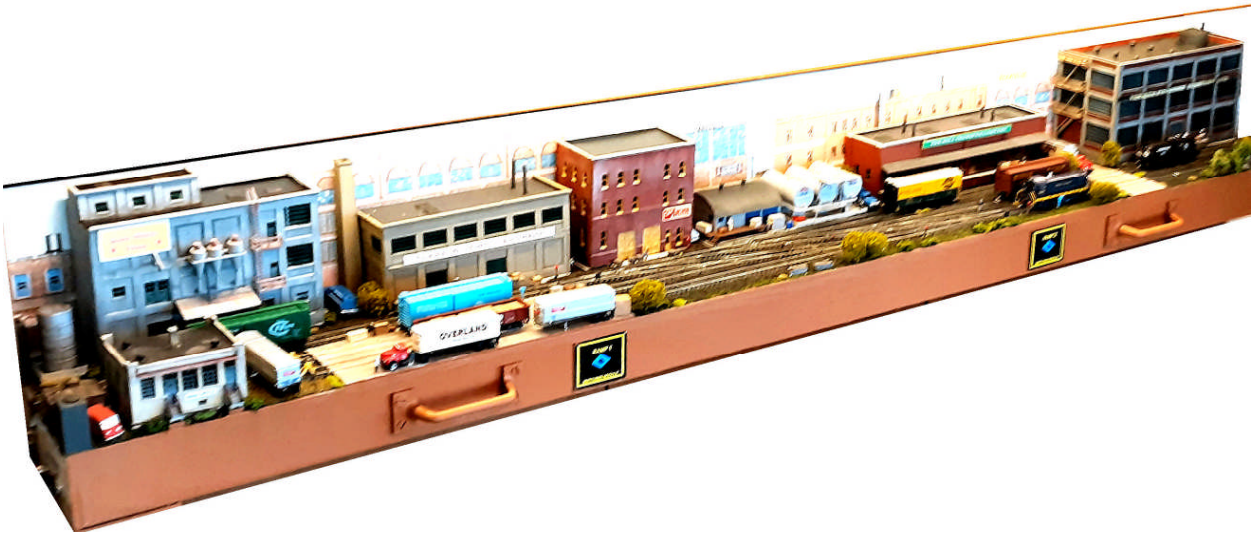
N-SCALE SWITCHING LAYOUT ANIMATION PROJECT

By F. Miller, MMR

Contents

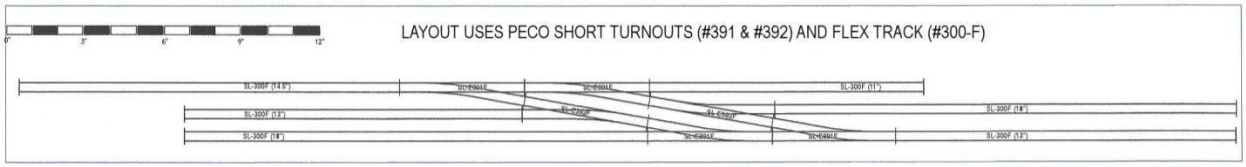
Introduction

The FOX HILL SWITCHING LAYOUT in N-Scale was developed as a fun project to demonstrate the capabilities of Arduino micro-controllers. The layout is a complex of spurs suitable for a switching challenge not unlike the famous John Allen switching puzzle. This project, however, makes use of micro-controllers to actually operate the layout and switching activities. In fact, in total (2) Arduino Megas, (4) Arduino ProMinis and (15) ATTINY85s are used to complete the automation.

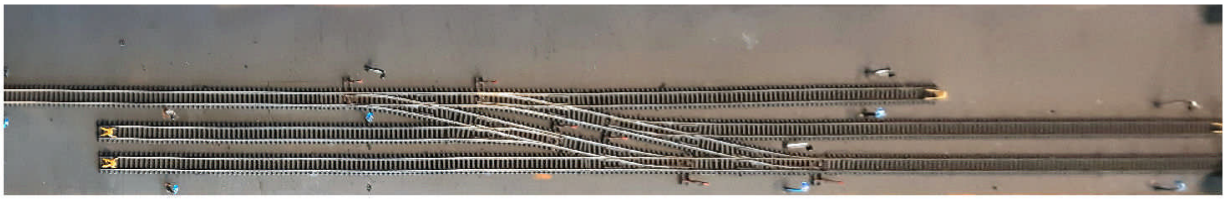


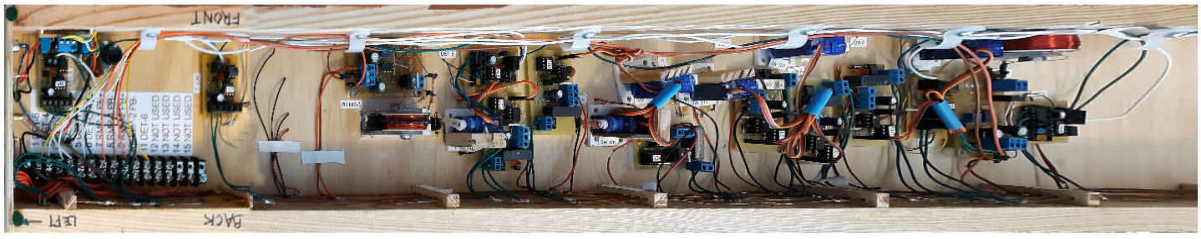
Layout construction

The layout is mounted on a simple 6” by 48” frame consisting of 1x2 base frame covered with a 1/4'” plywood top. The track configuration makes use of PECO code 55 track and includes 6 turnouts and surrounding flex track. The track schematics were designed using SCARM – *Simple Computer Aided Railway Modeler*, a design software package which has all of the PECO track libraries.



The layout is powered by DCC delivered through a DCC++ Base Unit (Arduino Mega). The turnouts are controlled by DCC Command Activated Servo Switch Machines (ATTINY 85 Micro-Controller). Two electric Uncoupling Ramps are activated with ATTINY85 Micros & MOSFET Transistors. Six IR Detection circuits are activated with ATTINY 85 Micro-Controllers.





Scenery

All of the track work is ballasted in cinders (Woodland Scenics #B76-Fine Cinders). Some surrounding territory is covered in fine grass and earth (Woodland Scenics #T45 & T42). A scattering of bushes (Woodland Scenics FC148) is also used to blend areas. The cinders and fine grass are positioned dry, and then mist sprayed with 70% alcohol. Water-diluted Carpenters glue is then dribbled into the

wetted materials.

Concrete roads and pads are simulated with a styrene sheet coated with grey paint and subsequently stained with chalks.

Structures are mostly kit-bashed N-Scale kits including two buildings fashioned from components of Walthers 'Red Wing Milling Company', another from components of Walthers 'George Roberts Printing'. Tanks and structure from Walther's Interstate Oil Company are repurposed. The Walthers Industry Office is built as per the kit. Both the DPM Trackside Transfer and the DPM Goodnight Mattress Co structures are kit-bashed to meet space requirements. All buildings are spray painted prior to mounting window fixtures. A coat of flat spray tones down any remaining plastic. Ink and alcohol washes are used for weathering.

To facilitate portability, all buildings are removable. Styrene positional bases are fixed to the layout and the buildings are snapped into pace.

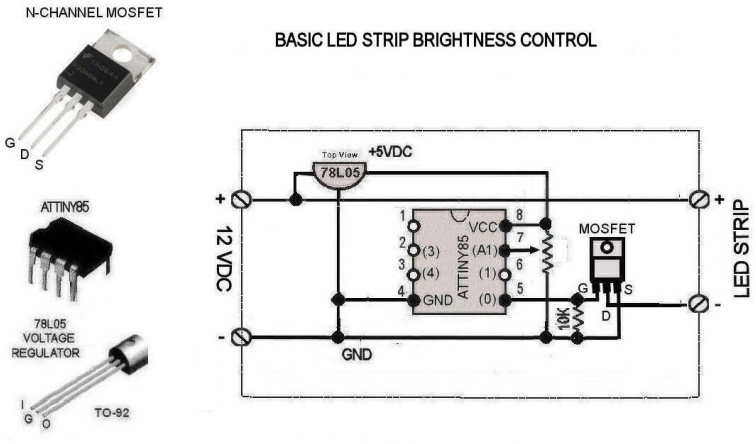
Various Classic Metal Works trucks are positioned around the layout including trailers at the exchange tracks.

The layout was constructed to slide out from under another HO Traction Layout. Space restrictions necessitated a maximum height of 5" above layout base. A removable sky-blue painted backdrop was affixed to the back of the layout. Printed industrial buildings from images obtained on the Internet were fixed to the background panel.

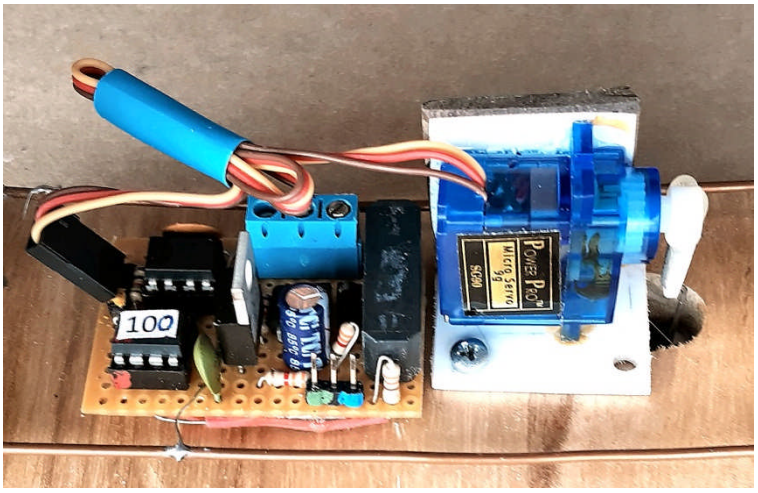
SLIDE OUT N-SCALE SWITCHING LAYOUT

Layout Lighting

A removable light bar provides layout lighting. The bar has a 12VDC LED strip fashioned to the bottom of a steel 'wire cover plate'. Power is routed to the strip by the brass uprights on either end and has a dimming circuit to adjust the lighting.

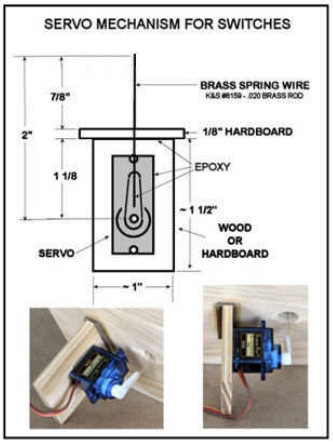


Turnout Controls

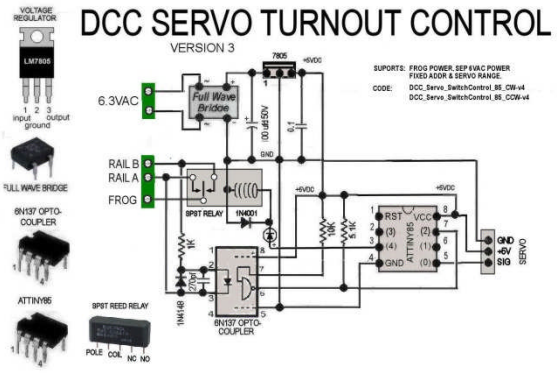


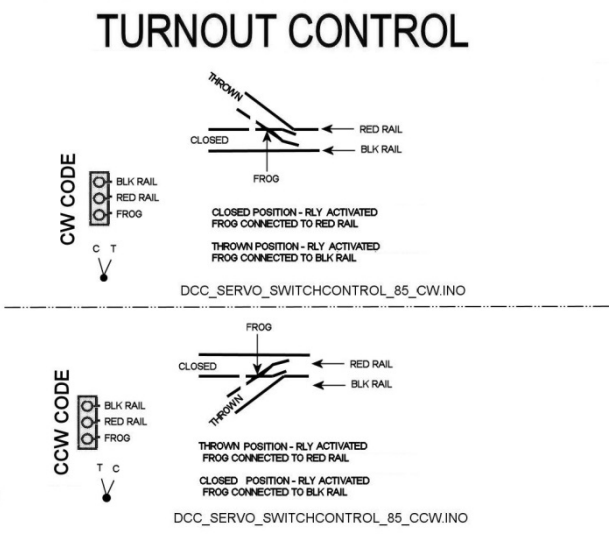
The turnout points are controlled by DCC Switch Commands from a DCC throttle or in this case the Animation Controls (discussed later). The turnout mechanism is a small Servo Motor operated by a circuit running in an ATTINY85 Micro controller. The DCC Switch Commands are presented on the rails but the controlling circuit is powered by a separate 6VAC bus line.

The turnout control board runs the servo motor at a slow speed, not snap action. Half-way through the motion, a relay is reversed to apply applicable rail power to the turnout's isolated switch frog.



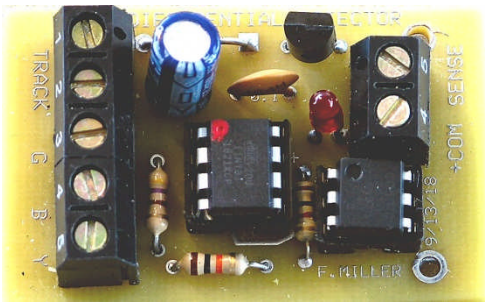
The software running on the ATTiny85 micro-controller was developed in the standard Arduino IDE environment and then down loaded to the smaller micro-controller. The Switch Address and the servo positions and direction are 'hard-coded' in the software and matched to each specific turnout.

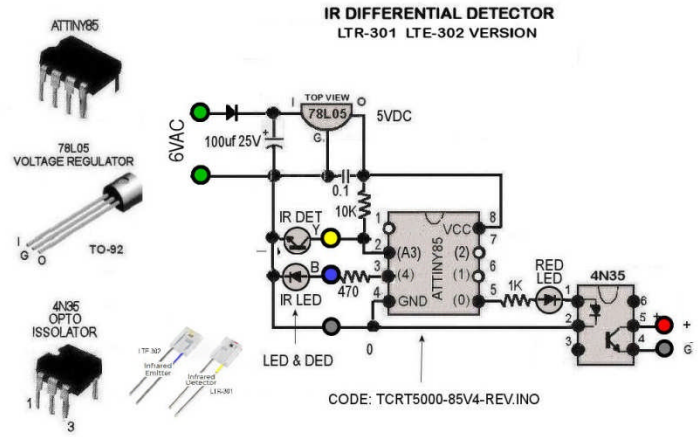




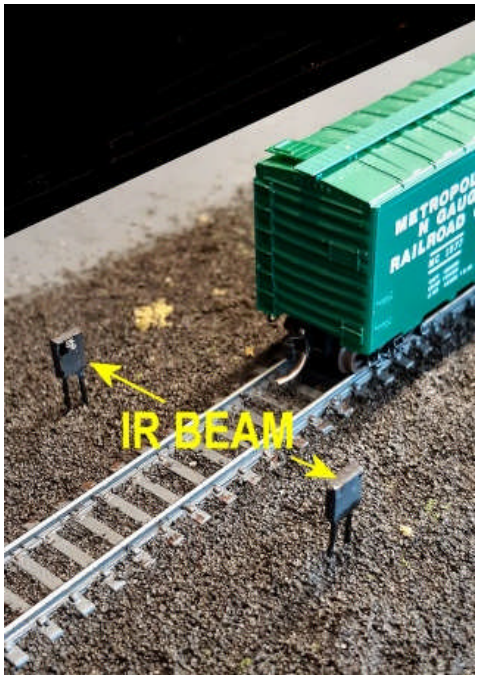
Detection Circuits

The Animation Control logic needs to monitor locomotive/car positioning while operating the Switching layout. This position detection is provided by IR-Detection circuits. An interruption of the IR beam across the track signals a detection situation. An ATTINY85 circuit runs the IR LED emitter and IR transistor receiver in such a way that spurious light does not affect the detection. (The circuit compares received IR energy in both an energized and quiescent IR LED emitter. When the difference reaches a threshold, the detection is signaled.)





The IR detection circuit is powered by the same bus delivered 6VAC as the Switch Control Circuits. The circuit is electrically isolated from the Animation Controls.

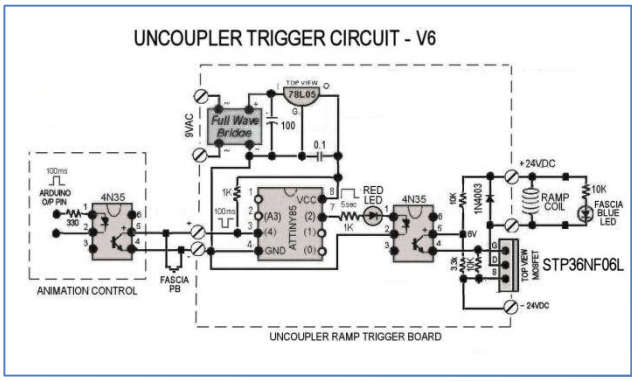


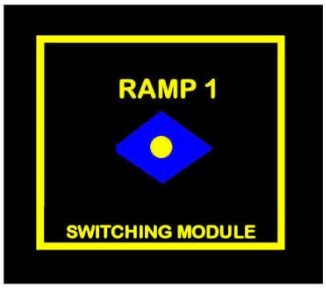
The IR LED Emitter (LTE-302) and the IR transistor Receiver (LTR-301) are very small units, easily hidden in the scenery or buildings surrounding the detection site. (Previous implementations of this circuit on an HO trolley layout used LEDs and IR Receivers based on 3mm packaging which was fine for the larger scale but not useful for between parallel tracks in N-Scale.)

Color coded wires are soldered directly to the LED and Transistor leads and the wires are passed through the layout down to the detector circuit boards. The LEDs and transistors are painted black and mounted across one or two tracks facing each other (with up to 3” distance for reliable detection)).

Powered Uncoupler Ramps

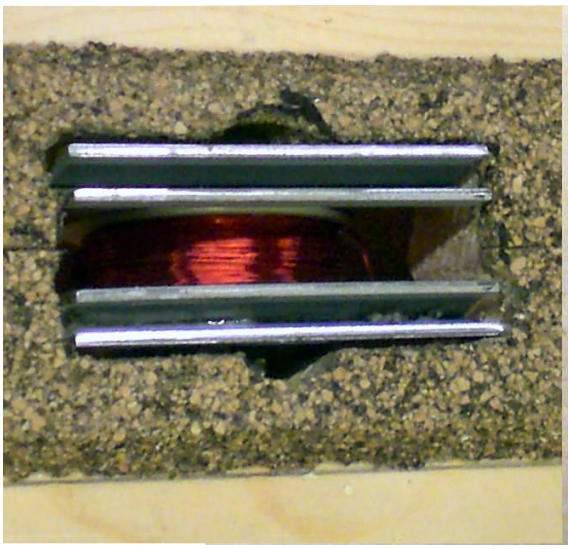
The Kadee® #309 Magne-Electric Uncouplers, when mounted under the rails, provides a solution to inadvertent magnetic uncoupling of the MicroTrains couplers which would result from the traditional magnet bars. However this powered uncoupler requires 3-4 amps of DC current at 18 or more volts, enough to overheat the coils if left on.

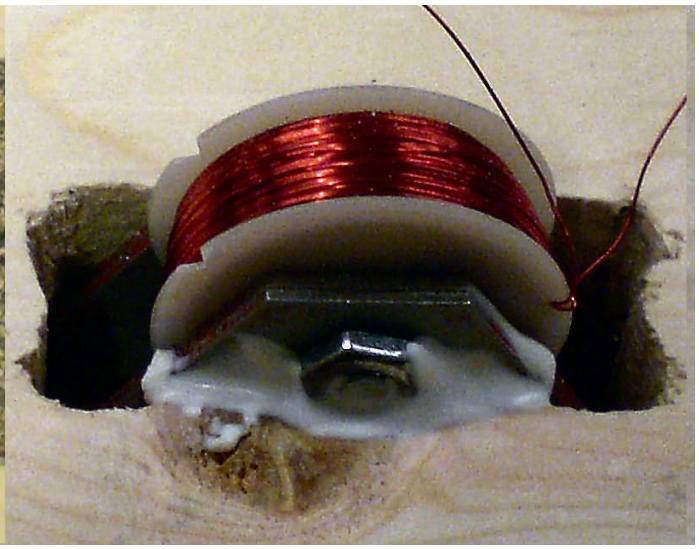




A separate 24VDC power source bus is provided to power the uncoupler coils.

The uncoupling circuit provides a 5 second burst of the required power to prevent overheating. Activation of the ramp is accomplished by a LED light/pushbutton on the layout fascia, or by a momentary pulse from the Animation Controls. The uncoupling circuit 'debounces' the input pulse to eliminate false triggers from noise.

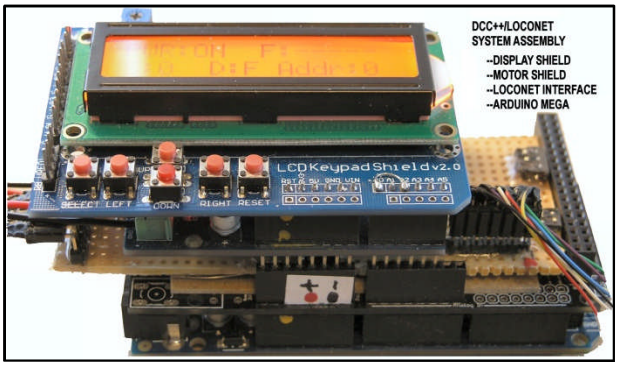




DCC/LOCONET COMMAND STATION

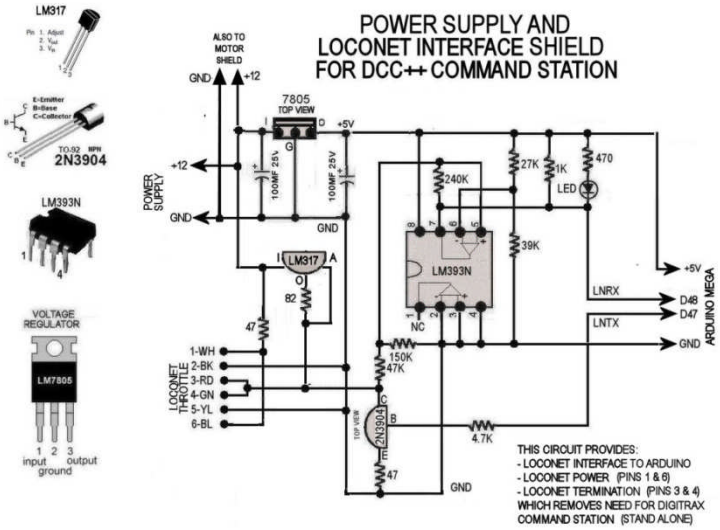
Instead of using a traditional DCC Command Station and Booster for my DCC power supply, I use an Arduino project called DCC++ BASE STATION which makes use of an Arduino Mega microcontroller and various other plug-in Arduino "shields." The software is readily available on the Internet but I made various changes to suit my needs.

My implementation provides LEDs to show track power status as well as a LCD display which shows currently selected Locomotive address and its speed and direction.



As noted, the project makes use Arduino Shields, which plug into each other over the Arduino Mega. All but one of the "shields" are commercially available. I added an additional custom board to provide a power supply for the unit and LocoNet interface.

The DCC++ Base Station has outputs for connection to the rails, as well as inputs for LocoNet throttles (or in this case, my Animation Controls.)



Animation Controls

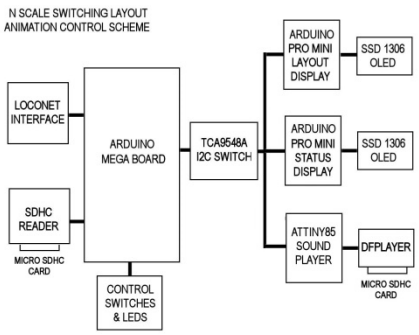
As noted earlier, the layout is a complex of spurs suitable for a switching challenge or puzzle. Although the layout could be operated with traditional throttles, this project makes use of microcontrollers to automatically operate the switching activities.

The Animation Controls use 'scripts' or schedules stored on a SDHC card. The script steps activate various activities. For example:

- Set Turnout positions to THROW or CLOSED
- Run a Locomotive Eastbound or Westbound at a selected speed.
- Stop the locomotive at a specific detection point
- Stop the locomotive after running for a specific time
- Run past detection points by a specified number of cars
- Perform an uncoupling action at specified Uncoupling Ramp
- Pause the script for a specified time delay.
- Repeat the script from the beginning.

The Animation Controls can operate each of the Script steps automatically in sequence, or do a single (next) step as commanded by a push-button.

The animation functions for the Switching Layout are performed by an Arduino Mega microcontroller and various other supporting toggle switches, pushbuttons, displays and other devices. A two color LED shows the operating mode (Hold/Normal/SingleStep) and one Display shows turnout positions and active detectors. Another display shows the Script Step, Number of 'moves' and details of the current animation step underway.



The Animation Controls box also has provision for audible narration of the current Script step, mimicking the text displayed.

The Animation Controls box is connecting to the DCC++ Base Station through a LocoNet cable. Control signals are received or passed to the layout through a DB15 cable.

The primary controls on the Animation Controls box include toggles for selecting an operating Mode and enabling Loco decoder sounds. Push buttons are used for Single Step cycling through the schedule and resetting the controls back to power up status. Display panels show the current turnout positions and the operating status and schedule steps underway. LEDs show operating Mode status and Loconet activity. In addition voice

narration indicates current schedule activity. A control knob is provided for setting the narration volume.

The 3-position Mode Select toggle determines the operational mode.

- Normal Ops (cycling through all steps of the schedule) – LED- mode indicator shows steady GREEN
- Hold Status (no schedule activity) - mode indicator shows alternate RED/GREEN blinking
- Single Step (each schedule step is activated, one at a time for each button press - mode indicator shows steady AMBER

The Single Step push button can also be used (when in Hold mode) to advance through the 'schedule' without executing the steps.

Once a 'schedule' is read from the micro SDHC card and activated the animation will step through each action and then repeat the schedule, unless the Mode switch is set back to Hold, in which case the schedule will terminate before restarting at the first step. If the Mode switch is set to Single Step, a press of the STEP pushbutton is required to move to each step in the schedule. The Mode LED will switch from AMBER to RED when a step has been completed and the controls are ready for another step (push button).

The Schedule

The schedule, stored on a micro SDHC memory card, makes use of five 'activities' and three additional control commands. The activities are:

- Run Loco Eastbound at specified speed to a specified IR Detector, or for a specified time.
- Run Loco Westbound at specified speed to a specified IR Detector, or for a specified time.
- Run Loco Eastbound as above, but performing an uncoupling action at uncoupling ramp 1
- Run Loco Westbound as above, but performing an uncoupling action at uncoupling ramp 2
- Set a specified Turnout to either THROW or CLOSE position.

The additional control commands are:

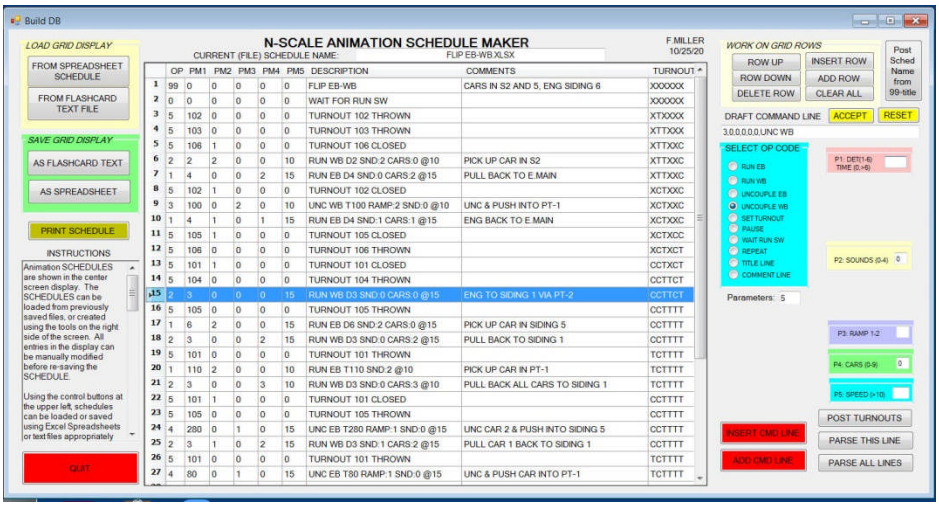
- Wait for the Mode switch to be set to Normal or Single Step. This is usually the first operating command of a Schedule.
- Repeat the Schedule. This is usually the last command in a schedule
- Pause operations for s specified amount of time.

A sample Schedule to move a car from Siding 3 the Siding 2 is shown below. The example contains lots of commentary but only the data shown within the RED box is actually stored on the MICRO SDHC card. Each line of the schedule contains the command code followed by 5 parameters

```
SCHEDULE: UNAMED                SCHEDULE MAKER                PRINTED 11-03-2020

001:  00, 000, 0, 0, 0, 00,  WAIT FOR RUN SWITCH           SAMPLE SCHEDULE TO MOVE CAR
002:  05, 103, 1, 0, 0, 00,  TURNOUT 103 CLOSED            ALIGN TURNOUTS FOR MAIN TO SIDING 1
003:  05, 106, 1, 0, 0, 00,  TURNOUT 106 CLOSED
004:  02, 002, 0, 0, 0, 10,  RUN WB D2 SND:0 CARS:0 @10    RUN ENG FROM MAIN TO PICK CAR SIDIN
005:  01, 004, 0, 0, 2, 15,  RUN EB D4 SND:0 CARS:2 @15
006:  05, 101, 0, 0, 0, 00,  TURNOUT 101 THROWN            ALIGN TURNOUTS FOR MAIN TO SIDING 2
007:  05, 103, 0, 0, 0, 00,  TURNOUT 103 THROWN
008:  03, 100, 0, 2, 0, 10,  UNC WB T100 SND:0 R:2 @10     UNC & PUSH CAR INTO SIDING 2
009:  01, 004, 0, 0, 1, 15,  RUN EB D4 SND:0 CARS:1 @15    RUN ENG BACK TO MAIN
010:  06, 000, 0, 0, 0, 00,  REPEAT SCHEDULE
```

The script or schedule is a text formatted file with 16 characters per line. It could be developed with a simple PC program such as Notepad, but to make the process easier I developed a custom PC program to develop schedules. It provides for easy insertion of schedule action steps with applicable parameters. The actions are automatically parsed for accuracy and narrative comments are added. The program also saves the step commands on a micro SDHC



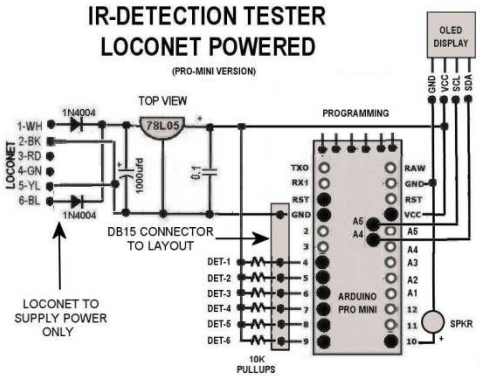
Operational considerations

In order to provide reliable operation of the automated activities careful adjustment of track turnouts and rolling stock is needed. Each car has several truck axles equipped with 'restraining' springs and is weighted at up to 2oz (beyond NMRA recommendations) in order stabilize the car during uncoupling and push back action. MicroTrains couplers are used throughout and adjusted for good performance.

Several different N-Scale switchers were tested and I found the Atlas Gold Series offered the best slow speed performance and nice sound capabilities. Note that standard two and three whistle blasts are used for all forwarded and reverse movements of the engine. The bell is activated for reverse movements.

Auxiliary devices

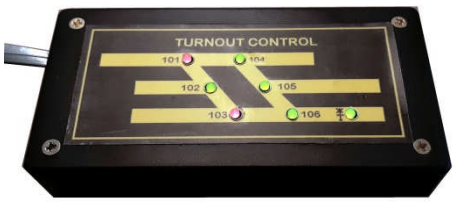
Two additional devices were developed to assist in the construction and operation testing.

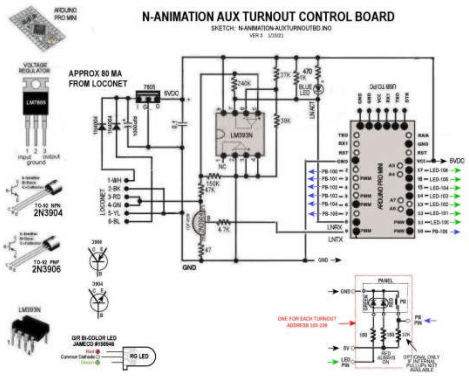


In order to properly position and adjust the IR detector units, an Arduino ProMini controlled device is used to display, with an audible beep, the occurrence of detection status.

The board is plugged into the layout using a DB15 cable. LocoNet is used to obtain power (only) for the board.

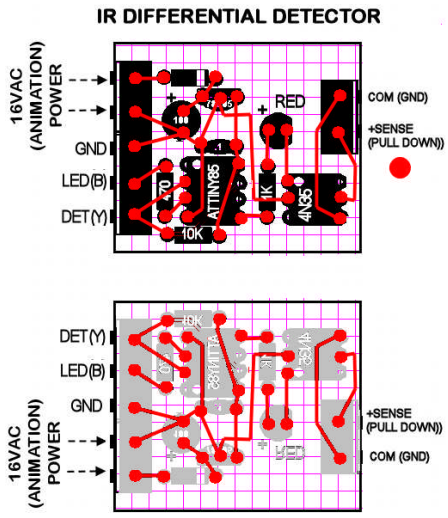
A separate turnout control device was developed to control turnouts. It includes a layout schematic and colored LEDs indicating positions. The LEDs also form Push Buttons to cycle turnouts between CLOSED and THROWN status.

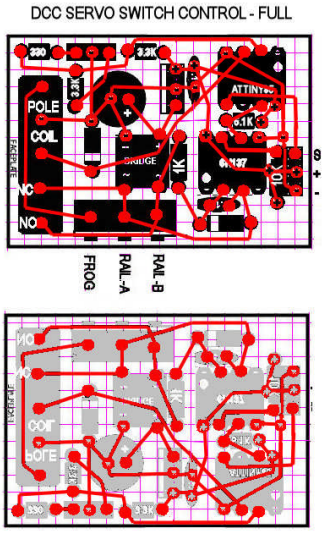


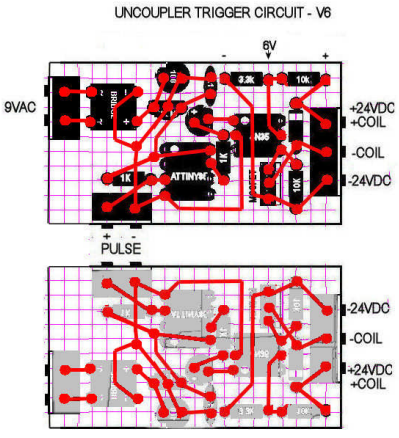


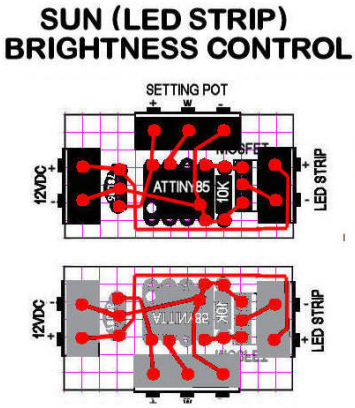
The circuit develops LocoNet Switch commands sent to the DCC Base Station. These are in turn echoed back to the rails as DCC switch commands, throwing the Servo Switch units. This unit can be used to throw turnouts on the switching layout in the same manner as a LocoNet Throttle.

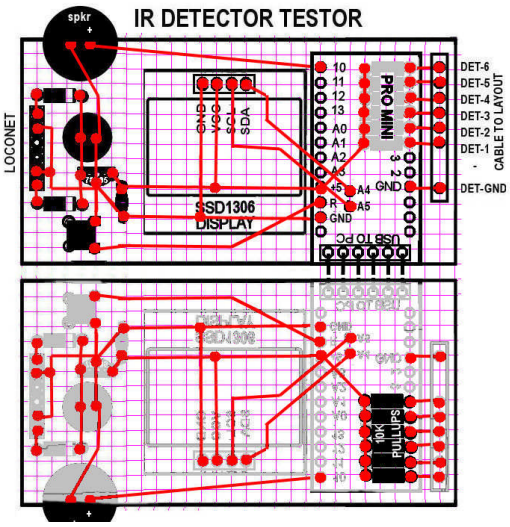
Circuit Board Layouts

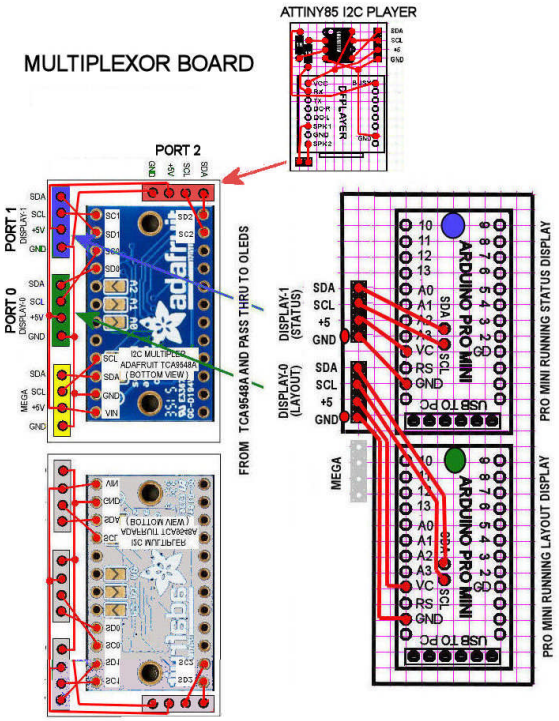


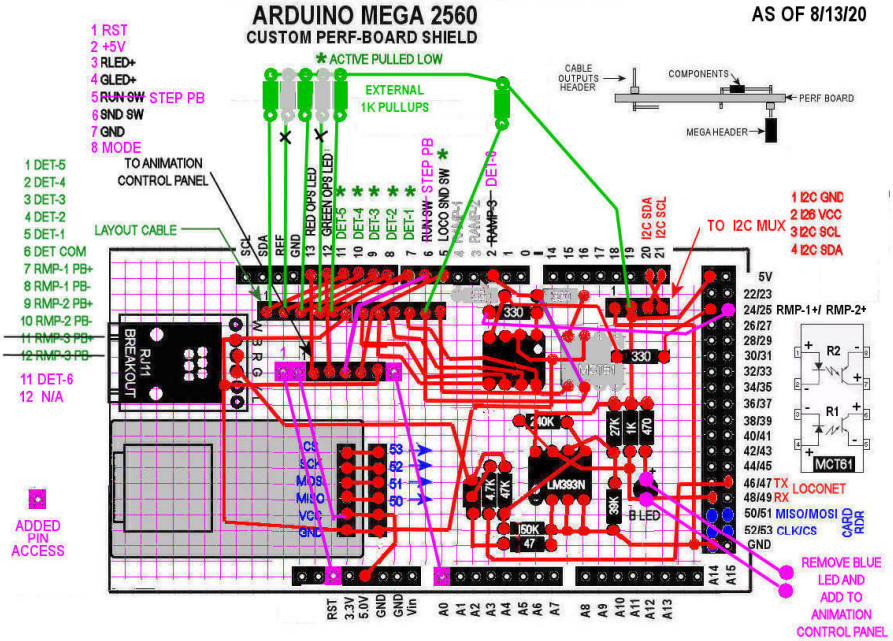







IR DETECTOR TESTOR
spkr
LOCONET
SSD1306
DISPLAY
PRO MINI
DET-6
DET-5
DET-4
DET-3
DET-2
DET-1
DET-GND
CABLE TO LAYOUT
10K
PULLUPS


ATTINY85 I2C PLAYER
MULTIPLEXOR BOARD
PORT 2
PORT 1
PORT 0
FROM TCA9548A AND PASS THRU TO OLEDS
DISPLAY-1 (STATUS)
DISPLAY-0 (LAYOUT)
ARDUINO PRO MINI
PRO MINI RUNNING STATUS DISPLAY
PRO MINI RUNNING LAYOUT DISPLAY
MEGA


ARDUINO MEGA 2560
CUSTOM PERF-BOARD SHIELD
AS OF 8/13/20
ACTIVE PULLED LOW
EXTERNAL
1K PULLUPS
STEP PB
TO ANIMATION
CONTROL PANEL
LAYOUT CABLE
TO I2C MUX
ADDED
PIN
ACCESS
LOCONET
REMOVE BLUE
LED AND
ADD TO
ANIMATION
CONTROL PANEL