

EMI-Prevention Pressure Sensor

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1. Introduction

Semiconductor pressure sensors that utilize micro-machining technology and IC processing are recently being applied to a wide range of applications in the automotive, medical and measurement fields. Especially in the automotive field where demand is quickly increasing for cleaner exhaust to comply with environmental regulations and high level electronic systems that achieve low emissions such as a direct fuel injection engine. In such applications, the high performance and low cost of pressure sensors holds much promise. On the other hand, as the engine room becomes more crowded, along with the adoption of a plastic chassis and the widespread use of car phones and mobile phones, the electromagnetic noise environment of automobiles has become severe. Electronic components to be installed in an automobile must have a high degree of protection against electromagnetic interference (EMI).

In 1992, Fuji Electric introduced a pressure sensor product that integrated onto a single chip a sensing unit and an amplifier and adjustment circuit. The newly developed EMI-prevention pressure sensor further integrates onto the chip a low pass filter for noise prevention. This chip realizes a low-cost pressure sensor that has the necessary noise immunity for automotive use. An overview of the EMI-prevention pressure sensor technology and products are introduced below.

2. Features

(1) Small size and high reliability

The sensing unit, amplifier and adjustment circuit, noise filter and their protection elements are integrated onto a single chip. The chip is constructed with a simple package containing a glass block for alleviating stress to the chip, and input and output pins. With this construction, there is no external mounting of noise prevention components and the chip can be used within the automobile engine room. Compared to the conventional pressure sensor, this sensor enables smaller sizes and lighter weights. (Fig. 1)

Furthermore, due to the wire bonding of the power supply and signal output, there are only three locations of electrical coupling, and high reliability can be achieved.

(2) Low cost

Conventional noise prevention measures required circuit components such as chip capacitors, feed-through capacitors, inductors and the mounting thereof, a circuit board for electrical connections, and a shield case. The costs of these components and assembly processes impeded cost reduction of the finished products. With the EMI-prevention pressure sensor, these externally mounted circuit components and assembly processes for noise prevention are unnecessary, and a low-cost pressure sensor can be realized.

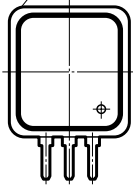
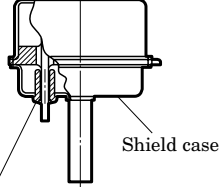
(3) High noise immunity

Proper operation is possible even in noise environments of 100 V/m, from 1 MHz to 1 GHz.

(4) Built-in amplifier and adjustment function

Adjustment and temperature compensation functions, which are formed by thin film resistor laser

Fig.1 Comparison of sensor shapes and additional user processes

	EMI-prevention pressure sensor	Former pressure sensor (EMI prevention by feed-through capacitor)
External view of pressure sensor (with noise prevention)	<p>Sensor body (resin case)</p>  <p>Number of components: 1</p>	<p>Sensor body (metal case)</p>  <p>Feed-through capacitors (3)</p> <p>Number of components: 5</p>
Additional user processes	<p>(1) Assembly (2) Final characteristics test</p>	<p>(1) EMI prevention assembly <ul style="list-style-type: none"> ○ Soldering three capacitors and shield case ○ Soldering three capacitors and terminals ○ Coupling the shield case (2) Assembly (3) Final characteristics test</p>

trimming, and an amplifier circuit are built into the chip, and by means of which, the user requested pressure signal can be obtained. These functions can be incorporated into the system without changing the electrical characteristics.

3. Chip and Circuit Design

A photograph of the EMI-prevention pressure sensor chip is shown in Fig. 2. The chip size is 3.5 by 3.5 (mm). Diffused strain gauges, transistors, and diodes are constructed by a bipolar process, and additional processes of thin film resistor sputtering and diaphragm etching are added. The low pass filter for noise rejection is constructed with capacitors and thin film resistors. However, a MOS process is utilized for formation of the capacitors because high quality oxidized film is required.

Figure 3 shows the circuit diagram. A C-R secondary filter is connected between the power supply voltage input pin (VCC) and the GND pin, and between the signal voltage output pin (VOUT) and the GND pin. This filters remove line noise that enters through these harness.

The output voltage of a strain gauge bridge

Fig.2 Top view of EMI-prevention pressure sensor

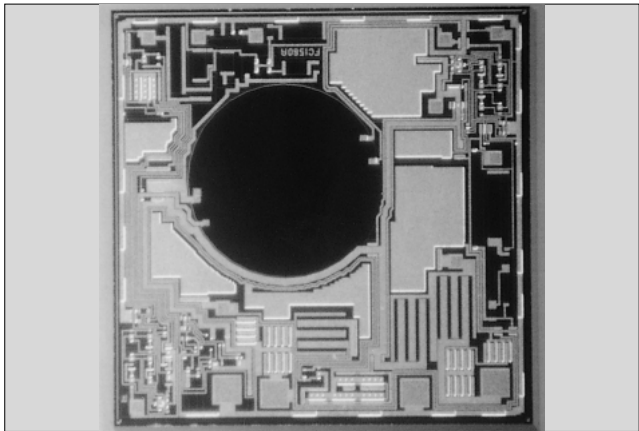
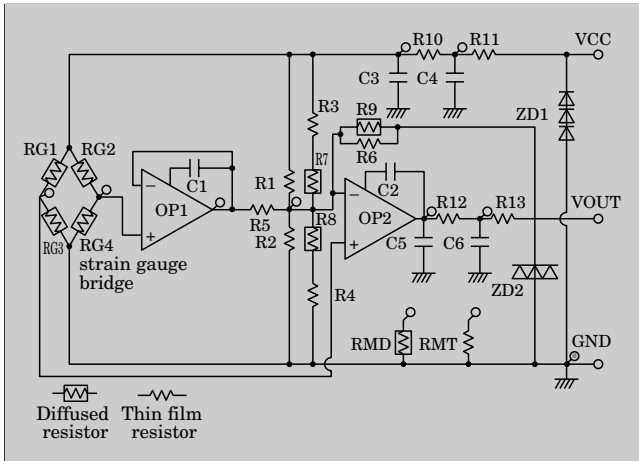


Fig.3 Circuit diagram of EMI-prevention pressure sensor



composed of RG1 to RG4 is amplified, adjusted and then temperature compensated by a circuit formed from operational amplifiers OP1 and OP2, thin film resistors and diffused resistors, and then output.

4. Design for Noise Prevention

4.1 Noise filter design

A MOS capacitor, which was utilized as the capacitor for the low pass filter, is close to an ideal capacitor and its frequency characteristics are exceedingly good. Figure 4 shows those frequency characteristics. For the resistor of the low pass filter, a thin film resistor having low parasitic capacitance and good high frequency characteristics was utilized.

Characteristics of the low pass filter near the cut-off frequency are shown in Fig. 5. In the harness connected to the input and output of the sensor, noise is caused by electromagnetic waves above the vicinity of 10 MHz where they would equal the harness length. Therefore, C and R values are selected so as to set the cut-off frequency to 10 MHz. A secondary filter was selected so that the attenuation characteristic of the low pass filter would have a steep slope.

To suppress voltage drop due to the filter at the power supply voltage input pin, the supply current is suppressed with a strain gauge unit, operational amplifier, compensation and adjustment resistors. As a result, an output operating range of 0.2 to 4.75 V can

Fig.4 Frequency characteristics of MOS capacitor

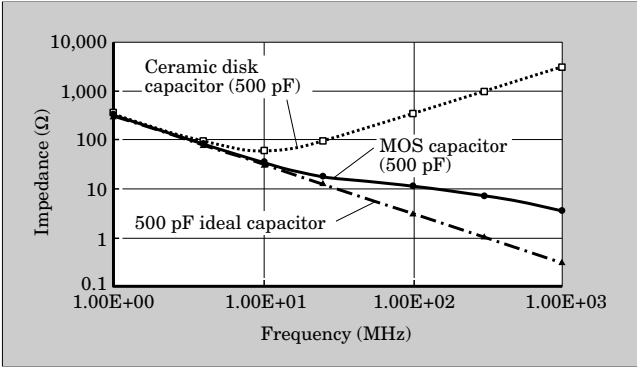


Fig.5 Frequency characteristics of low pass filter in EMI-prevention pressure sensor

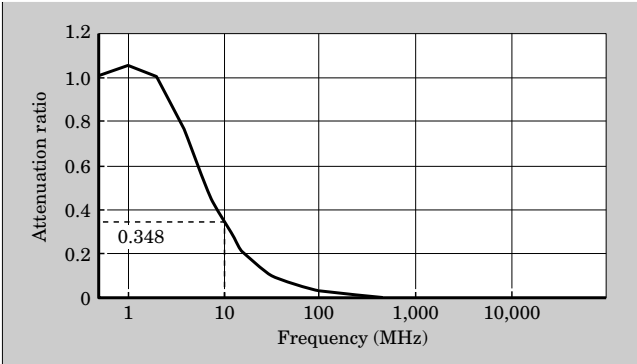


Fig.6 Structure of EMI-prevention pressure sensor

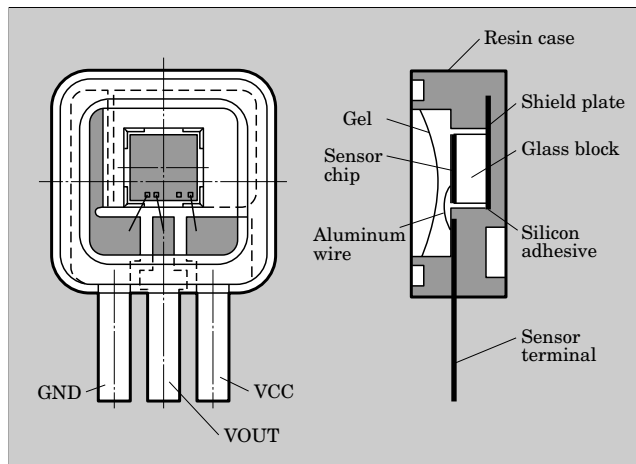


Fig.7 Electromagnetic immunity test system (TEM cell)

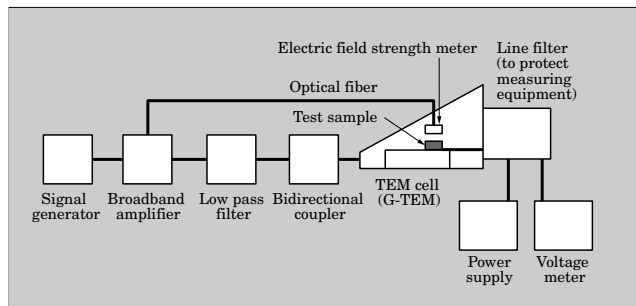
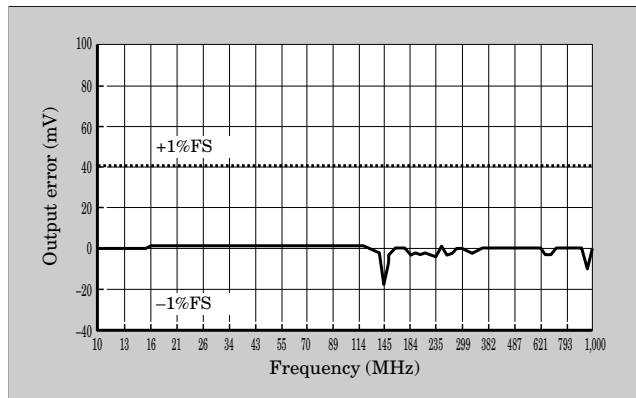


Fig.8 EMI test results for EMI-prevention pressure sensor



be maintained with a power supply voltage of 5 V.

To protect the capacitor of the low pass filter, a zener diode is connected to input and output pins to absorb static electricity and surge voltage. This guarantees the necessary durability for automotive applications.

4.2 Structure design

A structural diagram of the EMI-prevention pressure sensor is shown in Fig. 6. To suppress the infiltration of external noise, the chip and case are wire bonded only at the locations of three input and output pins. Further, to prevent radiated emission noise, a metal shield plate is built-in inside the resin

Table 1 Main specifications of EMI-prevention pressure sensor

Characteristic	For manifold pressure	For barometer
Maximum allowable pressure	450kPa	196kPa
Storage temperature	-40 to +150°C	-40 to +120°C
Operating temperature	-40 to +130°C	-40 to +90°C
Power supply voltage range	4.75 to 5.25V (standard 5 V)	4.75 to 5.25V (standard 5 V)
Output characteristics (power supply voltage 5 V)		
Error	25°C : ±1.5%FS -40 to +130°C : ±2.5%FS	25°C : ±3.0%FS -40 to +90°C : ±6.0%FS
Supply current	5 mA (max.)	
Sink current	1 mA (min.)	
Source current	0.1 mA (min.)	
Electrostatic immunity	±250V : 0Ω, 200pF ±2kV : 1.5kΩ, 100pF	
Output impedance	23 Ω (max.)	
Response	5 ms (max.)	

case. This shield plate is connected to the GND pin and has the effect of shielding the chip.

5. Specifications

The test system based on TEM cell for the EMI-prevention pressure sensor is shown in Fig. 7. Using a G-TEM that can test up to 1 GHz, the field intensity is monitored with an electrical field strength meter and the generator power is controlled to obtain a field intensity of 100 V/m over the entire frequency range.

The test results with this system are shown in Fig. 8. It was verified that the output error due to noise was 1% FS or below and that this level is not problematic for practical applications.

Other main specifications are listed in Table 1.

6. Conclusion

Owing to the intensified price competition and the increasing urgency for noise prevention that accompanies the globalization of markets, expansion of the market and applications is expected for small, low-cost pressure sensors with built-in noise prevention measures. Fuji Electric is determined to develop new products, advance its series of products and respond to market requests.



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