A high-energy Capacitor Discharge Ignition system

Based on an article by 'Silicon Chip' (Septermber 1997)

This completely new capacitor discharge ignition system has been designed from the ground up to provide a high energy "multiple spark discharge" to cope with engines which have very high RPM rates. It is intended particularly for use with two stroke engines, high performance four strokes and older vehicles.

Main Features

- »Suitable for 2-stroke, older 4-stroke and performance engines (racing).
- »Multiple spark output (see Table1).
- »Operates on reluctor, points or Hall effect signals.
- »Two points inputs for twin coil engines.
- »Usable to beyond 1000 sparks/second (equals 15,000 RPM for a V8).
- »Regulated 300V supply for consistent spark energy.
- »High frequency operation eliminates audible oscillator noise.
- »Efficient circuitry for minimum heat generation.
- »Components rated to operate up to 100°C.

Introduction

Twenty or so years ago, Capacitor Discharge Ignition (CDI) was the acknowledged solution for automotive enthusiasts wanting a high energy ignition circuit. CDI gave a really hot spark which would fire virtually any spark plug no matter how fouled or grotty it was. Tens of thousands of enthusiasts installed them on their cars and hence forward swore by them as the greatest innovation system since Karl Benz thought of the horseless carriage. Well, maybe it wasn't quite that good but you get the picture.

But there was another aspect of CDI which wasn't good and that was "crossfire". Because the CDI spark was so hot and more importantly, because it had such a fast rise-time of only a few microseconds, it often fired the plugs in other cylinders. This problem was most troublesome in V8s, in some sixes and even some four cylinder cars such as the air-cooled VW which had the spark leads running close and parallel right across the engine fan housing.
Cross-fire is caused by the capacitance between adjacent spark plug leads. The capacitance between the leads causes the fast-rising voltage from the coil to be coupled into the adjacent leads and thereby can deliver unwanted sparks in other cylinders.
Cross-fire can cause severe engine damage and sounds similar to pinging.
Ultimately, CDI fell into disuse for mainstream cars because of the introduction of lean fuel mixtures in an attempt to meet rising anti-pollution standards. The very fast and very short spark of CDI wasn't all that good at igniting lean mixtures. Car manufacturers introduced transistor-assisted ignition with long spark durations to ensure that lean mixtures did burn properly. There was one CDI design which attempted to overcome the lean mixture drawback and that was the so-called "multiple spark discharge" system. However it was a complex design which never really caught on.
These days, there is no modern car with an engine management system which uses CDI, to our knowledge. Whether they are single coil, multi-coil or direct-fire systems, they are all variants of the tried and true transistor assisted ignition (TAI) system. So why design a new CDI?
We have tended to disparage CDI systems for years, knowing that our very popular high-energy TAI system has a well-earned reputation for reliability. But some readers were not about to be put off. They wanted a CDI design and they wanted it for a number of reasons. They wanted them for two-stroke and four-stroke motors on motor bikes, outboards and Go-Karts. And they wanted them for older cars which don't have lean mixtures and which can be particularly hard, if not impossible, to start when the ignition system gets wet. Old Mini Coopers and 850s are legendary in this regard.
Some readers also wanted a CDI for racing applications where multiple spark discharge systems still have a keen following.

With all of these reasons being cited, who were we to say that all these people were wrong? So we went back to the data books and put on our thinking caps. A new CDI design had to be a distinct improvement over the 20-year old designs which did have their fair share of drawbacks. Like what, for example?

First, many CDIs had very high voltages applied to the ignition coil, as much as 500V or 600V in some cases.

They did this to avoid the inevitable fall-off in spark energy as the engine RPM rose. This very high coil voltage had the drawback of often causing internal breakdown in ignition coils, it made the cross-fire problem significantly worse than it would have been with a lower coil voltage and it put considerably more stress on the ignition leads. So design aim number one was to set the coil voltage to a much more moderate level of about 300V.

Second, because the DC-DC inverters of the time used relatively slow bipolar transistors (eg, 2N3055s), the inverter frequency was typically only 2kHz. This typically sets an upper limit on the maximum spark rate of about 300 to 400 sparks per second, as the inverter needs a couple of cycles of operation after each discharge in order to recharge the dump capacitor.

The 2kHz inverter operation was quite audible too and could often be heard through car radios. So the new design would use Mosfets in the inverter and would operate at above 20kHz to make it inaudible.

Third, CDIs used an SCR (silicon controlled rectifier) to discharge the dump capacitor and these are typically rated for an AC supply frequency of 400Hz maximum. While the SCRs will operate at higher frequencies, it is an unspecified condition and it ultimately also sets a limit on the maximum spark rate. That effectively rules out using an SCR in the new design.

Fourth, and a rather serious drawback this one, some CDI systems would not operate when the battery was low. This meant that while the battery might be able to slowly crank the engine, the CDI's inverter would not start and hence there would be no spark. In other words, just when you most wanted the CDI to work, it would not be on the job.

Another factor which limited the inverter operating frequency was the speed of the rectifier diodes. High speed fast recovery diodes were expensive and so, even if the inverter could have run much faster, the standard rectifier diodes could not have handled the high frequency output.

Applications

While we have addressed all the above disadvantages, the drawback of potential cross-fire remains even though we have reduced the high voltage to 300V. Therefore, we do not recommend using the system on six cylinder and V8 engines unless you can improve the lead dress of the spark plug leads so that each lead is more widely separated from its neighbour.

Nor do we recommend using this CDI on any car with an engine management computer. We take the attitude that the factory designed ignition system will always be optimum for the particular car.

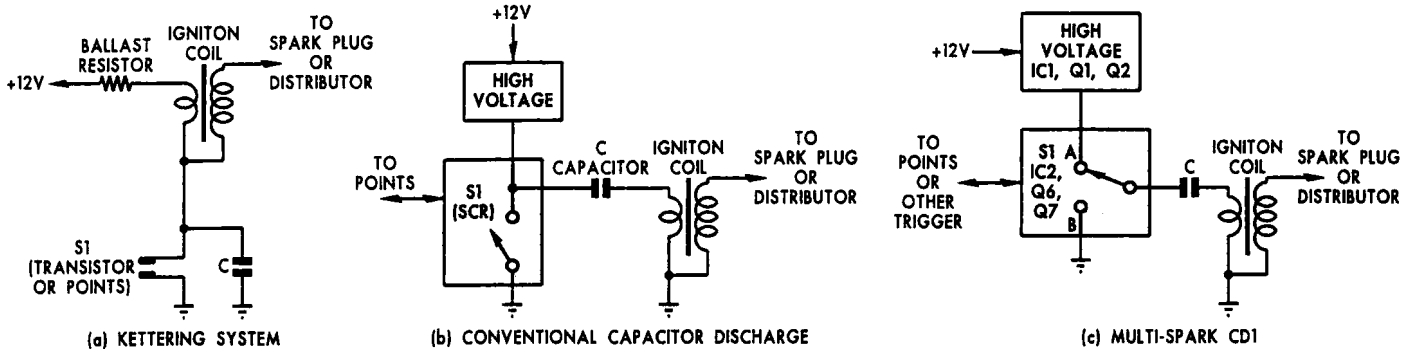
On the other hand, if you have an older car with factory electronic ignition there is no reason why this CDI system should not be a satisfactory substitute, particularly if the original module has failed and is expensive to replace.

The new CDI system can be connected to distributors with conventional points, Hall effect or reluctor pickups. It is capable of operation to very high engine speeds, much higher than even racing engines. For example, it can run as high as 30,000RPM in a 4-cylinder engine. This figure is so high that it's academic but it does indicate that full spark energy is maintained over the entire RPM range of any practical engine.

All the other features of the new design are summarised in the features and specifications panels elsewhere in this article. However, we do need to explain one of the key features and that is "multiple spark discharge".

Multiple spark discharge

Fig.1: *These three circuits show the three types of ignition circuit.*
Fig.1(a) *is the original points-based system.*
Fig.1(b) *shows a typical CDI system which uses a DC-to-DC inverter to charge a capacitor which typically has a value of lμF. Each time the switch points in the distributor open, it fires an SCR to dump the capacitors's charge into the coil primary winding.*
Fig.1(c) *shows the arrangement of our new CDI system. It has a DC-to-DC inverter with a regulated 300VDC output which charges up a lμF capacitor. Instead of using an SCR to dump the capacitor's charge into the coil, it uses a pair of Mosfets which are depicted as S1, a single pole double throw switch.*



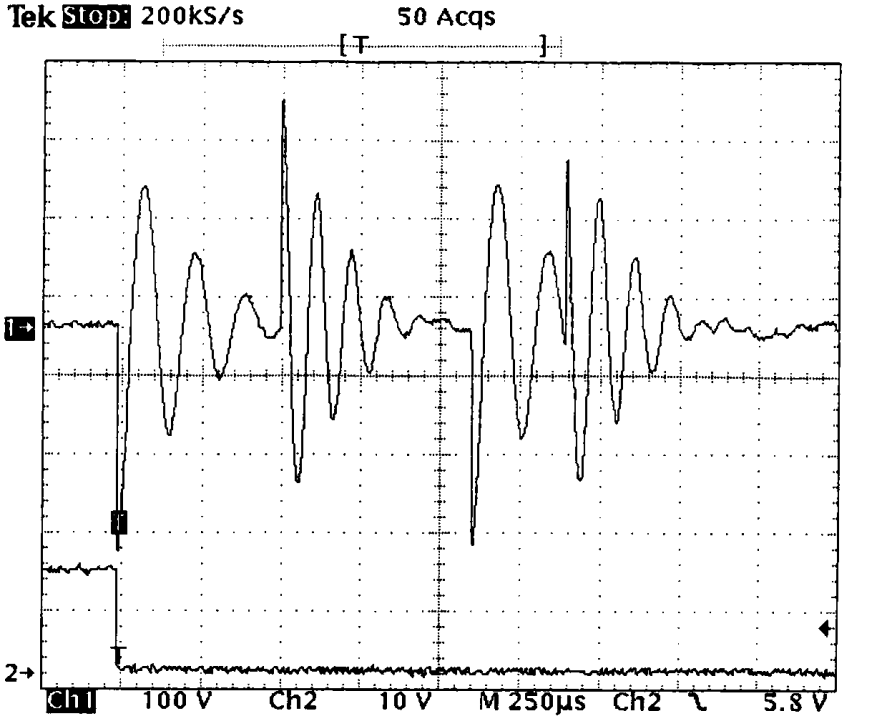
Whereas the original CDI designs produced just one spark each time the points opened, the multi-spark discharge (MSD) CDI was able to produce several sparks in quick succession each time the points opened. Our new design incorporates this feature and produces up to 10 sparks each time a spark plug is to be fired, depending on the engine speed. This feature can be disabled so that the CDI produces just two sparks for each cylinder firing, regardless of engine speed.

Now let us have a look at some of the details of the new design.
Fig.1 (a) shows the schematic diagram of the conventional Kettering ignition system which has been used on cars for over 60 years. It comprises an ignition coil which has its primary winding connected to the battery supply with a switch at the negative side.
The switch can be a conventional set of points or a switching transistor, as used in most modern ignition systems. When the switch is closed, current builds up in the primary winding with the ultimate value limited by the internal resistance of the coil and a ballast resistor, if used. This current is usually around 3 to 5 amps.
When the switch opens, the resulting collapse of the coil's magnetic field causes the secondary winding to produce a high voltage to fire the spark plug. As the engine speed rises, the current has less time to build up in the coil primary and so inevitably the spark energy is reduced. Modern transistor assisted ignition systems get around this problem by using dwell extension, lower inductance coils or more than one ignition coil.

Fig.1(b) shows a typical CDI system which uses a DC-to-DC inverter to charge a capacitor which typically has a value of lμF. Each time the switch points in the distributor open, it fires an SCR to dump the capacitor's charge into the coil primary winding. The poor old coil gets such a belt that it produces a much higher voltage in the secondary and fires the spark plug.

Fig.l(c) shows the arrangement of our new CDI system. It has a DC-to-DC inverter with a regulated 300VDC output which charges up a 1μF capacitor. Instead of using an SCR to dump the capacitor's charge into the coil, it uses a pair of Mosfets which are depicted as S1, a single pole double throw switch. The capacitor charges up via the coil to 300V when S1 is in position A and discharges through the coil when the switch is in position B. Thus each time a spark plug is to be fired, two sparks are produced, one with positive polarity and one with negative polarity. With a simple change to the timing circuitry controlling the two Mosfets, the CDI can be made to produce more than two sparks by repetitively charging and discharging the dump capacitor during each spark plug firing period.

Fig.3: *This is the primary coil voltage when producing four sparks (top waveform). Note the 284V negative exursion for the first and third sparks and the 294V positive excursion for the second spark.*
The lower trace is the tachometer output signal which was used to trigger the oscilloscope.



The oscilloscope waveforms show the primary coil voltage when producing four sparks (top waveform). Note the 284V negative excursion for the first and third sparks and the 292V positive excursion for the second spark. The lower trace is the tachometer output signal which was used to trigger the oscilloscope.

Circuit description

Figure 2 shows the circuit diagram of the Multi-Spark CDI.
It can be split into two separate sections, each using an IR2155 self-oscillating half bridge Mosfet driver. IC1 and Mosfets Q1 & Q2 comprise the 12VDC to 300VDC inverter. IC2 and Mosfets Q6 & Q7 charge and discharge the dump capacitor via the ignition coil primary and provide the multiple spark feature.
IC1 oscillates at about 22kHz as set by the 33kΩ resistor between pins2 and 3 and the 0.001µF capacitor from pin3 to ground. Two complementary outputs at pins 5 & 7 alternately switch Mosfets Q1 & Q2 to drive the centre-tapped primary winding of transformer T1.

Table 1 shows the multi-spark information for four, six and eight cylinder engines. Here we show the RPM versus the number of sparks produced. As you can see, the number of sparks ranges from as many as six sparks per firing at 600RPM in a 4-cylinder engine down to two sparks per firing at 15,000RPM, again in a 4-cylinder engine.

Table1: *RPM vs. Spark No. & Duration*

RPM	No. of Sparks	Spark Duration Crankshaft Degrees
4-Cylinder 4-Stroke Engines		
600	6	8
900	6	13
1200	6	16
1500	6	20
2250	4	19
3000	4	25
4500	4	37
9000	2	21
15,000	2	36
6-Cylinder 4-Stroke Engines		
400	8	8
600	8	12
800	6	11
1000	6	14
1500	6	21
2000	4	16
3000	4	24
6000	2	14
10,000	2	22
8-Cylinder 4-Stroke Eingines		
300	14	11
450	12	13
600	10	15
750	10	18
1125	8	21
1500	8	20
2250	6	29
4500	4	32
7500	2	15

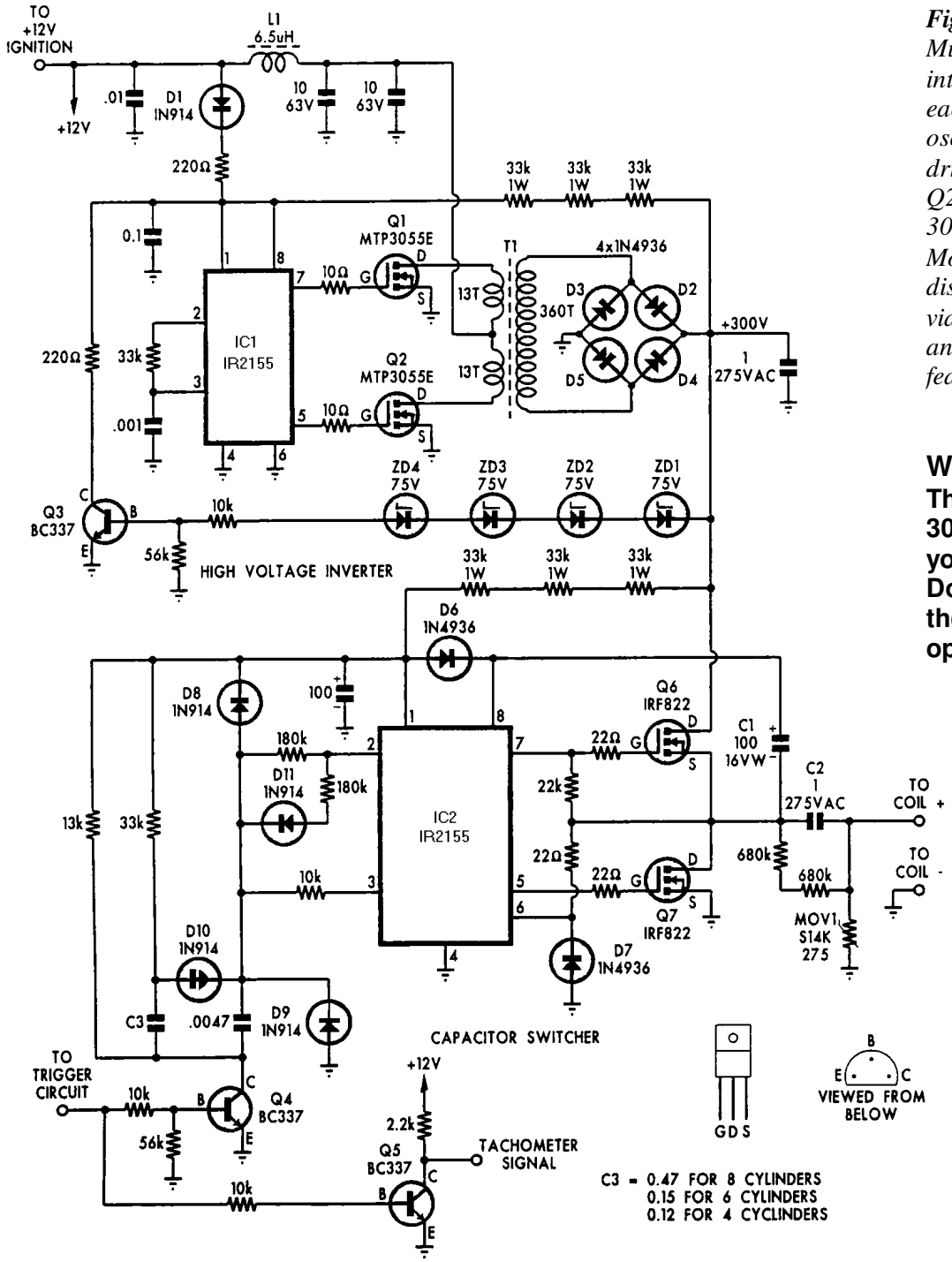


Fig.3: *Tthe circuit of the Multi-Spark CDI can be split into two separate sections, each using an IR2155 self-oscillating half bridge Mosfet driver. ICl and Mosfets Ql & Q2 comprise the 12V DC to 300V DC inverter. IC2 and Mosfets Q6 & Q7 charge and discharge the dump capacitor via the ignition coil primary and provide the multiple spark feature.*

WARNING!
This circuit produces 300V DC which can give you a nasty shock. Do not touch any part of the circuit while it is operating.

With Q1 on, the full 12VDC is applied to the top half of the transformer primary winding. Because of the transformer coupling to the second primary winding, the lower half of the transformer primary winding also has 12V across it. Similarly, when Q2 turns on the 12V is also impressed across the top primary winding. The resulting waveform on the primary is stepped up by the secondary winding. Q1 & Q2 have internal avalanche protection. Should the switch off transient across them reach 60V, the internal zener diode will safely quench the spike voltage. The 10Ω resistors in series with the gates of the Mosfets are included to slow their switching speed and thus reduce the interference which would otherwise be induced into the vehicle's electrical system.

Two 10µF MKT capacitors are used to decouple the DC supply to transformer T1. They effectively bypass the supply lead inductance so that the full 12V supply is delivered to the transformer at the high switching rate. Inductor L1 is connected in series with the supply to prevent 22kHz switching currents from appearing on the vehicle's electrical supply. The 0.01µF capacitor on the 12V input is there for the same reason.

The stepped up secondary voltage of T1 is full-wave rectified by high speed diodes D2-D5 and the resulting 300VDC is filtered with a 1µF 275VAC capacitor.

Voltage feedback trickery

As described so far, the circuit does not have any means of maintaining a constant 300VDC output and so variations in the battery voltage and spark rate would inevitably cause the high voltage DC output to vary over a fairly wide range which would be undesirable. However, the IR2155 Mosfet driver has no inbuilt means of providing voltage regulation. Therefore, we have to trick the circuit into maintaining a more or less constant voltage.
The voltage feedback comprises four 75V zener diodes ZD1-ZD4 which are connected in series so that they begin to conduct at 300V. When current flows through the zeners they switch on transistor Q3 via a 10kΩ base resistor.

When transistor Q3 turns on, it pulls pin1 of IC1 from close to +12V down to around +6V and this tricks the IC into activating its internal undervoltage cutout circuit (threshold +8.4V) which switches both pins7 and 5 low. This stops the Mosfets from driving transformer T1 and this situation is maintained until the zeners stop conducting; ie, when the high voltage supply drops back below 300V.
Transistor Q3 then switches off and IC1 resumes normal operation. Thus, the output voltage is stabilised at 300V while Q3 turns the oscillator on and off at a rate dependent on the load current drawn from the 300V supply and the actual DC supply voltage.

Circuit feeds itself

Three 33kΩ resistors in series feed current from the 300V output back to the supply pins of IC1 and an internal zener limits the resulting voltage to 15V. With +15V present at pins1 & 8 of IC1, diode D1 is reverse biased and therefore the IC no longer draws current from the +12V battery line. The idea behind this to make sure that the circuit will run even with a very flat battery. Hence the circuit will start with as little as 9V from the battery and then will continue to run even if the battery drops down to 5V. This could make all the difference when you have a sick battery which can barely crank the engine over or if you have to push start the car.

The 300V supply also feeds IC2, the second IR2155. Note that IC2 is connected to operate in a different fashion to IC1. In this case, the drain (D) of Q6 is connected to the 300V supply which is at a much higher potential than the +15V at pin1 of IC2. For Q6 to fully turn on, its gate (G) must be raised above the drain by several volts. This is achieved using diode D6 and capacitor C1.
Initially, IC2 starts with a 15V supply derived from the 300V rail, as mentioned above. Q7 is the first to be switched on and it pulls one side of capacitor C1 low. C1 then charges to the +15V supply via D6 and Q7.
When Q7 turns off and Q6 turns on, Q6 pulls pin6 of IC2 up to the 300V rail and so pin8 is jacked up above +300V by the 15V across C1. C1 maintains the voltage between pins7 and 8 until next recharged via D6 and Q7. (Note that pins6, 7 & 8 of the IR2155 are floating outputs which can be shifted to 600V above the pin4 ground).

C1 needs to be relatively large at 100µF since it can be called upon to keep its charge for up to 100ms during slow cranking of the motor. The totem-pole output of Mosfets Q6 and Q7 drives the ignition coil primary via the 1µF 275VAC capacitor C2. Diode D7 is included to prevent pin6 from going much below the pin4 ground while D7 itself is current limited by the series 22Ω resistor. The 22kΩ resistor between pin7 and the source of Q6 ensures that this Mosfet is held off when there is initially no supply between pins8 and 7. The 22Ω gate resistors slow the turn on and turn off times for Q6 and Q7 to limit transients when switching the 1µF 275VAC capacitor.

Multi-sparking

Pins2 and 3 of IC2 are connected to an assortment of resistors, diodes and capacitors and these are instrumental in providing the multi-spark operation. These components comprise a timer and an astable (oscillator) connection. The astable oscillator is formed by the 180kΩ resistor at pin2 and the 0.0047µF capacitor at pin3.
The 10kΩ resistor between pin3 and the 0.0047µF capacitor is there to prevent excess current into this pin when driven by the monostable part of the

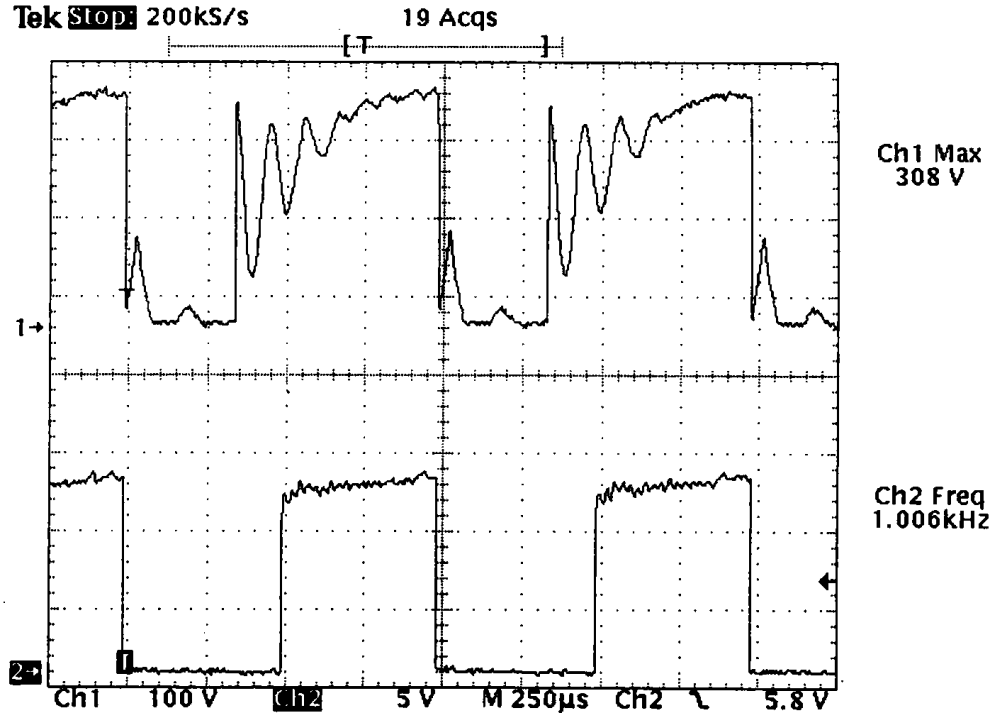
circuit. The only other difference to the normal astable mode is the addition of diode D11 and the 180kΩ resistor in series. This ensures a longer discharge time for the 0.0047µF capacitor via one 180kΩ resistor and a shorter charge time via both 180kΩ resistors when D11 is forward biased.

Note that the 0.0047µF capacitor is only tied to ground when transistor Q4 is switched on via the trigger circuit from either points, Hall effect or reluctor signals. Capacitor C3 is also connected to the collector of Q4. Initially, when Q4 is off, C3 is discharged and held at the pin1 supply voltage (+15V) via the 13kΩ resistor at Q4's collector and the 33kΩ resistor at D10's anode. This last resistor pulls pin3 well above the upper threshold (2/3rds the pin1 supply) via D10. Pin2 goes low but the 0.0047µF capacitor cannot be discharged and so IC2 does not oscillate; so Q7 is off and Q6 is on (if there is supply voltage across C1).

When Q4 switches on, the anode of D10 is pulled low via C3. Thus, the 33 kΩ resistor is effectively out of the oscillation circuit and so the 0.0047µF capacitor is charged and discharged via the components at pin2 as previously discussed. Q6 and Q7 now switch on and off alternately, so the coil is fired repetitively via C2.

C3 charges via the 33kΩ resistor and when this voltage reaches the upper threshold of pin3's input, D10 conducts and stops IC2 from oscillating again. The circuit thus remains with Q6 on and Q7 off until triggered again. Note that, at high RPM, Q4 is off for less time than it takes C3 to recharge via the 33kΩ resistor and switch off IC2's oscillation. The instant this transistor switches off, IC2 stops oscillating since C3 is immediately pulled high. This is a fail-safe condition to prevent sparks designated for one cylinder from accidentally firing the next cylinder in sequence.

Fig.4: *The CDI produces very high spark rates. The top trace shows the voltage measured at the source of Q6 when driving the ignition coil, while the lower trace is the tachometer output which indicates that the rate is 1000sparks/second. Note that capacitor C2 charges up to the full 300V (308V shown) before firing into the coil on the negative edge of the lower trace. This means that the circuit can deliver the full spark energy even at this excessively high engine speed.*



The trigger circuit also drives transistor Q5 to provide a low voltage (+12V) tachometer output. This is necessary since a tacho connected to the coil would otherwise give false readings.

The Figure left shows some more waveforms which demonstrate the circuit performance. The top trace shows the voltage measured at the source of Q6 when driving the ignition coil while the lower trace is the tachometer output which indicates that the input spark rate is at 1kHz (60,000 RPM). Note that capacitor C2 charges up to the full 300V (308V shown) before firing into the coil on the negative edge of the lower trace. This means that the circuit can deliver the full spark energy, even at this excessively high rpm.

Disabling multi-spark operation

If you wish, the multi-spark feature can be easily disabled by

(1) removing C3, D10, D11, the two 180kΩ resistors and the 33kΩ and 13kΩ resistors; and

(2) installing a 180kΩ resistor in place of the 33kΩ resistor and a link in place of D10.

This causes IC2 to produce a single 0.5ms pulse to switch on Q7. This fires the coil in one direction when Q7 switches on and in the other direction when Q6 switches on.

A Metal Oxide Varistor (MOV1) is connected across the coil to quench the high voltage transient which will occur if the coil is left open circuit on the secondary. Leaving the coil output open circuit can cause it to break down internally and this quickly leads to failure. In addition, there is provision on the PC board to use two 1µF capacitors to drive the coil.

Two 680kΩ resistors are connected in series across C2 to discharge it should the coil become disconnected from the circuit. This improves safety since a 1µF capacitor charged to 300V can produce a nasty shock.

Trigger circuits

The Figures show the alternative circuits provided for points, Hall effect and reluctor triggering. These are all included on the PC board.

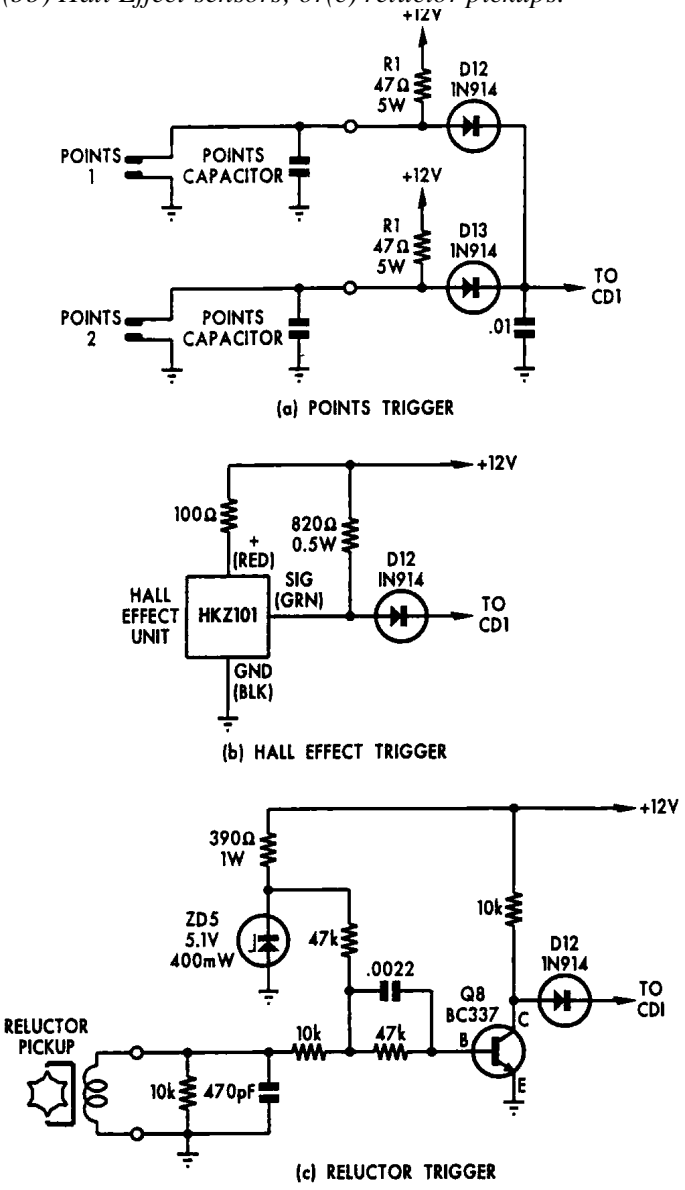
The points circuit is easy enough and we have provided for distributors which have one or two sets of points. Both pairs of points have a 47Ω 5W resistor to provide a "wetting current". This current keeps the points clean and thereby provides more reliable operation. Diode D12 or D13 feeds the respective points signal into transistor Q4.
The two-points facility provides for twin-cylinder engines with two coils or for rotary engines which have two plugs per chamber.

The Hall effect circuit has power supplied via a 100Ω resistor. The 820Ω resistor is the pullup for the internal open collector transistor. Diode D12 supplies the high-going signal to Q4.

The reluctor circuit comprises a 10kΩ load across the pickup coil together with a 470pF noise suppression capacitor. Transistor Q8 is biased on using a 5.1V zener diode. The circuit is designed to trigger after the reluctor signal goes negative. The 0.0022µF capacitor is used to speed up the switch off action of Q8 while the 10kΩ pullup resistor on Q8's collector provides the signal to Q4 via diode D12.

This Figure shows the reluctor output (lower trace) and the resulting source voltage of Q8 with no coil connected. Note that the coil fires on the negative edge of the reluctor waveform.

Fig.5: *The circuit caters for distributors with (a) poinzs; (bb) Hall Effect sensors; or(c) reluctor pickups.*



Construction

The Multi-Spark Capacitor Discharge Ignition is constructed on a PC board which is coded ZA1159 (05309971) and measures **112x144mm**. It is housed in a diecast case measuring **171x121x55mm**.

Begin assembly by checking the PC board against the published pattern. There should not be any shorts or breaks between tracks. Make any repairs as necessary. Note that the PC board provides two semicircular cutouts on the sides to fit into the recommended case. The corners should also be rounded off and small notches are need to give clearance for the vertical channels in the diecast case. Make sure the PC board fits into the case before starting assembly. Other types of diecast cases with multiple integral ribs on the sides cannot be used since the Mosfets need to be bolted to a flat surface.

The figure right shows the component overlay for the PC board with trigger input circuitry for a reluctor distributor.

Figure 8 shows the different trigger components for a Hall effect distributor while the figure below shows the trigger components for a conventional points distributor.

You can start the board assembly by inserting the PCB pins at the external wiring connection points and then installing the wire links. Note that there are two links that run beneath the inverter transformer (T1). This done, install the resistors and use the colour code table and your multimeter to check each value.

When inserting the diodes and zeners, take care with their orientation and be sure to place each type in the correct position.

Fig.6: *These waveforms show the reluctor output (lower trace) and the resulting source voltage of Q8 with no coil connected.*
Note that the coil fires on the negative edge of the reluctor waveform.

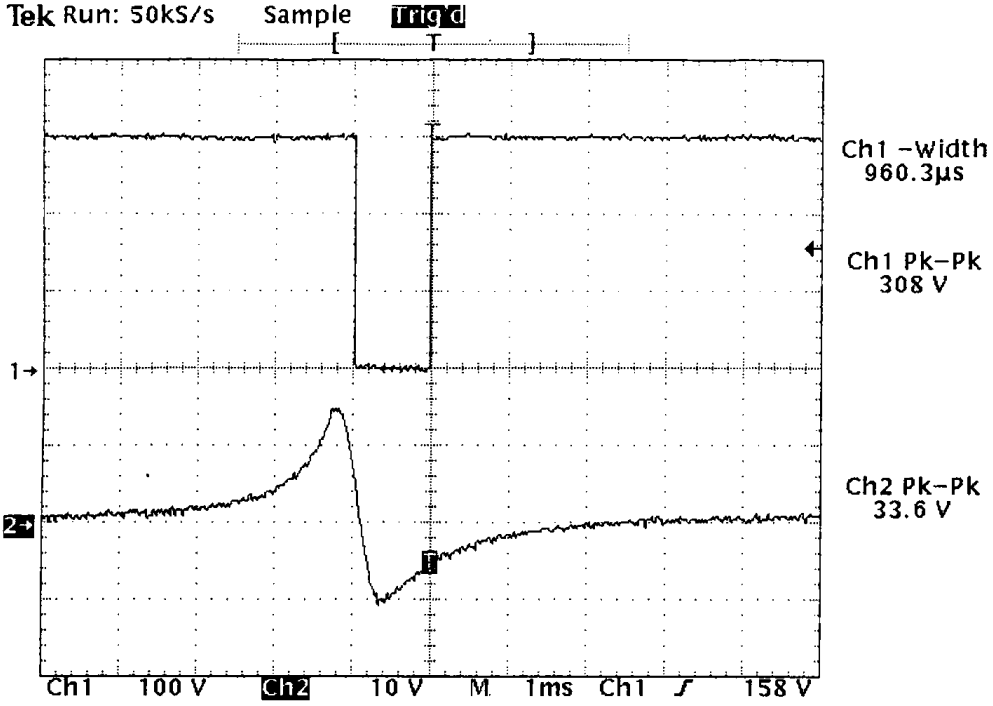


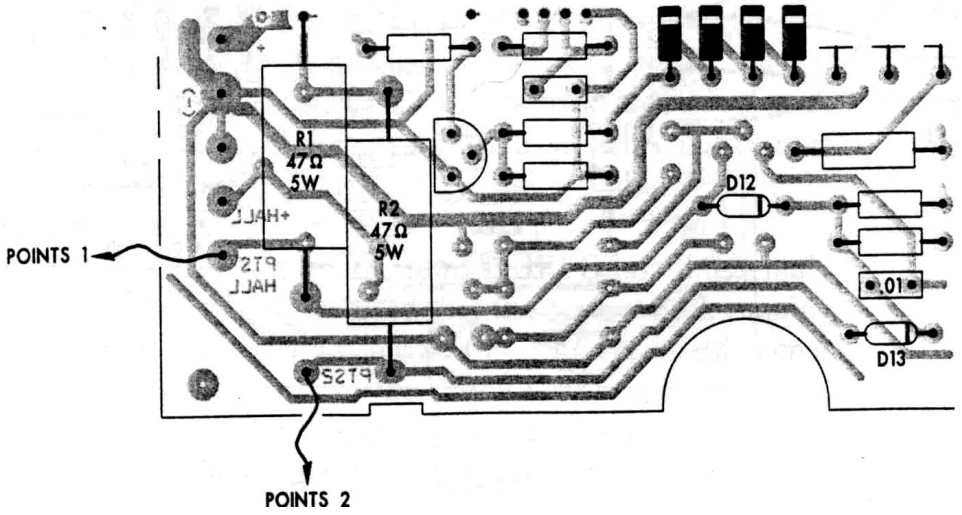
Fig.7: *This component overlay for the PC board includes the trigger input circuitry for a reluctor distributor.*



Fig.8: *This diagramm shows the trigger components for a Hall effect distributor.*



Fig.9: *The trigger components for a conventional points distributor.*



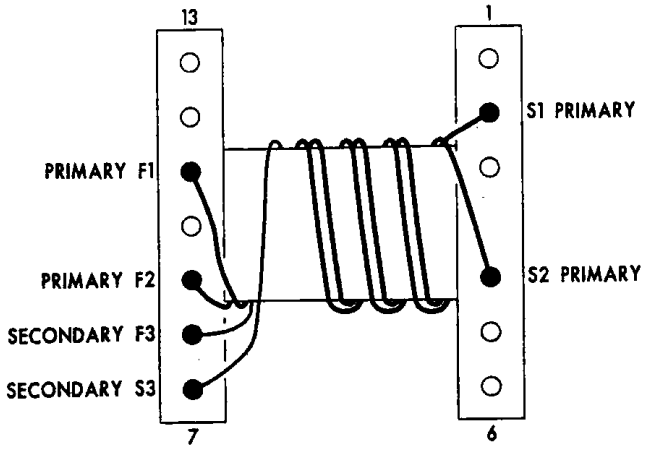
Install the ICs and transistors, taking care to orient them as shown. The Mosfets are oriented with their metal flanges towards the edge of the PC board and are seated as far down on the board as they will go. Be sure to install the correct type in each location.

The capacitors can be installed next. The accompanying table (table 2) shows the value codes which will be printed on each component. The electrolytic capacitors must be oriented with the correct polarity. Once the capacitors are in, install the varistor (MOV1).

The battery input filter toroid core (L1) is wound with **12 turns** of 1mm enamelled copper wire. Ensure that the wire ends are stripped of insulation before soldering it into place. The toroid is affixed to the PC board using a screw and nut with an insulating bush to locate the screw and protect the winding.

Fig10: *Here are the winding details for the bobbin of transformer T1. Note that the primary windings are bifilar; ie, they are wound together.*

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S1-F2 primary     13t 0.63mm ENCU
S2-F2 primary     13t 0.63mm ENCU
S3-F3 secondary 360t 0.25mm ENCU
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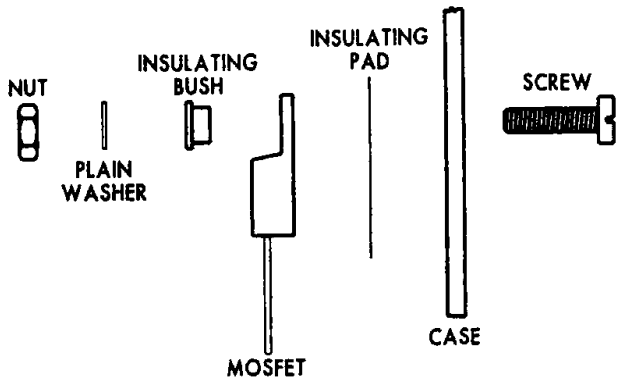


Winding the transformer

Transformer T1 is wound as shown in the diagram. Start by terminating the 0.25mm enamelled copper wire on pin7 as shown. Neatly wind on **360 turns** and insulate between each winding layer with insulation tape.
Terminate the winding on pin8.
The primary windings are wound together (bifilar) side-by-side. Terminate the 0.63mm enamelled copper wires at pins 2 and 4 as shown, then wind on **13 turns** and terminate on pins 11 and 9 respectively. Check that pin2 connects to pin11 and pin4 connects to pin9, using a multimeter on the "Ohms" range. Finish the windings with a layer of insulation tape.

The ferrite cores are inserted into the bobbin and secured with the clips or a cable tie. Insert and solder the transformer into the PC board with the orientation shown in Fig.7.
Next, insert the PC board into the case and mark the positions for the Mosfet mounting holes on the side panel. Remove the PC board and drill out these

Fig.11: *The four Mosfets are mounted on the side of the case, using an insulation washer and an insulation bush.*



holes and two holes at each end for the cord grip grommets. Also drill a hole for the earth lug screw. The holes for the Mosfet mounting must be deburred with a larger drill to prevent punch-through of the insulating washer.

Attach the PC board to the case with the supplied screws and secure each Mosfet to the case with a screw, nut, insulating washer and insulating bush. Fig.11 shows the details. If you use a mica washer apply a smear of heatsink compound to the mating surfaces before assembly. Silicone rubber washers do not require heatsink compound. Use two washers each for Q6 and Q7. Check that the metal tabs of the Mosfets are indeed isolated from the case by measuring the resistance with a multimeter.
Finally, attach the wires for the supply, trigger input and coil output and secure them with the cordgrip grommet.
The earth connection goes to a solder lug which is secured to the case.

You can test that the inverter operates by connecting the circuit to a 12V 3A power supply. **The voltage between the tab of Q6 and the case should be about 300V. Take care, however, since this voltage can cause a severe electric shock.**

Installation

If you are using the existing points or a reluctor distributor, the CDI unit can be installed into the vehicle. Be sure to locate the CDI case in a position where air flows over it and make sure it is away from the exhaust side of the engine. It can be secured to the engine bay with self-tapping screws into the two diagonally opposite external securing points on the case.
Alternatively, you could use brackets. Wire up the positive connection to the positive 12V ignition, the negative wire to the chassis and the trigger input to the points or reluctor. The ignition coil requires a connection to both sides of the primary. Disconnect any other wires that are part of the original ignition system.
Note that the reluctor coil requires the correct polarity connection in order to give the correct spark timing. This is best determined by testing the engine. If it does not fire, reverse the reluctor leads and try again.

You may find that with the CDI installed, the spark timing is little advanced, due to its fast rise time. If so, you may need to retard the static timing slightly to prevent pinging or a slightly rough idle.

When starting an engine fitted with this CDI, it is a good idea to turn on the ignition for one or **two seconds before cranking** the engine. This will give the circuit time to generate the 300VDC and fully charge the 100µF supply capacitor for IC1.

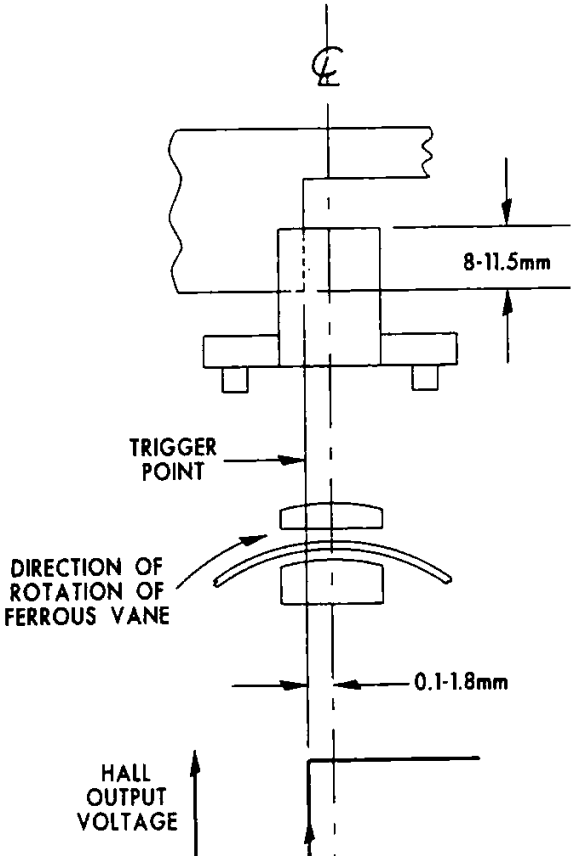
If you are going to install the CDI on an engine with two coils and two sets of points, you can use the trigger circuit with the two points facility. The CDI can then drive both coils in parallel. Both coils will then fire simultaneously when each set of points open. This is more or less standard practice with racing rotaries. If you do want to fire two coils simultaneously, you will probably need to add an extra 1µF 275VAC capacitor (C2). There is provision for this on the PC board.

Hall effect trigger

While many readers will wish to use their original points/distributor setup in their initial installation, a Hall effect distributor is a much better proposition. A Hall effect pickup does not suffer from any wear

and tear and is unaffected by dirt. The Hall sensor recommended is the Siemens HKZ101 available from Jaycar Electronics. You must also obtain a rotating vane assembly to suit your distributor.

Fig.12: *This is how the Siemens Hall sensor should be installed to provide reliable triggering. The vane needs to penetrate the sensor by between 8mm and 11.5mm. The triggering point is between 0.1mm and 1.8mm from the centre line of the unit..*



These are available from automotive after-market retailers selling Bosch ignition systems. Make sure that you have one of these before purchasing the Hall sensor.
Fig.12 shows how the Siemens Hall sensor should be installed to provide reliable triggering. The vane needs to penetrate the sensor by between 8mm and 11.5mm. The triggering point is between 0.1mm and 1.8mm from the centre line of the unit.

To install the sensor, first remove the distributor from the vehicle. To do this, rotate the engine until cylinder number 1 is at the firing point; this is indicated when the rotor button is aligned with the number 1 spark plug lead. With the distributor out of the engine, find the position where the points just open for the number 1 cylinder and mark the position on the distributor where the centre of the rotor is now positioned. This is the point where the Hall effect sensor's output should go high.
Next, remove the rotor, points and capacitor plus ancillary components. The Hall sensor should be mounted near where the points were located so that there is sufficient lead length to exit from the distributor. The exact location for the Hall sensor is determined as follows.
Fit the vane assembly to the distributor and align the rotor with the marked firing point. The Hall sensor should now be positioned so that the leading edge of one of the metal vanes is about halfway through the slot. You will have to know the distributor rotation direction. Mark the position for the sensor, taking care to ensure that the vane will pass through the gap without fouling.

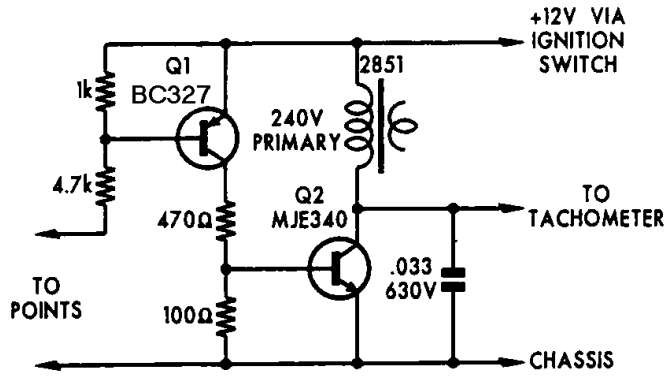
Note that Fig.12 shows the configuration for a clockwise rotating distributor. Anticlockwise rotating distributors are timed as the vane enters the Hall sensor from the other side.
A suitable mounting plate can now be made to fit the Hall sensor onto the distributor advance plate. The mounting plate must be elevated so that the vane penetrates the Hall sensor by 8-11.5mm. The Hall sensor is riveted to the adaptor plate through 3.5mm holes which are countersunk beneath the plate. The adaptor plate can then be secured to the advance plate using machine screws, nuts and washers. Try to take advantage of existing holes left where the points were mounted. The leads from the Hall sensor should pass through the existing points lead grommet. Check that the vanes pass through the gap in the sensor without fouling and that the lead dress allows for full movement of the distributor advance plate.

Now reinstall the distributor in the engine, with the rotor pointing towards the number 1 cylinder firing point. Do a static timing check, with the engine set to fire when the vane is central to the Hall sensor. Connect the Hall sensor leads to the CDI unit using suitable automotive connectors. Start the engine and use a timing light to set the spark timing.

Tachometer connection

The tachometer output signal is a 12V square wave which should be sufficient to trigger most electronic tachometers. For example, the tachometer featured in the August 1991 issue can be directly triggered without modification. If the signal does not work with your tacho, it may be an impulse type which

Fig.13: Use this circuit to provide a tacho signal if your car has an impulse tachometer.

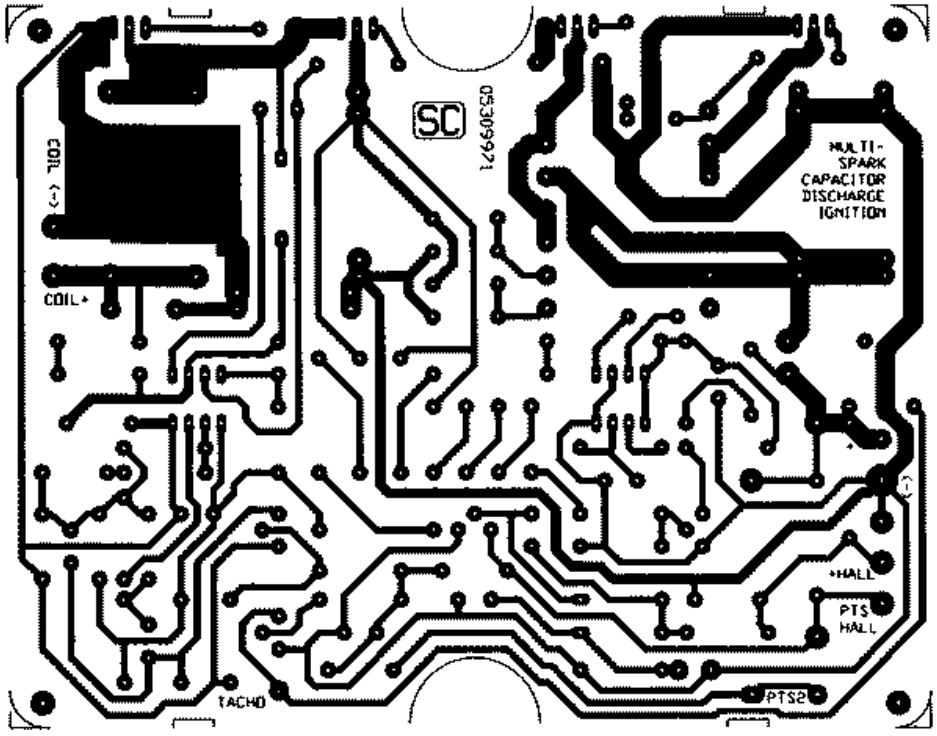


requires a high voltage. The circuit shown in Fig.13 should solve this problem.

As shown, this uses the primary of a 2851 240VAC to 12VAC mains transformer to produce a high voltage pulse when switched via transistors Q1 & Q2. The coil voltage is limited by the 0.033µF capacitor connected between collector and emitter of Q2.

APPENDIX:

Fig.14: This is NOT the full-size etching pattern for the PC board..



Specifications

Spark energy	45mJ
Number of sparks per firing	Minimum of 2, (see Table1)
Spark Separation	0.5ms for the first 2 sparks then 0.66ms, 0.34ms, 0.66ms, etc
Spark duration	About 200µs per spark
Multiple spark duration	2 sparks 500µs; 4 sparks 1.3ms; 6 sparks (add 200µs for last spark) 2.2ms; 8 sparks 3.1 ms; 10 sparks 4.1ms; 12 sparks 5ms; 14 sparks 6ms
Reluctor Circuit sensitivity	400mV RMS
Inverter operating frequency	22kHz
Operating voltage	Down to 5V (requires a minimum of 9V to start circuit)

Part Lists

CHECK	QTY	DESCRIPTION	COMPONENT IDENTIFICATION &/OR LOCATION
Resistors			
	6	33kΩ 1W 5% Resistor	orange-orange-orange-gold
	1	390Ω 1W 5% Resistor (Reluctor trigger cct)	orange-white-brown-gold
	2	680kΩ 1/2W 1% Resistor	blue-grey-black-orange-brown
	2	180kΩ 1/2W 1% Resistor	Brown-grey-black-orange-brown
	2	56kΩ 1/2W 1% Resistor	green-blue-black-red-brown
	2	47kΩ 1/2W 1% Resistor (Reluctor trigger cct)	yellow-purple-black-red-brown
	2	33kΩ 1/2W 1% Resistor	orange-orange-black-red-brown
	1	22kΩ 1/2W 1% Resistor	red-red-black-red-brown
	1	15kΩ 1/2W 1% Resistor	brown-green-black-red-brown
	1	3kΩ 1/2W 1% Resistor	brown-orange-black-red-brown
	6	10kΩ 1/2W 1% Resistor (2x Reluctor trigger cct)	brown-black-black-red-brown
	1	2kΩ 1/2W 1% Resistor	red-red-black-brown-brown
	1	820Ω 1/2W 1 % Resistor (Hall effect cct)	grey-red-black-black-brown
	2	220Ω 1/2W 1% Resistor	red-red-black-black-brown
	1	100Ω 1/2W 1% Resistor (Hall effect cct)	brown-black-black-black-brown
	3	22Ω 1/2W 1% Resistor	red-red-black-gold-brown
	2	10Ω 1/2W 1% Resistor	brown-black-black-gold-brown
	2	47Ω 5W Resistor (Points trigger cct - one optional - see text)	
Capacitors			
	2	470pF 100V MKT (Reluctor cct)	470-100
	2	100µF 16V Electrolytic	
	2	10µF 100V MKT	
	1	0.47µF MKT Polyester	470n/474k
	1	0.15µF MKT Polyester	150n/154k
	1	0.12µF MKT Polyester	120n/124k
	2	0.1µF MKT Polyester	100n/l04k
	1	0.01µF MKT Polyester (Points cct)	10n/103k
	1	0.0022µF MKT Polyester (Reluctor cct)	2n2/222k
	1	0.0047µF MKT Polyester	4n7/472k
		0.001µF MKT Polyester	1n/102k

CHECK	QTY	DESCRIPTION	COMPONENT IDENTIFICATION &/OR LOCATION
Semiconductors			
	2	IR2155 Self Oscillating Half Bridge	IC1, IC2
	2	MTP3055E MOSFET	Q1,Q2
	2	IRF822 MOSFET	Q6,Q7
	4	BC337/877 NPN Transistor	Q3-Q5
	9	1N4148 / 1N914 Diode (D12 Reluctor/Points/ Hall cct; D13 Points cct optional)	D1, D8-D11
	6	1N4936 Fast Recovery Diode	D2-D5, D6, D7
	1	5.1V Zener Diode (ZD5 Reluctor trigger cct)	
	4	751W Zener Diode 1N4761	ZD1-ZD4
	1	S14K 275 VAC MOV	MOV1
	2	8-Way Machined IC Socket	
Transformer and Accessories			
	1	ETD29 Former	
	2	N2 7 Ferrite Core (2 pieces)	
	2	Clip (2 pieces)	
	1	Neosid Ringcore 17-732-22	
	1	0.25mm ECW Spool	
	2m	0.63mm ECW	
	0.5m	1mm ECW	
Hardware			
	6	3mm Nut	One to be used with L1
	6	3x15mm Bolt	One to be used with L1
	6	3mm Shakeproof Washer	One to be used with L1
	2	Large Nylon Grommet	
	2	5mm Ring Terminal	Automotive coil terminals
	1	Solder Lug	
	4	TO-220 Silicon-Impregnated Rubber Washer	
	5	TO-220 Bush	One to be used with L1
	2m	1mm Solder	
	15cm	0.71 Tinned Copper Wire	
	8	PC Pin	
	2m	Red Auto Cable	
	2m	Black Auto Cable	
	1m	Green Auto Cable	
Case and PCB			
	1	Diecast Case 171 x 121 x 55mm	
	1	PCB SC05309971 112 x 144mm	

Table2: *Capacitor Codes*

Value	IEC Code	EIA Code
1µF	1u0	105
0.47µF	470nF	474
0.15µF	129nF	154
0.12µF	120nF	124
0.1µF	100nF	104
0.01µF	10nF	103
0.0047µF	4n7	472
0.0022µF	2n2	222
0.001µF	1n0	102
470pF	470p	471

Table3: *Resisitor Colour Codes*

No.	Value	4~Band Code (1%)	5-Band Code (1%)
2	680kΩ	blue grey yellow brown	blue grey black orange brown
2	180kΩ	brown grey yellow brown	brown grey black orange brown
2	56kΩ	green blue orange brown	green blue black red brown
2	47kΩ	yellow violet orange brown	yellow violet black red brown
6	33kΩ	orange orange orange brown	orange orange black red brown
2	33kΩ	orange orange orange brown	orange orange black red brown
1	22kΩ	red red orange brown	red red black red brown
1	13kΩ	brown orange orange brown	brown orange black red brown
6	10kΩ	brown black orange brown	brown black black red brown
1	2.2kΩ	red red red brown	red red black brown brown
1	820Ω	grey red brown brown	grey red black black brown
1	390Ω	orange white brown brown	orange white black black brown
2	220Ω	red red brown brown	red red black black brown
1	100Ω	brown black brown brown	brown black black black brown
3	22Ω	red red black brown	red red black gold brown
2	10Ω	brown black black brown	brown black black gold brown

Personal note:
I removed 3 photos embedded in the the original SC aricle to keep this file as small as possible. They're not very expressive, gooogle for Cap-dis-ignit-CDI.pdf which has them all included in nice resolution.

Picture1: Opened finished CDI housing
„Designed by JOHN CLARKE"

Picture2: Opened case fixed in an engine compartment
„Here the new Multi-Spark CDI is shown mounted in the engine compartment of a Mitsubishi Sigma. Note the long parallel run of the spark plug leads. We suggest that the spacing between these leads should be increased to reduce any possibility of cross-fire."

Picture3: Not surprising – opened case with a detailed view to most of components
„The Multi-Spark Capacitor Discharge Ignition system is housed in a diecast box which provides adequate heatsinking for the four Mosfets."