Output Card Assembly Guide

LCC Fusion Project

Output Card Assembly Guide

Contents

Introduction

The **Output Card** works in conjunction with the **LCC Fusion Node Card** and **Node Bus Hub** to provide control over up to 16 individual output devices. These devices can be actuated in response to **LCC Events**, allowing for automation and interaction within the layout. The Output Card interprets event IDs generated by sensor-based cards or other event sources, and then controls the corresponding output devices, providing a robust solution for managing lighting, motors, and more within your model train layout or other automated systems.

Through this design, the **Output Card** offers precise **ON/OFF control** for each connected device, enabling seamless interaction between the layout's automation logic and the physical components.

Key Features:

- **Controls up to 16 Output Devices**: The Output Card offers up to 16 output channels, allowing you to control a wide range of devices like LEDs, relays, motors, and more.
- **Supports Configuring up to 16 Output Cards per LCC Node**: Each LCC Node can support up to **16 Output Cards**, providing extensive output control for large or complex layouts. This allows up to **256 individual outputs** across a single node, giving users incredible flexibility for controlling multiple devices.
- **Selectable 5V or 12V Output**: Each output can be configured to deliver either **5V** or **12V**, providing flexibility to control devices that require different voltage levels. This makes the Output Card compatible with a variety of low-voltage and higher-power devices.
- **Flexible Voltage Options**: Output can be configured for either 5V or 12V devices, providing versatility for different types of equipment.
- **Configurable Resistor Options**: Choose to use integrated current-limiting resistors or external resistors, depending on the power requirements of your devices.
- **Lines 8 & 16 Flexibility**: The 8th and 16th output line can be configured for standard output control or alternatively used as a ground (GND) connection, adding extra wiring flexibility to the design.

Typical Use Cases:

The **Output Card** can control a variety of devices for model train layouts, industrial automation, or hobbyist projects, offering flexibility and reliability.

Example Devices:

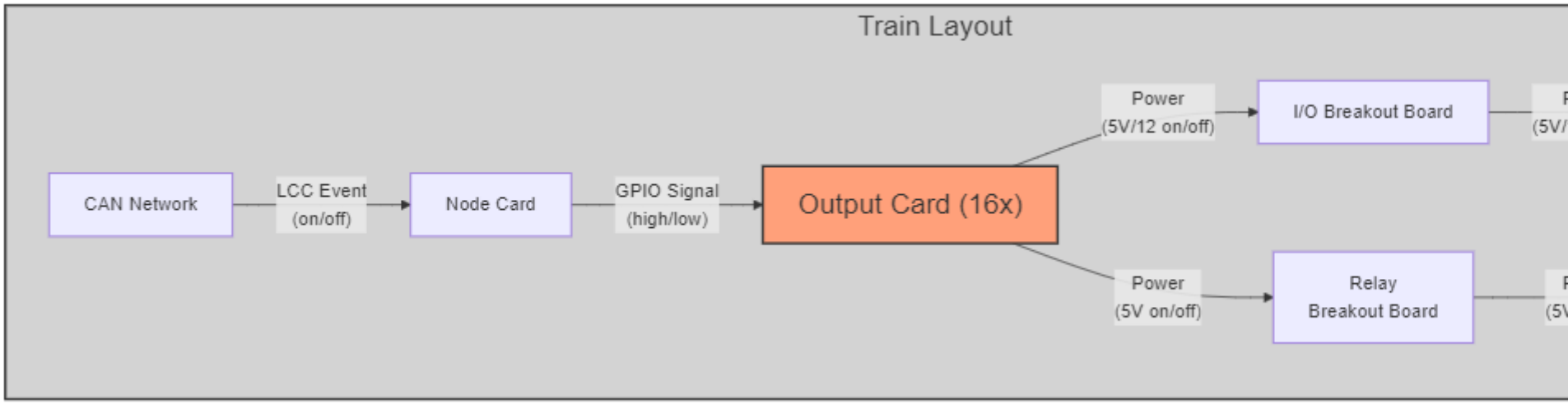
- **LEDs**: Control layout signals, indicators, or lighting effects using simple ON/OFF control.
- **Relays**: Switch larger loads such as lights, track power, or other high-power devices.
- **DC Motors**: Drive small motors for moving elements, such as turntables or gates.
- **Buzzers**: Trigger alarms or audio indicators in response to layout events.
- **Solenoids/Electromagnets**: Control solenoid-based mechanisms like point motors for turnouts or electromagnets for uncoupling systems.
- **Fans**: Activate ventilation systems or cooling fans for system components or scenery effects.

System Overview:

The **Output Card** is part of the **LCC Node** ecosystem and is typically controlled by the **LCC Fusion Node Card**, which processes LCC Events. When a sensor-based card detects an event (such as a train passing, a switch being thrown, or a button being pressed), it generates an event ID. The LCC Node consumes this ID and sends the appropriate signal to the Output Card, which then toggles the corresponding output device ON or OFF based on the event logic.

For example:

- A track sensor detects a train approaching a signal, generating an LCC event.
- The Node Card interprets the event and sends a command to the Output Card.
- The Output Card then turns on an LED to signal "stop" or activates a relay to power a motor or solenoid.



Hardware Configuration Options:

The **Output Card** includes several configurable options, allowing for flexibility in different scenarios:

- **Communication Address**: The card supports two I2C buses (bus 0 or 1) and offers address offsets from 0 to 7, enabling multiple cards to be used within the same node.
- **Voltage Selection**: The output voltage can be configured for either 5V or 12V devices, making it compatible with a wide range of components.
- **Resistor Configuration**: Choose whether to use built-in current-limiting resistors for each output or to use external resistors, depending on the device's power needs.
- **Line 16 Configuration**: Line 16 can either be used as a standard output line or as a ground connection (GND), providing additional flexibility for powering devices.

{% include terminology.html %}

Specifications

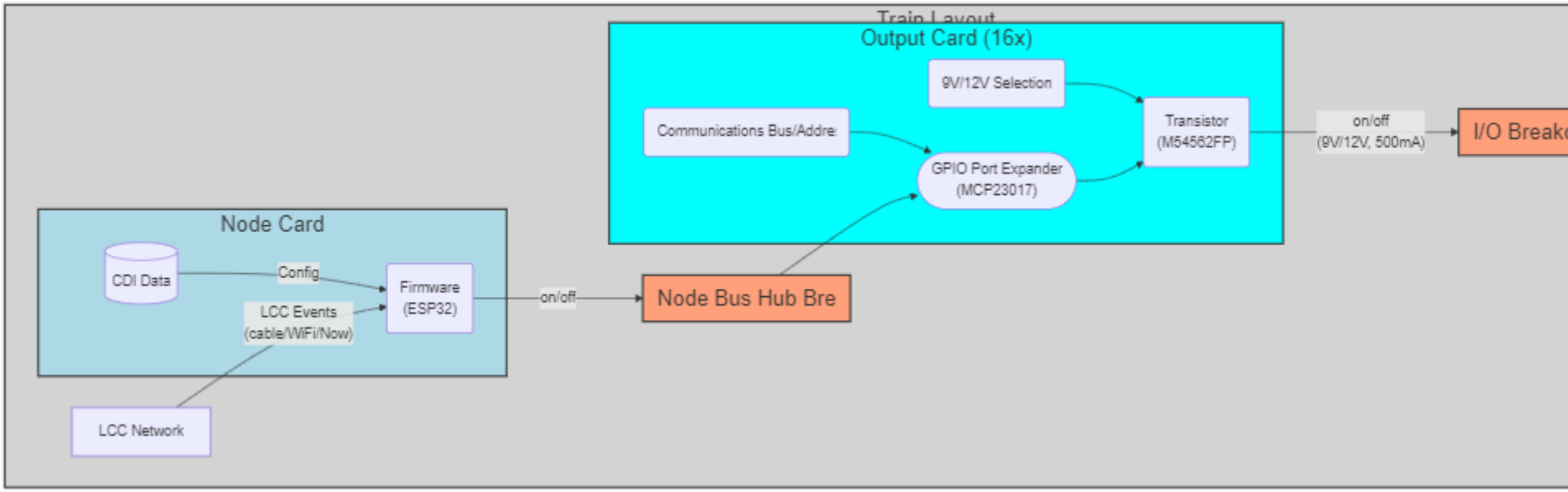
Specifications for the card include:

Characteristic	Value
Max Output Lines	16
Max Output Line (based on M54562FP IC)	500mA
Max Total Output (using Line 16)	16
Maximum Number of Cards per LCC Fusion Node Cluster	161
LCC Fusion Node Bus HubConnectors	12

1. The LCC Fusion Node Cluster can support up to 16 cards, distributed across two I2C hardware buses, with a maximum of 8 cards per bus.
    - Note: total includes all cards using the I2C address range of `0x20` (MCP23017 IC).
2. GND, 5V, 12V (optional), SLA0/SDA0, and SDA1/SCL1 (optional)

How It Works

The following outlines the flow of activity for the Output Card:



The firmware of the LCC Fusion Node Card interfaces with the Output Card's port expander (MCP23017), leveraging the bus and address details specified in the card's CDI I2C section.

Output is performed on a line as follows:

1. Upon receiving an LCC Event-related signal, the LCC Fusion Node Card's firmware dispatches an I2C command to the Output Card, instructing it to set the port state to either HIGH or LOW.
2. The port expander sets the base of the corresponding Darlington Transistor Array's input pin HIGH/LOW, which then switches the current for the corresponding output line HIGH or LOW.
3. The output voltage to the line, either 5V or 12V, is determined by the card's **VOLTAGE** selector switch.
4. The output current to the line is determined by the card's **RESISTOR BYPASS** selection and corresponding line's resistor value.

   The output line must be attached to an output device (LED, etc.) that is grounded to the same common as the LCC Fusion Node Card using either Line 16 or the Accessory Bus.

Connections

Component Designator	**Connector Label**	Connector Type	**Connection Number**	**Description**
J1, J2	OUTPUT DEVICES	RJ45 Socket	1 - 8	Connection to output devices and/or **I/O Breakout Board**
JP1, JP2	COMM BUS	Male Header	A, B	COMM BUS selection (I2C hardware bus) for BUS A or BUS B. Mu
JP3, JP4	LINE 8, LINE 16	Male Header	GND, OUTPUT	LINE 8 and LINE 16 selection to GND or Output. Set to GND whe
JP5	VOLTAGE	Male Header	5V, 12V	VOLTAGE selection for setting Vcc for output lines. Affects all outp
SW1	COMM ADDR	Slide Switch	1, 2, 3	COMM ADDR selection (I2C address offset 0-7). Added to base add
SW2, SW3	REGISTER BYPASS	Slide Switch	1 - 8	Enable/disable current limiting resistors (R1-R16). Used to bypass t

Protection

The Output Card is equipped with several protective components to ensure reliable operation and safeguard the board and connected devices from potential electrical issues. Below is an overview of the protection mechanisms implemented:

Protected Component	**Protection Component**	**Function**
I2C Communication Lines	**PESD1CAN Diode**	Protects the I2C lines from **ESD (Electrostatic Discharge)** and other electrical surges.
I2C Communication Lines	**BLM31 Diodes**	Provides additional protection to the I2C lines by filtering out high-frequency noise and p
I/O Control Lines	**1kΩ Current Limiting Resistors**	Limits the current on the output lines.
I2C Address Selector	**10kΩ Current Limiting Resistors**	Limits the current on the I2C address configuration pins, preventing excessive current fro
MCP23017 Port Expander	**0.1µF Decoupling Capacitor**	Reduces noise and stabilizes the power supply to the MCP23017, ensuring smooth operati

Components List

PCB for the card can be ordered from any PCB fabricator using these Gerber Files.

PCB Components - listing of items used for PCB assembly

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The design of the Output Card includes provisions for integrating current-limiting resistors and an optional bypass feature. These resistors do not have to be 10kΩ as shown on the PCB. Instead, match the resistor to the needs of the devices. For LEDs, see Choosing the Right Resistor for LEDs for additional information.

Below is a list of the PCB components used for this card (see diagram on right for reference):

Component Identifier	Count	Type	Value	Package	Required?	Purpose
Capacitors						
C1	1	Capacitor-Ceramic	0.1uF	1206 SMD	Required	Decoupling Capacitor for IC Protection
Diodes						
D1, D2	2	Diode-Schottky	SS310	SMD	Required	Circuit protection from reverse current from
D3	1	ESD Diode	PESD1CAN	SOT-23 SMD	Optional	I2C data bus electrostatic discharge (ESD) p
Filters & Noise Suppression						
FB1, FB2	2	Ferrite Bead	BLM31PG121SN1L	1206 SMD	Required	I2C Network Bus Data Line Noise Suppressi
Connectors						
J1, J2	2	RJ45 Socket	8P8C	PTH	Required	Network cable (CAT5/6) connection to a br
Resistors						
R1-R16	16	Resistor	1kΩ	1206 SMD	Optional	Limits current to the output device. May be
R17-R19	3	Resistor	10kΩ	1206 SMD	Required	Limits current to SW1 and MCP23017 for I
Selectors & Indicators						
JP1, JP2	2	Male Header	3P, 0.1" spacing	PTH	Required	COMM BUS selection (I2C hardware bus) f
JP3, JP4	1	Male Header	3P, 0.1" spacing	PTH	Required	LINE 8 and LINE 16 selection to GND or C
JP5	1	Male Header	3P, 0.1" spacing	PTH	Required	VOLTAGE selection for setting Vcc for outp
SH1-SH5	5	Jumper Caps	2.54mm	N/A	Required	Used with I2C Bus and Vcc selections. Tall
SW1	1	DIP / Slide Switch	3P, 2.54mm spacing	PTH	Required	COMM ADDR selection (I2C address offset
SW2, SW3	2	DIP / Slide Switch	8P, 2.54mm spacing	PTH	Optional	Enable/disable current limiting resistors (R1
ICs						
U1, U3	2	Darlington Transistor	M54562FP	SOP20	Required	Amplifies low-current signals from MCP2301
U2	1	I/O Expander	MCP23017	SSOP28	Required	Expands I2C serial interface to control 16 G

Tools Required

List of recommended tools.

Safety Precautions

- See Safety Precautions.

Assembly Instructions

Below are the high level steps for assembly of the Output Card:

1. Clean PCB with alcohol to remove residue. See Cleaning_PCB for details.
2. When using a PCB stencil to apply the paste, align the stencil over the PCB using the 2 Tooling Holes located at the top and bottom of the card. There are very small holes with no labels or markings. Use a thick straight pin or wire for the alignment, pushing down into a soft foam surface to hold the pin/wire in place.
3. Apply soldering paste for all SMD components
4. Place SMD components into paste.

Component Identifier	Component (Package)	Required?	Orientation
C1	0.1uF Capacitor (1206 SMD)	Required	None
D1, D2	Diode, SS310 (SMD)	Required	Cathode end has a white line and positioned towards PCB **left** edge
D3	Diode, PESD1CAN, SOT-23 SMD	Optional	Fits only one way
FB1, FB2	Diode, BLM31PG121SN1L, 1206 SMD	Required	None
J1, J2	RJ45 socket (8P8C)	Required	Fits only one way
JP1, JP2, J3, J4	Male headers (3P, 0.1" spacing)	Required	None
U1, U3	M54562FP IC (SOP20)	Required	IC indent (pin 1) is positioned towards PCB **left** edge
R1-R16	1kΩ resistors (1206 SMD)	Optional	None
R17-R19	10kΩ resistors (1206 SMD)	Required	None
SW1, SW2, SW3	DIP / Slide Switch (3P, 2.54mm)	Required	Position so switch so **ON** is towards PCB **top** edge
U2	MCP23017 IC (SSOP28)	Required	IC indent (pin 1) is positioned towards PCB **left** edge

    1. Capacitors: no specific orientation required (C1)
    2. Diodes SS310: note orientation, cathode (vertical line) faces left (D1,D2)
5. Diodes PESD1CAN with no orientation required (D3)
    1. Ferrite Beads: BLM31 with no orientation required (FB1,FB2)
    2. Resistors: no orientation (R1-R19)
    3. MCP23017 IC: orientation ident is on the left side (U1)

4. M54562FP IC: orientation indent is right side (Q1, Q2)

6. Reflow the solder for the SMD component (refer to Soldering Tips).
7. Place PTH components (, starting with the smaller components.
    1. Solder (5) 3-Pin Male Pin Headers (JP1, JP2, JP3, JP4, JP5)
    2. Solder (1) 3-Position DIP Slide Switch (SW1)
    3. Solder (2) RJ45 sockets (J1, J2)

    See also: Soldering Tips

Testing and Verification

Configure the card:

1. Select the I2C bus (**COMM BUS**) by positioning (2) Jumper Caps on either BUS A or BUS B male header pins (JP1, JP2)
2. Select the I2C address **(COMM ADDR)** switch (SW1) by slide each of the 3 switches to either the ON or OFF position. Setting a switch to ON increments the address by 1, 2, or 4 for an address range of 0 to 7. Up to 8 devices can then be configured for BUS A and 8 for BUS B.
3. Select the output voltage by positioning a Jump Cap on (1) pair of **VOLTAGE** male header pins (JP5)
4. Select the function of Line 16 as an output line or as a ground (GND) connection by positioning a Jumper Cap on (1) pair of **LINE 8** and **LINE 16** male header pins (JP3, JP4).

The following test and verifications of the card should be performed after a through inspection of the card's soldering. Check all of the PTH component pins and SMD pads. Make sure there are no solder bridges between pins and pads.

Visual Inspection

1. **Initial Check**: Examine the board for any obvious issues like missing components, solder bridges, or components that are misaligned or not fully seated.
2. **Solder Joint Inspection**: Use a magnifying glass or a microscope to inspect solder joints. Look for cold solder joints, insufficient or excessive solder, or any shorts between pads.
3. **Component Orientation**: the IC's are correctly oriented according to the PCB silkscreen or schematic.

Connectivity Testing

1. **Continuity Check**: Use a multimeter in continuity mode to check for shorts between power rails and ground, and to ensure there are no open circuits in critical connections.

Power-Up Tests

1. Assembly a tested Power Module to the LCC Fusion Node Card.
2. Apply Power to the Power Module and verify the following:
    - **Check for Hot Components**: Feel for components that are overheating, which could indicate a problem like a short circuit or incorrect component.

Functional Testing

I2C Verification

1. Verify that the I2C connection between the LCC Fusion Node Card and the Output Card work. See Testing I2C Cards for details on how to test the I2C for a I2C enabled card.

Output Line Verification After validating the LCC Fusion Node Card can connect with the Output Card, test each of the output lines as follows:

1. Connect an network cable (CAT5/6) to RJ45 connector. Use the other end of the cable with a breakout board, or exposed wires to connect to devices for testing.
2. Configure each line of the card for output using an LCC CDI Configuration Tool
3. Attach an LED anode to each line. Attach the LED cathode to common (GND) used by the LCC Fusion Node Card.
4. Set the card's Vcc (5V or 12V)
5. Set the current limiting DIP switches to ON
6. Test using LCC events:
    1. Send the configured on/off LCC Event ID's for each output line
    2. Validate that LED(s) turn on/off
        - If some of the lines work and some don't, it probably a soldering connection for the bad line

- If none of the lines work correctly, check the connections for the voltage settings

Troubleshooting

- See I2C Trouble Shooting.

References

1. Choosing the Right Resistor for LEDs.