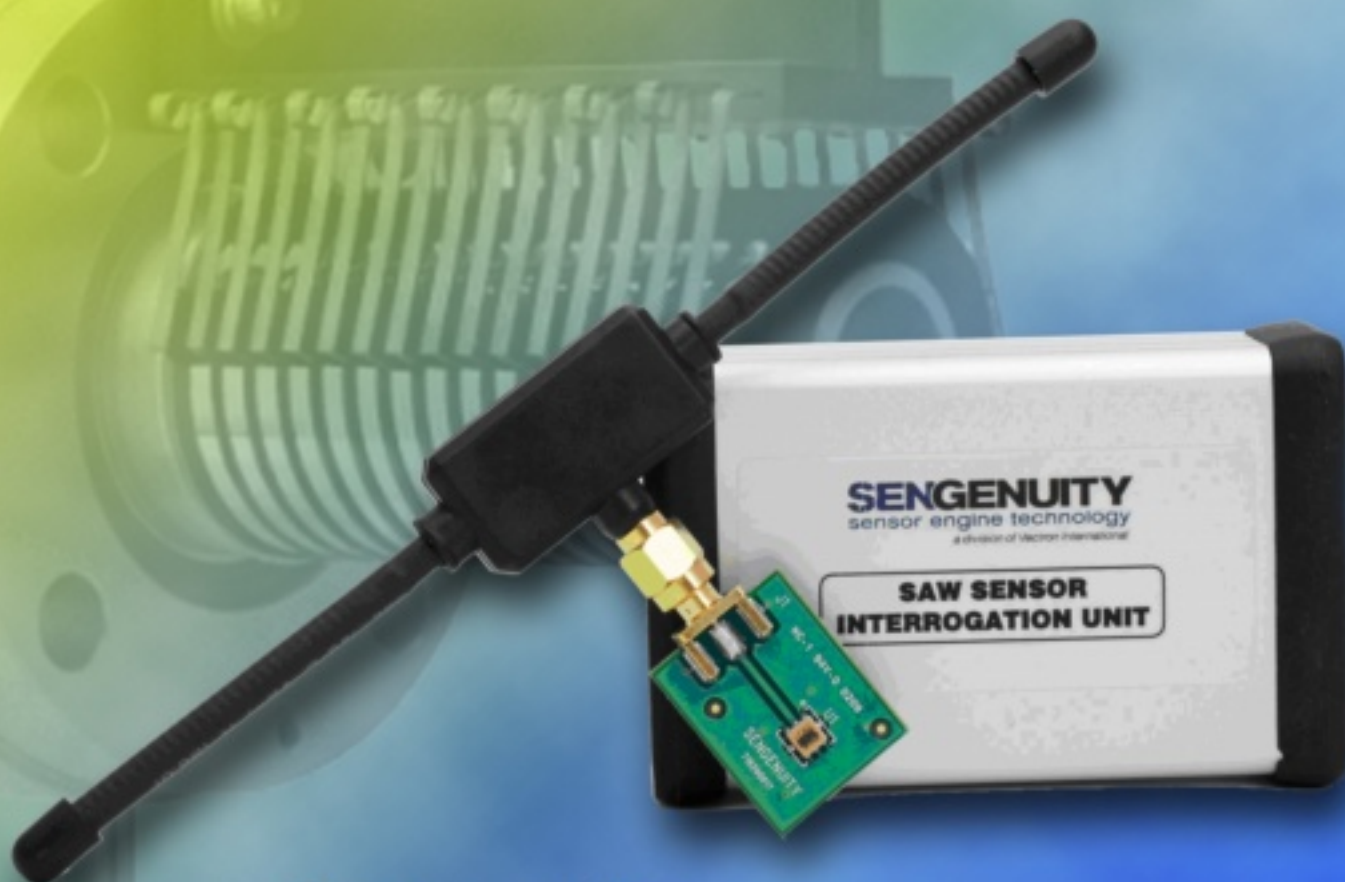


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Design and Manufacturing Precise Wireless Car Engine's Speed Sensor

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Abstract: Today sensors are used in different fields especially in vehicle and aerospace industry. This paper presents the design and manufacturing of car engine's speed sensors. By using this system one can transfer engine's speed sensor data with high frequency to rev counter. This system works with radio wave transmitter. Electronic motor and choke produce analog waves and converter circuit converts these waves to digital waves and sends them to transmitter, so a receiver can get these pulses. This system was tested in different conditions like rainy weather and for distance amount 80 meters. Advantages of this system are reduction in wires and car weight, accurate data transmission, and engine noise does not affect output signals. By virtue of using oscillator and suitable circuit such as a divider when speed increases or decreases by 2 rpm, the change is observable, which is more precise comparing similar systems that have sensitivity of 2.15 rpm. Also due to use high frequency transmitter and receiver engine's and environment's noise doesn't have any effect on data transferring. *Copyright © 2009 IFSA.*

Keywords: Wireless sensor, Pulse counting, Wireless data transfer, Vehicle sensor, Engine's speed, Pulse generating

1. Introduction

Possibility of wire corruption or short connection as well as complexity of systems in which wire is utilized to transfer information such as temperature, engine speed, fuel quantity, brake fluid and etc. caused wireless systems become more popular in electronic equipments [1, 2].

In 1985, scientists at NASA, used wireless sensors to measure aircraft's engine speed. These sensors are able to measure the speed by Hall effect [3].

In this set we have used a 1MHz quartz crystal oscillator which is able to generate one million pulses per second, and this is what makes this system different from other current HAL effect sensors. We are also able to measure very high engine speeds better than available sensors.

In an ordinary vehicle, sensors gather information of several parts and circuits convert them to the comprehensive information for processors, using electronic elements [4]. Currently, this information transmission is done by wires like today's vehicle engine speed sensors. As indicated, this kind of information transmission will cause several problems such as: connection interruption, short connection (especially in long wires like vehicle's front to rear wires) in which discovering and finding the failing cable is very difficult [5]. So that in wireless transmission of information, all the above mentioned problems are to be resolved.

Wireless information transmission, is possible either by radio waves and infra red light, where in infra red systems, transmitter and receiver must be located in front of each other [6]. In vehicles, due to placement of sensors inside engine container and need of communication between saloon and engine space, it is impossible to locate transmitters and receivers next to each other, thus using infra red has the above disadvantages which is the worst drawback of these systems [7]. To overcome this problem utilizing radio wave transmitters and receivers is the right solution and the only issue may raise with this method is interference of engine's emissions, which can be resolved by using higher radio frequency than engine's noise and vehicle power transmission's one [8]. And this is related to the type of transmitter and receiver [9].

In designing of data transmission systems, main purpose is to accessible bandwidth utilization and maximum transmission to gain the maximized ration of signal to noise at receiver end [10].

2. Designing the System

2.1. Flow Generation (Engine Speed Sensor Simulator)

For this purpose, by installing magnet on the rotating wheel (by electrical motor) the way polarities of magnets are S and N sequentially, we created fixed magnetic fields. By rotation of wheel and effecting magnetic field, magnetic flow changing affects the coil installed next to wheel:

$$E = - N (d\Phi / dt), \quad (1)$$

which is related to the engine's speed and coil turn (N). In this case due to low engine speed 4 magnets have been used to make the speed of passing magnets 4 times as much, and consequently more flow is inducted.

This is like the real engine speed sensor of the vehicle to which is installed a static magnet in front and the operation of flow changing is done by movement of gear on the flywheel. Now, this electrical flow

which is shown in the Fig. 1 must be converted to a meaningful flow for the Electronic control unit (ECU).

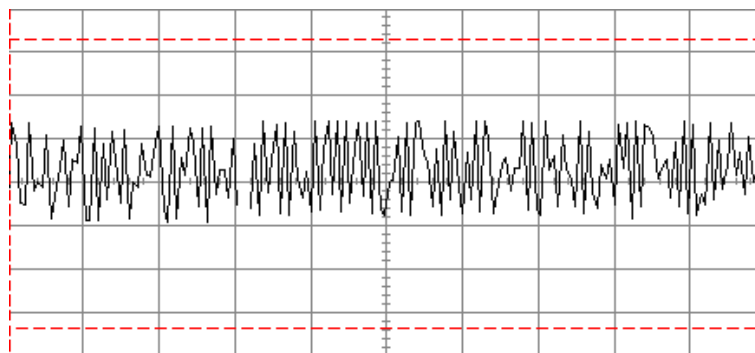


Fig. 1. Visualization of outcome from simulation of engine speed sensor.

2.2. Square Wave Signal Generation

Square wave signals are recognizable by ECU, to generate them we have leveraged a circuit called Zero Crossing Detector, by which generated flow (coil's output) is converted to square wave signal. A comparator IC is used to achieve that. As we see in Fig. 2 there are 4 comparators inside the IC.

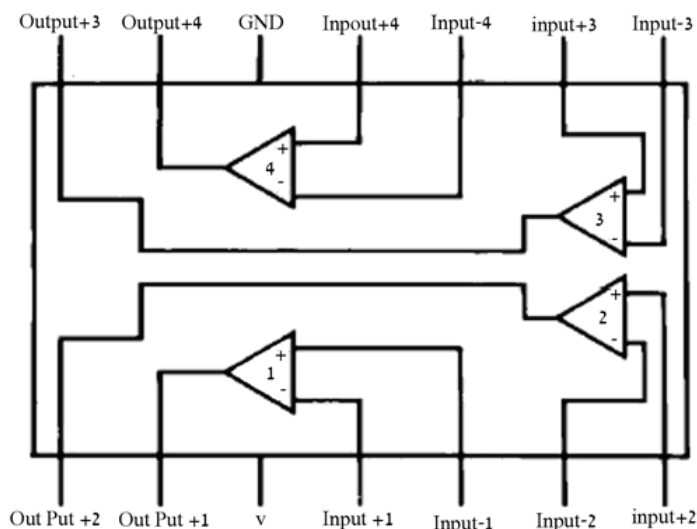


Fig. 2. Comparators to convert the signal to square wave.

This way, when voltages raises in positive half, the converter simulates a digital 1 in output, and once it is in the negative half, a digital 0 will be at output. The total output (when not connected to the circuit) can be seen in the Fig. 3.

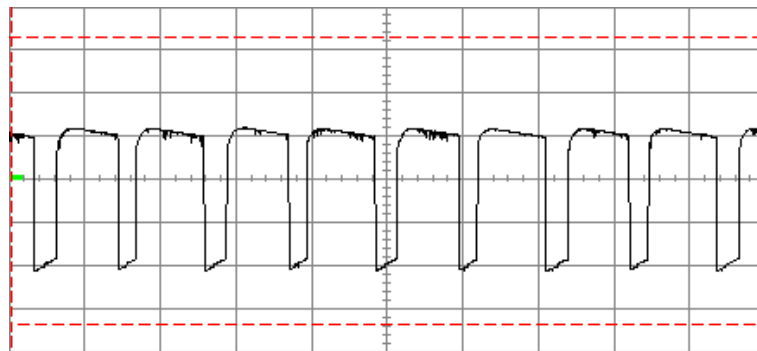


Fig. 3. Converted square wave signal (output of this circuit is not connected to the system).

By entering output to the counter, number of times magnet passes by the coil will be counted. (necessary to note, the indicated number divide by 4 is considered with the round per second measurement unit and if it is multiplied by 60/4 or 15 then it will result in rotation speed in round per minutes(rpm) unit.

By the way, by increasing engine's speed, length of generated pulses will be reduced according to Fig. 4, where by these changes the electronic control unit (ECU) is able to calculate the advance of sparks.

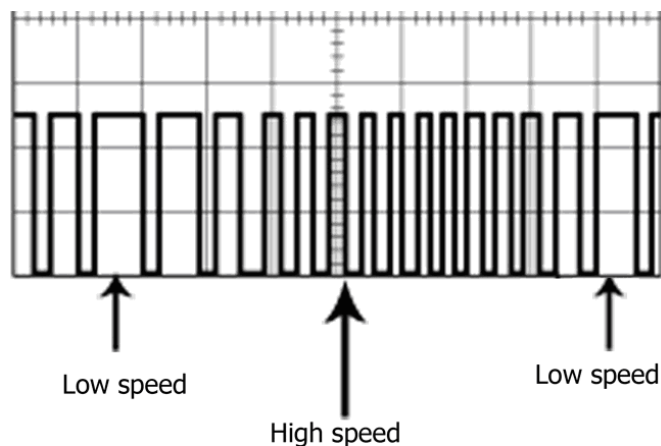


Fig. 4. Output signal of square wave circuit in low and high speeds (output of circuit is connected to other parts of the system).

2.3. Preparing Square Wave Signal for the Oscillator and Counter

To do this, an IC is used which has 4 electronic switches. In those switches, by applying lower voltage than circuit main voltage, two pins are short connected for the following two reasons:

- To convert received signal by receiver to a suitable pulse for seven segments
- To generate oscillator's reverse pulse.

Because latch enable of decoder is active low, output of oscillator must be reversed.

2.4. Transmitting Signal for the Oscillator:

As long as the timer IC is used, circuit is considerably sensitive to its input voltage. For instance, when input voltage of one party is weakened, error will be raised and to overcome this issue we can use a crystal oscillator instead.

We have used a 1 MHz crystal and this oscillator is able to generate one million pulses per second, where we need only one pulse per second. To resolve this, we used a divider circuit. This circuit as shown in Fig. 5, is a divider which is able to divide by up to 2^{31} . But to achieve one pulse per second, we need to divide 1000000 by 2^{20} , so, $(1000000/2^{20}) = 0.965$, which is approximately close to 1.

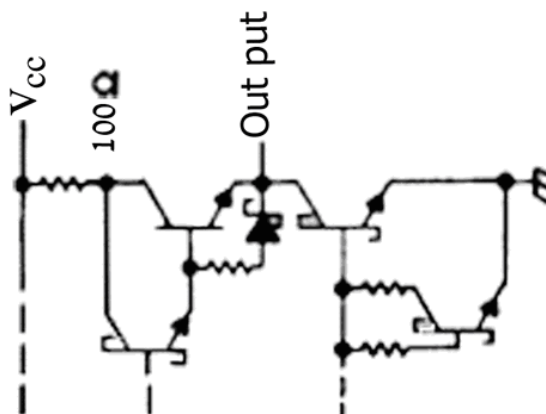


Fig. 5. Pulse divider [11].

2.5. Entering Pulses to the Counter

For the operation of counting, a counter IC has been used. This IC works by receiving pulses and is able to count 4 binary digits. It is important to note that this IC has both binary and decimal modes. In decimal mode, after counting digit 9, counter became zero and one output pulse (referred to as carrier) is sent. In binary mode, after number 15 or F on carrier signal will be sent. The active low enabled pin is normally connected to ground by a resistor. If we activate the pin number one by entering a digital one to it, we can load the amounts in preset pins to the counter. We leverage this to preset the counter two zero (Fig. 6).

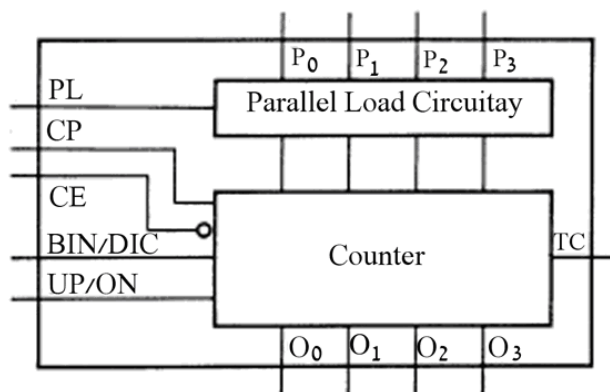


Fig. 6. Pulse counter circuit [11].

In this system, we have used two counter ICs which are able to count two decimal digits (0 to 99).

When first counter IC is in decimal mode, at the time of changing from 9 to 0, a carrier pulse will be sent to carrier output, which by connecting it to the clock pulse pin of the next digit counter, they are increased by one.

And this way, by increasing number of these ICs, the more number of digits can be supported and showed by more seven segments.

As we mentioned above, the enabled pin is connected to the ground by a resistor, because if this resistor doesn't exist, when oscillator sends out the digital one pulse, it will be constantly grounded and no pulse will be appeared, which is the main output of this IC.

2.6. Interface Operation or Preparing Information for Seven Segment Indicators

We have used decoder IC which converts binary input to the suitable output for seven segments. Within this decoder IC, there are 10 types of different outputs (0 to 9) which are adapted to 7 rows of output for the seven segments.

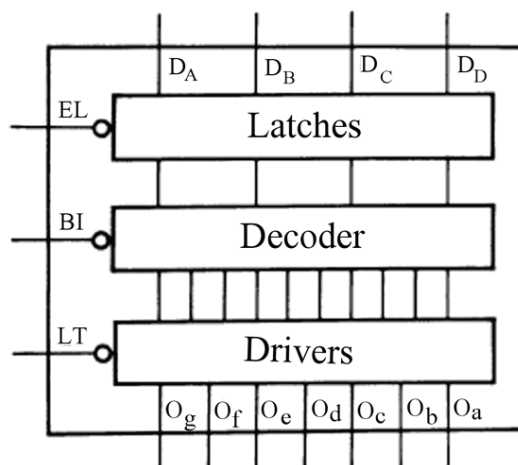


Fig. 7 Decoder circuit [11].

As shown in the Fig. 7, in this IC there are 8 latches, and the values displayed on the seven segment are exactly the same as in the latches, and once enable pin of latch is activated (ground connection) the input from flip-flops are loaded.

2.7. A-Synchronizing Reset and Load Operations

To do this, we have used an IC in which there are 8 D flip-flops, where are located between the counter and decoder circuit, in order to prevent simultaneous load and reset operation.

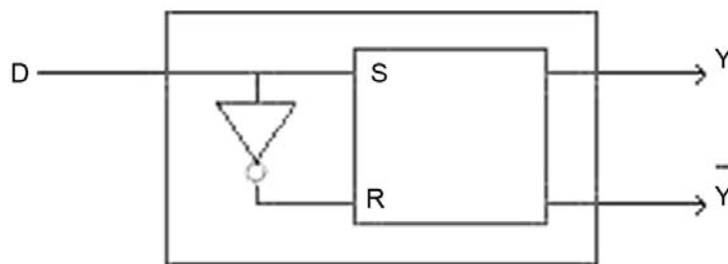


Fig. 8. Internal circuit of D flip-flop [11].

D Flip-Flop (Fig. 8), has an input, output and a clock pulse pins, where by sending pulse to the clock pulse pin, the value on D input, will be stored in the flip-flop and thereafter until next pulse, that value will be available on the flip-flop output.

2.8. Examining and Information Transmitting

Transmitter and receiver are leveraged for the transmission. When a converter circuit converts every complete cycle to the square wave pulse and sends it to the transmitter, the transmitter transmits the pulses for the receiver and receiver receives them accordingly.

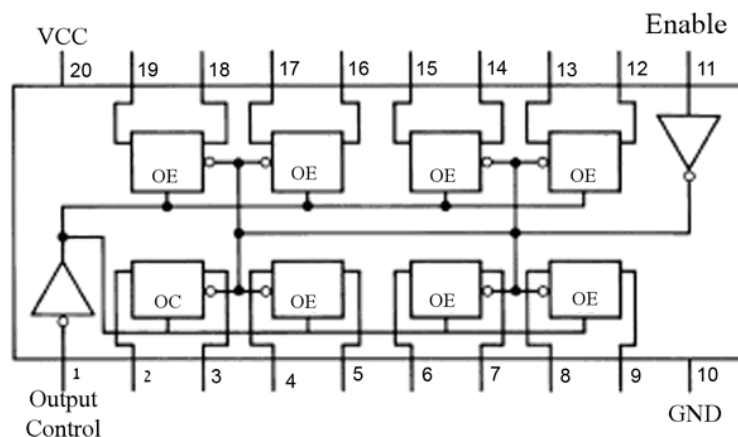


Fig. 9. Sequential circuit including 8 flip-flops [11].

Receiving of these signals via clock pulse input of the counter, causes in increment of the number in the counter by one, with each positive pulse. Also by each pulse, as shown in Fig. 9, available number at the counter, is stored in the flip-flop. This way, oscillator has no activity during one second, but after that the active low output of the counter, counts the input pulses and show the counted number on the seven segments. At this moment, oscillator's output pulse, enables the latch enable pin of the decoder circuit and the stored number of counter in the latches, enters the decoder circuit and seven segment show that number until next 1 second.

At the same time, output of the oscillator is inverted using switches, and by entering the inverted pulse to the preset pin of the counter, counters preset to zero, and this is task is done frequently (Fig. 10).

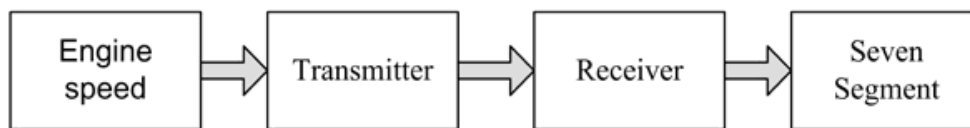


Fig. 10. Data transferring.

To better examine the system, we have used several kinds of power supplies such as 3, 4, 5 and 9 volts, to supply different speeds of the motor, and subsequently experience different numbers on the seven segments as shown in Figs. 11 and 12. So that, every value is displayed on the seven segment of the transmitter module, is displayed on the seven segments of receiver module as well, and engine's speed is at the reach of driver, leveraging waves (wireless).

Finally the system was tested in rainy weather due to examine effect of weather's moisture on system operation and because of using high frequency transmitter and receiver cloudy and rainy weather doesn't have any effect on the system. Also by change transmitter's and receiver's position system performing range was obtained amount 80 meter that is suitable range.

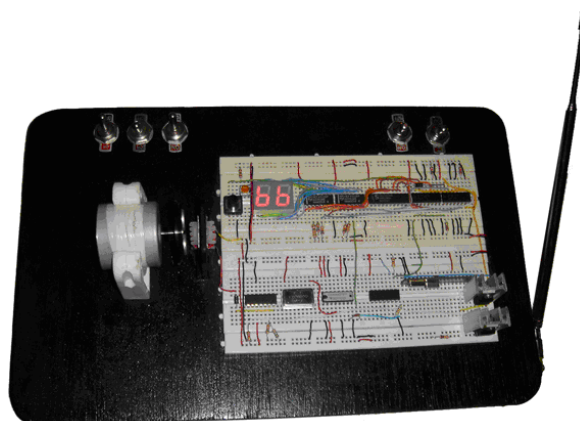


Fig. 11. Transmitter module is sending information.

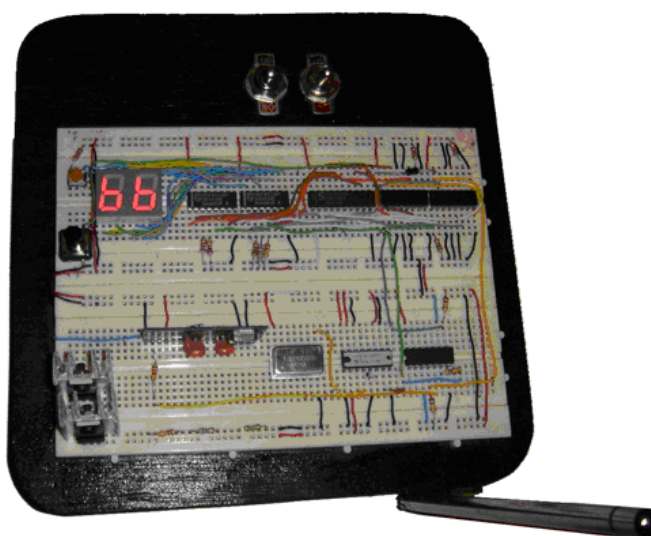


Fig. 12. Receiver module is receiving information.

3. Conclusion

Some applications of this system where used in power transmission systems of vehicles are to benefit from:

- 1) Reducing usage of wire in vehicle.
- 2) vehicle's weight reduction
- 3) transmitting finer data
- 4) Make users unable to disable some sensors such as speed sensor.
- 5) Easy troubleshooting.
- 6) Eliminating some difficulties like wire corruption.
- 7) Preventing impacts of engine's noise on the system.

In addition, by other methods it is possible to find replacement for sensors of types thermal, smoke and gas detection, water and fuel meter and so on.

In comparing other available systems, option of using faster transmitters and receivers is one of bright advantages of this system.

As we mentioned, by changing engine's speed, output signals become closer and (ECU) can use this change to estimate the amount of sparkling advance timing. When speed increases or decreases by 2 rounds per minute, the change is observable, which is more precise comparing similar systems that have sensitivity of 2/15 rpm, and that is because of using oscillator and divider circuit in the system.

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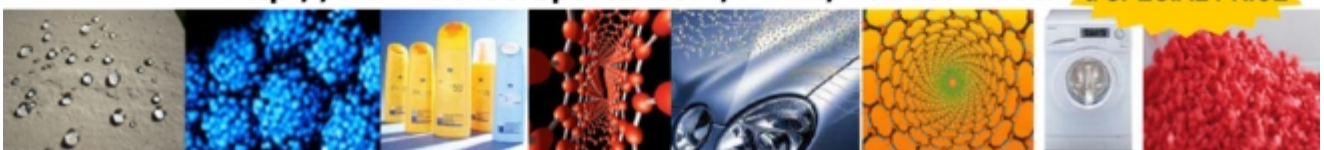
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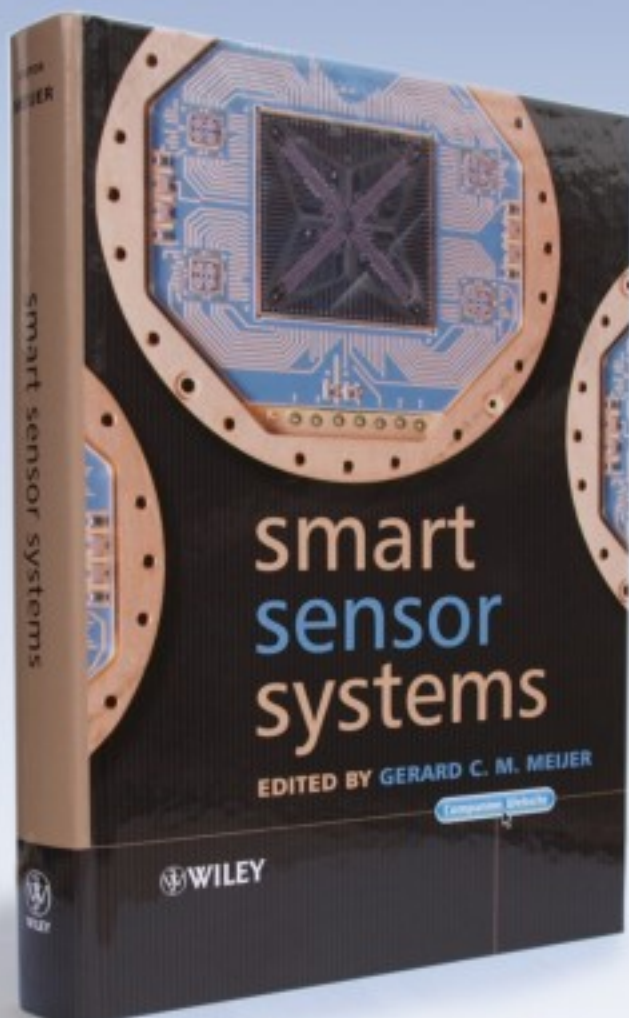
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