MIS-3600 series (Preliminary)

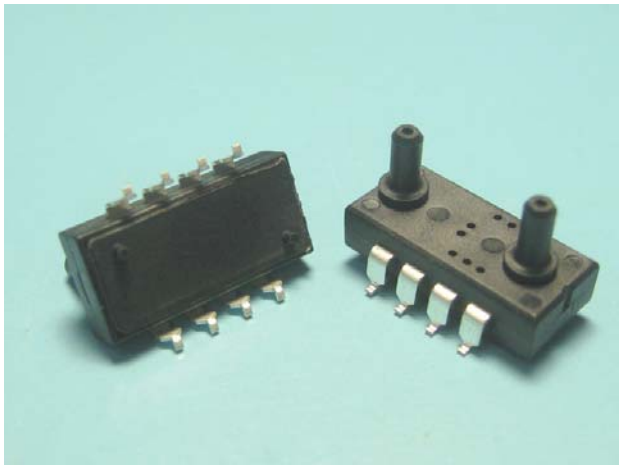
Intelligent Pressure Sensor

■ Features

- □ Supply Voltage 2.0 to 3.6V
- □ 0.5, 1, 5.8, 15, 30 psi differential pressure range
- □ Low standby current: <0.1μA
- □ Factory calibrated and temperature compensated
- □ SPI and I2C digital signal output

■ Applications

- □ Airflow meter
- □ Ventilation and air flow monitors
- □ Sleep apnea monitoring and therapy equipment
- □ Pneumatic controls
- □ HVAC



The MIS-3600 is an intelligent pressure sensor which consist of a MEMS piezoresistive pressure sensor and a signal conditioning ASIC. The signal conditioning ASIC is a 16-bits AD convertor with embedded 512 bits OTP memory. The sensor was calibrated and temperature compensated in factory. The factors for temperature compensation were stored in OTP memory. Users can implement temperature compensation via an external micro processor. The external microprocessor read the raw output data from MIS-3600 and do simple calculation according to the factors stored in OTP memory. Therefore using MIS-3600 series is easy to get rid of bothersome calibrations and temperature compensations. MIS-3600 provide SPI or I2C digital serial output interface to communicate with microprocessors. MIS-3600 series is specially designed for low voltage and low power consumption concerned applications.

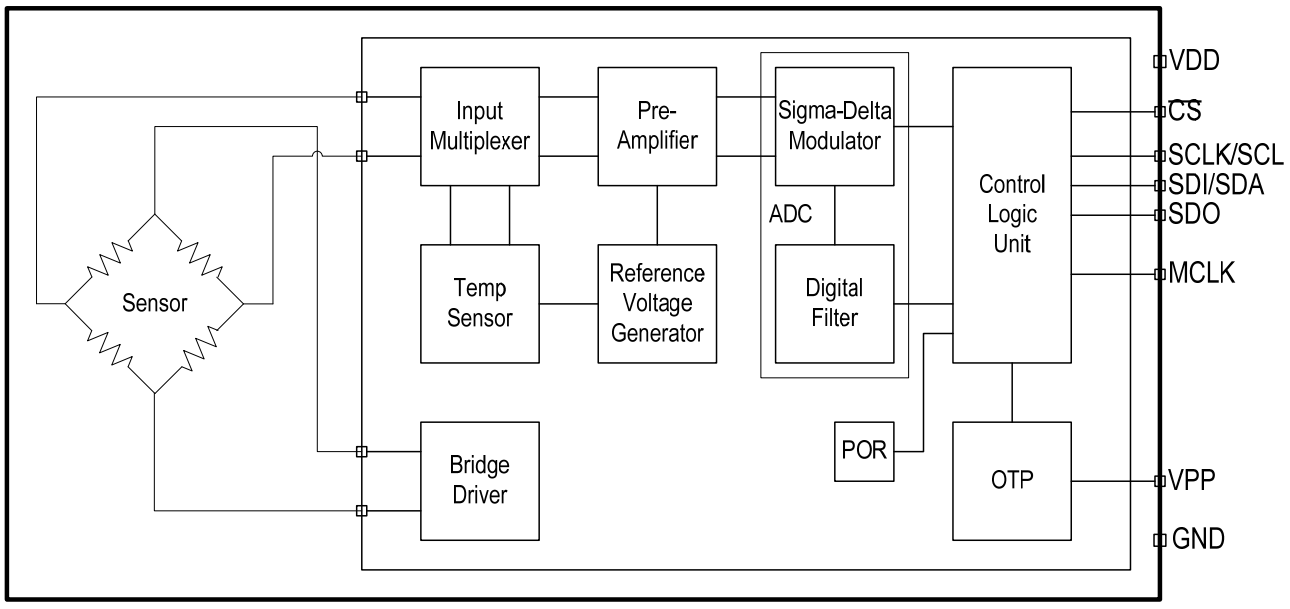


Fig. 1 Functional Block Diagram of MIS-3600

■ Specifications

Parameter	Symbol	Conditions	Min	Typ	Max	Units	Notes
1. Absolute Maximum Ratings							
Supply Voltage	VDD		-0.3		4	V	
Inputs voltage to VSS			-0.3		VDD+0.3	V	
Storage Temperature Range			-40		125	°C	
Maximum Overpressure					2X	Rated pressure	
ESD Rating HBM MM			 4000 400			 V	
2. Recommended Operating Conditions							
Pressure Range			0.5, 1, 5.8, 15, 30			psi	3
Operating Temperature Range			-40		85	°C	
Humidity			0		95	%RH	
Supply Voltage	VDD		2.0	3	3.6	V	
Supply Current Peak Current During Conversion Standby Average	 I_{sc} I_{ss} I_{avg}	VDD=3V 1 conversion/s		 600 0.1 21.6	 0.5 30.5	 μA μA μA	
Conversion Time	t_{conv}	MCLK=32.768kHz		34.5		ms	
External clock signal	MCLK		30000	32768	35000	Hz	
Duty cycle of MCLK			40	50	60	%	
Serial data clock	SCLK				500	kHz	
3. Electrical Parameters							
Analog to Digital Converter							
Resolution				16		Bits	
Output Code Range			2048		63487		
Conversion Time	t_{conv}	MCLK=32.768kHz		34.5		ms	
Output update rate					25	Hz	
Integral Nonlinearity			-4		+4	LSB	TBD
Differential Nonlinearity			-1		+1	LSB	TBD
SPI Interface							
Digital Inputs							
Serial data clock					500	kHz	
Input High Voltage	V_{IH}	I_{IH}< 5μA	80%VDD		VDD		
Input low Voltage	V_{IL}	I_{IL}< 5μA	0		20%VDD		
Input leakage current					0.1	μA	
Rise time	t_r				200	nS	
Fall time	t_f				200	nS	
Digital Outputs							
Output High Voltage	V_{OH}	SDO, Isource=0.6mA	80%VDD				
Output low Voltage	V_{OL}	SDO, sink=0.6mA			20%VDD		
Output low Voltage	V_{OL}	SDI, Isink=1.0mA			20%VDD		
Rise time	t_r	C_{load}= 50pf			200	nS	
Fall time	t_f	C_{load}= 50pf			200	nS	
Pressure Output Characteristics							
Full scale range 0.5, 1psi 5.8psi 15psi 30psi			 11 12.4 12.8 13	 11.6 12.9 13.4 13.5	 12 13.4 13.7 13.8	 bits	
Pressure Accuracy 0.5psi, 1psi		T=-40～-20℃ T=-20～70℃ T=70～85℃		±2 ±1 ±2		%FS	2

Pressure Accuracy 5.8psi、15psi、30psi		T= -30～85℃ T= -40～-30℃		±1 ±2		%FS	2
Temperature Output Characteristics							
Resolution				0.1		℃	
Accuracy		-40 to 85℃	-2		2	℃	

Notes：

1. Unless otherwise specified, measurements were taken with a supply voltage of 3 Vdc at a temperature of 25±3℃ and humidity ranging from 0～95% RH.
2. Maximum error of pressure reading over compensated temperature range and pressure range.
   That include all errors resulted from offset, span, linearity, temp. drift of offset and temp. drift of span.
3. Pressure range was defined as pressure of port A subtract pressure of port B.（Please refer to the drawing on page 12）

■ Pin Configuration and Function Descriptions

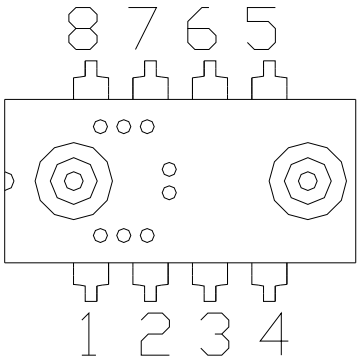


Fig. 2 Pin configuration of MIS-3600

Pin No.	Pin Name	Description
1	VPP	OTP Programming Voltage.
2	CS	Chip Select Input. Control data conversion timing and enables the serial input/output register.
3	GND	Ground.
4	SCLK/SCL	External Clock Input. This clock synchronizes serial data I/O.
5	SDO	Serial Data Output. Data is shifted on the RISING edge of DCLK. This output is high impedance when CS_ is HIGH.
6	SDI/SDA	SPI Serial Data Input I2C data I/O
7	MCLK	External Clock Input. This clock runs the A/D conversion process.
8	VDD	Power Supply.
Note! Pin1 was used only for calibration by the manufacturer and should not be connected.		

■ Ordering information

MIS-3 6 0 0-001 D I

C
A
B

A	Pressure type	B	Pressure range
D	Differential bipolar	C50	0.5 PSI
S	Differential unipolar	001	1 PSI
		006	5.8 PSI
		015	15 PSI
		030	30 PSI
C	**Interface**		
I	I2C		
S	SPI		

Part No.	Pressure type	Pressure range	Digital interface	Note
MIS-3600-C50DI	Differential bipolar	-0.5～0.5 PSI	I2C	
MIS-3600-C50SI	Differential unipolar	0～0.5 PSI	I2C	
MIS-3600-C50DS	Differential bipolar	-0.5～0.5 PSI	SPI	
MIS-3600-C50SS	Differential unipolar	0～0.5 PSI	SPI	
MIS-3600-001DI	Differential bipolar	-1～1 PSI	I2C	
MIS-3600-001SI	Differential unipolar	0～1 PSI	I2C	
MIS-3600-001DS	Differential bipolar	-1～1 PSI	SPI	
MIS-3600-001SS	Differential unipolar	0～1 PSI	SPI	
MIS-3600-006DI	Differential bipolar	-5.8～5.8 PSI	I2C	
MIS-3600-006SI	Differential unipolar	0～5.8 PSI	I2C	
MIS-3600-006DS	Differential bipolar	-5.8～5.8 PSI	SPI	
MIS-3600-006SS	Differential unipolar	0～5.8 PSI	SPI	
MIS-3600-015DI	Differential bipolar	-15～15 PSI	I2C	
MIS-3600-015SI	Differential unipolar	0～15 PSI	I2C	
MIS-3600-015DS	Differential bipolar	-15～15 PSI	SPI	
MIS-3600-015SS	Differential unipolar	0～15 PSI	SPI	
MIS-3600-030DI	Differential bipolar	-30～30 PSI	I2C	
MIS-3600-030SI	Differential unipolar	0～30 PSI	I2C	
MIS-3600-030DS	Differential bipolar	-30～30 PSI	SPI	
MIS-3600-030SS	Differential unipolar	0～30 PSI	SPI	

■ Package Outlines

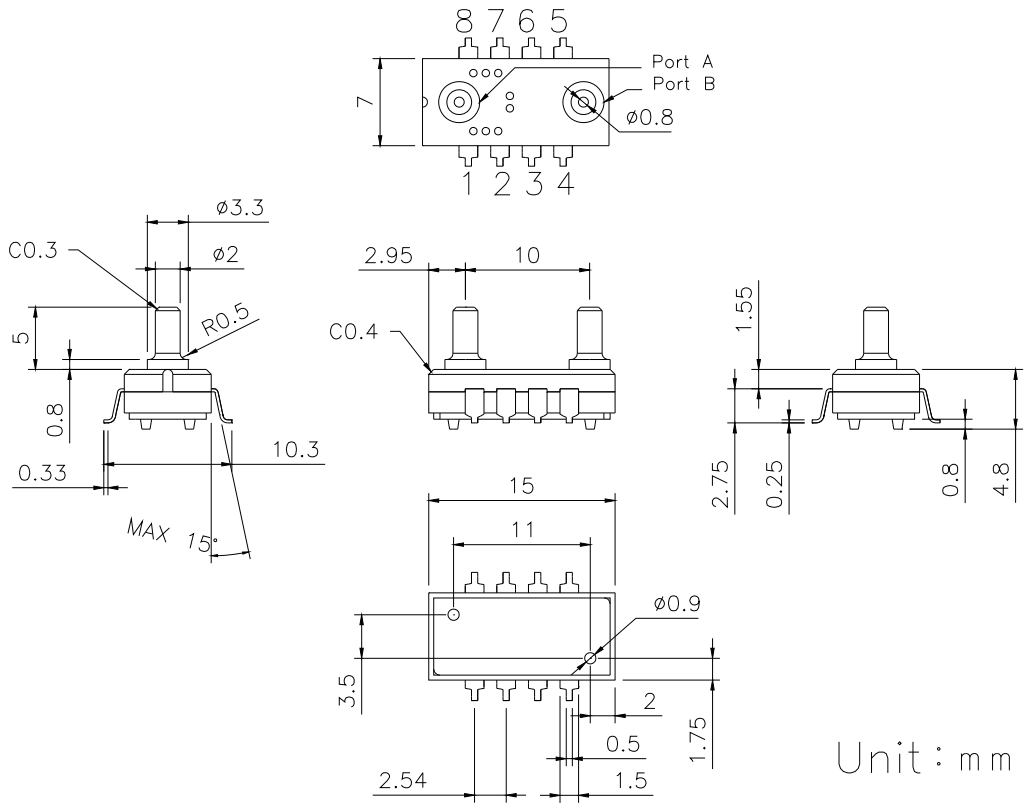


Fig. 3

■ Recommended footprint

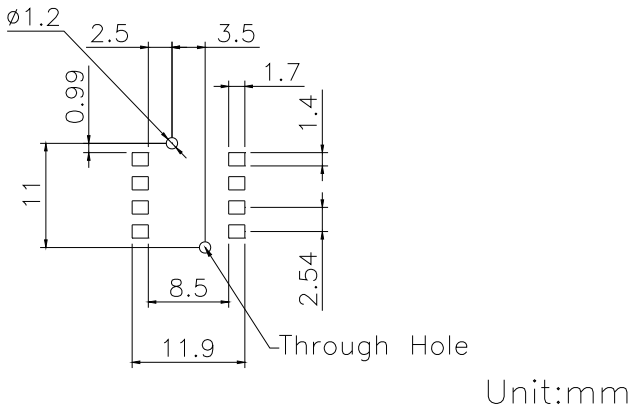


Fig. 4

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MIS-3600 Series

■ Application Information

General

The MIS-3600 is SIP device consisted of a MEMS pressure sensor and a signal conditioning ASIC. A 16-bits ADC is used to convert analog pressure and temperature signal to a 16-bits digital data. Due to the strong temperature coefficient of sensor output voltage, it is necessary to be compensated for practical applications. By a dedicated program running at an external microcontroller, this compensation will be performed.

Factory calibration

Each sensor was individually calibrated in the factory. There are several coefficients stored in OTP memory for compensation. Resulted from process variation and temperature variation of sensor, the coefficients have to be read by microcontroller and calculated by software to correct temperature drift of sensor.

Pressure and Temperature Measurement

The sequence of reading pressure and temperature as well as software compensation is shown as fig. 3.

First the coefficients C1 to C13 have to be read from OTP memory via serial interface. This can be done once reset the MIS-3600. The data format of coefficient is unsigned 16-bit. In order to measure pressure, the microcontroller have to read the 16 bit data for pressure（D1） and temperature（D2）. Then, the microcontroller calculate the compensated pressure by D1, D2, and coefficients C1 to C13. The general flow for temperature compensation calculation was listed as fig. 3.

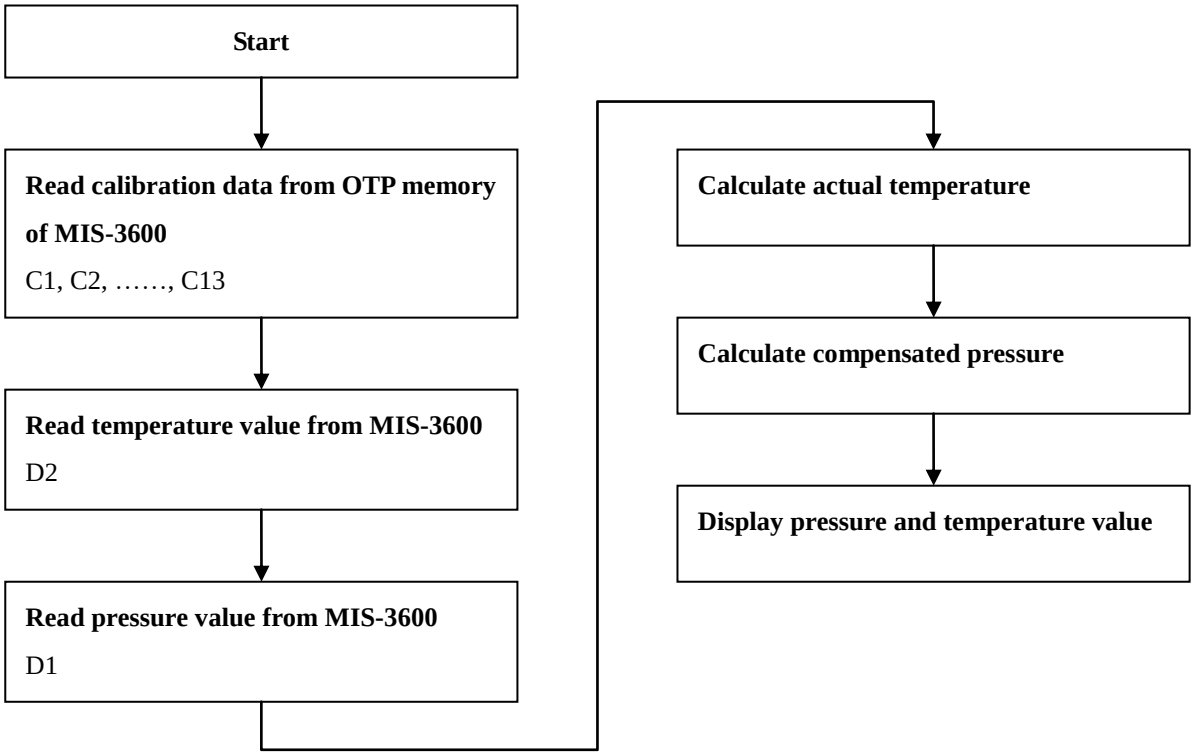


Fig. 1

Decoupling Capacitor

The decoupling capacitors, 0.1μF ceramic plus 1μF tantalum capacitor, have to be placed as close as possible to the MIS-3600 VDD and GND pin. This capacitor will stabilize the power supply during data conversion and thus, provide the highest possible accuracy.

Application Circuit example

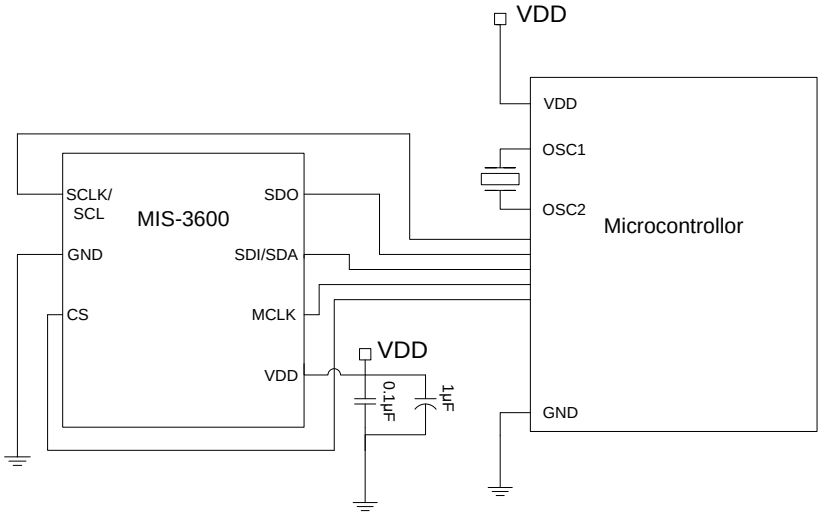


Fig. 2 Typical application circuit of MIS-3600 in SPI mode

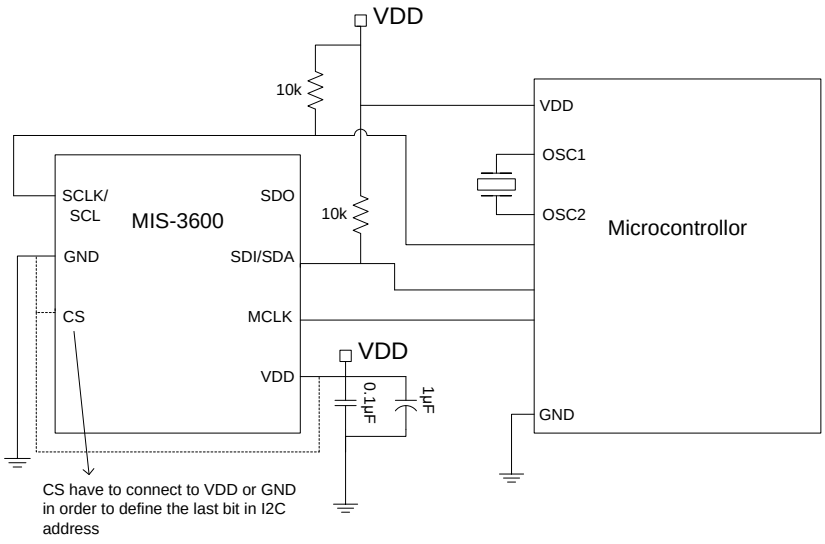


Fig. 3 Typical application circuit of MIS-3600 in I2C mode

■ Serial Interface

The MIS-3600 can provide two types of serial interfaces as SPI or I2C. The type of serial interface is defined as the device manufactured. The user can`t choose the type of serial interface by hardware wiring. So the user have to decide the type of serial interface as ordering the device.

■ SPI Interface

The MIS-3600 have a SPI（Serial Peripheral Interface）bus to communicate with the microprocessor and other digital systems. The functional block diagram of MIS-3600 was shown as fig.1. The SPI bus consists of four wires as SCLK, SDI, SDO, CS.

Serial Clock Input

The SCLK is the serial clock input for the device, and all data transfers (either on SDI or SDO) occur with respect to the SCLK signal. Each bit is shifted out of the SDO pin on the falling edge of SCLK and data is shifted into the SDI pin on the rising edge of SCLK. The SCLK-signal is generated by the microprocessor's system.

Chip Select Input

The CS (Chip Select Input) is an active low logic input used to select the MIS-3600. The CS can be used to select the MIS-3600 in systems with more than one device on the serial bus or as a frame synchronization signal in communicating with the device. CS can be hard-wired low, allowing the MIS-3600 to operate in 3-wire mode with SCLK, SDI, and SDO used to interface with the device.

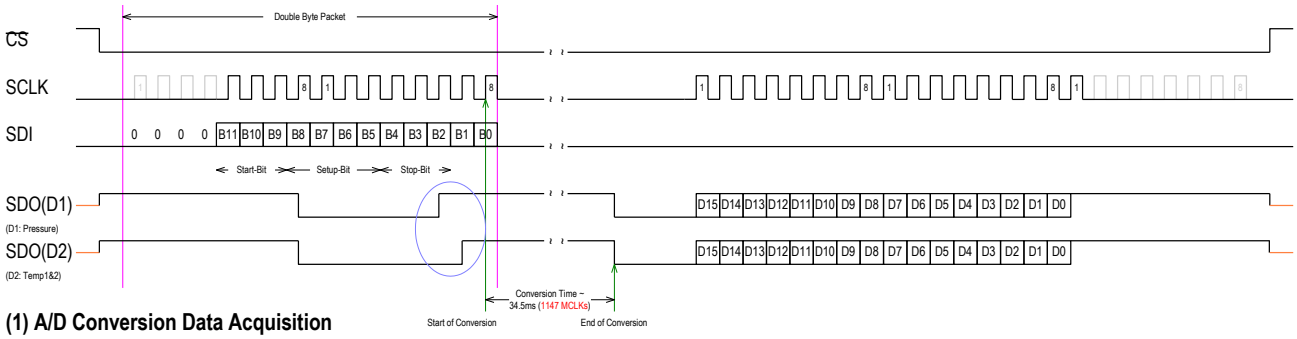
Serial Data Output (SDO)

The SDO pin provides the result of the last conversion as a serial bit stream during the data output state. In addition, the SDO pin is used as an end of conversion indicator during the conversion. When CS is HIGH, the SDO driver is switched to a high impedance state in order to share the data output line with other devices. If CS is brought LOW during the conversion phase, the SDO pin will be driven HIGH. Once the conversion is complete, if CS is brought LOW, SDO pin will be driven LOW indicating the conversion is complete and the result is ready to be shifted out of the device. The digital data sent by MIS-3600 SDO pin is either the conversion results or the calibration data stored in OTP. The selection of the output data is done by sending the corresponding instruction on the SDI pin.

Serial Data Input (SDI)

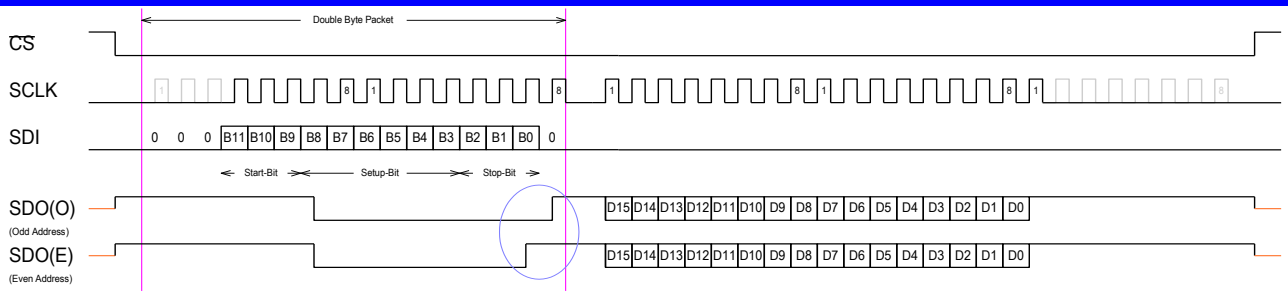
The SDI pin is used to select the input channel (Pressure or Temperature) and to access the OTP memory. Data is shifted into the device during the data output/input state on the rising edge of SCLK while CS is low

Timing Waveform Diagrams



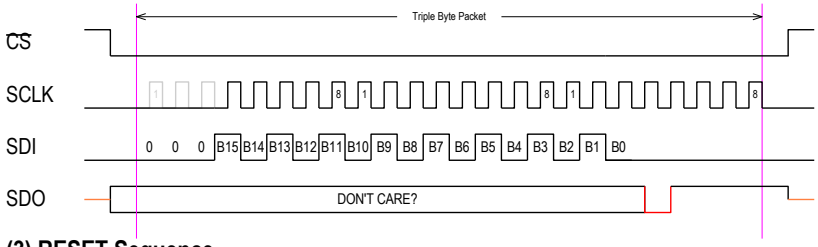
(1) A/D Conversion Data Acquisition

Fig.4



(2) OTP Data Acquisition

Fig.5



(3) RESET Sequence

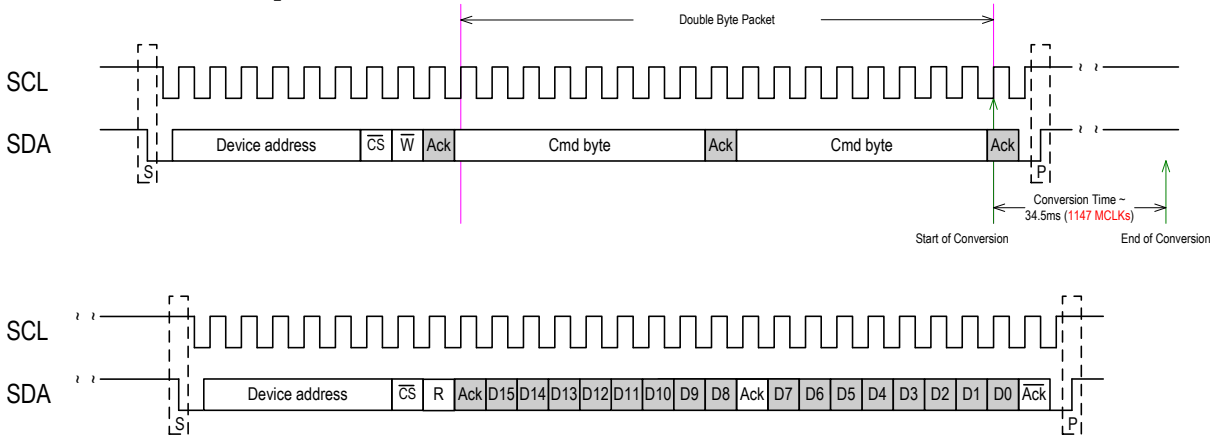
Fig. 6

■ I2C Interface

Typical I2C communication starts with the start condition and is ended with the stop condition. The device address consisted of six pre-defined bits plus a pin defined bit. The device address is 111011C. The value of C is determined by the $\overline{CS}$ pin connected with VDD or GND.

$\overline{CS}$ connected to	Device address
VDD	1110111
GND	1110110

A/D conversion data acquisition



From master to slave S: Start condition W: Write=0 ACK: Acknowledge

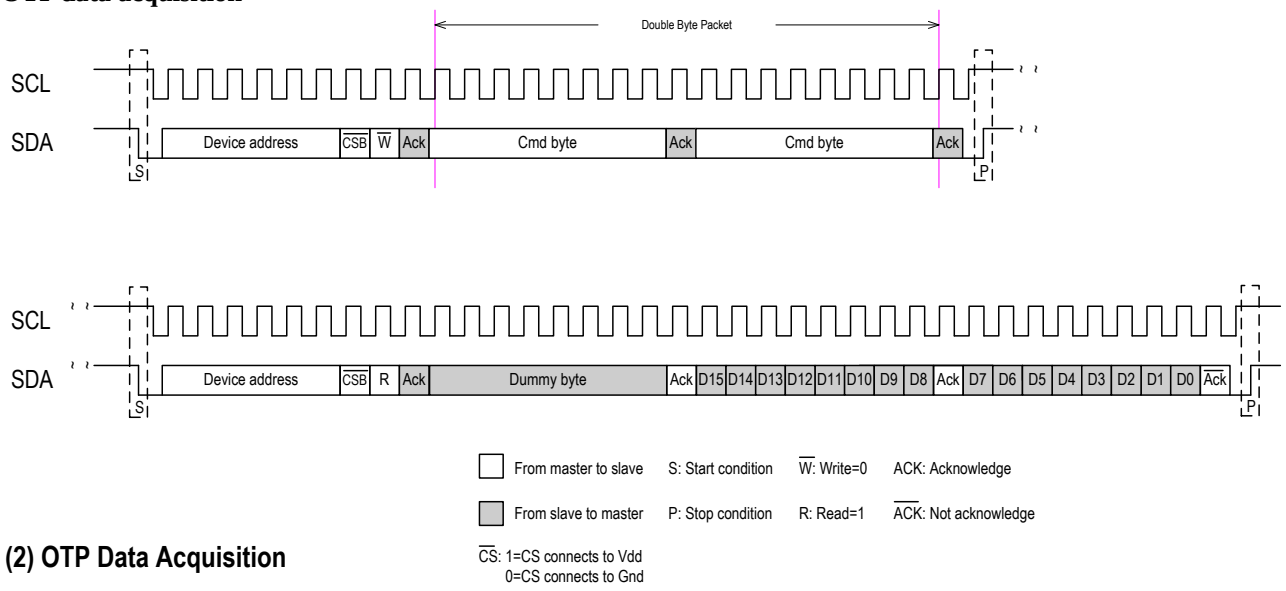
From slave to master P: Stop condition R: Read=1 ACK: Not acknowledge

$\overline{CS}$: 1=CS connects to Vdd
0=CS connects to Gnd

(1) A/D Conversion Data Acquisition

Fig. 7

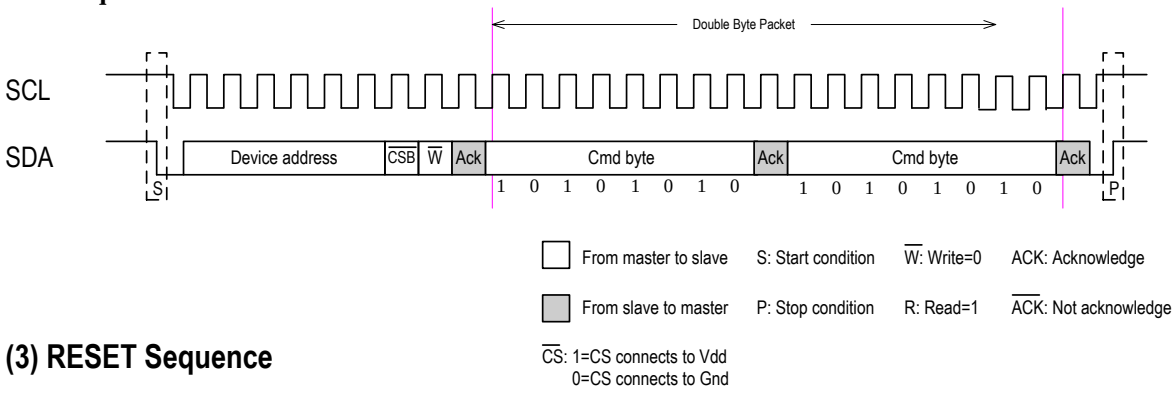
OTP data acquisition



(2) OTP Data Acquisition

Fig. 8

Reset sequence



(3) RESET Sequence

Fig. 9

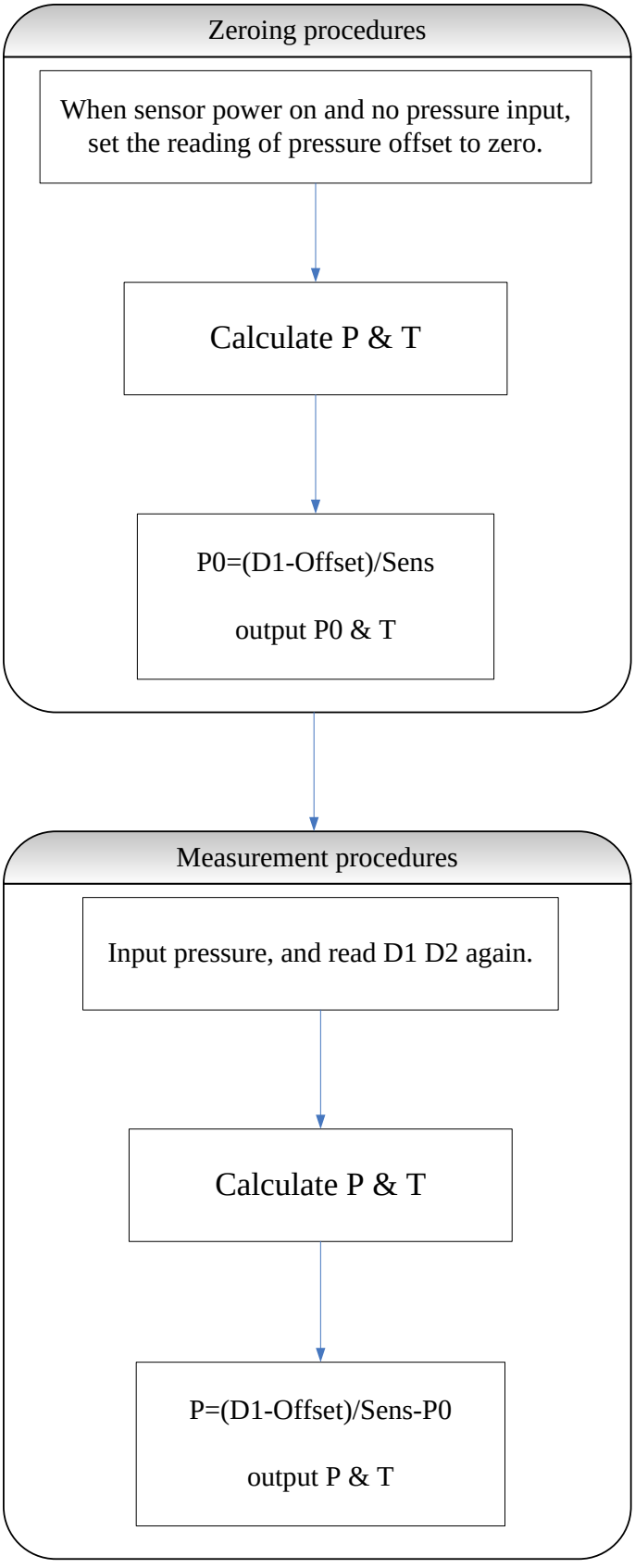
■ Pressure and temperature reading instructions

Here we will give several examples to introduce reading pressure, temperature and calibration coefficients. All the commands for pressure, temperature and coefficients reading is listed as following table.

Action	**Instruction**	
	SPI mode	**I2C mode**
Conversion start for pressure measurement（D1）		
For 5.8 & 15 psi	0Fh & 49h	0Fh & 49h
For 0.5 & 1 psi	0Fh & 59h	0Fh & 59h
Conversion start for temperature measurement（D2）	0Fh & 21h	0Fh & 21h
Reading coefficient C1	1Ch & 40h	0Eh & 20h
Reading coefficient C2	1Ch & 50h	0Eh & 28h
Reading coefficient C3	1Ch & 60h	0Eh & 30h
Reading coefficient C4	1Ch & 70h	0Eh & 38h
Reading coefficient C5	1Ch & 80h	0Eh & 40h
Reading coefficient C6	1Ch & 90h	0Eh & 48h
Reading coefficient C7	1Ch & A0h	0Eh & 50h
Reading coefficient C8	1Ch & B0h	0Eh & 58h
Reading coefficient C9	1Ch & C0h	0Eh & 60h
Reading coefficient C10	1Ch & D0h	0Eh & 68h
Reading coefficient C11	1Ch & E0h	0Eh & 70h
Reading coefficient C12	1Ch & F0h	0Eh & 78h
Reading coefficient C13	1Dh & 00h	0Eh & 80h

■ Calculation of pressure and temperature

For 0.5psi range sensor：MIS-3600-C50DI、MIS-3600- C50SI、MIS-3600- C50DS、MIS-3600- C50SS



Please refer to the procedure in fig.13

Please refer to the procedure in fig.13

Fig.10

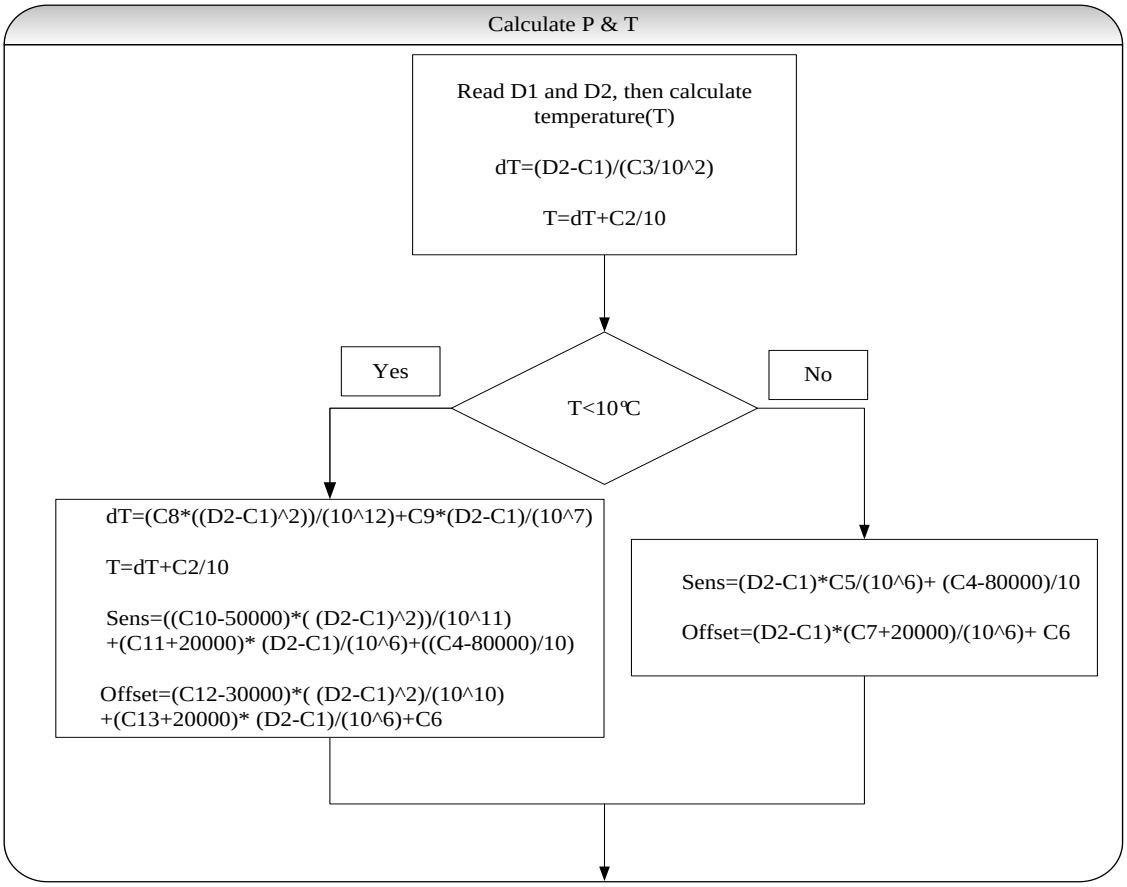
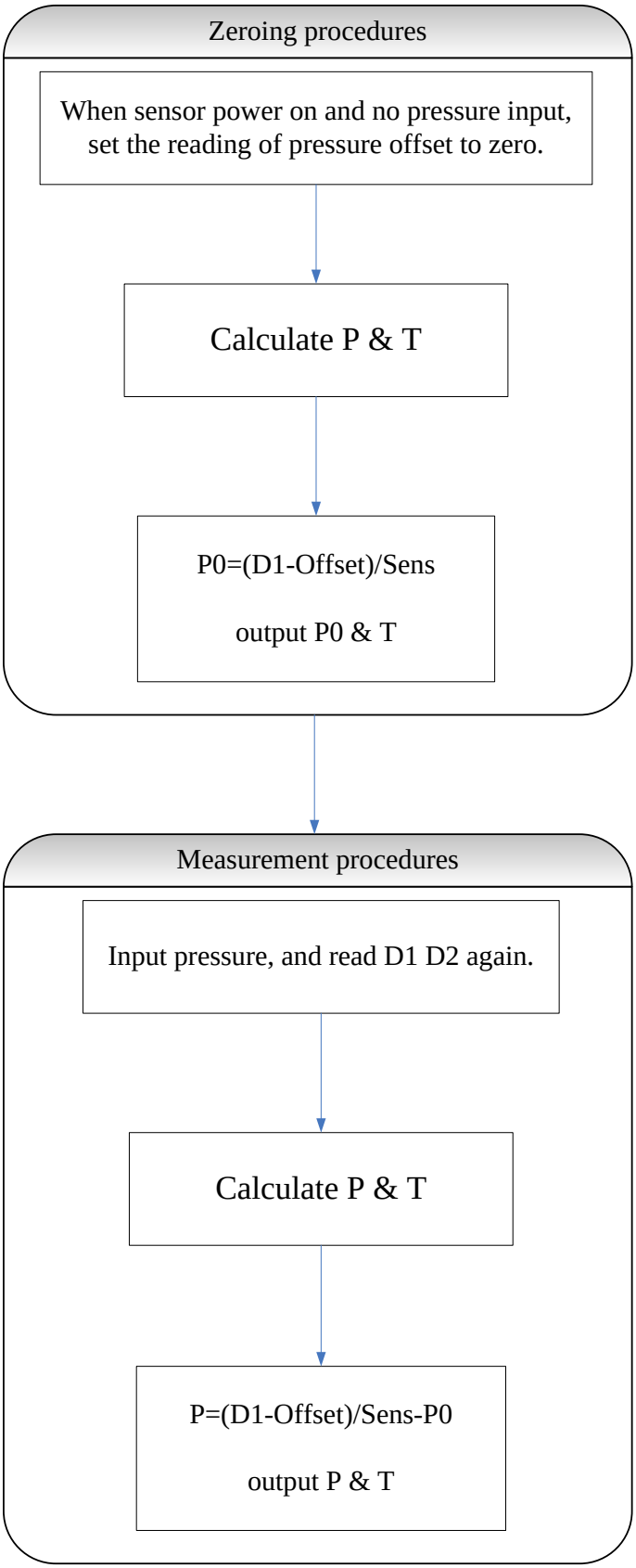

Calculate P & T
Read D1 and D2, then calculate temperature(T)
dT=(D2-C1)/(C3/10^2)
T=dT+C2/10
Yes
T<10℃
No
dT=(C8*((D2-C1)^2))/(10^12)+C9*(D2-C1)/(10^7)
T=dT+C2/10
Sens=((C10-50000)*((D2-C1)^2))/(10^11) +(C11+20000)* (D2-C1)/(10^6)+((C4-80000)/10)
Offset=(C12-30000)*((D2-C1)^2)/(10^10) +(C13+20000)* (D2-C1)/(10^6)+C6
Sens=(D2-C1)*C5/(10^6)+ (C4-80000)/10
Offset=(D2-C1)*(C7+20000)/(10^6)+ C6

Fig.11

For 1psi bipolar range sensor：MIS-3600-001DI、MIS-3600-001DS



Please refer to the procedure in fig.15

Please refer to the procedure in fig.15

Fig.12

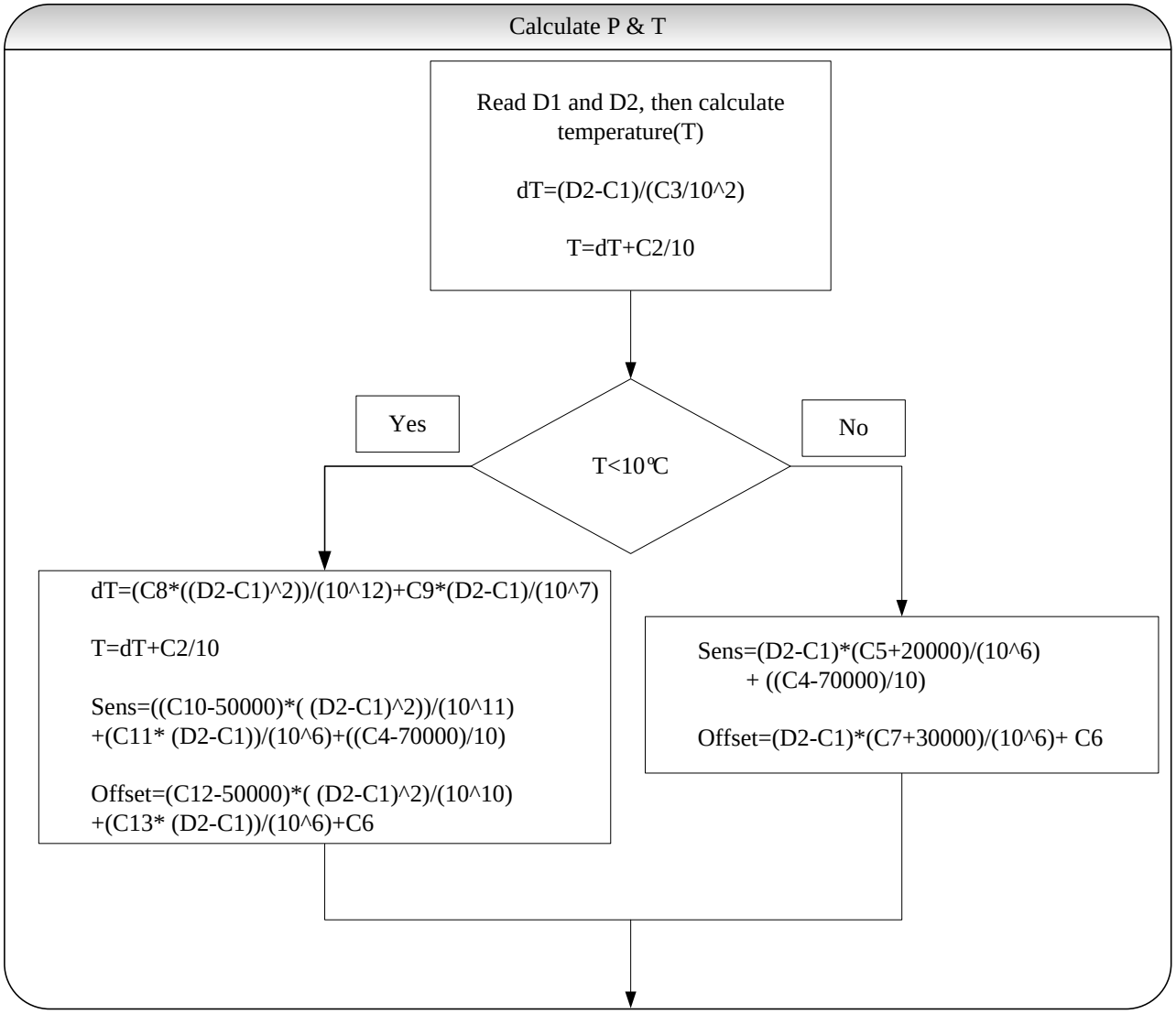
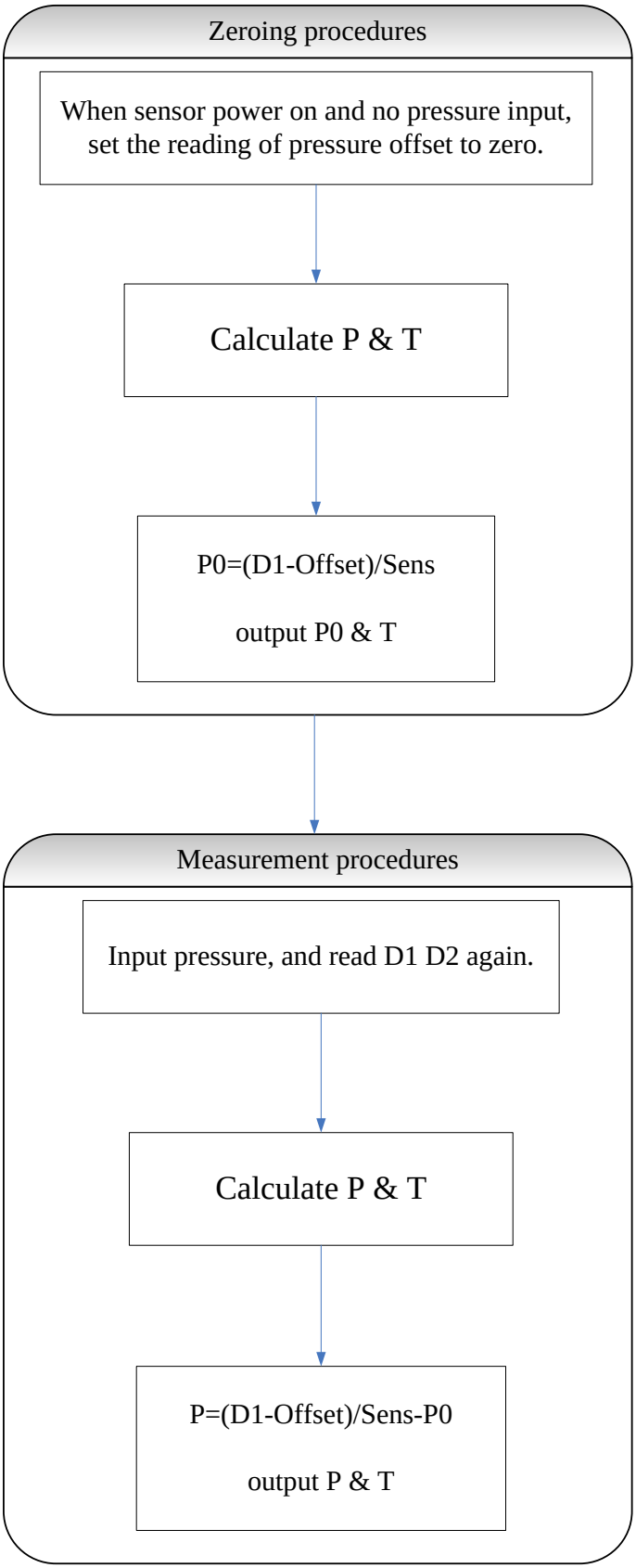

Calculate P & T
Read D1 and D2, then calculate temperature(T)
dT=(D2-C1)/(C3/10^2)
T=dT+C2/10
T<10℃
Yes
No
dT=(C8*((D2-C1)^2))/(10^12)+C9*(D2-C1)/(10^7)
T=dT+C2/10
Sens=((C10-50000)*((D2-C1)^2))/(10^11) +(C11* (D2-C1))/(10^6)+((C4-70000)/10)
Offset=(C12-50000)*((D2-C1)^2)/(10^10) +(C13* (D2-C1))/(10^6)+C6
Sens=(D2-C1)*(C5+20000)/(10^6) + ((C4-70000)/10)
Offset=(D2-C1)*(C7+30000)/(10^6)+ C6

Fig.13

For 1psi unipolar range sensor：MIS-3600-001SI、MIS-3600-001SS



Please refer to the procedure in fig.17

Please refer to the procedure in fig.17

Fig.14

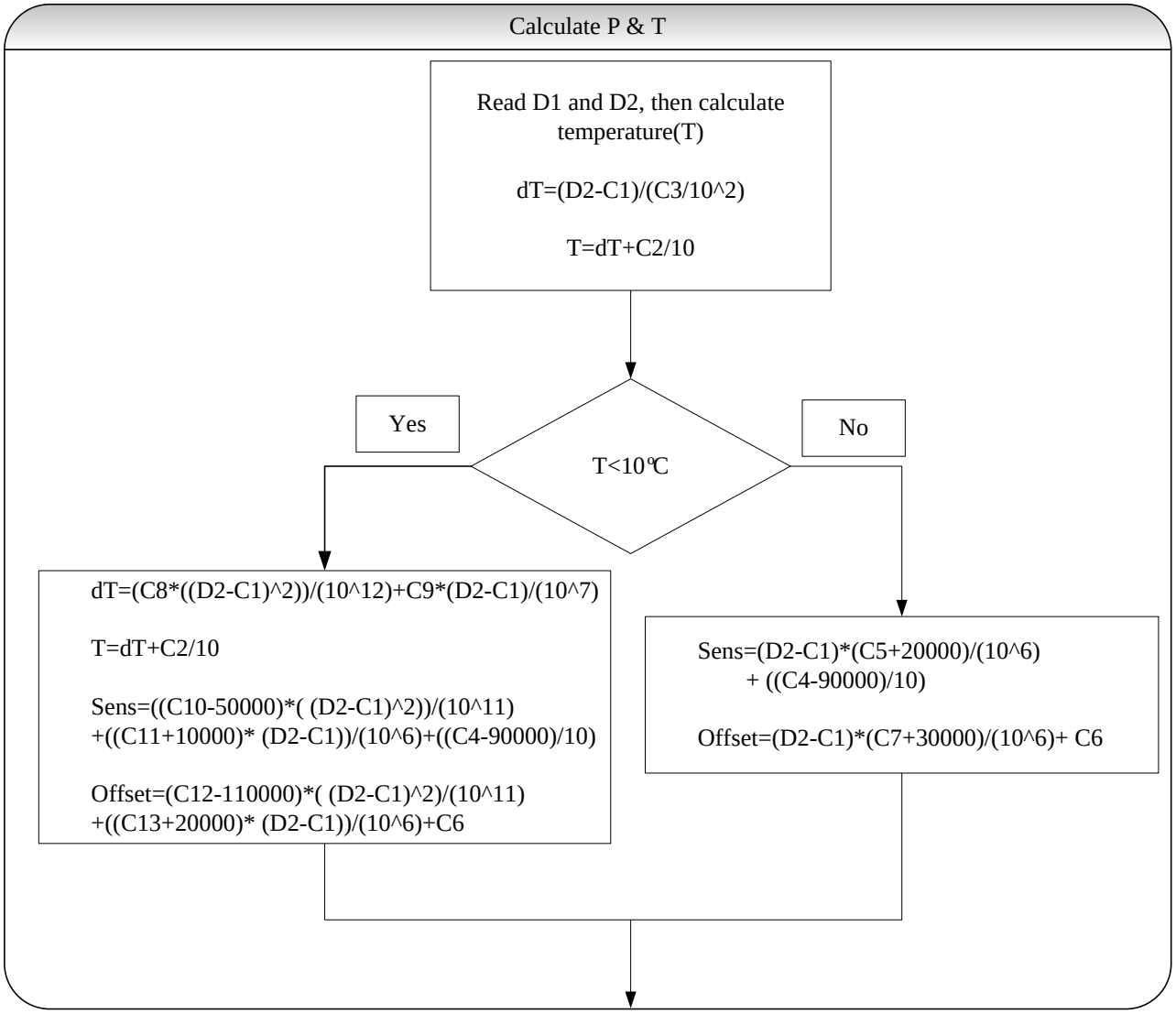

Calculate P & T
Read D1 and D2, then calculate temperature(T)
dT=(D2-C1)/(C3/10^2)
T=dT+C2/10
T<10℃
Yes
No
dT=(C8*((D2-C1)^2))/(10^12)+C9*(D2-C1)/(10^7)
T=dT+C2/10
Sens=((C10-50000)*((D2-C1)^2))/(10^11)
+((C11+10000)* (D2-C1))/(10^6)+((C4-90000)/10)
Offset=(C12-110000)*((D2-C1)^2)/(10^11)
+((C13+20000)* (D2-C1))/(10^6)+C6
Sens=(D2-C1)*(C5+20000)/(10^6)
+ ((C4-90000)/10)
Offset=(D2-C1)*(C7+30000)/(10^6)+ C6

Fig.15

For 5.8psi range sensor：MIS-3600-006DI、MIS-3600-006SI、MIS-3600-006DS、MIS-3600-006SS

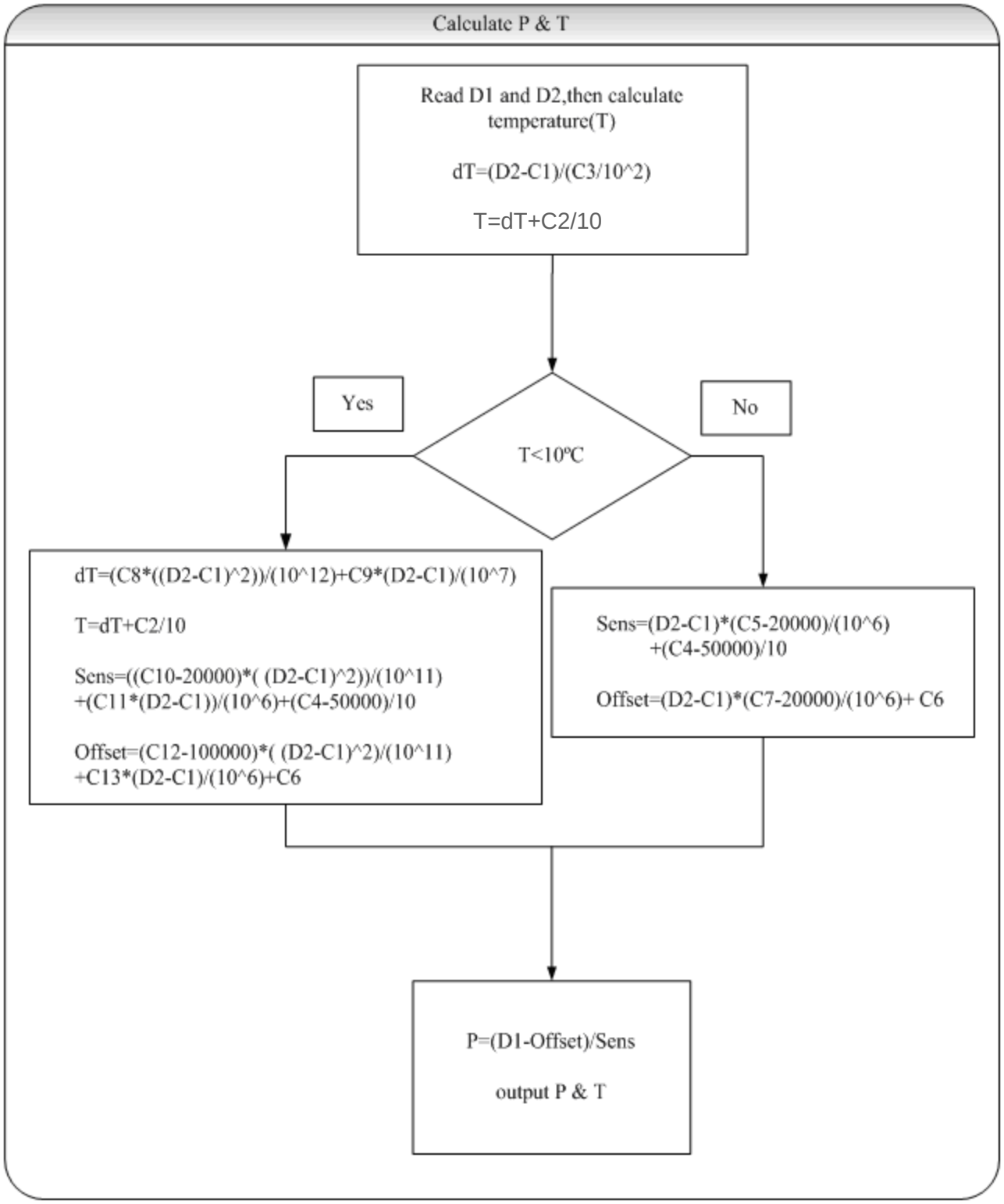


Fig.16

For 15psi range sensor：MIS-3600-015DI、MIS-3600-015SI、MIS-3600-015DS、MIS-3600-015SS

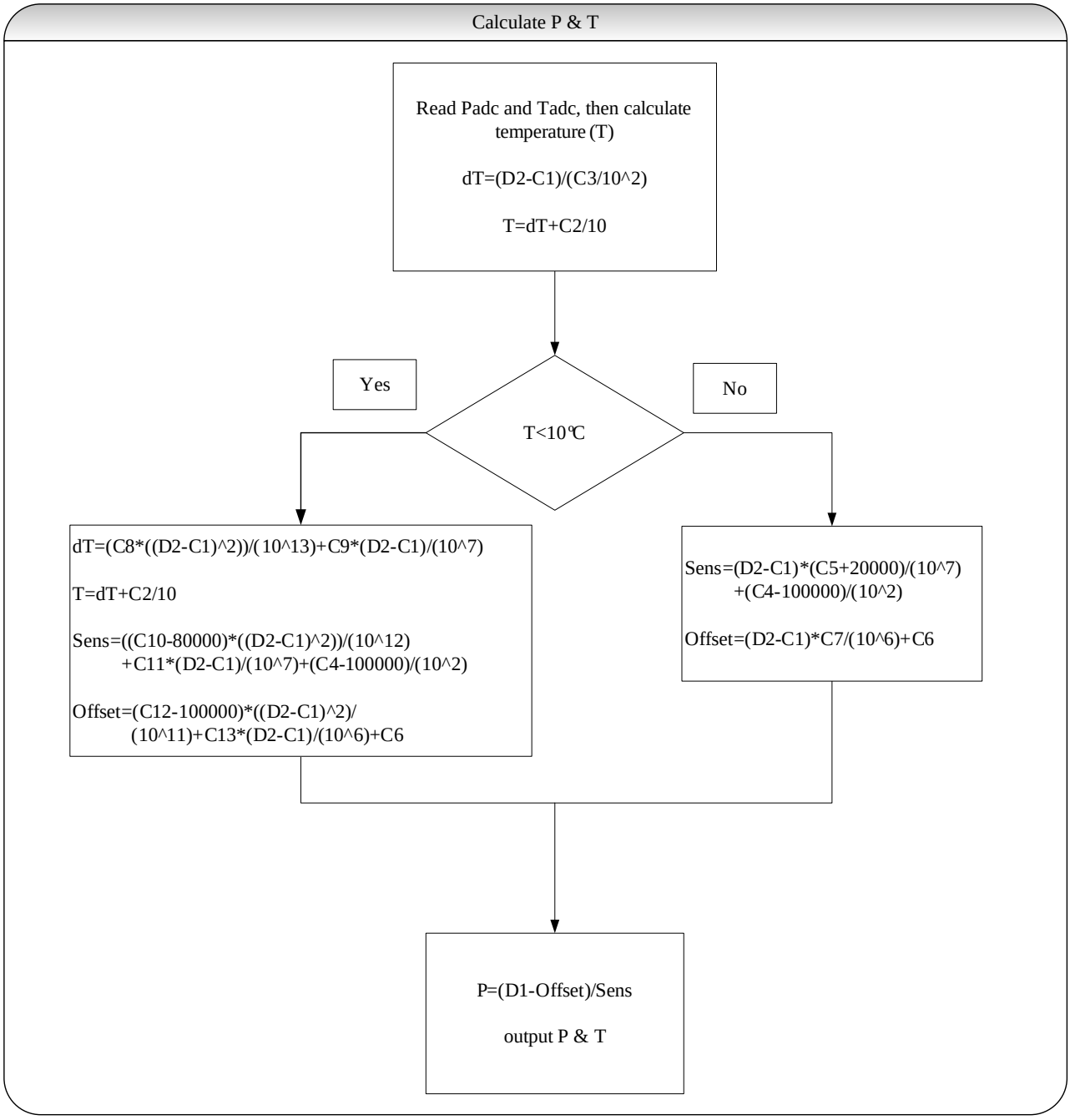


Fig.17

For 30psi range sensor：MIS-3600-030DI、MIS-3600-030SI、MIS-3600-030DS、MIS-3600-030SS

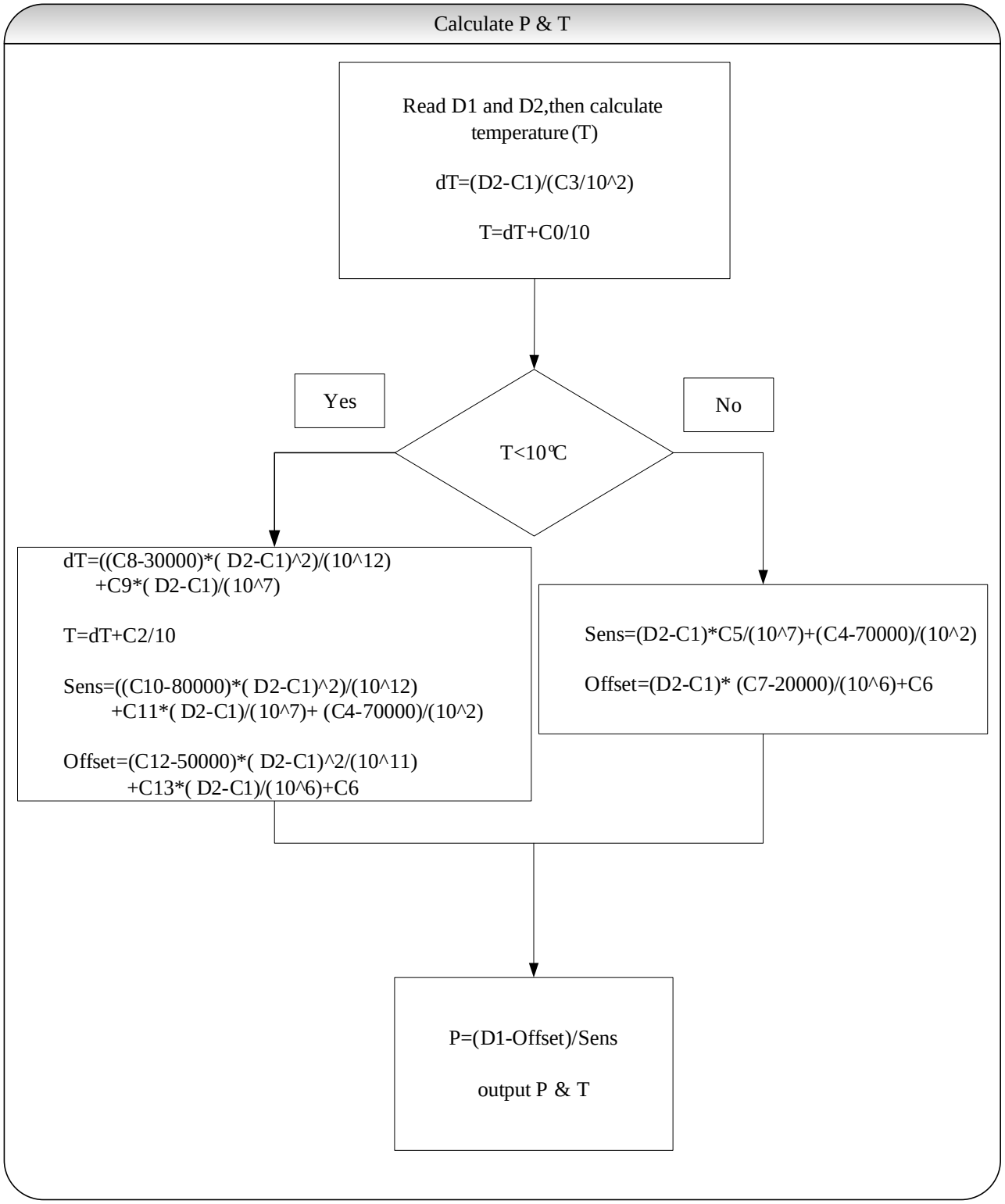


Fig.18

■ Package Outlines

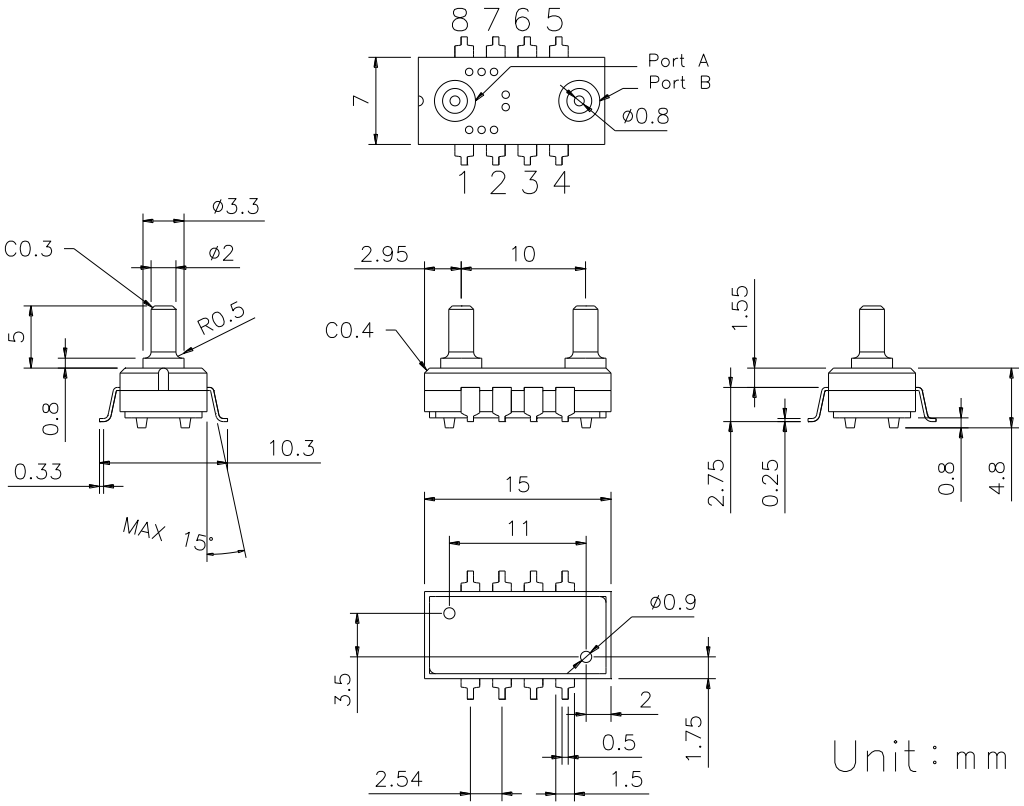


Fig. 19

■ Recommended footprint

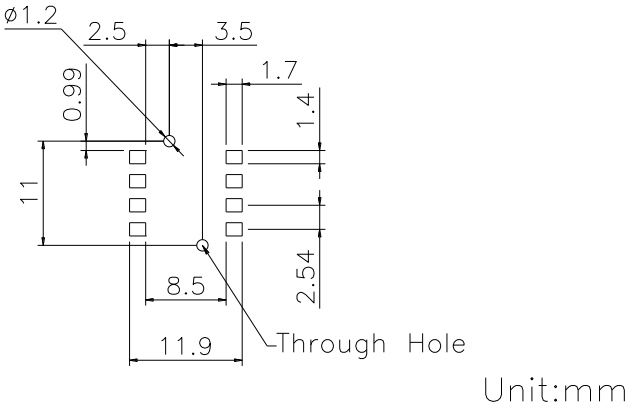


Fig. 20

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