Ignition Coil Primer

This document contains general information about small coils used for small IC engines. For more details and technical information, see the book “Ignition Coils and Magnetos in Miniature” by Bob Shores.

Theory of Operation

A coil converts relatively low battery voltage to high voltage to create a spark at the spark plug. An ignition coil contains two sets of internal windings - usually a primary wrapped around an iron core, and a secondary wrapped around the primary. The primary winding is then momentarily charged by an ignition module (or points/micro-switch), but interestingly enough, high voltage in the secondary winding is NOT generated until current is suddenly halted in the primary. The collapse of the primary magnetic field then causes a high voltage surge in the secondary, and thus a spark to jump in the spark plug.

Connections:

4-Wire Coil: Each winding has two leads - one on each end, and since there are two windings, there will be a total of 4 leads. The primary winding is connected indirectly to the battery via an ignition module, points, or micro-switch. The windings are not polarized, so it doesn’t matter which end is connected to the battery, and which end is the battery ground. For the secondary winding, one end is connected to the engine ground, and the other to the top of the spark plug. Again, the winding is not polarized, so it doesn’t matter which wire is connected to the plug or engine.

3-Wire Coil: The common denominator of the 4-wire coil is each winding is connected to a ground, so some coil manufacturers will connect one end of each winding together internally, and then label it the “negative” wire. The other end of the primary winding is then forced to be the positive, and the other end of the secondary winding is then forced to be the spark plug connection. This does eliminate one extra wire on the coil, however, in this configuration, the battery negative must also be connected to the engine ground.

(If your coil has only two connections and an exposed steel core, like the Emgo 24-71532, then most likely each winding is connected to the steel core for the ground. Simply connect your ground to the steel core).

Coil Testing / Identifying the Leads:

If there are no identification markers on your coil terminals/wires, you can determine which is which with an ohm meter. Internally, the primary winding is much shorter and uses a larger gauge of wire than a secondary, and thus it will have much less resistance, usually around 1 ohm. The secondary wire is MUCH longer using a smaller gauge of wire (again, internally). A secondary can easily be 100 times longer than the primary. It’s resistance is usually thousands of ohms.

Using all the possible combinations, simply connect your ohm meter to two wires/terminals at a time. When you get a reading of approx 1 ohm, you have found the primary winding. When you get a reading in the thousands (4k, 5k or even 10k), you have found the secondary (note that this could be the primary AND secondary in series if the windings are connected internally (a 3-wire coil), so you can’t reliably find the secondary on a three connection coil). If you get no reading, then most likely you have one lead from each winding. Skip that pair and try another combination. If you cannot find the primary and/or secondary, check your ohm meter settings and try again. If there’s no doubt the meter is working properly, then you may have a bad primary, secondary, or both.

Coil Installation:

When mounting your coil, allow room around the coil for air circulation. The cooler your coil operates, the better. Your ignition coil can be mounted by fabricating a clamp, using ties, or epoxy or a silicone adhesive. If clamping the coil, use just enough force to hold it securely. It is a good idea to mount the coil as far away from any electronic circuitry as possible to minimize or reduce the amount of magnetic interference.

If your coil has isolated primary and secondary windings (4 wires), some experts would recommend that you keep each circuit totally separate and isolated. This means that you would NOT ground the primary and secondary coils together. This will prevent the possibility of any high voltage feedback to your electronics, which could damage or destroy them. Also, use a high voltage wire for the secondary leads, and keep each wire away from all other wires to prevent the possibility of the spark jumping where wires cross or touch. Yes, this can happen even with insulated wire!

If the primary and secondary are connected internally, then it is imperative that your ignition module has a good ground connection back to the engine head.

Operation Considerations:

HEAT is the biggest enemy of all things electrical. Here are a few things to consider: INPUT VOLTAGE (current) DWELL, ENGINE SPEED, and RUN TIME.

INPUT VOLTAGE: Use the lowest voltage that runs your engine properly. If your engine runs with an input voltage of 3.6V, using 6V will increase the current through the coil and generate needless and potentially damaging heat! The increased current also places an unnecessary load on your battery which will decrease your operating time.

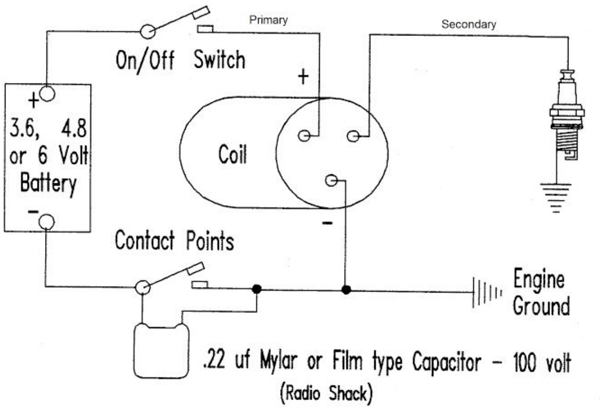
DWELL: The dwell angle is the number of degrees the crankshaft (on a two cycle engine), or the cam shaft (on a four cycle engine) rotates with the coil primary winding energized by the battery. Coils need approximately 2/1000 of a second to build up the magnetic field. Any more than that causes excessive heating and battery drain. To calculate the proper dwell angle for your engine, multiply the maximum engine RPM times .0075. For example, a four cycle engine engine with a top speed of 5,000 RPM, the cam shaft will turn 2,500 RPM, so 2,500 x .0075 = 18.75 dwell angle. A two cycle engine at 5,000 RPM would need a dwell angle of 37.5 degrees on the crankshaft. At low RPM such as idle, the dwell is excessive and will cause more coil, etc. heating than at higher RPM. This can't be helped, so avoid long idle times.

ENGINE SPEED: A two-cycle engine with a dwell of 10 degrees will never reach 10,000 RPM (as an example). As the engine speed increases, the amount of time the points remain closed (or that the magnet activates a Hall sensor) becomes less and less. This does not provide enough time for the magnetic field to fully develop and the output of the coil will diminish. The required dwell for a two-cycle engine running at 10,000 RPM is approx 75 degrees. Beginning to get the picture? Conversely, an engine with a dwell setting of 75 degrees that only runs at 1,000 RPM is heating the coil and wasting battery capacity. Choosing the correct dwell for your engine's operating RPM is important.   Note that dwell consideration is greatly diminished, or completely eliminated, by using a computerized ignition module like the PICTIM.

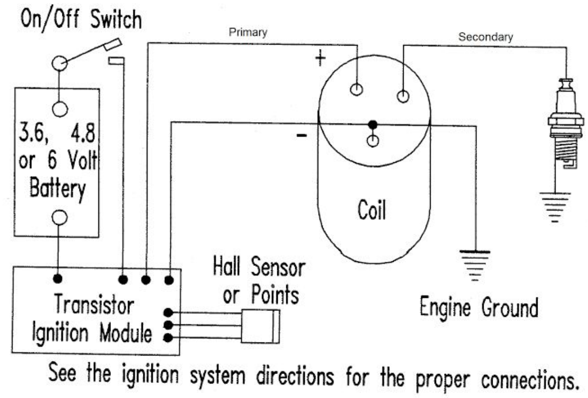
RUN TIME: In a new installation, check the coil every 5 or 10 minutes of run time for up to an hour to see if it's getting too warm. "Warm" is OK, up to about 100 degrees. Even 120 degrees is OK for short lengths of time,

but if much more than this, it is running too hot and you'll need to check your dwell or voltage requirements. Again, if you have an engine with a high degree of dwell (for a high RPM engine), and you idle the engine for an extended period of time, you might notice your coil is warmer than usual.
CAUTION! Never operate a coil in an "open circuit" condition, that is, without a "load" or an acceptable spark gap. Also, never operate any coil to see how far the spark will jump! Doing either of these can, and probably will damage the secondary winding insulation causing a short in the windings. Always provide a reasonable spark gap for the spark to jump across. A .200" spark gap is considered MAXIMUM, and a regular spark plug is much preferred.

The following two diagrams are for coils with 3-wire connections:



Example Using Standard Points & Condenser



Example Using a TIM-6 Transistor Ignition Module

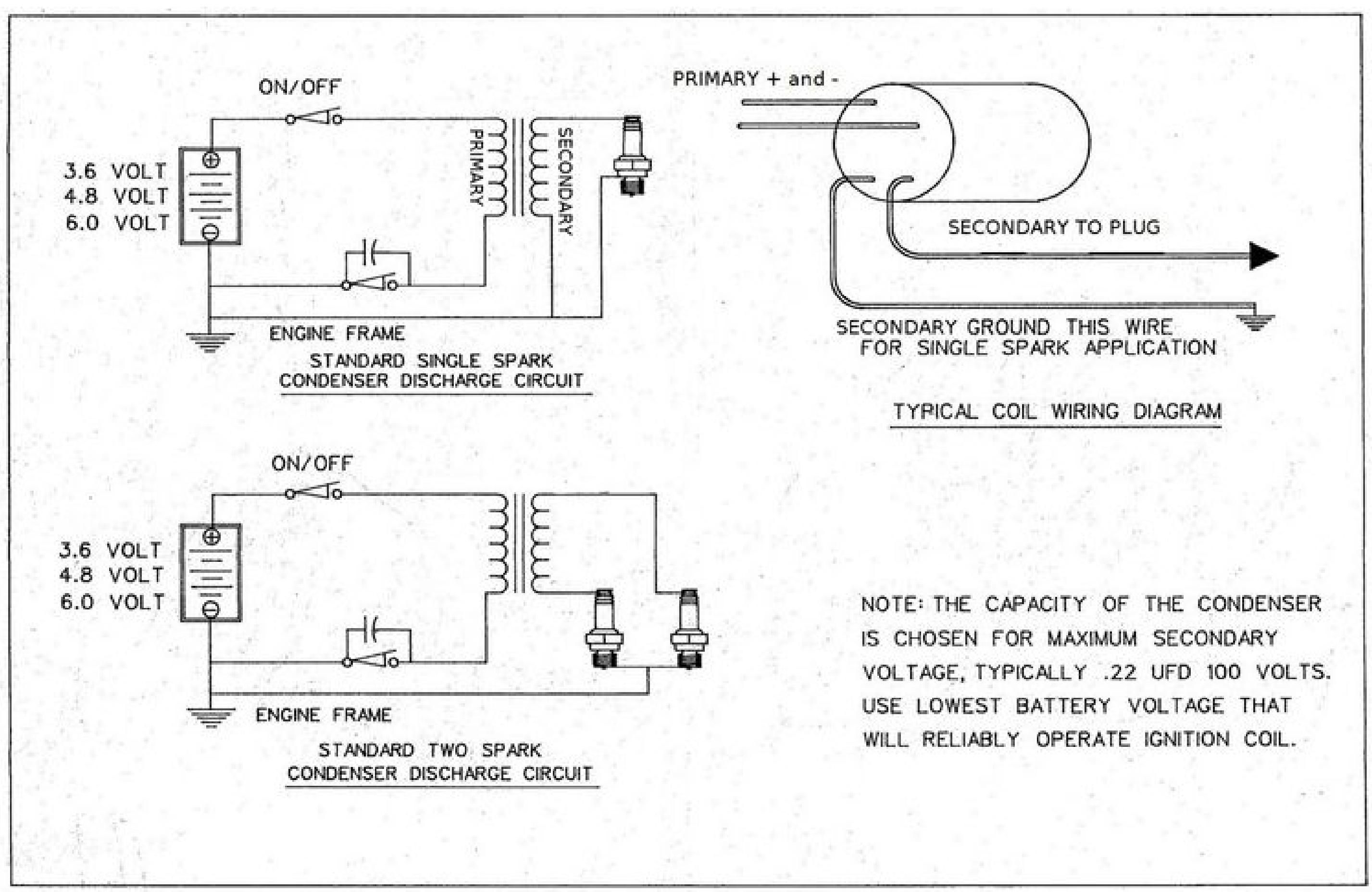


Diagram above an example for a coil with 4-wire connection.