

## HAWKEYE MODEL RAILROAD CLUB

### SOLENOID-BASED TURNOUT CONTROL STUDIES – AUGUST 2007

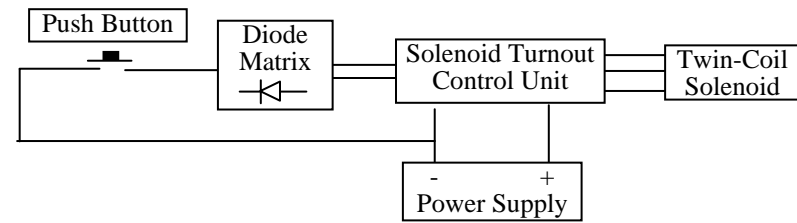
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#### 1.0 INTRODUCTION

The purpose of this document is to describe the studies associated with the effort to develop a method to control turnouts using twin-coil solenoids. In particular, the effort associated with using the TCH Solenoid Turnout Control (STC) unit (<http://www.tchtechnology.com>) is emphasized. This document complements the document "Layout Electrical Systems for Phase I."

A schematic of the components for a solenoid-based turnout control system is shown in Figure 1.1. The components consist of push buttons, a diode matrix if necessary, STC units, twin-coil solenoids, and a power supply. To use a Solenoid Turnout Control unit, the diode must face the push button as illustrated in the box labeled diode matrix and the polarities of the power supply must be connected as shown. N. J. International (NJI) makes the twin-coil solenoids. A single wire runs from each push button to the diode matrix. There are two wires from the diode matrix to each STC unit, and three wires from a unit to a twin-coil solenoid. A power supply is used to provide electrical energy to activate a solenoid. To activate a solenoid, a push button is momentarily depressed to ground.



**Figure 1.1 Schematic of components for track routing control system.**

The information presented in this document consists of (1) a summary of communications with TCH Technology and the events associated with the development of the electrical system for the solenoid-based turnout control system, (2) a description of the STC unit, and (3) the tests used to develop the capability to activate multiple solenoids from a single power supply.

## 2.0 ACTIONS REGARDING TCH TECHNOLOGY

A summary of the communications and actions taken with regard to the STC units follows.

In early January 2007, TCH Technology was contacted about using their STC units. A summary of the comments from TCH follows:

The unit will drive an NJI solenoid switch machine.

Push buttons are used to activate the unit.

The circuit is similar to that which appeared in an article in the October 1993 issue of Mainline Modeler.

It is OK to place the unit close to the solenoid.

The push buttons can be a distance from the unit.

Connectors come with the unit.

There is not a provision at this time for indicator lights.

A single test unit was purchased in February 2007. For 16 vdc, two additional 6800  $\mu\text{f}$  capacitors in parallel with the on-board 2800  $\mu\text{f}$ , 16 vdc capacitor had to be used to get the NJI switch machine to throw reliably and soundly. Based on these results, it was decided to use a 24 vdc power supply. The on-board capacitor was replaced with a 2200  $\mu\text{f}$ , 25 vdc capacitor and the solenoid operated properly on 24 vdc.

Twenty-two STC units were purchased at the end of February 2007.

Two units were installed in the South Junction. The units did not work. Inspection of the units revealed that four resistors were different from those on the original (ORIG) unit. At the suggestion of TCH, the four resistors were replaced in all units and a jumper wire was used for the fuse. The two modified units in the South Junction worked properly.

Near the end of March 2007, ten units were installed in the East End. Using a 24 vdc, 2.8 amp power supply, only two solenoids could be activated properly at a time. A 24 vdc, 8 amp power supply could activate three units. With three power supplies, one at 2.8 amp and two at 8 amp, the routing diode matrix for the East End worked.

In July 2007 using a test stand of six solenoids (see Section 4.0), it was discovered that six solenoids could be operated properly using (1) a power supply rated at 24 vdc, 2.8 amp, (2) a resistor of 6 ohm installed on the ground side of the power supply, and (3) a capacitor of 9100  $\mu\text{f}$ .

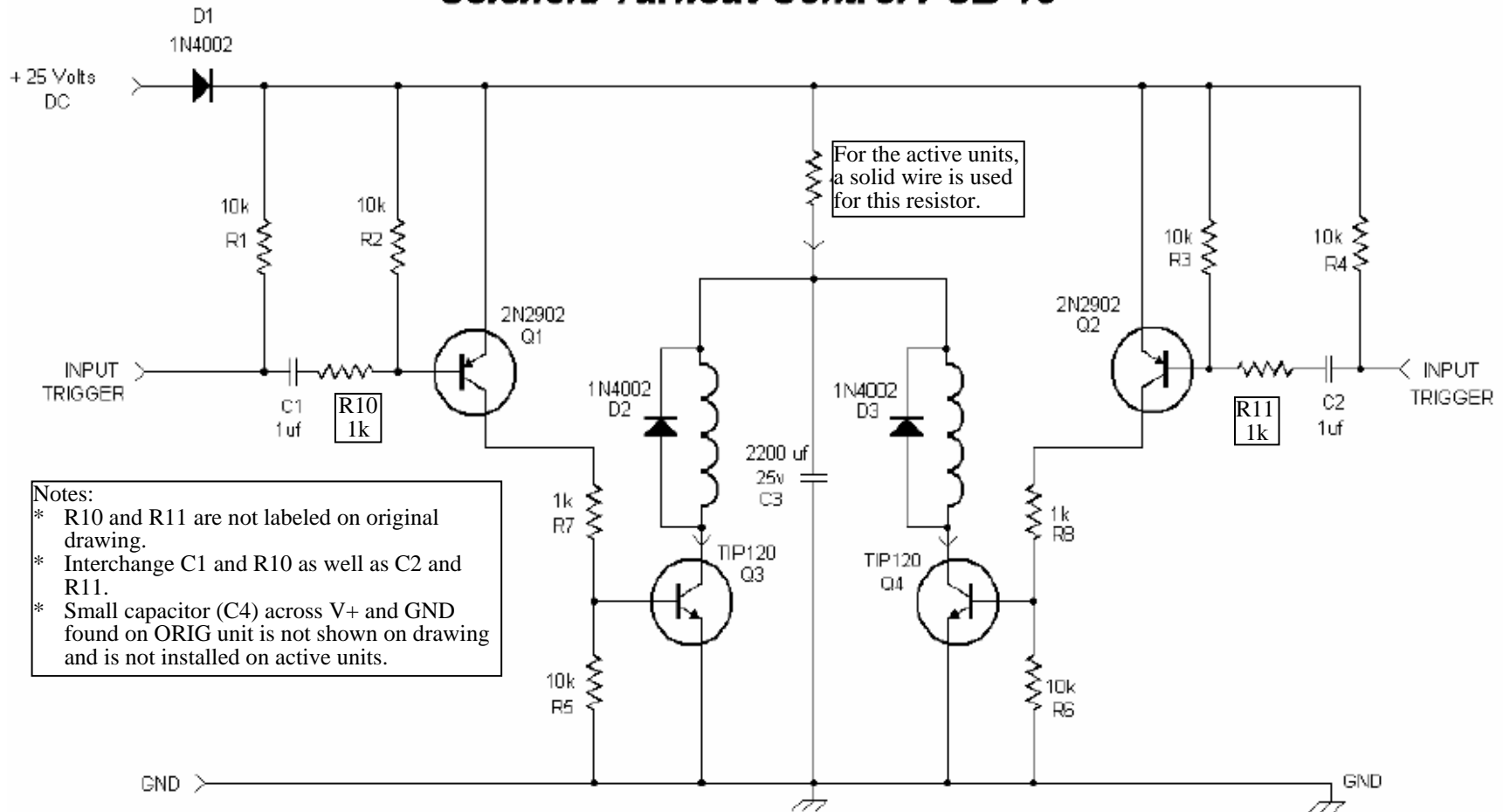
At the end of July 2007, the resistor and capacitor mentioned in the previous line were installed in the circuitry for the East End. The power supply rated at 24 vdc, 2.8 amp operated the 10 solenoids.

In October 2007, a similar circuitry for the East End was installed in the West End and the routing system worked properly.

### 3.0 SOLENOID CONTROL UNIT

#### 3.1 Circuit diagram for unit

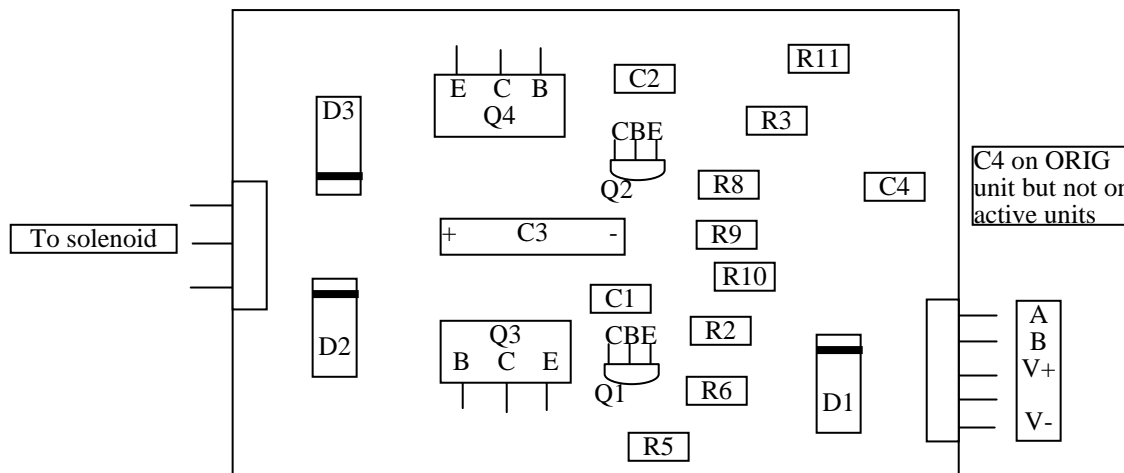
## ***TCH Technology Copyright 06/06/07 Solenoid Turnout Control PCB-15***



### 3.2 Component arrangement and values

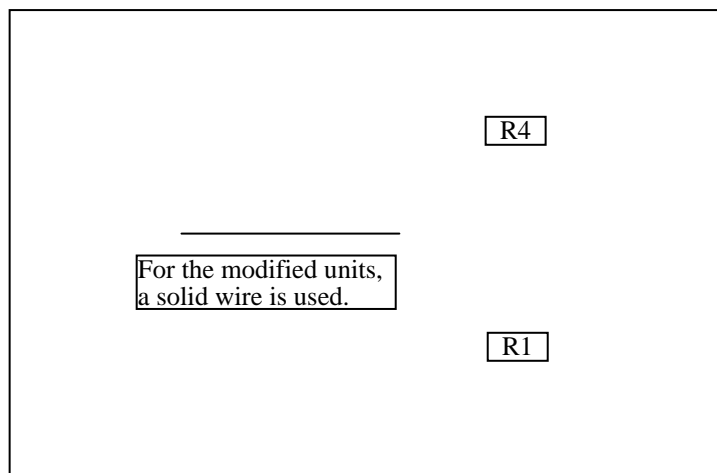
#### 3.2.1 Component side

C1 = 1  $\mu$ f  
 C2 = 1  $\mu$ f  
 C3 = 25v, 2200  $\mu$ f  
 D1 = 1N4002  
 D2 = 1N4002  
 D3 = 1N4002  
 Q1 = PNP 2N2902  
 Q2 = PNP 2N2902  
 Q3 = NPN TIP120  
 Q4 = NPN TIP120



#### 3.2.2 Foil side

R1 = 10k ohm  
 R2 = 10k ohm  
 R3 = 10k ohm  
 R4 = 10k ohm  
 R5 = 10k ohm  
 R6 = 10k ohm  
 R7 = 1k ohm  
 R8 = 1k ohm  
 R9 = 1k ohm (short)  
 R10 = 1k ohm  
 R11 = 1k ohm

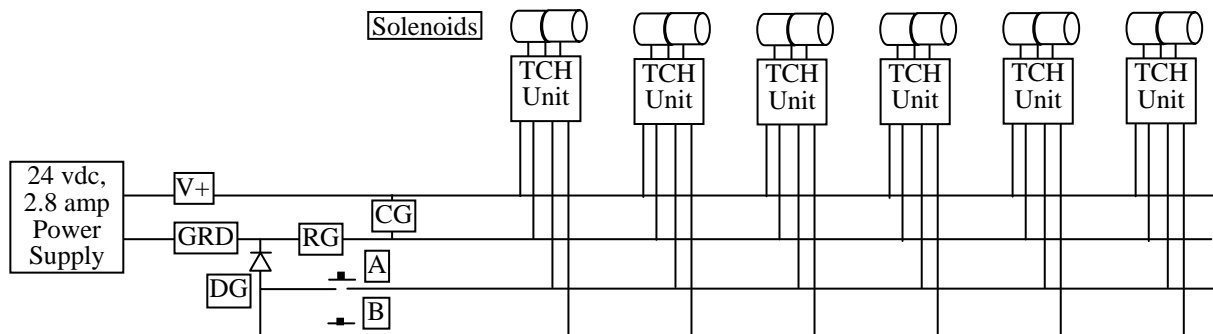


## 4.0 TESTS

### 4.1 Test arrangement

#### 4.1.1 Setup

By trying several arrangements of the components and attempting to get the circuit to perform properly, the following configuration of the components was found to work reliably (See photos in Appendix).



RG – Resistor (about 6 ohm) formed from three 20 ohm, ½ W resistors in parallel.

CG – Capacitor (about 9100 µf) formed from one 4700 µf and two 2200 µf electrolytic capacitors in parallel.

DG – Diode to represent voltage drop caused by the diode matrix

#### 4.1.2 Observations

- \* On-board capacitors (C1 and C2) for trigger circuit may need to be larger for a longer time constant.
- \* Time constant for TCH coupling capacitor may be too short (solenoid throws more reliably with this capacitor shorted, but coupling capacitor is good idea).
- \* On-board capacitor (C3) for solenoid may need to be larger to throw solenoid when capacitor is charged and V+ is disconnected. It appears that a capacitor with a rating of 12000 µf is needed to store enough energy to throw solenoid when V+ is disconnected.
- \* Placing RG on the V+ side still resulted in some solenoids not throwing properly.

### 4.2 Test Results

With CG and DG, the 24 vdc, 2.8 amp power supply was able to throw properly six NJI solenoids.

### 4.3 Other facts

The following are a few other facts that have been observed over the years when working with twin-coil solenoids to operate turnouts.

- \* The coil resistances of an NJI Twin Coil Switch Machine are  $R1 = 2.9$  ohm and  $R2 = 2.7$  ohm.
- \* An Atlas Twin Coil Switch Machine has  $R1 = 4.9$  ohm and  $R2 = 4.4$  ohm.
- \* A North Coast Engineering Snap-It driving an NJI Twin Coil Switch Machine needs two 1000  $\mu\text{f}$  on-board capacitors and one 2200  $\mu\text{f}$  external capacitor.
- \* A toggle circuit with a LED display needs three 6800  $\mu\text{f}$  capacitors in parallel to drive an NJI Twin-Coil switch machine.
- \* A Circuitron Capacitor Discharge unit has an on-board can-type capacitor rated at 4700  $\mu\text{f}$ , 35 v.

### 5.0 SUMMARY

The resistor RG and capacitor CG greatly improved the ability of one power supply to operate multiple solenoids. The use of RG and CG has been successfully applied to a routing scheme on a model railroad layout where a maximum of six solenoids must be operated for a particular route. No effort was made to optimize the components for the system so there is a need to determine if other combinations of the components would produce similar results.

### 6.0 CONTRIBUTORS

Ted Smith prepared this document. Jim Ehrhardt, Bob Perkins, and Allan Winder helped develop the solenoid-based turnout control system. Special thanks are given to Steve Warner for coming up with the use of resistor RG and capacitor CG. The help of Thomas Barnhart and John Kostman of The University of Iowa, College of Engineering, Electronics Shop is acknowledged.

## APPENDIX: LITERATURE AND PHOTOS

TCH Technology 1076 41<sup>st</sup> Drive Street Chanute, Kansas 66720 620-212-2072 <http://www.tchtechnology.com>

### Solenoid Turnout Control

Please read directions completely before beginning your installation.

*For best results, use filtered, regulated, DC voltage.*

Do not use the variable output of a throttle control.

The **Solenoid Turnout Control** was designed to be used with two pole magnetic style turnout controls.

Wiring the control is simple and straightforward. There is a five-pin jack or plug, (depending on the specific one purchased) for the inputs. A three-pin jack is used on the output for the solenoid control.

(See figure 1)

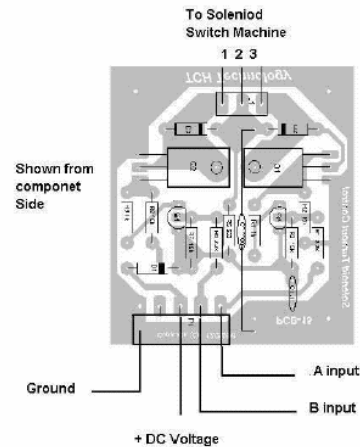


Fig. 1

The PC board can be mounted anywhere that you choose.

#### Five Pin connections

Five-pin plug or jack starting from the left looking at the PC board from the component side.

1. Ground (minus DC voltage)
2. No connection
3. DC voltage (Plus DC voltage)
4. A input
5. B input

#### Three pin connector to the Solenoid control.

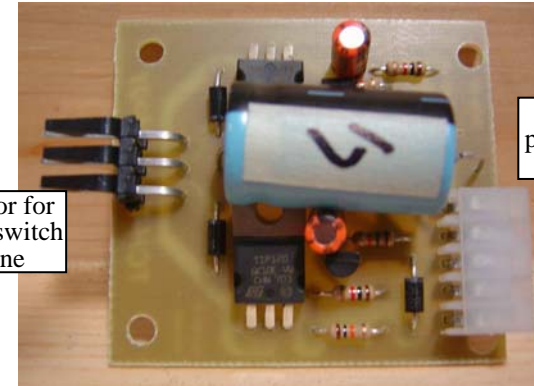
1. side of the solenoid control
2. Common
3. side of the solenoid control

The A and B inputs are used to control the direction of the turnout. By applying a ground to either on of the input controls, the turnout will move in one direction or the other. Momentary pushbuttons work quite well. Three wires should be connected from the Three-pin jack to the Solenoid control.

The **Solenoid Turnout Control** was designed to be use in a matrix system. Using several in conjunction with the **Diode Matrix System** and the **Turnout Control Switch**, staging yards and visible yard ladders could be controlled.

Another use is connecting two **Sensa-Traks** to the A and B inputs and using it to control a turnout in a reversing loop. One caution is to position the **Sensa-Traks** at least one train length before and after the turnout.

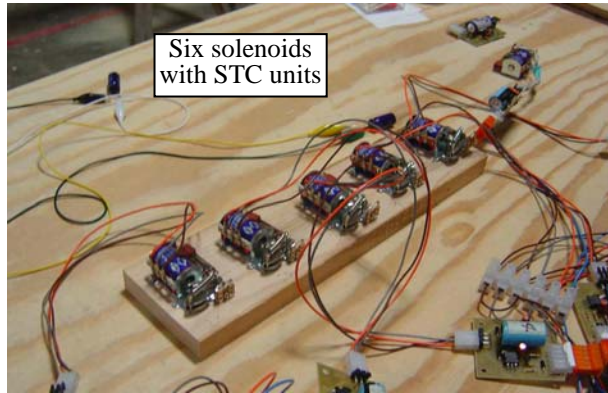
**NOTE:** The circuit described in this document has been tested under a variety of conditions, it is impossible to foresee and test under all circumstances to which the circuit may be subjected. Furthermore, many performance aspects are directly linked to the physical layout of the components and the method of connections.



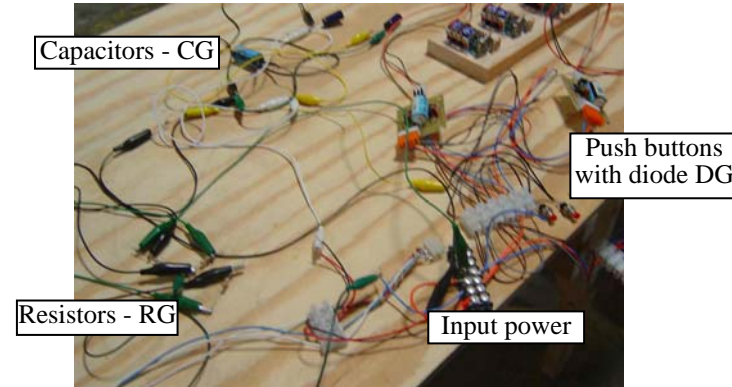
Connector for solenoid switch machine

Connector for power and push buttons

Photo of STC Unit.



Test solenoids.



Test resistors and capacitors.