

### CAPACITIVE DISCHARGE IGNITION

#### INTRODUCTION

In the world of small motor, such as mopeds or lawn movers the ignition system design is based exclusively on CDI <sup>(1)</sup>. In automobile CDI was in the past only used in the replacement module market. Today, due to new standards of pollution control, the CDI system is becoming one of the most efficient choice available.

The purpose of this paper is to analyze the behavior of the CDI, the solutions we propose today in small motor applications and the state of the art in automotive.

Note: 1. CDI: Capacitive Discharge Ignition

#### CDI PRINCIPE

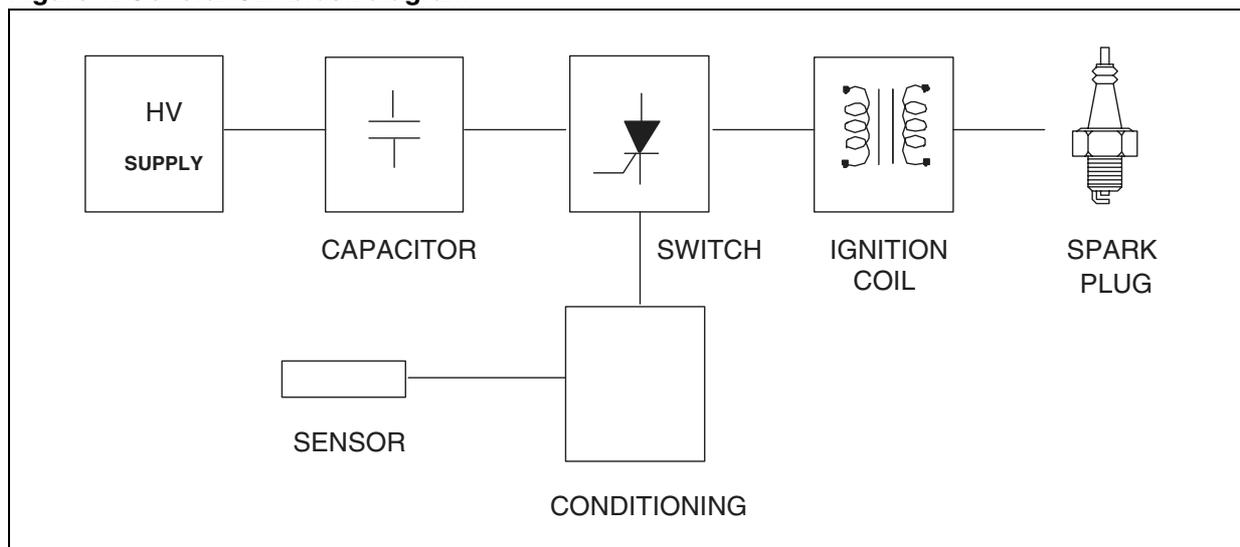
The spark necessary to ignite the air/petrol mixture in the combustion chamber is produced by the CDI module. This system consists of 7 stages.

#### HV supply

The HV supply differs from small motors to automobiles. The small one or two cylinder motors one or two stroke have a fly-wheel which includes a supply winding. This coil produces, after rectification, a positive voltage variable between 100V and 400V.

The HV for an automobile CDI is supplied by a DC/DC converter. This stage produces generally 400V from the 12V battery voltage.

**Figure 1. General CDI block diagram**



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### Capacitor

The capacitor between 0.47 and 2 $\mu$ F is used firstly, to store the charge from the HV supply. During the second phase of the ignition cycle the capacitor is discharged through the ignition circuit.

### Switch

The switch transfers the energy stored in the capacitor to the primary of the ignition coil. This function is carried out by a SCR or a triac. The switch is generally linked to a diode for the reverse current.

### Sensor

The goal of the sensor is to synchronize the spark with the engine rotation. For the small motor the sensor detects a bump at each engine revolution. For car modules the sensor system gives a pulse for each cylinder ignition point.

### Conditioning

The conditioning is a very important stage which must assume the following functions:

- Optimisation of the SCR gate current for all the RPM range.
- Filtering of parasitic strikes occurring on the sensor signal.
- For the most sophisticated small engine and all the car systems, it has to ensure the correct lead angle.

This stage is realized using few passive components for small motor modules, while for automotive management systems a microprocessor is needed.

### Ignition coil

The ignition coil is a step up transformer which delivers high voltage to the spark plug. This value can be between 5 and 20kV depending on the working conditions.

### Spark plug

The spark plug is the final element of the ignition chain. High engine efficiency and a complete gas combustion are linked to a good spark quality.

Generally we estimate a minimum of 20 millijoules is necessary at spark plug.

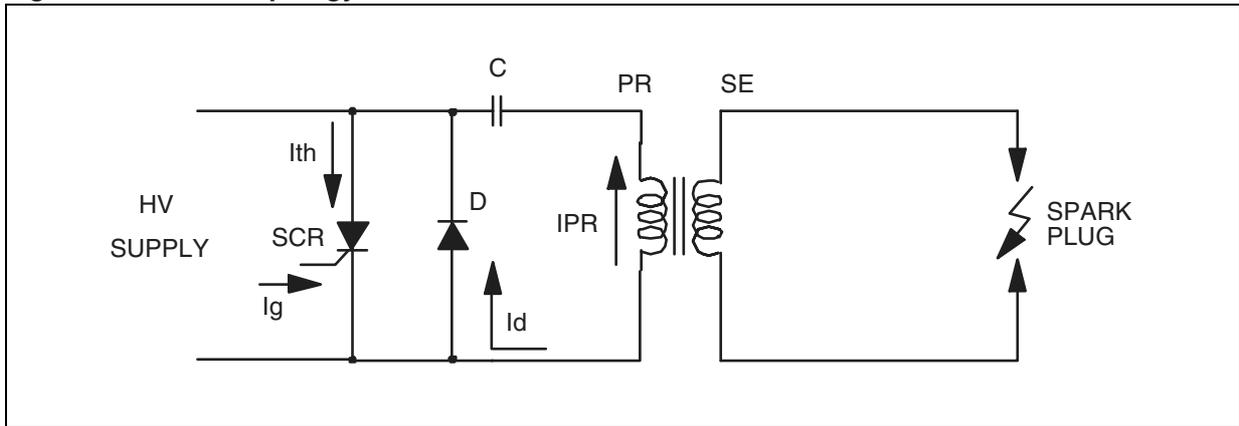
**HOW DOES IT WORK?**

Two different topologies are possible.

**First topology**

Figure 2 shows the first possibility of discharge circuit.

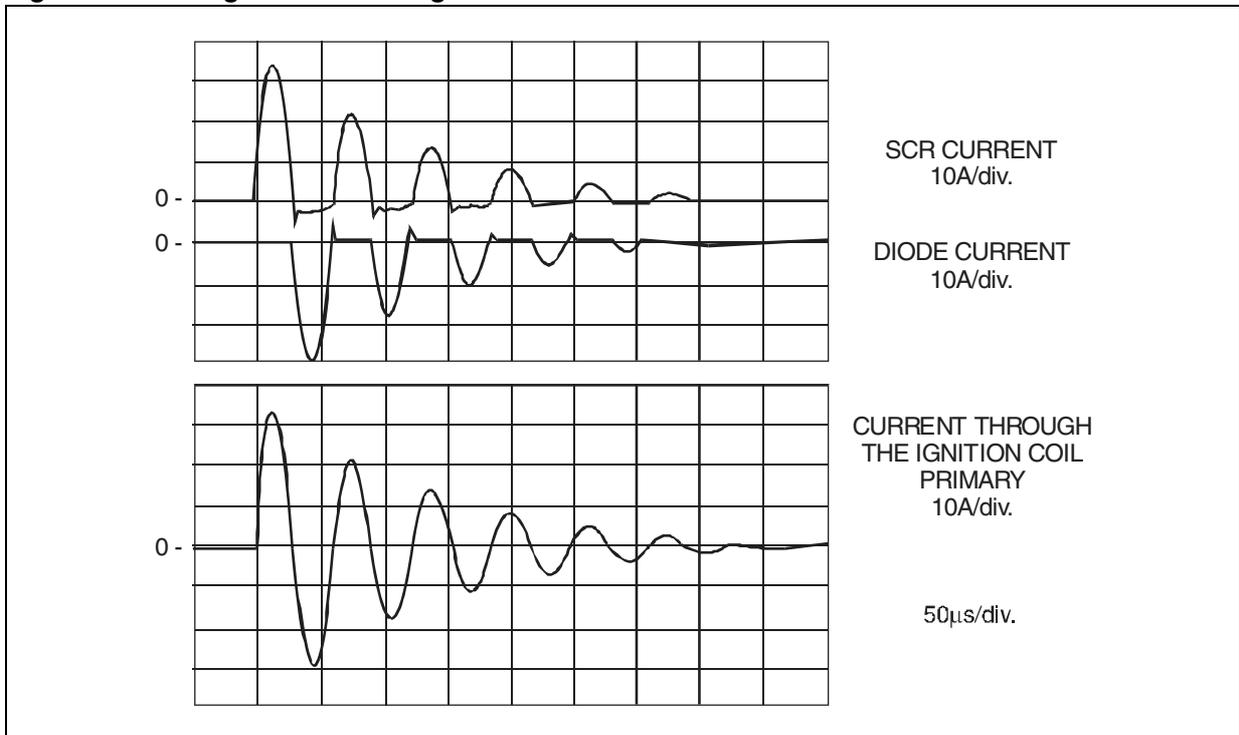
**Figure 2. First CDI topology**



When spark is needed a current  $I_g$  is injected to the SCR gate which then fires the SCR. The SCR firing initiates the capacitor discharge which generates an alternative current.

The SCR conducts during all the positive phases of the discharge current while the diode D acts for the negative parts.

**Figure 3. Discharge current through the circuit**



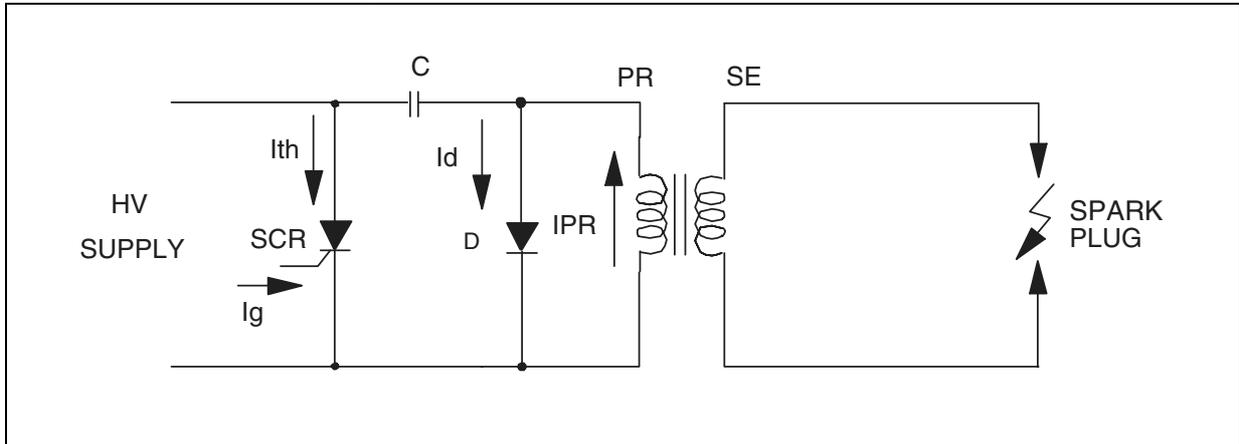
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### Second topology

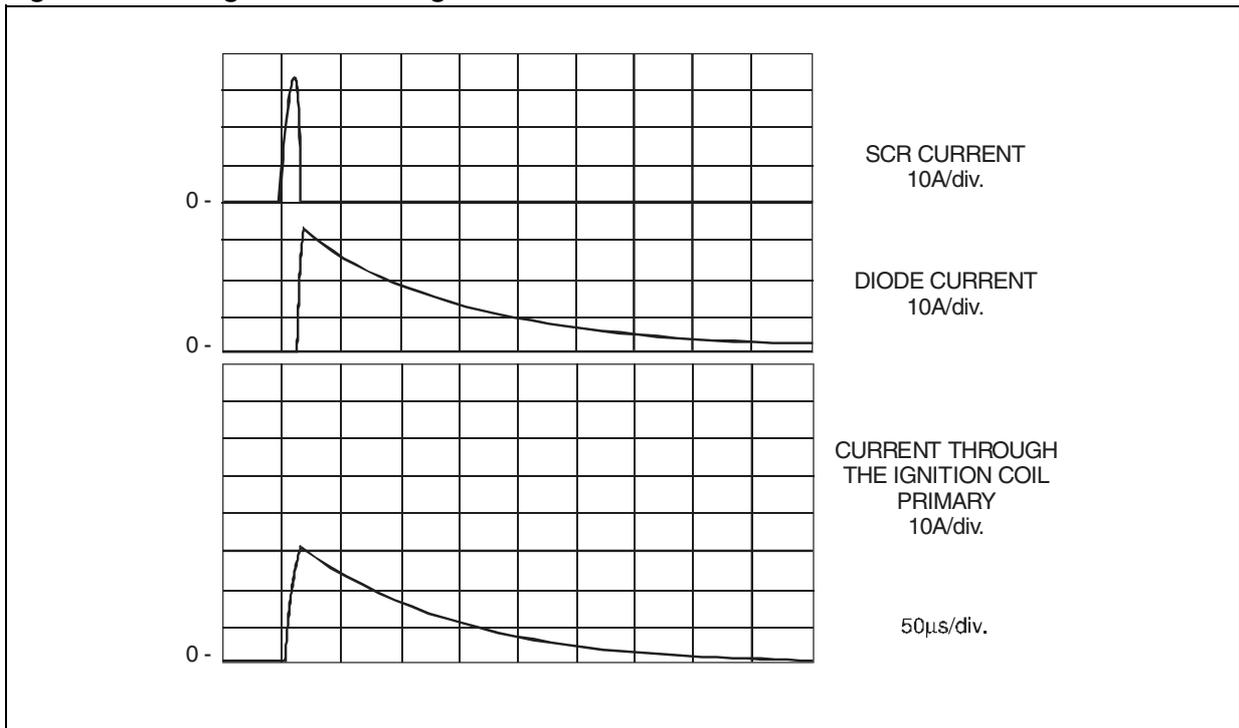
In the topology shown by figure 4 the SCR acts during the first part of the current cycle until the capacitor voltage reverse.

Then the free wheeling diode D conducts as long as there is energy remaining on the primary coil.

**Figure 4. Second CDI topology**



**Figure 5. Discharge current through the circuit**

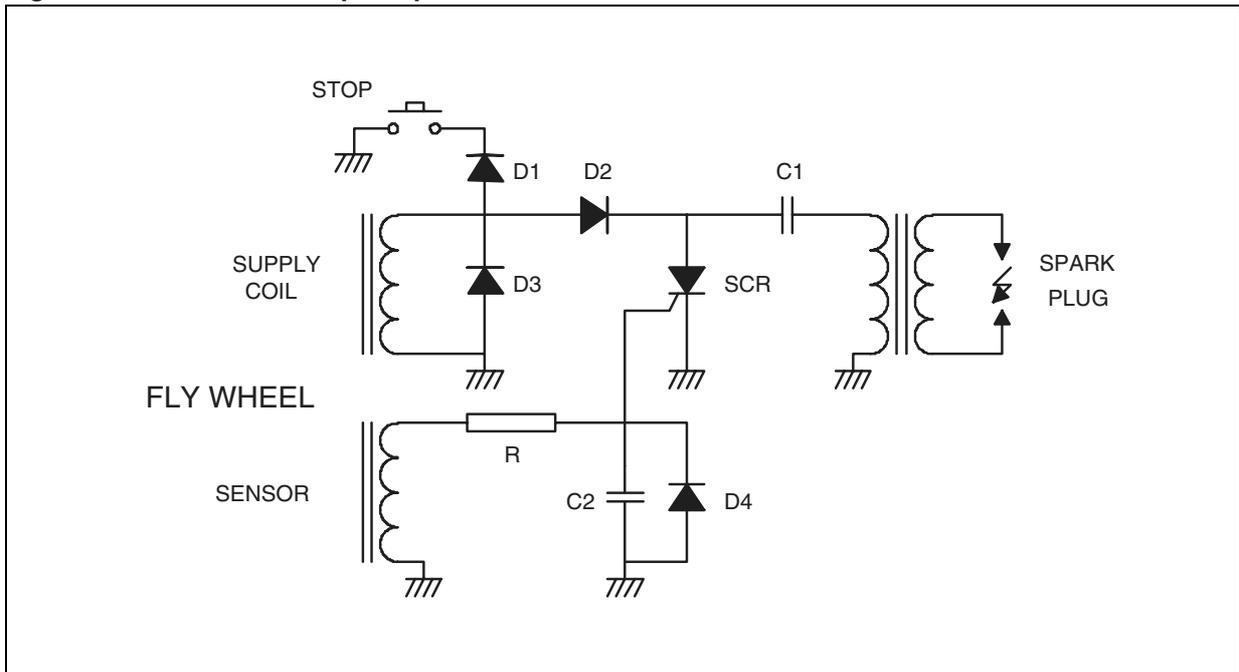


**SMALL ENGINE SYSTEM**

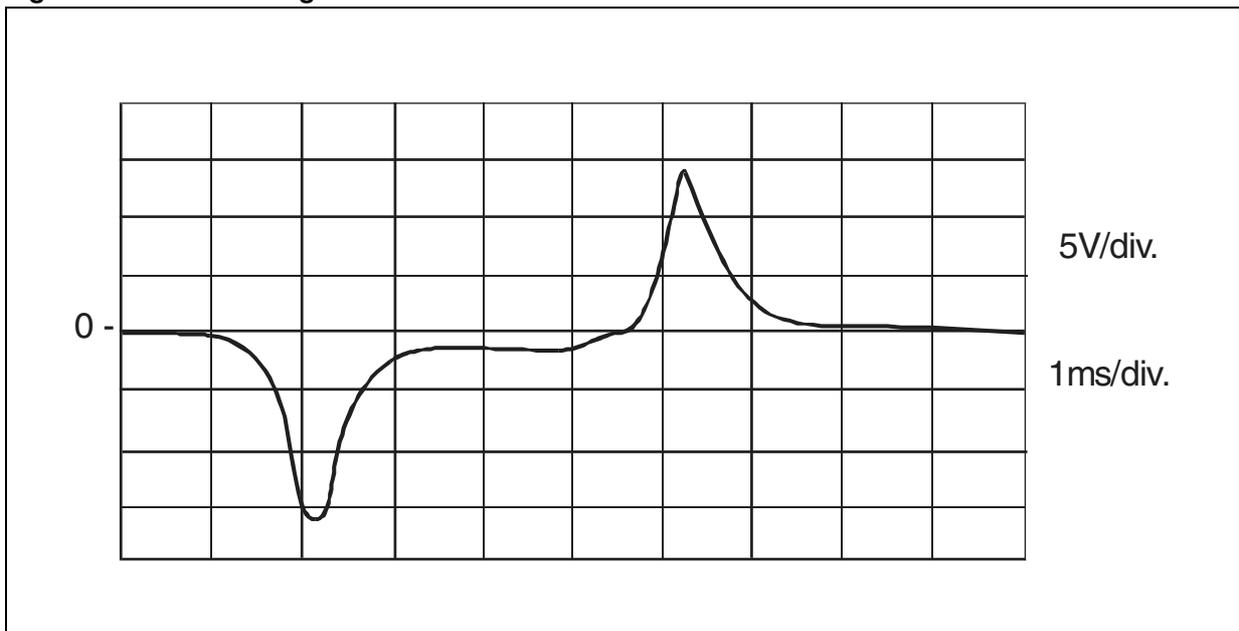
Figure 6 shows the topology we have chosen for the small motor CDI module.

The supply coil generates an alternating voltage, in which the positive parts are rectified by D2 and the negative parts are clamped by D3. This circuit configuration allows the designer to use 400V diodes for D2 and D3 instead of 1000V user in other design. The capacitance C1 is loaded by the positive rectified current.

**Figure 6. Small motor CDI principle circuit**



**Figure 7. Sensor coil signal**



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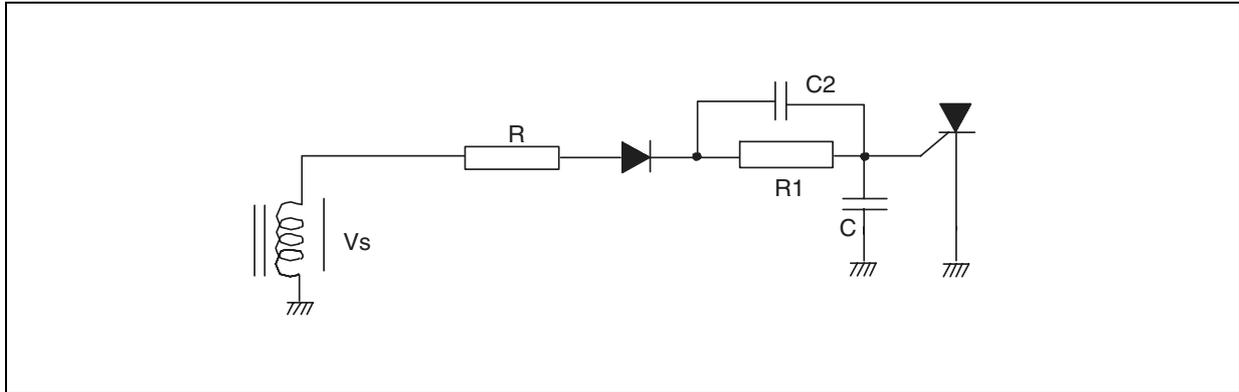
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The sensor coil generates, at each engine revolution a signal as shown in Figure 7.

The negative part of this signal is clamped by D4 while the positive part produces a current through the gate, firing the SCR.

Due to parasitic voltage occurring on the sensor signal we suggest the use of the conditioning stage shown in Figure 8.

**Figure 8. Conditioning stage**



This gate drive circuit, using  $R_1$  between 1 and 10k $\Omega$  and  $C_1$  between 1 and 10 $\mu$ F allows the SCR to run without problems of parasitic firing.

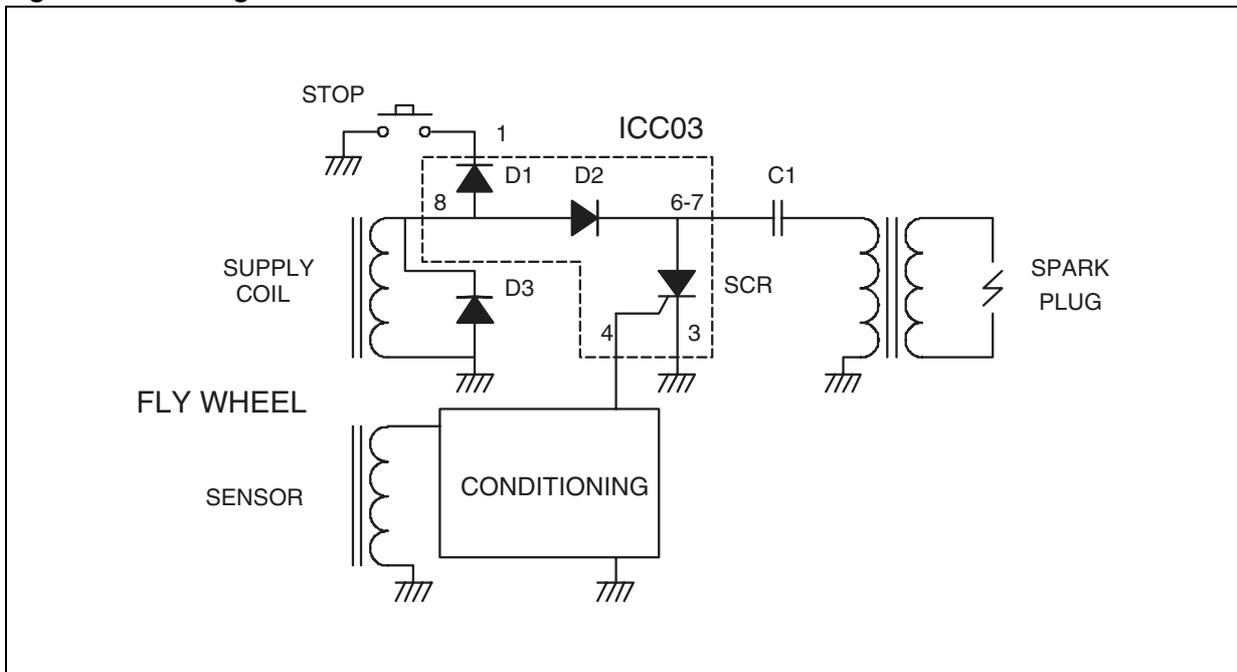
**SMALL MOTOR APPLICATION CIRCUIT**

Figures 9 and 10 show the same application circuit using both ICC01 and ICC03. In both cases the conditioning stage limits the current through the gate, its maximum value being calculated as follows:

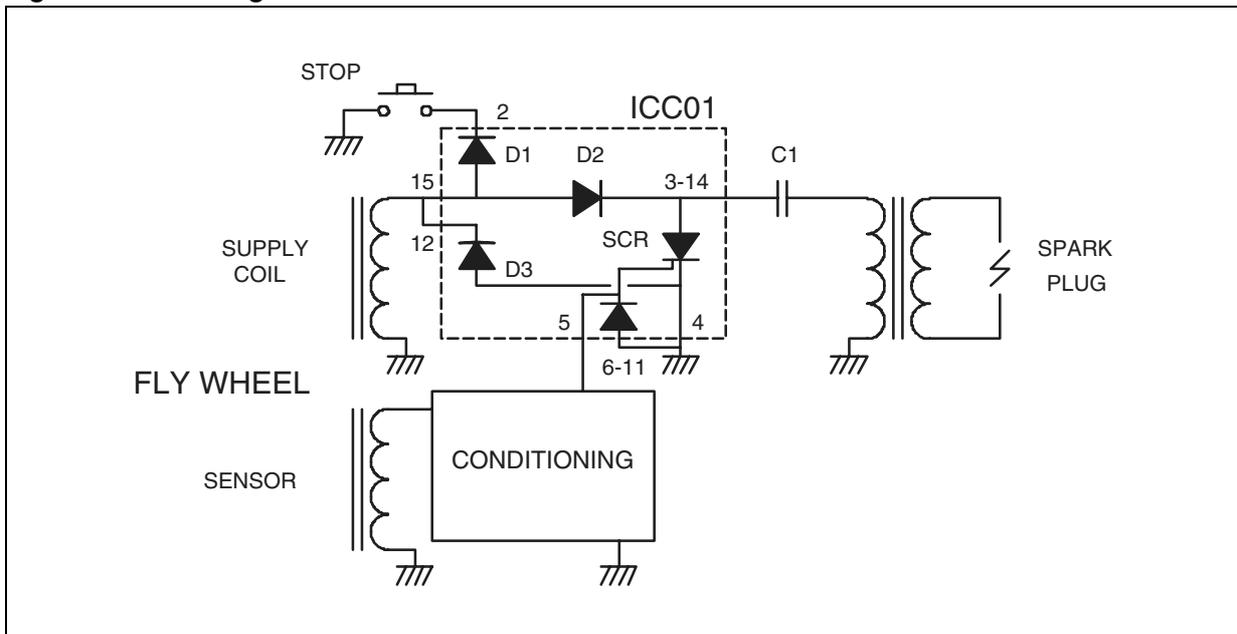
$$R_{max} = (V_S \text{ min} - V_{GT} \text{ max}) / 2 I_{GT} \text{ max}$$

with  $V_S$  = sensor voltage.

**Figure 9. CDI using ICC03**



**Figure 10. CDI using ICC01**

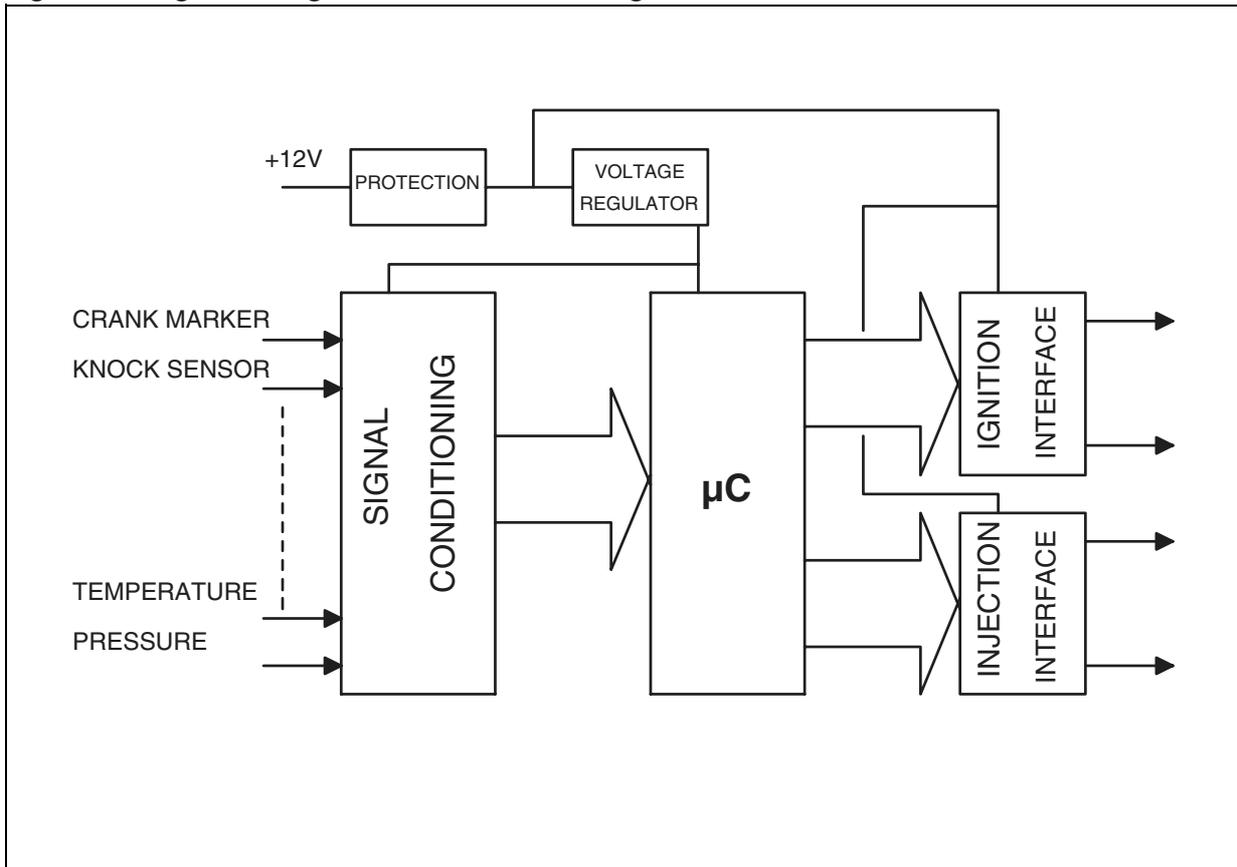


**CAR CDI SYSTEMS**

Figure 11 shows the general block diagram of an automobile engine management module. In such a system the ignition function is linked to a  $\mu\text{C}$  which assumes also the other functions needed for a correct operation of the engine.

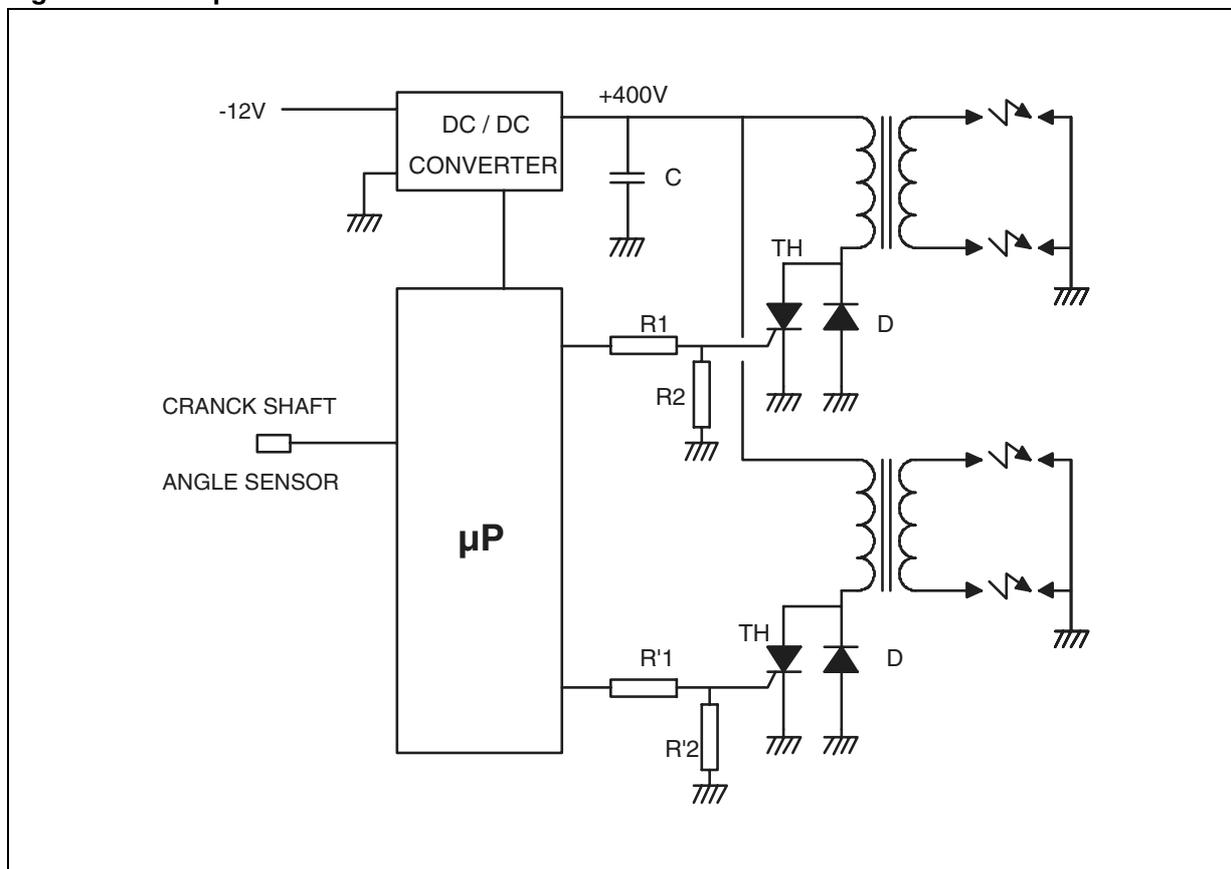
For example the crank shaft angle detector is not directly connected to the CDI switch but conditioned by the  $\mu\text{C}$ .

**Figure 11. Engine management module block diagram**



The circuit of figure 12 is an example of a CDI for an automotive engine. This uses two SCR directly triggerable by  $\mu\text{C}$  outputs.

**Figure 12. Example of CDI circuit for automotive**



### CONCLUSION

Capacitive discharge ignition systems are the only choice for the small engines. They are also found frequently in racing car engine management computer. For the future the CDI could be the solution meet the new anti-pollution standard requirements.

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### REVISION HISTORY

**Table 1. Revision History**

<b>Date</b>	<b>Revision</b>	<b>Description of Changes</b>
June-1995	1	First Issue
10-May-2004	2	Stylesheet update. No content change.

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