SGS-THOMSON
MICROELECTRONICS

APPLICATION NOTE

FULLY PROTECTED HIGH VOLTAGE INTERFACE FOR ELECTRONIC IGNITION

By S. PALARA ; M. PAPARO ; R. PELLICANO

INTRODUCTION

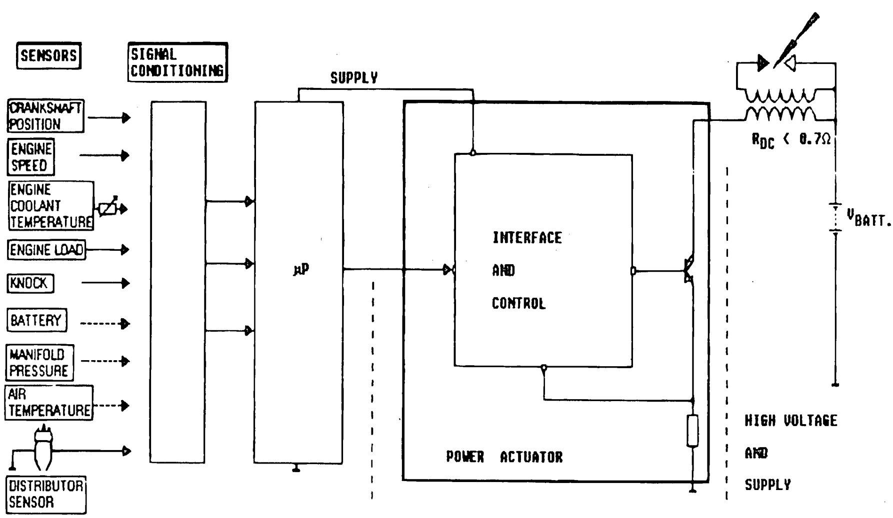
It is well known that an electronic car ignition system must be able to generate and supply the high energy discharge to the spark plugs, firing the petrol/air mixture at a precise point in each piston cycle.This job is performed by means of an high energy coil, its driver stage and the most suitable controller ; an example is shown in fig. 1.

In the most recent car ignition systems the coil current loading signal is controlled by a microprocessor that can also optimize the ignition timing. This ensures the correct spark at every speed for all environmental conditions.

The engine efficiency is so optimized ensuring the minimum toxic exhaust gas emission.

The high voltage necessary to generate the spark is obtained by charging the primary winding of the ignition coil with a controlled energy, i.e. a controlled current.

Figure 1 : Car Ignition System.



At the firing point this current is suddenly interrupted transferring the stored energy to the secondary winding and produces output voltage in excess of 20KV and therefore the spark.

The fig. 1 power actuator must also limit the current to a max of 10A and the voltage on the primary to a maximum of about 400V.

The voltage clamp avoids any damage to the power actuator : if the spark plug, for example, is disconnected, the energy stored in the coil is transferred back to the power actuator.

The device described in this paper realizes these power actuator functions with a very innovative integrated single chip solution.

THE VIPOWER M1 TECHNOLOGY

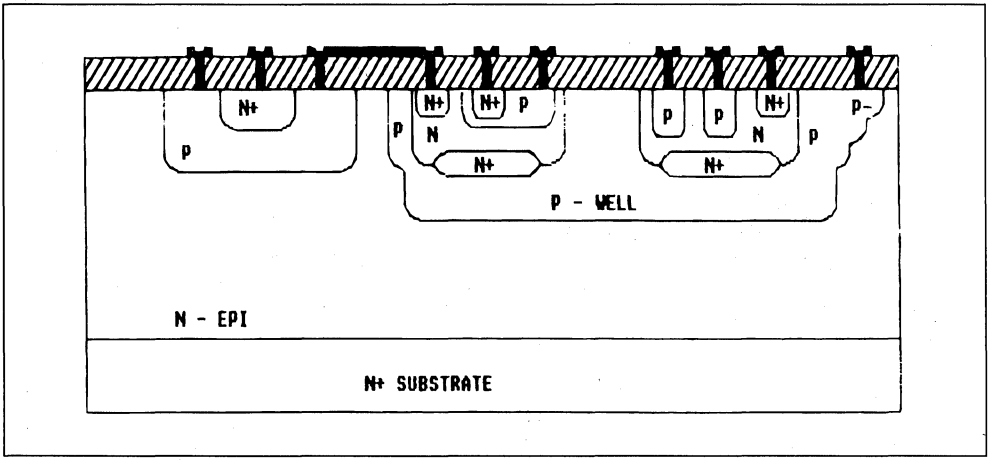
The VIPower M1 structure shown in fig. 2 combines a vertical current flow NPN power transistor and a low voltage junction isolated I.C. on the same silicon substrate.

This is realized inside a diffused p-type well that takes the place of a reverse-biased p-substrate of conventional ICs and must be connected to the most negative supply.

As in a standard discrete BJT, the first epitaxial layer thickness and resistivity set the Vceo and the ruggedness of the high voltage device, the second epi growth fixes the features of the low voltage components (up to 100V V_{CBO}).

The maximum voltage the power device can withstand is neverthless also dependent on the maximum field strentgh at the silicon surface and on the n^+/p–well parasitic diode breakdown voltage.

Figure 2 : VIPower Technology Vertical Structure.



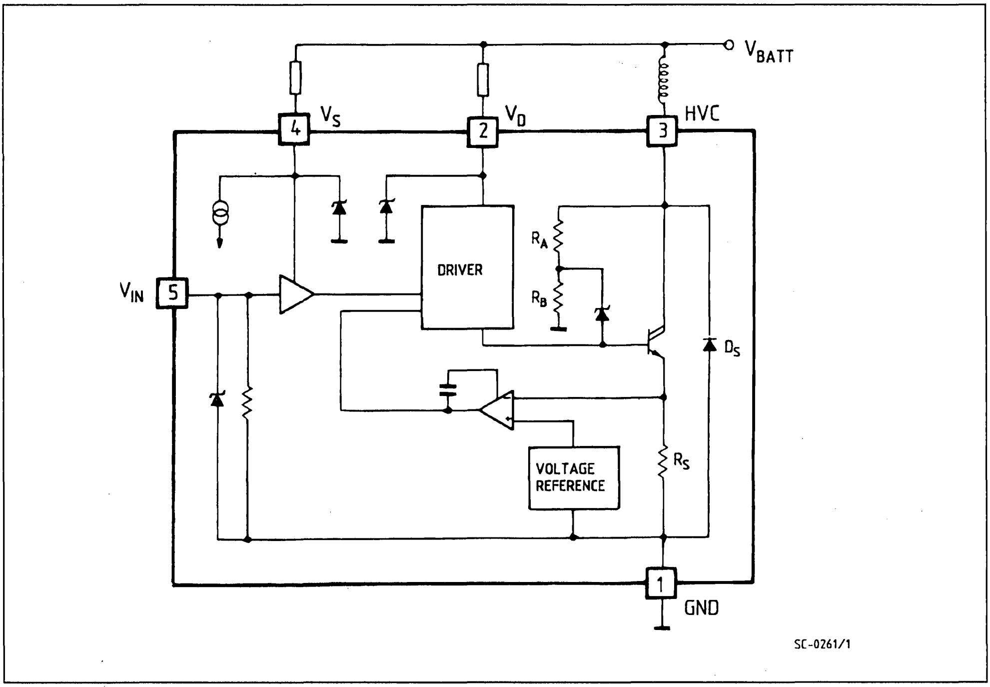
The high voltage termination of the integrated circuit is achieved by a p-diffused resistor in spiral from connected between the substrate (power darlington collector) and ground.

DEVICE CHARACTERISTICS

The device realizes the ignition, power actuator sub-system of fig. 1.

In the block diagram of fig. 3 the power Darlington with its driver and input stage, the current limit, voltage clamp circuitry and the overvoltage protection are shown.

Figure 3 : Device Block Diagram.



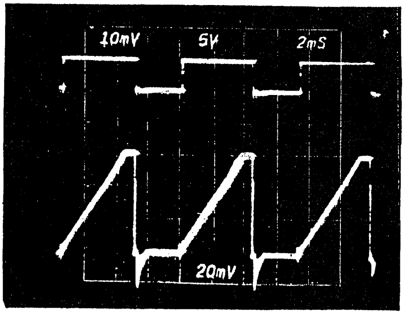
A TTL/CMOS compatible input signal coming from a logic interface, like a microprocessor, determines the turn on of the power darlington integrated in the chip.

The darlington collector current charges the coil linearly as long as a set level is reached, typically 6A ± 3%, sensed by an internal aluminium emitter resistance.

The voltage drop on this resistor is compared with an internally generated threshold (~ 200mV) and limits the current, thus controlling the Darlington base current until the input signal causes the output Darlington to switch off.

Photo 1 shows the coil current behaviour together with the corresponding input signal.

Photo 1 : Collector Current and Corresponding Input Signal.

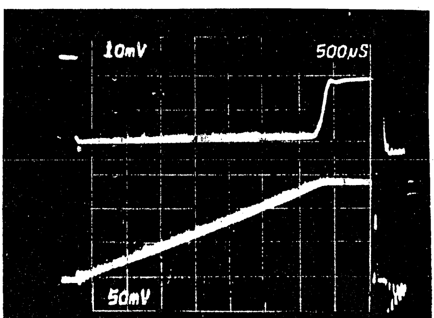


Input signal (5V/div)

Coll. current (2A/div)

The current loop is made by compensated operational amplifier ensuring enough precision of the set value and hence of the stored energy without requiring external components.
The regulation stability is infact mandatory in the car ignition system to avoid spurious sparks on the secondary coil winding.
During the current limiting phase, the Darlington collector voltage reaches the battery voltage minus the voltage drop on the coil (due to the primary resistance). It causes high power dissipation in the power actuator which the microprocessor minimizes by delaying the output Darlington switch on.

Photo 2 : Collector Voltage During Coil Charging.



Coll. volt. (5V/div)

Coll. current (2A/div)

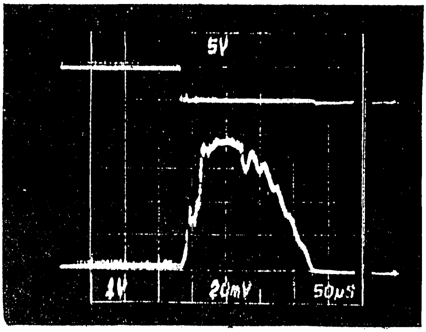
The overvoltage on the power Darlington collector during the transition from the coil charging to the current limiting phase is low enough to avoid undesiderable sparks.

At the input signal switch-off the power Darlington is immediately turned off and the energy stored in the coil is transferred from the primary to the secondary winding causing the spark.

The collector voltage of the power Darlington then rises very rapidly and is detected by the spiral resistor used as the high voltage termination for the chip.

This resistor, used as a divider, is connected to a low voltage zener circuit that turns on the power Darlington, holding the collector voltage at a value determined in the chip (~ 400V ± 10%) which is less than the Darlington V_{CEO}.

Photo 3 : Voltage Clamp.



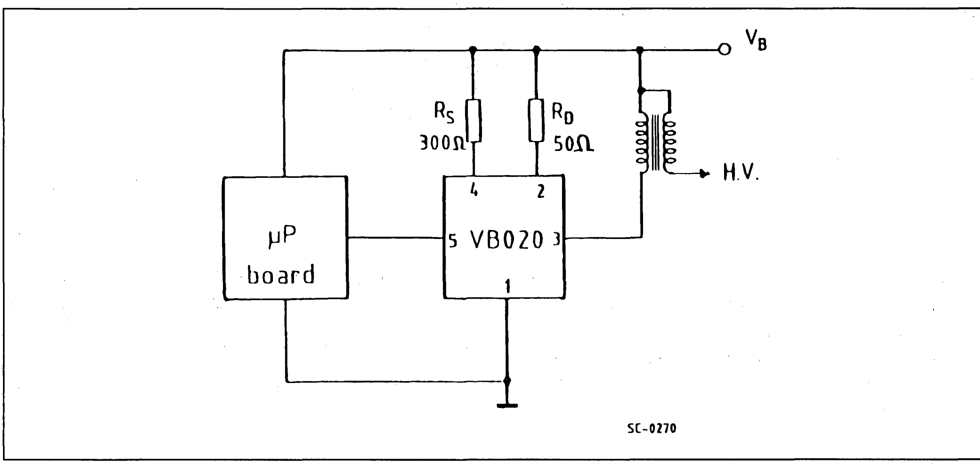
Input signal (5V/div)

Coll. volt. (100V/div)

Photo 3 shows the collector voltage during the clamp in absence of the spark plug i.e. the worst case for stress on the integrated circuit.

Fig. 4 shows the application circuit for this device.

Figure 4 : Application Circuit .



Two separate pins for the supply : pin 4 and pin 2, are connected to the battery by means of two different resistors.
Pin 2 represents the supply of the driver with a current of up to 200mA.
Pin 4 is the supply for the rest of the circuit ($I_{4.1}$ ~ 3mA).
A picture of the die is shown in photograph 4.
The device is assembled in a new fully insulated five-lead plastic power package, ISOWATT 5 and shown in figure 5.

Photo 4 : The Die.

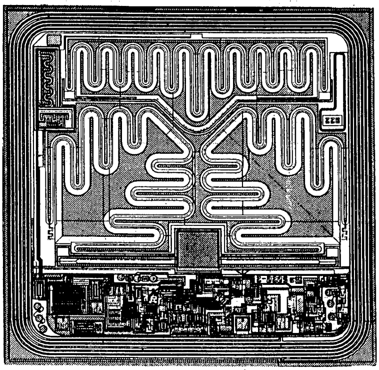
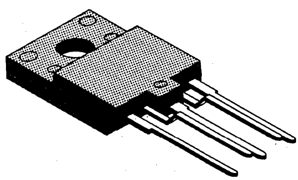


Figure 5.

ISOWATT 5



CONCLUSION

The ignition controller described in this paper completely substitutes the existing hybrid solution which requires additional components and manufacturing processes (i.e. insulating substrates, ink layers, active and special passive devices, laser trimming, encapsulation etc..). This single chip solution leads to an intrinsic increased compactness. The subsequent higher reliability is further enhanced by the known advantages of integration.

Additionally to that a cost reduction benefit through this approach is also achievable.