

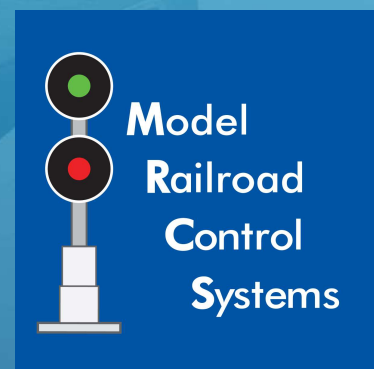
ARDUINO-BASED CIRCUITS FOR OPERATION

Easy and inexpensive circuits enhance operations and animation

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Many of us model prototypes that did not have extensive signaling systems or Centralized Traffic Control. In many cases, simpler signaling systems (ABS/APB) overlaid Timetable and Train Order schemes which date back to the 1850s. These manual systems, supplemented by Interlocking Plants (Towers) served the railroads well into the modern era, being supplanted by radio and verbal authority with the adoption of GCOR in 1986. These systems had their own requirements, such as Train Order Boards, Approach Indicators and Interlocking Plants which can be easily modeled with Arduino based circuits.

YOU DON'T NEED A COMPUTER RUNNING
TO HAVE INTELLIGENT AIDS TO OPERATION



- ▶ Circuit boards are easy to design using free* tools such as EAGLE and KiCad, these tools have utilities to optimize your design, enforce design rules and even automatically design your board** minimizing do-overs and waste
- ▶ Turnaround is quick and prices are low from several off-shore sources, and some on-shore, too!
- ▶ It takes about as long to lay out a circuit board as it does to wire a prototype, but once the design is done, lots more boards are as little as 96 hours away at \$1-2 each “landed” (after shipping and duties).
- ▶ PCB boards do not have hidden cold solder joints, loose wires etc. and you can easily build a few spares, so it’s easy to replace a suspected bad unit or expand your system
- ▶ These designs are easy to share, and you often find someone has done something like what you want, so you can use that design or modify it to suit your requirements.

*for non-commercial use with size limitations

**not the optimum design but something to get you started

WHY NOT JUST SOLDER UP A BREADBOARD?



- ▶ “Arduino is an open-source electronics platform based on easy-to-use hardware and software. It’s intended for anyone making interactive projects.”
- ▶ The initial target audience was artists who wanted to animate their work: sounds a lot like us!
- ▶ Arduino boards can read inputs such as a train over an optical sensor, or a finger on a button, and turn it into an output, activating a switch motor or servo, or lighting a LED Signal. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language, and the **free** Arduino Interactive Development Environment (IDE) which runs on PCs, Mac and Linux.

WHAT IS AN ARDUINO?

www.arduino.cc



I've developed simple circuit boards for Arduinos to perform functions used on operating railroads:

- ▶ Train Order Board Controllers using Servos
- ▶ Approach Indicators to notify Train Order operators when a train is "on the bell"
- ▶ Morse Code Sounder Controllers to identify which station is being called
- ▶ Interlocking Plants and yard entrance controllers

THIS CLINIC WILL FOCUS ON A FEW APPLICATIONS, BUT YOUR IMAGINATION IS THE ONLY LIMIT!



- ▶ Servo switch machine controllers
- ▶ Stall Motor and MP Motor switch machine controllers
- ▶ Grade Crossing Controllers
- ▶ Stepper Motor Controllers for Animation

OTHER FUNCTIONS AND ANIMATIONS



- ▶ I mostly use Arduino Nanos and ProMinis, these are about 0.75"x 1.5"
- ▶ Slightly different programming arrangements (USB, FTDI)
- ▶ Use same (ATMega 328P) processor as the Arduino Uno
- ▶ Some smaller devices (turnout controllers) use the ATTiny85
- ▶ leverage the Arduino eco-system (Arduino Relays) to keep costs low
- ▶ These boards are "break outs" which bring the needed Arduino connections out to push buttons, LEDs, motor connectors and needed components to minimize wiring on your part

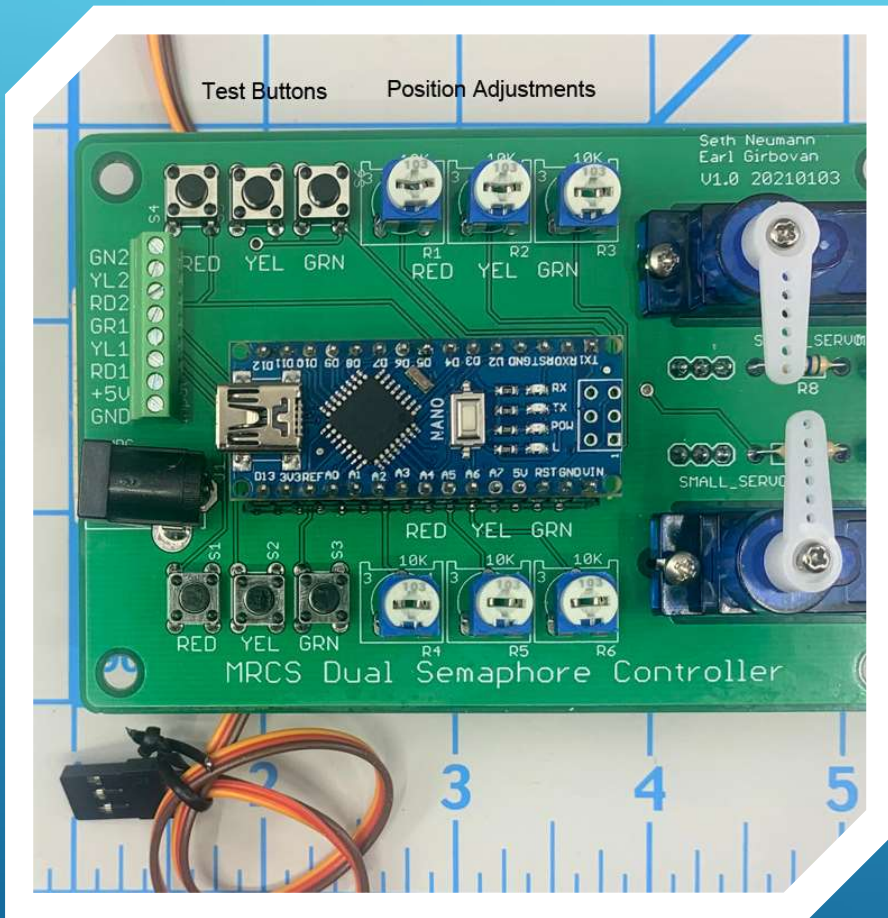
ARDUINOS ARE EASY TO FIND AND
INEXPENSIVE



- ▶ The (Uno) shield devices stack vertically and there is no mechanical support except for the thin pins on the connectors, so they tend to lean or come loose and are difficult to mount under a layout
- ▶ Much of what we do is lighting LEDs and very few of the shields have provision for current limiting resistors
- ▶ You can use Shield type boards for prototyping, but I find the dedicated boards easier to work with in permanent installations

WHY NOT USE “SHIELD” TYPE ARDUNIOS
LIKE UNOS AND MEGAS?





- ▶ Mounts 2 servos for a 2 arm semaphore
- ▶ Train order board, ABS mast with 2 arms or 2 single arm masts facing at an ABS block boundary
- ▶ 6 Potentiometers to adjust Green/Yellow/Red position on each Semaphore
- ▶ Test button for each position
- ▶ Power for a LED to illuminate the roundel
- ▶ Connectors for Servos on back
- ▶ Uses a 5 volt, 1A wall wart for power
- ▶ Local switch or computer control

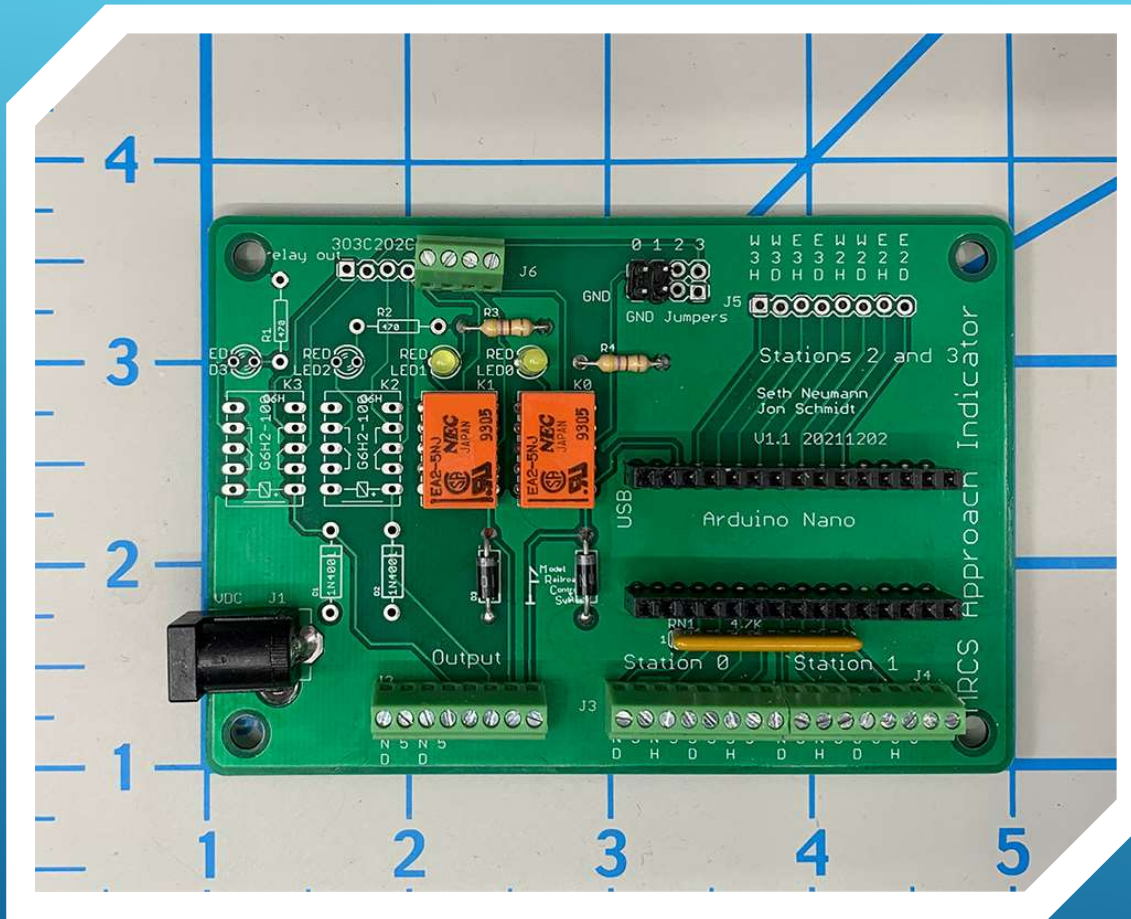
DUAL SEMAPHORE SERVO CONTROLLER

- ▶ The sketch is a Jon Schmidt contribution and can be freely downloaded and modified subject to the Creative Commons license. The Eagle CAD board design is also open source so you can modify either to taste.
- ▶ See (Dual Semaphore software developer) Jon Schmidt's article in the April 2023 RMC page 90 on this board!
- ▶ The Dual 3 Position Semaphore Servo Controller has a 2.1 mm power connector for 5 volts to power the Arduino Nano and the servos on board. The Dual 3 Position Semaphore Servo Controller draws about 50 mA in the idle state and momentarily draws about 300 mA when a servos is moving.

DUAL SEMAPHORE DETAILS



APPROACH INDICATOR

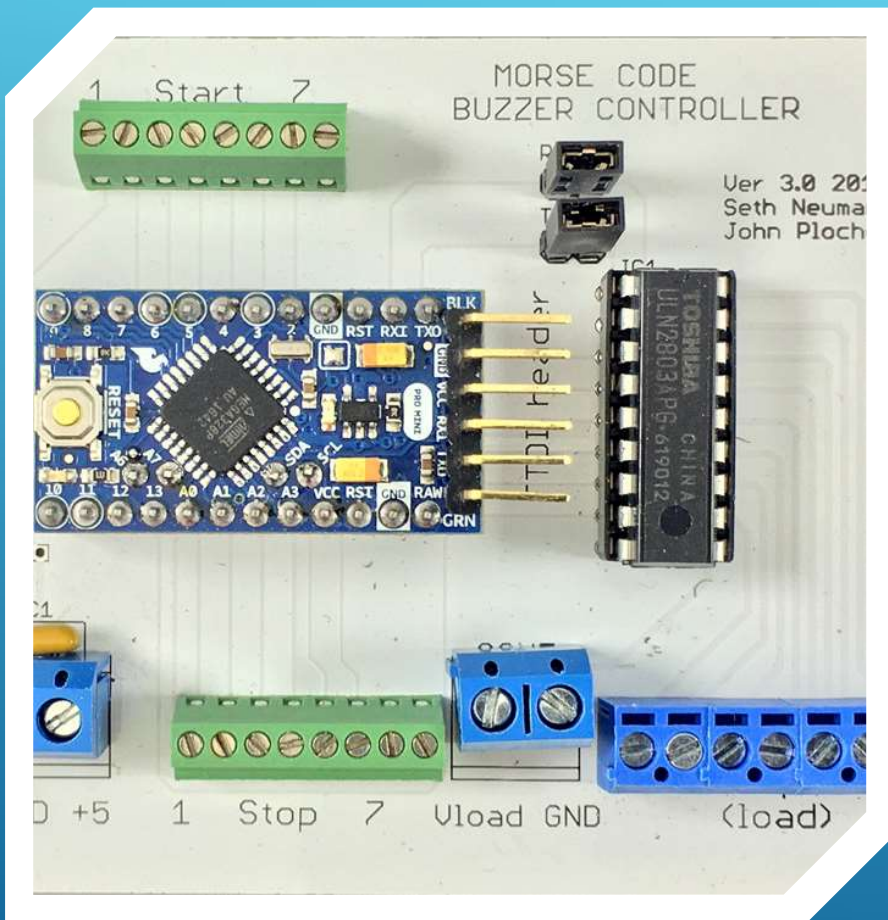


- ▶ Often a train order operator was situated such that s/he could not see approaching trains. This was a problem if the operator was expected to deliver an order on the fly with a hoop, so “approach” bells were provided to indicate the impending arrival of a train
- ▶ The Approach Indicator board alerts a train order operator that a train is on approach (“on the bell”) and that he should contact the Dispatcher to determine if there are additional orders for the train or that s/he should prepare to deliver an order.
- ▶ Jon Schmidt developed the sketch which is available on his [GitHub](#) page, I offer the board bare and in various assembled and tested configurations. Open Source CAD files are on my website.

- Supports one or two stations with internal conditioning of photo transistor signals
- Supports an additional one or two stations with digital inputs from detector assemblies
- All connections including +5 and ground are brought to 0.100 connectors
- A 2.1mm barrel jack is provided if you choose to supply power from a 5V wall wart.
- All components use through-hole technology for ease of assembly and repair.
- Logic level outputs are provided for each station, as well as isolated “dry contacts” on relays. The relays are rated at 1A @ 48VDC.
- The relay outputs can optionally connect to ground by use of onboard jumpers
- Each output has an associated LED which is helpful in debugging



APPROACH INDICATOR DETAILS

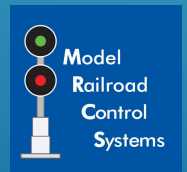


- ▶ On many operations-oriented model railroads, particularly those which use time-table and train-order (TT&TO) or tower-based dispatching, there is a need to provide telephone communications between the dispatcher and the agent/operators. However, even on large model railroads with multiple agent/operators, the physical distances between the operator positions are often insufficient to allow the operators to reliably determine “that’s my phone ringing.”
- ▶ The Morse Code Buzzer Controller serves up to seven stations, tapping out each ringing station's Telegraph call sign in Railroad Morse.
- ▶ Steve Williams developed the sketch, this board uses an Arduino ProMini

MORSE CODE BUZZER CONTROLLER

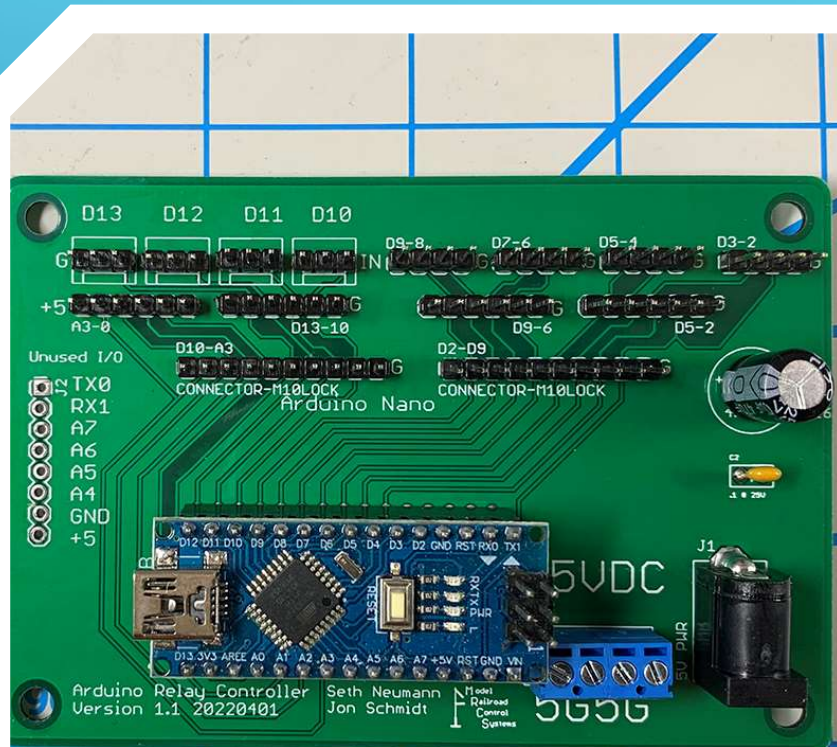
- ▶ The board accepts push button inputs, stops when the phone goes off-hook (phone must have a suitable contact to provide an isolated ground) and can drive loads of up to 0.5 Amp at up to 48 Volts DC. All buzzer/sounder devices must use the same supply. Sounders must have have a coil resistance of greater than 40 ohms if using a 12V supply, or use our sounder driver,
- ▶ Requires a 12 VDC power supply rated at $\geq 0.5A$. not included.

MORSE CODE BUZZER CONTROLLER DETAILS



- ▶ Arduino Relays are inexpensive modules with 1,2,4,8, or 16 SPDT Relays that operate from 5-volt power and are controlled by logic level inputs, usually by an Arduino or similar 5V micro-controller. These have lots of handy applications for model railroaders and DIY electronics.
- ▶ In this case we needed to control a group of Arduino Relays which in turn controlled a group of Sound Animation modules. The board has a socket for the Nano and 4 sets of male headers which correspond to the +5, GND and inputs for various configurations of Arduino Relay.
- ▶ This enables connection via standard “Dupont” connector cables.

ARDUINO RELAY CONTROLLER

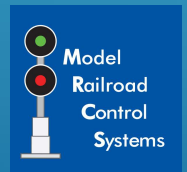


- ▶ The first application, for which I designed this board, was control of a group of Arduino Relays which in turn controlled a group of Sound Animation modules. Jon Schmidt contributed a sketch which controls up to 16 outputs with varying probability and duration (so the barking dog didn't drive you crazy!)

- ▶ Other Applications (not exhaustive)

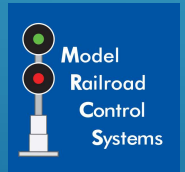
- ▶ Interlocking plant
- ▶ Yard throat
- ▶ Staging yard controller with power cutout
- ▶ Anything you could do with a diode matrix but also using timing and checking for outside events, such as track occupancy
- ▶ Intelligent Control Panels
- ▶ There is no “magic” to Arduino Relays, you can connect anything with a compatible table to these pins and use them as inputs or outputs!

ARDUINO RELAY APPLICATIONS





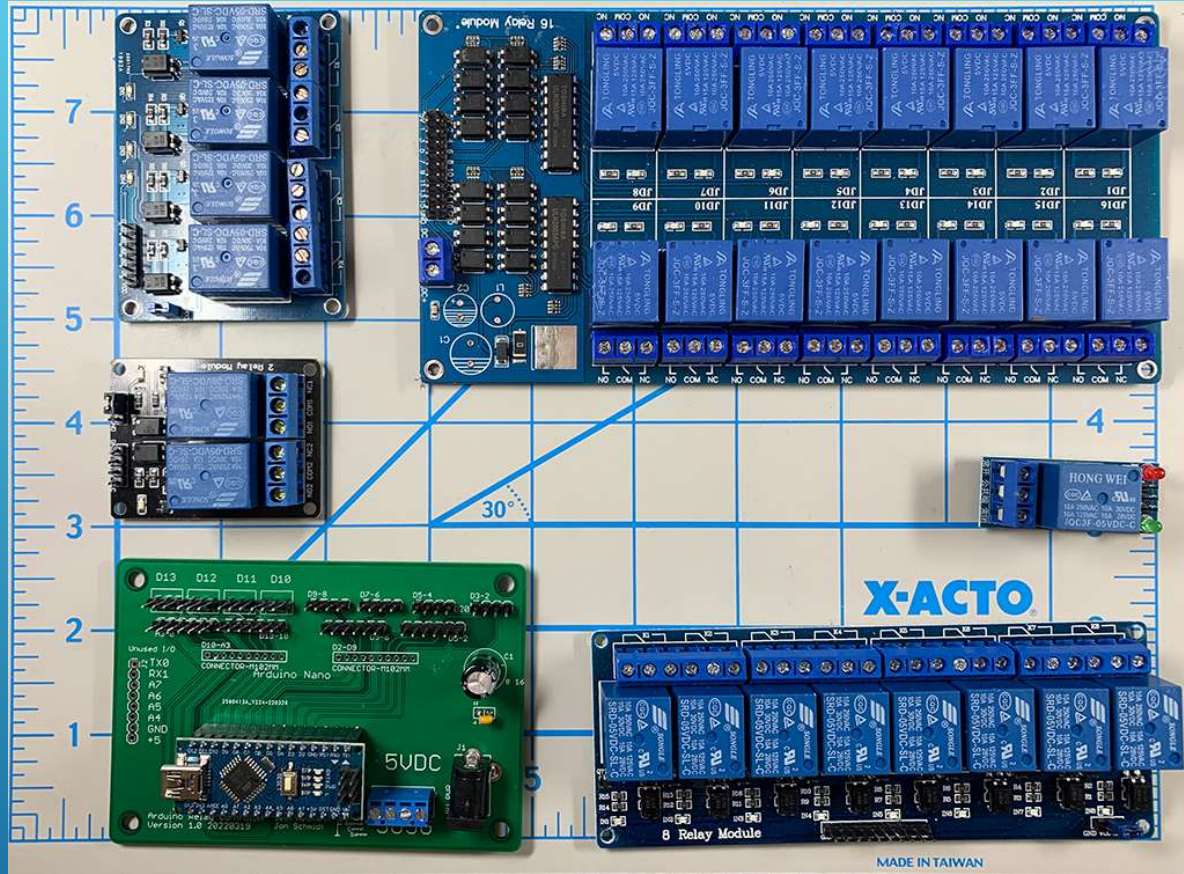
SP XING ON JIM PROVIDENZA'S SANTA CRUZ NORTHERN



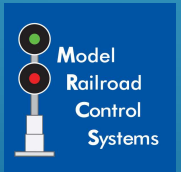
- ▶ **Arduino relay, 1,2,4,8,16**
- ▶ **8 position DPDT relay**
- ▶ **SMC-08 (8 position stall motor controller)**
- ▶ **i/o expander (IOX, dedicated Arduino Relay board coming) if you need more than 16 i/o lines, you can control up to 128 additional devices (16 base + 128 = 144)**

MEET THE “FAMILY”



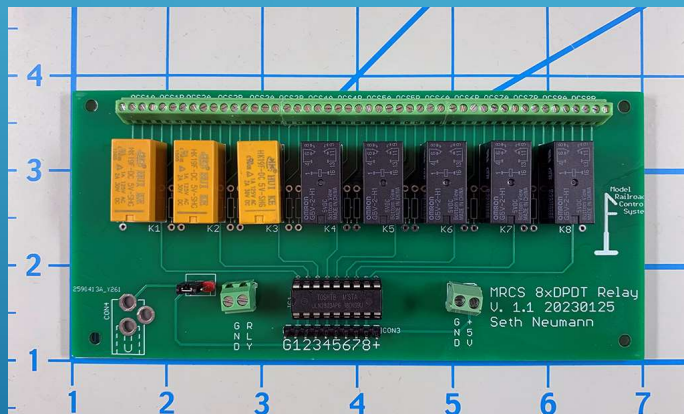


ARDUINO RELAYS COME IN 1,2,4,8,16 SECTIONS AT AS LITTLE AS \$1 PER SECTION

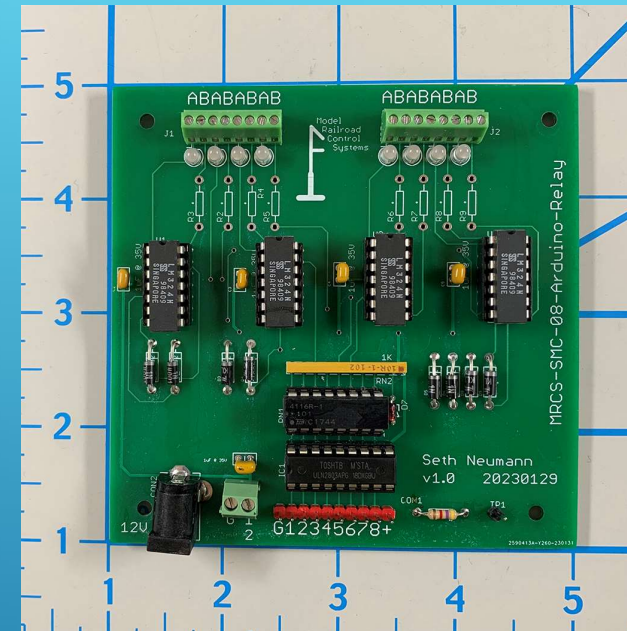


▶ The generic Arduino relays have SPDT relays, but what if:

- ▶ You need more contacts?
- ▶ You want to control Tortoise by Circuitron switch machines?

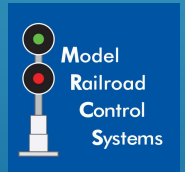


8 DPDT Relay – same cable pin out



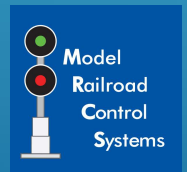
8 Tortoises – same cable pin out
Essentially the same circuit as
Bruce Chubb's SMC-12

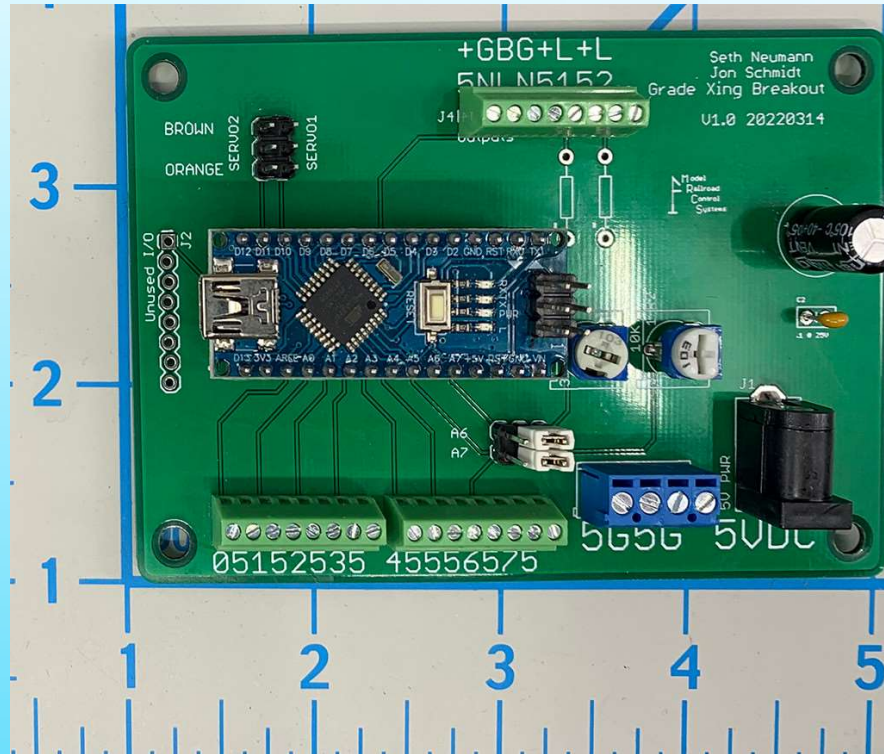
ARDUINO RELAY ALTERNATIVES



- ▶ The board has a socket for the Nano and 4 sets of male headers which correspond to the +5, GND and inputs for various configurations of Arduino Relay. Basic power filtering is provided as are a choice of 2.1 mm barrel jack and 3.5mm screw terminals.
- ▶ Connectors
 - 2 x 10 position 0.100 headers for either 2 8 position or 1 16 position Arduino Relay (D2-D13 + A0-A3) Each header has Ground, +5 and 8 outputs
 - 4 x 6 position 0.100 headers for 4 position Arduino Relays (D2-D13 + A0-A3)
 - 4 x 4 position 0.100 headers for 2 position Arduino Relays
 - 4 x 3 position 0.100 headers for single Arduino Relays (note the pattern is different for the singlets)
 - Barrel Jack for 5VDC (1A recommended) as well as 2 pairs of +5/GND on the 3.5 mm screw terminal, you can use either or use the screw terminal to distribute power to adjacent modules
 - 0.100" Pads are provided for the unused Arduino i/o pins and +5 and Ground
- ▶ Note that there is no magic about using Arduino Relays: this board can be used to consolidate i/o and power to any type of device you like and there are many sensors and output devices compatible with Arduinos that use this cabling standard.

ARDUINO RELAY CONTROLLER DETAILS





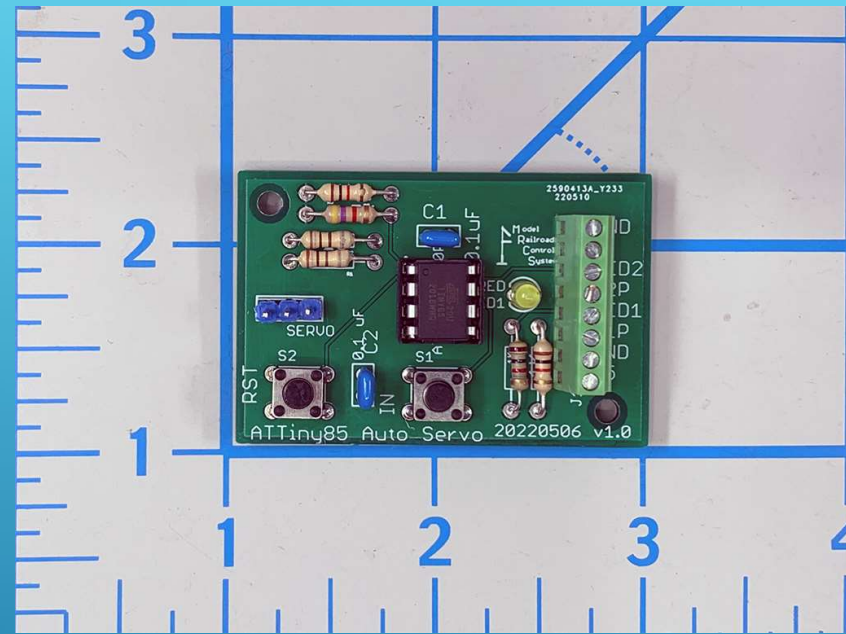
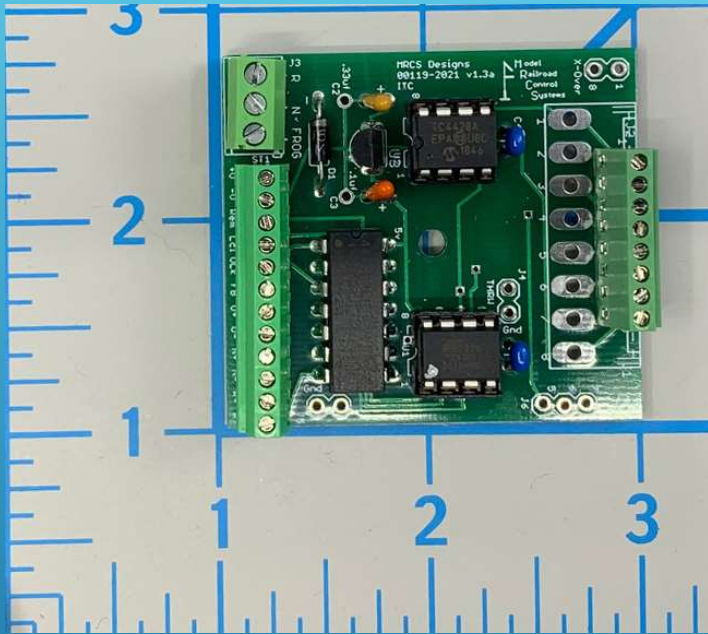
There are many excellent Grade Crossing sketches out there, this board supports Jon Schmidt's sketch. It features direct detection of photo transistors (no external resistors or comparators required) for the approach and island circuits for a single track.

GRADE CROSSING CONTROLLER

- ▶ **Direct detection of photo transistors (no external resistors or comparators required) for the approach and island circuits for a single track.**
- **Provision is made for cross buck LEDs (cut-able pads are provided for limiting resistors, if desired).**
- **Position adjustment pots and connectors are provided for servos to control moving gates.**
- **Output to trigger an Iowa Scaled Grade Crossing Bell module**
- **pads for an 0.100 connector for the unused i/o if you want to use this board for another project**
- **Uses a regulated 5 VDC, 1Amp supply**

GRADE CROSSING CONTROLLER DETAILS





SWITCH MOTOR CONTROLLERS USING ATTINY85

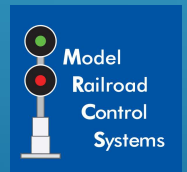
Intelligent Turnout Controller (ITC):

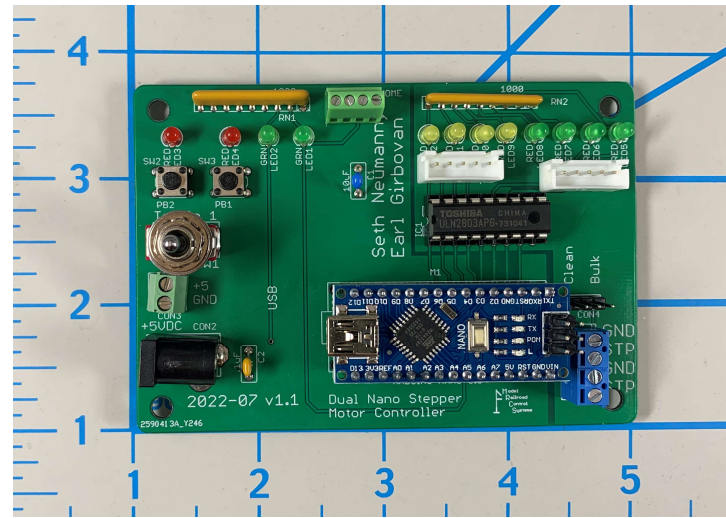
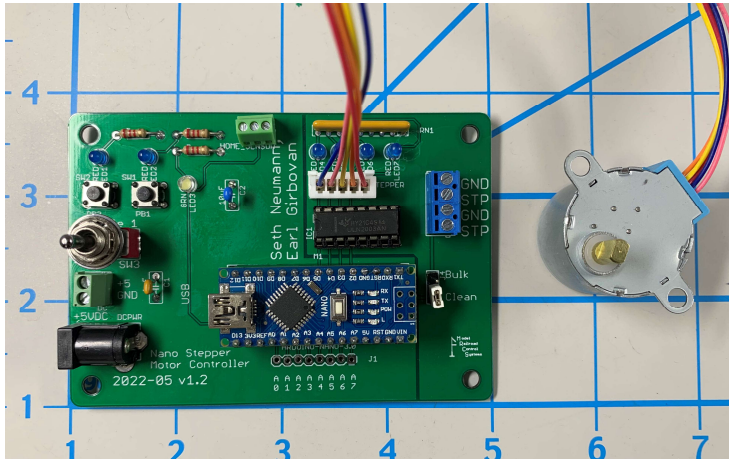
- ▶ The ITC is designed to provide all control functions needed for remote, local, and locking of a turnout for stall and MP turnout motors. The ITC provides LED outputs with onboard current limiting resistors for route and switch lock status.
- ▶ The ITC can operate as a standalone turnout controller, with no computer needed. When connected to a computer for remote turnout control and the computer is not running, the ITC comes up in local mode. This allows for turnouts to be thrown manually using the Local input.

Single Servo Turnout Controller:

- ▶ Controls one SG90 or equivalent servo as a switch machine
- ▶ Replaces our earlier PIC based Servo Controller
- ▶ Automatically detects end of travel with adjustments for easy installation and reliable operation over time
- ▶ Status LEDs for remote control panel
- ▶ 5VDC, 0.5A

SWITCH MOTOR CONTROLLERS





STEPPER MOTOR CONTROLLER

Earl Girbovan has used Stepper motors for:

- ▶ Building elevators
- ▶ Ore unloaders (like Hulett's)
- ▶ Crane Hoist Animation

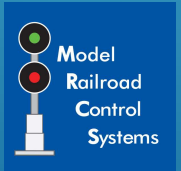
Stepper Motors have been used for turntable control, train elevators and many other applications calling for precise control using pulley and jack screw drives

STEPPER MOTOR APPLICATIONS



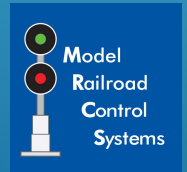


EARL GIRBOVAN'S ORE DOCK



Single-ended stepper motor controller (not an H Bridge). These Boards control one or two 5 lead stepper motors. It is the functional equivalent of a Nano with one of the small boards containing a ULN2003 and a JST connector, often sold with a small stepper motor. This board provides a single place to connect the whole project, including run/stop switch, 2 push buttons several status LEDs, JST connector, socket for the high current driver, barrel jack and screw terminals for power and basic power conditioning. Earl Girbovan used an early version of this board for his ore unloader model shown at the 2022 PCR Convention.

STEPPER MOTOR DETAILS



- ▶ **Ask! I may have something similar in mind**
 - ▶ Different connectors
 - ▶ Different version of Arduino
 - ▶ Different “stuff” on board
- ▶ **If I haven't made one and it looks interesting, I'll do your design, depending on time available**

WHAT IF I HAVEN'T MADE A BOARD FOR
YOUR APPLICATION?



- ▶ **AdaFruit**
- ▶ **Seeed Studio**
- ▶ **Sparkfun**
- ▶ **Marketplaces**
 - ▶ Amazon
 - ▶ AliExpress
- ▶ **Distributors**
 - ▶ Jameco
 - ▶ All Electronics
 - ▶ Digikey/Newark/Mouser etc.
- ▶ **Me (Model Railroad Control Systems) <https://www.modelrailroadcontrolsystems.com/>**

PARTS SOURCES



- ▶ Arduino <https://www.arduino.cc/> (Arduino IDE, Arduino Specs, tutorials)
- ▶ Model Railroad Control Systems <https://www.modelrailroadcontrolsystems.com> (Bare boards, Assembled and tested boards, Accessories)
- ▶ GitHub Repositories
 - ▶ Me (Seth Neumann) <https://github.com/SethNeumann/> (Source Code, CAD Design Files)
 - ▶ Jon Schmidt <https://github.com/joneschmidt>
 - ▶ John Plocher <https://github.com/plocher>
- ▶ “Arduini” list on Groups.io
- ▶ CAD Programs for making circuit boards:
 - ▶ Eagle/Fusion 360 <https://www.autodesk.com/products/eagle>
 - ▶ Kicad <https://www.kicad.org/>
- ▶ PCB Board Fabricators
 - ▶ JLCPCB (China) <https://jlcpcb.com/>
 - ▶ Seeed Studio (China) https://www.seeedstudio.com/fusion_pcb.html
 - ▶ PCBWay (China) <https://www.pcbway.com>
 - ▶ OSHPark (US) <https://oshpark.com/>

RESOURCES

