

PWM Circuit for MC-2100 Motor Controller Board

For those interested in getting an MC-2100 motor controller board working, I offer this writeup on my experiences and the process I used to get it working. I cannot claim that the final design of the circuit is all of my invention but rather it is an accumulation of research I did and the assistance I received from others. I have provided references throughout and at the end of this document for those wanting to do further research but I have offered the required information here such that you can accomplish the same end result without the need to go elsewhere. I also provide the basics so that hopefully even a new person to electronics can complete this.

I received a lot of assistance from **schoolie** at the Sons of Invention blog (<http://sonsofinvention.wordpress.com/>) through this entire process. He has his own original design of a PWM circuit which I reviewed and took inspiration from. Check it out and the other projects he is working on.

Now, lets get on with it..

I received an MC-2100 board (Figure 1) from a friend who wanted to control the motor on his lathe. He also provided me with the circuit (Appendix B) which was obtained from elsewhere on the internet. Seeing that the circuit contained a 556 dual timer I thought 'how difficult could this be?'. Obtaining the specs of the board (Appendix A) is what I began with.



Figure 1 : MC-2100 Motor Controller Board

PWM Circuit for MC-2100 Motor Controller Board

The specs state that the board requires a 5VDC variable pulse width signal on the blue wire of the HD2 connector. It also states that a voltage source ranging from 9VDC to 12VDC is available on the same connector via the red wire. The reason for the variance in the voltage source is due to different revisions of the board; the board I was using ended up with a 9VDC value.

With this in mind it is not difficult to see that with the circuit, a 9VDC source and the knowledge that the 555 timer outputs the same voltage level for its highs as it receives from the source power (in this case 9V), the circuit would be supplying a signal to the blue wire with its highs reaching 9V while the MC-2100 is expecting 5V. So, immediately I felt I had to add in a voltage regulator (7805) to bring down the 9 volts to 5 volts. Simple enough.

For those of you new to voltage regulators, check this out: http://www.youtube.com/watch?v=GSzVs7_aW-Y

The MC-2100 board I used differs from a number of board layouts I have found on the internet but ended up working the same. My board appears to be a newer version as it includes a number of surface mount components instead of thru hole components. The model # of this board is MC2100LTS-50W REV B as you may see in the picture. The connector on this board to which the PWM signal needs to be connected is labeled as HD3 instead of HD2 on other layouts.

I was lucky enough to already have a treadmill allowing me to easily disconnect all connections to its board and attach to the MC-2100. In order to work completely and properly a load needed to be attached to the motor terminals on the MC-2100 as **schoolie** noticed. If you don't have a motor, then a resistor could be added across the motor terminals as he states. My guess is that it needs to be of a sufficient wattage rating otherwise you may fry it. I don't know what that may be since I never tried it. Check out **schoolie's** blog for some direction.

Since I didn't have a 556 chip I chose to use two separate 555s since that is what I did have. Now, the specs state that the on board LED will blink when the proper frequency is received on the blue wire. As many people have found this can vary from 40 ms to 50+ ms and each board can be slightly different. Which makes sense due to tolerances on individual components.

From here you should refer to my final circuit in Figure 4. In the circuit, the frequency is adjusted with the first 555 timer (IC1) as it is configured as an astable multivibrator as determined by the values of C1, R1, R2 and R3. The output of this is fed into the second 555 timer (IC2) which acts as a monostable multivibrator. The 10k trimmer pot (R2) offers a fine adjustment such that the proper frequency can be found easily enough. A regular linear pot could be used initially if you don't have a trimmer but you can't get the precise settings and could easily run past the required resistance and essentially get frustrated. Trust me, that is one of the mistakes I made.

There is plenty of information on the internet to assist with both astable & monostable circuits using the 555 timer.

The formula for the astable circuit is as follows to calculate the total period of the signal:

$$T = 0.693 \times (R1 + R2 + 2 \times R3) \times C1$$

Using the values from my circuit the total period range works out to:

$$\begin{aligned} T &= 0.693 \times (27k + 0k + 2 \times 1k) \times 2.2\mu F \\ &= 44ms \end{aligned}$$

$$\begin{aligned} T &= 0.693 \times (27k + 10k + 2 \times 1k) \times 2.2\mu F \\ &= 59ms \end{aligned}$$

PWM Circuit for MC-2100 Motor Controller Board

With a fairly small value for R3 the low pulse will be very short compared to the duration of the high level. The negative going pulse is what triggers the monostable multivibrator.

To calculate the pulse width:

$$T_{\text{pulse}} = 1.1 \times (R4 + R5) \times (C2a + C2b + C2c)$$

So, in my case this works out to:

$$\begin{aligned} T_{\text{pulse_min}} &= 1.1 \times (22\text{k} + 0\text{k}) \times 0.3\mu\text{F} \\ &= 7\text{ms} \end{aligned}$$

$$\begin{aligned} T_{\text{pulse_max}} &= 1.1 \times (22\text{k} + 100\text{k}) \times 0.3\mu\text{F} \\ &= 40\text{ms} \end{aligned}$$

The longer the pulse, the faster the motor will go.

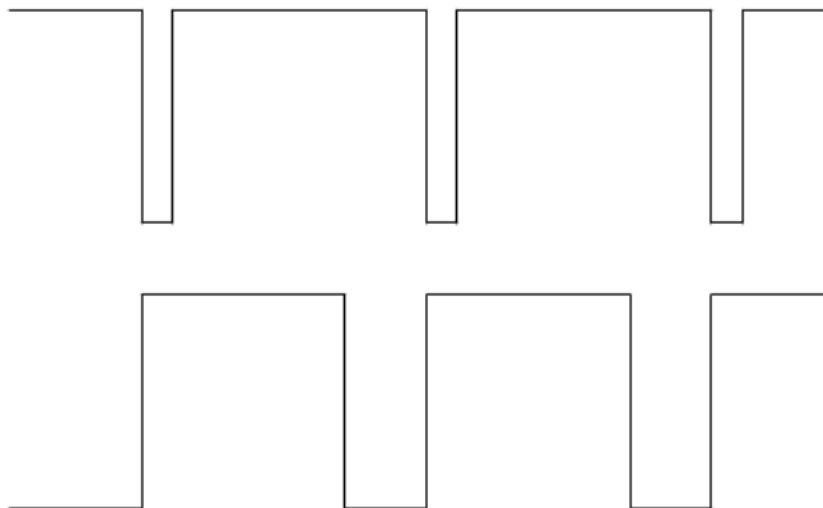


Figure 2 : Expected signals from each 555 (not to scale)

This figure shows what we are looking for from each stage of the circuit. The top is the output from the first stage (astable) while the bottom is from the second stage (monostable). As you can see, when the astable pulse goes negative the monostable pulse goes positive for its calculated pulse width duration.

At this point some may ask, "Why the need for two stages of output? Looks like the pulse can be varied using the first stage only." Well, yes and no, and indeed that is one question I asked myself as well. Certainly the astable circuit can be designed to provide the required pulse at a specific frequency. However, a single 555 timer cannot have the pulse width altered without the frequency also changing. Thus, with this two stage design the first stage is the basis of the frequency required while the second stage provides the variable pulse.

PWM Circuit for MC-2100 Motor Controller Board

So, with my first prototype laid out on a breadboard I proceeded to do some testing. I initially started testing using only a simple multimeter (analog to boot!!!) and a small DC motor to determine voltage levels and see if the motor would in fact vary in speed. It showed me some of the results I was looking for but I wasn't satisfied. When the circuit was attached to the treadmill I could get it working...some of the time. I thought there was something wrong with the timing of the first stage and spent a great deal of time switching out resistors in the astable circuit. I also noticed that my voltage regulator was getting very hot to the touch...which did not make any sense on such a small circuit.

After weeks of frustration and "blind" testing with the analog voltmeter and the treadmill I finally managed to obtain an oscilloscope to check out the signal. What I found is that when the PWM circuit is connected to the MC-2100 the output from the monostable was greatly affected in voltage level. All looked fine with the signals from the PWM circuit when on the bench and disconnected from the MC-2100. At this time I went back to the original circuit (Appendix B) and wondered why a voltage regulator was not used in this case. I thought there may have been something I was missing about the MC-2100 since the author of that circuit did not mention any requirement to bring the source voltage down. So, I removed the voltage regulator from my circuit and re-attached it to the MC-2100. Things started to work better...until I started to smell smoke. Quickly removing power I found I had burnt out a resistor which I found to be labeled R2 in the MC-2100.

With that little set-back I figured I needed to investigate how the MC-2100 worked. Specifically, where the PWM is connected to the MC-2100. Once again **schoolie** was of assistance and provided a schematic of a version of the MC-2100 (Appendix C). Although not exactly my version it was close enough. Figure 3 shows the section I was specifically interested in. What I found is that the blue wire of the MC-2100 has a 22 ohm resistor and an opto-isolator to ground. This was a good design because it isolated external circuits and reduces the amount of potential damage. Which was the case for me because it only burned out the 22 ohm resistor. With **schoolie's** assistance we found that the MC-2100 specs are not exactly right. Although it was expecting a pulse on the blue wire, which in turn will get the motor running, the problem is the voltage level; 5V volts directly applied is certainly too high. The opto-isolator has a 1.2 constant voltage drop across it. So, that would mean the current through the 22 ohm resistor would be $(5V - 1.2V) / 22 \text{ ohms} = 172\text{mA}$. Way too much for the maximum rating of 50mA of the opto-isolator. So, this implies that an additional resistor from the PWM circuit would probably be a good idea.

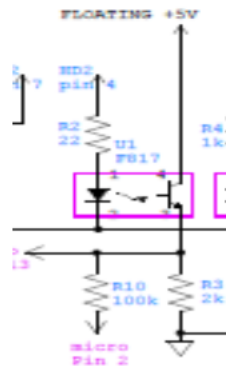


Figure 3 : What the PWM signal feeds into on the MC-2100

And indeed while I was researching opto-isolators, **schoolie** proceeded to take a closer look at the control panel from a treadmill. I believe we came to the same conclusion at the same time. My research showed the need for a resistor in testing an opto-isolator (Appendix D) while he found that there was a 240 ohm resistor in the control panel going to the MC-2100 blue wire. Using this value with the existing 22 ohm for a total resistance of 262 ohms, the current then works out to: $(5V - 1.2V) / 262 \text{ ohms} = 14 \text{ mA}$...certainly much better. Using this **schoolie** suggested that I could increase the value of the resistor and completely remove the voltage regulator. I liked this idea as I originally thought it was overkill for such a small circuit and much needed real estate was desired on the prototype board. So, I went with a 680 ohm resistor which also cleared up the overheating issues...Bonus!!!

PWM Circuit for MC-2100 Motor Controller Board

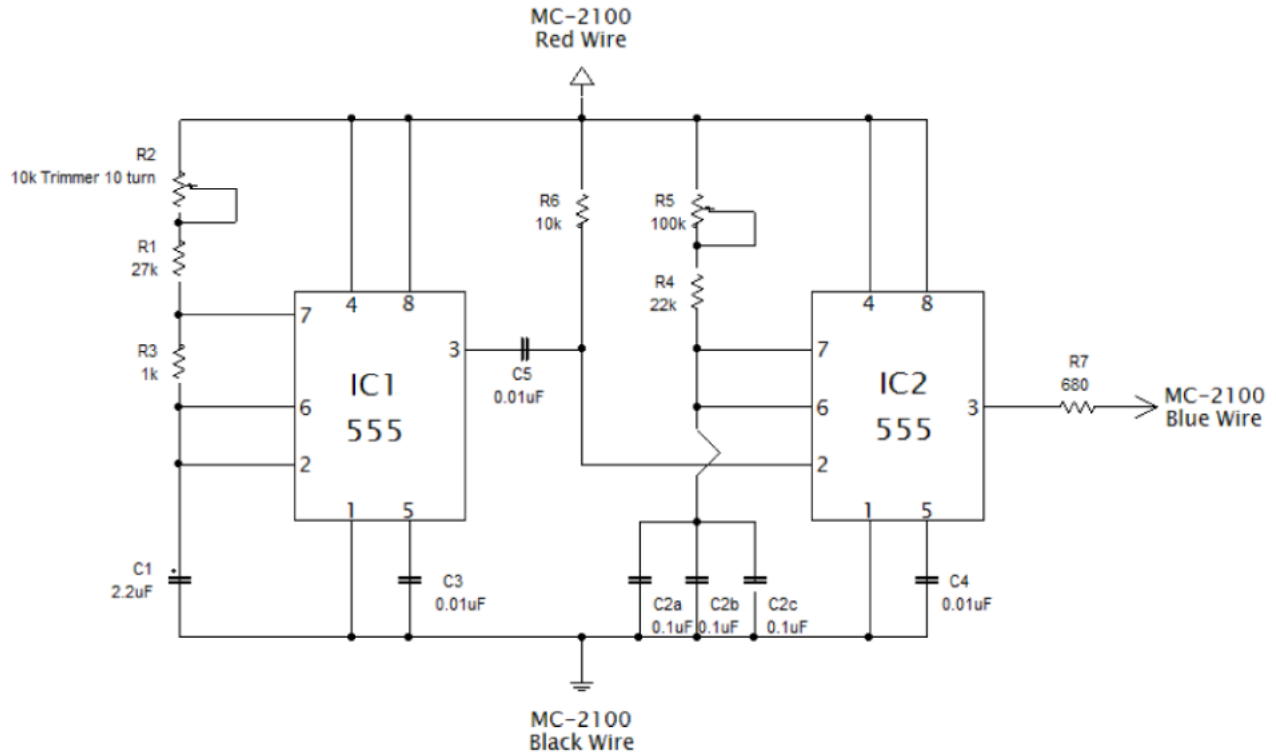


Figure 4 : My final working circuit

Figure 4 shows my final circuit. You may notice that I have three capacitors (C2a, C2b, C2c) in parallel and wonder why. Simply put, that is what I had in hand to get to the 0.3uF value I wanted. As you know capacitors in parallel can be added together.

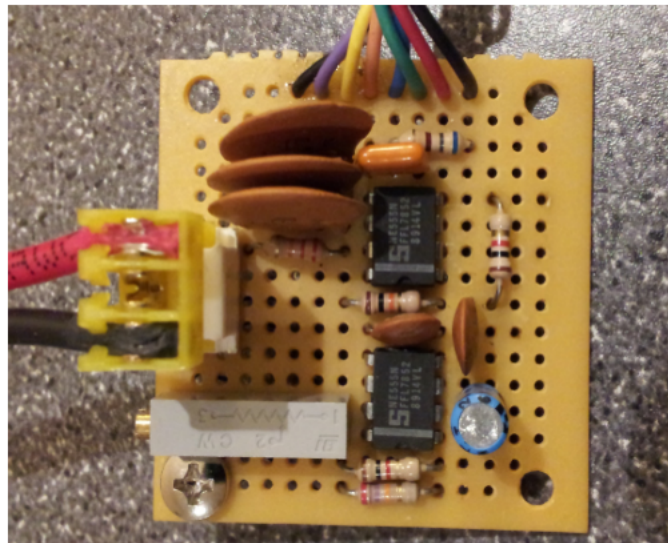


Figure 5 : My final design on prototype board

PWM Circuit for MC-2100 Motor Controller Board

Final Conclusions & Thoughts

Anyone trying to do the same thing may find the circuit I used a choice for them. For the most part I think all the components would probably be identical except for R1 which may vary with the board you may use. The frequency on the circuit I used worked out to be at the upper bounds of 59 ms.

During my final testing as I was trying to figure out my optimal R1 value, I stumbled across different timing that worked as well. I found that a pulse at close to 180ms worked as well as one around 60ms. Don't know exactly why but I can only think because 180 is a multiple of 60. So, possibly a value near 120ms would also work. I don't think this provides any real advantage as the higher pulses require larger value resistors, however, I just thought it was interesting enough to mention.

I didn't have issues while I was testing but when my friend finally attached it to his lathe he found that after powering down the equipment the motor did not start up again when power was reapplied. He found that the MC-2100 was used to a 'user input' from a treadmill and was designed as a safety precaution so that it was not restarted at full speed. Including a switch in line with the R5 pot fixed the issue.

As a final note, I found out that for those looking for a simpler solution, apparently some boards such as the MC-60 only requires a external potentiometer to be attached in order to control a motor.

References and further research:

Sons of Invention

www.sonsofinvention.wordpress.com : **schoolie** has board layout and specs, his own circuit design as well as a schematic of the MC-2100.

Voltage Regulators: http://www.youtube.com/watch?v=GSzVs7_aW-Y

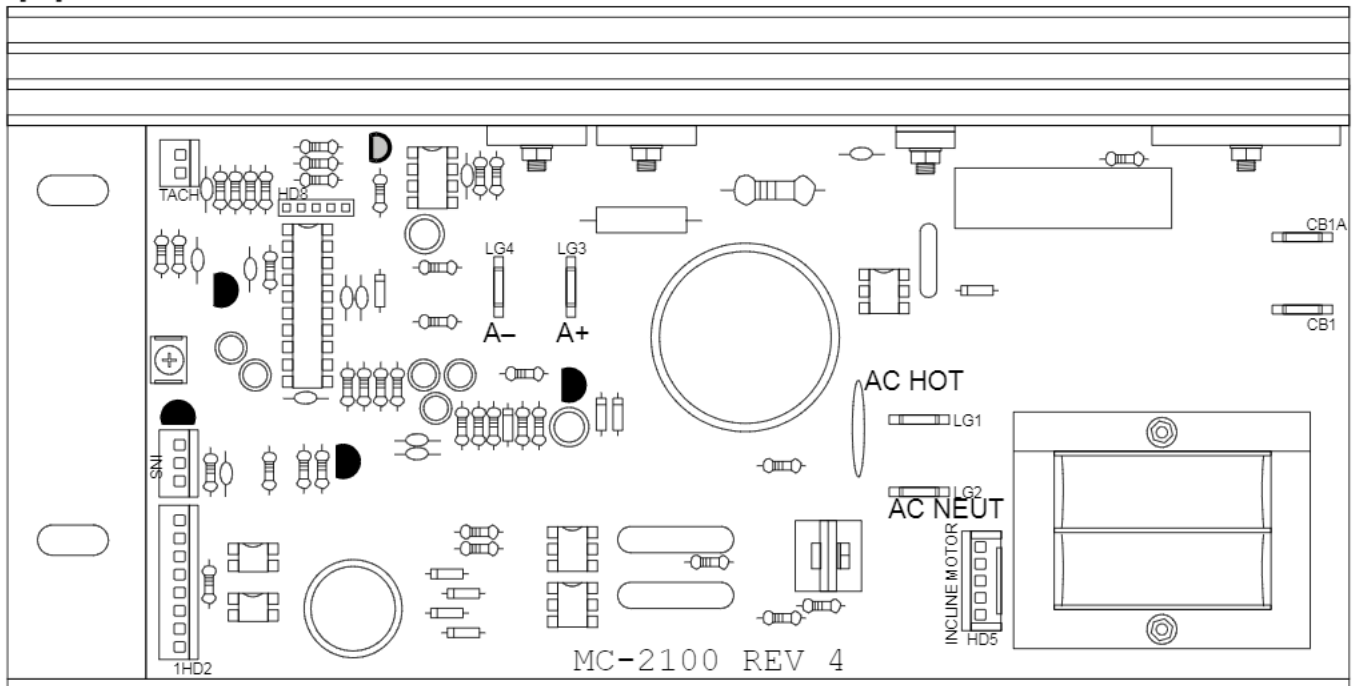
The following last sheets show some reference material I mentioned throughout my write-up which the reader may also find worth value. It includes the MC-2100 board layout and specs, the initial circuit I started with, a schematic I reference to isolate the requirement for an additional output resistor as well as a primer on testing opto-isolators.

That is it. Hopefully others will find this document helpful with their own motor controller board, MC-2100 or other. Feel free to contact me directly should you have any questions or find any errors.

Thank you.

Terry
tvd12000@gmail.com

Appendix A



MC-2100/MC-2100E Motor Controller

The MC-2100 combines a PWM motor controller with a power board. It is designed to replace the combination of an MC-60 or MC-2000 with a PB-12i (or other) power board. The controller uses the same eight wire harness that has been used on Icon treadmills for the past several years. The wire colors and voltage signals are identical. A European version, the MC-2100E, functions identically, except the input voltage is 230 VAC 50 Hz. A specialized version of the MC-2100E, the MC-2100ENI, does not include any incline circuitry. Only the first four wires in the wire harness connect it to the console.

One difference between the MC-2100 and earlier controllers is that the on/off circuit breaker has its own connection directly on the board. On some MC-2100's, the switch will be hard-mounted directly on the circuit board. These controllers will mount directly to the belly pan. Other MC-2100's will have two spade connectors allowing the on/off circuit breaker to be mounted in another location. The switch is then connected to the controller with two jumper wires.

The MC-2100 has its own processor and software, which allows it to communicate with the console. This is done by a small digital signal carried by the GREEN tach wire. By entering calibration mode on the console, two alternate screens can be accessed which give information on the controller, including the status of the troubleshooting LED, motor voltage, and motor amperage. This greatly increases the amount of troubleshooting that can be done without removing the treadmill's motor hood.

Some MC-2100 controllers will have the transformer mounted on the circuit board as shown above. Other versions will have a larger transformer mounted directly to the treadmill frame with jumper wires connecting it to the controller. This allows a higher amp draw from consoles with many LEDs/LCDs. All MC-2100E controllers will have a separate transformer.

Controller Voltages

CB1, CB1A- These connections are for the two terminals of the on/off circuit breaker. The on/off breaker may be soldered directly onto the circuit board or attached by wires. When soldered, the incoming AC Hot wire (BLACK) will be routed through the thermal switch on the drive motor. When attached by wires, one wire will be routed through the thermal switch. 120 VAC will be measured across the open switch when power is applied. 0 VAC will be measured when the switch is closed. *NOTE: These connections are not present on the MC-2100E.*

LG1- Labeled AC HOT, this spade connector receives the incoming 120 VAC (BLACK) from the power cord (or BLUE from the thermal switch if the on/off circuit breaker is hardwired to the MC-2100). This voltage will be present whenever the treadmill is plugged in.

LG2- Labeled AC NEUT, this spade connector is where the AC Common (WHITE) wire is attached from the power cord.

LG3- Labeled A+, this terminal is the positive connection for the RED drive motor wire. Voltage between this connection and LG4 will measure 0 VDC when the treadmill is at rest to approximately 100 VDC when the treadmill is running at full speed.

- LG4- Labeled A-, this connection is for the BLACK drive motor wire. This is the negative terminal for the motor wires
- HD2- This eight wire connection attaches the controller to the console. Each wire carries the following voltage signal:
- BLACK- (Two wires) These are the ground wires for the console. All other voltages taken on the 8-wire harness are in reference to either of these wires. *Note: On the MC-2100SDI, the second Black wire (the one next to Violet) carries a very small pulsing voltage the console monitors to count the number of steps taken by the user.*
 - RED- This wire supplies the console with 9 VDC.
 - GREEN- This wire brings the speed sensor signal to the console. This is a pulsing 0, 5 VDC signal as the treadmill is running. When the treadmill is at rest, this voltage may measure either 0 VDC or 5 VDC.
 - BLUE- This wire carries the square wave speed control signal from the console to the power board. The duty cycle of this 5 VDC signal is used to set the speed of the treadmill. At the maximum duty cycle of 85% (meaning the 5 VDC is being sent 85% of the time and not being sent 15% of the time), approximately 4 VDC can be measured. At lower speeds, a lower voltage will be measured. *NOTE: Many digital multimeters have difficulty measuring this square wave signal. They may only show a maximum of 1.5 VDC when the treadmill is set to its maximum speed. What is important to see in this instance is that the voltage goes up as the treadmill speed is increased.*
 - ORANGE- This wire carries a 3.5–5 VDC signal to the power board to cause the power board to send 120 VAC to the incline motor to increase the incline setting of the treadmill. This voltage should only be present when the incline is being increased.
 - YELLOW- This wire carries a 3.5–5 VDC signal to the power board to cause the power board to send 120 VAC to the incline motor to decrease the incline setting of the treadmill. This voltage should only be present when the incline is being decreased.
 - VIOLET- This wire carries the incline sensor signal to the console This is a pulsing 0, 5 VDC signal as the incline is moving. When the incline is at rest, this voltage may measure either 0 VDC or 5 VDC.
- HD5- This connection is for the incline motor wire harness. The RED (down) and BLACK (up) wires are separated by a WHITE (AC Common) wire. When an *Incline* button is pressed on the console, the controller receives the incline signal and sends 120 VAC to the incline motor to turn it in the appropriate direction.
- TACH- This connection is for the reed switch wire. This allows the tach signal to be received by the controller and passed to the console wire harness, where it is sent up the GREEN wire. Voltage is a pulsing 5 VDC when the treadmill is running. When the treadmill is at rest, this voltage may be 0 VDC or 5 VDC, depending on the whether the magnet is closing the reed switch or not.
- INS- This connection is for the incline sensor. While it will usually be a reed switch, an optic switch can also be connected. 5 VDC will be present across the open switch. Whenever the switch closes, 0 VDC will be measured. As the incline motor turns, this voltage will pulse on and off. The number of pulses is used by the console to determine how far it has changed the incline. When the incline is at rest, this voltage may measure 0 VDC or 5 VDC, depending on the position of the switch in relation to the magnet (or optic disk).

Troubleshooting LED

The MC-2100 has a single troubleshooting LED. Unlike earlier motor controllers, which had several LEDs monitoring different conditions, the MC-2100's LED can give multiple signals. Each LED state and its meaning is given below:

- OFF- The controller is NOT receiving AC voltage
- ON (Solid)- The controller is receiving AC voltage, but is not receiving a speed signal.
- ON (Blinking rapidly)- The controller is receiving a PWM signal and is sending voltage to the drive motor (A+ and A-).
- ON (Blinking on and off once per second)- The controller is operating near its current limit. This indicates the controller is working harder than it should to maintain treadmill speed. Check for friction problems between the board and belt, an over tightened belt, or check the roller bearings.
- ON (Blinking VERY slowly, on one second, off one second)- The controller has entered its 'fold-back' mode. This means the controller is working as hard as it can to turn the drive motor without success. It then 'folds back,' or reduces, the voltage and amp draw of the drive motor to prevent overheating.

The state of the troubleshooting LED is also shown on the treadmill console when in calibration mode. To view this information, enter calibration mode by inserting the safety key while holding the *Stop* and *Speed* ▲ buttons. Release the buttons, and then press *Stop* four times to advance to level 5 of calibration mode. Press and hold the two *Speed* buttons for two seconds to display the alternate calibration screen. The Speed window will now display the status of the LED. This is given as a numerical value:

- 0- The controller is not running (idle state)

- 1- Controller is in the RESET state. The drive motor will not be running. *Equivalent to +12V lighting on the MC-60.*
- 2- The high voltage buss is charged.
- 4- The high voltage buss is charging.
- 6- The high voltage buss is charged and the unit is running. *Equivalent to SPD CNTL and SCR TRIG lighting on the MC-60.*
- 14- Current Limit is active. *Equivalent to CUR LIM lighting on the MC-60.*
- 30- Controller is in fold-back. To prevent overheating, if the controller remains near its current limit for an extended time, it will reduce, or 'fold back,' the amount of current allowed. The controller will return to normal operating levels once the high current condition is corrected.

Appendix B

One of the most crucial drawbacks of the 555 astable multivibrator is that the generated frequency and the duty cycle are interdependent. When you change one, the other changes too. Usually manual control is set up through a variable resistance, because wide-range variable capacitors are expensive and hard to find. Unfortunately, the same resistances in the circuit control both the output frequency and the duty cycle of the generated waveform.

The circuit shown in Fig. 3-10 shows a neat way around this problem, using both sections of a 556 dual-timer IC. The first stage is an astable multivibrator with a manually variable frequency through potentiometer R2. The value of resistor R3 is relatively small, so the duty

Adjust R2 until the desired frequency is achieved. (note: this is when the red led on the Mc-2100 begins to flash. Try to turn to the mid point between where the led does flash. Once the frequency is set you should not need to adjust again. Some forums indicate this board operates at 51ms. I found my board operates at a calculated value of 43ms.

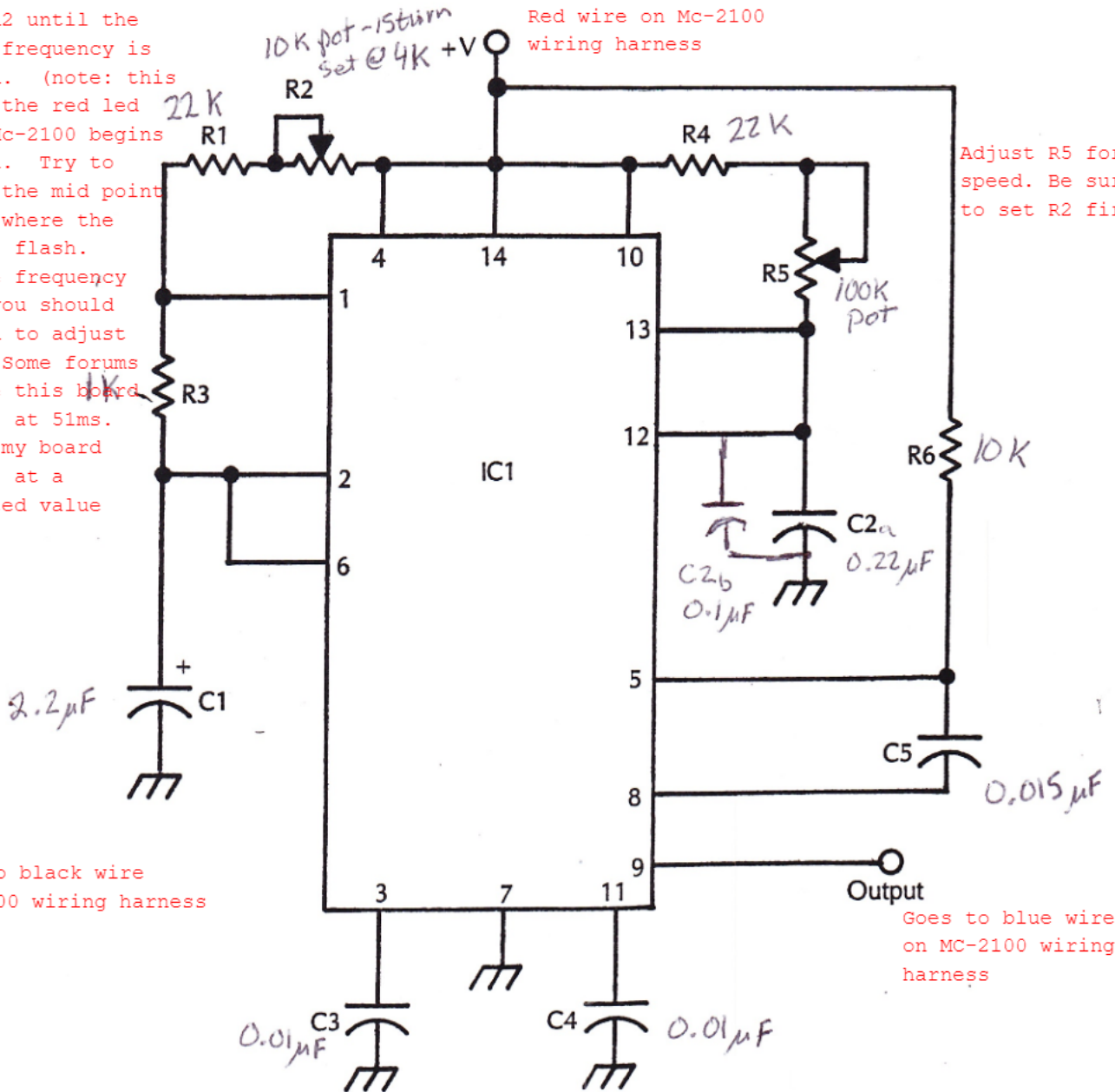


Fig. 3-10 Project 16: Variable-frequency/variable-duty-cycle rectangle-wave generator.

Astable Multivibrator - first half of 556 dual timer

$$T(\text{frequency}) = \frac{1}{0.693 \times C1 \times (Ra + 2R3)}$$

Working Scenario

Factor		0.693
C1	2.2 μF	0.0000022
R1	22 k	22,000
R2	10 k pot	4,000
Ra = R1+R2		26,000
R3	1.0k	1000
Frequency =		23.43
Milliseconds =		42.69

Monostable Multivibrator - second half of 556 dual timer

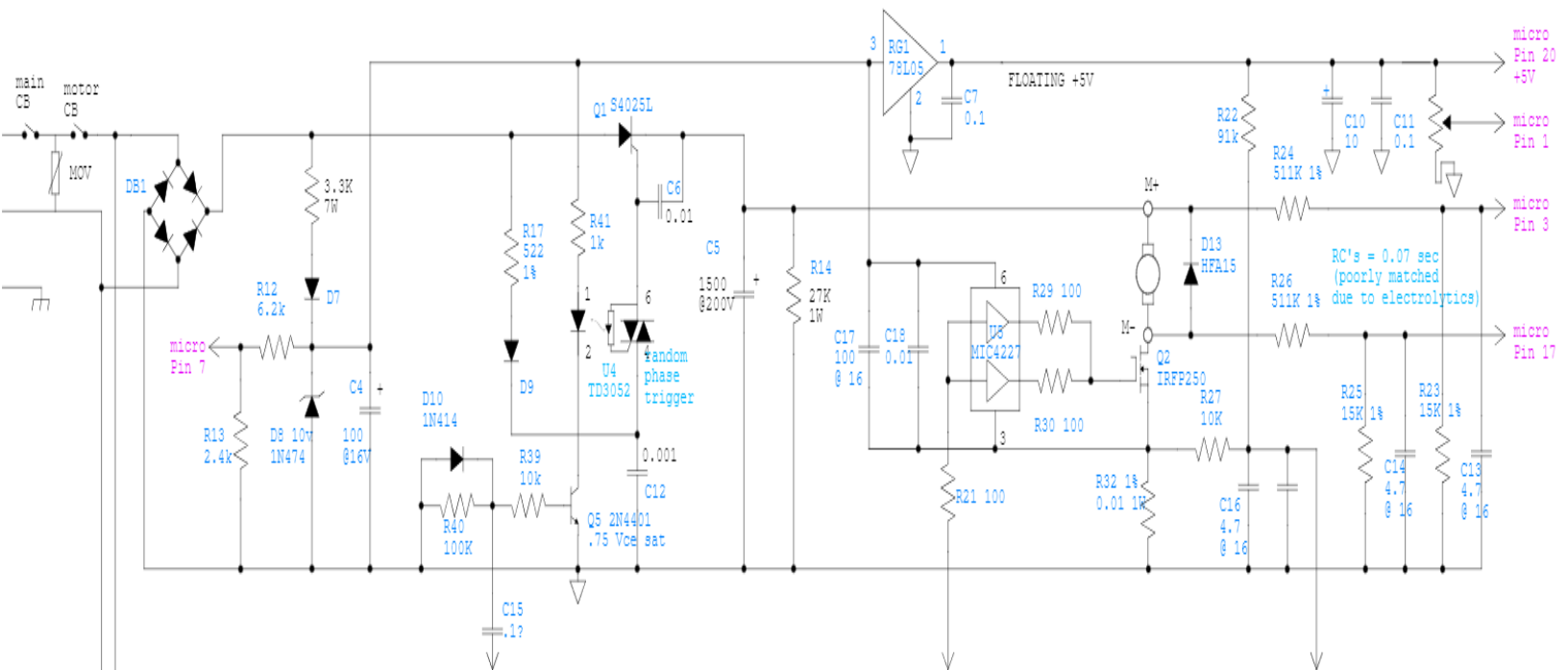
$$T(\text{pulse width}) = 1.1 \times Rb \times C2$$

Factor		1.1
C2a + C2b	0.33 μF	0.00000033
R4	22 k	22,000
R5	100k pot	50,000
Rb = R4+R5		72,000
Pulse width (seconds)		0.0261
Downtime (seconds)		0.0166
		<hr/> 0.0427 <hr/>
Duty cycle		61.2%

Parts List

IC1	556 dual-timer	R1	22 k
C1	2.2 μF, 35 volt electrolytic	R2	10 k pot @ 4 k
C2a	0.10 μF	R3	1.0 k
C2b	0.22 μF	R4	22 k
C3	0.01 μF	R5	100 k pot
C4	0.01 μF	R6	10 k
C5	0.015 uF		

note: c5 Should be 0.001uf; 1nf; or 1000pf



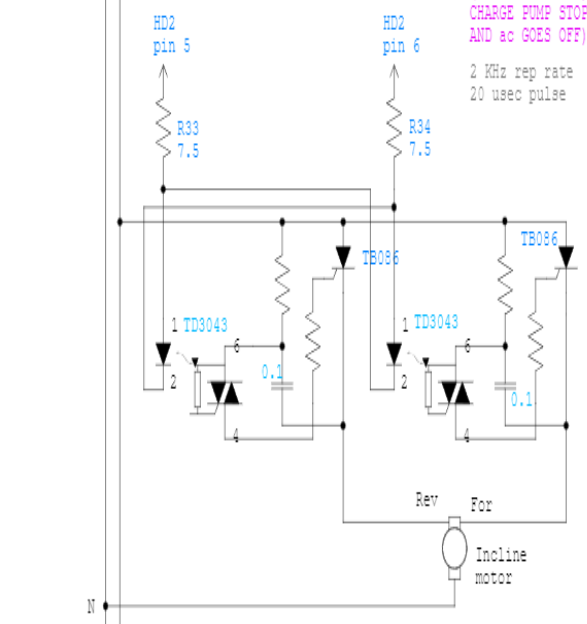
micro Pin 12
(IF MICRO HANGS,
CHARGE PUMP STOPS
AND ac GOES OFF)

2 KHz rep rate
20 usec pulse

micro Pin 8
60 usec fixed period
4 usec ON => slowest
0.25 uSec step resolution

micro
Pin 4

Appendix C



HD7 pin 1 2
(tach
read sw)

micro Pin 19
(clk 2)

micro Pin 6

micro Pin 18
(clk 1)

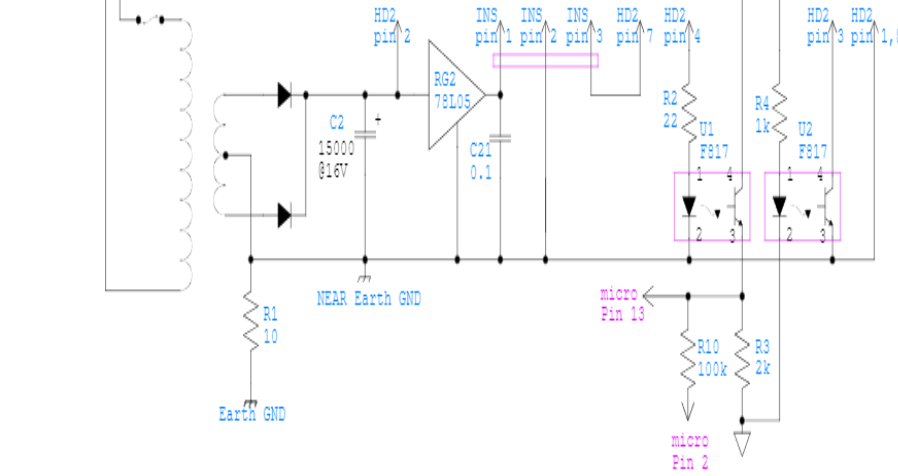
micro Pin 5

micro Pin 11

micro Pin 15

- HEADER 2
- Pin 1 BLK GND
 - Pin 2 RED
 - Pin 3 GRN
 - Pin 4 BLUE PWM from console
 - Pin 5 ORNG
 - Pin 6 YELL
 - Pin 7 VIOL
 - Pin 8 BLK

50 msec fixed period
8 msec ON => slowest
25 msec - half speed



FLOATING +5V

micro Pin 14

micro Pin 1

micro Pin 2

micro Pin 3

micro Pin 4

micro Pin 7

micro Pin 13

micro Pin 2

- micro Pin 1 pot analog V (max speed cal adj)
- Pin 2 opto sense of data from console
- Pin 3 motor +V sense
- Pin 4 motor current sense analog sig
- Pin 5 Base of Q3
- Pin 6 1N914 drive to LED & Tach
- Pin 7 AC power Voltage sense
- Pin 8 FET PWM drive to driver
- Pin 9 PGM HDR pin 4 & Cath of LED
- Pin 10 GND
- Pin 11 PGM HDR pin 5 direct
- Pin 12 Deadman clock to AC enable SCR charge pump
- Pin 13 opto console-sense: possible drive override
- Pin 14 Opto drive for data to console
- Pin 15 PGM HDR pin 3 direct & Collector of Q3
- Pin 16 n.c.
- Pin 17 motor -V sense
- Pin 18 clk 1 sensing PGM HDR pin 1 via 100K divider
- Pin 19 clk 2 from tach
- Pin 20 +5V

- micro Pin 1 analog IN
- Pin 2 analog IN/OUT
- Pin 3 analog IN/OUT
- Pin 4 analog IN
- Pin 5 Switch mode pump OUT
- Pin 6 port 1-7
- Pin 7 port 1-5
- Pin 8 port 1-3
- Pin 9 port 1-1 / SCLK
- Pin 10 GND
- Pin 11 port 1-0 SDAT
- Pin 12 port 1-2
- Pin 13 port 1-4
- Pin 14 port 1-6
- Pin 15 ext reset
- Pin 16 analog IN
- Pin 17 analog IN/OUT
- Pin 18 analog IN/OUT
- Pin 19 analog IN
- Pin 20 V+

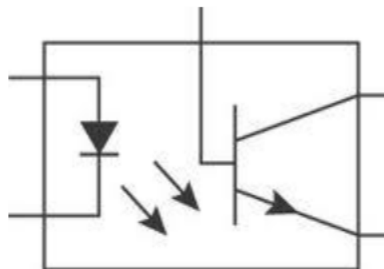
Appendix D

Understanding and testing opto-isolators

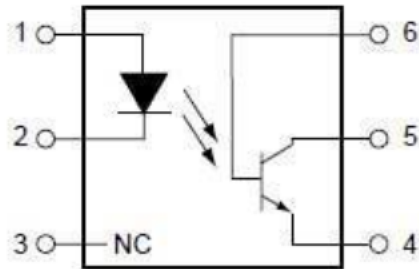


Understanding opto-isolators:

The opto-isolator is simply a package that contains both a light emitting diode (LED) and a photo-detector such as a photosensitive silicon diode, transistor, Darlington pair, or silicon controlled rectifier (SCR). The most common type uses an infrared LED and a phototransistor. Other circuitry, for example an output amplifier, may be integrated into the package. An opto-isolator is usually thought of as a single integrated package, but opto-isolation can also be achieved by using separate devices as well. Opto-isolators are very common in many devices especially in the feedback section of SMPS circuits found in LCD and Plasma TVs and most other consumer electronics as well. You will typically see 4 and 6 pin opto-isolators, 4 pin definitely being the most common. Some opto-isolator ICs will also have multiple opto-isolators in one package.

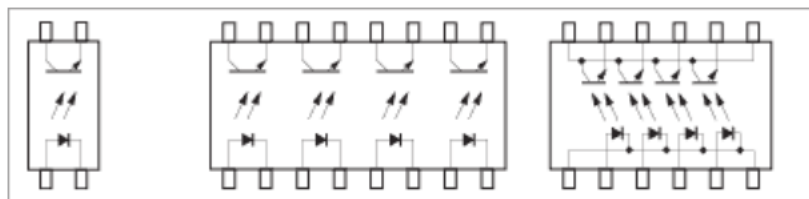


Symbol for 4 pin LED/Phototransistor type opto-isolator IC.



- PIN 1. ANODE
- 2. CATHODE
- 3. NO CONNECTION
- 4. EMITTER
- 5. COLLECTOR
- 6. BASE

Symbol for 6 pin opto-isolator IC.



Picture showing multiple opto-isolators in one package.

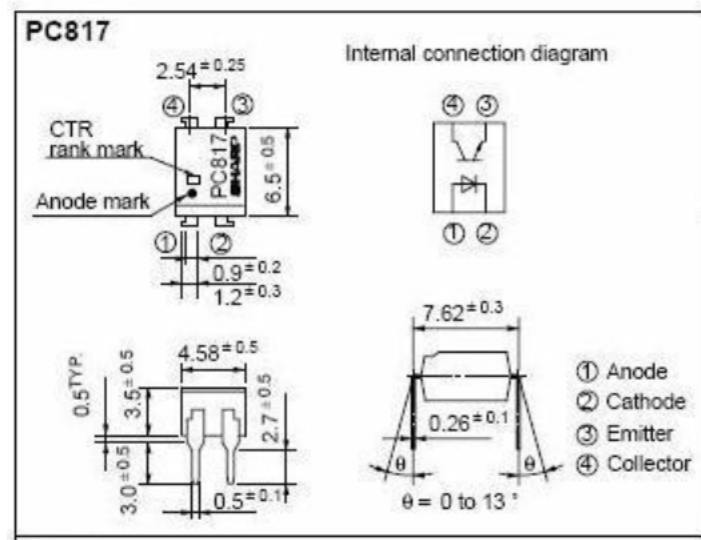
An opto-isolator also called an opto-coupler or photo-coupler allows a signal to pass from one circuit to another but allows the two circuits to remain electrically isolated. The most common opto-isolator which comes in IC package consists of an LED which shines onto the base of a photo-transistor (usually an npn transistor) and allows current to flow between collector and emitter until the LED is turned off. When a signal is applied to the LED it then shines light that is varied in brightness with the same amplitude as the input signal, this light lands upon the photo-transistor (the resistance of the collector/emitter junction now changes with the varying light) which passes the signal onto the next circuit.

3 methods for testing opto-isolators:

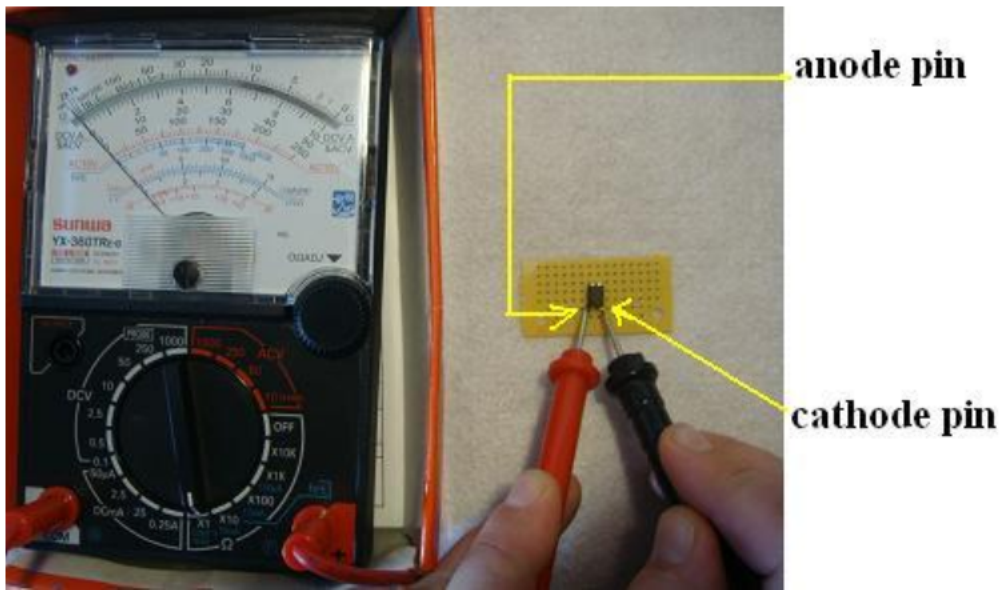
These methods will cover testing the most common opto-isolators found in electronics equipment, 4 pin LED/phototransistor opto-isolators.

Method 1:

Remove the opto-isolator from circuit or at least de-solder and lift the emitter and cathode pins from the circuit to get accurate readings. If you completely remove the opto-isolator from the circuit you can use a piece of PCB prototype board to hold it in place, do not solder it to the board only stick the leads through the holes. Using your analogue meter set to the x1 ohm range test the LED side of the opto-isolator. Which will be found by looking up the part number online or referring to the circuit's schematic diagram. A common opto-isolator found in LCD TVs is the 817 type for instance the PC817.

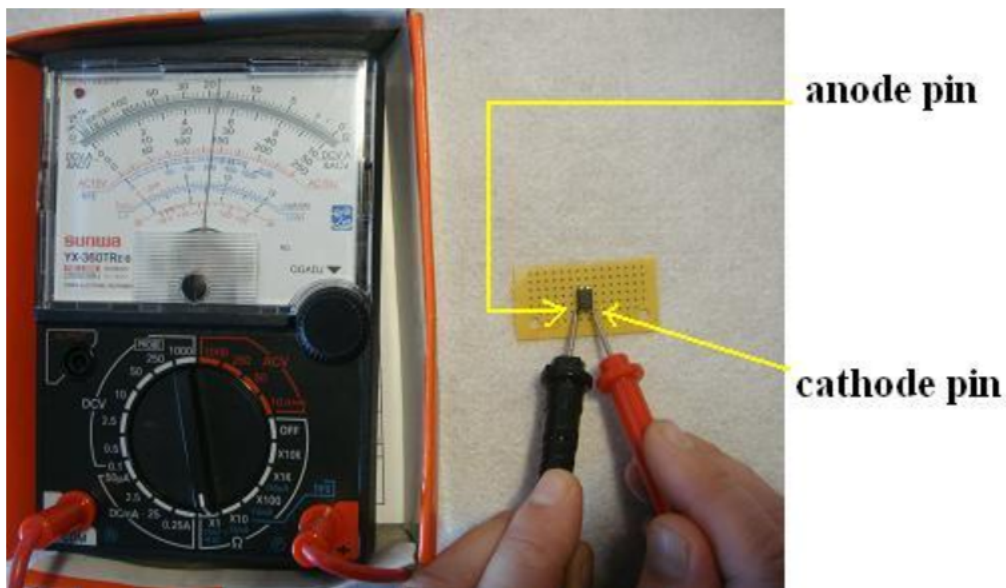


Place the red test lead on the anode pin and the black test lead on the cathode pin, the reading should be infinite.



Infinite reading with red test lead on anode and black test lead on cathode.

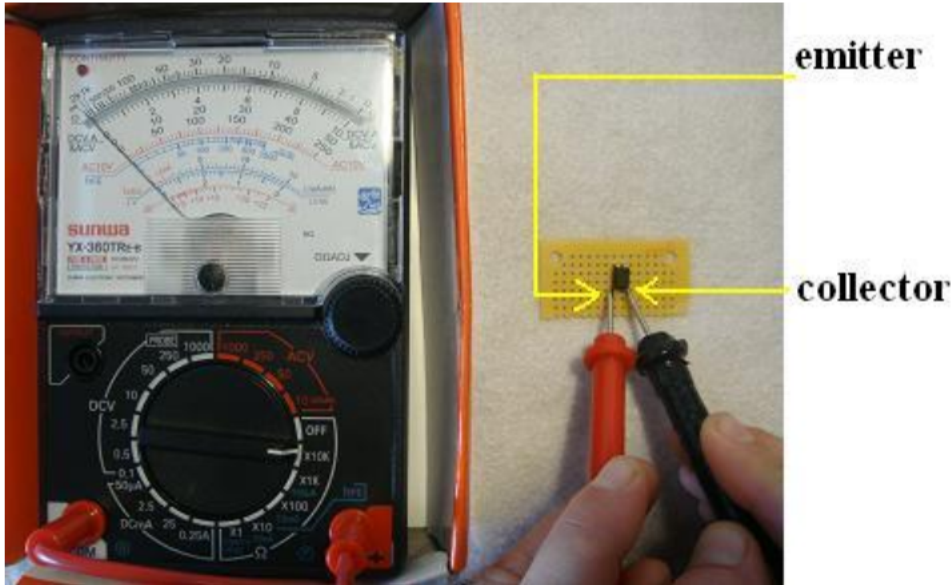
Next place the black test lead on the anode and the red test lead on the cathode, now you should get a resistance reading that is low, typically around 20 ohms or so.



Meter indicates a low resistance reading of 17 ohms with black test lead on anode and red test lead on cathode.

If you get a low resistance or 0 ohms reading in both directions the LED is considered shorted and the opto-isolator must be replaced. If you get a reading of infinity in both directions the LED is considered open and again the opto-isolator must be replaced.

Now to test the phototransistor side of the opto-isolator. Set your analogue meter to the x10k ohm range. Place the black test lead on the collector pin and the red test lead on the emitter pin of the opto-isolator, you should get a resistance reading of infinity.



Infinite reading with black test lead on collector and red test lead on emitter.

Next place the red test lead on the collector and the black test lead on the emitter. You should get a large resistance reading, typically around 500k ohms or so. If you get a 0 ohms or low resistance reading in both directions the collector/emitter junction of the phototransistor is shorted and the opto-isolator must be replaced.

Note: Testing shown is on a 4 pin opto-isolator , when testing a 6 pin opto-isolator use the same procedure, but double check the pin configurations for the particular opto-isolator.

Method two:

De-solder and remove the opto-isolator you want to test from the circuit it is in. Using alligator clips or some other method attach a DMM (digital multimeter) test leads to the collector and emitter pins of the opto-isolator, polarity does not matter. Set the DMM to the resistance or ohms setting. The meter should read O.L (Over Limit), infinity or something that indicates the resistance is beyond the range of the meter.

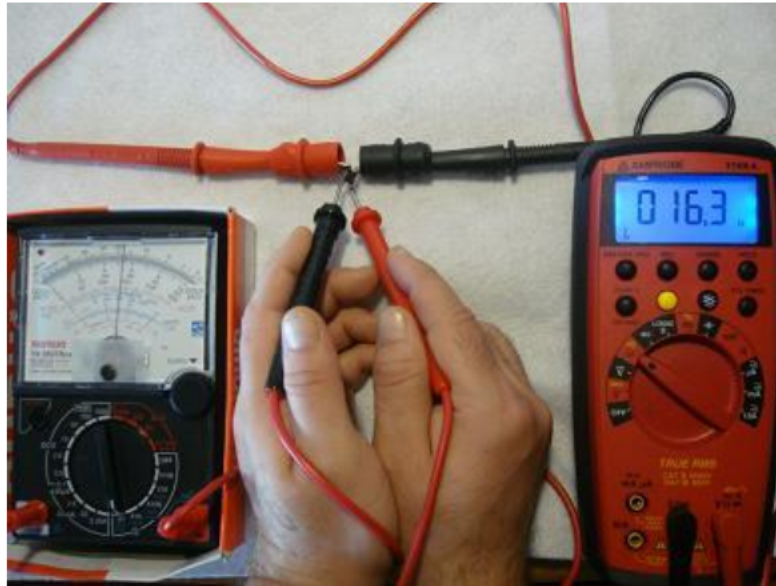


Attach test leads to the emitter and collector pins, polarity does not matter.



Set the DMM to the resistance setting, reading should be O.L.

Now using your analogue meter set to x1 ohm range, place the red test lead on the cathode pin and the black test lead on the anode pin, you should get a low resistance reading on the analogue meter and also if you look at the digital multimeter it will now also show a low resistance reading.

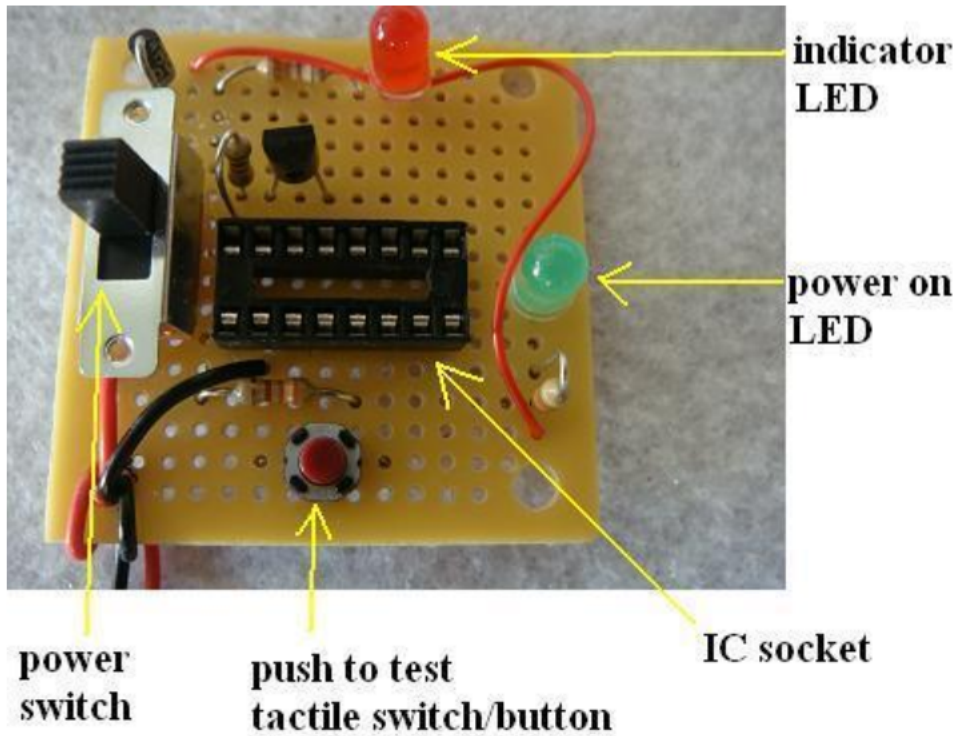


With analogue meters black test lead on the anode pin and the red test lead on the cathode pin the DMM now shows a low resistance of 16.3 ohms between the collector and emitter.

This is the characteristics of a good opto-isolator.

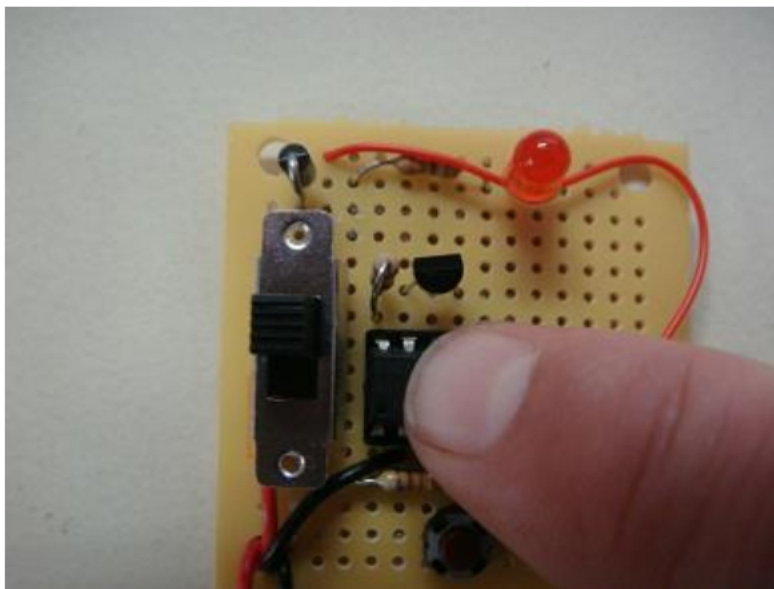
Method three:

The third method requires assembling an easy to make opto-isolator tester.

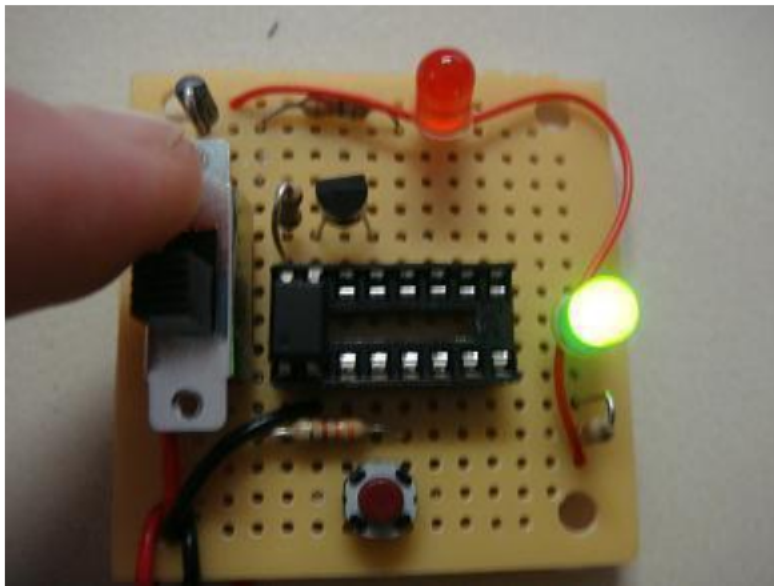


4 pin, LED/phototransistor opto-isolator tester

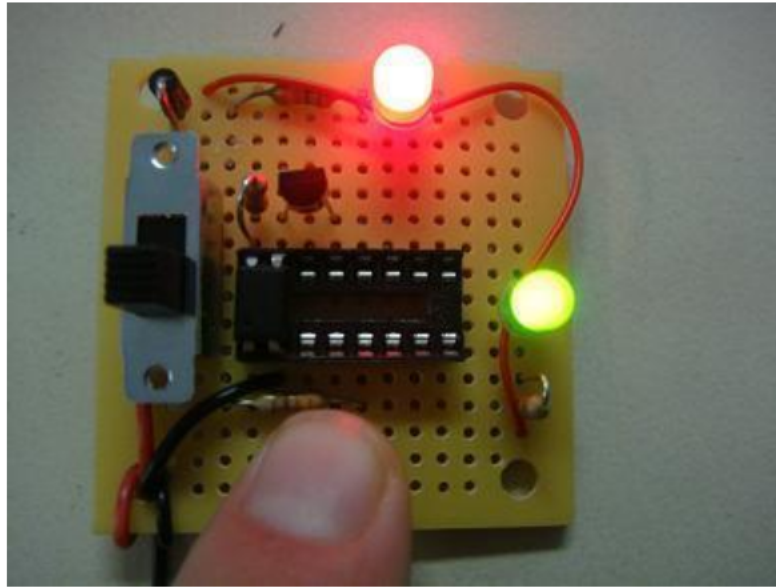
The idea is simple, with the power on and an opto-isolator placed in the proper section of the IC socket, pressing the push to test button will cause the red indicator LED to light otherwise the opto-isolator is no good and must be replaced.



Place opto-isolator into proper section of the IC socket.

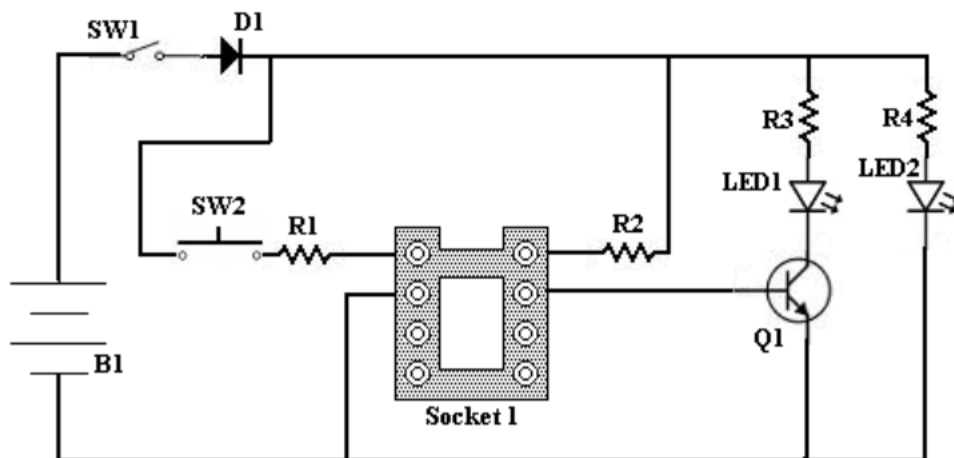


Turn tester power on, the "power on" LED is now illuminated.



If the opto-isolator is good when the “push to test” button is pressed the red “indicator” LED will light.

This tester is good for testing many different 4 pin LED/phototransistor type opto-isolators like the PC817, PC123, 817B, EL817 and more. You can also make one that will test 6 pin opto-isolators or both 4 and 6 pin. You can also design testers for other types of opto-isolators besides the LED/phototransistor type.



Schematic for opto-isolator tester used in this article

Parts list for opto-isolator tester used in this article:

SW1, SPST slide switch.

SW2, SPST momentary contact push to make tactile switch.

B1, 9V battery.

D1, 1N4001 PN diode.

R1,R3 and R4, 330 ohm ¼ watt carbon film resistors.

R2, 1k ohm ¼ watt carbon film resistor.

Q1, 2N3904 NPN bipolar junction transistor.

LED1, 5mm red LED.

LED2, 5mm green LED.

Socket1, any size IC socket will do, the one used in this article was a 16 pin IC socket only because that is what I had on hand.

Hope you enjoyed this repair article and remember if you ever have any electronics related questions you can always email me john@preher-tech.com. Also don't forget to visit our website, www.preher-tech.com.

Recommended Books:

[Troubleshooting & Repairing LCD TVs](#)

[LCD TV Repair Case Histories](#)

[LCD Monitor Repair](#)

[Troubleshooting & Repairing Switch Mode Power Supplies](#)

[Testing Electronic Components](#)

[How To Find Burnt Resistor Value](#)

[Electronics Repair Articles](#)