Rambling on about Ignition – More Modern Circuits for Model Engine Ignition

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About 30 years ago high voltage spark ignition began to change. Circuits have been improved and even the ignition coil has changed. The primary focus here is how these system work electrically.

In the last rambling, we discussed using a transistor circuit with points and how this was superior to a just points system. This time the focus will be on the transistor and changing from points to a hall sensor.

Transistors like most parts have recommended operating parameters. For ignition, we care about 3 of them. First, the transistor must be able to handle the maximum current required by the coil. This is called I_C if it is much higher than the required current it is OK, typically I_C is 8-15 amps for ignition transistors. The transistor must be able to withstand the voltage pulse the coil produces when turned off, this is V_{CEO} and the higher the better, V_{CEO} = 400—800 volts is typical for these devices. The final parameter is power dissipation P_D. When the transistor is used as a switch, it has a voltage of about .3 volts across it. The typical coil current is 6 amps so 1.8 watts (voltage X current) is lost as heat in the transistor. The P_D rating indicates how much power can be removed from the transistor. Typically, the NPN power transistors used as the actual switch are packaged in a metal can or plastic package with a metal tab. The metal can and metal tab are there to let heat conduct away from the actual transistor inside the package. Most modern transistors will fail internally at a temperature of 150ºC (300ºF). Should the engine stop with the coil on, a transistor with no additional heat sink area can overheat and fail in a few minutes. Two or 3 square inches of aluminum will be enough heat sink so the transistor does not overheat.

Batteries, especially lead acid, NiCd, or NiMh should have a fuse. They all have very high short circuit currents that could melt wires, damage parts, or the battery. For a 6 Amp coil, I use a 4 amp slow blow fuse. A 4 amp slow blow will open in about 10 minutes at 6 amps. If my engine stops with the coil on the fuse will go and nothing else will over heat and be damaged. If I did not have a slow blow, I would use a fast acting fuse at least 125% of the coil current or 8 Amps in my example. The fast acting fuse will protect against shorts only.

Many people use these transistor circuits so they can replace the mechanical points with a magnet and a Hall sensor. A Hall sensor is an integrated circuit that can measure the strength of a magnetic field. Some Hall sensors provide a linear analog output land some act like a switch. We need ones that act like a switch, when the strength of the magnetic field reaches a set intensity it turns on. The Hall sensor has internal voltage regulation, temperature compensation, and reverse voltage protection. When the magnetic field is strong enough a transistor that conducts a positive voltage to ground turns on. This transistor can only conduct a few hundredths of an amp which is fine since our transistor circuits operates at about 1/100 amp at the points. The output of the Hall sensor is connected to the transistor drive circuit to replace the mechanical points.

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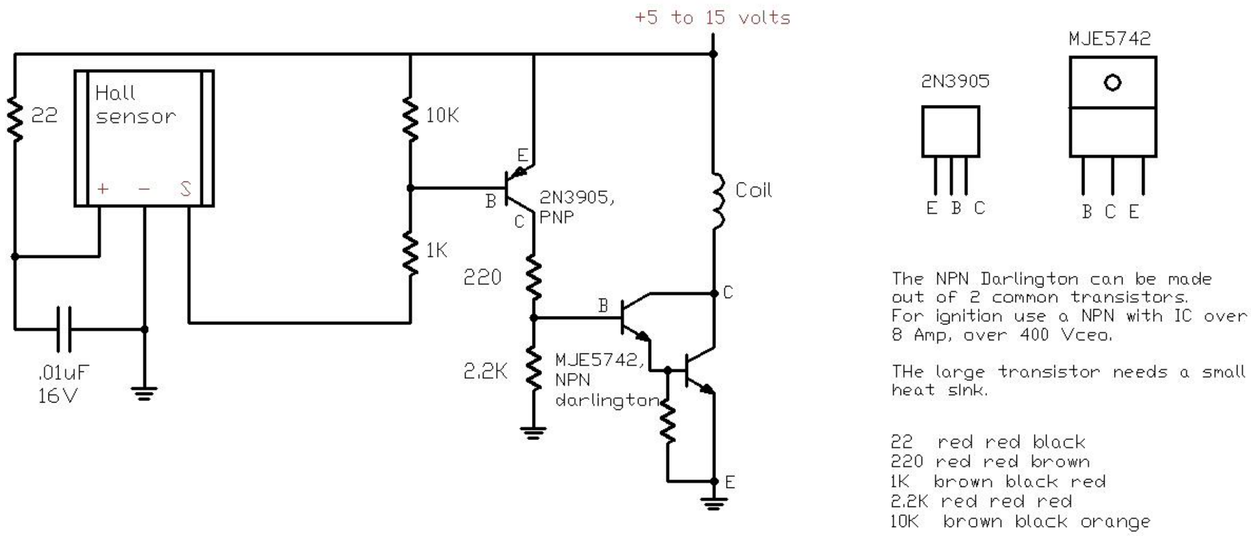

The same battery that runs the coil can power the hall sensor. The Hall sensor operates on a wide range of voltages but none are tolerant of any voltage that exceeds the maximum rating, typically 30V, even for a nanosecond. The ground signal for the hall sensor should not be the ground for the ignition spark, use 2 wires. Secondly, a filter will protect it from other electrical noise in the ignition system. A small capacitor 0.01μF should be placed across the Hall sensor power leads as close to the chip as possible. A resistor 10-22Ω, 1/2W should be put in series with the positive voltage lead.

The magnetic field for the Hall Sensor comes from a small rare earth magnet. The magnet is mounted on a non-magnetic hub or wheel that replaces the cam that triggered the old points.

Most Hall sensors respond to a South magnetic field. The south field is the one on a compass needle that points south. These little magnets are so strong is they are put on edge on a smooth non magnetic surface they will spin and align themselves with the Earth's magnetic field. The end pointing south is the one that should point to the Hall sensor.

If we have a hub that is 0.500 inch in diameter, a magnet that is 1/8 inch in diameter, and a 1 cylinder, 4cycle engine, with the hub on the cam shaft we can calculate the dwell angle. The circumference of the hub is 1.571 inches, of that the magnet is 0.125 inch, so by dividing we calculate the magnet represents 8% of the circumference. One turn of the camshaft is 2 turns of the crankshaft, so the dwell angle is 8% of 720 degrees or 57 degrees of crankshaft motion. We can calculate the actual dwell time that varies inversely with engine speed by dividing 60 by the speed in RPM to get the period of one revolution then we calculate how much of that is represented by 57 degrees of rotation.

Dwell Angle	RPM	Period (SEC)	Dwell Time (Sec)
57	600	0.100	0.016
57	1800	0.033	0.005
57	3200	0.019	0.003
57	4800	0.013	0.002

In the past, we discussed dwell time and how it is the time required by the coil to have a full magnetic field form around it. Typically, this time is about 0.003 seconds. Less time stores less energy and makes a weaker spark. This combination will be good to about 4800 RPM and then ignition may cause misfires and limit the speed.

For low speed or single cylinder engines, this is not much of a concern, but as the number of cylinders increases and the engine speed increases it needs attention. For our 1 cylinder example could reduce the dwell angle if the speeds were going to be low by increasing the diameter if the hub. If we wanted higher speeds, we need a longer dwell, a larger diameter magnet or a smaller hub will do it.

If you are working on a multiple cylinder engine with evenly spaced firing pattern, you can use a magnet for each cylinder. The magnets need to be kept at least one magnet diameter apart. For a multiple cylinder with irregular spaced ignition, like a V motorcycle engine, 2 Hall Sensors with 1 or 2 magnets is used with independent coils and drivers. It is also possible to use one magnet on the far side of the hall sensor to detect a notch in a steel rotating hub. This is a less expensive way to handle multiple cylinder operation.

When planning on how to mount the hall sensor have about 0.030 gap to the rotating magnet. It is also a good idea to have a way to move the sensor so you can adjust the timing of the engine. A simple mounting with slots that allow it to rotate of shift will be sufficient.

Next time I will continue with CDI Capacitor Discharge Ignition.