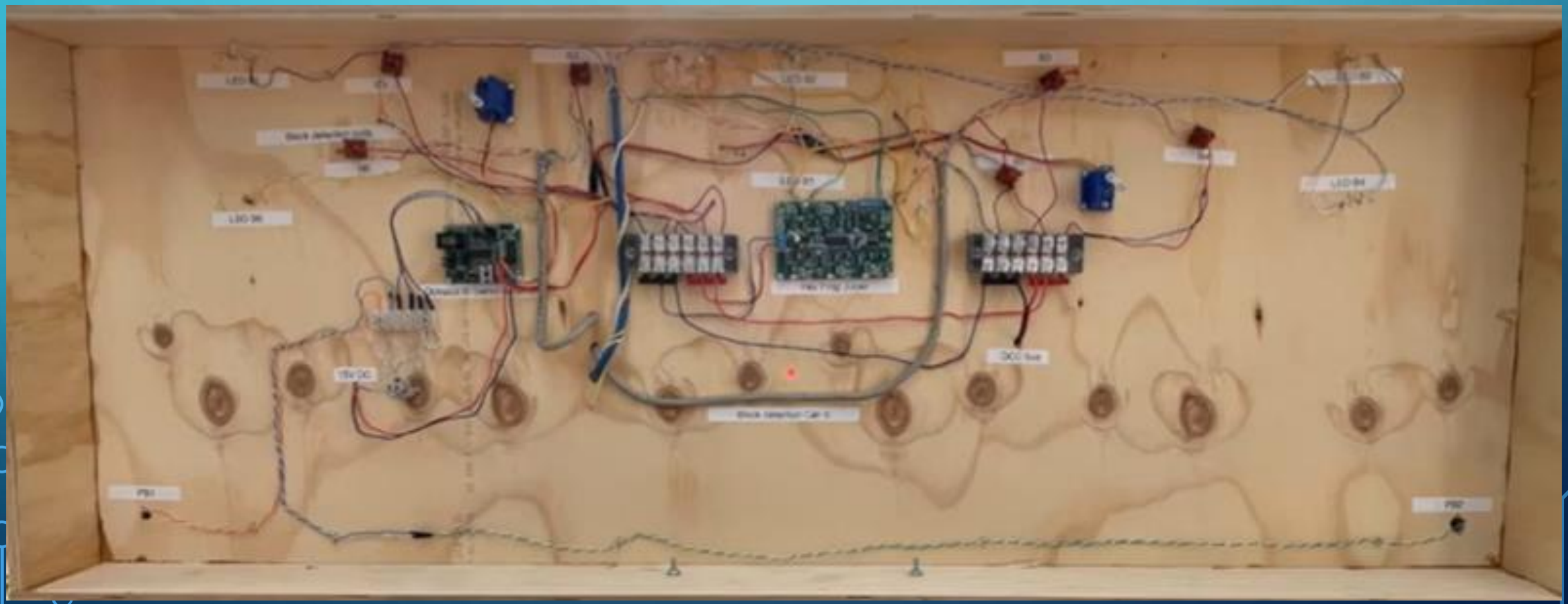
Example: LCC Evaluation Module

- Simple evaluation / test module in Sn3 (48" x 18"):
  - Added basic ground cover!
- NCE command station (centre) attached with Velcro
- Simple power connectors for DCC & LCC (bottom right):
  - 15V DC for LCC and Octopus III (servo controller)
  - 15V AC for NCE DCC command station
  - Aim: make this transportable for demos
- Block detection via current detection coils:
  - Block occupancy indicated by LEDs, hidden in bushes
- Turnouts operated by servos via Octopus III controller:
  - LCC connected to the Octopus III
  - Frog polarity controlled by a Tam Valley Frog Juicer
- LEDs to indicate turnout position:
  - 2 x pushbuttons to operate crossover. Either toggles crossover



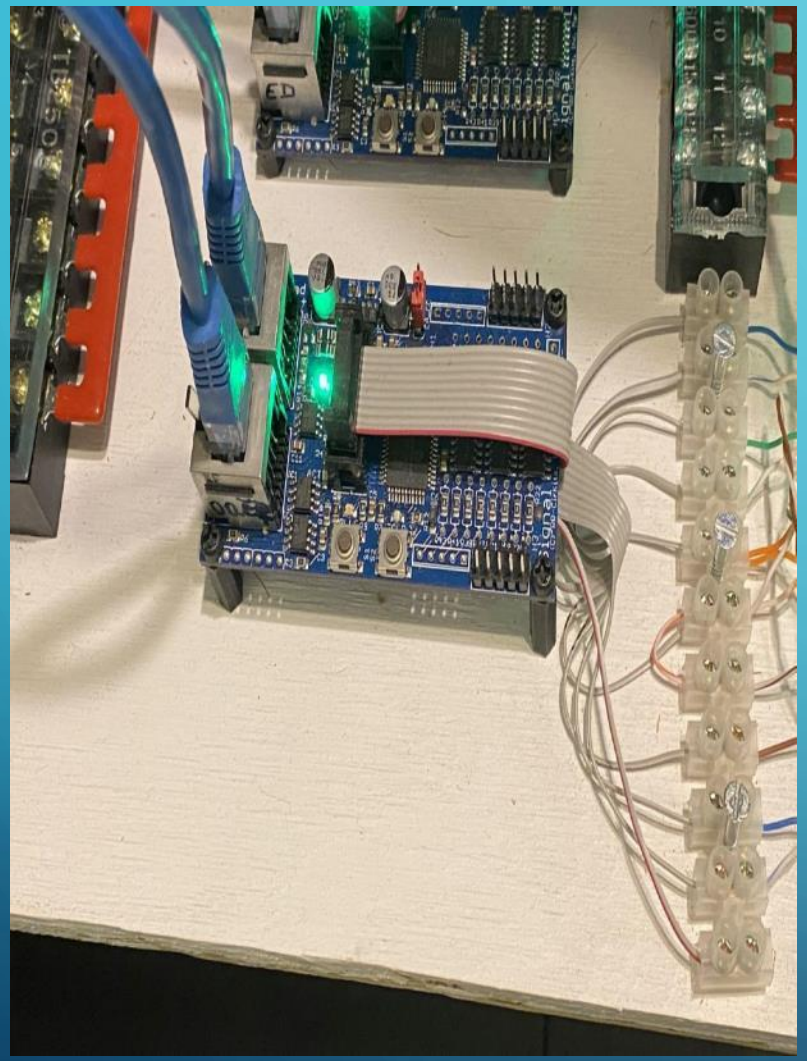
Source: Robin Peel, YouTube Video: https://www.youtube.com/watch?v=jjaNdu0cgaE

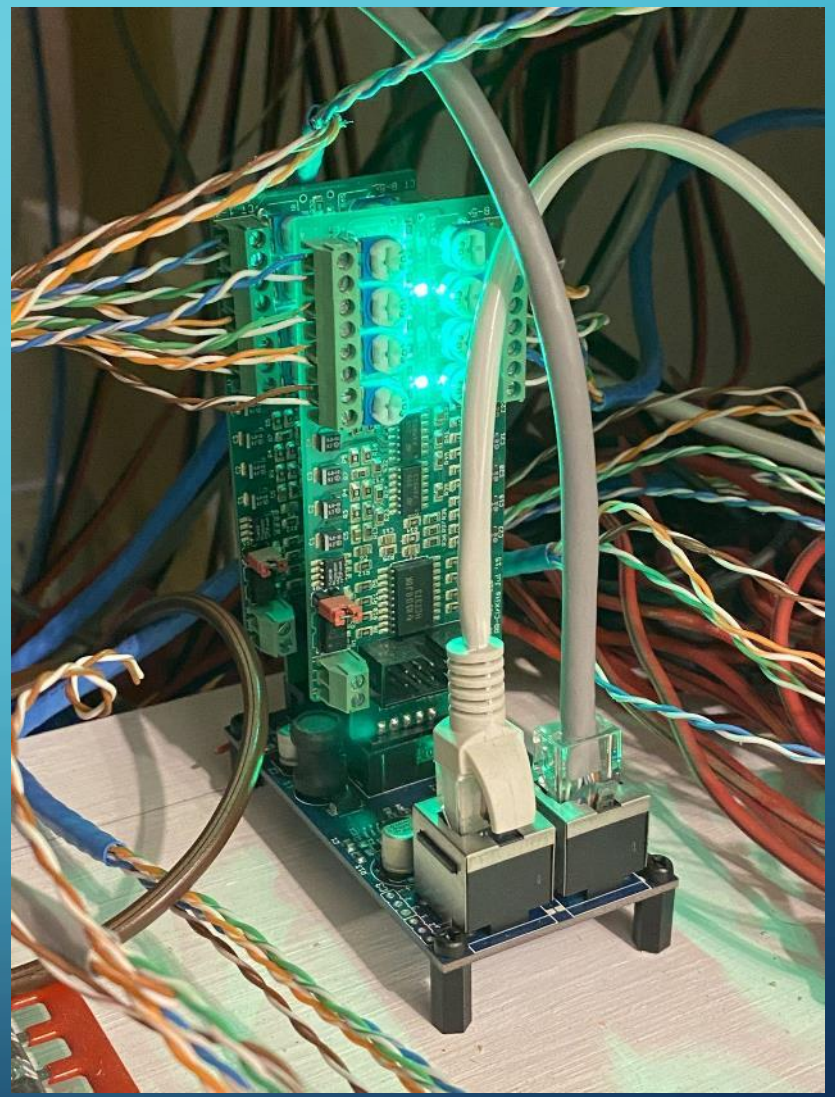
LCC LAYOUT DEMONSTRATION MODULES (CONT)



Source: Robin Peel, YouTube Video: https://www.youtube.com/watch?v=jjaNdu0cgaE

PRODUCT INSTALLATION: RR-CIRKITS (CONT)





Source: https://www.rr-cirkits.com/wiring/

OTHER PRODUCTS & PROJECTS

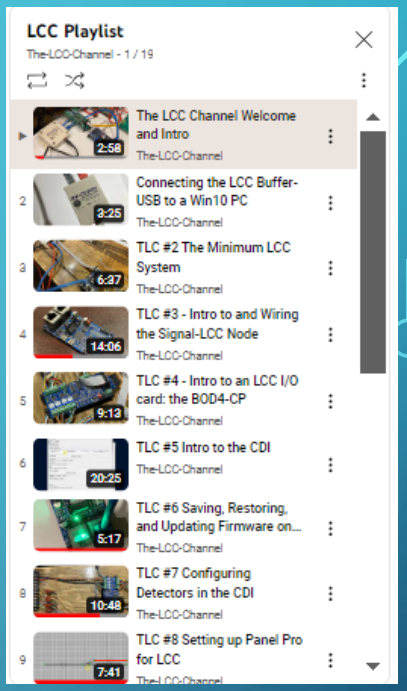
- TCS CS-105 by Train Control Systems, https://www.tcsdcc.com/cs-105
  - Announcement: https://www.youtube.com/watch?v=hswuW1iz-Co
  - The-LCC-Channel Overview: (Detlef Kurpanek, https://www.youtube.com/watch?v=BfaoZgjfcBg)
  - Command Stations that supports both DCC and LCC
  - Supports DCC wired throttles; NCE, Lenz, SystemOne, and more
  - Provides two RJ45 sockets for LCC (CAN connections)
    - Up to 300 macros to control both DCC and LCC accessories (generates LCC Events), LCC Wi-Fi throttles (wired, Wi-Fi)

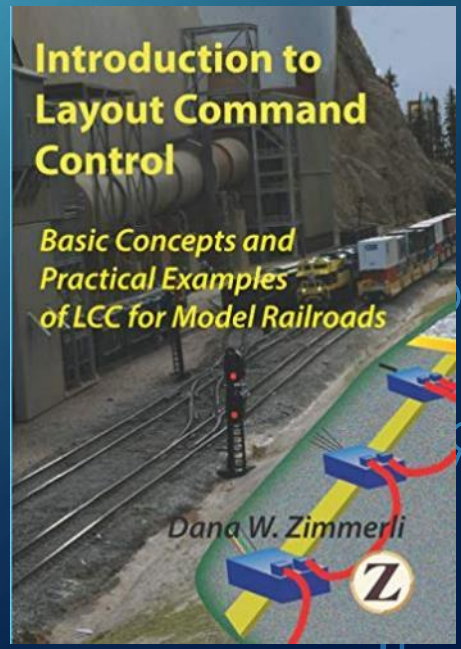
- MRC Nexxt Gateway
  - New product, discussion: https://www.trainboard.com/highball/index.php?threads/new-mrc-products-announced-at-amherst-rail-show.154111/#post-1289975
  - Support for LCC throttles, LCC Wi-Fi modules and upgrades
  - Plugs into Prodigy Cab Bus, providing Wi-Fi access via LCC or WiThrottle protocols to existing Prodigy systems
- LCC Fast Clock by Logic Rail™ Technologies
  - Configure to generate LCC events to LCC Nodes based on Fast Clock times. https://www.logicrailtech.com/xcart/product.php?productid=16355&cat=0

- Light EFX-16 by Logic Rail™ Technologies
  - Generate > 30 lighting effects via LCC Events or DCC commands. 16 outputs. https://www.logicrailtech.com/xcart/product.php?productid=16357&cat=&page=1
- LccTools by Bob Jacobsen, https://apps.apple.com/us/app/lcctools/id1640295587
  - Mac/iPhone/iPad app for configuring and operating LCC from Apple devices
  - Throttle – works with TCS CS-105 to control locomotives
  - Send events, configure CDI, monitoring of LCC bus activity, and more
  - Use Wi-Fi LCC network hub from TCS CS-105, JMRI, and others
- Model Railroad Systems by Deepwoods Software, Robert Heller, https://www.deepsoft.com/home/products/modelrailroadsystem/
  - LCC software, hardware designs, and DIY Kits
- CUE X by Rick Lull
  - DIY Kit for an LCC Node to control Track Siding

LCC EDUCATION RESOURCES

1. Tip: Search 'LCC' on youtube.com
    1. Introduction to Layout Command Control (LCC) (Robin Peel, https://www.youtube.com/watch?v=jjaNdu0cgaE)
    2. LCC – Best Way to Move Points (Jeff Gerow, https://www.youtube.com/watch?v=5GcjrlOH1ds&t=2203s)
    3. Layout Command Control (Detlef Kurpanek)
        - LCC Channel – 20 videos (introduction to configuration of signals) – highly recommended
        - Video Playlist: https://www.youtube.com/watch?v=Cx4hxv0-GJ8&list=PLaVRheJZ60pPkUZOzWV2GM_mgPnEiN4Vo
    4. LCC for the Rest of Us (Dick Bronson, RR-CirKits Inc)
        - Part 1(overview)
        - Part 2 (details)
2. An Introduction to Layout Command Control (Dana W. Zimmerli, PhD 2019)
    - Recommend, in depth with examples, Amazon - $30
3. OpenLCB Group
    - Website: https://openlcb.org/#
        - Knowledge base (technical and standards docs)
    - User Groups:
        - Discussions on using and configuring LCC products
        - Website: https://groups.io/g/layoutcommandcontrol
        - Subscribe: layoutcommandcontrol+subscribe@groups.io
4. Discord NMRA Interchange
    - #lcc channel
5. NMRA https://www.nmra.org/lcc (docs and FAQs)





LCC FUSION PROJECT

An LCC DIY Open Source project by Pat Fleming

LCC FUSION PROJECT: WHY?

- Exploit Model Railroading electronics, an area of interest
- Grow LCC awareness and usefulness
- Enhance Model Railroading Layout Automation (watch Miniatur Wunderland videos for ideas)
- Example:
  - Train Station:
    - Train approaches a train station and based on the fast clock time, slows down, provides horn/bells, and stops at the train station.
    - Announcements occur and engine powers down
    - Later, train resumes after signaling with bells / horn
    - Automation: requires clock events and block occupancy events to control DCC and track power.
  - Routes:
    - While operations are occurring, several trains are running continuously on changing routes and using warning signals at tunnels, crossings, yard, station.
  - Sounds:
    - Add sound for more realistic layout. Sounds in woods, industry, stations, city, streets, etc.

PROJECT GOALS

- For LCC DIY's
- Support additional I/O devices
- Reduce wiring complexities (Wi-Fi, use of CAT network cables)
- Exploit Espressif ESP32 low-cost and capabilities (Bluetooth, Wi-Fi, Touch Pads, I2C, CAN, etc.
- Open Source of both hardware and software (Github downloads)
  - Hardware PCB design files (Gerber files), ready for PCB fabrication)
  - Software source and binaries
  - Documentation:
    - Hardware: ordering PCBs, assembly of PCBs
    - Software: CDI configuration

LCC FUSION PROJECT

- Project Components
  - LCC Fusion Framework – consistent and architected approach to the project
- LCC Fusion Framework (conceptual, guidelines)
  - Interoperable with all other LCC products/projects (support CAN, Events, Configuration Tools)
  - Designed for enhancements
  - Hardware
    - Consistent PCB form factor for 'Cards' and 'Breakout Boards'
    - Introduces LCC Node Bus for direction connection between Node Card and I/O cards
    - Expandable Node Bus Hub (much like a computers PCI bus, or USB hub)
    - LCC Node Cluster (Node Card with physically connected I/O Cards)
    - Virtual LCC Node Cluster (Node Card with Wi-Fi connected I/O Cards to allow for wireless movement of I/O cards)
  - Software
    - Simplified use of OpenMRN stack software (new C++ object wrapper)
    - Many examples of producers and consumers
    - Support for a virtual cluster using ESP32-NOW (simplified Wi-Fi)
    - Support for I2C connectivity
  - Documentation
    - Tools: Doxygen (code), Markdown (non-code), GitHub.io (landing page), Hyde (publication)
    - Covers: DIY PCB assembly, planning, software configuration, etc.

LCC FUSION PROJECT

- LCC Fusion Connect (implementation)
  - Hardware and software implementation for the LCC Fusion Project
  - Software
    - LCC Node firmware – includes all I/O devices supported
    - I/O device firmware – some devices require an ESP32 to control devices (e.g. MP3 Players)
    - Windows Installer – customize LCC Node configuration (wizard based)

GOALS

- Modular PCB Design
  - I/O specific PCB ‘cards’, matched to specific breakout boards
  - Simplified wiring
  - Distributed connectivity (centralized cards connected to remote breakout boards)
- Plug & Play
  - Auto detection of I/O cards being connected
- Scaling of a Node I/O support (lots of ‘cards’ per Node)
  - Custom Node Bus Hub (backplane) supporting both centralized and distributed I/O card
- Advanced Automation
  - Crossing Grade; train detection and direction, move crossing arms, blink signal lights, crossing arm lights, slow down train (DCC), sound bells/horn
  - Station; similar to crossing grade, detection, train controls (slow, stop, bells/horn), station sounds

LCC FUSION CONNECT: LCC NODE CLUSTER

1. Node Bus Hub
   - Connectors: 6x total (3 front, 3 back)
   - Hub-to-Hub Expansion (local)
   - Hub-to-Hub Expansion (remote)
2. LCC Node Card
   - CAN Communications
   - CAN Network Connections
   - Power Regulators (3v3, 5v, 12v)
   - ESP32 /w firmware
3. Sound Card
   - MP3 Players (3)
   - ESP32 (controls players)
   - Speaker Connector (RJ45)

- Raspberry PI – CAN Card
  - RPI 4
  - CAN Communications (MCP2515 Module)
  - JMRI (to LCC Node Card)
  - Wi-Fi (to computer)

I/O CARDS

Card	Specifications (MAX of 16 cards per type)	Use Case
Node Card	CAN connections, 8x I/O lines, Bluetooth, Wi-Fi, Alexa voice support, provides power, and I2C.	Required, Implements LCC support via ESP32 and firmware. Connects to input devices (sensors, buttons, etc) and output (relays, LEDs, etc). Communications with other LCC Nodes (wired or wireless), Bluetooth to phones (admin)
Output Card	16x output lines	Consume LCC events to drive output devices on/off (relays, LEDs, etc)
Input Card	16x input lines	Connect to input devices to produce on/off LCC events based on input from switches/sensors
I/O Card	16x input / output lines	Connect to input devices to produce on/off LCC events based on input from switches/sensors Consume LCC events to drive output devices on/off (relays, LEDs, etc)
Button Card	16x input lines	Connect to buttons to produce on/off LCC events based on mechanical buttons pushes (debounce)
Touch Pad Card	12x touch pads	Connect to capacitive touch pads to produce on/off LCC events based on touch
Block Occupancy Detection (BOD) Card	8x Block Detections	Connect to track blocks to produce LCC events based on occupancy (occupied, not occupied)
Positional Occupancy Detection (POD) Card	4x Position Detection	Place optical sensor between ties to produce LCC events based on exact position of cab/cars
Switchable Circuit Overload Detection (SCOD) Card	8x Track Blocks	Connect to track blocks; Consume events to turn current power on/off • Produce LCC overload event when circuit overload detection occurs
Turnout Card	8x turnout motors (stall, twin-coil)	Connect to turnout; Consumes LCC throw/close events to move turnout point sets • Produces LCC thrown/closed events after point set movement is done
DCC Card	Cab speed, direction, sounds	Consume LCC events to control train speed, direction, and sounds (horn, whistle, bells sequences)
Sound Card	4x MP3 Players	Consume LCC events to select and play/pause MP3 files thru layout speakers
PWM Card	16x PWM Devices	Consume LCC events to control Lamp LEDs (on/off, blink, brightness), Servo Motors, DC Motors, NeoPixels strips
Stepper Motor Card	4x Stepper Motors	Consume LCC events to control stepper motor movements
RFID NFC Card	1x RFID NFC Reader	Produces LCC identification events in the presence of RFID tags (mounted on cabs/cars)
Ultrasonic Occupancy Detection (UOD) Card	15x Sensors	Produces LCC detection events when an object (person) is within configured range of sensor

DOCUMENTATION
USAGE GUIDES

Button Card Usage Guide

Buttons on a model train layout provide tactile control and interaction, enhancing the user experience and allowing for precise operation of various features. Use Cases

Below is an assortment of ways the Button Card can be utilized to operate for your model railroad layout:

Button Use	Description
Start/Stop Trains	Use buttons to manually start or stop trains on various tracks.
Change Train Directions	Allow operators to change the direction of a train's travel.
Activate Sound Effects	Trigger sound effects like train whistles, station announcements, or ambient noises.
Control Lighting Effects	Turn on or off specific lighting elements, or change lighting scenarios (e.g., day to night).
Operate Turnouts	Switch the rail turnouts to direct trains to different tracks.
Animate Scenery	Activate moving parts in the scenery, such as opening bridge, rotating windmill, or animated figures.
Control Level Crossings	Operate gates and signals at level crossings manually.
Activate Special Effects	Trigger special effects like smoke from chimneys, fire scenes, or water effects.
Emergency Stop	A safety feature to immediately stop all trains and moving parts in case of an issue.
Cycle Through Scenes	Change between different scenes or layouts, for modular train setups.
Activate Display Lights	Control additional lighting for display purposes, not part of the layout's operational lighting.
Launch Automated Sequences	Start a sequence of events, like a complete train journey with multiple actions.

Usage Guides

- One for each PCB
- Help generate ideas for the card
- Covers possible uses of the I/O card

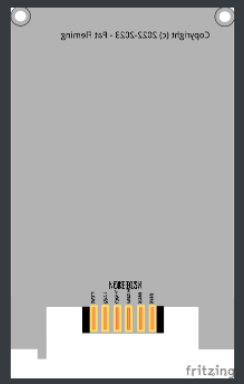
DOCUMENTATION
ASSEMBLY GUIDES

Assembly Guides

@tableofcontents

Assembly Guides {#assembly_guides}
Breakout Boards
Additional Materials:
Supplies
Informational Guides
How to Guides

Cards are PCB (boards) that provide specific functions for adding layout automation. Cards are connected together using a **Node Bus Hub** to form the project's **Node Cluster.** Each cluster requires one Node Card to run the firmware for the LCC Node.



Included below are the assembly guides for cards:

- Node Bus Hub - integrates multiple cards for assembling an **LCC Node Cluster.**
- Output Card - supports adding output device controls (LEDs, etc.)
- RPI-CAN Card - supports RPI, JRMI, and CAN integration into the LCC Node Cluster (no additional wiring)
- Sound Card - supports adding sounds to the layout using MP3 players.

Breakout Boards

-

Additional Materials:

Supplies

Assembly Guides
- One for each PCB
- Usage examples
- Specifications
- How it works (steps/diagrams)
- List of components
- Tools required
- Assembly instructions
- Testing / Verification

BACKUP

WHY ISN'T LCC PART OF DCC?

- **Separate Communication Systems**:
  - LCC is designed as a complementary system to DCC, providing a separate communication network specifically for accessories and layout control.
  - DCC is primarily focused on controlling the locomotives on the track, including speed, direction, and functions like lights and sound.
- **Different Control Objectives**:
  - LCC handles layout automation, including signals, turnouts, and other non-locomotive elements, which are not the primary focus of DCC.
  - DCC provides a direct control method for locomotives, but LCC offers a more flexible and scalable solution for managing layout infrastructure.
- **Bidirectional Communication**:
  - LCC supports bidirectional communication allowing for feedback and status updates from various devices on the layout, which is not a standard feature in traditional DCC systems.
  - This feedback mechanism in LCC facilitates more complex automation and monitoring of layout components.
- **Interoperability and Standardization**:
  - LCC is designed with interoperability in mind, ensuring that products from different manufacturers can work together seamlessly, which has been a challenge with proprietary DCC accessory decoders.
  - The NMRA standards for LCC aim to create a universal language for layout control, which is independent of the DCC protocols.
- **Enhanced Layout Management**:
  - LCC provides advanced features for layout management, such as event-driven operations and simplified wiring, which go beyond the capabilities of DCC accessory decoders.
  - The system is designed to be future-proof, allowing for updates and expansions without the need for physical access to the hardware, unlike many DCC components.
- **No Centralized Control Requirement**:
  - LCC operates on a peer-to-peer network, eliminating the need for a centralized command station, which is a core component of DCC systems.
  - This decentralized approach of LCC enables more robust and resilient layout operation.

FRITZING FOR CIRCUITS AND PCBS

(HOBBYIST VIEW OF YET ANOTHER "HOBBY WITHIN THE HOBBY")

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NOTE: FOR POWER POINT, USE SLIDE SHOW (FOR LINKS AND SLIDE ANIMATIONS)