TURN SIGNALS - ALL YOU NEED TO KNOW

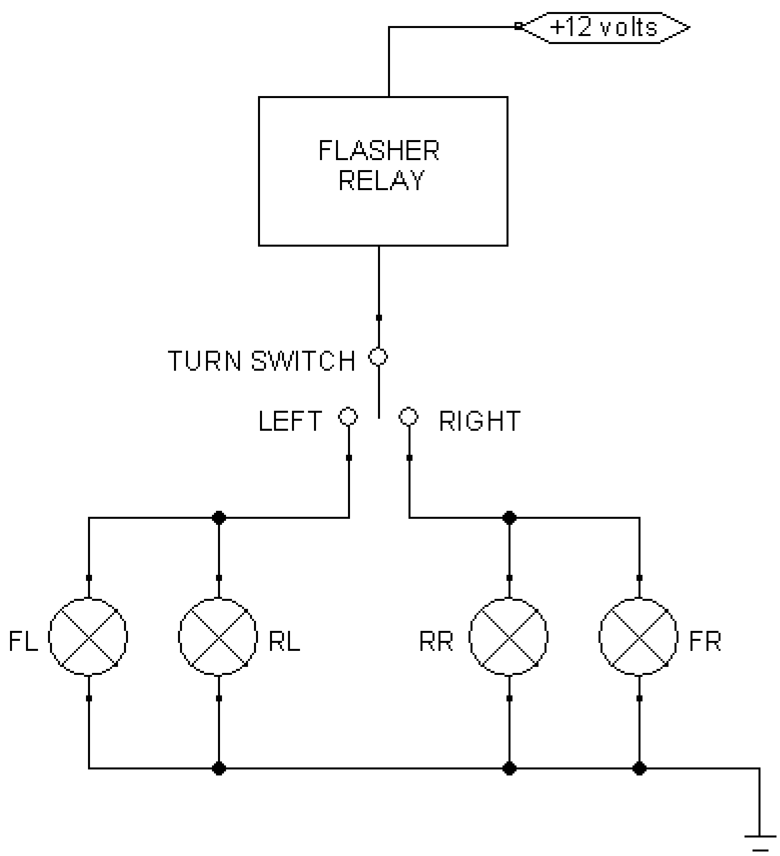
By

RiPPER

I get asked a lot about turn signals. The system is very simple, yet can be confusing, so I am writing this as an all-in-one tutorial that will tell you all that you would need to know, to troubleshoot or modify the system. It is intended more for the novice, so I have written this tutorial in the simplest terms that I can think of, therefore I ask those readers who have some knowledge of wiring for their patience.

Let’s start with a typical basic turn signal circuit. I have left out what we don’t need right now, we will come to those later, but the diagram below shows the way that the turn signals are wired on any vehicle, be it a car, truck or motorcycle.

The system consists of a flasher relay, a 3 position switch with centre off position and the lamps. In a typical turn signal system there are 4 lamps, and these are connected in front/rear pairs to each side. So the Left side has a front lamp and a rear lamp connected together, and the same for the right side. The way that the lamps are connected to each other is called ‘in Parallel’. I have marked the lamps in the drawing FL (Front Left), RL (Rear Left).. you get the picture. Now we can look at the individual components.

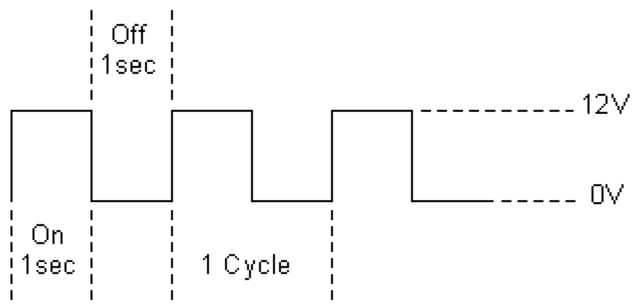


__The Turn Switch__

This is a 3 position switch, which connects the flasher relay to the lamps in the two outside positions, but when in the centre position the switch is not connected to anything. This is called a ‘Centre Off’ switch. On a motorcycle the switch has a small spring loaded mechanism that returns the switch to its centre off position when the rider presses the switch. In a car, this is done automatically by a mechanism on the steering column, which returns the switch to the centre position when the steering wheel is turned to straighten the wheels.

The Flasher Relay

This is the main component of the system. Inside it is a piece of electronics called an 'oscillator' which drives an ordinary mechanical relay, hence the clicks as it switches. An oscillator produces pulses of fixed duration. The pulse (on) duration is equal to the off duration, and combined they make one cycle. An oscillator is one of the basic building blocks in electronics and has two output states, on and off. However the circuit is not stable in either state so the output alternates between on and off. This is called a 'square wave' output and is used to drive the relay.



The guidelines in the UK and the USA are that the relay must operate between 60 and 90 cycles per minute, but flasher relays typcally operate at 60 cycles per minute. This means that the lamps are lit for one second then extinguished for one second.

As said previously there are typically 4 lamps in the system but some flasher relays will handle more, for example the extra 2 lamps on a trailer or caravan. These extra lamps are simply added on to the system through the trailer cable. The flasher relay usually has printed on one side, how many lamps it will handle, and what wattage the lamps should be. Note the line which says '2(4)x21W+0W...4W'. This gobbledygook is saying that the relay will handle a maximum of 2 lamps (or 4 with hazards on), of 21 watts each, plus dashboard indicator lights up to 4 watts (this could be either a single 4 watt bulb, or 2 bulbs at 2 watts each). This relay is clearly no good for adding on a trailer then... but wait - excluding the dashboard lights, 21 watts x 4 lamps = 84 watts, and as long as you stay within this limit the relay will feed more lamps, so if your car and trailer had, for example 10 watt lamps, then theoretically the relay would feed 8 lamps. However, 21 watts is the norm for a car, and swapping out 21 watt bulbs for 10 watt ones would make the lamps too dim. Many relays simply state their maximum wattage, and it is up to you to divide this among the lamps you have. For a car plus trailer with 21 watt lamps (6 in total), plus the 4 watts for the dashboard lights, this would add up to 130 watts, so you would choose a 150 watt relay.

Load Dependency

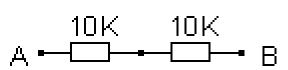
A typical flasher relay is known as 'load dependent'. This simply means that the relay must have the correct load (number of lamps, wattage) to operate properly. Whilst the turn switch is in its centre off position, the relay is disconnected from all the lamps and without a load the oscillator will not start, so a load dependent relay must have a minimum load in order to work at all. On the lamp output of the relay is a load sensing circuit. This senses the lower current draw when a bulb has blown, and speeds up the oscillator, doubling the flash rate. This serves to alert the driver that a lamp bulb is out. For these reasons, a load dependent relay is unsuitable for LED lamps.

A Quick Tutorial On Resistance

Just some rules of thumb to remember here. There are two ways of connecting components, in parallel (as the lamps in a turn signal system are connected), and in series. Let's have a look at both methods and what effects they have.

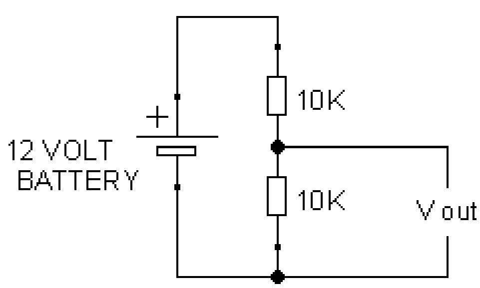
Bulbs have resistive filaments, and as the bulb begins to glow its resistance rises. This can be put to good use, but for now we are just concerned with connection methods and what happens to the resistance with each. For this I will substitute the bulbs for resistors.

Series connected resistors - this is where two or more resistors are connected in a daisy chain fashion.

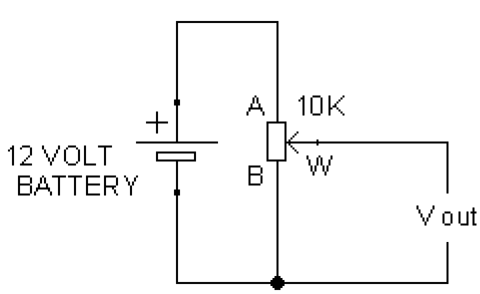


The total resistance between A and B is the sum of the two resistors. In this example the resistors are 10 Kilohm (10,000 ohms), so the total resistance between points A and B would be 20 Kilohms (20,000 ohms). The current flowing through the circuit is halved in relation to a single resistor.

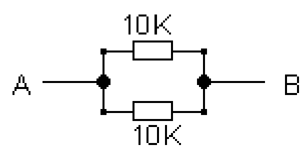
Connecting resistors in series is used to step down voltage. The series connected resistors in this context become a voltage divider, where a lower voltage is made available at the connection between the resistors, as in this circuit. The actual value of the resistors is irrelevent, its their **ratio** that determines the voltage. In this example both resistors have a value of 10 Kilohms, giving a total resistance of 20 Kiloms. That means each resistor's value is 50% of the total, and so with a battery of 12 volts, the voltage that will appear at Vout will be 50% of the battery voltage, which is 6 volts.



Multiple resistors can be connected in this way, giving a number of Vout points with different voltages. This is known as a resistor ladder.



We can make this variable - instead of having series connected resistors in a ladder, with all those Vout points, we can replace the resistor ladder with a potentiometer (variable resistor). This consists of a resistive carbon track with a wiper (W) as Vout. As the wiper moves nearer to the top end of the track at point A the voltage at Vout rises, the resistance between W and point B increases and the resistance between W and point A decreases. This is exactly how the volume control on your stereo works.



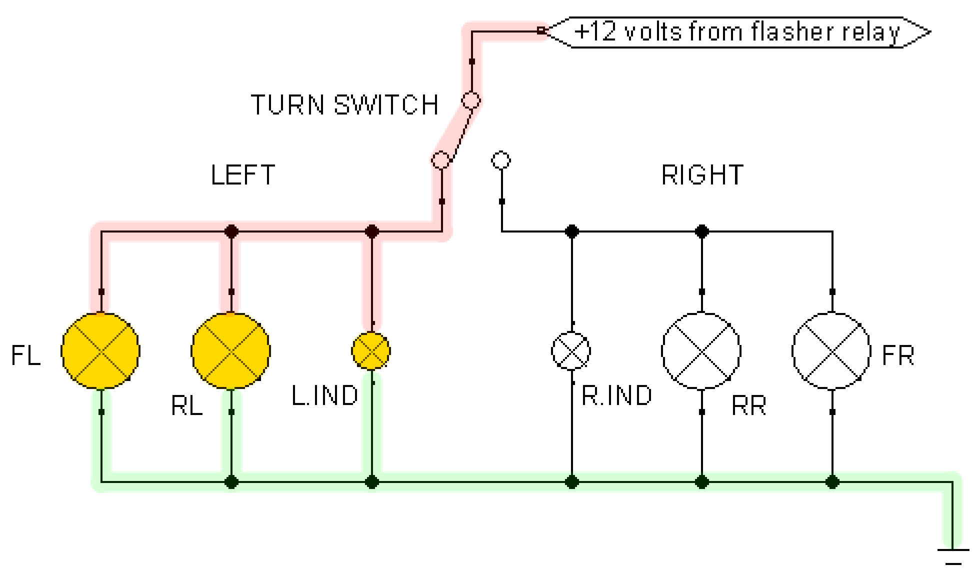
Parallel connected resistors - this is where two or more resistors are connected across each other. If the resistors are of equal value, the total resistance between A and B will be half the resistance of either resistor. In this example we are using two 10 Kilohm resistors, so the total resistance between A and B will be 5 Kilohms and the current flowing through the circuit is doubled in relation to a single resistor. If the resistors are of unequal values, then the total resistance between A and B will be less than the lower value resistor, for example, if we replace one of the 10 Kilohm resistors for a 1 Kilohm, then the total resistance between A and B becomes 0.9 Kilohms.

There are a number of reasons for connecting resistors in parallel:

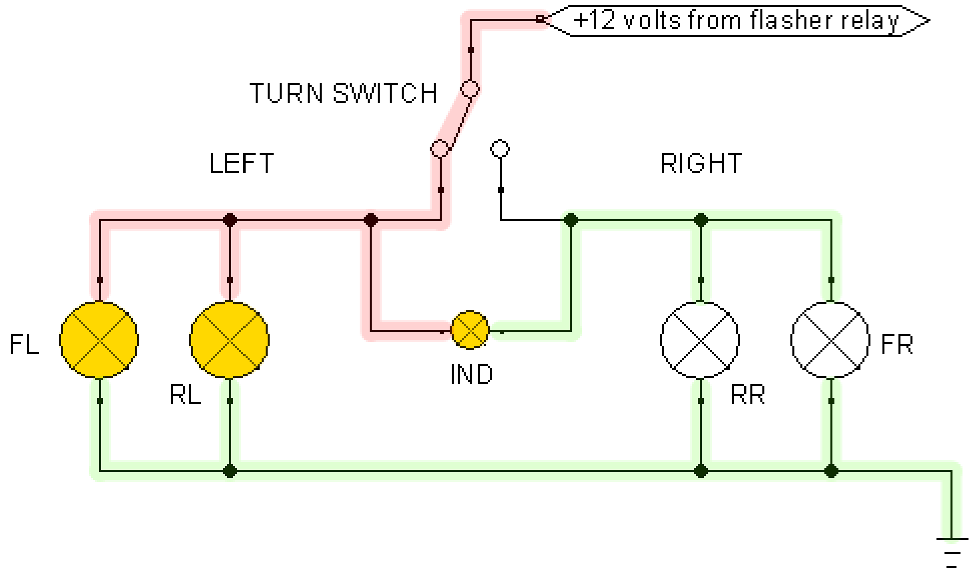
- To obtain a non standard value.
- To create a higher wattage resistor.
- To obtain a precise value.

The Dashboard Indicator Light

I decided that this component deserves a section of its own, since in typical turn signal systems it can have alternative configurations. It is also known as the instrument panel light, or among motorcyclists, the ‘idiot light’. Some systems, especially those in cars, have two of these lights, one for left and one for right. This configuration does not require much explanation since the two bulbs are simply connected in parallel with the turn lamps and abide by the same rules. This is the wiring layout of a 2 light system, with the current path highlighted in red, and ground paths highlighted in green. For clarity I have omitted the flasher relay.



The other configuration has a single dashboard indicator light which is shared between left and right sides. It works in a much more convoluted way than the two light configuration. The bulb, instead of being wired in parallel with the signal lamps, is wired across both sides. So, as the bulb is wired across two power points with no visible ground connection, how does it manage to light up? Well, the bulb takes its power from the turn switch just like the signal lamps, but gets its ground connection through the wire filaments of the turn lamps on the **other side**, which are not lit. When the turn switch selects the other side, the process is reversed. This is a system using a single dashboard indicator light. Again, the current path is in red and the ground path is in green.



In the illustration you will see that the dash indicator is in parallel with the left side lamps, yet it is in series with the right side lamps, which would beg the question: why does the dash indicator light up without lighting the turn lamps as well? After all, the dash indicator has a wire filament too, so it must be providing power from the turn switch to the unlit lamps. The answer lies in the resistance of the filaments and series connection.

A low wattage bulb like the dash indicator has a much higher resistance than a high wattage bulb like the turn lamps. What's more, the turn lamps are fixed in parallel, so the resistance of the two bulbs will be half that of a single bulb, which conveniently provides a low resistance ground path for the dash indicator.

A low wattage bulb takes much less current to light it than a high wattage bulb, and the resistance of its filament (this rises further as the filament heats up) means that only a few mA (1mA = 1/1000th of an amp) flows to the turn lamps, which, at 21 watts would need 1.75 amps each to light at full brighness. So the answer to the question is, yes, the dash indicator does supply power to the turn lamps, but nowhere near enough to light them.

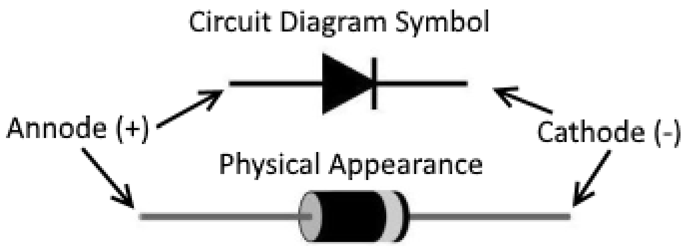
The single dash indicator configuration is ingenius in the way that it works, but can be the spawn of Satan when used with LED turn lamps, which we will tackle next.

LED Turn Signals

In recent times LED turn signals have become quite the rage in all vehicles, due to their low power consumption, next to no heat emission and fast response - when a bulb lights it comes up to full brightness much slower than a LED, due to the time it takes for its filament to heat up or cool down. In comparison a LED will snap on or off since it needs no heat up or cooling time. Instant light. In addition the LED has a much longer life than a bulb, typically 50,000 hours in comparison to the average 1,000 hours of a bulb. But before we talk about LED turn signals....

An Introduction To Diodes

Mysterious to some, a diode is one of the most useful components in electronics. The diode's most outstanding characteristic is that it will only pass current in one direction. Think of electrical energy flowing through a wire just as water flows through pipes (that's why they call it current). A diode is like a one-way valve, it lets current through in one direction but blocks it in the other.



The drawing above shows circuit symbol and actual physical appearance of a diode. The circuit symbol is like an arrow with a bar across. The arrow shows the direction that the diode will let current pass through it, the bar means that if current is fed into the diode from that end, the current will be blocked.

The actual diode has a coloured band (usually silver, or black on small signal diodes) on one end, and this means the same as the bar in the circuit symbol.

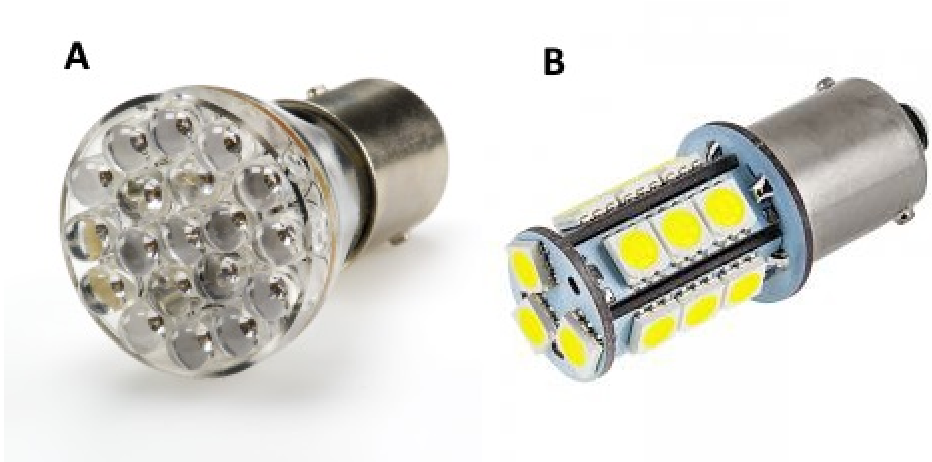
A LED is a diode too. LED stands for Light Emitting Diode, and it has exactly the same one-way valve characteristic as a conventional diode. The only difference between a LED and a diode is that the LED lights up whenever current passes through it.

Converting To LED Turn Signals

Converting from incandescent turn signals to LED ones is a worthwhile thing to do, and is very easy and straight forward. The easiest way is by replacing the bulbs with LED bulbs that use the same fitting, but especially with motorcycles, whole aftermarket lamp sets are available which are tailored for the job and perform much better. If just replacing bulbs, there are a couple of things to remember:

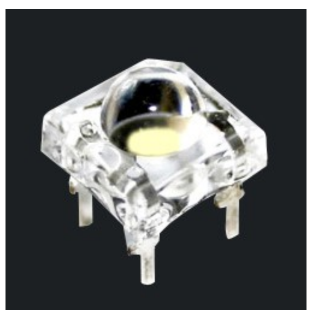
Never use white LEDs inside a coloured lens. White light contains all light frequencies and most of the light escapes through the lens, some of the frequency you require goes with it. Red lights appear to be pink and amber appears as a very pale yellow. Always use LED bulbs which are the same colour as the lens. That way you will get a more efficient lamp with a rich colour.

Choose the right type of bulb for the job. Light from LEDs is very directional and the viewing angle is narrow. Unlike an incandescent bulb, placing a reflector behind the bulb is not much use, since an incandescent has an almost full 360 degree viewing angle. The best that can be expected from a LED is about half this, so the only light that reaches the reflector is that which gets bounced back from the inside of the lamp body. Almost none of the reflected light comes directly from the bulb itself. So though a reflector will help a little bit, LEDs do not need them, and purpose built LED lamps do not have reflectors. Instead, the LED bulb has LED chips facing in the required direction of the light. As an example, consider the two types of LED bulbs below. Bulb B is a 'Corn' bulb and the majority of its LED chips are on the side. This means that almost all the light from bulb B will be put out to the side. In contrast, bulb A has all of its LED chips focussed forward. This makes bulb A the better choice for a vehicle where the light needs to be seen directly from the rear, such as a tail light or turn signal.



However, the LED chips of bulb B have a much wider viewing angle than those of bulb A, so the ideal solution to maximize rearward light would be to use a bulb of type A which has the same LED chips as bulb B.

The LED chips with the widest viewing angle are called Piranha LEDs. These are typically used in electronic notice boards and have a viewing angle of 160 - 180 degrees which makes them ideal for vehicle rear lights.



When Piranha LEDs are used for vehicle lights, they are usually mounted on a board, which has a flying lead with a bulb connector on the end that plugs into the bulb holder. The reflector is removed.

You will also need to replace the flasher relay. As stated earlier, the relay in an incandescent system is load dependent and not suitable for LED systems. The differences between a relay intended for use with LEDs and a conventional relay for bulbs, are that the LED relay does not have the load sensing circuitry. It consists simply of an oscillator driving a relay. It also has a much lower minimum load requirement and will typically operate lamps right down to 0.02 amps (20mA) each, or lamps right up to 3 amps each, which means that the LED relay is just as happy in an incandescent system.

Problems And Countermeasures In Converting To LED

There are a few problems that crop up on a regular basis whenever people convert to LED turn signals from incandescents. I find that the easiest way to cover them is to list them here as problems and solutions.

I have replaced one of my dash light bulbs (not the turn signal indicator) with a T5 wedge fit LED, but it won't light up.

A LED is a diode and so will only light up in one direction. Wedge fit bulbs will fit into the socket either way around. Take out the bulb, turn it through 180 degrees and replace it in the holder.

I got a set of LED turn lamps but they will not work at all. I have checked that the wiring is correct.

This is because the LED lamps do not draw enough current to present a load for the relay to work. Swap the relay for one that is not load dependant.

I have LED turn lamps on the rear, and incandescent lamps on the front. The turn lamps flash very fast.

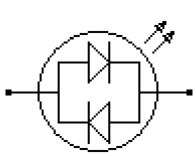
This is due to the very light load of the LEDs. The flasher relay is behaving as it would if a bulb had blown. Swap the relay for one that is not load dependant.

I have an incandescent turn signal system with single dash indicator and have replaced the bulb with a LED. It will only light whenever one side is selected.

A LED is a diode and so will only light up in one direction. When the opposite side is selected the polarity of the LED is reversed and it blocks the current. There are two solutions to this, either replace the LED with a bi-directional one, or modify the wiring to the dash light with two diodes (see the next section).

I have fitted a LED system and have replaced the bulb in the single dash indicator with a bi-directional LED. Now all 4 lamps flash like hazards. Help!

Bi-directional LEDs actually consist of two LEDs in one bulb, and they are arranged in opposite directions, so that no matter which way around the LED is wired, one or the other of the internal LED chips will conduct and light up. These will work exactly like a bulb when in an incandescent system, but just like a bulb, will conduct enough current to light LED lamps up. The solution is to modify the wiring to the dash light with two diodes (see the next section).



Modifying The Dash Indicator Light

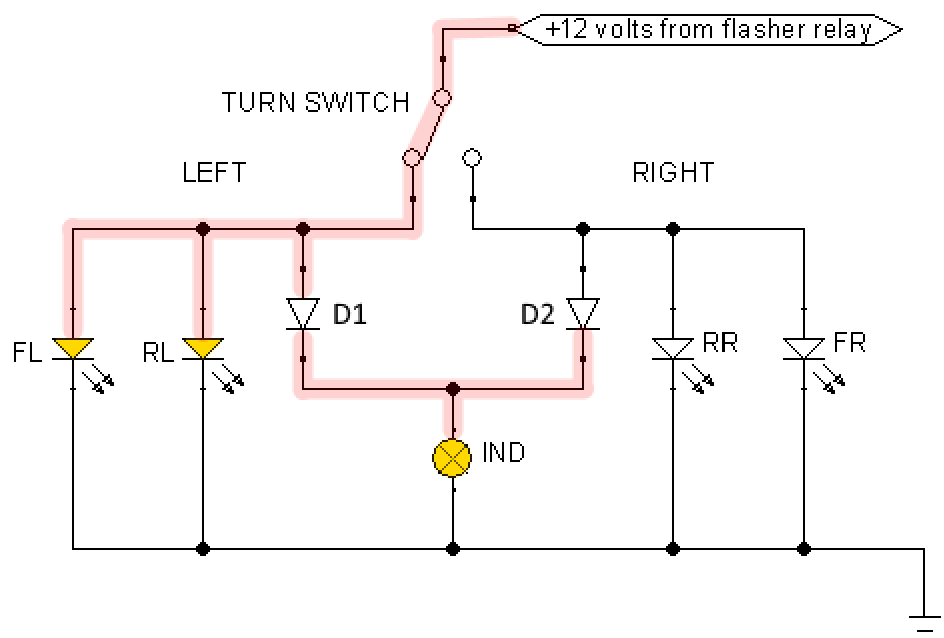
In a turn signal system which has 2 indicator lights on the instrument panel or dash, no problems are encountered. But when the system only has a single dash light, the method used to share it between left and right can cause problems if the incandescent turn lamps are swapped for LED ones. This modification is therefore only relevant to turn signal systems with a single dash light.

What we need to do is change the wiring so that the single dash light is configured exactly the same as the ones in a system with 2 dash lights. However, the problem remains that the dash light still has to be shared between left and right, so we use the ‘one way valve’ characteristics of two diodes to help to achieve this.

In the system with 2 dash lights, the lights are grounded directly, so they are not dependent on the bulbs of the other side for their ground path. So the first thing to do is to cut both the dash light’s wires and connect one of them to any convenient ground point. For example, this can be the ground wire of one of the other dash lights or instrument illumination. If the dash light has a bulb or LED that fits either way around it doesn’t matter which wire you use as the ground, but if the bulb will only fit one way in the holder, use whichever wire is connected to the holder or bulb body.

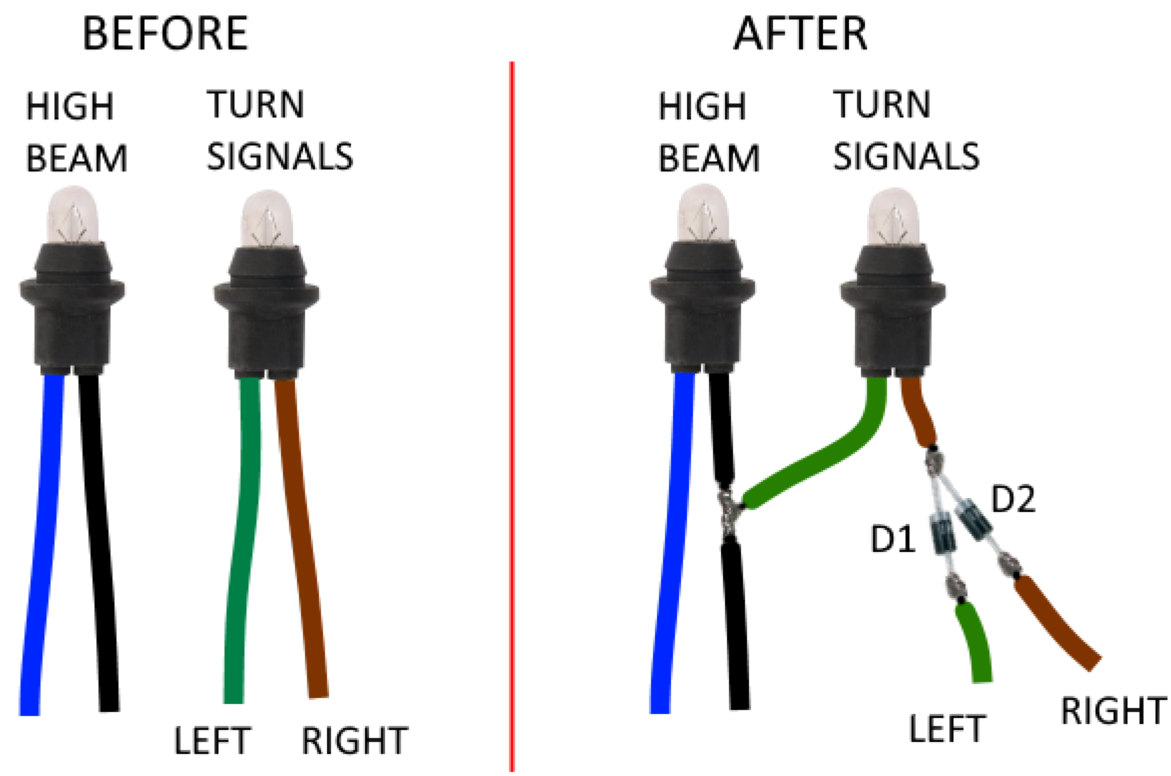
Motorcyclists take note - do not use the oil pressure light to ground to. The light’s ground is disconnected by the pressure switch when the engine starts, so the turn signal dash indicator would not light up whilst the engine is running.

This leaves us with two turn signal wires, and one wire from the dash light. Take the two diodes and connect the ends with the bands together. That should form a ‘V’ with the diodes. Connect the joined ends of the diodes to the remaining wire on the dash light. You should now have a connection that looks like a ‘Y’. Insulate the conection with heat shrink tubing. Now connect the other ends of the diodes to the two turn signal wires (it does not matter which wire goes to which diode). Insulate the connections with heat shrink tubing. The modification is now complete and your new circuit should look like the diagram on the left.



From now on, it does not matter whether you use an incandescent bulb or a LED in the dash light. The current path is highlighted in red. When the left side is selected by the turn switch, diode D1 conducts to light the dash light, but at the same time diode D2 blocks current, preventing it from reaching the other side and lighting the turn lamps. When the right side is selected the process reverses and D2 then conducts, whilst D1 blocks.

Diagrams and descriptions show how it works, but a visual aid of the actual modification would be useful!



Soldering vs. Crimping

For clarity I have shown the solder connections in the above illustration without insulation, but it is very important to insulate all connections after the joints have been made. The cheapest method is to slip a piece of heat shrink tubing over each connection, then another piece over the diodes to wrap them together into a 'diode pack'. For those who do not wish to solder or have no access to soldering equipment a Scotchlok or Posi-Tap connector could be used for the ground connection to the high beam dash light and crimp-on bullet connectors for the diode connections. Solder joints have the advantage of being compact and cheap, but in this case it means that the two dash lights are permanently joined together. There are two methods of making the ground connection between the two dash lights which would allow them to plug together, as illustrated below.