Turnout Servo Switch Machine Breakout Board Assembly Guide

Introduction

The **Turnout Servo Switch Machine Breakout Board**, used in conjunction with the LCC **LCC Fusion Node Card**, **Turnout Card**, and a servo stall motor based switch machine, provides PWM based servo motor control and turnout point position sensing, while also handling frog polarity switching. The board leverages dual mechanical relays to reliably switch the frog between **Rail A** and **Rail B**, based on the turnout's position. Each relay is responsible for controlling one frog, ensuring proper electrical connection as the turnout moves between the **Thrown** and **Closed** positions.

> 🗩 **Important**
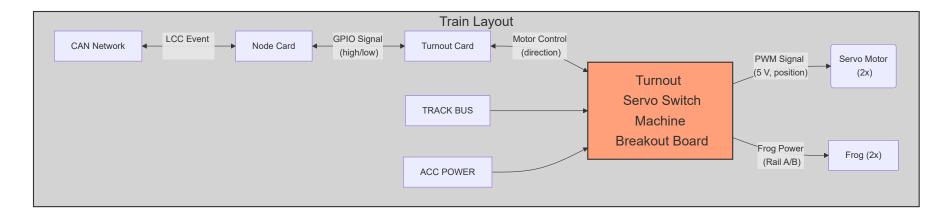>
> Requires a PWM based 5V 3-wires servo (i.e. SG90).

To accommodate various turnout and configuration, servo movement is configuable in increments of 15° (15°, 30°, 45°, 90°) based on installation of a resistor.

By interfacing directly with the Turnout Card, this breakout board provides a seamless way to control the turnout motor direction and manage frog polarity automatically, making it ideal for complex layout control and automation.

Usage:

This breakout board is for use with 3-wire servo used as a stall motor switch machines. Wiring examples:

Manufacturer	Product	Breakout Board to Switch Machine Connects	Comments
	SG90 9g	Connect `S` to `Yellow` wire Connect `V+` to `Red` wire Connect `G` to `Black` wire	Servo comes with a standard JST XH 3P plug to plug into the breakout board JST XH socket

Components List

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

PCB Components - listing of components used for PCB assembly

PCB Parts - listing of parts used for PCB assembly

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

Component Identifier	Count	Type	Value	Package	Purpose
Capacitors					
C1, C7	2	Capacitor-Ceramic	1µF	1206 SMD	Pullup for Timing Circuit for PWM 50Hz (period / duty cycle)
C2	1	Capacitor-Tantalum	0.33µF	3216 SMD	Used by 5V voltage regulator for input filtering.

Component Identifier	Count	Type	Value	Package	Purpose
C3	1	Capacitor-Ceramic	0.1µF	1206 SMD	Used by 5V voltage regulator for output filtering.
C4	1	Capacitor-Polymer	220uF, 35 V	8x10.5, SMD	Smooths rectified DC voltage
C5, C8	2	Capacitor-Ceramic	0.01uF	1206 SMD	Filtering for CV1/CV2
C6, C9	2	Capacitor-Ceramic	0.1uF	1206 SMD	Pulldown for pulse width controls
Diodes					
BR1, BR2	2	Bridge Rectifier	MB6F	SMD	Converts AC to DC
D1	1	TVS Diode	SMBJ18A	SMA	GPIO pin Transient Voltage Spike (TVS) protection
D2, D5	2	Diode-Schottky	SS310	SMD	Prevent flyback from relay coils
D3, D4, D8, D9	4	Diode-Schottky	SS310	SMD	Reduce risk of excessive reverse current during polarity transitions of optocoupler internal LEDs
D6, D7	2	Diode-Schottky	SS310	SMD	Prevent backflow from servo PWM signal

Component Identifier	Count	Type	Value	Package	Purpose
Fuses & Protection					
F1, F2	2	Fuse-PTC Polymer	JK30, 3A, 16 V (or more)	5.1mm pitch, PTH	Current overload protection to frog. Adjust value to match max current expected.
Connectors					
J1	1	Connector	JST XH (2P)	2.54mm	Connector to PWR BUS ground connection. Ground must be connected to the same ground as the **LCC Fusion Node Card**
J2	1	Connector	JST XH (2P)	2.54mm	Connector to turnout frog
J3	1	Connector	JST XH (2P)	2.54mm	Connector to Track Bus
J4, J5	2	Connector	JST XH (2P)	2.54mm	Connector to servo motor(s)
J6	1	Connector	RJ45 (8P8C)	PTH	Network cable (CAT5/6) connection from Turnout Card.
Resistors					

Component Identifier	Count	Type	Value	Package	Purpose
R1, R9	2	Resistor	4.7kΩ	1206 SMD	Timing Circuit for PWM 50Hz (period / duty cycle)
R2, R10	2	Resistor	100kΩ	1206 SMD	Timing Circuit for PWM 50Hz (period / duty cycle)
R4, R11	2	Resistor	10kΩ	1206 SMD	Controls pulse with for both servo movements
R5, R12	2	Resistor	270Ω	1206 SMD	Controls 1ms pulse
R6, R13	2	Resistor	420Ω	1206 SMD	Controls 2ms pulse
R7, R8, R14, R15	4	Resistor	1kΩ	1206 SMD	Current limiting for optocoupler LED anodes
R16-R19	4	Resistor	10kΩ	1206 SMD	Current limiting for LEDs
Relays					
K1, K2	2	Relay	DPDT TQ2-5 V	PTH	Controls track Rail A and Rail B to frog and Point Sense line to ground
ICs					

Component Identifier	Count	Type	Value	Package	Purpose
U1, U4	2	Timer IC	NE556	DIP14, PTH	Provides PWM signal to servo motors.
U2, U3	2	Optocoupler	MCT6H	DIP8, PTH	Convert RJ45 bipolar control signal into lower power signals to drive transistor and timer
Voltage Regulators					
VR1	1	Voltage Regulator	LM7805CV	TO-220 SMD	Provides 5V to NE556 timer, MCT6H Optocoupler, and servo motor(s)

1. The value for these resistors determines both the direction and degrees of the servo's movement. Use the table below to determine the resistor values for the amount of movement from the servo's 90° position. Note that the values shown below are **additive to the 10kΩ resistor** and are calculated for use with a **0.1uF capacitor**.

Movement (Degrees)	Position / Resistor	Position / Resistor
15°	75° / 300Ω	105° / 420Ω
30°	60° / 270Ω	120° / 470Ω
45°	45° /130Ω	135° / 530Ω
60°	30° / 60Ω	150° / 580Ω
75°	15° / 0Ω	165° / 600Ω
90°	0° /0Ω	180° / 720Ω

Tools Required

[List of recommended tools.

Safety Precautions

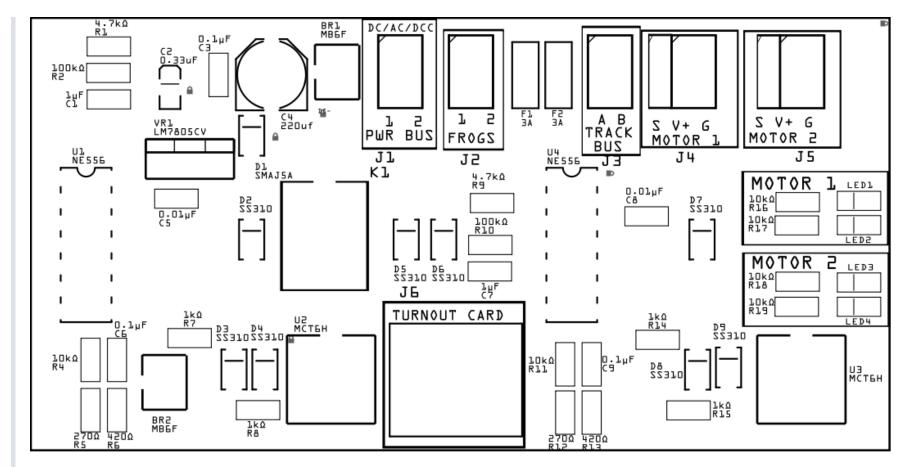- See Safety Precautions.

Assembly Instructions

Below are the high level steps for assembly of the Block Breakout Board:

> 🗨 **Important**
> Clean PCB with alcohol to remove residue. See Cleaning_PCB for details.

> See also: Soldering Tips

Component Identifier	Component (Package)	Orientation
BR1, BR2	Bridge Rectifier, MB6F	DC- position to PCB **bottom left** (indent to PCB **left** edge)
C1, C7	Capacitor, 1uF (1206 SMD)	None

Component Identifier	Component (Package)	Orientation
C2	0.33uF Capacitor-Tantalum (3216 SMD)	Position cathode end (tan line) to PCB **top** edge
C3, C6, C9	Capacitor, 0.1uF (1206 SMD)	None
C4	Capacitor, 220uF, 35 V	Use silkscreen for orientation
C5, C8	Capacitor, 0.01uF (1206 SMD)	None
D2 - D9	Diode, SS310 (SMD)	Position cathode end (white line) to PCB **top** edge
D1	Diode, SMBJ18A (SMD)	Position cathode end (white line) to PCB **top** edge
F1, F2	Polyfuse, 3A (PTH)	None
J1 - J5	JST XH Socket (2P, 2.54mm), or 2-Position Spring Terminal Connector (2.54mm, PTH, vertical or horizontal)	Position connection towards PCB **top** edge
J6	RJ45 socket (8P8C, PTH)	Fits only one way
K1	Relay, DPDT, TQ2-L212V (PTH)	Position IC's small dimple in corner (pin 1) towards PCB **top** edge
Q1, Q2	NPN Transistor, BSS138, SMD	Fits only one way
R1, R9	4.7kΩ resistors (1206 SMD)	None
R2, R10	100kΩ resistors (1206 SMD)	None
R4, R11, R16-R19	10kΩ resistors (1206 SMD)	None
R5, R12	270Ω resistors (1206 SMD)	None
RR6, R13	420Ω resistors (1206 SMD)	None

Component Identifier	Component (Package)	Orientation
R7, R8, R14, R15	1kΩ resistors (1206 SMD)	None
U1, U2	Dual timer, NE556 (PTH)	Position IC indent towards PCB **top** edge
U3, U4	Optocoupler, MCT6H (PTH)	Position IC indent towards PCB **top** edge
VR1	Voltage Regulator, LM7805CV (TO-220, SMD)	Position with heat sink towards PCB **top** edge

Testing and Verification

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.

Functional Testing

- Supported servo switch machines (bidirectional):

  1. Switch Tender Switch Machine (MicroMark, 12 V, slow motion) w/o switch

     Note: Use different size resistors to get stall current to be as small as possible

  2. Rapido RailCrew Switch Machine

     - instructions, wiring

  3. DCC Concepts Cobalt (point motor)

  4. Walthers 942-101 Switch   Machine $25, (instructions

     - Note: Refer to section 4.5 on connecting 'stall' motor type of wiring to the 2 POWER pins

  5. MP4, MP5 and MP10 Switch Machine by Model Railroad Control Systems

     - MP4 - 3rd wire for bidirectional (wiring PDF)

- Note Supported (non-stall motor)

1. [Tam Valley Singlet Servo](#) and [SwitchWright Servo Driver Board](#) (servo controlled)

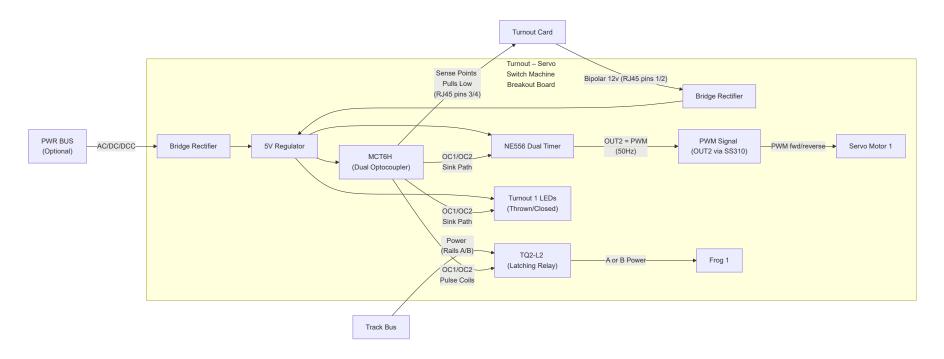2. [MP1 Version 2 Switch Motor](#)

Troubleshooting

Appendixes

Specifications

Specifications for the [Turnout Slow Motion Switch Machine Breakout Board](#) include:

Characteristic	Value
Max Servos	2
Input (accessory bus or dedicated power supply)	7 V - 35 V
Output (servo)	5 V
Output (frog)	Track Voltage
Max Input (track bus)	2.5 A
Max Output (frog)	2.5 A
Max Output (servo)	1.5 A

How It Works

The **Turnout – Servo Switch Machine Breakout Board** provides reliable and precise control of **servo-based switch machines**, driven by standard **bipolar 12V turnout logic signals** from the **Turnout Card**. Using a single **NE556 dual timer** and a **dual optocoupler (MCT6H)**, it generates continuous PWM signals to control a servo's position without a microcontroller. The board also supports **frog polarity switching** via MOSFETs and provides **turnout position feedback** to the Turnout Card.

1. Power Supply

- The board is normally powered from the **Turnout Card's +5 V logic rail**, which supplies power to the **NE556 timer**, **servo**, and **MOSFET driver circuits**.

- Optionally, the board can be powered from the **layout's accessory bus** using **AC, DC, or DCC**. This power source is connected through a **bridge rectifier** and a **5 V regulator**, and will **override the Turnout Card power** when present.

- This feature allows for **power load balancing** across multiple sources, which is especially useful in larger layouts with many turnout mechanisms.

- A shared ground is maintained between logic, servo, and signal sections regardless of the power source.

2. Turnout Position Selection

- The Turnout Card **bipolar 12V control signals** for setting the turnout position (from RJ45 Pins 1/2 for Switch 1 or 5/6 for Switch 2) are connected to a **dual optocoupler (MCT6H)**.

- Only one optocoupler channel is active at a time, depending on the polarity of the control signal.

- The optocoupler outputs (OC1 / OC2) are used to:

- Select the RC path to control pulse width (i.e., servo position)

- Pulse one of the **dual-coil latching relay coils** to switch frog polarity

- Pull the turnout **sense lines** low for position feedback

- Illuminate an LED indicator showing the current turnout position:

  - A **current-limiting resistor and LED** are connected from V+ to each collector

  - When the collector sinks current (i.e., the opto is active), the LED lights up

  - This provides a clear, visual indication of whether the turnout is **thrown** or **closed**

3. Timer 1 – 50 Hz Trigger Pulse Generator

- **Timer 1** of the NE556 is configured as an **astable oscillator**, generating a continuous **50 Hz square wave** (i.e., one cycle every 20 ms).

- This output appears on **Pin 5 (OUT1)** and is used to **trigger Timer 2** via **Pin 8 (TRIG2)**.

- The astable timing circuit uses:

  - **R1 = 4.7 kΩ**

  - **R2 = 100 kΩ**

  - **C1 = 1 μF**

- These components are connected in a standard 555-style astable configuration and provide consistent timing for servo control pulses.

- Timer 1's job is simply to **generate the repetitive trigger signal** required to keep the servo signal active and holding its position.

4. Timer 2 – Servo Pulse Width Generator (Monostable)

- **Timer 2** of the NE556 is set up as a **monostable** that generates a single output pulse each time it's triggered by Timer 1.

- The pulse width is determined by a selective

  RC timing network:

  - A shared 10 kΩ base resistor from VCC feeds a node connected to:

    - **270 Ω** path through **OC1 (optocoupler collector)** → GND for ~1.13 ms (30° forward, Closed)

    - **420Ω** path through **OC2 (optocoupler collector)** → GND for ~1.62 ms (30° reverse, Thrown)

  - A **0.1 μF capacitor** connects the shared node to GND

- - The optocouplers ensure that only one path is active at a time
- This results in:
  - A **1.1 ms pulse** for the **closed** position
  - A **1.6 ms pulse** for the **thrown** position
- The output on **Pin 9 (OUT2)** is passed through an **SS310 Schottky diode** to the servo's signal line.
- The repeated triggering ensures that the servo continues to hold its selected position with full torque.

5. Frog Polarity Switching (via MOSFETs)

- The optocoupler outputs (OC1 and OC2) also drive a latch or direct gate circuit that controls **two IRLZ44N MOSFETs** per switch.
- These MOSFETs toggle the frog connection to either **Track Bus A or Track Bus B**, depending on turnout direction.
- Each gate is connected through a **1 kΩ resistor**, and a **10 kΩ pull-down** ensures clean switching and gate discharge.
- This provides reliable frog polarity without relays.

6. Turnout Point Sensing

- The OC1 and OC2 outputs are also connected to the RJ45 sense lines:
  - **Pins 3/4 for Switch 1**
  - **Pins 7/8 for Switch 2**
- When a turnout is thrown or closed, the corresponding optocoupler output **pulls its sense line low**, signaling the turnout's state back to the **Turnout Card**.

7. Diode Protection

- The servo signal output, is routed through an SS310 to prevent leakage or back feed during switching events.

Timing Resistor Values for Fine Angle Control

To fine-tune servo throw distance, adjust the **R2 resistor** in the NE556 monostable circuit. The following values approximate servo movement away from center:

Movement (° from 90°)	R2 (Forward)	R2 (Reverse)
15°	300 Ω	420 Ω
30°	270 Ω	470 Ω
45°	130 Ω	530 Ω
90°	0 Ω	720 Ω

> **R1 is fixed at 10kΩ**, and **R2 is placed between the shared RC node and GND**, controlled by the optocoupler.

📌 Notes:

- Movement direction (left/right of center) is controlled by which **optocoupler output** is active.
- You can experiment with different R2 values to suit different mounting geometries or turnout throw lengths.
- The standard configuration assumes **0.1 µF for the timing capacitor (C)**.

Connections

The purpose of the **Turnout Servo Switch Machine Breakout Board** and its connectors is to facilitate quick and easy connections between the **Turnout Card** and a turnout controlled by a servo.

Component Designator	Connector Label	Connector Type	Connection Number	Description
J1	PWR BUS	JST XH, Spring Terminal	V+, GND	Connection to the layouts power bus (AC, DC, or DCC)
J2	FROGS	JST XH, Spring Terminal	1, 2	Connection to power turnout frogs

Component Designator	Connector Label	Connector Type	Connection Number	Description
J3, J4	MOTOR 1 / MOTOR 2	JST XH, Spring Terminal	S, V+, G	Connection to servo. `S` is for the servo's PWM signal wire, V+ is the 5V wire, and `G` is for the ground wire. Note that most SG90 5V servos have a wiring harness with a JST XH plug that matches this arrangement.
J5	TRACK BUS	JST XH, Spring Terminal	A, B	Connections to the layout track bus for Rail A and Rail B. Used to power the frog when. If necessary, switch the connections to match the frog to the correct rail.
J6	TURNOUT CARD	RJ45 Socket	1 - 8	Refer to Turnout Card's connection table for the function of each pin

Protection

Protected Component	Protection Component	Function	Specifications	Location
Turnout Card (MCP23017 GPIOs)	**MCT6H Optocoupler**	Electrically isolates control signals from high-current switching, preventing back-EMF and voltage spikes from reaching the Turnout Card.	**- Isolation Voltage: 5300 V RMS** **- Forward Current: 10 mA** **- Output Type: Open-Collector**	Between RJ45 input control signals and BSS138 MOSFET Gates
5 V Regulator & Power Supply	**Bridge Rectifier**	Ensures correct polarity, allowing AC, DC, or DCC power sources while preventing reverse polarity damage.	**- Maximum Input Voltage: 600 V AC** **- Forward Current: 0.5A (Max 1A surge)** **- Forward Voltage Drop: 1.1 V per diode** **- Reverse Leakage Current: 5µA (at 600 V)**	Between external power input and 5V regulator
Entire Circuit	**PPTC Polyfuse**	Protects from sustained overcurrent conditions by increasing resistance when the current exceeds 1,5A. Resets once the fault condition is cleared.	**Hold Current:** 1.5A **Trip Current:** 3A	In series with the motor's Vcc line. Adjust the fuse type to match the max current expected by the servo motor.
Track Power	**PPTC Polyfuse**	Protects from sustained overcurrent conditions by increasing resistance. Resets once the fault condition is cleared.	**Fuse Rating:** Based on max track current (typically 3A depending on track power).	In series with the track power supply, between the power source and the track.

Protected Component	Protection Component	Function	Specifications	Location
Relay Coils	**Flyback Diode**	Protects the circuit from high-voltage spikes caused by inductive loads (relay coils) when switching off.	**Diode Type:** Schottky **Max Current:** Min 0.5A **Reverse Voltage:** Min 12 V	Across the relay coil and servo motor terminals
LM7805CV Regulator	**Capacitors (Input/Output)**	Stabilizes voltage and reduces noise on the input and output of the voltage regulator.	**Input Cap:** 0.33µF, 220uF **Output Cap:** 0.1µF	Input cap across the input pin and GND. Output cap across the output pin and GND.

Assembly-Configuration Options

The **Turnout Servo Switch Machine Breakout Board** supports multiple assembly configurations to fit various use cases.

Configuration	Required/Optional	Description	Required Components	Optional Components
Turnout Card	**Required**	Connection to Turnout Card for 12v bipolar inputs and point set position outputs	Turnout Card Connector (J6)	
Power via PWR BUS	**Optional**	Allows board to be powered from layout accessory bus (AC, DC, or DCC)	• Connector (J1) • Bridge Rectifier (BR1) • 5V Regulator (U2) • Filter Capacitors (C2, C3, C4)	TVS Diode (D1)

Configuration	Required/Optional	Description	Required Components	Optional Components
Power via Turnout Card	**Optional**	Allows board to be powered from Turnout Card (via LCC Node Bus, LCC Node)	• Bridge Rectifier (BR2) • 5V Regulator (U2) • Filter Capacitors (C2, C3, C4)	TVS Diode (D1)
Primary Servo Output	**Required**	Generates PWM control signal for a single turnout servo	• NE556 Timer (U1) • Servo 1 Connector (J4) • 50Hz and Timing: Resistors (R1, R2, R4, R5, R6, Capacitor (C1, C6), Diodes (D5, D6) • Optocoupler: (U2, D3, D4, R7, R8)	—
Second Servo Support	**Optional**	Adds support for controlling a second servo using the same timing pulses	NE556 Timer (U1, R9, R10, C7, C8) • Servo 2 Connector (J5) • Optocoupler: (U3, D8, D9, R14, R15)	—
Frog Polarity Switching	**Optional**	Switches frog connection between Track Bus A/B using latching relay	• Dual-Coil Latching Relay (K1) • Frog Connector (J2) • Track Bus Connector (J3) • Flyback Diodes (D2) • Servo 1 (F1, D2) • Servo 2 (F2, D7)	—
Turnout Position Indicators (LEDs)	**Optional**	Provides visual indication of turnout state based on OC1/OC2 opto output	• Indicators (LED1 - LED4) • Current-Limiting Resistors (R16 - R19)	—kk

References

- [Preparing a PCB for Soldering](#)
- [Solder Tips](#)
- Turnout Motor list: https://dccwiki.com/Turnout_Motors