A CMOS INTEGRATED SYSTEM FOR KNOCK DETECTION IN SPARK IGNITION ENGINES

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Abstract
In integrated custom circuit for the detection of knock phenomenon is described. The circuit is an analog, digitally controlled, structure. It contains 24 equivalent op-amps and its area is 10 mm².

Summary
Knock phenomenon is a rapid combustion started by self ignition in the combustion chamber wall. The effect is accompanied by a high frequency pressure oscillation which generates a typical sound around the combustion chamber. The frequency of this sound corresponds to the acoustic resonances of the cylinder cavity at the operating temperature.

It is very important, for engine optimization, to detect the crop up of knock and to control, in feedback, the engine regulation. Since the knock signal is mixed up with the background noise, its detection is a difficult topic. In order to solve this problem a custom IC was designed. Its block diagram is shown in Fig. 1. It consists of a suitable analog interface which receives the signal coming from a piezo microphone put in the close proximity of the engine. Three analog processing chains, digitally controlled, perform the following operations: band pass filter, full wave rectification, integration over a given time slot. The first processing chain is digitally tuned around the first resonance of the knock signal, the second one is tuned around the second resonance, while the third one is set in order to detect the background noise. The resulting signals are then processed and compared in order to check the presence of the knock phenomenon. Three output buffer also permit to observe the results of the analog processing.

The analog processing is get by a suitably designed switched capacitor structures. Finite gain and offset insensitive architectures ware extensively used. The digital control of the frequency response of the filters and the one of the integrator time constant is ensured by a microprocessor interface.

The circuit was integrated with a 3 µm double poly (10 V) technology. The silicon area is 10 mm², the power dissipation is 20 mW.

Experimental measurements showed an excellent sensitivity of the system to incoming knock. The novel used input protection demonstrated its effectiveness even in presence of severe overvoltages.

Measures of typical frequency response of the digital programmable filters are shown in Fig. 2. A microphotograph of the chip is shown in Fig. 3. The analog output of the three integrator chains for a typical situation is shown in Fig. 4. It can be noted that an incoming knock can be detected within around a 30% margin.
Fig. 1 Block diagram of the integrated circuit

Fig. 2 Measured frequency responses of digital programmable SC filters

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Fig. 3 Chip microphotograph

Fig. 4 Analog chip outputs

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