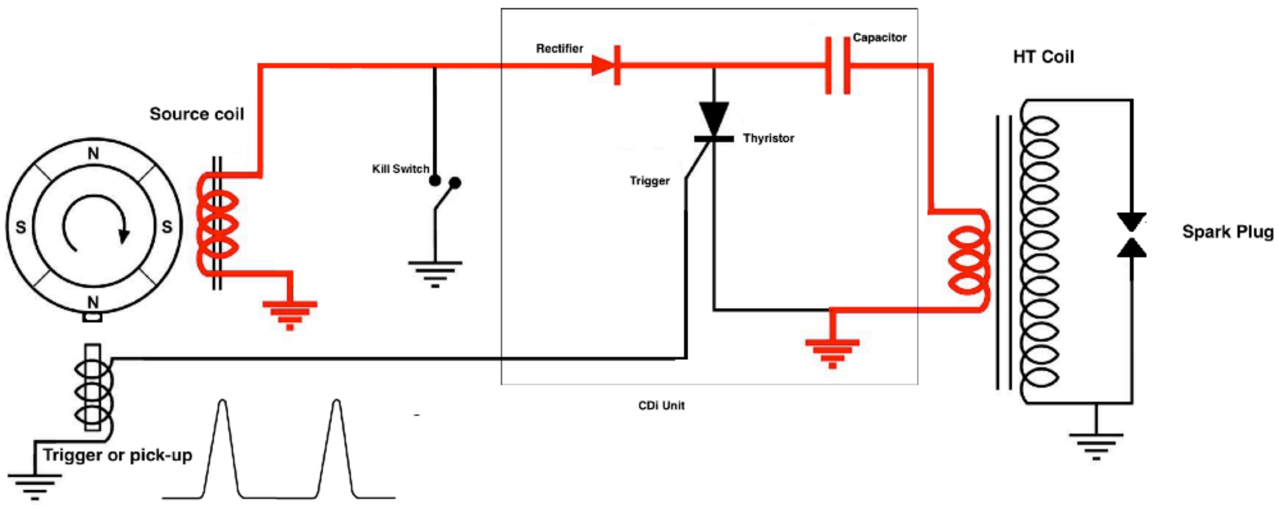
Capacitor Discharge Ignition Fault Finding

CDi ignition is a system of finely matched components and as the system ages it can throw up some perplexing and unique problems. The shop manual is often vague, data given proves misleading and very common problems are often not mentioned. We have created this guide to illustrate these issues and show how to identify faults so that owners can avoid the common mistakes and errors that inexperienced mechanics make. One trap that many fall in to is to assume that because a new part has not fixed a problem that new part must be faulty. This is a common error novices make when dealing with old electrical systems. Our experts take you through fault finding old CDi ignition systems and demonstrate how to avoid such mistakes and wasted time.

Self generating CDi ignition comprises several elements; source windings and trigger windings that are energised by magnets in a crankshaft mounted flywheel, CDi unit, kill circuit, HT coil, plug cap and spark plug. It is a simple, reliable system that works without a battery. It operates at around 200 volts, hence must not be connected to the vehicle's charging system. The CDi unit, windings that produce the power and trigger it are all very finely matched and work together like parts inside an engine. Just like mechanical parts these all must be exactly to OEM specifications and in good order for the system to function properly.



Shop manuals tend to be very misleading when it comes to trouble shooting CDi ignition. Our methods have helped thousands of our customers over many years to get to the bottom the perplexing range of problems aging CDi ignition systems create. Before we get in to looking any further these are extremely important points to appreciate first and before any troubleshooting commences:

Warning: Self generating CDi or the HT coil must never be connected to the DC Battery power. This means the system is never 'live' when the ignition switch is on. It is powered direct from the generator and only when the engine is running

1. CDi units are not testable without specialist equipment, however very useful information can be gained from the rest of the system with a multimeter.
2. The shop manual can (and does) mislead you with resistance measurements of windings, particularly when they give an acceptable 'tolerance' on what is a pass or fail. We will show you how to get far more accurate results.
3. Do not make up your own tests, at best there is no reliable data to define a good or bad result. Many dreamt up tests will expose the person doing them to dangerous voltages.
4. When checking CDi systems, turn the engine normally with the kick start (as if starting the engine), electric starter or starting rollers. Do not use electric drills or any other such methods

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as these often lack the rate of acceleration to energise the windings and electronics. At low RPM acceleration is key to allow the ignition to ‘light up’.

5. If electrics really is not your thing get help from someone who understands electrics and who knows how to use and read a multimeter.
6. There is no substitute being able to see the full system with the bike there in front of you.
7. Fitting new piston rings to a badly worn piston and barrel then expecting the engine to run like new is the mechanical equivalent to replacing just one item in an old CDi system and expecting miraculous results.

Start simple. Define what the machine is doing. Follow the shop manual for standard trouble shooting. We can’t stress this enough - and get a copy of the shop manual. Replace spark plugs (don’t clean them or get old ones from the tool box - fit new ones) - modern fuel is not kind to them and cleaning them is not always a guarantee they will work. Check plug caps with a multimeter, most should be 5KΩ (5,000 ohms).

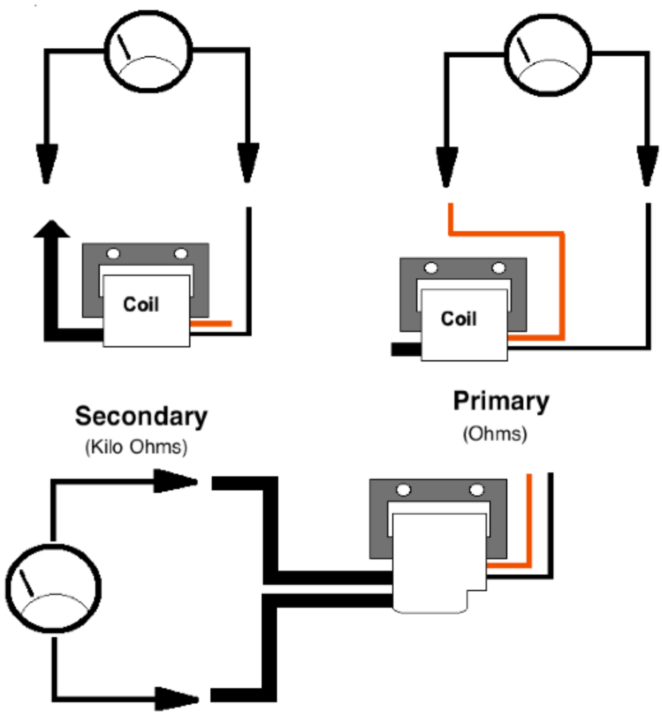
If there is no spark first check the operation of the ignition switch and any kill switches. The wiring diagram in your shop manual will identify the wire that kills off the sparks, it will be the one that goes from the CDi box to the ignition switch and kill switch (if one is fitted). If it is disconnected and the ignition sparks when you kick the engine over, you have a switch or wiring fault.

HT coils. Visually inspect them for damage and obvious faults like cracks, shoddy connectors and cuts in leads. Tired, old coils should be replaced. More in depth testing requires a multimeter. Such tests are done with the the HT cap(s) removed.

The resistance of the primary is measured between the two primary connections, if there is only one then the coil’s metal frame is the second (earth). The secondary is measured between the HT lead and primary earth connection. You are looking for a steady reading in both cases.

On dual HT lead coils the secondary is measured between the two HT leads. The primary is measured between the two primary wires as before.

Warning: Dual lead HT coils MUST have both HT leads with a path to earth if testing by cranking the engine and looking for a spark. The coil will burn out even just kicking the bike over a few times if the path to earth is lost on either lead.



The metal frame is the earth if there is only one primary wire

The secondary of dual lead coils is check between both HT leads

The primary is exactly the same. The metal frame is the earth if there is only one primary wire

Consult your shop manual for values

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Typical system construction. A CDi system consists of finely matched parts, all of which must be within their useful life expectancy and precisely to OEM specification if it is to work at maximum efficiency (within 2% for newly manufactured or repaired parts). The CDi unit needs very exact signals and voltages in order to give the correct timing.

The source winding that powers a CDi unit is made up of tightly bunched, very fine wire that carries around 200 volts when operating. There is a very thin coat of insulation on the wire although it is clear, so the wire looks like plain copper, this coating prevents shorting to the surrounding wires. A layer of base insulation stops power leaking to the laminate core. As this insulation ages it is no longer able to withstand high voltage, allowing power to randomly leak away. It is the random way power bleeds away through old insulation that gives many baffling symptoms and problems.

Multimeters test wire resistance, not insulation strength. Also multimeters only use a tiny current when measuring resistance to avoid damaging the part under test. This checks the copper wire resistance but not the insulation strength between the wires or to the laminate core, so a multimeter by no means tells you the full story. Weak insulation is the most common reason why parts checked by a multimeter pass, yet in use do not to work properly.

Common sense vs unrealistic expectation. Electrical parts 'wear out' just as the other parts of the machine do. Your can't measure this like measuring a piston, none the less electrical insulation degrades as it ages - even if not used. Therefore time since manufacture is the key method to determine how 'worn' an electrical part is. NOS electrical parts are a last resort for this reason. Where a fault exists time since manufacture is so vital it has to be applied arbitrarily, even to N.O.S parts. A visual inspection is also very important, dry and flaking windings will be very apparent.

Manufacturers do not state when windings etc should be replaced but it is apparent from failed parts sent in for test and repair that across all manufacturers, windings and electronic units become very much less reliable when they reach 10 years old, with the failure rate increasing exponentially the older the part becomes.

Age of system	**0-10 Years**	**10-20 Years**	**20 Years and over**
Success rate when replacing just one part in the system	**95%**	**50%**	**25% or less**

Time since manufacture VS success rate of single item replacement in CDi Ignition systems

So from everyday experience we see that if you replace a single component in CDi ignition component in the green zone, you have a 95% chance that one part is all that's needed, orange is 50%, red zone its 25% or less. At this end of the scale you have to consider the whole system will need a thorough and careful overhaul back to its OEM new condition. Time since manufacture is the key identifier for electrical parts, just like mileage covered is used to indicate engine condition.

Having said this, if you have a system that is in the orange or red zone, just like a high mileage engine it may carry on working fine for many years. But this does not mean it is giving the same performance as when new and if you try and make a tired engine perform like new, all you actually achieve is cause it to breakdown very soon. Electrical items such as CDi units and the windings that power them lose 'performance' with age too. If you replace say the ignition module the capacitor inside is new and will try and drive the generator windings like new, in an old system the only result may be that the new part highlights weakness in the rest of the system.

It is simply unrealistic to blame brand new parts for problems when they are mixed with end of life parts in the red, 'time since manufacture' zone. This a mistake inexperienced mechanics often make. The common sense solution is to trace what else in the system is stopping the new parts from working correctly, then replace or overhaul these too.

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Specific Symptoms. CDi is nothing more than a magneto with an electronic switch and a large capacitor instead of points, its more accurate and the electronics can be made to produce different timing curves, but at the end of the day the system is just a magneto. Those who are familiar with the Kawasaki triples will see the CDi unit is marked ‘Solid State Magneto’ or SSM which is a very apt description.

If you are old enough to remember motorcycles with separate magnetos, you may have come across one that fades and losses its spark when the engine warmed up. This is due to aged insulation in the magneto winding. Old CDi systems suffer the same problems that come on when the engine is hot and go away when its cool due to the high voltage windings that power them.

CDi ignition may show the following symptoms and faults:

-Starts normally when cold but is hard to start hot or won’t start hot.
-Engine runs then a misfire develops or engine cuts out. Fault clears when cool.
-No, weak, intermittent, yellow or thin white spark is often seen.
-Runs with an old CDi unit but not a new one.
-Will start and rev in neutral, when loaded engine won’t rev out.
-Mis-fires at higher RPMs (where all other factors have been eliminated).
-Won’t kick start, but will start on the electric starter or bump start.
-Not running on all cylinders.

A twin cylinder machine with a single HT coil and two HT leads has the same CDi as found on a single cylinder machine. When the generator is weak, or the capacitor no longer stores enough power there is insufficient power to send a spark strongly to both HT leads. The fault may swap cylinder randomly or stay on one, or get worse as the engine warms up.

Most of these symptoms are caused either by the power leaking away through weak insulation, shorted windings or tired old capacitors that have dried out not storing enough charge. These faults can be there all the time or only show themselves when heated or the engine is placed under load. A brand new CDi will place the full normal load on the source windings, if these have old, weak insulation they may stop working, the result is no spark.

It seems obvious but be sure you are not missing a fuelling issue because you have assumed ultra-sonic cleaning and a jet kit fixes 30 year old, worn out carburettors. It does not. Experience shows ultra-sonic cleaning is far from a sure method. Complex, inaccessible chambers and galleries are very often not effectively cleared, even after several sessions in the cleaning tank.

How to get better results from winding resistance readings. This test is commonly shown in the shop manual and is a very valid check. Our method is to improve on this method and clarify the resistance data by applying realistic tolerances and temperature compensation. If you carry out resistance checks and get an obvious fault such as no reading, one that is not steady or one out of tolerance given you have found the problem. However very often you get readings that sort of seem OK. Weak insulation that has yet to fail completely will not show up on this test but a fault that comes on when the engine is hot is a sure sign of weak insulation inside the winding.

1. **Copper wire changes resistance with ambient temperature,** however nowadays it is very easy to use an online calculator to correct your readings for temperature. Alternately fill out the test results form at the end of this document and our technicians will correct the figures for you. The resistance of windings is always given at a specified temperature, normally 20 degrees C (70F). You will only need to do this if you are more than a few degrees away from 20 degrees C. This vital information is often missing in the shop manual.

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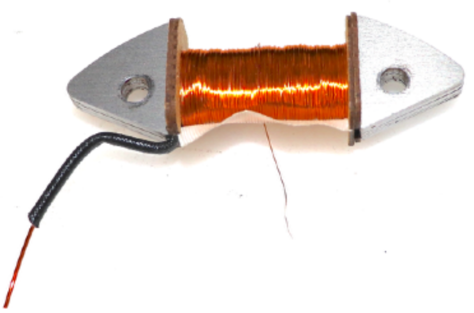
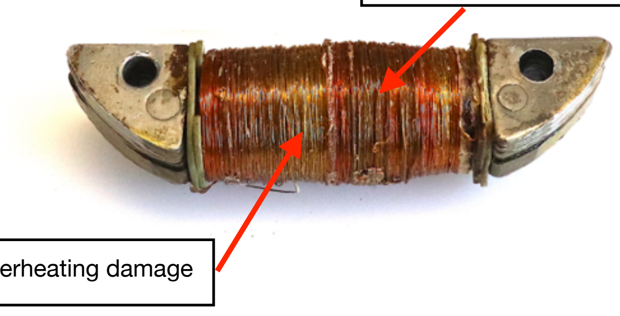
2. Windings are manufactured to exact specification. If they are now **ANY** different either:
1) they are not at 20 degrees
2) The windings are failing and need repair or replacement.

A jump in resistance indicates windings are shorting together. More commonly we see a lower resistance which tells us that the turns are shorted to each other and decreasing the winding's over-all resistance. Alternately the failing area may not be good electrical connection so readings may be unsteady, or higher.

Brand new CDi winding, note how fine the wire is.



Darker area shows shorted windings



Overheating damage

Electrical parts have precise specifications like mechanical parts have precision dimensions and these must be exactly right for the system to work. A poorly executed rewind that is off specification or still has the old insulation left in place often proves equally as problematic as an old winding.

3. Use insider knowledge when assessing readings: Apply winding manufacturer's tolerances to trouble shooting, you will quickly see where the fault is. Calculate +5% and -5% of the new winding resistance given in the shop manual (take 10% and half it). Make a list of all the windings to be tested with the +/- 5% and note down the temperature. The engine must not have run for many hours and be completely cold. Our technical team can do a temperature correction to your readings or use an on-line copper resistance change vs. temperature calculator.

-With your results in a list it is easy to compare your results. If there is a reading outside or closer to the 5% limit than the others, that winding is suspect. Using a list is good as if all the readings are little high or low you can consider that down to temperature or your meter, yet one that sits differently in the range will always be the problem winding.

-Some manuals give only a resistance range without the new resistance figure. Unfortunately this can prove less than useless for troubleshooting purposes. A wide resistance tolerance would be the same as saying a 10mm wear tolerance on a 75mm piston is acceptable. When faced with this situation write down your results next to the range in the manual - one reading that has shifted may be more obvious when in a list. Don't be fooled in to thinking because they are all in the range they must be good. Where the meter reading compared to manual data doesn't show an obvious fault you can only really decide based on what the machine is doing and how old the system is.

One issue to watch out for when using resistance readings is old, weak insulation, as we have already discussed is not registered by multimeters. When a winding gives a perfect resistance result but the system still has problems the 'time since manufacture' rule must be applied.

We have found these methods have accurately identify the problem an has helped in thousands of cases over the years, saving the bike's owners considerable time and money, not to mention head scratching. CDi ignitions throw up some very odd faults that defy logic when you aren't familiar with the system.

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Example: A motorcycle starts and runs for a while then misfires and stops, it needs to be left for 20 minutes after it stopped before it would restart. The tank breather was checked and the mechanic knew the owner had several of the same bikes that ran, so the carb was swapped from another, only to find the first bike was the same. The HT coil was checked and the lead had a wear mark on it and look to be the original old part. The mechanic thought that perhaps the CDi was warming up and failing as it was a very hot day. Kill switch and ignition switch worked normally.

The mechanic decided to follow his experience and change the HT coil and CDi unit. Unfortunately this approach appeared to make matters worse as the new HT coil made it run for just a few seconds before stopping. A new CDi unit resulted in no spark at all.

The new parts are not faulty. Something is stopping them working properly.

Define the symptoms and what is available for us to do: We see an engine that gets warm and stops, it is a good sign of an electrical issue in the generator. We know you cannot test CDi units without very complex and expensive test equipment. So lets get the information from the shop manual and check the generator windings which can be tested with a multimeter.

Shop manual data: Low Speed Source 380 Ω. High Speed Source 10Ω. Low speed trigger 91Ω, High speed trigger 16Ω at 20 degrees C. The shop manual gives a very wide (unhelpful) 10% tolerance. The ambient temperature is 30 degrees C

Winding	Calculated 5%	Measured readings	Temperature corrected	Result
Low speed source	361- 399Ω	360Ω	346Ω	Out of tolerance
High speed source	10.5-11.5Ω	10.5Ω	10Ω	Correct
Low speed trigger	90-100Ω	99Ω	95Ω	Correct
High speed trigger	16-18Ω	17Ω	16Ω	Correct

Diagnosis: Compare the temperature corrected values to the 5% calculated values. These readings show that the Low Speed Source has a shift away from the new value given in the manual. Deviation in resistance can only be due to temperature or a fault, but the temperature correction shows elevated temperature is not the reason as the winding is still different to it's new value whereas the others are not. Again compiling the data in to list helps see this. The manual causes confusion by stating this reading is OK, in fact it would allow a reading of 324Ω to pass. We now understand wide tolerances in precision electrical parts are nonsense, very much 'sand papering a scored bore and filing seize marks from a piston' territory.

If you still aren't sure about the resistance tolerance then the fact the bike stops when hot and has to cool before restarting is a big clue. The bike is an American market XT500, built in 1980, which puts the ignition system well in to the red time since manufacture zone. These factors back up the change in the source winding resistance - the stator is the most likely in need of overhaul.

Fix: The stator was fully rewound to OEM specification, then the new CDi and HT coil ran normally with a healthy blue spark, it even started 1st kick.

To recap on advice that has helped many people, CDi ignition is a system comprising source windings, trigger windings, CDi unit, HT coil and ignition switch. As the system ages insulation and electronic components dry out, the electrical equivalent of mechanical parts wearing out. The older the system becomes the less likely it is that replacing just one part of it will fix it. To understand test results we have to improve on the data given in manuals and work accurately and methodically to assess our findings. We hope this will be of help to you in getting to the bottom of an ignition problem.

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Below is a table to add your data to when trouble shooting. You can use it for your own reference or send it our technical team: tech@rexs-speedshop.com

Make		Year	
Model			

Temperature: ………………………..C or F (circle as applicable)

Record both the figures given in the manual and your own readings				
Test	**Item**	**Manual figures**	**Readings observed**	**Calculated 5% range**
2	HT Coil Primary (Ωohms)			
	HT Coil Secondary (ΩK - thousands)			
3	Low speed source Ω			
4	High speed source Ω			
5	Low speed pick-up Ω			
7	High speed pick-up Ω			

How to calculate a 5% a tolerance:

The manual says the source winding should read 250Ω.

10% of 250 is 25.

Half of 25 is 12.5.

Subtract 12. 5 from 250 = 237.5

Now add 12.5 to 250 = 262.5

So your 5% range is 237 to 262 (ignore the decimal).

Even this is a little wide, but this will allow for differing standards of test equipment etc.

If you are unsure how to set or read your meter please have someone do this for you as without good clear data our technicians are unable to help, nor will you be able to see where the fault is.

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