Build a Diode Matrix

A diode matrix can simplify a few model railroad wiring tasks including:

- Combining multiple signal inputs to control an “interlocking” signal section.
- Lining-up turnouts for a single route into multiple tracks. A diode matrix works well when using twin-coil switch machines. It can be adapted for motorized turnout machine using small inexpensive dpdt reversing relays.
- Any other application you can think of where you want a set of single input to control multiple outputs.

The example I will describe here is a crossover between two tracks that are protected by signals at either end. Refer to Figure 1. This configuration has a double target mast facing the turnout points and a single target mast facing away from the turnout points and represents a common prototype practice. On each double-target mast, the upper target signals the main route and the lower target signals the diverging route.

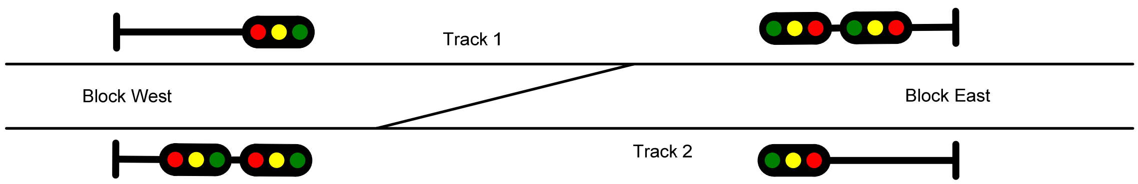

Figure 1: Signal Protected Crossover

This design assumes that each signal target uses a control unit that will display a red indication, and no other, whenever it receives a red indication. The function of the diode matrix is to receive red indications from various sources including the turnout alignment and the block occupancy detection units. It also assumes that your switch machines have a set of contacts that can be used to indicate their alignments. This design also ensures that you have a clear route through the crossover section to avoid the embarrassment of running onto a reverse polarized turnout frog.

The first step is to determine how many inputs and outputs your matrix will require.
Inputs:
Each turnout that the matrix includes will require two inputs:

- *Normal*, in prototype terminology, means the main route through the turnout.
- *Reverse* means the diverging route through the turnout.

Each approach track that has an occupancy detector will require one input.

Outputs:
Each signal target your matrix will control requires one output.

It is an arbitrary decision whether the inputs will be oriented vertically and the outputs horizontally, but I have found that there are generally more inputs than outputs, so the orientation shown above works best.

Once you have determined the number of inputs and outputs, you need to draw the layout of your matrix. Because of the size restrictions of the 1N4001 diodes, the inputs and outputs will need to be separated by about 3/8 inches (9 millimeters). If you are going to use screw terminals (recommended) allow at least ½ inch on one or both sides and either top or bottom for these connections. Figure 2 shows the matrix layout for the track and signal diagram in Figure 1. The labels on this drawing indicate the following:

- West South Hi and West South Low indicate the outputs to the high and low targets for the west end (west facing) signal for the south track.
- West North Hi indicates the output to the west end signal of the north track.
- East South Hi indicates the outputs to the high and low targets for the east end signal for the south track.
- East North Hi and East North Low indicate the output to the east end signal of the north track.
- 1N and 1R indicate the normal and reverse inputs for turnout 1 on the north track
- 2N and 2R indicate the normal and reverse inputs for turnout 2 on the south track
- 1W and 1E are the detector inputs for the track 1 blocks east and west of the crossover.
- 2W and 2E are the detector inputs for the track 2 blocks east and west of the crossover.

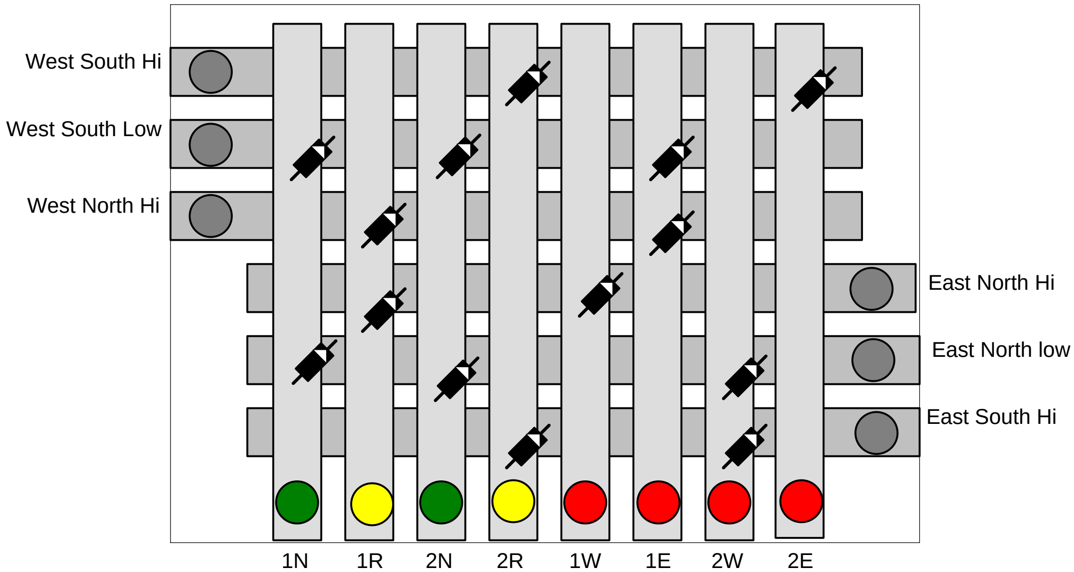

Figure 2: Full Size Diode Matrix Layout

The first step in constructing the matrix is to select the substrate that it will be built on. There are several possibilities:

- A pre-punched perfboard

- A Plexiglass board
- A masonite board that is smooth on both sides.

I have found that a clear Plexiglass board is the most economical and it has the advantages of being easily drilled and tapped while the ability to see through it enhances the ability to locate the diode mounting holes. It will also withstand the heat of soldering as long as the heat is applied quickly.
When you have selected your substrate and cut it to size, apply the conductive material. My choice is Flat Copper Cable made by Busch and available from Walthers, catalog #189-1799. This "cable" or tape is 1/4 inch wide and comes in 10 meter spools (approximately 33 feet.) One side contains a plastic adhesive backing that is easy to remove. After cutting it into appropriate lengths, remove the backing and place it on the substrate. The vertical strips should go on one side and the horizontal strips on the other. The tape is conductive on both sides, so do not put the horizontal and vertical strips on the same side.

I prefer to use #4-40 x ¼ inch machine screws for attaching leads to the matrix, but the leads can be soldered directly to the tape. The advantage of screws is that the leads can be easily removed if you find that you need to make corrections after installation. I drill a hole through the substrate with a #43 drill and tap the hole with a 4-40 tap mounted in a large "pin vise". After applying the tape, punch a hole through the tape and insert a #4-40 screw. Figure 3 shows a Plexiglass board which has been pre-drilled and tapped with the copper tape applied.

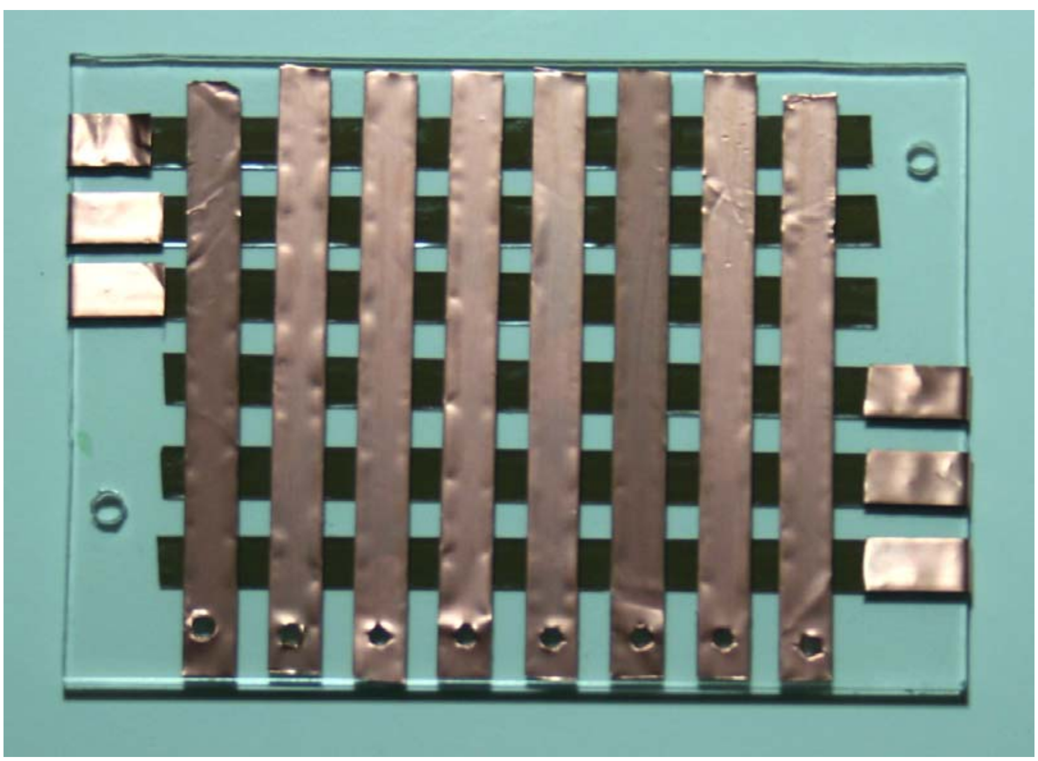

Figure 3: Plexiglass Board with Copper Tape Applied

With the tape installed you are now ready to drill holes for the diodes. Each hole must pass through only one layer of tape. Choose a drill that is slightly larger than the diode leads. I find a #60 drill is about right. The holes must be spaced so that the diode leads, when bent 90 degrees will pass through the holes easily. It is Ok if you drill too many holes as long as you don't damage the tape. I use a variable-speed Dremel tool for drilling the holes. Run it at the lowest possible speed, otherwise the drilling heat will melt some plexiglass and gum up the drill. A sharp new drill also works best.

The critical part of the project, and probably the most time-consuming, is determining where the diodes must be located. A crude "checkerboard" of your matrix is good for this. Draw a "trackplan" above or below the matrix to define the turnouts that will be controlled. I use an Excel spreadsheet for as a work sheet as shown in Figure 4. Clearly mark the rows and columns with the inputs and outputs. Now do a paper and pencil exercise to trace the various routes through your trackwork to determine which routes will turn which signals red. Mark an "X" or something where you think a diode must go. Don't be afraid to go over your diagram multiple times, making erasures and changes when necessary, until you are certain your configuration is correct. When you are satisfied with the diode placement, transfer to locations to your matrix. Compare the position of the X's with the diode placement in Figure 5.

West 2 Hi				x				x	
West 2 Lo	x		x			x			
West 1 Hi		x				x			
East 1 Hi		x			x				East 1 Hi
East 1 Lo	x		x				x		East 1 Lo
East 2 Lo				x			x		East 2 Lo
	Ty 1 N	Ty 1 R	Ty 2 N	Ty 2 R	West 1	East 1	West 2	East 2	

			Ty 1		
Wes t 1 D	Trac k 1	________ _	_________ _	______1	East 1 D
Wes t 2 D	Trac k 2	________ _	____/____	________ _	East 2 D
		2	Ty 2		

Figure 4: Excel Spreadsheet Used for a Diode Matrix Worksheet

When your diodes are in place, make a final check to ensure your diodes are correctly oriented, with the silver band to the right, then solder the leads to the copper tape. There should be one solder connection on the front and one on the back for each diode. Check each connection for cold solder joints. Figure 6 shows what a completed matrix should look like. Finally connect your switch machine routing contacts and block occupancy detector outputs to the appropriate matrix inputs and the matrix outputs to the signal controllers. Your matrix will give you decades of faithful service.

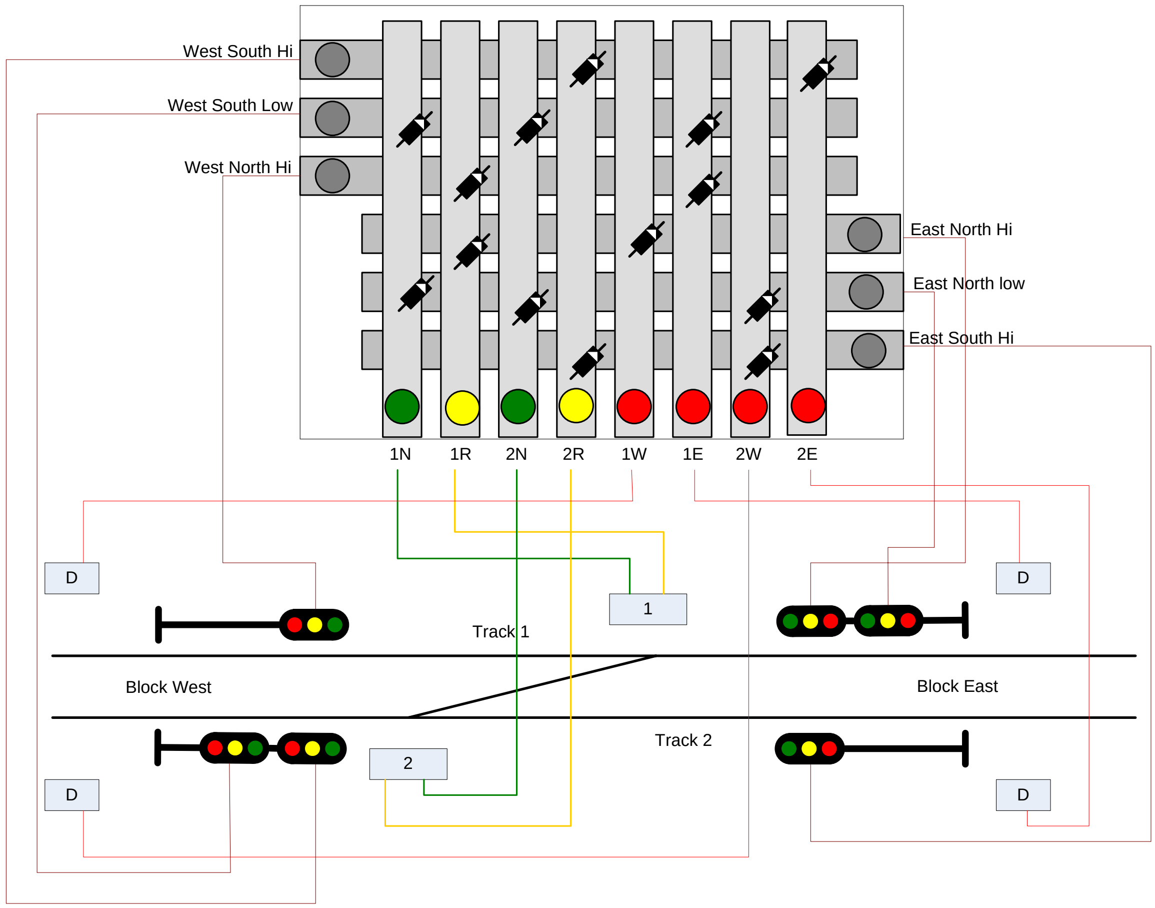

Figure 5: Complete Diode Matrix Layout for a Single Crossover

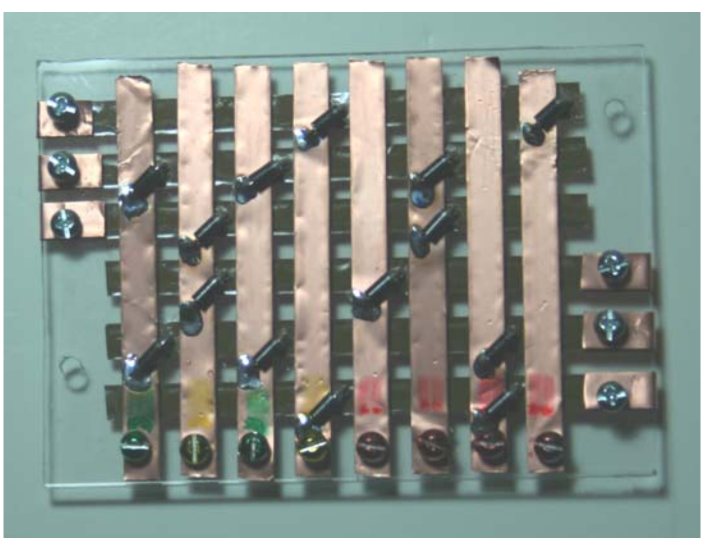

Figure 6: Completed Diode Matrix

Appendix A

I built and installed several such units for use on the Sunrise Division's modular layout. I have also built many units for my own layout. Figure 7 below shows an alternate matrix design built from perf-board and wire that controls six signal targets for the interlocking junction configuration shown in Figure 8. Five simple turnouts, a double slip switch and three block detectors provide the inputs to this matrix. Also, the column of diodes to the right turns all signals red when the drawbridge beyond the junction is raised. This matrix has been operating successfully for many years.

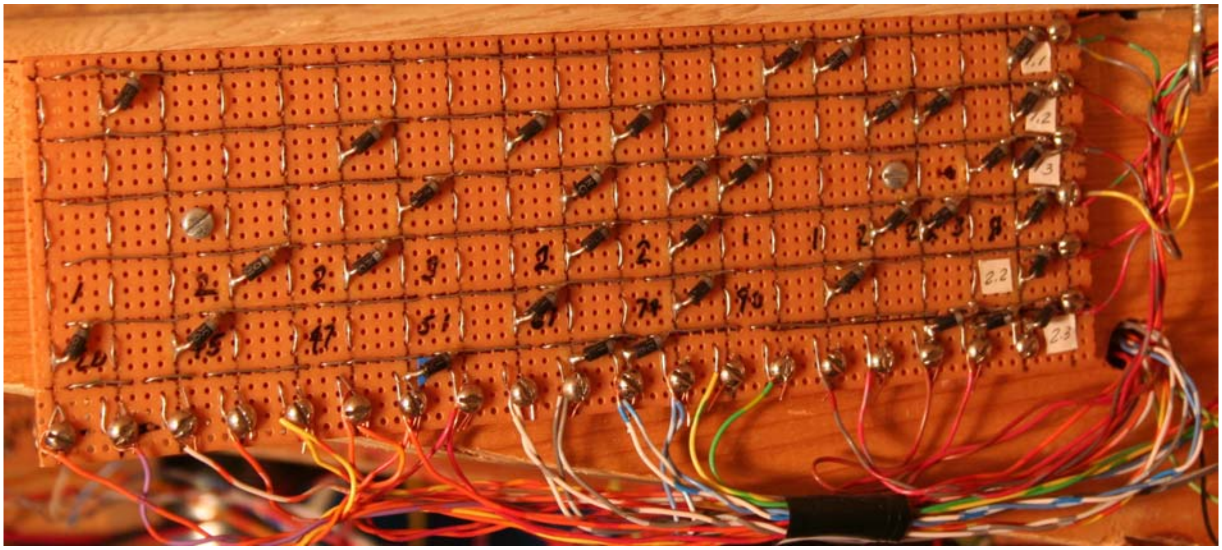

Figure 7: Diode Matrix for Complex Interlocking

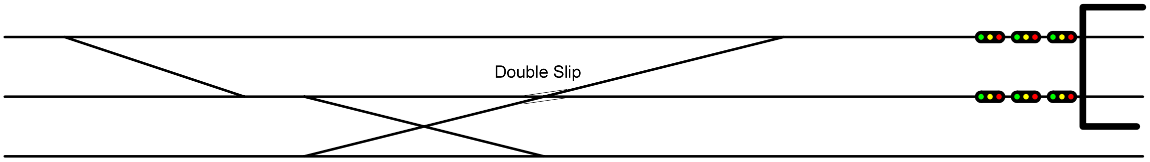

Figure 8: Interlocking Junction Configuration