Low-Cost Integrated Signal System

Why Signal Your Layout?
How often have you seen a layout that represents a Class 1 railroad main line but lacks a Signal System, even a non-operating one? Certainly, apart from branchlines, few Class 1 railroads during the last century could operate effectively without one. An operating signal system goes beyond prototypical detail. It adds additional interest to operations, and if you are using a DCC system, it can help to avoid head-end and rear-end collisions. Implementing a model signal system is often perceived as an expensive and complicated project, but it doesn't necessarily need to be. This presentation describes a system that is modular, inexpensive, uses readily available components, is easily assembled including complex interlocking, and provides reasonably accurate prototype functions. A few features are not implemented, such as approach lighting and tumbledown, but could be added with additional circuitry

This presentation divides the system into three sections:

- Signal Display Modules,
- Train Detector Modules, and
- Block Wiring and Interlocking.

Signal Controller Display Modules
The Display Module (DM) is the heart of the system and enables each signal target to display one aspect at a time (red, yellow or green). Normally the display module enables the green display, but if either the yellow or red input is powered it extinguishes green and displays the indicated color. A red input disables both yellow and green even if yellow is powered. The display module functions as an electronic relay that eliminates mechanical relays and reduces complicated wiring significantly. It is designed to control signal targets that use low-cost LEDs that have lower power requirements than incandescent bulbs, are very long-lasting, are lower in cost, and do not generate heat, so they can safely be used in plastic targets. Many commercial kits now use LED's and these modules can function as drivers for them.

There are two display module flavors. One is designed to operate bi-color red/green LEDs that model type SA (searchlight) signals. The other is designed to operate any signal target type that uses separate red, yellow and green LEDs (designated here as Type D), including vertical alignments, triangular alignment (Type G), color position light (B&O, N&W, NS) and monochrome position light (PRR, NH, LIRR). Although each signal target requires a separate module, you can assemble each module using less than $1.50 worth of components, depending on your sources. Depending on your construction method and experience, you can assemble a module in about 15 to 30 minutes. The design of both display module types is similar, but there are differences to accommodate the types of signals being used. Both module types have three inputs to accept red, yellow and green inputs and a ground terminal. The type D has three outputs: red, yellow and green to connect to the signal display. The type SA has only a red and green output for the red and green anodes of the bi-color LED. All circuits described here may be assembled using either printed circuit boards or pre-punched (perforated) boards.

Type D Display Module
Figure 1 shows a schematic diagram for the Type D Module. In operation, six volts is always applied to the green input. If no power is applied to the red or yellow input, transistor Q1 conducts current to the green output. However if six volts is applied to the yellow input, it turns off Q1 and provides current to the yellow output instead. If six volts is applied to the red input, it turns off both Q1 and Q2 and provides current to the red output only. Diodes D3, D4 and D5 prevent any feedback voltage to other parts of the system. The resistors drop the six-volt inputs to about 2.5 to 3 volts that is safe for LED operation. Diodes D1 and D2 in series ensure that the voltage supplied to the emitter of Q1 will not exceed the voltage applied to the base of Q1 if current is applied to either the red or yellow input. Figure 3 shows a printed circuit board mask layout and Figure 2 shows the component placement on a PC board. Figures 19-21 show actual perf board and printed circuit assembly layouts.

Note that you may choose to implement a system using 12 volts or another voltage. Also your LED's may operate on a lower voltage than the 2.5-3 volts assumed here. In either case you must adjust the values of all resistors. Refer to the section on Adjusting Resistor Values

Type SA Display Module

Figure 4 shows a schematic diagram for the Type SA Module. To obtain the yellow indication with bi-color LEDs, both red and green are illuminated simultaneously. Trimmer resistor R5 provides the ability to adjust the red saturation to provide the desired yellow hue which may vary from yellow-green to red-orange. In this circuit the green output is shut off only when six volts is applied to the red input. Figure 6 shows a printed circuit board mask layout and Figure 5 shows the component placement on a PC board. Figures 22-24 show perf board and printed circuit assembly layouts.

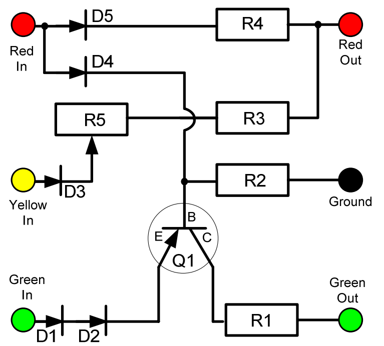

Figure 1 Type D Display Module Schematic

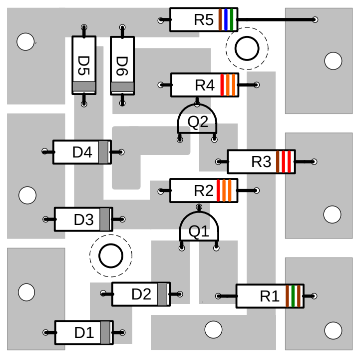

Figure 2 Type D Display Module Component Layout

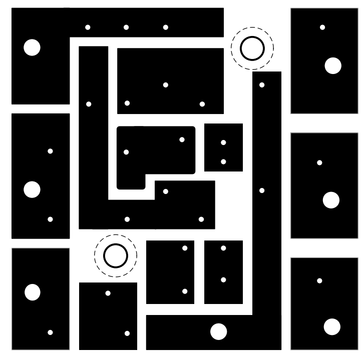
Figure 3 Type D Display Module PC Etching Mask

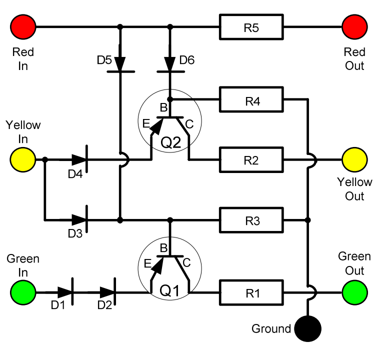

Figure 4 Type SA Display Module Schematic

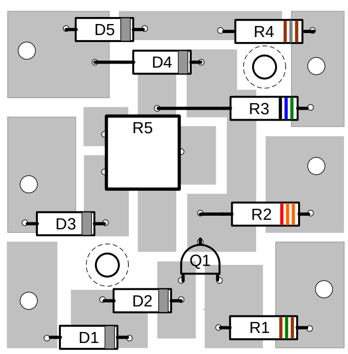

Figure 5 Type SA Display Module Component Layout

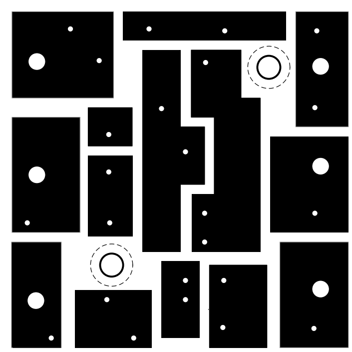
Figure 6 Type SA Display Module PC Etching Mask

Track Occupancy Detector Modules

Any commercial detector that will operate on 6 or more volts and provides a positive voltage output when a train occupies a corresponding electrical block is usable. I have adapted a circuit described in the March 2001 *NMRA Bulletin: Block Occupancy with 100K Isolation*, by Robert Frey, for use with these display modules. This detector works equally well with either DCC or standard DC control systems and can be assembled from readily available components for less than $3 per Module. One advantage of DCC control is that it provides a constant voltage on the track that enables the detectors to work even when a train is stopped. Figure 7 shows the basic schematic for this detector. Figure 9 shows a printed circuit board layout and Figure 8 shows the component layout on the printed circuit board.

This circuit basically consists of a detection circuit and an amplifier circuit. The detection circuit consists of two power diodes D1 and D2 with opposite orientation that pass the bulk of the train current. However they shunt a small amount of current through NPN transistors Q1 and Q2 to provide the detection. This is a variation of the Twin-T circuit that has been described many times in the model press over the past 50 years. Transistors Q3 through Q6 amplify the detection current sufficiently to drive multiple signals. The amplifier circuit is grounded through R3 (100K ohms) that allows just enough train current to flow to activate the circuit. The detector is sensitive enough to detect a current as little as 3-4 milliamperes.

Capacitor C2 (4.7 uF) provides a shut-off time delay of about 2-4 seconds after the detection circuit stops sensing a track current. This prevents the circuit from oscillating on and off if the train current is momentarily interrupted by dirty track and provides a steady red indication. It also provides several seconds of grace when the train exits the signaled block. LED L1 in the amplifier circuit is optional, but provides a visual indication that the detector is working correctly. The LED will illuminate when the detector senses a train on the track and extinguishes when the train exits the block. It is quite useful for testing and trouble shooting. Figures 16-18 show actual perf board and printed circuit assembly layouts.

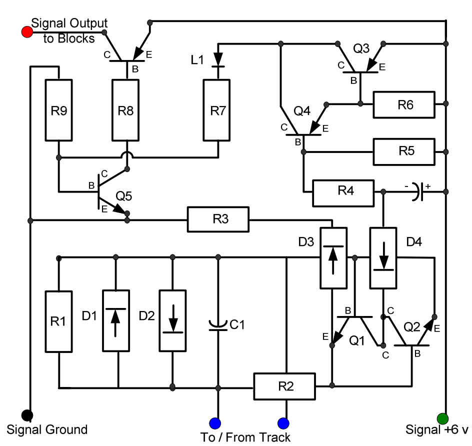

Figure 7 Block Occupancy Detector Schematic

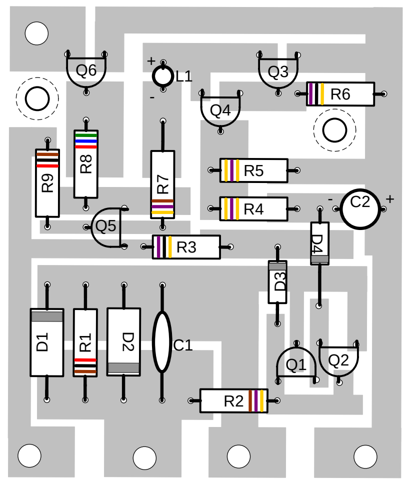

Figure 8 Block Occupancy Module Component Layout

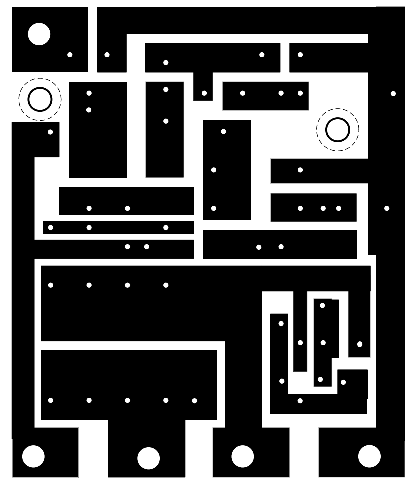

Figure 9 Block Occupancy Detector Etching Mask

Circuit Board Assembly

There are several techniques for assembling each circuit:

- Pre-punched circuit boards (0.1 inch hole spacing perf boards);
- Printed circuit boards that you can prepare yourself;
- Any board with self-adhesive copper tape (the kind sold for dollhouse 'wiring') applied.

To assemble a circuit on a pre-punched board, bend the leads of all components and push them through appropriate holes on the board, then bend them again behind the board and solder the appropriate leads together. Trim any excess lead length after soldering. Use Figures 2, 5, and 8 as a guide. This method is most useful for creating prototype modules or installations were only a few modules will be used. When assembling circuit boards, the orientation of diodes, transistors, and radial electrolytic capacitors is critical. Resistors may be oriented in either direction.

For larger installations, making printed circuit boards may be the easiest, fastest and least expensive method overall. Several distributers sell materials for making your own printed circuit boards. Figures 3, 6, and 9 show printed circuit board layouts. To make a printed circuit board, copy the appropriate mask(s) to a computer file (note: the images must be mirror-image), then print the file onto a transfer sheet using a laser printer. Transfer the printed image to a prepared copper board using a hot electric clothes iron. After the image is transferred to the board, etch the board using an etching solution to remove the unwanted copper. Clean the etching mask from the board and drill the board to accept the electronic components. The printed circuit kits come with good instructions so I will not elaborate further here. An alternate method for making a printed circuit board is to replicate the mask using plastic tape before etching. Plastic tape may also be used to cover areas where gaps appear when the mask is ironed onto the board. I found that ordinary Scotch tape works well.

Printed circuit boards may be prepared for either front or back mounting. When creating a front-mounted board remember to reverse the transfer image (mirror image) so it is oriented correctly when transferred onto the circuit board. Most components can be located successfully if the pattern is reversed, however transistors will have to be oriented differently. After you have etched the board, drill holes to accept the components. A number 60 drill is satisfactory for most components. Holes for the 1N5400 diodes for the Detection Module will require a #54 drill

For external connections I prefer to drill and tap each board to accept 4-40 round- or pan-head machine screws, however these connections can be soldered directly onto the board. You can use smaller screws (i.e. 2-56) but you will probably want to place a washer under the screw head. For a 4-40 screw, drill the board with a #43 drill and tap. When providing screw terminals, I prefer front-mounted components where all solder connections are made on the front of the board. If you are using pre-punched circuit boards you may want to install brass terminal pads under the screw terminals. I punch (or drill) .0005 sheet brass with 1/8 inch holes, place them under the machine screws and solder the appropriate leads to them. Brass or steel washers will also work.

Detector assembly follows the same general procedures as the display modules. The orientation of diodes D3 and D4 is critical. The direction of D1 and D2 is not critical as long as they are oriented in opposite directions. The position and orientation of NPN (PN2222A) transistors Q1, Q2 and Q5 and PNP (2N2907) transistors Q3, Q4 and Q6 is critical. Capacitor C2 must be oriented so that the negative lead (usually marked with several minus signs "- - -") is oriented toward the center of the board. LED L1, if used, must also be oriented correctly. The orientation of capacitor C1 and resistors R1 through R9 is arbitrary.

If not using a printed circuit board, ensure that you use adequate conductors to connect R1, D1, D2 and C1 to the track (Number 24 wire or greater) since these must carry the full current load to all locomotives and other current-drawing rolling stock in the block.

The Detector Module provides sufficient current to light multiple signal targets. If Q6 is a PN2907 the detector output is rated at about 500-600 ma. A typical LED draws about 20-30 ma, so the detector can drive up to 15 signals with no danger of overloading. One detector is required for each signaled block. Typically the detector on a single track main will light four targets: red for the signals at each end of the block and yellow for each signal in the approach block. However when connected to an interlocking network the detector may drive several more.

Adjusting Resistor Values

Figures 2, 5 and 8 show the appropriate resistance values. Most LEDs have a safe operating voltage of about 2.5 to 3 volts, however some may have a lower safe operating voltage. Refer to the product documentation, if available, or test starting with about 1 volt or less. If you determine that your LEDs have a lower operating voltage you will have to increase the values of all resistors in the display modules. If you build a system that uses a 12 volt power supply, most resistor values will have to be tripled or quadrupled to protect the LED's adequately.

You can use Ohms Law ($E = I * R$) to calculate the required value of any resistor. Yellow and green LEDs that operate safely at 2.5 volts typically draw a current of 30-40 milliamperes (0.035 amperes). Red LEDs typically draw about 20 millimperes. For a 6 volt system, the voltage at the collector of Q1 will be about 5 volts. Resistor R1 must therefore drop the voltage by 2.5 volts. To calculate the resistance, use the formula:

R (resistance in ohms) = E (voltage in volts) / I (current in amperes).

To drop 2.5 volts with a current of 0.035 amps the calculation becomes 2.5 / 0.035 = 71 ohms. Double this to provide a safety factor. Resistors are manufactured in specific values, so select the closest value, about 150 or 180 ohms. Remember that exact resistor values are not critical. If the higher value reduces the luminosity significantly, drop the resistance to the next lower value to improve performance. Adequate resistance will ensure that you signals will operate safely for many years. Replacing a burned out LED in a signal target is a nuisance.

Display Module Testing

Once you have completed a module you will want to test it. The easiest way to test a display module is to use an available wired signal or a testing jig that has the necessary LEDs installed on it. If you have an available power supply, use that, or create a temporary power supply using four 1.5 volt batteries in a battery holder. Connect the six volt power supply to the green input and the ground to the ground. The green LED should illuminate. If it does not, check for correct connections and orientation of diodes D1, D2, transistor Q1 and the LED. If the connections are correct, check for cold solder joints. A VOM is useful for checking bad solder connections. There should be no resistance between component leads that should be connected together. If the connections look good, check the R1 resistor value. If the green LED still does not light, check to determine that it is still functional. If the LED appears to be too bright or burns out immediately, check resistor R1 for a correct value. If R1 is approximately correct, replace it with a higher value and test again. If the LED illumination is too dim replace the corresponding resistor with a slightly lower value.

If everything checks out and green still does not illuminate, bypass Q1 by connecting a jumper from Q1's emitter to the collector. If green now illuminates, check to ensure that R2 (SA) or R3 (D) is adequately soldered to Q1's base and that its value is not too high. It should not be greater than 5K ohms.

When the green LED illuminates successfully, connect a jumper from the green input to the yellow input. This should illuminate the yellow LED and extinguish the green LED for a Type D controller. If this does not happen, repeat the green sub-circuit diagnostics for the yellow sub-circuit.

For a Type SA controller, the green LED element should remain illuminated when connecting six volts to the yellow input, and the red LED element should illuminate sufficiently to produce a yellow color. At close range you will probably be able to see distinct red and green point sources, but at a distance they should blend to appear yellow. Adjust the R5 trimmer until you achieve the yellow hue you prefer.

When the yellow display illuminates successfully for Type D, connect a six-volt jumper to the red input. For a Type D controller, the red LED should illuminate and both the yellow and green LED should extinguish. If red does not illuminate, check the connections for R5. If those are good, check the red LED to ensure that it is still functional. If the green LED still fails to extinguish, check the connections from D5 to the base of Q1 and from the base through R3 to ground. If the yellow LED fails to extinguish, check the connections from D6 to the base of Q2 and from the base through R4 to ground.

For a Type SA controller, connect a six-volt jumper from the green input to the red input. This should extinguish the green emitter and illuminate only the red emitter. If green fails to extinguish, check the connections of D4 to the base of Q1 and to R2 and the connection of the base of Q1 through R2.

Occupancy Detector Testing

Testing the Occupancy Detector is a little more complicated. When assembly is complete, begin testing by connecting a six-volt (+) lead from your signal power supply to the green input and the ground lead to the ground input. With power applied, LED L1 should not illuminate and no voltage should appear on the red output.

If this first test is successful, connect one lead of your track power supply to the track input/outputs. If you are not using a locomotive for this test, use 12-volt lamp or correctly oriented LED with an appropriate dropping resistor to provide a load as well as a visual indicator that the track circuit is working. If the lamp or LED illuminates successfully, LED L1 should also illuminate and approximately six volts should be present on the red output. Note that if you did not install the LED indicator, you must provide a jumper between the two LED connections. If LED 1 does not illuminate, check for a correct orientation. Remove the track load. L1 should remain illuminated for about two to four seconds, then slowly extinguish. When L1 is extinguished, there should be no voltage on the red output. If this test fails with a locomotive on the track, ensure that the problem is not caused by dirty track.

If this test is still not successful, check the values, orientation and solder connections of all components. Correct any errors then reconnect the module to the signal power and track power with voltage applied and a load present. Trace the circuit forward and back to determine if there is any voltage, however small, at each component lead. If there is no voltage, check for a poor solder connection and re-solder if necessary.

Power Supply

You may use any 5-6 volt power supply to power your signals. If you build your own, Figure 10 shows a schematic diagram for the circuit. For T1, I use a 6.3 volt, center-tap transformer with rectifying diodes D1, D2 (optional) and D3 for power. Note that the voltage between D1 and D2 is 12.6 volts, but is only 6.3 volts between D1 and D2 and D3 and D2. (I actually double the diodes in parallel to provide reserve current capacity.) Connect the center-tap lead to the signal power ground through D2 (optional). The two outer leads are connected to the 6 volt positive conductor through diodes D1 and D3. I also added a capacitor C3 (optional) to provide filtered DC to the system, although unfiltered power works just as well.

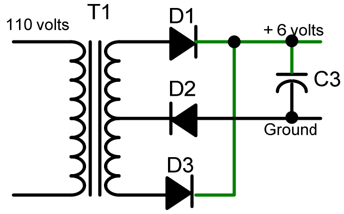

Figure 10 Signal System Power Supply Schematic

Wiring the Signal System

The Display Modules and occupancy Detector Modules are the building blocks for creating a working signal system. You have only to connect these components to your track and signals to create an effective and realistic system. The display module design makes this process quite simple. The red, yellow, green and ground outputs connect directly to the signal LED leads. I wire the signal LED's with 30 gauge color-coded wire-wrap wire. This wire will carry adequate current to the LED's and you can easily slide multiple wires through a reasonably scale-sized signal mast. The green input and ground input/output for each display module must be connected to the signal power supply. The red and yellow inputs connect either to the appropriate block Detector Module(s) or diode matrix outputs, where used.

Figure 14 shows typical wiring for a single track that has a series of blocks with signals at each end of the block. A multi-track main line is really only two or more single tracks, side-by-side, unless there are turnouts or crossovers that need to be signaled (more about that later.) Although the diagram looks complicated, it isn't. Only five signal conductors pass from one end of a block to the other. The green (6 volts) and black (ground) wires provide the operating current for the system. The other three wires include one red, to actuate the red indication at each end of the block, and two yellow wires to pass the yellow indications to the approach blocks, one in each direction. To pass electrical signals between block DMs, I prefer to use CAT-5 cable because of its relatively low cost. One frequently-asked question is "do the signaled blocks need to be gapped?" The answer is "yes."

My favorite method for connecting one end of a block to the other is to use CAT- 5 computer networking cable. Cat 5 cable contains eight color-coded number 24 gauge conductors, although you generally will use only 5 of them. However for double track you can use all eight wires from a single cable. Because it is widely used for networking computers, CAT-5 cable is relatively inexpensive. You can find 5-conductor cable, but it will generally be more expensive.

Interlocking

One of the advantages of this system is that you can easily implement fairly complicated interlocking using a simple diode matrix that indicates turnout routings as well as block occupancy. Many railroads treat passing sidings as interlocking districts. Figure 15 shows wiring for a simple interlocking junction that can be either a diverging route or one end of a passing siding (the other end would be a mirror image.) Here a diode matrix provides the necessary connections between detector modules, switch machine contacts and display modules. For a passing siding, the diode matrix requires five inputs: two for the turnout indications, one for the mainline detector module to the east, one for the mainline detector module to the west, and one for the passing track detector module. It requires four outputs: one for each signal target shown in Figure 15. General prototype practice has the upper target signaling the mainline and the lower target signaling the passing track. To connect turnout routings requires that you use switch machines that have a set of contacts you can use to indicate the turnout position. If you use LED control panel indicators to indicate turnout orientation, these may share the same set of contacts

A diode matrix can also simulate a very complicated interlocking plant. Such a matrix must provide one output for each display module, two inputs for each turnout that must be protected, and one input for each detector module. The outputs are wired primarily to the red inputs of the individual display modules and secondarily to the yellow display module inputs for the approach signals. The biggest challenge to making a matrix is ensuring that you have the right inputs connected to the right outputs. I recommend making a diagram for each matrix, clearly marking the detector inputs by block and turnout inputs (normal and reverse) for each matrix input and the intended display module for each output. It is then a simple exercise to determine which inputs turn which signal targets red. It is much easier to correct errors on the diagram before committing the design to hardware. (Of course you can wire the necessary diodes directly between the Detector Modules and, turnout routing outputs and the Display Modules, but the resulting maze of wiring is guaranteed to create eternal confusion. Don't go there!)

You can make a diode matrix several ways:

- A solid (such as Plexiglas) or pre-punched perf board using wire or adhesive copper tape;
- A double sided, etched printed circuit board.

To assemble a matrix, size board to allow for the required number of input conductors and the required number of output conductors spaced at least 0.4 inches apart plus 0.4 inches at the bottom and one side to allow for diode connections. Whatever type of board you prefer, one set of conductors must run vertically on one side of the board and horizontally on the other. I prefer to drill and tap the external connection points for 4-40 machine screws for ease of connecting to the system. To install the diodes, bend the leads as close to the end as possible, push them through the board and solder them orienting the diode so that the unbanded end connects to an input conductor and the banded end connects to the output conductor. One end of the diode must connect to the conductor on the front side of the board and the other to the conductor on the back. If you do make wrong connections, it is usually easy to unsolder the diode, reposition it and re-solder it.

Conclusion

How simple or how complex your system will become depend on how many signaled blocks you want to implement and how many routing variations you want to support. Remember that even a complex system is a collection of basic building blocks connected together in a logical way, and a cookie-cutter approach can be used to wire most of your system.

Component Sources:

DeMar Electronics
P.O. Box 7215
Algonquin, IL 60102
1-877-655-6433

All Electronics
14298 Oxnard Street
Van Nuys, CA 91411
1-800-826-5432

Radio Shack
Local stores

Type SA Display module Components:

Component ID	Description	Radio Shack Part Number	De Mar Part Number	All Electronics PartNumber
Q1	PNP Transistor PN2907	276-2023	NA	PN2907
D1 – D6	1N4001	276-1101	1N4001	1N4001
R1	150 Ohm Resistor	271-1109	*	*
R2	1.2K – 4.7K Ohm Resistor	271-1120 to 271-1124	*	*
R3	270 Ohm Resistor	271-1112	*	*
R4	68 Ohm Resistor	271-1106	*	*
R5	Variable	271-280		TPR-1K

* Request by value

Type D Display module Components:

Component ID	Description	Radio Shack Part Number	De Mar Part Number	All Electronics PartNumber
Q1, Q2	PNP Transistor PN2907	276-2023	NA	PN2907
D1 – D6	1N4001	276-1101	1N4001	1N4001
R1	150 Ohm Resistor	271-1109	*	*
R2	220 Ohm Resistor	271-1111	*	*
R3, R4	1.2K – 4.7K Ohm Resistor	271-1120 to 271-1124	*	*
R5	560 Ohm Resistor	271-1116	*	*

Signal Diodes:

Component ID	Description	Radio Shack Part Number	De Mar Part Number	All Electronics Part Number
L1	Red T-1 (3mm)	276-026	L03RD	MLED-1
L2	Yellow T-1 (3mm)		L03YD	MLED-2
L3	Green T-1 (3mm)		L03GD	MLED-3
L4	Bi-Color T-1 (3mm) (3-Lead)		L303RGD	LED-67

Block Detector Components:

Component ID	Description	Radio Shack Part Number	De Mar Part Number	All Electronics Part Number
Q1, Q2, Q5	NPN Transistor 2N2222A	276-2058	NA	
Q3,Q4, Q6	PNP Transistor 2N2907	276-2023	NA	PN2907
D1, D2	Diode	276-1141	1N5400	1N5400 or D620
D3, D4	Diode	276-1101	1N4001	1N4001
C1	0.1 uF Capacitor	271-135	NA	103D50
C2	4.7 uF Capacitor, 35 v	272-1024	NA	Radial Electrolytic 4.7
R1, R9	1K Ohm ¼ watt Resistor	271-1321	*	*
R2, R7	470 Ohm ¼ watt Resistor	271-1317	*	*
R3, R6	100K Ohm 1/8 watt Resistor	271-1347	*	*
R4, R5	470K Ohm 1/8 satt Resistor	271-1133	*	*
R8	560 Ohm ¼ watt Resistor	271-1116	*	*

Signal Power Supply

Component ID	Description	Radio Shack Part Number	De Mar Part Number	All Electronics Part Number
T1	6.3 Volt Center-Tap Transformer, 3-5 Amp	273-1511	TF-122 or TF-124 (check for center tap)	TX-123 or TX-125
D1, D2, D3	1N5401 or D620 Diode			103D50
C1	4700 uF Capacitor			

Miscellaneous Components

Component	Description	Radio Shack Part Number	De Mar Part Number	All Electronics Part Number
Circuit Boards	Perf Board 6x8	276-1396	22-514 or 22-516	See catalog
Copper Boards	Copper coated		See catalog	PCB-46 or PCB-612
Signal Wire	30-gauge Wire-wrap wire – Red / White / Blue	278-501, 278-502, 278-503		
Connecting cable	Cat-5 cable	278-830		CTE-5

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Denver, CO 80222
303-757-4215
E-mail: jonesjcsh@msn.com

Highway Crossing Flasher Circuit

This circuit is designed to actuate a common highway crossing flasher signals that alternates illuminating a right and left red warning signal using red LED’s. It can be constructed from simple components: transistors, capacitors and resistors, and contains no moving parts. Capacitors C2 and C3 with transistors Q1 through Q4 cause two LEDs to be illuminated alternately. Resistor R1 is a 1K variable resistor that will adjust the brightness of the LED’s

The capacitors are radial electrolytic types. When building this circuit, you must observe their correct polarity. The negative lead is general marked with several “minus signs” (“- - -“) If they are incorrectly connected, the circuit will not work and the capacitors may be destroyed.

This circuit is designed to operate on 6 volts DC with common red LEDs. You may connect multiple signals to a single controller. I have one installation that contains 16 LEDs (eight showing in each direction.) Note that the LED cathode (negative lead) connects to the LED output and the LED anode (positive lead) connects to the positive 6 volt-source. If you plan to use commercial signals, select those that use LEDs and verify that there are separate negative leads for each LED (or set of LEDs for double-facing signals. The circuit will probably work with 12-volt incandescent bulbs also if the bulbs will light sufficiently with 6 volts. It is probable that they will look better and last much longer operating on 6 volts. With incandescent bulbs there is no polarity, so the leads can be connected in either direction.

To operate the circuit, connect the 6-volt input to the output of one or more track occupancy detector modules. The detector modules will drive the signal display modules and the flasher simultaneously. If you are connecting to more than one detector to the flasher module, then you must place a correctly-oriented diode between the detector and the flasher. Failure to do this will cause feedback and false actuation of track signal on adjacent tracks. Examples where you may want to do this include a crossing of two or more parallels tracks or a crossing near a block boundary where you want a train in either block to actuate the signals.

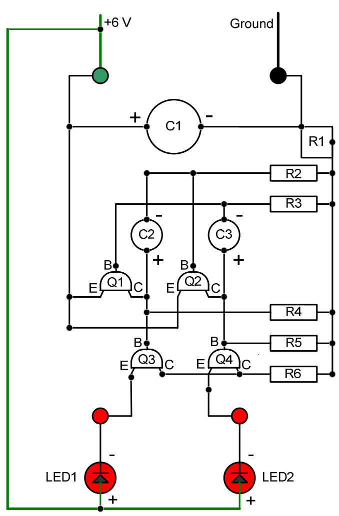


Figure 11 Highway Crossing Flasher Schematic Diagram

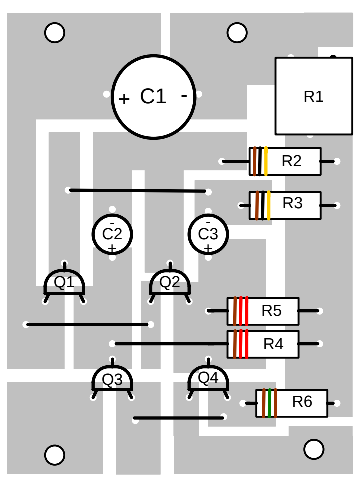


Figure 12 Highway Crossing Flasher Component Layout

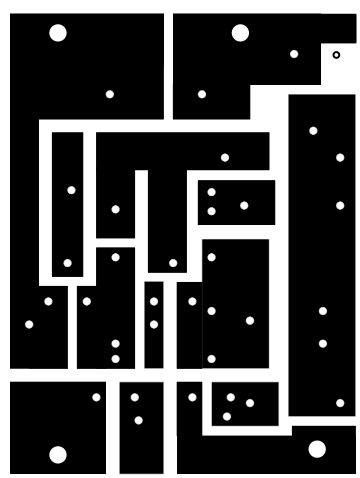


Figure 13 Highway Crossing Flasher Printed Circuit Mask

Component	Description	Radio Shack	All Electronics	DeMar Electronics
R1	1K Variable Resistor	271-280		TPR-1K
R2-R3	100 K ¼ watt Resistor	271-1347	*	*
R4-R5	1.2 K ¼ watt Resistor		*	*
R6	150 Ohm ¼ watt Resistor	271-1109	*	*
C1	100 mf Electrolytic Capacitor 35 V	272-1028	*	
C2-C3	10 mf Electrolytic Capacitor 35 V	272-1025	*	
Q1-Q4	PNP Transistor: 2N2907 or equivalent	276-1604 *	PN2907	

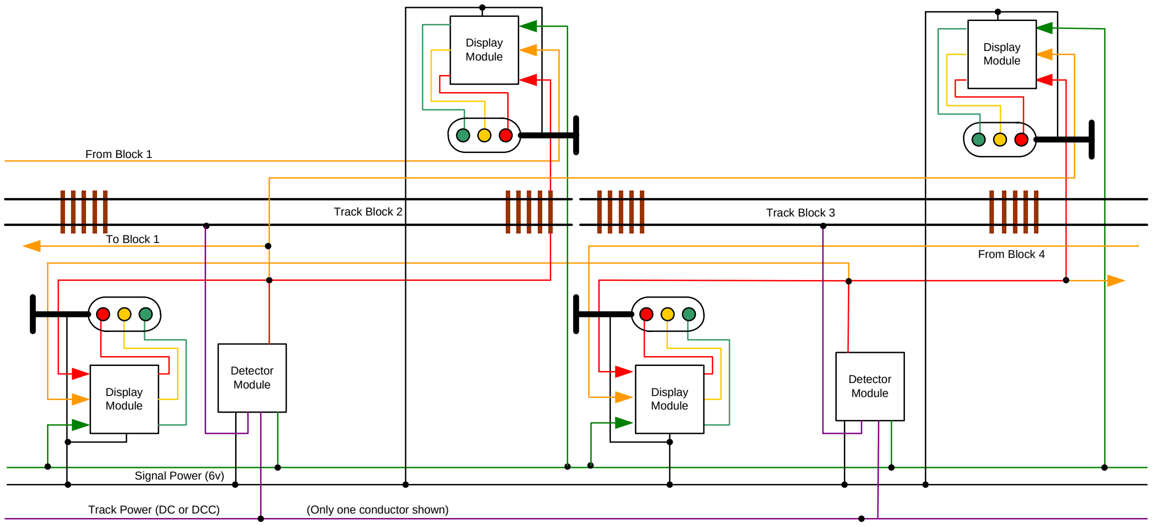


Figure 14 Typical Single Track Block Wiring

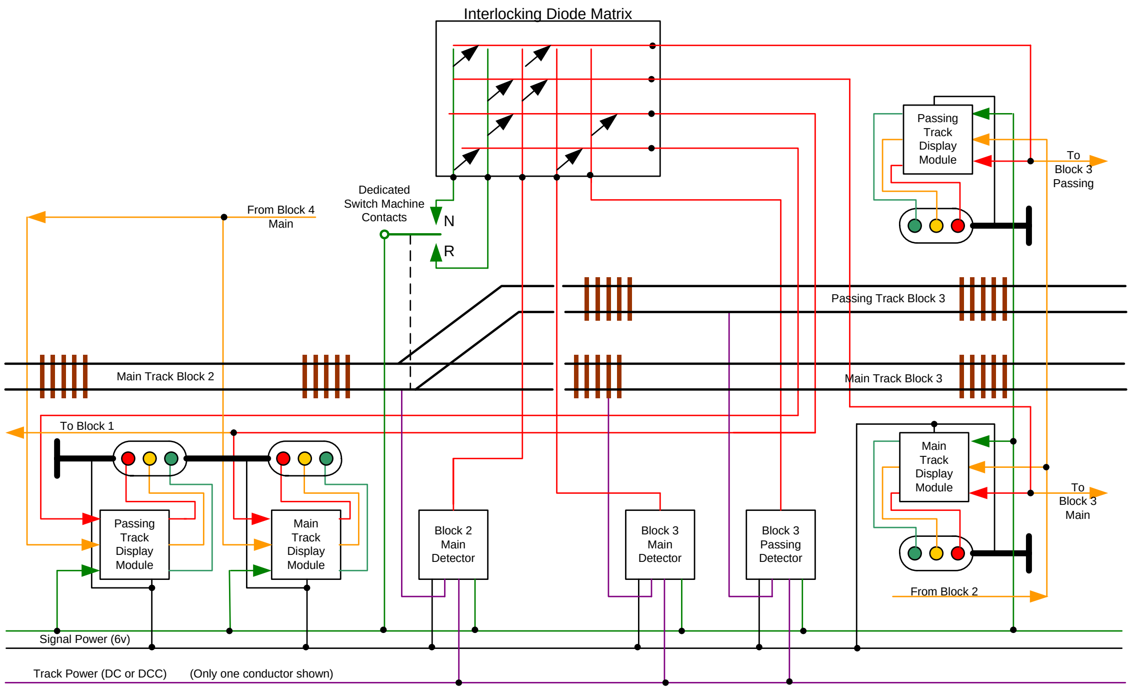


Figure 15 Sample Interlocking Block Wiring

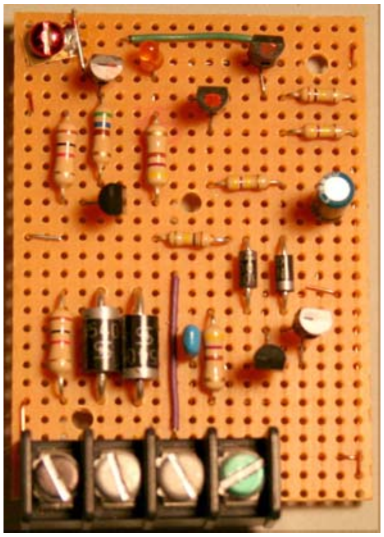


Figure 16 Decector Module Component Front Layout


Figure 19 Type D Display Module Component Front Layout

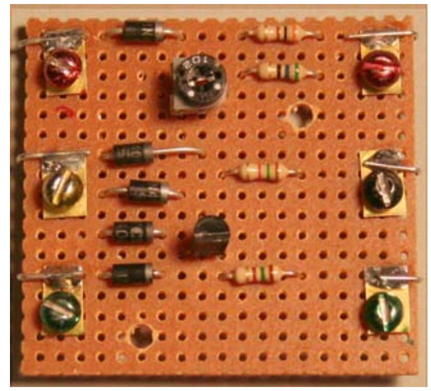


Figure 22 Type SA Display Module Component Front Layout


Figure 17 Decector Module Back Layout

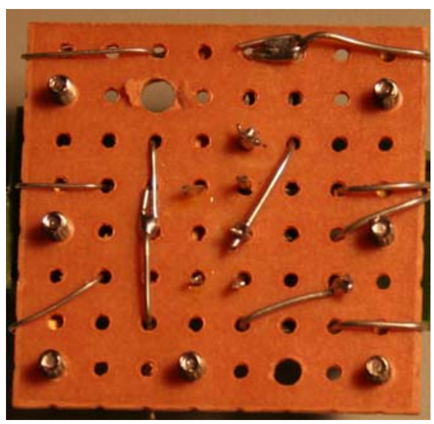


Figure 20 Type D Display Module Back Layout

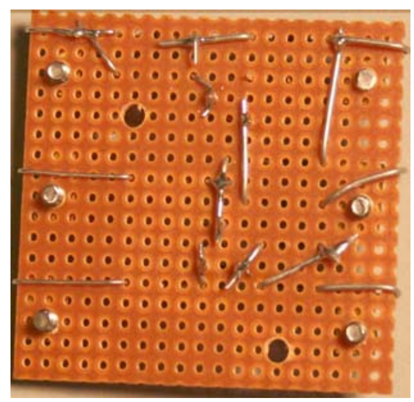


Figure 23 Type SA Display Module Back Layout

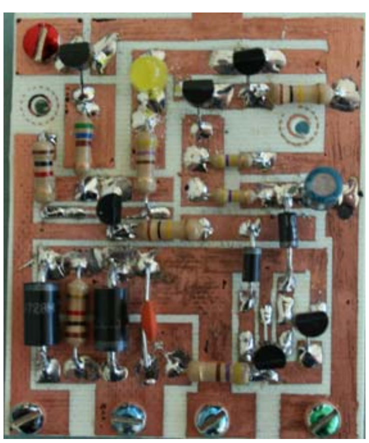
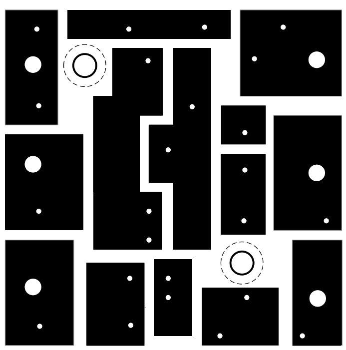


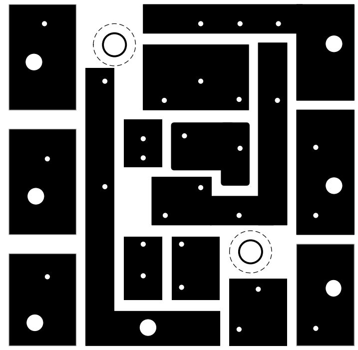
Figure 18 Detector Module Printed Circuit Component Layout


Figure 21 Type D Display Module Printed Circuit Component Layout

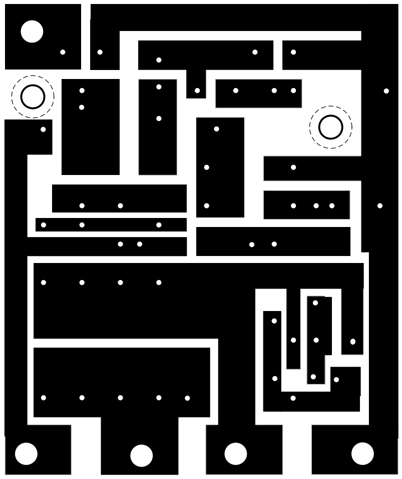

Figure 24 Type SA Display Module Printed Circuit Component Layout



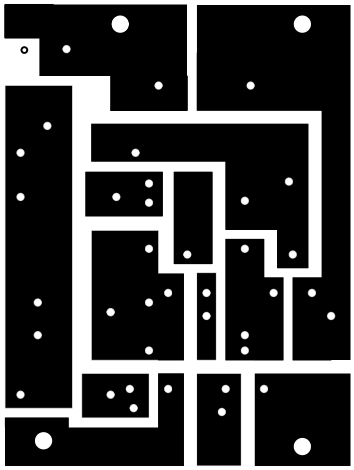
Type SA Printed Circuit
Mirror Image Edit Mask



Type D Print Circuit
Mirror Image Edit Mask



Detector Module Printed
Circuit Mirror Image Edit
Mask



Highway Crossing
Printed Circuit Mirror
Edit Mask

To Create templates for printed circuit transfers, copy the mirror image masks, above, and paste them onto a separate Word document that may be used as the source for creating a transfer sheet.