High-Energy Multi-Spa for Performance Cars

This capacitor discharge ignition (CDI) system is designed to provide a very high energy multi-spark discharge each time the spark plug is fired. It enables complete mixture combustion in virtually all internal combustion engines used in cars and motorcycles, and is especially effective with engines that run at high RPM.

WHILE FACTORY-SUPPLIED ignition systems in modern vehicles operate reliably and give a high-energy spark, there are many situations where a multi-spark capacitor discharge ignition (CDI) can provide a better result than the standard ignition. Perhaps the best examples are old 4-stroke engines with conventional points ignition and all 2-stroke engines.

The faster rise time, hotter sparks and multiple spark discharges can easily fire plugs that are fouled up with carbon caused by oil in the fuel. Again, with an older engine, a multi-spark CDI system can be especially beneficial when the engine is cold and running with a rich fuel mixture.

A CDI also draws less power from the vehicle's 12V battery compared to conventional ignition systems. This can be a real advantage where a vehicle has a low output alternator or generator, or in some racing vehicles where no alternator is fitted (eg, in drag racing).

One drawback of CDI systems is the potential of cross-fire between spark plugs due to the rapid rise time of the spark voltage. Cross-fire sounds like 'pinging' and can cause severe engine damage if it happens consistently. Therefore, we do not recommend using our *High-Energy Multi-Spark CDI* system on 6-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.

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Part 1: By JOHN CLARKE

Features and specifications

Main features

- Suitable for 2-stroke and 4-stroke engines
- Multiple spark output (see Table 1)
- Provides a shorter-duration hotter spark than traditional ignitions
- Operates on reluctor, points, optical, engine management or Hall effect signals
- Usable to 1000 sparks/second (equivalent to 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

Specifications

- Spark energy without multi-sparking: 11mJ measured with Bosch GT40 ignition coil, 15mJ with VW Caravelle T4 ignition coil
- Number of sparks per firing: minimum of two (see Table 1)
- Spark separation: 0.5ms for the first two sparks, then 0.66ms, 0.33ms, 0.66ms...
- Spark duration: About 200μs per spark
- Multiple spark period: two sparks = 700μs; four sparks = 1.5ms; six sparks = 2.4ms; eight sparks = 3.3ms; 10 sparks = 4.3ms; 12 sparks = 5.2ms; 14 sparks = 6.2ms
- Reluctor circuit sensitivity: 400mV RMS
- Inverter operating frequency: 60kHz
- Operating voltage: down to 9V
- Current drain at 13.8V with multi-sparking: 200mA @ 0Hz, 1A @ 50Hz, 2A @ 150Hz, 3A @ 400Hz, 4A @ 500Hz
- Delay between trigger and firing: 1μs

If you have an older car, 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.

Our new CDI system can be triggered by conventional ignition points, Hall effect, optical, engine management or reluctor pick-ups. It's capable of operation to very high engine speeds, much higher than even racing engines reach. For example, it can run as high as 30,000 RPM 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.

Multiple-spark discharge

So what is 'multi-spark'? Standard transistor-switched and CDI ignition systems produce a single spark each time the mixture in the cylinder is ignited. 'Multi-spark' produces several sparks which are fired in quick succession. Our new design produces up to 10 sparks each time a spark plug is to be fired, depending on the engine speed.

If you wish, this feature can be disabled so that the CDI produces just two sparks for each cylinder firing, regardless of engine speed.

The advantage of multi-sparking is that it ensures a more complete burn of the fuel, especially when firing is prone to be difficult in a cold and rich-running engine.

Fig.1(a) shows the schematic diagram of the conventional Kettering ignition system which has been used in cars since 1910 (originally introduced on the Cadillac). It comprises an ignition coil which has its primary winding connected to the battery supply and a switch in the negative side.

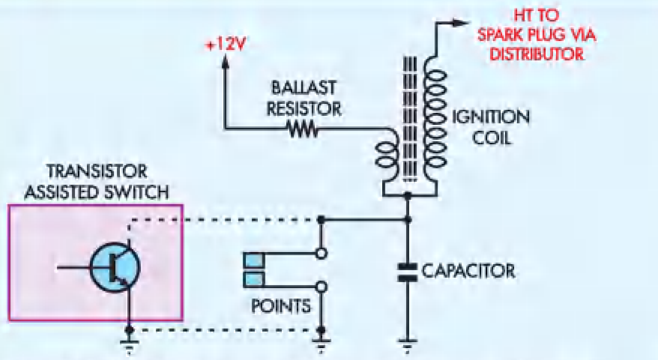


Fig.1(a): the Kettering ignition system uses points or a transistor to interrupt the current through the coil.

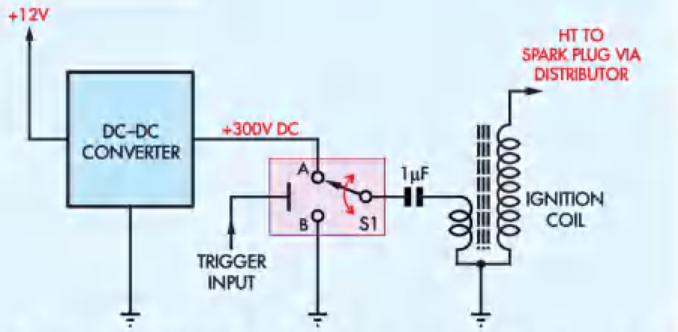


Fig.1(b): the *Multi-Spark CDI* uses a DC-to-DC inverter to charge a 1μF capacitor when S1 is at A. This capacitor then discharges through the coil when S1 switches to B.

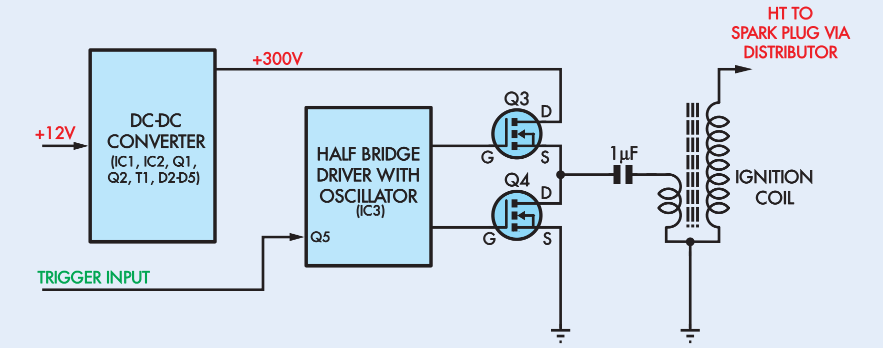


Fig.2: block diagram for the *CDI Multi-Spark Ignition*. The 300V output from the DC-DC converter is fed to the drain of MOSFET Q3 which is used as a switch to direct current flow through a 1µF capacitor. MOSFET Q4 then shunts the lefthand side of the capacitor to ground to fire the coil (after first switching off Q3). When Q4 is switched off and Q3 is switched back on again, another spark is generated as the 300V DC is re-applied to the capacitor.

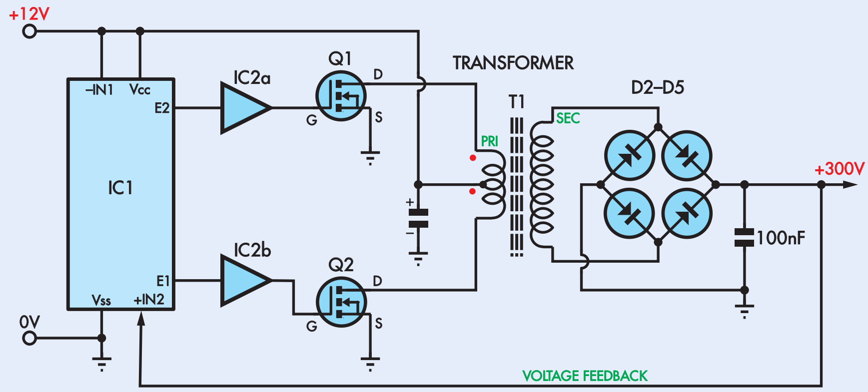


Fig.3: simplified circuit of the DC-DC converter. MOSFETs Q1 and Q2 are driven by a switch-mode PWM waveform generated by IC1 via buffers IC2a and IC2b. The MOSFETs in turn drive the centre-tapped primary winding of transformer T1 and the output from the secondary is fed to a bridge rectifier (D2-D5) and a 100nF filter capacitor to produce the 300V DC output.

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 increases in the primary winding and is only limited by the internal resistance of the coil and a ballast resistor (if used). The maximum current is usually up to 5A.

When the switch opens, the resulting collapse of the magnetic field in the coil 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, as in direct-fire ignition systems.

Fig.1(b) shows how a typical CDI system works. It has a DC-to-DC inverter with a regulated 300V DC output which charges up a 1µF capacitor. This 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 fired, two sparks are produced – one with positive polarity and one with negative polarity. The CDI can be made to produce more than two sparks for each firing by repeatedly charging and discharging the 1µF capacitor.

Note that older CDI design versions have the lefthand side of the capacitor permanently connected to the DC-DC converter output. This side of the capacitor is switched to ground for firing, usually by an SCR. This arrangement means that the DC-DC converter is effectively shorted to ground and needs to shut down on each firing (otherwise the SCR would continue to conduct).

Fig.2 shows the block diagram for CDI ignition. The DC-DC converter’s 300V output connects to the drain of MOSFET Q3 which is used as a switch to direct current flow through the 1µF capacitor. MOSFET Q4 then shunts the left side of the capacitor to ground to fire the coil (Q3 is switched off first). When Q4 is switched off and Q3 switched back on, there is another spark generated as the 300V is reapplied to the capacitor.

DC-DC converter basics

The basic principle of the DC-DC converter is simple. It works by alternately switching the 12V battery supply to each half of a centre-tapped transformer primary winding. The resulting square waveform is stepped up by the transformer’s secondary and then rectified and filtered to provide the 300V DC supply rail.

Fig.3 shows the simplified circuit of the DC-DC converter. The circuit operates at a switching frequency of about 60kHz and uses a high-frequency ferrite transformer. The centre-tapped primary winding of the transformer is driven by MOSFETs Q1 and Q2. Q1 drives the top half of the step-up transformer, while Q2 drives the bottom half. The secondary winding’s output is fed to a bridge rectifier and filter capacitor to produce the 300V DC output rail.

The MOSFETs are driven by a switch-mode PWM (pulse-width modulation) waveform generated by IC1. This feeds complementary (ie, out of phase) gate signals to the MOSFETs via buffers IC2a and IC2b. Negative feedback is applied to the +IN2 input of IC1 from the 300V DC output via a voltage divider (not shown). This feedback circuit acts to reduce the width of the pulses applied to the MOSFETs if the DC voltage rises above 300V.

Conversely, the pulse width from the driver circuit increases if the output voltage falls below 300V. Since the MOSFETs are switched in anti-phase, when one half of the winding is conducting, the other is off.

The DC-DC circuit also incorporates a low-voltage cut-out to protect the battery from over-discharge. It monitors the battery voltage at –IN1 and if it drops below 9V, the DC-DC converter switches off.

Circuit details

Refer now to Fig.4 for the full circuit of the *High-Energy Multi-Spark CDI*. Its DC-DC converter is based on a

Parts List

1 PCB, available from the *EPE PCB Service*, code 05112141, 110.5 × 85mm
1 diecast metal case, 119 × 94 × 57mm
1 ETD29 transformer (T1) consisting of 1 × 13-pin former, 2 × N87 cores (element14 Cat. 1781873) and 2 × clips
1 S14K 275V AC metal-oxide varistor (MOV1)
2 IP68 cable glands, 4-8mm cable diameter
4 M3 × 9mm tapped spacers
4 TO-220 silicone insulation washers
4 insulating bushes
1 100kΩ top-adjust multi-turn trimpot (VR1)
4 M3 × 9mm tapped nylon spacers
5 M3 × 10mm screws
4 M3 × 6mm screws
4 M3 × 6mm countersink-head screws
5 M3 nuts
2 3mm star washers
2 solder lugs
1 20m length of 0.25mm-diameter enamelled copper wire (for T1 secondary)
1 1200mm length of 1.0mm-diameter enamelled copper wire (for T1 primary)
1 2m length of red automotive wire
1 2m length of black automotive wire
1 2m length of green automotive wire
1 2m length of white automotive wire

Semiconductors
1 TL494CD SOIC switch-mode PWM control circuit (IC1)*
1 TC4427COA SOIC high-speed MOSFET driver (IC2)*
1 L6571AD SOIC high-voltage half-bridge driver with oscillator (IC3)*
2 STP60NF06 60V 60A N-channel MOSFETs (Q1,Q2)*
2 FDP10N60NZ 10A 600V N-channel MOSFETs (Q3,Q4)*
2 BC337 NPN transistors (Q5,Q6)
1 16V 1W Zener diode (ZD1)
1 75V 1W Zener diode (ZD2)
1 1N4004 1A 400V diode (D1)
5 UF4007 fast rectifier diodes (D2-D6)
3 1N4148 switching diodes (D7-D9)
* available from element14.com

Capacitors
1 4700µF 16V PC low-ESR electrolytic
3 100µF 16V PC low-ESR electrolytic
1 10µF 16V PC electrolytic
2 1µF 50V monolithic multilayer ceramic (MMC)
1 1µF X2 class 275VAC MKP metallised polypropylene (Vishay BFC233922105*)
2 100nF X2 class 275VAC MKP metallised polypropylene
3 100nF 63/100V MKT
1 4.7nF 63/100V MKT
1 1nF 63/100V MKT
1 C1 (470nF for 8-cylinder, 150nF for 6-cylinder, 120nF for 4-cylinder), 63/100V MKT
* available from element14.com

Resistors (0.25W, 1%)

3 1MΩ	1 13kΩ
2 680kΩ	7 10kΩ
2 270kΩ	1 8.2kΩ
2 180kΩ	2 4.7kΩ
1 56kΩ	1 2.2kΩ
2 47kΩ	2 22Ω
1 33kΩ	3 10Ω
2 33kΩ 1W	

Points version
1 100Ω 5W resistor (R1)

Reluctor version
1 BC337 NPN transistor (Q7)
1 5.1V 1W Zener diode (ZD3)
1 2.2nF MKT polyester capacitor
1 470pF ceramic capacitor
1 100kΩ top adjust multi-turn trimpot (VR2)
1 47kΩ 0.25W 1% resistor
1 10kΩ 0.25W 1% resistor
1 10kΩ 0.25W 1% resistor (R4)
1 1kΩ 0.25W 1% resistor (R3)
2 150Ω 0.25W 1% resistors

Hall Effect/Lumenition Module
1 5.1V 1W zener diode (ZD3)
1 150Ω 0.25W 1% resistor
1 1kΩ 0.25W 1% resistor (R3)
1 100Ω 0.25W 1% resistor (R2)

Optical Pick-up
1 optical pick-up (Piranha or Crane)
1 5.1V 1W zener diode (ZD3)
1 22kΩ 0.25W 1% resistor (R3 or R6)
2 150Ω 0.25W 1% resistors
1 120Ω 0.25W 1% resistor (R4 or R5)

Miscellaneous
Heatshrink tubing, angle brackets for mounting, automotive connectors, self-tapping screws

Texas Instruments TL494 switch-mode driver (ICI).

This device has been available since the early 1980s and is still used today in many switch-mode power supplies. The IC contains all the necessary circuitry to generate complementary square-wave outputs at pins 9 and 10 and these drive the gates of the MOSFETs via MOSFET drivers. The IC also contains control circuitry to provide output voltage regulation and low voltage cut-out.

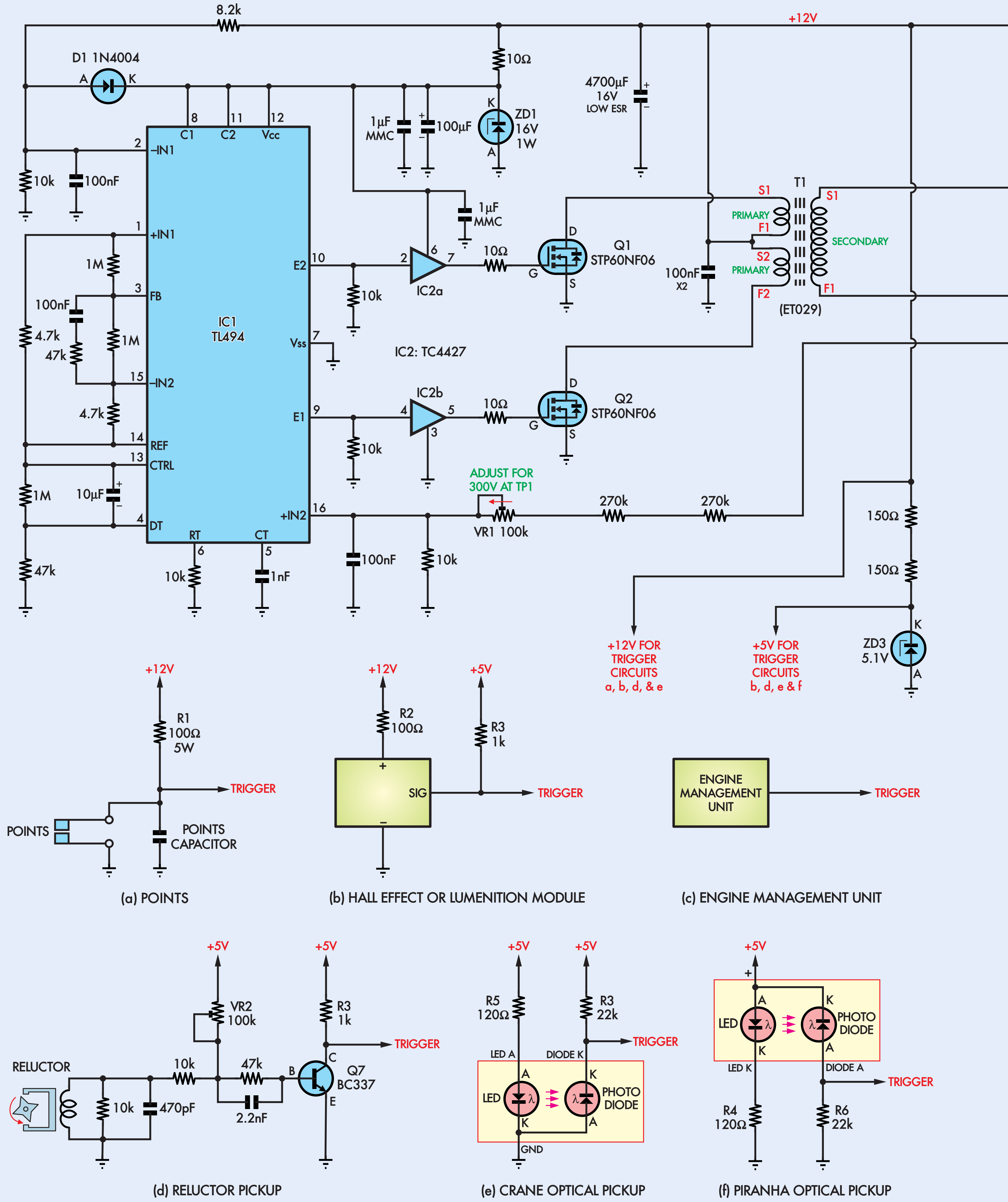
Fig.5 shows the internal circuitry of the TL494. It's a fixed-frequency PWM controller containing a sawtooth oscillator, two error amplifiers and a PWM comparator. It also includes a dead-time control comparator, a 5V reference and output control options for push-pull or single-ended operation.

The PWM comparator generates the variable-width output pulses by comparing the sawtooth oscillator waveform against the combined outputs of the two error amplifiers. The error amplifier with the highest output voltage sets the pulse width.

The control (CTRL) output at pin 13 of IC1 is used to set either single-ended output or push-pull operation. In our design, push-pull (ie, anti-phase) outputs are selected and these are produced at the transistor emitters at pins 9 and 10 (E1 and E2). These internal transistors have their collectors tied to the positive supply rail.

Dead-time comparator

The internal dead-time comparator ensures that there is a brief delay before one output goes high after the other has gone low. This means that the outputs at pins 9 and 10 are both low for a short time at the transition



MULTI-SPARK CAPACITOR DISCHARGE IGNITION

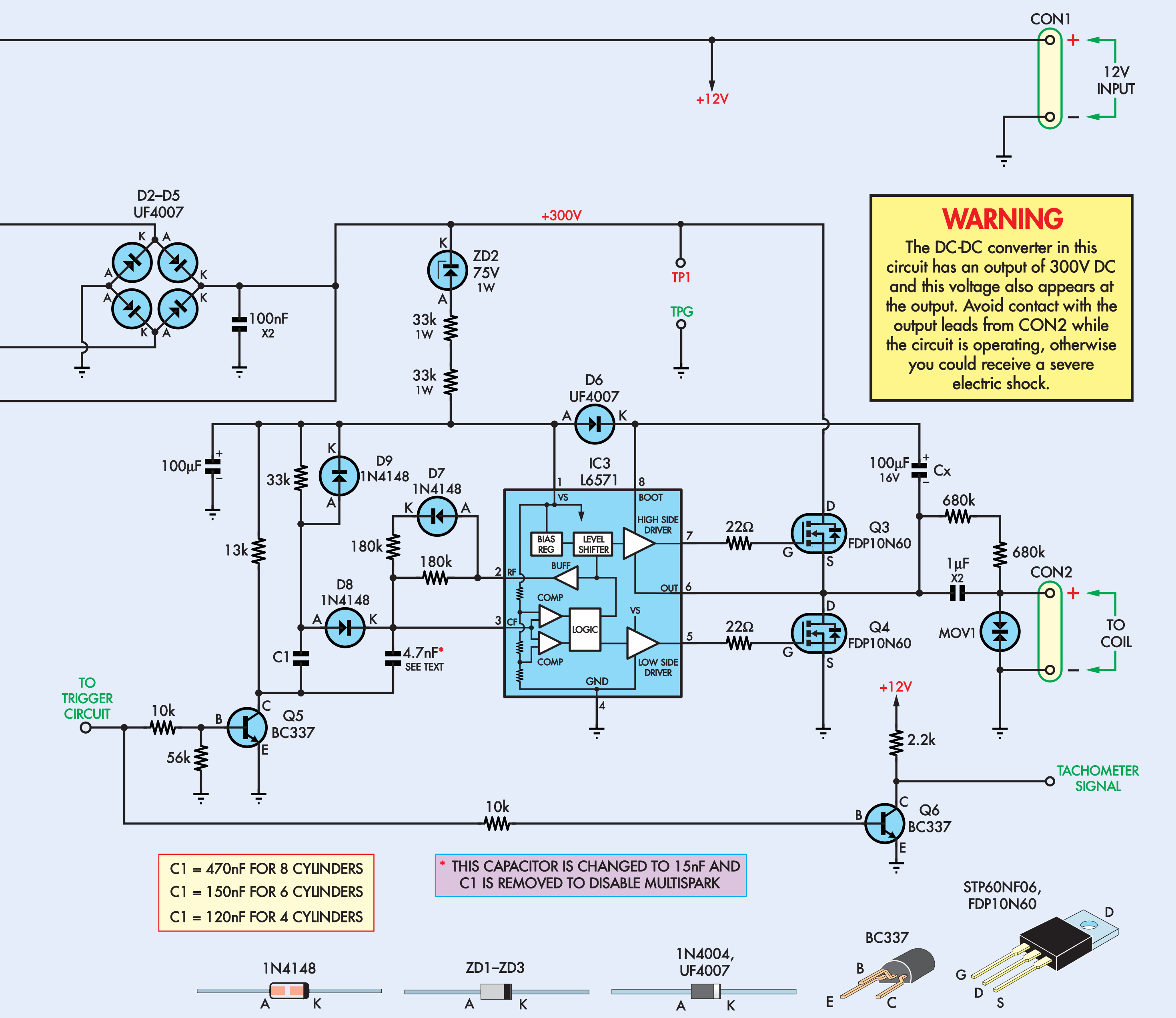


Fig.4: the circuit is based on IC1, which is a TL494 switch-mode driver. This combines with MOSFETs Q1 and Q2, transformer T1 and bridge rectifier D2-D5 to form the DC-DC converter. IC3, an L6571AD high-voltage half-bridge driver and oscillator, is used to alternately switch MOSFETs Q3 and Q4 to charge and discharge the 1µF capacitor via the ignition coil. The circuit caters for six different input triggers: (a) points; (b) Hall effect/Lumenition triggering; (c) engine management module triggering; (d) reluctor pickup; (e) Crane optical pickup; and (f) Piranha optical pickup.

points. This dead-time period is essential because without it, the MOSFET driving one half of the transformer primary would still be switching off while the MOSFET driving the other half was switching on. As a result, the MOSFETs would be destroyed as they would effectively create a short circuit across the 12V supply.

One of the error amplifiers in IC1 is used to provide the under-voltage cut-out feature. This is done by connecting its pin 2 inverting input to the +12V rail via a voltage divider consisting of 10kΩ and 8.2kΩ resistors. The non-inverting input at pin 1 connects to IC1's internal 5V reference at pin 14 via a 4.7kΩ resistor.

When the voltage at pin 2 drops below 5V (ie, when the battery voltage drops below 9V), the output of the error amplifier goes high and the PWM outputs at pins 9 and 10 go low, shutting the circuit down. Note the 1MΩ resistor between the non-inverting input at pin 1 and the error amplifier output at pin 3. This provides a small amount of hysteresis so that the output of the error amplifier does not oscillate at the 9V threshold.

The second error amplifier in the TL494 is used to control the output voltage of the DC-DC converter. The feedback voltage is derived from the positive side of the bridge rectifier and fed via a voltage divider consisting of two 270kΩ resistors and trimpot VR1 in series, plus a 10kΩ resistor to ground. The resulting voltage is then

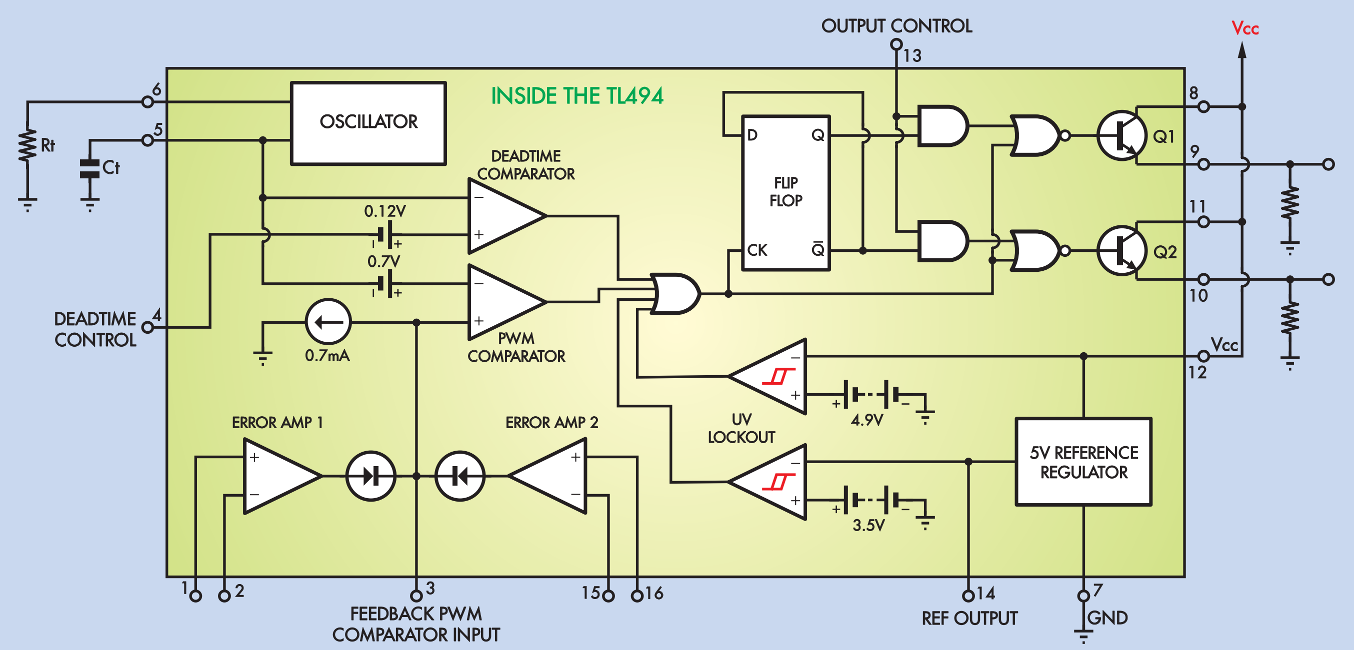


Fig.5: the internal circuit of the TL494 switch-mode pulse-width modulation (PWM) controller. It is a fixed-frequency PWM controller containing a sawtooth oscillator, two error amplifiers and a PWM comparator. It also includes a dead-time control comparator, a 5V reference and output control options for push-pull or single-ended operation.

fed to pin 16 of IC1 and compared to the internal 5V reference, which is applied to pin 15 via a 4.7kΩ resistor.

Normally, the attenuated feedback voltage should be close to 5V. Should this voltage rise (due to an increase in the output voltage), the output of the error amplifier also rises and this reduces the output pulse width. Conversely, if the output falls, the error amplifier's output also falls and the pulse width increases.

The gain of the error amplifier at low frequencies is set by the 1MΩ feedback resistor between pins 3 and 15 and by the 4.7kΩ resistor to pin 14 (V_{REF}). These set the gain to about 213. At higher frequencies, the gain is set to about 9.5 by virtue of the 47kΩ resistor and 100nF capacitor in series across the 1MΩ resistor. This reduction in gain at the higher frequencies prevents the amplifier from responding to hash on the supply rails.

The 10kΩ resistor and 1nF capacitor at pins 6 and 5 respectively set the internal oscillator to about 120kHz. This is divided by two using an internal flipflop to give the resulting complementary (anti-phase) output signals at pins 9 and 10. The resulting switching rate of the MOSFETs is 60kHz.

Pin 4 of IC1 is the dead-time control input. When this input is at the same level as V_{REF}, the output transistors are off. As pin 4 drops to 0V, the dead-time decreases to a minimum. At switch on, the 10µF capacitor between V_{REF} (pin 14) and pin 4 is discharged and this initially holds pin 4 at 5V. This prevents the output transistors in IC1 from switching on.

The 10µF capacitor then charges via the 47kΩ resistor (between pin 4 and ground) and so the duty cycle of the output transistors slowly increases until full control is gained by the error amplifier. This effectively provides a soft start for the converter. The 1MΩ resistor between pins 4 and 13 has been included to provide more dead-time. It prevents the 10µF capacitor from fully charging to 5V and this increases the minimum dead-time period.

Complementary outputs

As stated, the complementary PWM outputs at pins 9 and 10 of IC1 come from internal emitter-follower transistors. These each drive external 10kΩ pull-down resistors and MOSFET drivers IC2a and IC2b, which can deliver up to 1.5A charge/discharge current into the MOSFET gates, for fast and clean switching.

Note the 100nF X2 capacitor and the 4700µF low-ESR capacitor between the centre tap of the transformer primary and ground. These are there to cancel out the inductance of the leads which carry current to the transformer. They effectively provide the peak current required from the transformer as it switches.

Transformer T1 is a relatively small ferrite-cored unit designed to be driven at high frequencies. This is a similar arrangement to that used in the *Ultrasonic Cleaner* (*EPE*, August 2012) and in the *Ultrasonic Anti-Fouling Unit For Boats* (*EPE*, September and November 2012). Its primary and secondary windings are wound using enamelled copper wire, with the number of turns set to provide the required output voltage.

In operation, the power MOSFETs alternately switch each side of the transformer primary to ground, so that the transformer is driven in push-pull mode. When Q1 is on, the 12V supply is across the top half of the primary winding, and when Q2 is on, the supply is across the bottom half. This alternating voltage is stepped up by the secondary and applied to a full-wave bridge rectifier comprising UF4007 ultra-fast recovery diodes D2-D5.

These ultra-fast diodes are necessary because of the high switching frequency of 60kHz. A 100nF X2 capacitor filters the 300V DC output and this is fed to the drain of MOSFET Q3

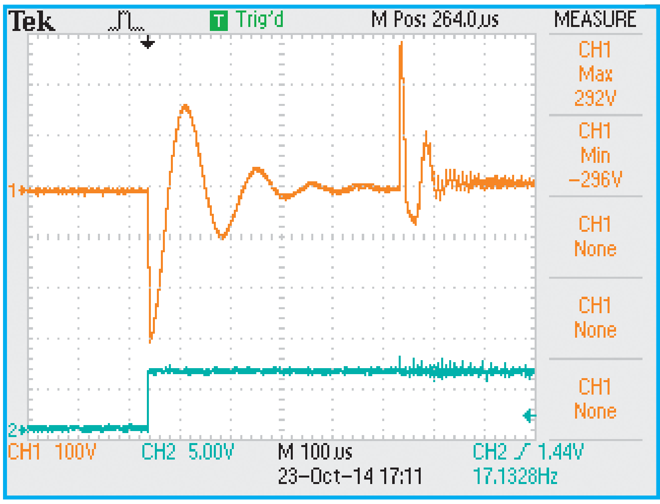


Fig.6: channel 1 (orange trace) of this scope shot shows the primary coil voltage at the coil+ output with multi-sparking disabled, while channel 2 (cyan) shows the input trigger signal. Note the –296V first spark voltage at the firing point and the +292V voltage excursion for the second spark 500µs later.

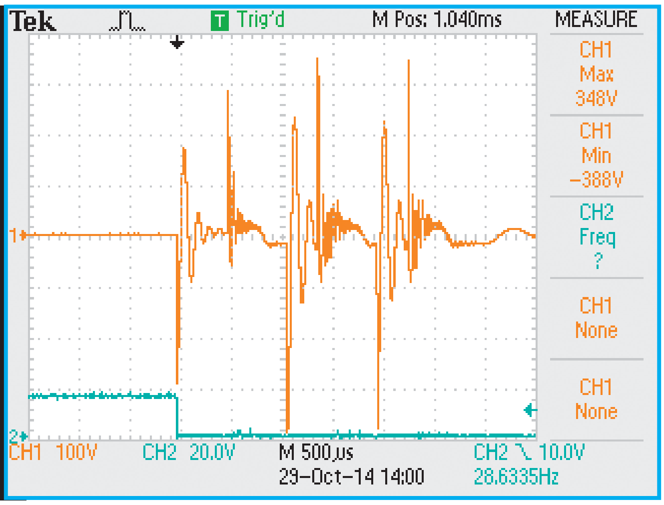


Fig.7: in this shot, channel 1 (orange) shows the primary coil voltage when six sparks are produced, while channel 2 (cyan) is triggered by the tacho signal.

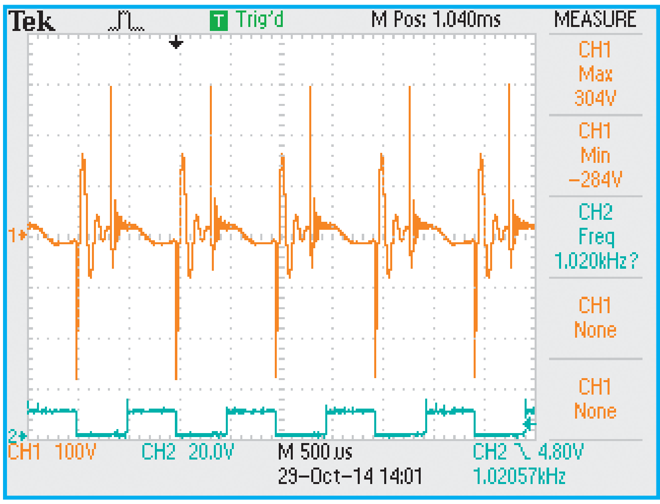


Fig.8: this scope shot shows that there is no drop off in the peak voltage applied to the coil (channel 1, orange) for a 1kHz input trigger frequency (channel 2, cyan).

and also to IC3, an L6571 half-bridge MOSFET driver and oscillator, via 75V zener diode ZD2 and two series 33kΩ 1W resistors.

IC3's supply at pin 1 is set to 15V by an internal zener diode. ZD2 is used to drop the 300V supply before feeding it to the 33kΩ resistors, so that each dissipates no more than 334mW.

Driving Q3

In order for MOSFET Q3 to fully turn on, its gate must be raised above its drain by several volts and this is the job of IC3, the L6571 half-bridge driver. It produces the necessary higher gate voltage using diode D6 and a 100µF capacitor (Cx) between Q3's source and pin 8.

Initially, IC3 starts with a 15V supply derived from the 300V rail, as mentioned above. Q4 is the first to be switched on and it pulls one side of capacitor Cx low. Cx then charges to the +15V supply via D6 and Q4.

When Q4 turns off and Q3 turns on, Q3 pulls pin 6 of IC3 up to the 300V rail and so pin 8 is jacked up above +300V by the 15V across the capacitor. The voltage across Cx is then maintained until next recharged via D6 and Q4 (note that pins 6, 7 and 8 of IC3 are floating outputs which can be shifted up to 600V above the pin 4 ground).

Cx needs to be relatively large (100µF) since it can be called on to keep its charge for up to 100ms during slow cranking of the motor. The totem-pole output of MOSFETs Q3 and Q4 drives the ignition coil primary via the 1µF X2 capacitor.

The 22Ω gate resistors slow the turn-on and turn-off times for Q3 and Q4, to limit transients when switching the 1µF capacitor.

Multi-sparking

Multi-sparking is possible because IC3 incorporates a self-oscillating section involving two comparators, as shown by its internal block diagram on Fig.4. The series resistor string sets the inputs of the two comparators at 2/3 and 1/3 of the 15V supply, while the external 4.7nF capacitor and 180kΩ resistor configure the two comparators as an astable multivibrator. It operates in a very similar way to a 555 timer IC connected in astable mode.

In our circuit, we have added diode D7 and another 180kΩ resistor in series. This ensures that the discharge period for the 4.7nF capacitor via one of the 180kΩ resistors is much longer than the charging period via both 180kΩ resistors and D7 when the latter is forward biased by pin 2.

Note that the 4.7nF capacitor is only tied to ground when transistor Q5 is switched on via the trigger circuit. Capacitor C1 is also connected to the collector of Q5. Initially, when Q5 is off, C1 is discharged and held at the pin 1 supply voltage (+15V) via the 13kΩ resistor at Q5's collector and the 33kΩ resistor at D8's anode. This last resistor pulls pin 3 of IC3 well above the upper threshold (2/3 the pin 1 supply) via D8. As a result, pin 2 goes low but the 4.7nF capacitor cannot be discharged and so IC3 doesn't oscillate.

Table 1: RPM vs spark number and duration

RPM	Distributor trigger frequency (Hz)	No. of sparks	Multiple spark duration (crankshaft degrees)
4-Cylinder 4-Stroke engines			
600	20	6	8
900	30	6	13
1200	40	6	16
1500	50	6	20
2250	75	4	19
3000	100	4	25
4500	150	4	37
9000	300	2	21
15,000	500	2	36
6-cylinder 4-stroke engines			
400	20	8	8
600	30	8	12
800	40	6	11
1000	50	6	14
1500	75	6	21
2000	100	4	16
3000	150	4	24
6000	300	2	14
10,000	500	2	22
8-cylinder 4-stroke engines			
300	20	14	11
450	30	12	13
600	40	10	15
750	50	10	18
1125	75	8	21
1500	100	8	20
2250	150	6	29
4500	300	4	32
7500	500	2	15

This in turn means that MOSFET Q4 is off and Q3 is on.

When Q5 switches on due to an input trigger signal, D8's anode is pulled low via C1. Thus, the 33kΩ resistor is temporarily out of the oscillator circuit and so the 4.7nF capacitor is charged and discharged via the components at pin 2, as previously discussed. Q4 and Q5 now switch on and off alternately and so the coil is fired repetitively.

C1 now charges again via the 33kΩ resistor and when its voltage reaches the upper threshold of pin 3's input, the oscillator stops as described before.

Note that at high RPM, Q5 is on for less time than it takes C1 to recharge via the 33kΩ resistor and switch off IC3's oscillation. The instant this transistor switches off, IC3 stops oscillating since C1 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.

The trigger circuit also drives transistor Q6 to provide a low voltage (+12V) tachometer output. This is necessary, since a tachometer connected to the coil would otherwise give false readings.

Disabling multi-spark mode

If you wish, the multi-spark feature can be easily disabled by removing C1 and replacing the 4.7nF capacitor with a 15nF capacitor instead.

This modification now causes IC3 to produce a single 0.5ms pulse to switch on Q4. This fires the coil in one direction when Q4 switches on and in the other direction when Q3 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.

Two 680kΩ resistors are connected in series across the 1µF X2 output capacitor to discharge it should the coil become disconnected from the circuit. This is a safety measure since a 1µF capacitor charged to 300V can produce a very nasty shock.

Trigger inputs

Because this *Multi-Spark CDI* is intended for use with a wide range of engines, we have made it compatible with six different trigger sources. These are all shown on the main circuit of Fig.4.

The points input circuit (a) simply comprises a 100Ω 5W resistor connected to the 12V supply. This resistor provides a wetting current for the points to ensure their contacts remain clean. The points connect to the trigger input associated with Q5.

The Hall effect or Lumenition (optical trigger) module input (b) uses a 100Ω supply resistor (R2) to the +12V rail. This resistor limits the current into the internal clamping diode of the Hall effect or Lumenition unit. The 1kΩ resistor (R3) pulls the output voltage up to +5V when the internal open-collector transistor is off. Conversely, the output voltage falls to near 0V

Beware of similar ICs!

Note that there are similar half-bridge self-oscillating MOSFET drivers to the L6571, such as the IR2155 – note that the IR2155 is now an obsolete part.

There are also what may appear to be similar drivers. These include the IR2153, the IR25603 and the IRS2153. Don't use these in this circuit – they won't work properly!

The *High-Energy Multi-Spark CDI* is housed in a rugged diecast metal case which provides good heatsinking for the four MOSFETs. It's mounted in a splash-proof location in the engine bay, preferably where air can flow over it and well away from the hot exhaust manifold and exhaust pipes.

when the internal transistor turns on.

The engine management input (c) is very straightforward; the 5V signal output from the vehicle's engine management unit simply connects to the trigger input.

Reluctor triggering

The reluctor input circuit (d) is the most complex. In operation, the reluctor coil produces an AC signal which switches transistor Q7 on and off. This works as follows: with no reluctor voltage, transistor Q7 is biased on via trimpot VR2 and the 47kΩ resistor to its base. The actual voltage applied to Q7's base depends on the 10kΩ resistor connected to the top of the reluctor coil and on the internal resistance of the reluctor.

Trimpot VR2 is included to cater for a wide range of reluctor resistance values. In practice, VR2 is adjusted so that Q7 is just switched on when there is no signal from the reluctor. When the signal goes positive, Q7 remains switched on. When the signal goes negative, Q7 is switched off.

Resistor R4 provides loading for the reluctor, while the 470pF capacitor shunts any high-frequency signals. The 2.2nF capacitor speeds up Q7's switch-on and switch-off times.

Optical triggering

Two optical (photoelectric) triggering versions are catered for, one for a Crane pick-up (e) and one for a Piranha pick-up (f). The Crane trigger has a common-ground connection, while the Piranha has a common positive. For the Crane trigger, resistor R5 feeds current to the internal LED from the +5V supply, while R3 functions as a pull-up resistor for the photodiode.

Similarly, for the Piranha trigger, R4 is the current resistor for the LED, while R6 functions as pull-down for the internal photodiode.

That's all for this month. Next month, we'll describe the PCB assembly and the test and installation procedures.

Warning – High Voltage!

This circuit produces an output voltage of up to 300V DC to drive the coil primary and is capable of delivering a severe (or even fatal) electric shock. DO NOT TOUCH any part of the circuit or the output leads to the coil from CON2 while power is applied.

To ensure safety, the PCB assembly must be housed in the recommended diecast case. This case also provides the necessary heatsink for the four MOSFETs – see Part 2 next month.