

Easy Traffic Lights Controller

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Business Field:

- Semiconductor Quality Assurance support in Japan for foreign semiconductor company
- Analog related Circuit Design

Book:

TITLE: Operational Amplifier Specifications and Applications (Japanese)

This book refer operational amplifier specification, measurement method and application of the specification. This book covers DC/AC/Noise specifications. "Application of the specification" mean calculation method of errors on the application circuit. This book also has some suggestions of calculation method and measurement method for cases that difficult to calculate from ideal models, "know-how" in other words. 452 pages.

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Here is a traffic lights controller that uses analog devices. Figure 1 to 3 are all of circuit diagram. You can control one or two traffic lights. And you can use for railway signal also.

This controller has +5[V] to +15[V] of wide power supply range.

This is useful circuit for modelers, because this decoder consist of some analog devices. You don't need sense of computer devices and environment of computer system, micro-controller development tool for example. If you have experience of building electronics circuit, that's fine.

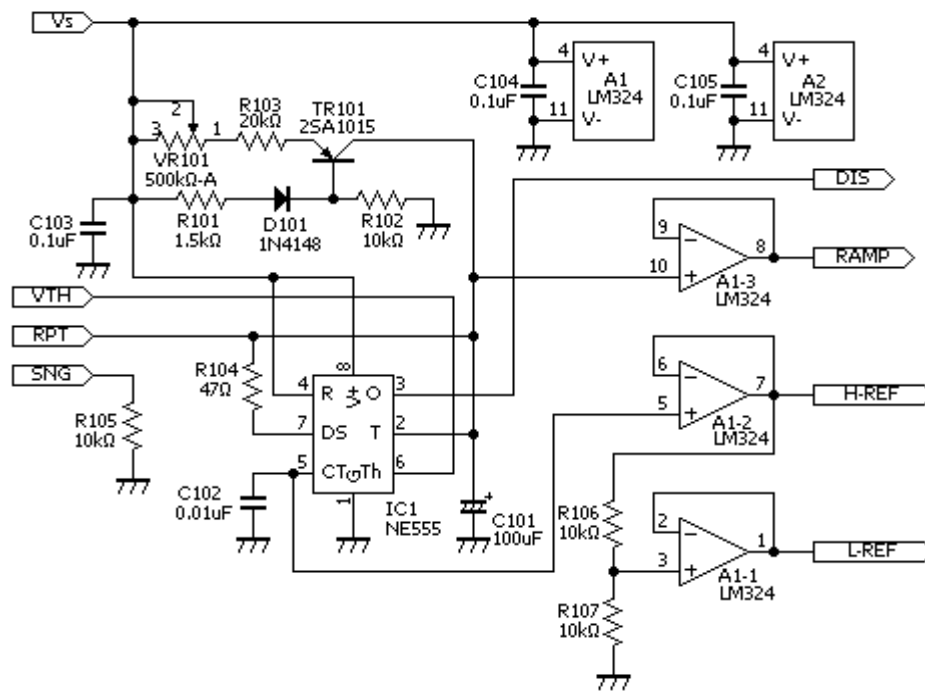


Figure 1. RAMP

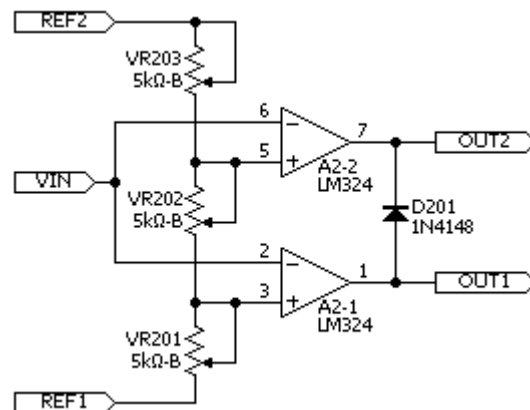


Figure 2. COMP1

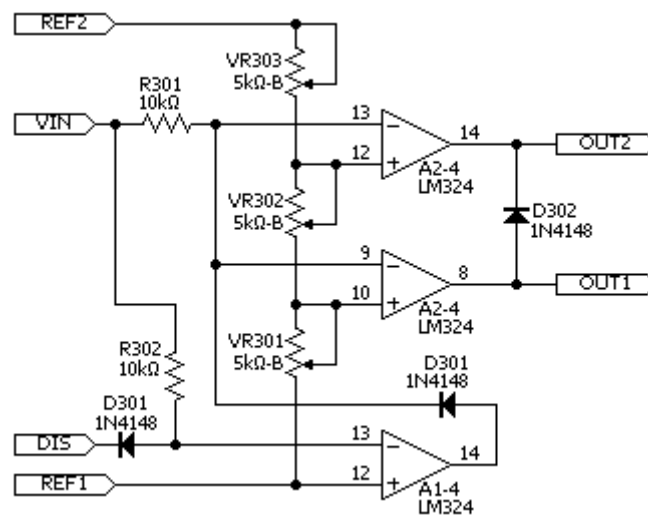


Figure 3. COMP2

This controller repeat the following sequence when traffic lights mode :

Step	1	2	3
Light	G	Y	R

Table 1. One Traffic Lights control

Step	1	2	3	4	5	6
Light 1	G	Y	R	R	R	R
Light 2	R	R	R	G	Y	R

Table 2. Two Traffic Lights control

Table 3 is for railway signal. The operation is, when train detected, right after railway signal turn from Green to Red and it will change with steps in Table 3. Signal stay step 3 (Green) until next train detection.

Step	1	2	3
Signal	R	Y	G

Table 3. Railway Signal control

Theory of Operation

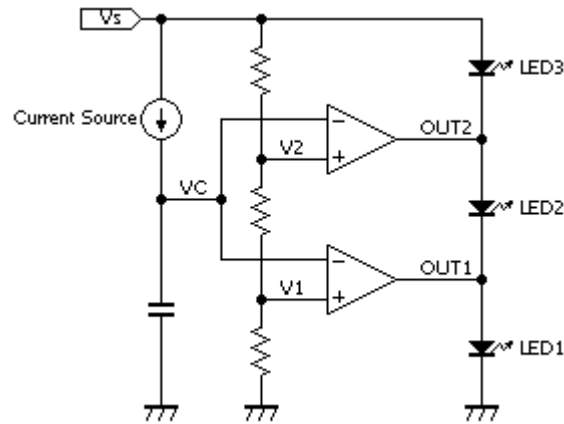


Figure 4. Basic Circuit

Figure 4 indicates basic idea of the controller. Current Source charges the capacitor. Voltage of capacitor (VC) go up with the following equation:

$$VC = \frac{I \times t}{C}$$

I : Current [A]

t : Time [sec]

C : Capacitance [F]

This equation indicates VC is proportional to t (Time) with monotonic.

Capacitor connected to operational amplifiers and these operational amplifiers use with comparator operation (No feedback circuit). So operational amplifier output switch H/L depending on VC. Table 4 indicates VC and operational amplifier output status :

VC	<V1	V1 to V2	>V3
OUT1	H	L	L
OUT2	H	H	L

Table 4. Output Status of Figure 4

Before explanation, we assume LED driving current is appropriate value and operational amplifiers output swing 0V to Vs.

From Table 4 and Figure 4, LED lights when LED has voltage difference.

From this, when VC takes <V1, LED1 will light. VC takes V1 to V2, LED2 will light. VC takes >V2, LED3 will light. One LED lights in each case (other two LEDs turns off, because of no voltage difference).

When we use G(Green), Y(Yellow) and R(Red) LEDs, we can get traffic lights operation.

We can control LED ON/OFF timing with resistors that connect to operational amplifiers + input pins (non-inverting input pin). We can control one cycle time with capacitor value or current source value. This controller use variable current source.

This is the basic idea of the controller.

Single Traffic Lights Operation

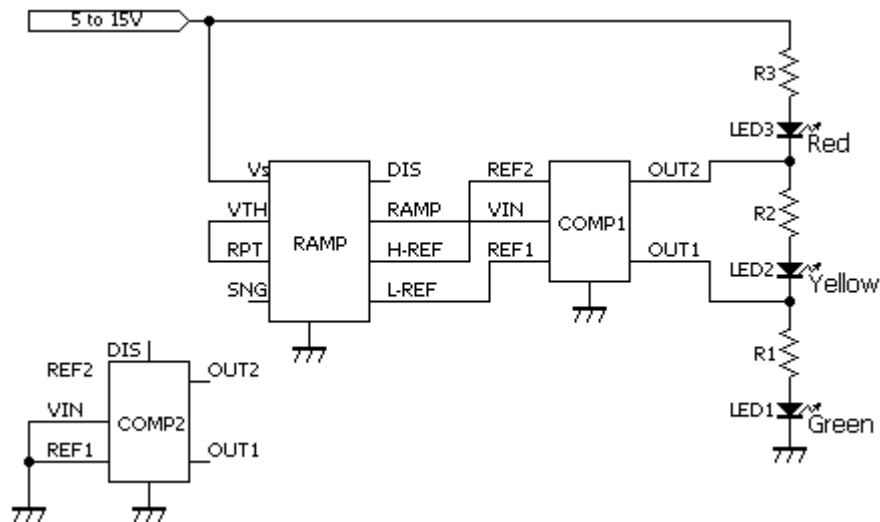


Figure 5. Connection for Single Traffic Lights Operation

Figure 5 is the connection for this operation. The sequence of LED lighting is Green-Yellow-Red (Return to Green and repeat).

You have to choose appropriate resistor for LED current limiter (R1, R2 and R3). OUT1 and OUT2 voltage generate LM356 and output voltage swing is not from 0[V] to V_s with LED drive. This mean, when you hope the same brightness to all of LEDs and you use the same type LEDs, R1, R2 and R3 takes different value. I recommend to use a potentiometer for getting resistance.

Maximum output current of LM324 is ~20[mA]. When you need large current, you can replace from LED1, LED2 and LED3 to opto-isolators. Figure 6 is an example. Opto-isolator is able to drive relays, so you can drive valves.

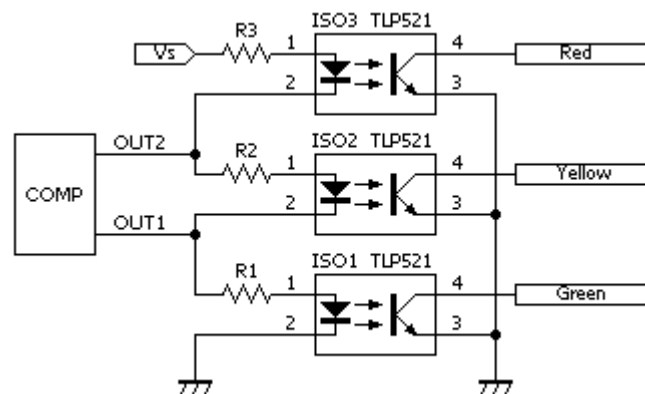


Figure 6. Using Opto-Isolator for outputs (corresponding Figure 5)

At the 1st cycle that right after power ON, time period of LED1 is long. It's approximately LED1 time period + 1 cycle time period. After 2nd cycle, it's become the same setting of potentiometer. So when you adjust LED lighting period, you should ignore the first cycle.

Dual Traffic Lights Operation

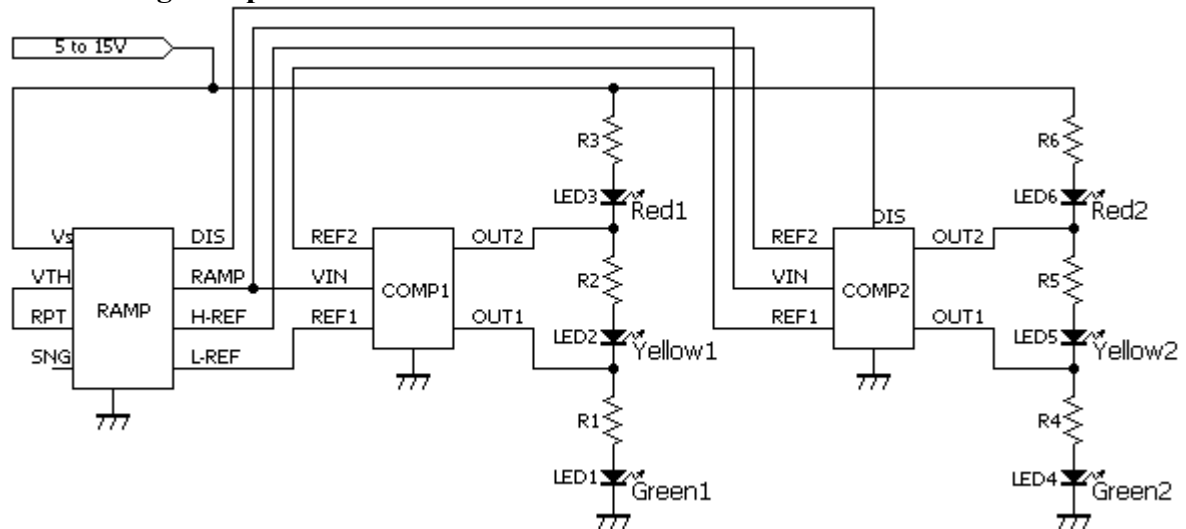


Figure 7. Connection for Dual Traffic Lights Operation

Resistance and solution for drive current are the same as the Single operation.

The sequence of LED lighting is Green1&Red2-Yellow1&Red2-Red1&Red2-Red1&Green2-Red1&Yellow2-Red1&Red2 (Return to Green1&Red2 and repeat).

COMP2 is complex circuit from COMP1. The reason of this is prevention of wrong LED lighting during C101 (refer to Figure 1) discharge period.

Railway Signal Operation

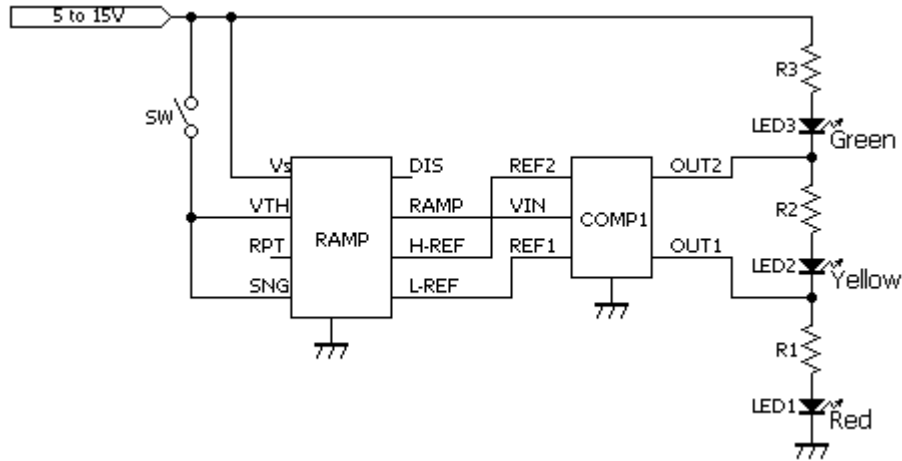


Figure 8. Connection for Railway Signal Operation

This circuit need start signal and it is SW in Figure 8. The operation of this is the following :

The stable state is, Green LED lights and other LEDs are OFF. Right after SW closed, Green turn OFF and Red lights. After that, an order of light is Yellow-Green and stay Green until SW close. SW should open before reach to Green LED lights again.

Please take care, LED position is opposite from traffic lights.

Adjustment of RAMP

RAMP circuit (Figure 1) has VR101, it fix one cycle time. TR101 that including peripheral components, this is a variable current source. This current source has power supply dependency, because IC1 (NE555) has power supply dependency for timing. Both of power supply dependency canceled each other. So, when you use non-regulated power supply, the effect to one cycle time is small.

I recommend to use Logarithmic Taper Potentiometer for VR101. It should connect one cycle time go up with clock-wise direction.

You can get 5 to 150[sec] (typical value) for one cycle time at the current setting.

You can change from variable current source to a resistor like NE555 typical application. In this case, you have to do complex calculation. Variable current source is the solution of this. However, you don't have intent to change the setting in the future or restriction of the cost, it's possible way.

Adjustment of COMP1 and COMP2

There are VR201 - VR203 in COMP1 (Figure 2) and VR301 - VR303 in COMP2 (Figure 3). These potentiometers sets a period of LED lighting time.

Please refer to Table 2. VR202 sets for lighting time of Step1, VR202 sets Step2, VR203 sets Step3, VR301 sets Step4, VR302 sets Step5 and VR303 sets Step6.

The following steps are the method of setting each potentiometer.

At first, make a table that like Table 1 or Table 2.

Step	1	2	3	4	5	6
% of Period	40	10	5	30	10	5

Table 5. Timing plan of the Lighting (Example of Dual traffic lights)

Table 5 is an example of Dual Traffic Lights Operation (it has the same number of steps to Table 2). The maximum number in Table 5 is 40% at Step1. Corresponding potentiometer set to maximum value and VR201 in this case. This mean, 100% of position is for 40%, other steps sets with the same method. So, 25% of position is for 10%, 12.5% of position is for 5% and 75% of position is for 30%.

From this setting, Linear Taper Potentiometer should use for VR201 - VR203 and VR301 - VR303.

You can use fixed value resistors when you don't change them often. When you use fixed value resistors, I recommend 10[kohm] to 100[kohm] for total resistance (VR201+VR202+VR203+...).

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