Grade Crossing Flasher

by David King

History

Over the years the railroads have been concerned about the public's safety any time that the public is close to rail operations. In the earliest days the railroad police would chase the public away from the trains. Usually this had more to do with protecting the cargo the trains were carrying then the safety of the public. The outcry from the public grew over the years and the railroads had to start reforming the perception of the public and look like they were interested in protecting the public from themselves. The railroads then began the use of flagmen at grade crossings in populated areas but over time this became expensive and the need for automation was making financial sense. As the automated systems improved the governments started to make more and more rules and standards that the railroads were required to follow. The grade crossing flasher was born and is widely used today. Let's build the electronics that can be used to automate this device on your layout.

First Steps

In order to construct the needed electronics we need to understand the basic operations that are needed in this project. The scope of this project is to have the grade crossing flashers activate as a train is approaching a level grade crossing. The lights must continue to flash while the train is occupying the crossing and then shut off shortly after the crossing has cleared.

Now that we know what the grade crossing flashers must do we can figure out what events will make satisfy our scope.

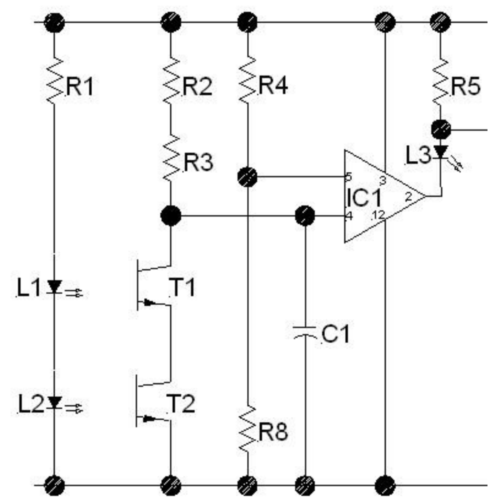
1) Sense the approach of a train as it nears the crossing.
2) Turn on the warning lights.
3) Make the lights flash in an alternating pattern.
4) Keep the lights on as the train proceeds through the level crossing.
5) Turn off the lights shortly after the exit of the train.
6) Reset the system so that the crossing will work for the next train.

Sensing the Train

The first item on our list is to sense the approach of the train. We can do this in many different ways and some of these are as follows.

1) Reed switches. A magnet on the leading and trailing cars can activate a reed switch that is located between the rails and under the ties.
    a. Pro – simple to operate and the need for electronics is minimal.
    b. Con – every possible head and tail end car or locomotive needs to be modified with the addition of a magnet. Not easily installed on a three rail track layout.
2) Block Occupancy Detection. The track can be cut into sensing blocks and this can be used activate the flashing circuit. The head and tail end cars must be able to draw power from the rails so that the sensor will activate.
    a. Pro – this is the easiest to hide as gaps can be cut into the tracks and insulators installed. All of the electronics and wiring can be hidden below the layout.
    b. Con – again every head and tail end car must be able to draw power. A modification of adding a resistor between the wheels of the cars in order to draw minimal power from the tracks can be done. Specific detectors must be built depending on the type of track power that you are using.
3) Photo Resistors. Photo resistors can be placed between the ties at the ends of the sensing area and these can be used to activate the flashing circuit. The photo resistors require a visible light source to shine onto the sensor in order for it to work. The passing train simply blocks the visible light.
    a. Pro – no modifications need to be made to any cars or locomotives in order for this type of sensor to work. Room lights can be used as the light source for this type of sensor. Can be used with any track power system, as it is independent from track power.
    b. Con – if you run night operations on your layout, turning the lights very dim or off can trigger the sensor as the sensor thinks that the light source has been blocked giving a false trigger to the flasher. The photo resistor has to be placed between the rails and must remain visible in order to work. Photo resistors don't look very realistic.
4) Inferred Emitter and Detector. This is similar to the photo resistor with the exception that the light is not in the visual range but rather the light uses a light frequency that is beyond our visible range.
    a. Pro – no modifications need to be made to any cars or locomotives in order for this type of sensor to work. Room lights are not required so this system will work when running night operations. Can be used with any track power system, as it is independent from track power. Can easily be used with any scale. The emitter and detector can be hidden.
    b. Con – an emitter must be installed and aligned with the detector.

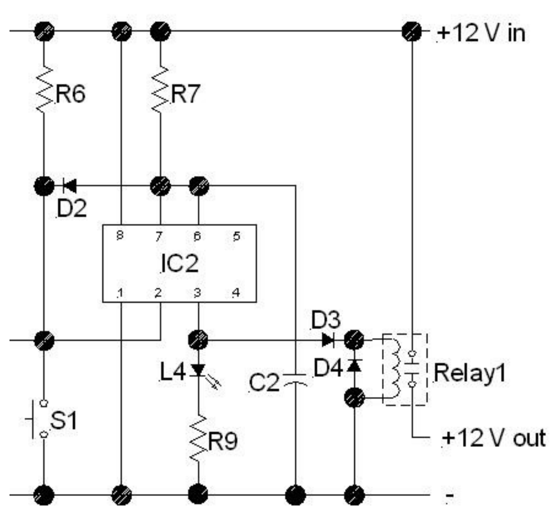
In this project we will be using inferred emitters and detectors because of the major advantages that the light source is not in our visual range. We can now take a closer look at that circuit.



In this circuit starting on the left side we have components L1 and L2 that are the inferred emitters. These are the devices that transmit a beam of inferred light. Next we have T1 and T2 that are the detectors, which are sensitive to the inferred light. IC1 is ¼ of a LM339 voltage comparator chip. The LM339 looks for changes in voltage on its inputs and turns on the output when voltages are close to being the same.

Keeping the Lights On

Now that we know how we are going to sense the train approaching we are going to need to keep the flashing circuit on until after the train has passed the detector. Depending on the type of rail car that is passing in front of the detector the sensing may not be activated continuously. To keep the lights flashing during these non-active periods we can use a timer to delay the shutting off of the flashing circuit. In most cases we would need less then a second of delay at the most but we can extend this time dramatically. In this example I will extend this time to about five seconds.



In this circuit we are using a LM555 flip-flop timer to give us the delay on the output to maintain the flashing circuit. We can trigger the output to energize by closing the switch at S1 in turn grounding pin 2 on the timer. Pin 2 is the trigger pin on a LM555 chip. When the S1 switch is opened the timer will start to count and the output of pin 3 will remain energized until the timer has finished resulting in the output of pin 3 turning off. At this time the timer is set to count for about 5.6 seconds. To achieve this time the value of R7 is 510,000 ohms and the value of C2 is 10 microfarads. The math to calculate the time is as follows:

R7 x C2 x 1.1 = seconds

510,000 x 0.00001 x 1.1 = 5.61 seconds

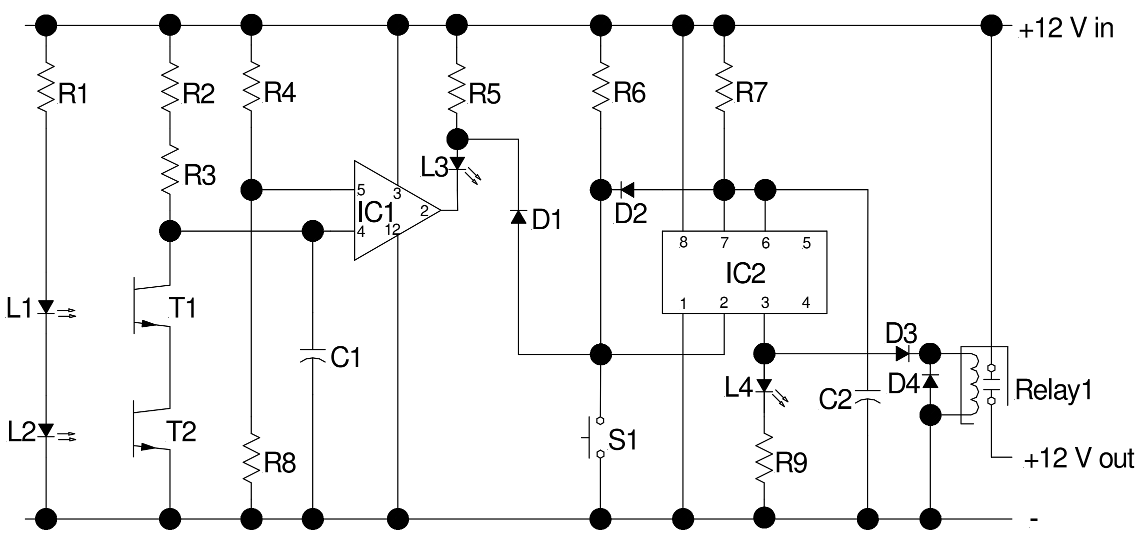
Changing the values of R7 and C2 can vary the time that the output pin will stay energized.

Relay1 has been added to the output of pin 3 to allow the power to be turned on and off going to the flasher circuit.

Joining the Sensor and Timer

The combined circuit would look like the following.

Inferred Detcetor and Delay Off Timer



R1, R9 = 470 ohms
R2, R3 = 100K ohms
R4, R6 = 10K ohms
R5 = 820 ohms
R7 = 510K ohms
R8 = 33K ohms

C1 = 100µf
C2 = 100µf
D1, D2, D3, D4 = 1N914
L1, L2 = IRD Emitter
L3 = RED LED
L4 = GREEN LED

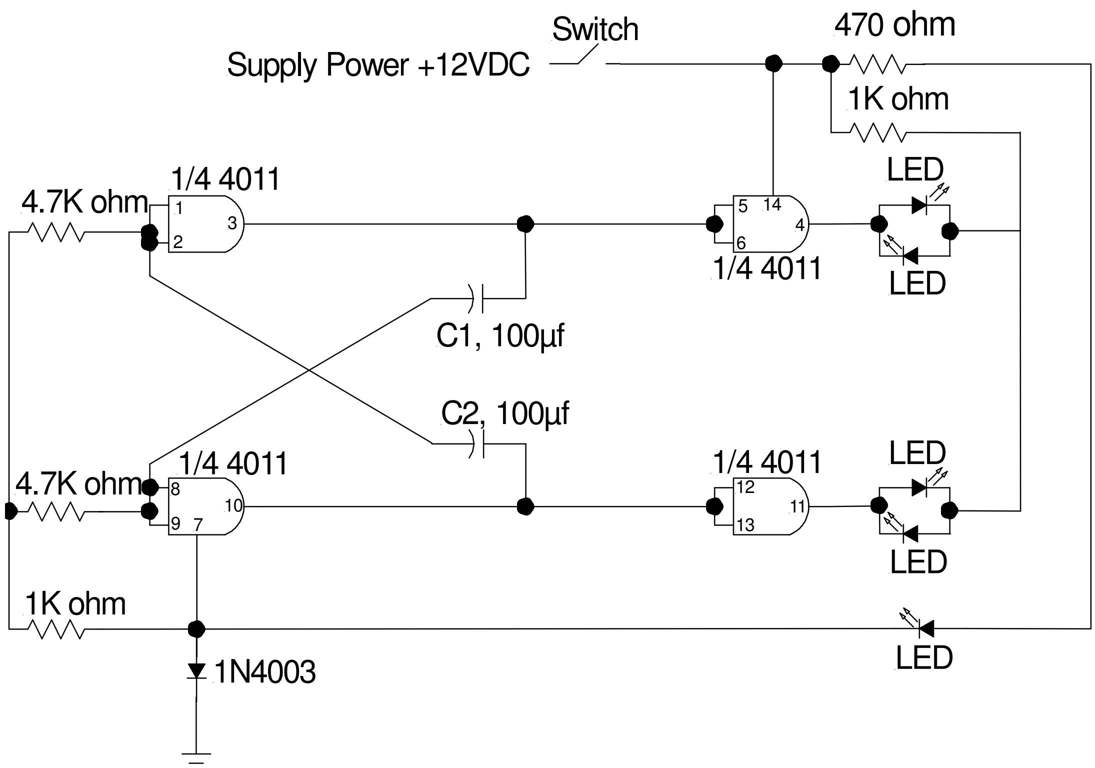
T1, T2 = Photo Detector
IC1 = 1/4 LM339
IC2 = LM555
Relay1 = 5 Volt Relay
S1 = SP Momentary Switch

The only added component to the two circuits is D1. D1 has been added so that when the output of the LM339, IC1, chip is energized the trigger on the LM555 timer will go low, close to zero volts which in turn activates the output of the LM555 timer but won't allow a reverse flow from the timer to reach the LM339 voltage comparator.

Flashing Lights at the Grade Crossing

The flashing circuit is very important to us since it is the one that makes the lights in the grade crossing flash in an alternating pattern so let us have a look at it now.

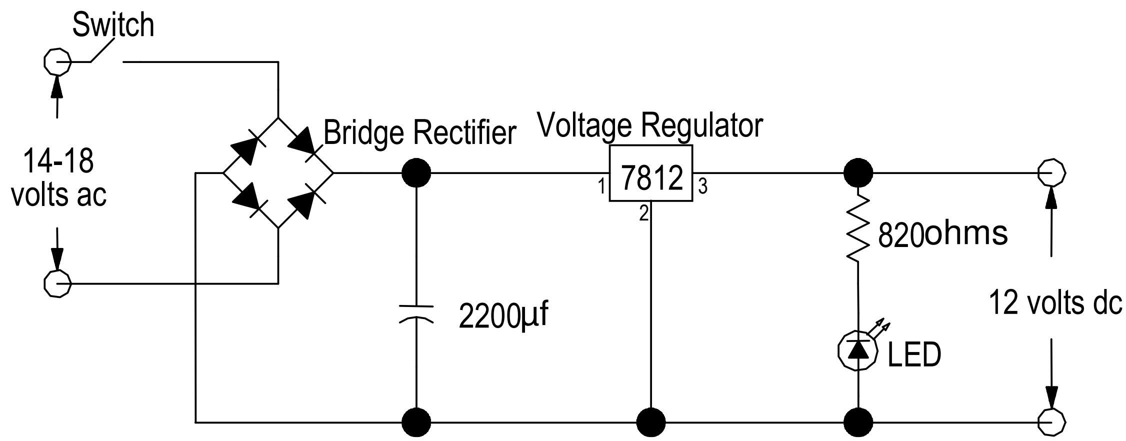
Flashing circuit for grade crossing



If this circuit looks familiar to some of you it is because I have introduced this in my previous layout lighting clinic. This time we are taking a closer look at it so that you can understand how it works. Here we are using all four parts of a CMOS logic chip, the 4011. For simplicity in this project I have left the switch out since the timer board has a relay acting as the switch. Here we are supplying the power to the LEDs and the 4011 logic chip. Each quarter of the 4011 has an AND gate so when both inputs are true the output will be true. The capacitors, C1 and C2, set the timing as they charge up. With the capacitors having a value of 100 microfarads the flash rate is about 1 hertz, which is 1 second on, and 1 second off. As one capacitor is charging up the other is discharging allowing the outputs of the second AND gate to go true and then false in that one second pattern. The output LEDs then turn on and off depending on the state of the output on that second AND gate. We are almost there.

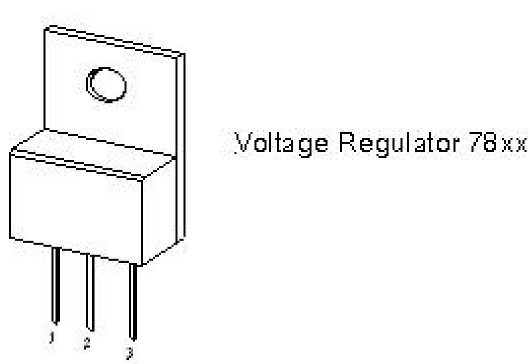
We Need Power!

This is the regulator that is in use for this project. It all starts here!



In the above voltage regulator circuit a power supply that has an output of 14 to 18 volts of alternating current is connected to the input terminals of the board. A switch has been installed to turn on or off the ac voltage to the voltage regulator board. The bridge rectifier then converts the ac voltage into a full pulse wave dc voltage. Next the 2200-microfarad capacitor is used to help flatten out the dc full pulse wave to a flat dc voltage. At this point the voltage is more then 12 volts making it unusable for the following circuits so this voltage needs to be reduced. The 7812 voltage regulator is used to reduce the voltage to 12 volts. The excess voltage is dissipated as heat by the regulator. At this point we now have 12 volts of dc power available to use with the other circuit boards.

One last item that I like to have on the voltage regulator board is an indicating light to verify that the 12 volt output is energized. For this purpose I used a light emitting diode, LED with a resistor connected in series to limit the voltage applied to the LED. In this case the LED draws 20 milliamps of current and requires 1.4 volts to illuminate. The resistor must use up the remaining 10.6 volts so that the LED will illuminate properly. The value of this resistor is 820 ohms.



The pins on the 7800 voltage regulator are set up as shown in the picture on the left.

That's it, enjoy and give electronics a try.