Beta Debug

The problem:

A few months back I went to go over a small log and the bike stalled causing me to crash on the log and crack some ribs. I initially believed this to be carburetion problem as float bowl removal showed fine wet sand accumulated in the bottom of drain plug and discoloration on main jet. Fuel tap is normally left on so water in the float bowl would not evaporate. A missing overflow tube may have been the ingress path for silty water. No other contamination found in carburetor. Carburetor disassembled and blown out with compressed air. Tower and float bowl gaskets replaced and jets replaced with new OEM. Float valve tested and working properly.

Carb replaced on bike. Engine ran normally for a minute or so then died again. This happened several times until the bike would not start at all. This behavior actually occurred once before the crash but I had not taken it seriously. DUH! Spark check showed weak and intermittent spark.

Visual inspection of stator, flywheel and hall sensor showed evidence of water intrusion with some rust on the flywheel and surface corrosion in the magnesium of the side cover. Rust on the ends of the stator coils. Magnet wheel is undamaged and required light cleaning to remove dust on surface. Nothing that would have prevented the ignition system from functioning so it was time to dig deeper. The stator, CDI and ignition coil were removed from the bike for bench testing. Without the ability to spin the flywheel over the stator there were limits of what can be tested for now.

The trigger sensor shows what appears to be curved asymmetric wear on the pole piece of the trigger sensor. Whether this is wear from contact with the flywheel or shaping from the factory is unknown. It just doesn't look very nice.

Executive Summary (Get to the point Dan!)

The bike is fixed though I don't know which fix fixed it. So here's a list of things done.

- **Connectors pulled apart and reseated with dielectric grease.**
- **Ground wire added for spark plug to ignition coil frame. Will be replaced with wire to cylinder.**
- **Corrosion on stator pole pieces removed with fine sandpaper (has no effect but looks better).**
- **Cut 5mm off spark plug wire and reattached cap.**
- **Cleaned rust off ignition coil's frame for better contact**
- **Paint removed on frame at base of CDI mount to improve ground connection.**
- **Pole piece of trigger sensor cleaned up (most likely no effect but it just looked trashy)**

Learndings (Simpsons fans will get the reference)

- **Trigger sensor is not Hall effect but reluctance sensor. Basically a coil and magnet.**
- **300Ω spec for trigger coil in Stator may be wrong. Nominal appears to be 184Ω.**
- **The ground for the frame is inadequate.**
- **The connectors under the seat are a pain to get back into position.**
- **Beta is getting better in their electrics but they can still improve.**
- **I suspect a fair number of the Stators sent to the rewinders really don't need to be repaired.**

Initial Plan of attack

Pinout of the CDI module is known for operational connections but operating details are unknown such as trigger sensor operating voltage. Operating voltage is provided by the CDI module. Assume the 2-wire interface for the trigger sensor detects change in current. Input AC signal from stator CDI charging coils is unknown. High voltage output from CDI module is unknown but is estimated to be~200Vac. Output from module may require load from ignition coil.

Power module with 14V DC from external supply.

Measure all pins of CDI module for static voltage.

Measure output voltage on Trigger Sensor pins 10 & 11.

Power Trigger Sensor and measure current draw for magnet present and not present.

Measure ignition coil primary and secondary with LCR bridge.

Measure Stator CDI charging coils with LCR bridge.

Reinstall stator and measure CDI charge coil while kicking over engine.

Install copper washer with tab to ground of ignition coil.

Future Work

I’d still like to design a way to test the individual components off the bike. First I need to understand the signals generated by the stator and how they are processed by the CDI. To do that I’m designing a “breakout” board that will plug into the CDI on one side and the Stator harness on the other. This will allow me to see the signals as the bike is running.

Versions	200cc	125cc - 250cc - 300cc
black-white	320 ohm±15%	320 ohm±15%
red-blue	300 ohm±15%	15 ohm±15%
yellow-brown	0,45 ohm±15%	
yellow-yellow		0,6 ohm±15%

3.10.1 TESTING THE IGNITION STATOR

The stator winding must be inspected while the temperature of the component is approximately 20 °C.
The inspection may also be performed with the generator coupled to the engine.
Disconnect the 12-way black connector between the generator and CDI and with the use of a multimeter, verify that the resistances read between the terminals shown below fall within the prescribed range.

Figure 1 The Stator values as noted in the owner's manual. I suspect the trigger value is from an earlier revision and has not been updated.

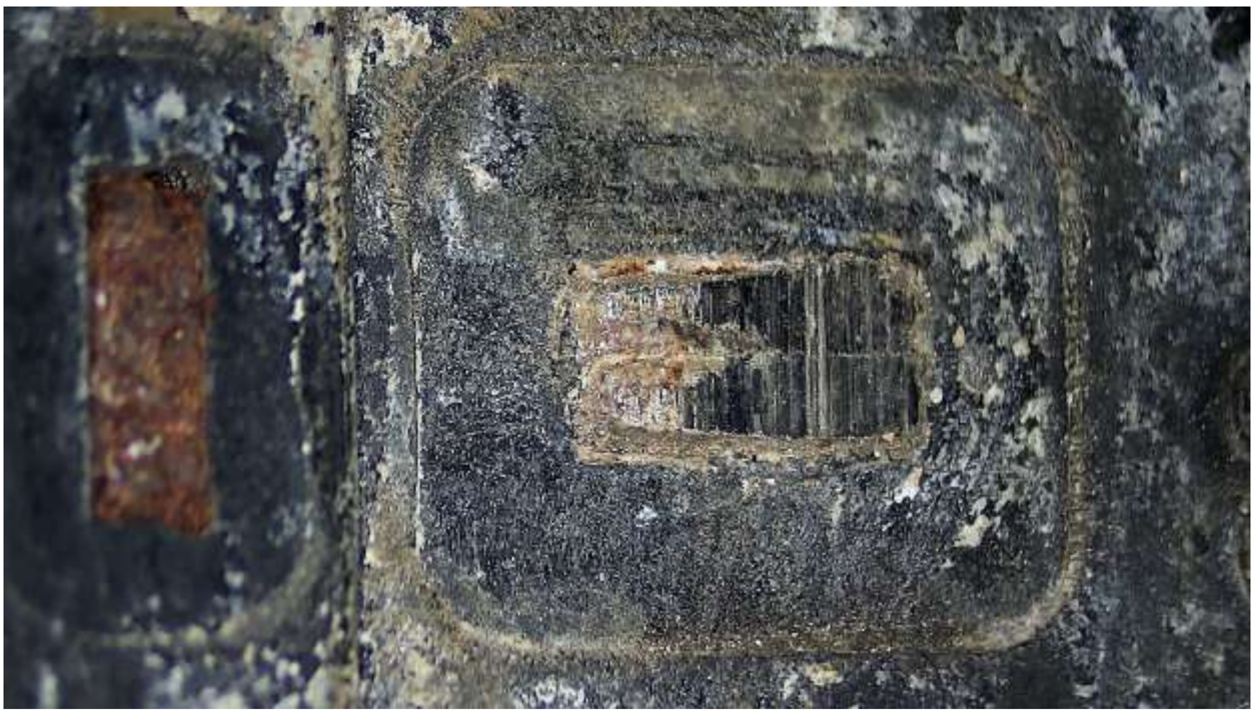


Figure 2 Close up view of the trigger module interface to the flywheel. Note the apparent wear on what I assume is a pole piece.

The CDI unit

Beta appears to use the same CDI hardware for all their current two-stroke models with the difference being how the modules are programmed. There is a part number sticker on the module that points to a generic CDI on the Beta service page with the note “contact the factory”. There is a second sticker on top of this that has the part number for the specific model of bike which denotes a programmed module. More details of what the module is capable of can be gleaned by looking at the schematic of the enduro models. These include an “Engine Fault status line three lines for a “Throttle Position Sensor”, a “Mixture Oil“ status line and two OBD lines. I suspect there are at least two to four lines for a serial programming interface using either SPI or I2C protocols. The CDI receives ~14.9Vdc from the regulator output while the engine is running. Initially this confused me as it is nominally a 12Vdc system but for systems using a battery for starting and power without the engine running the higher voltage is necessary to charge the battery and is typical of an automotive system. The CDI charge coils generate ~200Vac (untested but this is what I read somewhere) which I assume is rectified and fed to the high voltage capacitor. In a previous CDI I disassembled from 2001 this was a 400V 2uF polystyrene capacitor.

Figure 3 Part number for programmed 300 2T Factory module.

Figure 4 Number for unprogrammed module

The Stator (including trigger sensor)

One thing to note about the current Beta trials bikes is the stator no longer provides the system ground. From the stator's point of view, the system is isolated and "system ground" is no longer provided by the frame/engine with one exception which I'll get into later. All components of the electrical system have a ground wire which connects to a nexus within the wiring harness. In troubleshooting my bike all coils in the stator measured nominal except for the trigger sensor which measured 184 Ohms. This is outside the nominal spec for the trigger as stated in the service manual (300 Ohms ±15%). When I measured this on the second bike which has had no problem it also measured 184 Ohms. So I'm now thinking this is not a problem and the service manual may not be entirely accurate. I think I was wrong about Beta using a Hall Effect sensor for the ignition trigger. Static testing of the CDI using a bench power supply showed no voltage across the sensor which is necessary for a Hall sensor. With a Hall sensor, the output is a change in current when the sensor detects a magnetic field. Where a Hall sensor is used this is a static value and should show a constant current depending on magnetic field strength. When I looked at the output of the trigger sensor with a meter I noticed there was no static output but a current pulse appeared when the magnet was moved. This pulse showed up even with no power across the sensor. The pulse also showed when a ferrous metal was moved near the sensor. This behavior is characteristic of a variable reluctance sensor as a Hall sensor detects a *static* magnetic field while the reluctance sensor detects a *change* in magnetic field. A Hall sensor has a semiconductor chip that generates a tiny voltage in a magnetic field and typically requires a MOSFET to gain up the effect to a useable level. This is why Hall sensors require an external power source. A reluctance sensor is basically just a coil of wire with a magnet so it doesn't require an external power source and is by definition as reliable as a piece of wire. One thing that did confuse me in the static power up of the CDI is there is a pulse of approximately 1.24V that occurs on the trigger sensor line that shows up about once a second. I'm thinking this is part of the self-test mode of the CDI that will assert the Engine Fail indication that is used for the two stroke enduro models that are streetable in the EU.

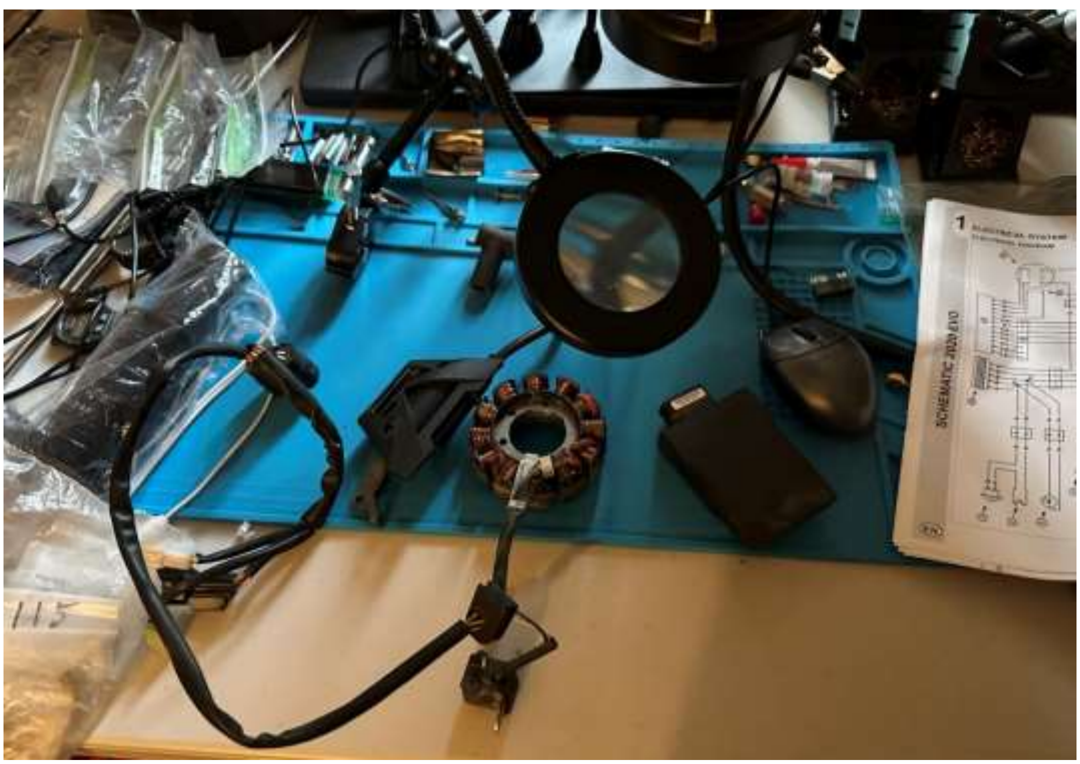


Figure 5 Ignition coil, Stator W/harness and CDI (Along with bags of carb jets, microscope lens and assorted other debris. As still lifes go it's no Vermeer)

The Connectors

I'll focus on the main connectors under the seat that interface the CDI/Stator to the rest of the bike and since this is an American market EVO all the lighting and street FooFoo has been stripped off other than the LED head and taillights.
The CDI module is connected via an 18-Pin automotive connector (JAE Electronics MX23A type if you're interested). Coming from the stator are the two trigger sensor wires and the two high voltage CDI charge wires to the CDI, the two wires from the lighting coils do not connect to the CDI but go directly to the Regulator/Rectifier under the headlight. Coming from the CDI connector and splitting off from the harness is a four wire connector that includes a wire that goes to the ground nexus, the wire that goes to the mapping switch, the wire that goes to the Kill switch and the high-voltage primary ignition wire that goes to the ignition coil. To the 18 pin CDI connector is another four wire connector with the 12Vdc from the Regulator/Rectifier output and three wires that are dead ended at the connector These are the "Engine Fault" wire and the two OBD wires.

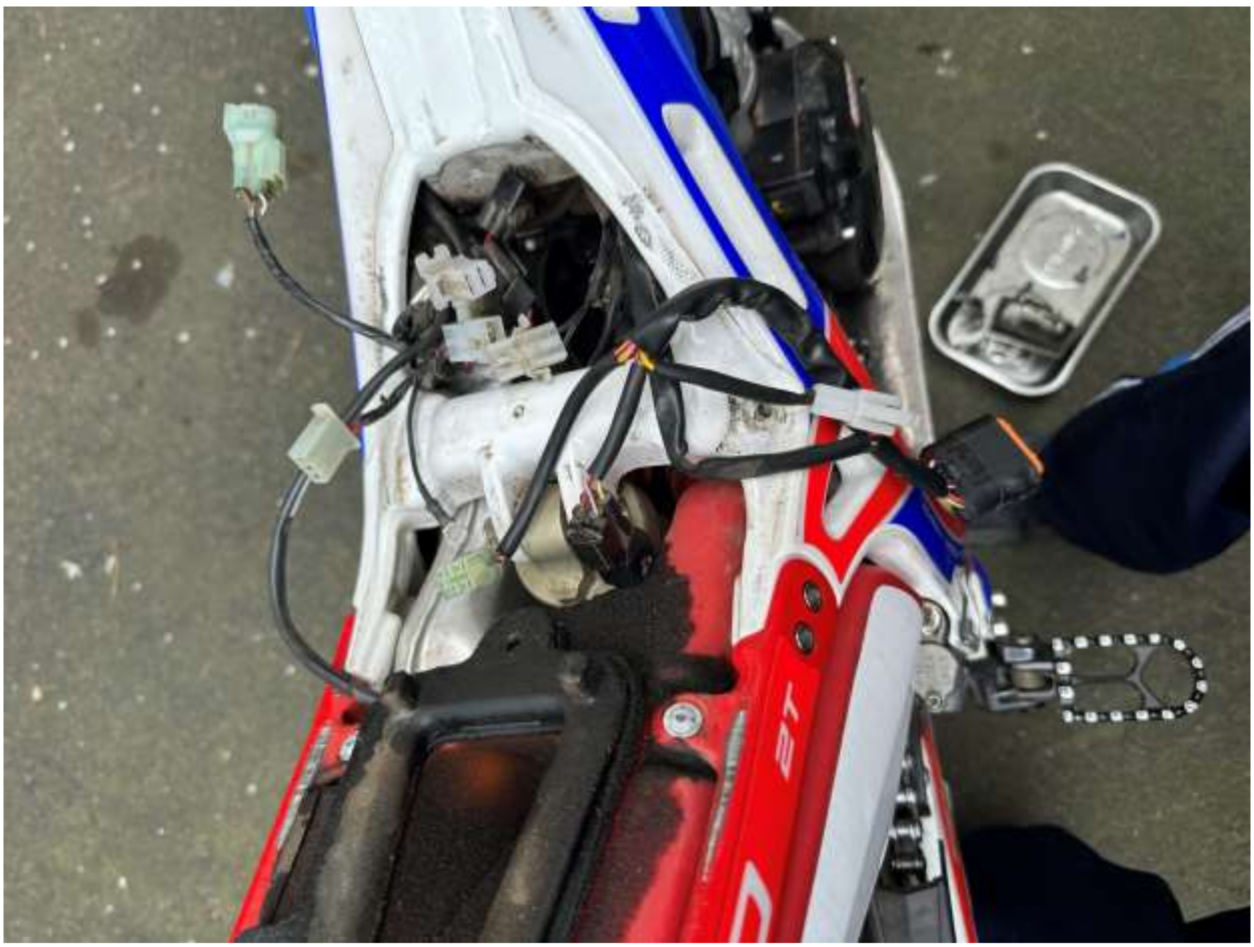


Figure 6 Bar puzzle of connectors. Good luck

Figure 7 CDI connector,
Note Red/White high voltage wire to ignition coil and Brown wire to ground nexus. Blue and Red wires are the CDI charging wires from the Stator. White/Black wire is the Kill Switch and Yellow/Red wire is the mapping switch.

Figure 8 CDI connector,
Note Black and White wires to trigger sensor on Stator. Red/Black wire is 12V from regulator.

Ignition Coil

The ignition coil is a common terminal type where the two windings share a common connection. There is no terminal for the coil ground relying on the mechanical connection of a wire lug secured to one of the mounting screws through the coils laminated core. There may also be a secondary ground connection through the mounting bracket to the engine though this may not be as secure a connection owing to the mounting to painted or oxidized points on the engine or frame.

Figure 9 These are the ignition coil connections. High voltage red/white wire to spade lug and black wire to coil frame from ground nexus.

The “Ground” Wire

As noted there is a ground nexus in the wiring harness that provides the reference point for all the electrics on the motorcycle. This is different than the classical method of grounding a vehicle electrical system through the frame/engine. There is one electrical component that requires ground through the engine though and that may be the weak point of how Beta has wired this bike. The spark plug return current requires a hard ground through the cylinder head. How this current gets back to the common point of the ignition coil is what bugs me. If we assume the mounting bracket of the ignition coil is not making stellar contact with the frame/engine case, then the entire return path for the spark plug is through a wire that comes from the ground nexus. This wire can be found under the seat connected to a single screw into the frame that also mounts the support bracket for the CDI module. This is not ideal as the frame is painted in this area and you are relying on contact through a small screw that may develop a higher than expected resistance. The other factor to consider is the inductance of the return path. The spark is a fast rise time high voltage/current signal. The return current has to pass through the spark plug shell to the cylinder head to the cylinder to the engine cases to the frame to the ground screw through the ground wire to the ground nexus to a wire connected to lug bolted to the ignition coil mount. Not a very straight forward path for a big pulse of current. In automotive systems, engines and frames are connected with wonking big wires and the assumption is they share a hard ground and it’s never thought of again. That’s an assumption that may not be valid the way Beta has wired the EVO.

Figure 10 This is the return path for the spark plug current. It may not be adequate.

One other note,

I have an S3 low compression head on my bike. It has a lovely gold anodized color. It didn't occur to me until I was trying to measure the continuity between the spark plug shell and the ground reference of the electrical system that anodized aluminum is an insulator. I'm reading ~150 Ohms between the cylinder and the spark plug shell simply because it is anodized. This may not be significant because the spark plug cap itself has a 5k Ohm resistance to minimize electrical noise (by slowing the rise time of the spark current) but it's something I noticed so I'm just putting it out there. I intend to pull the head off my bike and sand off the anodizing where the water jacket contacts the top of the combustion chamber just to make sure there is a good contact. I can them move the coil ground wire to one of the cylinder lugs.

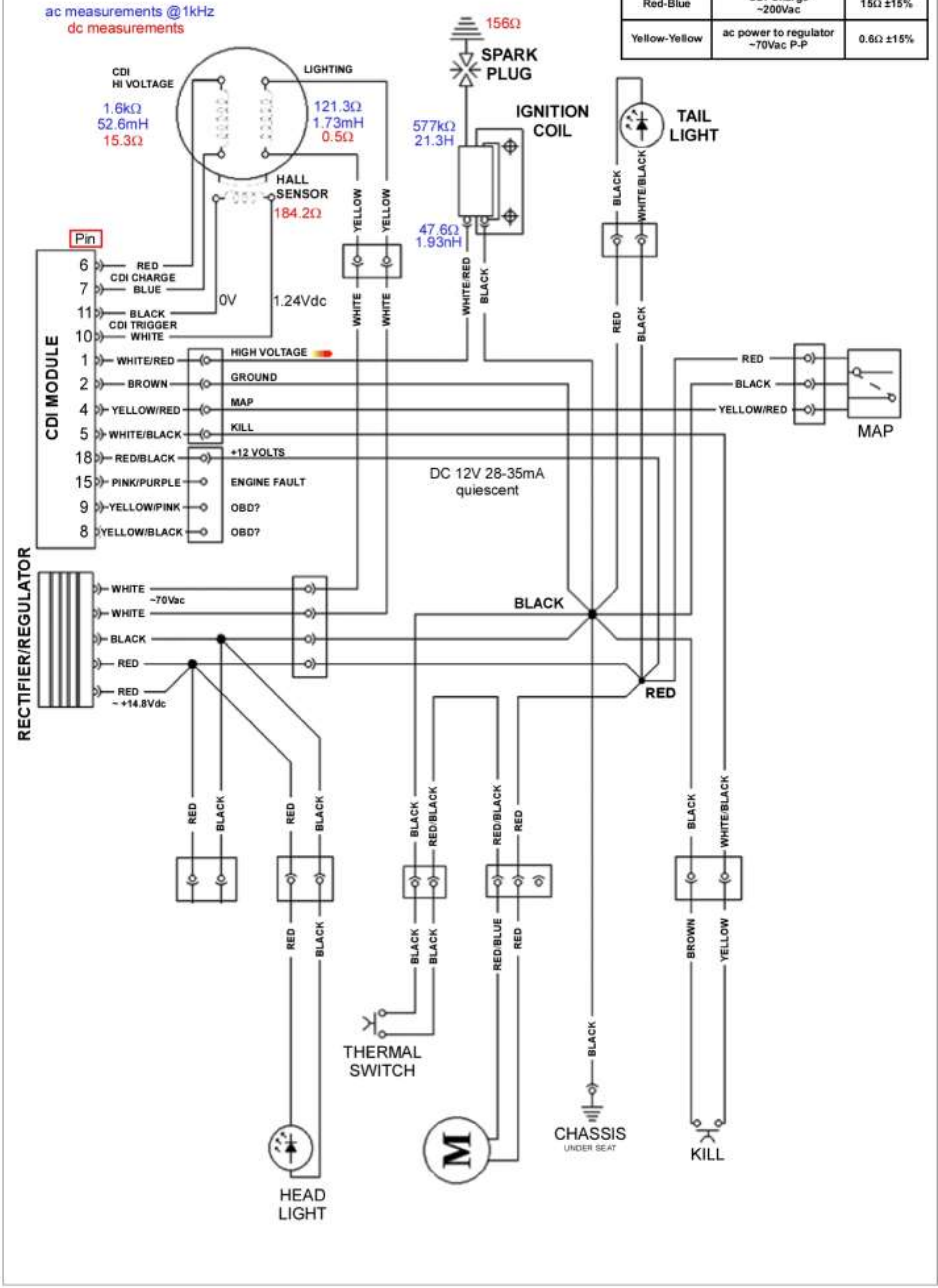
Figure 11 Temporary ground wire connected from spark plug base to ignition coil frame using a copper washer. This will be replaced with a wire from the cylinder base lug.

Addendum

Noticed this little detail while inspecting other pictures. This is the seal on the backside of the connector for the high voltage wire that goes to the coil. Probably irrelavant but noted.

ELECTRICAL SYSTEM

Nominal Stator Readings 125cc-250cc-300cc		
Black-White	CDI Trigger ??	320Ω ±15%
Red-Blue	CDI Charge ~200Vac	15Ω ±15%
Yellow-Yellow	ac power to regulator ~70Vac P-P	0.6Ω ±15%



SCHEMATIC 2020 EVO