

Section 2

The LBO-4

The original inspiration for this circuit came from slow motion switch machines. A good friend was doing detail work in preparation for an NMRA National Convention. He wanted to make a showing in the layout tour, so installed a goodly quantity of Tortoise® Switch Machines. They were the going rage at the time, being a fairly recent development.

The circuit requested was to allow push button operation of a Tortoise machine from the same panel that had a quantity of solenoid machines. The idea was to have the Tortoise controls transparent to the normal operation of the panel.

Now, this was (is) a fairly large home layout. Larger than some clubs I have attended over the years. There are numerous machines, and panels are scattered around many operating areas. Another request was to be able to operate any switch machine from multiple locations and accommodate route controls as they were added.

I devised a circuit using basic logic that would operate after the function of a "latching" relay. My first impulse was to use such a relay, until I checked the cost.... The circuit centers around a basic logic function called a "Flip Flop". An "R-S Flip-Flop" has "Set" and "Reset" inputs. Why R-S rather than S-R? Literally, because it's easier to say it when speaking of the circuit. It "rolls off the tongue" as it were.

The two outputs then turn on or off, depending on the state of the control circuit. The significance is that the two outputs oppose each other. When one is on, the other is off.

By connecting an "Amplifier" to the outputs, I created a directional motor controller, capable of driving most any size motor. Just a matter of using large enough transistors. The circuit is capable of being used for variable speed control and "Dynamic Braking" as well. Then I discovered how much current the Tortoise **doesn't** use. I could as easily have put its' motor directly in the Flip-Flop circuit.

Thankfully, things didn't work out that way and the LBO was born. Of course, I had other interests and after making a quantity of circuit boards sufficient to finish the project I moved on.

Twenty years later, I was asked to supply another run of the circuit boards for the Tortoise controllers. I had to have them produced by a company specializing in circuit board production. Health issues have taken me out of the acid etching business.

The company that produced the board required a label for the board. So I threw out "Bridge Oscillator Latch". It sounded impressive and looked good on the paper work. But when plugging the name "BOL" into the parts system for my communications business, it ended up being a component of another device that had no relation to Model Railroading. So, I decided on using LBO, or "Latch, Bridge, Oscillator". Hence the name not matching the printing on the circuit board. And, it does just sort of roll off the tongue, like an R S Flip Flop...

Over time, having devised numerous other utility circuits for Model Railroading, I came to the realization that a large portion of them were nearly identical. In form, at least. Some high current, some low. Some high speed, some low.

Consider a flasher and an oscillator, for example. Essentially, they are the same, the semantic difference being speed. A flasher you can see oscillating. An oscillator is only visible with an instrument.

While working on the design of the circuit board I saw a few places where if I ever needed a circuit, I could just move "that over here and this over there" and have a circuit for the function. Near the end of the project, I had one of those flashes of insight that all too often come *after* the fact. So I went back and made the changes (in a generic fashion) *before* production.

Now, with a little "creative" component placement and the occasional jumper, I can provide any number of useful circuits for the railroad hobby; ***all using the same circuit board.***

When an idea takes my fancy, as soon as the basic design is proven, I look into whether it will fit an LBO board. Over time, a goodly number of circuits for novel applications have been developed.

This *has* been a somewhat verbose introduction to the line of LBO-4 options. I truly believe it will suit many of your applications as well. If you don't see what you need, feel free to eMail me; I'm always interested in new possibilities.

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This manual consists primarily of the assembly and use instructions that are packaged with kits and assembled boards. **Constructive criticism is welcomed;** as the designer I am often too close to the circuit. I want the instructions clear and usable for the greatest number of users.

Bill Hudson

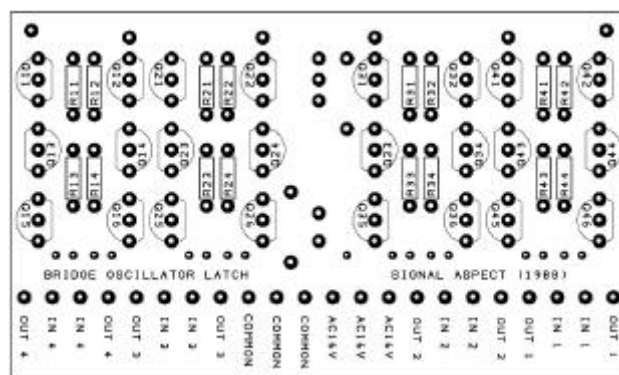
NMRA #2125

Introduction to the LBO-4

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Applications

- 1) Controller for "Slow Motion" switch machines. The "Tortoise®" linear actuator being the original design.
- 2) Oscillator for lighting 2 Colour LEDs in 3 colours.
(Works with any known 2 or 3 lead device)
- 3) Flasher, detection, and gate controller for grade crossings
- 4) "Latch" circuit for signalling "Check-in /Check-out" blocks
- 5) Optical (photo-cel) detection for signalling or control
- 6) DCC "CT" detection for signalling or control
- 7) Power switch for Approach Lighting with Common Anode LEDs or lamps
- 8) Signal controller for two colour, two aspect signalling. (Two blocks can be signalled with one board, using optical detection)
- 9) Controller for operating R.C. (Model Airplane) Servos. These actuators have enormous power for their size and can be positioned within a fraction of a millimeter with excellent repeatability.



A convenient size, it is a little smaller than a playing card, plugging into a 22 Pin edge connector with contact fingers on the foil side. The -4 means four iterations of the essential circuit on one card. Each is electrically independent, sharing only the power supply.

At the line side, the **preferred** power source is 8-12 Volts D-C. A very good, low cost supply is a 9 volt battery eliminator. They are common, you probably have a couple in *your* scrap box. A 3 to 4 watt supply will operate most any of these circuits. An exception to this is the servo controls that appear later. Those boards **require** 8-12 volts of rather stout **D-C** power capacity. Minimum 10 watts for the servos included in Signal Aspect kits.

Slow Motion Switch Machines

In the language of machine automation, these devices are known as "Linear Actuators". Some are straight line, some rotary. Some small, such as the recently introduced "Flea®" switch machine. Others large, such as the "damper" motor drive of a 900 HP pollution fan in a steel mill. As with most machines, the difference is size. Not only of the machine itself, but of the controlling elements.

As noted above, the initial design of this circuit was for the Tortoise®. The circuit board is screen printed for that function. Assembly and installation is almost intuitive. Everything is labeled for the application.

So, let's build one and put it to work...

One matter to note is that the operator push buttons take a lead to common. If you do not use common return for your accessory circuits, the buttons will be referenced to the same power return that is connected to pins 12-14. Only one common wire will be required for all push buttons connected to multiple boards sharing a power supply.

Note also, that each controller may be operated from multiple locations. That was the purpose for this design from the very beginning. Merely add push buttons or contacts wherever it is desired to control the switch. Wire them all together and connect to the board. This is illustrated in the application drawing.

Many layouts have both slow motion switch motors and "solenoid" type switch machines. Although the usual practice is to wire the common of the solenoid machines to ground, may I suggest an "old timer's" trick to reduce the cost of panel switches. By the way, this is the system used on the original layout for which the circuit was designed.

On the "Control Panel", locate the positions of switches in the graphics. At each switch place two small screws, 4-40 being about the largest practical. I usually use "flat head" screws so they can be countersunk flush with the surface. On the back of the panel, run wires from the backs of the screws to the solenoid switch machines. For the slow motion motors using the controller boards, run these wires to the "INPUT" pins. For each switch, use one circuit, two wires.

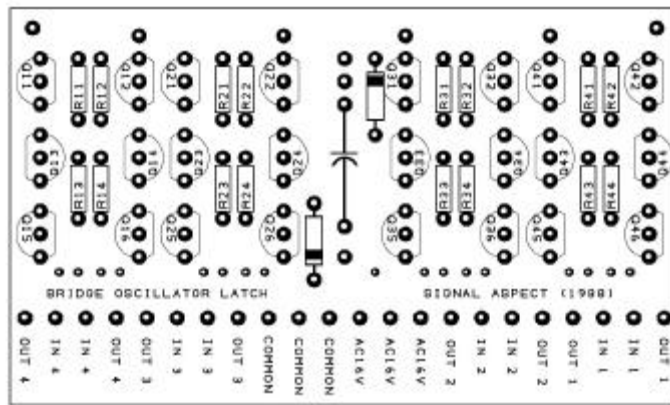
Connect the A-C accessory supply to the common or center pin of each solenoid machine and to the A-C in pins of the controllers. Connect the A-C return (common) to a long piece of wire at the control panel and to the COM pin(s) of the controller boards. As an electrical man, I highly recommend this common wire be grounded. The choice is your's.

An old meter or test lead is suitable for a "stinger" at the panel. The probe on the end of the test lead makes it an easily held and "sanitary" appearing control. Using the "Stinger", touch a screw on the graphics panel grounding it to operate the solenoid. When a screw is contacted for a slow motion motor, the latching portion of the controller board will set up, driving the motor in the desired direction.

This technique can save several dollars at each switch. On a large or complex layout, it can save enough to purchase that new locomotive you've been lusting after. When I was very young, I had to fabricate block selector switches out of hacksaw blades and machine screws. This technique is an extension of that experience.

Assembling the board

The resistors are low to the board, so should be installed first. Fold the leads 90 degrees at the resistor body, inserting them in the designated spaces. R1-2 will be 680 ohm, Blue-Gray-Brown. R3-4 are 2200 ohm, Red-Red-Red. Depending on your soldering skills, do them all together or a few at a time. Placing the coloured bands all the same way is a mark of workmanship, but has no bearing on operation.



When the resistors are in place, leads trimmed, install the diodes in the power supply section of the board. See the illustration above. The top diode is a rectifier, with the band toward the top of the board. The lower diode is to shift voltage levels, suppressing spurious operation. Install with the band down. Several pads are provided to mount the capacitor. Spaced to accomodate different sizes.

Place the center row of transistors. Q13-14, Q23-24, etc. These will be the PNP, 2N4403, in the kits identified with a yellow paint spot. Install them with the flat faces to the left, as indicated by the screening. It will be necessary to form the leads wide to fit the spacing. Use needle nose pliers. If you form the offset about a third the length of the lead, they will stand off the board a little. This gives a little "wiggle" room for your fingers if you need to remove one.

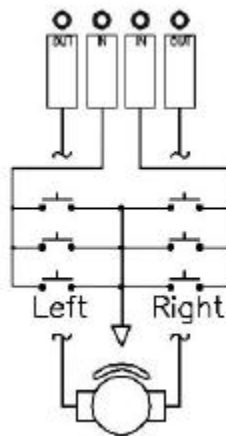
Now load the top row with 2N4401s. Q11-12, Q21-22, etc. They have no markings other than the part number. Flat face to the right, as indicated. Then the bottom row, Q15-16, Q25-26 etc, same alignment, same technique.

For A-C supply, install the capacitor in the center of the board. It is not required for D-C. Positive lead to the top of the board. If both leads come out the same end of the capacitor, the longer lead is positive. At the bottom of the board, between Q-35 and the lower diode is a pair of unmarked holes. Connect the negative lead here, in the upper of the two. Connect the positive lead to one of the three top holes, adjacent Q-22. All three are the same connection, use whichever is suitable for the capacitor in hand.

EXTERNAL CONNECTIONS

The terminals are identified at the edge of the board. For each control circuit, the two "IN" leads are taken to ground through pushbuttons, or studs as noted above. The two "OUT" leads go to the motor.

When connecting the motor and control leads, a group of four terminals comprises one controller. The two outer are motor leads, the two inner are control leads. When counting pins, 1 and 4 are motor leads, 2 and 3 are control leads. Same with 5 and 8 as motor leads and 6 and 7 as control leads. This count may be made from either end of the board. The terminals are symmetrical in this respect.



For "Tortoise®" brand machines, LEDs may be inserted in series with the motor leads. Use a 2 colour (2 lead) LED or wire 2 LEDs in inverse parallel. If you wish to use 3 lead 2 colour LEDs, please refer to the prints for connections. 2 lead LEDs and 2 LEDs in parallel may also be connected parallel to the motor, but will require their own current limiting resistors.

It should be noted that the LBO-4 circuit board need not be dedicated to this one specific circuit. It is possible to share the board across numerous applications, such as a motor controller, a flasher, and a detection circuit. See the crossing gate controller.

Some trouble-shooting notes

I try to make my designs as "oops-proof" as possible.... This one got by me. There *are* situations that can damage the board:

Rolling the control and motor leads. Such that an input (ground) gets connected to one of the motor leads when a pushbutton is operated.

How I found the other problem was during testing, using a test lead to ground a control input lead at the edge connector, a motor output lead was touched by mistake (my hand was shaking from working in an unusual position) while adjusting alignment of a Tortoise actuator.

In either situation, one of the top row transistors will be directly across the power supply line when a motor terminal is grounded. Should it be biased on at the time, the magic smoke will get out and it won't work any more. It's a coin toss when it happens, a 50-50 chance.

When it fails, it usually will fail shorted, which then takes other elements of the circuit with it. Should you manage to ground a motor lead, it is simplest to replace all four elements of the bridge in question. A hot component will tell the tale, just swap out all four for that specific bridge.

Technical Notes

During the somewhat verbose introduction, I spoke of the LBO being capable of "Dynamic Braking" and suitable for "Variable Speed" use.

The bridge amplifier is a common circuit in instrumentation applications. The drawing package that accompanies the complete manual contains elementaries of the LBO circuit, and includes notes on using the circuit in higher power applications such as an automatic reversing display control.

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Detection

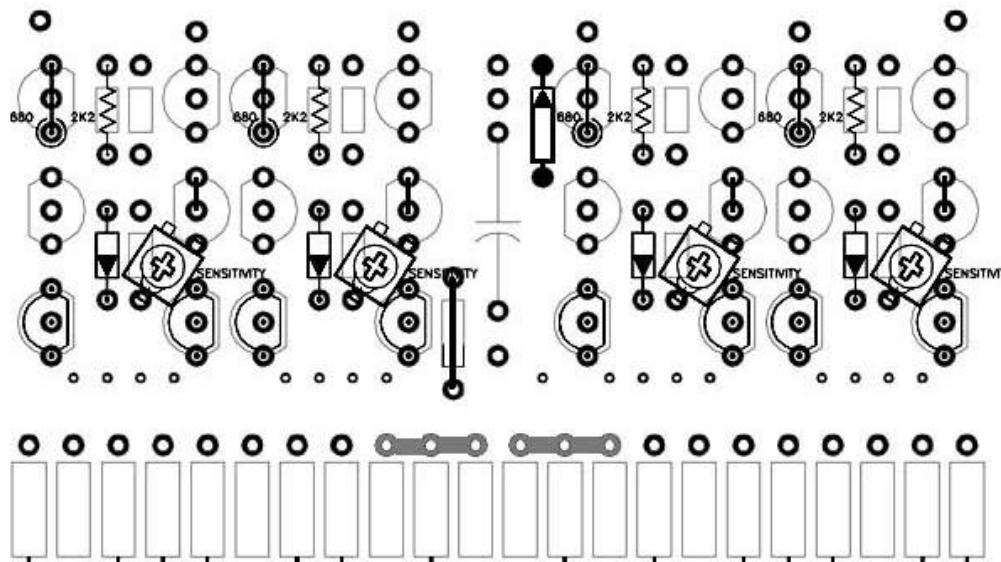
A Quad Detector] Photocel

A simple, two page project. And two pages *only* because I talk so much. This detection board is four iterations of the same circuit. Each circuit will accomodate four(4) photo-cels. That's four staging tracks or four blocks of optical signalling detection.

Construction time is a couple of hours at most, once the bench is cleared for electronics construction. If you're like me and and share bench space amongst numerous projects, add another hour.

You will need the following components:

- 4 680 ohm resistor
- 4 4K7 ohm resistor
- 4 20K trimmer(adjustable) resistor
- 4 1N914 signal detector diode
- 8 2N4401 NPN Transistor
- 1 1N4006 Rectifier Diode
- 1 47uF Filter capacitor (Optional for D-C Supply)
- 4 (minimum) Photo-cels



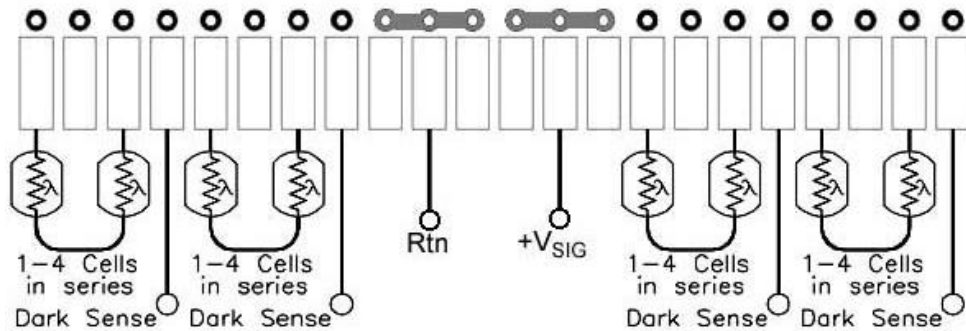
Start with the left-most circuit. When it is complete, duplicate it in the other three modules.

- [] Install 680 ohm(Blue-Gray-Brown) resistor at Q-11 Top to Q-13 Top.
- [] Install 2200 ohm(Red-Red-Red) resistor at location R-11.
- [] Install 1N914 Diode at location R-13. Band down as illustrated.
Solder and trim.
- [] Install Jumper at location Q-14 Top to Q-14 Middle.
- [] Install Jumper to the right of Q-26 as shown.
- [] Install 1N4006 to the left of Q-31 as shown.
Solder and trim.
- [] Install Trimmer at location R-14 lower to Q-14 Lower
- [] Install 2 pieces 2N4401 Transistor at location Q-15 and Q-16.
- [] Solder and trim all leads.

Wait until the board is complete to install the capacitor. They are the most bulky component and cumbersome while handling the board. There are numerous shapes and sizes of capacitors, the board has several pads to accomodate them.

EXTERNAL CONNECTIONS

As with most circuits for this board, power supply is Hot (DC+) to Pin 10 or 11, Return to Pin 12 or 13. A-C *will* work, 8-12V D-C is preferred. The capacitor is not required with D-C power.



The circuit has been tested and is stable with four photo-cels, as supplied by Signal Aspect, connected in series. If another supplier is used, the photo-cels should be of equal resistance within a 10% range. Absolute value is secondary.

With the photo-cels exposed to ambient light, wait for a couple minutes after power up for the photo-cels to stabilize. Adjust the trimmer for each module until the output triggers. Then back off until it just goes off. The closer this adjustment, the more sensitive the detection.

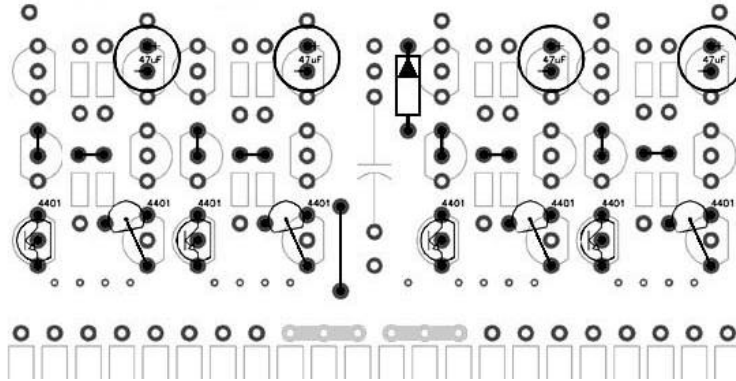
Detection

A Quad Detector Twin-T / Current

This detection board is four iterations of the same circuit. Each board will provide four blocks of current detection.

You will need the following components:

- 4 47uF Electrolytic capacitor
- 8 2N4401 NPN Transistor
- 17 1N4006 Rectifier Diode (Sub JE-125 when I can get them)
- 1 47-100uF Filter capacitor (Optional for D-C Supply)

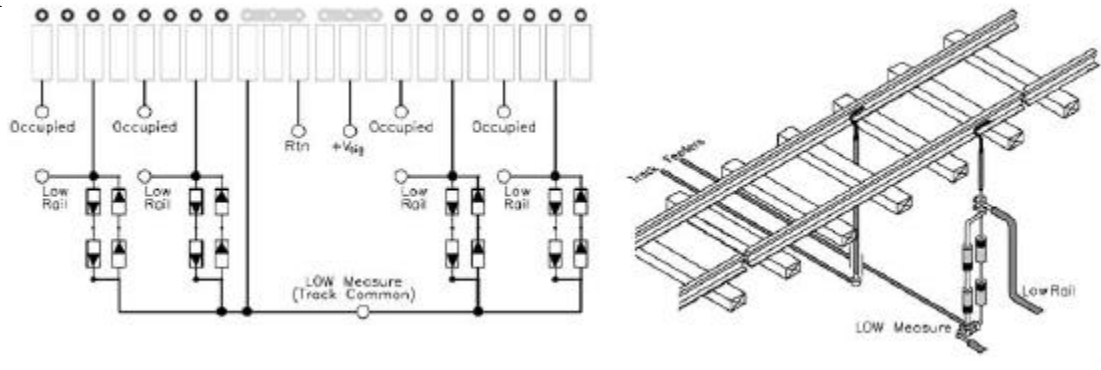


Start with the left-most circuit. When it is complete, duplicate it in the other three modules.

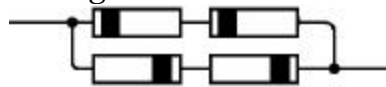
- [] Install 1 piece 2N4410 at location Q-5
- [] Install 1 piece 2N4410 at location Q-6 thusly:
Holding the transistor with the flat face and label facing you,
bend the center leg forward at about 75 degrees toward you.
Mount the transistor with the left leg in the lower pad of R-4 and the
right leg in the top pad of Q-6. Fold and guide the center leg into the
lower pad of Q-6. Adjust the position until the transistor has a work-
man like appearance. Solder and trim.
- [] Install Jumper from the upper pad of R-3 to the upper pad of R-4.
- [] Install Jumper from the upper pad of Q-3 to the center pad of Q-3.
- [] Install 47uF capacitor at location Q-2, with the negative lead
through the center pad and the positive lead through the upper pad,
as illustrated. Solder and trim.
- [] Install Jumper to the right of Q-26 as shown.
- [] Install 1N4006 to the left of Q-31 as shown.
- [] Solder and trim all leads.

EXTERNAL CONNECTIONS

As with many circuits for this board, power supply is Hot (DC+) to Pin 10, Return to Pin 12. A-C is acceptable, 8-12V D-C is preferred. The filter capacitor at the center of the board is not required with D-C power.



Detection is accomplished by measuring the “Fermi” level across diode junctions when current is flowing. Since, with D-C analogue, track power may be reversed for direction, diodes must be provided for both polarities. Two in series provides a voltage on the order of 1.3 volts. Two more in the opposite polarity accommodate reversal. The most common version of the diode will be the 1N4006. Kits pre-packaged may occasionally contain “JE-125” diodes, when I can get them. These diodes have a higher current rating but are not always available. Make up four diodes, as shown here, for each signal block.



Installation of the sense diodes is illustrated above. They should always be in series with the same side of the track and preferably returning to a “common” wire from the power packs. The length of the isolated rail is the length of the signal sensing.

From the rail you just isolated, run a wire to the diodes. From the other side of the diodes, run a wire back to the “common” point of the power packs. There will be other wires attached here shortly. If you want to see the detector in action right away, connect a 2-3 volt GoW lamp across the diodes and run a train. When the locomotive is in the isolated block, the lamp will light. Should you have a volt-meter, it will read on the order of 1.2 to 1.6 volts. This is the phenomenon we will use to operate the detection circuit. If the lamp doesn't light or you don't see the voltage, the “signal rail” isn't **fully isolated** and the detector won't.

Output of the circuit is “NPN open collector” to ground. External pull-up is expected. For internal pull-up, install a 2K2 resistor at R-1 of each module. Output may be indicated with an LED from Output to ground; on if the block is clear.

A **Dual C.T.** for **DCC Detection**

Assembly of the circuit board will require minimal soldering skills. If you already solder the wiring on your layout without melting insulation or cross-tie strips, with patience you should have sufficient skill. But anything over a 40 watt iron is out. Sorry. . .

For the hobbyist that solders on a casual basis, may I recommend an essay on basic soldering that is included in the "Random Thoughts" section of the SLC manual. Building my circuit boards doesn't require "Aero-Space" grade work, but there *are* limits to what the small components can take. Comments and recommendations on technique by an old hand in the electronics business may help you to improve your skills. Please understand, I cannot warrant boards where the foil traces have been delaminated from overheating.

Recommended bench space is the hobbyist's typical two square feet. Equipment needed is: Soldering iron on the order of 20-30 watts. (my bench iron is 20W, the field iron 32W) Also, long nose pliers, small wire cutters, flush cut if available. A clip on heat sink is nice, the pliers may be used if you prefer. A jig to hold the board is optional but not necessary. I don't normally use one. Play-Doh® is sometimes used here. Use Rosin Core solder, do not use an acid based flux. An old toothbrush and denatured alcohol make for good flux removal.

About C.T.s

C.T. is an acronym for "Current Transformer". The expression is often misused in the electronics business as "Current Trans**ducer**"; although a "meter shunt" is also but one of many "transducers". At the power end of electrical work, they are also colloquially known as "do-nuts" after the general shape of the coil in larger sizes.

A CT is a transformer that magnetically couples "watts" of electrical power. An in depth study of the subject would take more space than both of these manuals. And the magnetic theory has enough math to be of interest to only a very few "rocket scientist" types. All we care about here is that they **do** work in Model Railroad applications.

Of interest here is that CTs can generate enormous voltages, under certain conditions. High enough to let the "magic smoke" out of any transistors connected in the circuit.

These instructions call for a 1N914 diode across the CT. This diode must never be omitted. The reverse voltage can exceed the reverse rating of the transistors by a factor of three, or more. Letting **all** the magic smoke out...

Why only two detection circuits per board?

When the other methods have four.

Using CTs requires passing one of the track conductors through the donut, usually with two turns. Possibly three... Most layouts use a fairly heavy wire, AWG 18 or larger, for track feeders. This wire must be mechanically attached to the circuit board, putting considerable stress on the CT as well as the other wiring connections and edge connector.

Electrically, four iterations of the CT circuit will fit the LBO. If you are willing to carefully dress the wires and properly restrain them so they present no side forces on the board and its' components, four iterations per **will** make for an elegant and compact installation. The kits provide for two. However, all components are readily available; simply duplicate the circuit in the other two modules.

As with any other method of current detection, CTs require one rail be electrically isolated for the length of the block. Unlike the Twin-T, either rail can be used and polarity is not an issue. This presents the capability to over-lap the signal boundaries, a possibly useful technique.

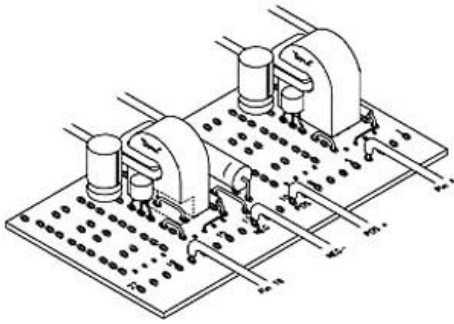
Limitations do rear their ugly head with CTs. They will only work on the high frequency bipolar data frames of DCC systems. CTs are not suitable for the 60 Hz A-C used with vintage large scale trains. And only theoretically marginally with the D-C superimposed of the CTC-16.

Twin-T circuits can detect in the micro-amp regions; my implementation can often detect a dry finger across the rails. 5000 ohm (m/l) wheelsets are available for this from a number of sources. When the Twin-T is used with DCC, it is not that sensitive. A relay is usually the best option for a retrofit. See the SLC manual for details if you're curious.

CTs require more current. This two transistor circuit will detect reliably at 25 mA idle current and two turns on the primary. Depending on the DCC data frame, it occasionally will detect as low as 10 mA. With the highly efficient motors used in the small scales, a shunt resistor is sometimes required. I suggest on the order of 470 ohms, as low as 330 ohms may be required. It can also be a matter of the DCC Decoder as much as the motor when trying to detect a standing train.

Module Assembly

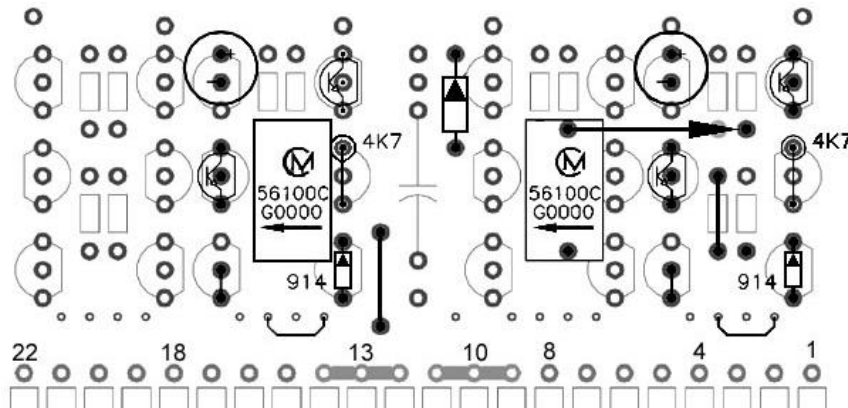
There are jumpers to be soldered on the board. They can be made of trimmings from the component leads or small wire. A single strand of AWG-18 stranded makes a good size.



Use of a plug-in edge connector is accommodated through the fingers on the foil side of the board. The row of solder pads immediately above the lettering is provided for those that wish

to connect directly to the board. Edge connectors add significant cost to the project but are usually well worth the additional expense.

Place the board in front of you so that the lettering "Signal Aspect 1988" is to the bottom right. Pin (1) will be to the right. The pin numbers are not screen printed intentionally.

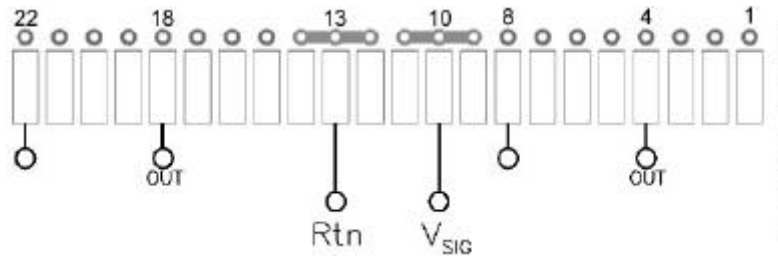


Take special care with the two jumpers at location R-23 and R-43. They will be installed on the foil side of the board, soldered on the front. Trim as flush to the board surface as possible leaving clear the location of the CT donut body. In the top illustration, one of the CTs has a cut-away showing the location of this jumper.

- [] Install jumper (2) at locations R-23 and R-43 as described above.
- [] Install jumper (2) at location Q-25 and Q-45, spanning the upper and center pads.
- [] Install jumper (1) in the two pads immediately right of Q-26, as illustrated above.
- [] Install jumper (2) in the small pads below Q-x5 and Q-x6, spanning from the rightmost pad to the third pad left, as illustrated above.

- [] Install 1N4006 (JE-125) immediately left of Q-31, as illustrated above
- [] Install 1N917 Diode (2) at location Q-26 and Q-46, spanning the upper and lower pads. The Cathode (banded end) is up, in the top pad. The diode will fit as described, but may be stood on end if desired; be careful of soldering heat by leaving room for a heat sink between the diode and the board.
- [] Install 4K7 (Yel-Vio-Red) resistor (2) at location Q-24 and Q-44. These will need to stand on end, they are larger than the diodes. Span the upper pad to the lower pad at this location.
- [] Install 2N4401 transistor (2) at location Q-22 and Q-42. The flat face is to the right, **aligned** with the screen printing.
- [] Install 2N4401 transistor (2) at location Q-23 and Q-43. The flat face is to the right, **opposite** the screen printing.
- [] Install 47uF capacitor (2) at location Q-21 and Q-41. The negative lead is normally the identified lead on electrolytics, usually with a broad stripe. The longer lead will be the positive. Install with the positive lead in the top pad and the negative lead in the center pad at this location.
- [] Install 47uF capacitor in the center of the board. It is optional when the board is powered with a D-C supply. There are multiple pads to accommodate various sizes and models of capacitors. Positive lead to the top grouping, negative to the lower grouping.
- [] Install the CT (2) with the bulk offset to the left of the off-center pins. The top pin is in the lower pad of R-22 (42) and the bottom pin in the lower pad of R-24 (44).
 There will be 1mm offset in the spacing, spread the pins slightly as needed for a good fit. In the illustration, the CT on the left is in place; on the right is an arrow showing placement permitting a view of the board below the CT.
 The arrow printed on the CT is not relevant to this application. It indicates magnetic polarity for other poly-phase applications.

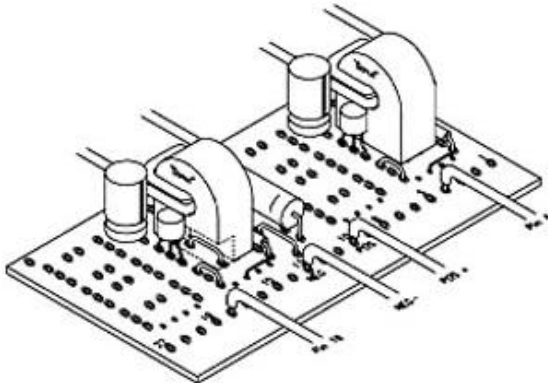
External Connections



The ideal power supply for a stand alone installation is a 9 volt battery eliminator, usually available as a “wall wart”. Any 8-12 volt supply will function well. Should it be necessary to power the board with A-C 12 volts, be sure the capacitor is installed in the center of the board. Up to 220uF might be desirable depending on the brand signal controller being used.

Power Hot (or positive) connects at Pin 10, power Return at Pin 13. (The jumpers shown above pins 10 and 13 are integral to the board and have no connections in this application.)

Output is NPN Open Collector to ground. It looks for 2200 to 4700 ohms pull-up to function properly. The AZ-947 relay from Signal Aspect has a 400 ohm coil; the circuit is known to function with that relay.



The transformer “primary” will be two passes of the power lead through the do-nut. This will be indicated by one tight wrap around the body, as illustrated here.

This is the normal start-up count for an unknown situation. There may be conditions requiring a third turn. This will be rare and can possibly damage the amplifier if used arbitrarily, therefore should be avoided if possible.

The track lead must be isolated with all track current passing through the one lead. If there is a shunt path, the detection circuit won't work. Use a 330 ohm resistor across the rails to test sensitivity. If the circuit can see the resistor but not the locomotive, the motor and/or decoder are too efficient. A shunt resistor will be required ahead of the decoder. Recommended starting size is on the order of 500 ohms, decreasing until the detection is reliable. A shunt resistance should never be less than 270 ohms, in any circumstances.

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Approach Lighting

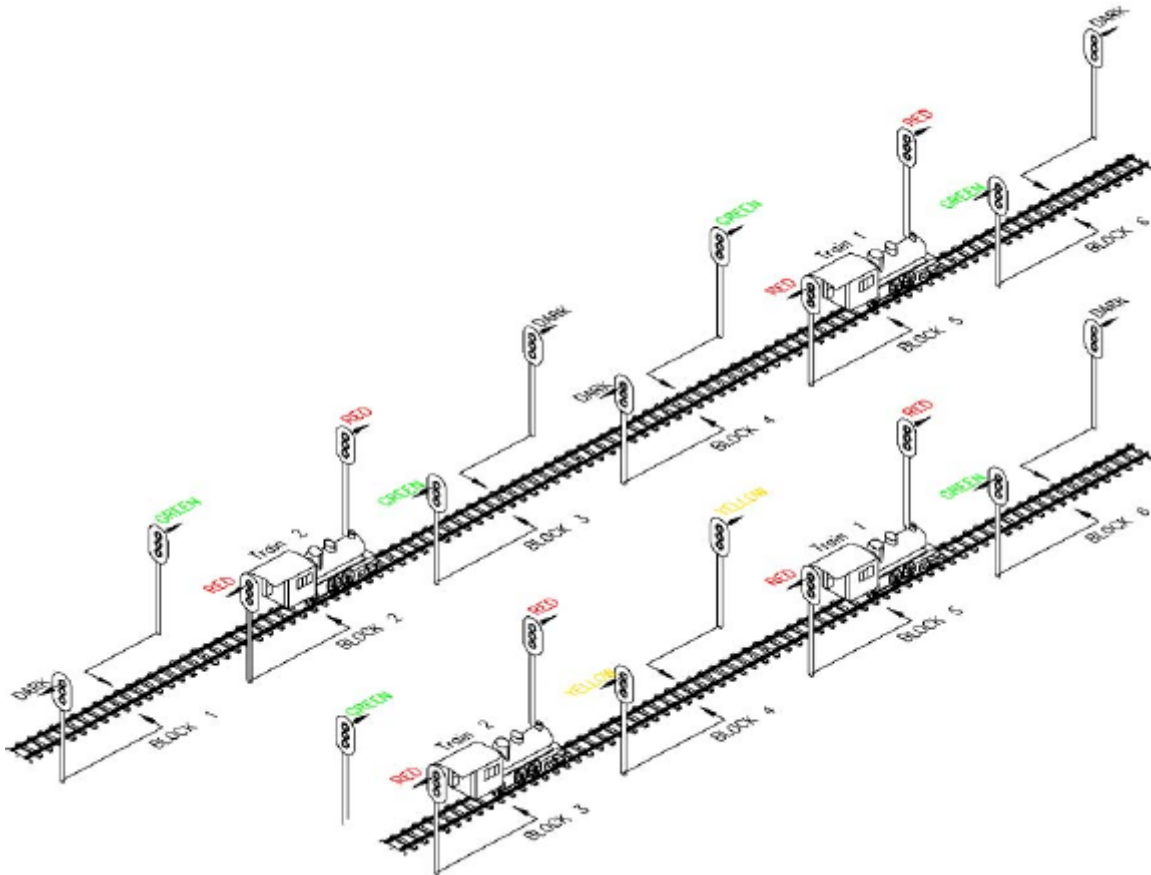
With the LBO-4

“Approach lighting” is used here to describe having the signals un-lit until a train is “approaching” the signal. Whereupon the signal comes to life to indicate the status of the block ahead.

In the largest scale of 12 inches to the foot, signal blocks can be very long and a signal needn't be lit until a train is within visual distance. Normally a small percentage of the block length. And can go dark soon after the locomotive has passed.

For the smaller scales, the visual distance will often cover three or more blocks. And train length can exceed the length of some blocks to the extent that special cars are often placed in the train simply to be detected so the block will continue to indicate “in use”.

My system for approach lighting will power up the signal for the current block(s) being detected and the two immediately adjacent signals. That being the minimum of four signal displays as each adjacent block is only lit at the boundary of the current in use block. And a maximum of the blocks in use plus the two for adjacent blocks.



Since this is **my** railroad and I like pre-USRA steam, the 4-6-0s have slide valve engines. (Though if you can see that, your eyes are *much* better than mine)

In the illustration above, there are two trains, one following the other. Let us assume Train 1 in Block (5), upper right, has stopped for a passenger whistle stop. Train 2 in Block (2) is a freight and is moving fairly slowly.

The East-bound signal for Block (4) is dark. As Train 2 advances into Block (3), both signals will light Red; the block is now occupied.

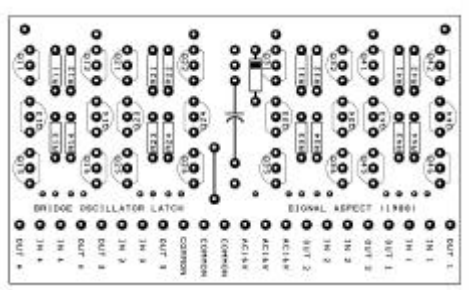
Both signals for Block (4) will light Yellow. The “Next” block in both directions is occupied.

The Westbound signal for Block (2) will light Green and the East-bound will blank. Both signals for Block (1) will blank.

This is the interaction of the “Next - Previous” connections between the SLCs and the detection power circuits described in the SLC portion of the manual. If the signal model is constructed with Common Cathode connected LEDs, there is no external power circuit required.

These instructions are for assembling the power switch for lamps and Common Anode LEDs using an LBO-4 board to carry the circuit. There are four(4) iterations of the circuit; to control power for four(4) blocks in bi-directional mode. If your layout has signals in only one direction, eight(8) blocks may be controlled.

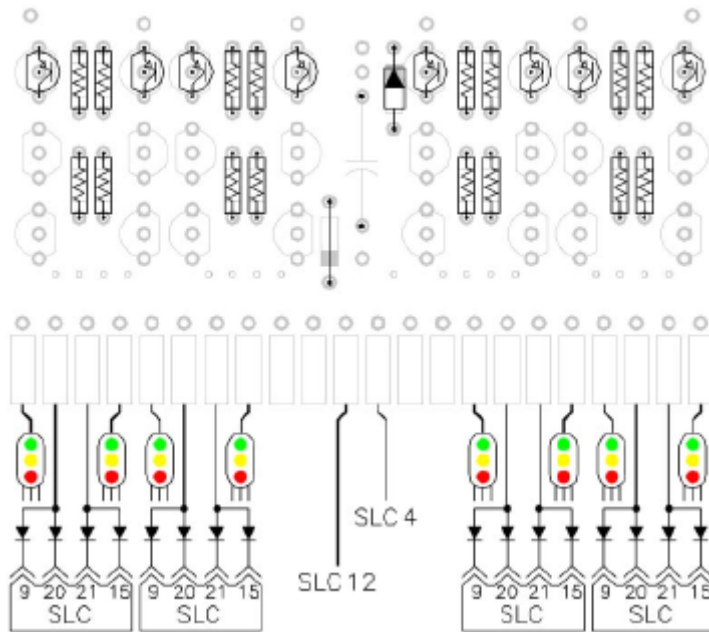
As usual, we start with the bare board. Foil side down and the edge connector fingers to the near side. “Signal Aspect 1988” to the right.



The diode and capacitor in the center of the board are protective and only mandatory if powering the board from an external source. Power may be derived from an adjacent SLC, using SLC-3 or -4. The jumper to the right of Q-26 is mandatory.

- [] Install eight pieces 33K (Ora-Ora-Ora) resistors at locations R-1 and R-2 for each module. The package may contain 27K (Red-Vio-Ora) depending on my inventory at the time. Any resistance above 15K is acceptable, up to about 80K.
- [] Install eight pieces 680R (Blu-Sla-Bro) resistors at locations R-3 and R-4 for each module. Here again, the absolute value is arbitrary. It should be a small fraction of the resistors at R-1 and R-2 and otherwise greater than 500 ohms.
- [] Install eight pieces 2N4403(PNP) transistors at locations Q-1 and Q-2 for each module. Take care to install the transistors reversed to the screen printing; keeping the flat face to the left.

The current rating for these transistors is 500mA, 500mW. They will handle multiple LEDs and smaller “Grain of Wheat” lamps. I have found miniature lamps being sold as GoW lamps but with a much higher current load, often upwards of 100mA. This circuit will handle the current but be aware of parallel loading. Single #67 automotive lamps are about the upper limit. For larger lamps in the larger scales, use of a relay is preferable. See the SLC instructions.



The external connections are described in the appropriate section of the SLC directions. For single direction use (8 blocks) it should be noted that the pin numbers are rolled for the incoming control lines. The signal on Pin (1) is controlled by the input on Pin(3) and the signal on Pin(4) is controlled by the input on Pin(2). Just think “even to even” and odd to odd”. This is another of the many traits of the LBO foil pattern that allow such novel solutions.

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Crossing Gate Actuator Linear Actuator

Module Assembly

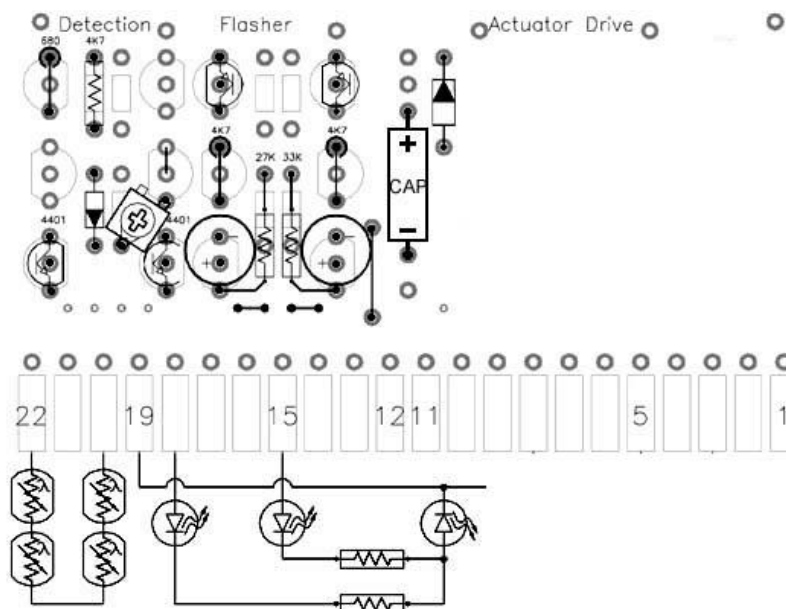
Assembly of the circuit board will require minimal soldering skills. If you already solder the wiring on your layout without melting insulation or cross-tie strips, you should have sufficient skill. But anything over a 40 watt iron is out. Sorry. . .

For the hobbyist that solders on a casual basis, may I recommend an essay on basic soldering that is included in the "Random Thoughts" section of this manual. Building my circuit boards doesn't require "Aero-Space" grade work, but there *are* limits to what the small components can take. Comments and recommendations on technique by an old hand in the electronics business may help you to improve your skills. Please understand, I cannot warrant boards where the foil traces have been burned off from overheating.

Recommended bench space is the hobbyist's typical two square feet. Equipment needed is: Soldering iron on the order of 20-30 watts. (my bench iron is 20W, the field iron 32W) Also, long nose pliers, small wire cutters, flush cut if available. A clip on heat sink is nice, the pliers may be used if you prefer. A jig to hold the board is optional but not necessary. I don't normally use one. Play-Doh® is sometimes used here. Use Rosin Core solder, do not use an acid based flux. An old toothbrush and denatured alcohol make for good flux removal.

For bench testing after assembly, you will want a power supply of 8-12V and couple of jumpers with small alligator clips. I use a 9 Volt "Wall Wart" for a testing supply. With the servos provided in the package, such a supply will be sufficient.

Attachment of the actuators to the model is left as an exercise for the user. Most every model will require techniques specific to that piece. In addition, the physical mounting of the model will have a considerable influence on the mechanical linkages involved.



- [] Install 680 ohm (Blu-Sla-Bro) resistor from the top pad of Q-11 to the lower pad of Q-11. This is most readily accomplished by standing the resistor on end and folding the upper lead over.
- [] Install 4K7 (Yel-Vio-Red) resistor at location R-11.
- [] Install 1N914 diode at location R-13. Note the banded end is down.
- [] Install 4K7 (Yel-Vio-Red) resistor at locations Q-23 and Q-24, also in a vertical fashion.
- [] Install 27K (Red-Vio-Ora) resistor from the top pad of R-23 to the lower pad of Q-25.
- [] Install 33K (Ora-Ora-Ora) resistor from the top pad of R-24 to the lower pad of Q-26.

In both cases, leave the leads a little long as illustrated. There will be other components mounted closely in this area.

Using trimmings from the resistor leads, install jumpers at the following locations:

- [] Install jumper from the top pad of Q-14 to the middle pad of Q-14.
- [] Install jumper in the two unmarked pads immediately to the right of Q-26 per the illustration above.
- [] Install jumper in the leftmost two (small) pads below Q-25.
- [] Install jumper in the rightmost two (small) pads below Q-26.

The latter two will be immediately below the two timing resistors.

- [] Install sensitivity adjust trimmer (the little square gizmo with three pins and a cross slot) between the lower pad of R-14 and the lower pad of Q-14. The third lead is not used and should be removed per the illustration. If the servo option is being assembled, there will be three pieces. The sensitivity adjuster will be 20K, marked (203). Servo trimmers are 2K0, marked (202).
- [] Install 2N4401 transistors (2) at locations Q-15 and Q-16. The flat face will be aligned with the screen printing; facing to the right.
- [] Install 2N4403 transistors (2) at locations Q-21 and Q-22. The flat face will be opposite the screen printing; facing to the left.
- [] Install timing capacitors (2 @ 47uF) at locations Q-25 and Q-26. Observe the polarity markings that the broad stripe for the negative end is toward the top of the board. The longer lead will be the positive side; it installs in the middle pad of Q-25 (or 26) with the negative lead in the top pad of the corresponding location.
- [] Install filter capacitor (value may vary) as illustrated. The capacitor will have a broad stripe indicating the negative lead. For capacitors with radial leads, the longer lead will be positive. The negative lead attaches to the second pad, just above the wire from the regulator. The positive lead connects to whichever of the three upper pads is most appropriate for the physical size.

At this point, the detection and flasher circuits are functional. If you want to see this portion in operation, install a diode as illustrated above, between the filter capacitor and Q-31. For the linear actuator version, the diode is part of the circuit and may be mounted low to the board in a permanent fashion.

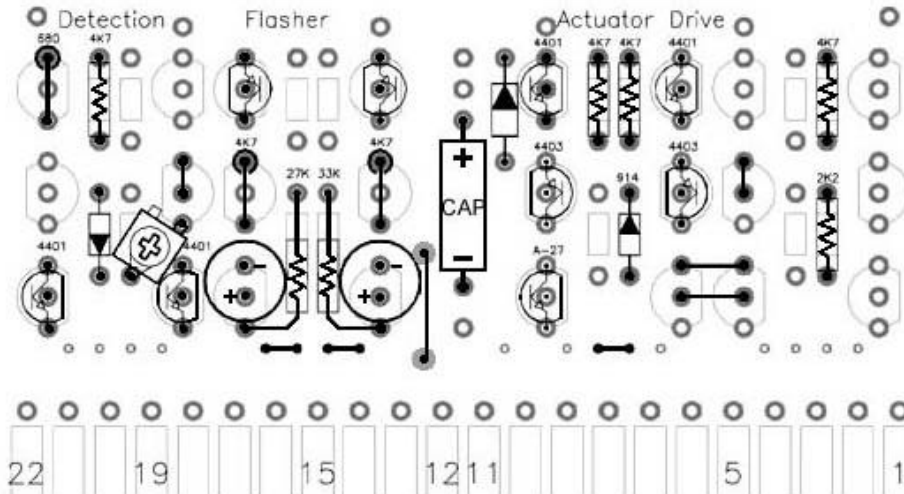
Connect Positive power at Pin 11 and Negative at Pin 12. Connect the external components as illustrated. The circuit will work with up to four photocels or as few as one. In ambient light, adjust the sensitivity until the lights just start to flash, then back off until they don't. The tighter this adjustment, the more sensitive the circuit. Covering the photocel will bring on the flasher.

Linear Actuators

In Model Railroading, there are many motorized switch machines and linear actuators. Some operate in “stalled” condition, others have limit switches. This circuit will work with any version up to 500mA D-C (1/2 amp) that I have yet to encounter or build.

Far and away the most common and well known version is the Tortoise® machine. This machine will be used to illustrate the external wiring. The function will be the same for any other such machine. If limit switches are necessary, it will be up to the user to make those external connections.

Observe the right side of the board as illustrated here;



Q-31 through Q-34 comprise an “H” bridge amplifier. Note the diode at location R-34 is installed with the banded end up. Also the jumper below Q-35 and Q-36; in this circuit, the jumper is between the two middle pads.

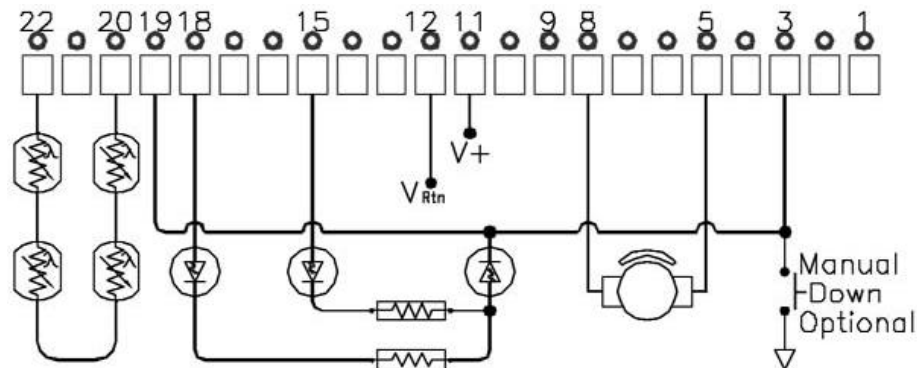
- [] Install jumper below Q-35, 36 as illustrated
- [] Install jumpers(2) as illustrated, between Q-36 and Q-45
- [] Install jumper at between the upper and middle pad at location Q-43

- [] Install 1N914 diode at location R-34, banded end up.

- [] Install 680 (Blu-Gra-Bro) resistors(2) at location R-31 and R-32.
- [] Install 2K2 (Red-Red-Red) resistors at locations R-42 and R-44.

- [] Install 2N4401 transistors (2) at locations Q-31 and Q-32. The flat face will align with the screen printed outline, to the right side.
- [] Install 2N4403 transistors (2) at locations Q-33 and Q-34. The flat face will align with the screen printed outline, to the left side.
- [] Install MPS-A27 transistor at location Q-35. The flat face will align with the screen printed outline, to the right side.

External connections



Pins 20 and 22 connect to the photocel(s). The usual installation will have one photocel on either side of the crossing, a foot or two out. (30-60cm) The gate will operate and the lights flash whenever at least one photocel is dark. A two track crossing can be guarded simply by adding two more photocels in series (as illustrated).

A light source directly above a photocel should be avoided, as it will cause the detection to respond to the gap between cars. Sensitivity is adjusted by tweaking the sensitivity resistor to the point where the lamps just barely go dark in ambient light. The LED illustrated below Pins 10-11 is constant, the LEDs at Pins 15 and 18 will flash opposing.

The connection from Pin 19 to Pin 3 (and the LEDs) transfers the detection to the gate actuator circuit and the LEDs. In addition, this function may be operated manually by connecting a switch between the lead and power supply return. It also can be used to either operate external signalling or to take an input from external signalling. In some cases, an isolation diode may be required; use a 1N914.

Assuming a Tortoise® switch machine, connect the Tortoise motor, the two outboard pins, to the LBO board Pins 5 and 8. These pins are the outputs from the “H” bridge. To reverse the operation of the drive mechanism, reverse the leads at the motor.

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LINEAR POSITIONING

with the LBO-4
and R-C Servos

The LBO-4 (SV) and (SG) options are designed to facilitate use of R-C Servos from the robotics and model aviation hobbies. These positioners offer a useful alternative to the actuators commonly available to Model Railroaders. The many advantages of these positioners include size, relatively low cost, precision, greater power, and mounting options. Two versions of the LBO-4 are available, each a self contained controller.

The “**SV**” option includes two servos with independant controllers designed as actuators for position type signals such as the common semaphore arm type, prevalent since the early days of railroading. The circuit was developed to provide positive and repeatable operation of the signal arm at each end of a block. This a goal long sought since the earliest days of Model Railroading. Control inputs are configured for direct connection to a SLC-32 Signal Controller, but may be operated by virtually any three light signal system that uses a logical low output to light the signal lamps.

These controllers may also be applied as switch machine operators. With the two servos included, two independant turnouts may be controlled. And with the capability to operate multiple servos under one control, a cross over (or even a scissors) may be operated with a single contact closure. Each servo will mirror the operation of the others. The servos I carry are very small for signalling purposes. Larger servos are readily available from numerous model aviation sources at a very modest cost.

The many other possible uses will be limited only by the imagination of the user. While designed to provide three positions, the input controls may be configured for as many as desired, from two to a practical upper limit of ten, controlled with a single contact closure for each position. The technical documentation includes directions for using the SV in such a manner. It is also possible to use variable resistors to provide linear manual control similar to that used by aviation modelers.

The “**SG**” option contains one servo controller, configured for two adjustable positions. The circuit is otherwise identical to that described for the SV option.

Included on the board are an optical(dark sensing) detection circuit and a dual flasher suitable for driving crossbuck lights at a grade crossing. The detection circuit will accept input from multiple photo-cels in tandem, permitting its' use across multi-track crossings.

In its' normal configuration, the SG board is used to operate crossing gates. Able to operate two or more servos from one amplifier, this allows separate drive mechanisms for each side of the crossing. As with the dual control of the SV option, the many uses of this circuit will be limited only by the imagination of the end user.

By moving a wire lead at the connector, it is possible to use the circuits for independant applications. The flasher circuit will operate both flashing LEDs and a constantly lit LED in the same circuit, such as would be seen on the gate arm.

As a rule, the operating current of RC Servos is somewhat higher than the usual RR actuators; they are very powerful when compared to the more common motor driven switch machine. While they are faster than the usual RR actuators, they are much slower than the "Snap" action of a solenoid type switch machine. A convenient mid point. They have sufficient power to deform sluggish mechanisms, so are suitable for positioning considerable loads. With the "standard" positions electrically adjustable, repeated precision adjustment of linkages should never be an issue.

In physical size, RC servos can be acquired that are physically smaller than one half (1/2) cubic inch. The servos included with Signal Aspect controls are 3/4x 3/8x 3/4 inch, approximately. While lacking the torque of the larger sizes, they are imminently suited for scale animation.

In the larger scales, such a small package permits direct mounting on the signal mast. In "G" scale, for example, the servo has a footprint of 24x 10 x 24(scale), a suitable size for the mast mounted positioner from Union Switch & Signal, a common supplier to the railroads.

In "O"-1/4, the size is 36 x 14 inches(scale), easily disguised as a crossing gate operator with the gate directly attached to the output shaft.

In H-O, they can be readily recessed into the roadbed alongside a switch, with the output shaft directly connected. With adjustable stroke, the tension at the switch points can be kept tight for smooth operation.

Semaphore Driver Module Assembly

Assembly of the circuit board will require minimal soldering skills. If you already solder the wiring on your layout without melting insulation or cross-tie strips, you should have sufficient skill. But anything over a 40 watt iron is out. Sorry. . .

For the hobbyist that solders on a casual basis, may I recommend an essay on basic soldering that is included in the "Random Thoughts" section of this manual. Building my circuit boards doesn't require "Aero-Space" grade work, but there *are* limits to what the small components can take. Comments and recommendations on technique by an old hand in the electronics business may help you to improve your skills. Please understand, I cannot warrant boards where the foil traces have been burned off from overheating.

Recommended bench space is the hobbyist's typical two square feet. Equipment needed is: Soldering iron on the order of 20-30 watts. (my bench iron is 20W, the field iron 32W) Also, long nose pliers, small wire cutters, flush cut if available. A clip on heat sink is nice, the pliers may be used if you prefer. A jig to hold the board is optional but not necessary. I don't normally use one. Play-Doh® is sometimes used here. Use Rosin Core solder, do not use an acid based flux. An old toothbrush and denatured alcohol make for good flux removal.

For bench testing after assembly, you will want a power supply of 8-12V and couple of jumpers with small alligator clips. I use a 9 Volt "Wall Wart" for a testing supply. With the servos provided in the package, such a supply will be sufficient. A digital volt meter is not a requirement but can be of assistance during the alignment phase of installation and for troubleshooting if there is a problem.

There will be active components located off the board. This serves several purposes; primarily to position the adjustments so they will be readily accessible during alignment and routine maintenance.

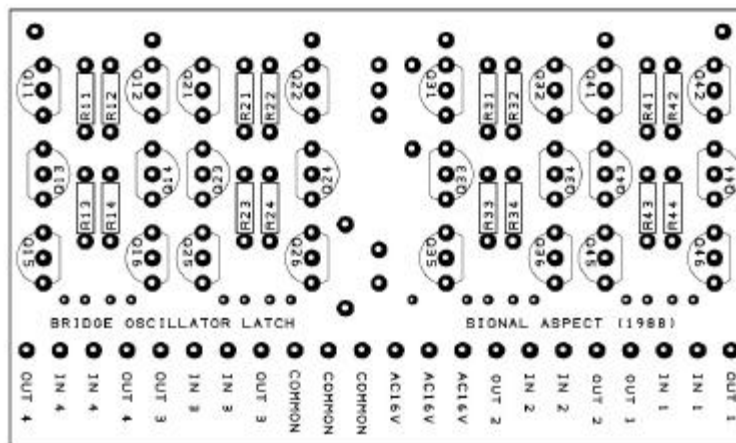
Attachment of the servos to the signal model is left as an exercise for the user. Most every signal model will require techniques specific to that model. In addition, the physical mounting of the signal will have a considerable influence on the mechanical linkages involved.

Package Contents:

2	Resistor	33000 ohm	Ora-Ora-Ora	(33K)
10	Resistor	2200 ohm	Red-Red-Red	(2K2)
2	Resistor	680 ohm	Blu-Gra-Bro	
2	Transistor	2N4401		(NPN)
4	Transistor	2N4403		(PNP)
4	Diode	1N400x	Power diodes	
4	Diode	1N914	Small signal detectors	
1	Capacitor	33-100uF	Value may vary	(Filter)
4	Capacitor	.47uF	Timing	
4	Trimmer	2000 ohm	Position adjust	
1	I.C. Regulator	7805 (or LM340-T5)		
2	Servos			

There are jumpers to be soldered on the board. They can be made of trimmings from the component leads or small wire. It is suggested that components be "layered", smaller components installed first. It allows the board to be pressed flat holding the components in place as they are soldered. These instructions will proceed in that fashion.

Place the board in front of you so that the lettering "Signal Aspect 1988" is to the bottom right. Pin (1) will be to the right. The pin numbers are not screen printed intentionally.



On the face of the board, observe that there are clusters of component locations; two such clusters on either end with a power supply section in the center.

- [] Install 2K2 resistor from the lower pad of Q-22 to the upper pad of R-22.
- [] Install 2K2 resistor from the upper pad of R-14 to the center pad of Q-23.
- [] Install 2K2 resistor at location R-23.
- [] Install 2K2 resistor from the lower pad of R-13 to the lower pad of Q-15.
Leave the lower lead in an (L) shape to avoid the screen for Q-15 and the solder pads below R-13.
- [] Install 2K2 resistor from the lower pad of R-14 to the lower pad of Q-16.
Leave the lower lead in an (L) shape to avoid the screen for Q-16 and the solder pads below R-14.
- [] Install 33K resistor from the lower pad of Q-13 to the lower pad of R-11.
- [] Install 680 resistor at location R-24. Solder and trim leads.

- [] Install 2K2 resistor from the lower pad of Q-42 to the upper pad of R-42.
- [] Install 2K2 resistor from the upper pad of R-34 to the center pad of Q-43.
- [] Install 2K2 resistor at location R-43.
- [] Install 2K2 resistor from the lower pad of R-33 to the lower pad of Q-35.
Leave the lower lead in an (L) shape to avoid the screen for Q-35 and the solder pads below R-33.
- [] Install 2K2 resistor from the lower pad of R-34 to the lower pad of Q-36.
Leave the lower lead in an (L) shape to avoid the screen for Q-36 and the solder pads below R-34.
- [] Install 33K resistor from the lower pad of Q-33 to the lower pad of R-31.
- [] Install 680 resistor at location R-44. Solder and trim leads.

- [] Install 2N4403 transistors(4) at locations Q-11, 12 and Q-31, 32.
Take note that these transistors install opposite the screen printing, with the flat face to the left.

- [] Install 2N4401 transistors(2) at locations Q-24 and Q-44.
Take note that these transistors install opposite the screen printing, with the flat face to the right. Solder and trim leads

- [] Install 1N4406 diode from the upper pad of R-21 to the lower pad of Q-21.
Take care to install the banded end (cathode) at Q-21. Make the leads long enough to stand the diode off the board to about the same height as the transistors. Solder and trim leads.

There may be a second diode installed here later, at the discretion of the user. The leads are left long to facilitate this as will be explained in the instructions for alignment. The diode has heavy leads; it is mounted at an angle to provide space for those leads.

- [] Install 1N4406 diode from the upper pad of R-41 to the lower pad of Q-41. Take care to install the banded end (cathode) at Q-41. Make the leads long enough to stand the diode off the board to about the same height as the transistors. Solder and trim leads.

There may be a second diode installed here later, at the discretion of the user. The leads are left long to facilitate this as will be explained in the instructions for alignment. The diode has heavy leads; it is mounted at an angle to provide space for those leads.

- [] Install 0.47uF capacitors(4) at locations Q-15,16 and at locations Q-35,36. The capacitor leads must be offset inward slightly to span the upper and center pads at each location. Solder and trim leads.
- [] Install 7805 Regulator I.C. thusly: Holding the TO-220 case so that the heat sink tab is up and the lettering is readable, bend the center tab back at a 90 deg angle. The bend should be 1/10 inch from the plastic case.

There is a solder pad just above the screen printing for Q-31. To the left of Q-31, there is a single solder pad. Beyond that, to the left, is a group of three pads. Insert the 7805 in the single pad above Q-31 and the single pad to the left of Q-31. The spacing is correct for this component. The center tab should extend out touching the top of Q-31.

Fold the 7805 to the front so it is facing the board and the center tab is vertical. Leave a quarter inch air space between the heat sink and the board. Refer to the illustration above for orientation. The heat sink extends beyond the edge of the board. This is intentional.

Route a short wire from the center tab of the case to the lower of two pads at the bottom of the board, as shown in the illustration. Solder the two pads at the top of the board. The wire lead may be soldered when the filter is installed.

The rather odd mounting is an after-thought. The original design called for a regulated +5 volt external supply for the board. This method permits tapping power directly from the SLC card when used for signalling, eliminating the need for a specialty power supply. The exposed heat sink tab provides overload protection for the servo. The 7805 has an internal self resetting thermal overload circuit.

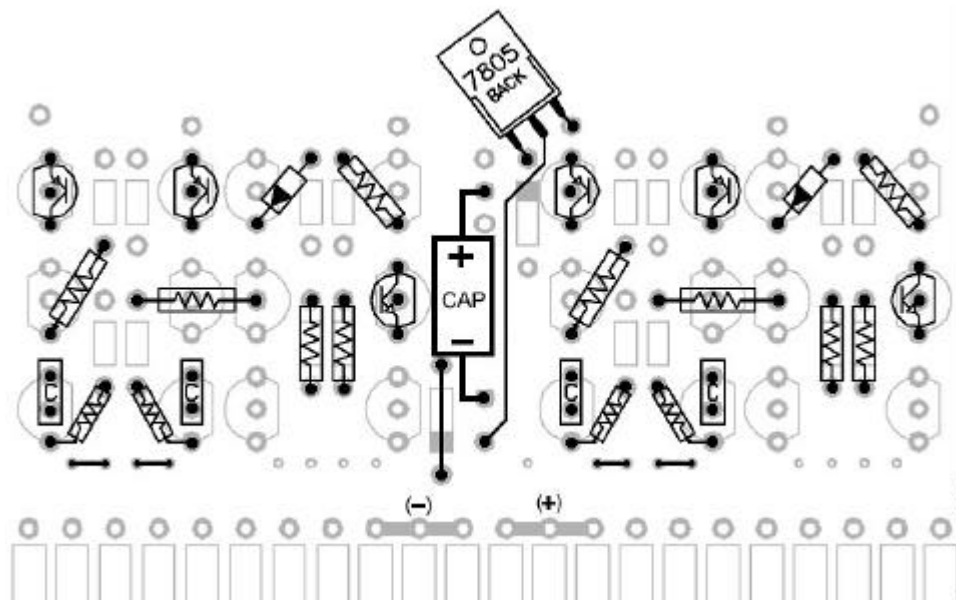
It is **normal** for the tab to be quite **warm** to touch. In an overload condition, the tab will get very hot and the regulator will reduce output to a low level. This protects not only the regulator but the servo and control circuitry as well.

[] Install the large electrolytic capacitor thusly: The capacitor will have a broad stripe indicating the negative lead. For capacitors with radial leads, the longer lead will be positive. The negative lead attaches to the second pad, just above the wire from the regulator. The positive lead connects to whichever of the three upper pads is most appropriate for the physical size. Solder and trim; including the regulator reference lead.

[] Install four(4) jumpers as follows:
Below Q-15,16 is a row of four(4) pads. The left two and the right two are to be jumpered as pairs. Refer to the illustration... Install two jumpers below Q-35,36 in a similar fashion.

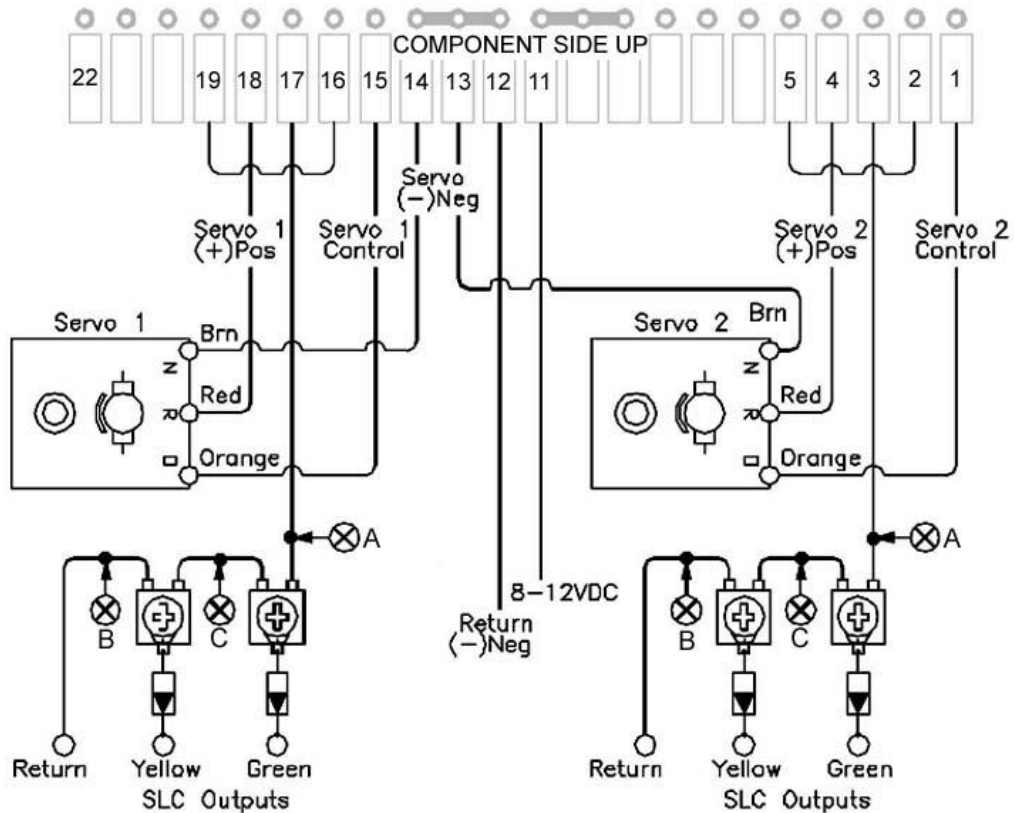
The pads are sized to accommodate a piece of scrap from a resistor. Barely... A single strand of small stranded wire may be used for ease of handling. It is a reference point only and has no current.

[] Install a jumper in the two pads to the right of Q-26 and to the left of the capacitor negative lead. See illustration...



(Same illustration as above)

External Connections



Power Supply; 8-12 volts **D-C is required** with this circuit. Power may be derived from an external supply, or if used with an SLC system, (+) may be taken from SLC-3 and (-) from SLC-13. The SLC power supply must then be **D-C** of sufficient capacity to accommodate the extra load. These devices are mechanical in nature and require more power than lamps or LEDs. Insufficient power will cause erratic operation of the servos.

Pair up two units of two(2) trimmer resistors in series. These will be the position adjustments for the servo mechanism. One lead of each will be connected to the negative power supply. It may be connected at the SV board or the SLC if used.

The other lead will connect to Pin 3 or 17 respectively. Use sufficient wire length to locate the trimmers in a conveniently accessible location. The references (A - C) will be explained later.

The center pin(wiper) of each trimmer is the control lead. The circuit illustrates diodes attached here. They permit the use of the servo in tandem with other devices from an SLC.

The diodes connect with the ANODE to the resistor. The BANDED end is toward the external control. When the diode is grounded, the servo moves to the appropriate position. For signalling, this “ground” is provided by the output of the SLC card. The diode prevents signal lamps from interfering with the control inputs.

For other “stand alone” use, a switch or relay contact may be used. In such an installation, the diodes are not required and may be omitted.

An edge connector is highly recommended with this board. Pads are provided for “hard wiring” should that be the preferred method. The pad above each edge connector finger is integral to the finger.

- [] Install a jumper between Pin 16 and 19.
- [] Install a jumper between Pin 2 and 5.

For signal purposes, these jumpers may be installed on the circuit board. An external control contact can be inserted here for some applications of the servo.

Servo Connections

The servos have three leads in a ribbon cable. Remove the connector and splice on suitable length wires to reach the controller from each signal location. Wire colours need not match the ribbon cable, but it **is highly recommended** that each lead be of a different colour.

Modern servos, those made within the last thirty odd years, have standardized wiring. The center lead is (+) power. Should the two outer leads be reversed, the servo and controller will not be damaged; they merely won't operate. The servos supplied with this kit meet that standard.

- [] For Servo(1), Red (center) is +V, Pin 18. Brown(-return) is Pin 14. Orange (control) is Pin 15.
- [] For Servo(2), Red is to Pin 3, Brown is to Pin 13, Orange is to Pin 1.

Initial testing

Inspect the board for solder bridges and that all leads are soldered. If a digital volt meter is available, the work may be tested when applying 8-12 volts at Pin 11 and Ground(or negative) at Pin 12.

For the first few cycles, the servo should not be connected to the mechanism it is to operate. This allows for mechanical alignment of the torque arm and coarse adjustment of the stroke length.

At the top of the diode at Q-21, measure the voltage to ground, Pin 12-14. The top of the diode should read +5 volts. The bottom of the diode is available at pin 18 and should measure on the order of +4.2 volts. A little above or below can be considered normal provided it is less than 5 volts. The same measurement may be taken at Pin 4 for the other diode.

The "Control" output lead to the servo consists of a pulse train with relatively low duty cycle. It can be measurable with an "A-C" meter, and is of low amplitude. The actual value will be dependant on meter. Of concern only is that the pulse train exists.

When power is applied, the servos will move to some extent. The position they stop is the "Home" position. As each diode is "grounded", the servo will move to its' position appropriate to that input. The absolute position may be adjusted with the trimmer. It is recommended the trimmers be adjusted approximately mid scale until the signal mechanism is connected.

Technical Notes and Pointers

There will be cases where a longer or shorter overall stroke is desirable. Depending on the mechanism, it may be desirable to extend the span between the control points. For such an adjustment, resistance on the order of 500 ohms may be added at reference points "A", "B", or "C". This also can serve to place the adjustments at near center for each position.

Resistance at reference "A" will reduce the overall stroke. Reference "B" will widen the span between "Yellow" and "Green". Reference "C" will widen the span between "Yellow" and "Home".

To change the span in the opposite direction, the resistor at location R-23 (or R-43) may be reduced to 1000 ohms. This is not a recommended modification but will serve the purpose. For operation, the resistance of R-23(or R-43) combined with the two trimmers **must not** be less than 5000 ohms nor greater than 8000 ohms.

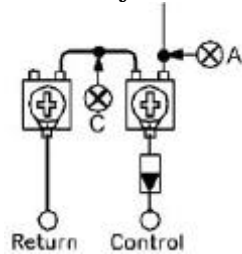
Excursion outside these limits may reference the servo beyond its' mechanical limits. This will be indicated by the servo vibrating or "buzzing" and continuous high current such that the regulator shuts down. If desired, an Ammeter may be used to measure the limits of travel for the servo and resistances adjusted accordingly. This also is not a recommended practice as continuous operation at the limits of travel will damage the servo.

There are many options available to this board. The servos supplied are designed for 6.0 volts. Testing has shown that the signal has a better appearance when the semaphore arm operates slower. Hence the 4 volt supply for the servo. If desired, a second regulator diode may be inserted in series with the one. This has the effect of slowing the servo considerably, but does incur the price of less torque. If the signal to be operated is mechanically free, insertion of a second diode will improve appearance. However, I can't promise it will work in every case.

The nature of R-C Servos is such that they operate in only one direction. Reversing polarity will only serve to damage the electronics in the servo case. If reverse operation is desired, the control inputs may be exchanged. Green position becomes Red and the grounded lead becomes the Green position.

Other Applications

The LBO-SV may be used for two position control. In such an installation, both positions are adjustable. With the two trimmers adjusted near their inner extremes, motion may be limited to a very few degrees.



For two position control, Reference (A) is the control input to the LBO board. The diode is omitted from the left hand trimmer RETURN and the wiper lead grounded. The servo will stroke between the positions set by the trimmers. Input will be by grounding the diode at CONTROL.

For a switch machine, the trimmers may be used as-is. For a crossing gate operator, resistance up to 1000 ohms may be added at reference (C) to lengthen the span of the stroke, if necessary.

The diode at CONTROL may be eliminated if there is no connection shared with other circuits.

Multiple servos may be connected in tandem, up to the current limit of the regulator. This would be convenient for applications such as switch machines at a cross-over.

Other Servos

The servos are available from Signal Aspect, of course. They are also readily available, at very reasonable cost, from suppliers to the R-C hobbies. Servos may be had with sufficient torque that they cannot be stalled by hand, with metal gears and roller bearings. All use the same control methods. Cost is proportional to size, quality of construction, and power.

Larger servos can be controlled with the LBO-SV but will require an external power supply proportional to the servo used. Make up the wiring as illustrated here but leave the power supply connection open.

Connect the negative lead of the LBO to the negative lead of the external 5 volt supply. Connect the servo power leads, (+) and (-), to the external supply. The control lead from the LBO-SV will control the servo position within the limits set by the control resistance.

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Crossing Gate Actuator Servo Option

Module Assembly

Assembly of the circuit board will require minimal soldering skills. If you already solder the wiring on your layout without melting insulation or cross-tie strips, you should have sufficient skill. But anything over a 40 watt iron is out. Sorry. . .

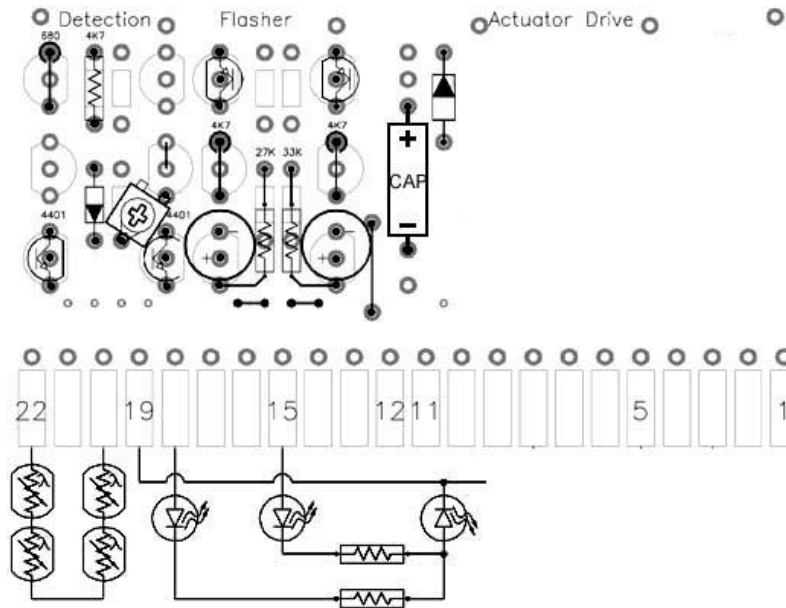
For the hobbyist that solders on a casual basis, may I recommend an essay on basic soldering that is included in the "Random Thoughts" section of this manual. Building my circuit boards doesn't require "Aero-Space" grade work, but there are limits to what the small components can take. Comments and recommendations on technique by an old hand in the electronics business may help you to improve your skills. Please understand, I cannot warrant boards where the foil traces have been burned off from overheating.

Recommended bench space is the hobbyist's typical two square feet. Equipment needed is: Soldering iron on the order of 20-30 watts. (my bench iron is 20W, the field iron 32W) Also, long nose pliers, small wire cutters, flush cut if available. A clip on heat sink is nice, the pliers may be used if you prefer. A jig to hold the board is optional but not necessary. I don't normally use one. Play-Doh® is sometimes used here. Use Rosin Core solder, do not use an acid based flux. An old toothbrush and denatured alcohol make for good flux removal.

For bench testing after assembly, you will want a power supply of 8-12V and couple of jumpers with small alligator clips. I use a 9 Volt "Wall Wart" for a testing supply. With the servos provided in the package, such a supply will be sufficient.

For the Servo version, there will be active components located off the board. This serves several purposes; primarily to position the adjustments so they will be readily accessible during alignment and routine maintenance.

Attachment of the actuators to the model is left as an exercise for the user. Most every model will require techniques specific to that piece. In addition, the physical mounting of the model will have a considerable influence on the mechanical linkages involved.



- [] Install 680 ohm (Blu-Sla-Bro) resistor from the top pad of Q-11 to the lower pad of Q-11. This is most readily accomplished by standing the resistor on end and folding the upper lead over.
- [] Install 4K7 (Yel-Vio-Red) resistor at location R-11.
- [] Install 1N914 diode at location R-13. Note the banded end is down.
- [] Install 4K7 (Yel-Vio-Red) resistor at locations Q-23 and Q-24, also in a vertical fashion.
- [] Install 27K (Red-Vio-Ora) resistor from the top pad of R-23 to the lower pad of Q-25.
- [] Install 33K (Ora-Ora-Ora) resistor from the top pad of R-24 to the lower pad of Q-26.

In both cases, leave the leads a little long as illustrated. There will be other components mounted closely in this area.

Using trimmings from the resistor leads, install jumpers at the following locations:

- [] Install jumper from the top pad of Q-14 to the middle pad of Q-14.
- [] Install jumper in the two unmarked pads immediately to the right of Q-26 per the illustration above.
- [] Install jumper in the leftmost two (small) pads below Q-25.
- [] Install jumper in the rightmost two (small) pads below Q-26.

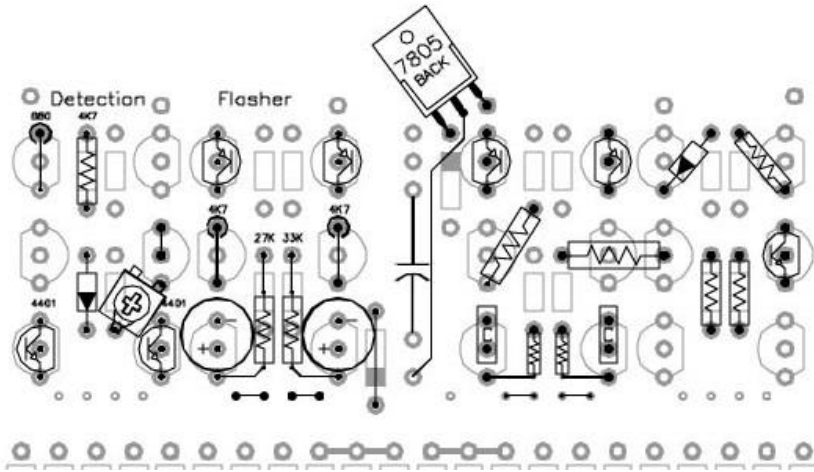
The latter two will be immediately below the two timing resistors.

- [] Install sensitivity adjust trimmer (the little square gizmo with three pins and a cross slot) between the lower pad of R-14 and the lower pad of Q-14. The third lead is not used and should be removed per the illustration. If the servo option is being assembled, there will be three pieces. The sensitivity adjuster will be 20K, marked (203). Servo trimmers are 2K0, marked (202).
- [] Install 2N4401 transistors (2) at locations Q-15 and Q-16. The flat face will be aligned with the screen printing; facing to the right.
- [] Install 2N4403 transistors (2) at locations Q-21 and Q-22. The flat face will be opposite the screen printing; facing to the left.
- [] Install timing capacitors (2 @ 47uF) at locations Q-25 and Q-26. Observe the polarity markings that the broad stripe for the negative end is toward the top of the board. The longer lead will be the positive side; it installs in the middle pad of Q-25 (or 26) with the negative lead in the top pad of the corresponding location.
- [] Install filter capacitor (value may vary) as illustrated. The capacitor will have a broad stripe indicating the negative lead. For capacitors with radial leads, the longer lead will be positive. The negative lead attaches to the second pad, just above the wire from the regulator. The positive lead connects to whichever of the three upper pads is most appropriate for the physical size.

At this point, the detection and flasher circuits are functional. If you want to see this portion in operation, install a diode as illustrated above, between the filter capacitor and Q-31. This diode will be removed after testing. Leave the leads a little long to make removal easier.

Connect Positive power at Pin 11 and Negative at Pin 12. Connect the external components as illustrated. The circuit will work with up to four photocels or as few as one. In ambient light, adjust the sensitivity until the lights just start to flash, then back off until they don't. The tighter this adjustment, the more sensitive the circuit. Covering the photocel will bring on the flasher.

Servo Controller



This will be the appearance of the finished board for servo use. Note the diode to the left of Q-31 is removed. The 7805 regulator IC is actually an after thought. It eliminates the need for a special power supply, allowing the use of nominal 8-12 volts D-C power. It also serves as an “overload” device to protect the servo and driver circuits should the servo linkage bind up or the servo operate near its’ mechanical limits.

It is **normal** for the tab to be **warm** to the touch. In an overload condition, the tab will get very hot and the regulator will reduce output to a low level. The 7805 regulator has an internal self resetting protection circuit. Reset by cycling power.

- [] Install 2K2 resistor from the lower pad of Q-42 to the upper pad of R-42.
- [] Install 2K2 resistor from the upper pad of R-34 to the center pad of Q-43.
- [] Install 2K2 resistor at location R-43.
- [] Install 2K2 resistor from the lower pad of R-33 to the lower pad of Q-35.
Leave the lower lead in an (L) shape to avoid the screen for Q-35 and the solder pads below R-33.
- [] Install 2K2 resistor from the lower pad of R-34 to the lower pad of Q-36.
Leave the lower lead in an (L) shape to avoid the screen for Q-36 and the solder pads below R-34.
- [] Install 33K resistor from the lower pad of Q-33 to the lower pad of R-31.
- [] Install 680 resistor at location R-44. Solder and trim leads.

- [] Install 2N4403 transistors(2) at locations Q-31, 32.
Take note that these transistors install opposite the screen printing, with the flat face to the left.

- [] Install 2N4401 transistor at location Q-44.
Take note that this transistor installs opposite the screen printing, with the flat face to the right. Solder and trim leads

- [] Install 1N4406 diode from the upper pad of R-41 to the lower pad of Q-41. Take care to install the banded end (cathode) at Q-41. Make the leads long enough to stand the diode off the board to about the same height as the transistors. Solder and trim leads.

There may be a second diode installed here later, at the discretion of the user. The leads may be left long to facilitate this as will be explained in the instructions for alignment. The diode has heavy leads and is mounted at an angle to provide the heavy leads sufficient room to bend properly.

- [] Install 0.47uF capacitors(2) at location Q-35,36. The capacitor leads must be offset inward slightly span the upper and center pads at each location. Solder and trim leads.

- [] Install 7805 Regulator I.C. thusly: Holding the TO-220 case so that the heat sink tab is up and the lettering is readable, bend the center tab back at a 90 deg angle. The bend should be 1/10 inch from the plastic case.

There is a solder pad just above the screen printing for Q-31. And another to the immediate left. Insert the 7805 in the single pad above Q-31 and the single pad to the left of Q-31. The spacing is correct for this component. The center tab should extend above Q-31.

Fold the 7805 to the front so it is facing the board and the center tab is vertical. Leave a minimum of a quarter inch air space between the heat sink and the board. Refer to the illustration above for orientation. The heat sink extends beyond the edge of the board intentionally.

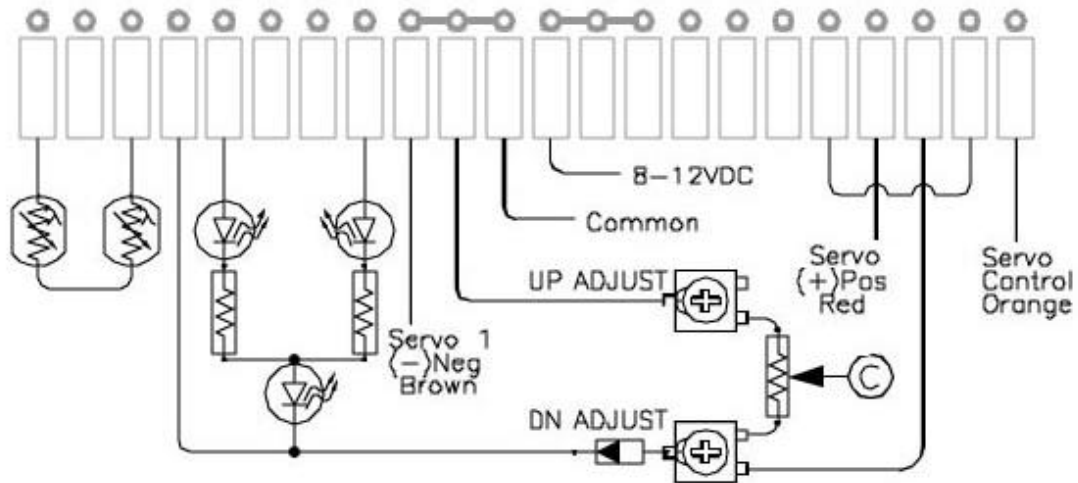
Route a short wire from the center tab of the 7805 to the lower of two pads at the bottom of the board, as shown in the illustration.

- [] Install two(2) jumpers as follows:

Below Q-35,36 is a row of four(4) pads. The left two and the right two are to be jumpered as pairs. Refer to the illustration; this will be the same as the jumpers below Q-25,26.

The pads are sized to accommodate a piece of scrap from a resistor. Barely... A single strand of small stranded wire may be used to ease handling. It is a reference point only and has no current.

External Connections



Power Supply; 8-12 volts **D-C is required** with this circuit. Power may be derived from a dedicated supply or from an existing D-C auxiliary or accessory source.

Pair up two(2) trimmer resistors in series. These will be marked (202) The sensitivity adjust trimmer is marked (203) This will be the position adjustment for the servo mechanism. One lead will be connected to the negative power supply at Pin 13.

The other lead will connect to Pin 3. Use sufficient wire length to locate the trimmers in a conveniently accessible location. The resistor at location (C) is optional and will be explained below.

The diode connects with the ANODE to the resistor. The BANDED end is toward the external control. When the diode is grounded, the servo moves to the appropriate position.

An edge connector is highly recommended with this version. Pads are provided for "hard wiring" should that be the preferred method. The pad above each edge connector finger is integral to the finger.

- [] Install a jumper from Pin 2 to Pin 5. This connection may be made on the circuit board at the edge connector pads if a plug in edge connector is not used.

Servo Connections

The servo has three leads in a ribbon cable. Remove the connector and add on suitable length wires to reach the controller from the actual gate installation. Wire colours need not match the ribbon cable, but it **is recommended** that each lead be of a different colour.

Modern servos, those made within the last thirty odd years, have standardized wiring. The center lead is (+) power. Should the two outer leads be reversed, the servo and controller will not be damaged; they merely won't work. The servo supplied with this kit meets that standard.

[] Servo wiring; Red is to Pin 4, Brown is to Pin 13, Orange is to Pin 1.

Initial testing

Inspect the board for solder bridges and that all leads are soldered. If a digital volt meter is available, the work may be tested when applying 8-12 volts at Pin 11 and Ground(or negative) at Pin 12.

For the first few cycles, the servo should not be connected to the mechanism it is to operate. This allows for mechanical alignment of the torque arm and coarse adjustment of the stroke length.

At the top of the diode at Q-41, measure the voltage to ground, Pin 12-14. The top of the diode should read +5 volts. The bottom of the diode is available at pin 4 and should measure on the order of +4.2 volts. A little above or below can be considered normal so long as it is no more than 4.5 volts.

The "Control" output signal to the servo consists of a pulse train with relatively low duty cycle. It can be measurable with an "A-C" meter, but is of low RMS value. The actual value will depend somewhat on the meter. Of concern is only that the pulse train exists.

When power is applied, the servo may move to some extent. The position it stops is the "Home" or "Up" position. It is recommended the "UP" adjust be set at mid-span and the mechanism be attached accordingly. When the diode is "grounded", the servo will move to its' "Down" position. The final "trim" adjustment may be made following installation on the layout.

When the board is installed and the gate mechanism “in place”, apply power. The “UP” position may be fine tuned at this point with the “UP” trimmer resistor.

The photocel detection may now be activated and the “DOWN” position fine tuned with the “DN” trimmer.

Technical Notes and Pointers

There will be cases where a longer or shorter overall stroke is desirable. Depending on the mechanism, it may be desirable to extend the span between the control points. For such an adjustment, resistance on the order of 500-1000 ohms may be added at reference point “C”.

To change the span in the opposite direction, the resistor at location R-43 may be reduced to 1000 ohms. This is not a recommended modification but will serve the purpose. In operation, the resistance of R-43 combined with the two trimmers **must be** minimum 5000 ohms and no greater than 8000 ohms.

Excursion beyond these limits may reference the servo beyond its’ mechanical limits. This will be indicated by the servo vibrating or “buzzing” and continuous high current such that the regulator shuts down. If desired, an Ammeter may be used to measure the limits of travel for the servo and resistances adjusted accordingly. This also is not a recommended practice as continuous operation near the limits of travel may damage the servo.

There are many options available to this board. The servo supplied is designed for 6.0 volts. Testing has shown that the gate has a better appearance when the arm operates slower. Hence the 4 volt supply for the servo. If desired, a second regulator diode may be inserted in series with the one at location Q-41. This has the effect of slowing the servo considerably, but does incur the price of lower torque. If the gate to be operated is mechanically free, insertion of a second diode will improve appearance. However, I can’t promise it will work in every case.

The nature of R-C Servos is such that they operate in only one direction. Reversing polarity will only serve to damage the electronics in the servo case. The linkage must be re-arranged to physically mount the servo in reverse orientation.