



DATE November 5, 2018

No. V-70107-E

Messrs. \_\_\_\_\_

# SPECIFICATION

\_\_\_\_\_  
Semiconductor Pressure Sensor

Model: AL4 Series

Project: \_\_\_\_\_

Distributor: \_\_\_\_\_

Reference: \_\_\_\_\_

A handwritten signature in black ink that reads 'Y. Uchiumi'.

\_\_\_\_\_  
Yoshiyuki Uchiumi, Application Engineer  
Sensor Business Unit  
Electronics Business Company  
Fujikura Ltd.

## Fujikura Ltd.

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### Table shown below is revision records of this specification

Rev.	Date	Name	Comment	Mark
Est.	Nov. 5, 2018	Y. Uchiyumi	Issued	

**1. General**

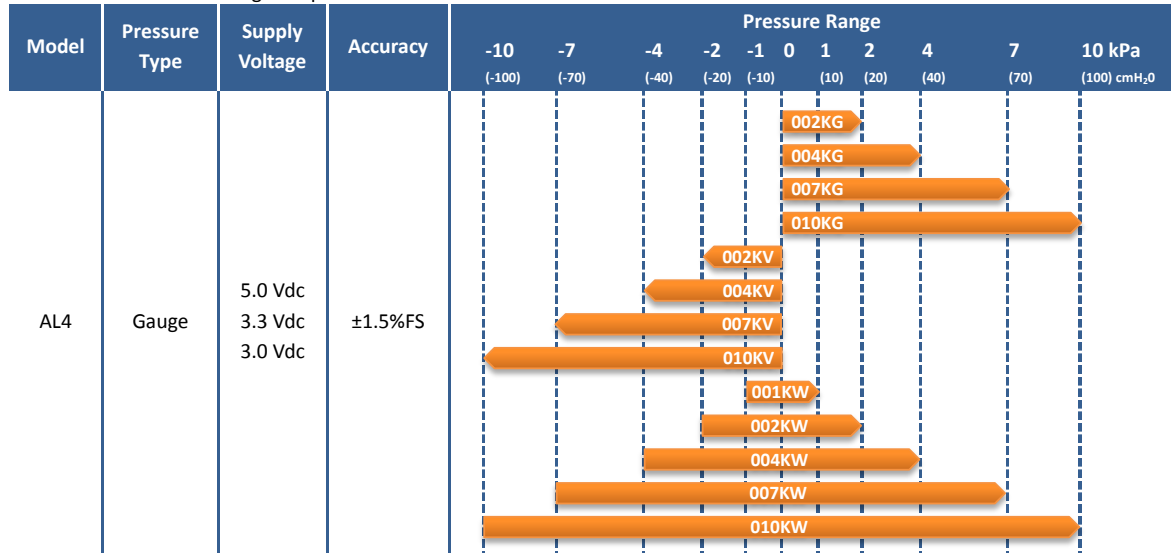
This document describes the specifications of the AL4 pressure sensors.

**2. Principle**

Fujikura Pressure Sensor is composed of a silicon piezo-resistive pressure sensing chip and a signal conditioning integrated circuit. The low-level signal from the sensing chip is amplified, temperature compensated, calibrated, and finally converted to digital data that is proportional to the applied pressure.

**3. Device Lineup**

This device has the following lineup.



**Features**

- ✓ Digital output
- ✓ Low pressure
- ✓ High proof pressure
- ✓ Moisture sensitivity level (MSL) 1
- ✓ Low power consumption
- ✓ High accuracy
- ✓ Modification available

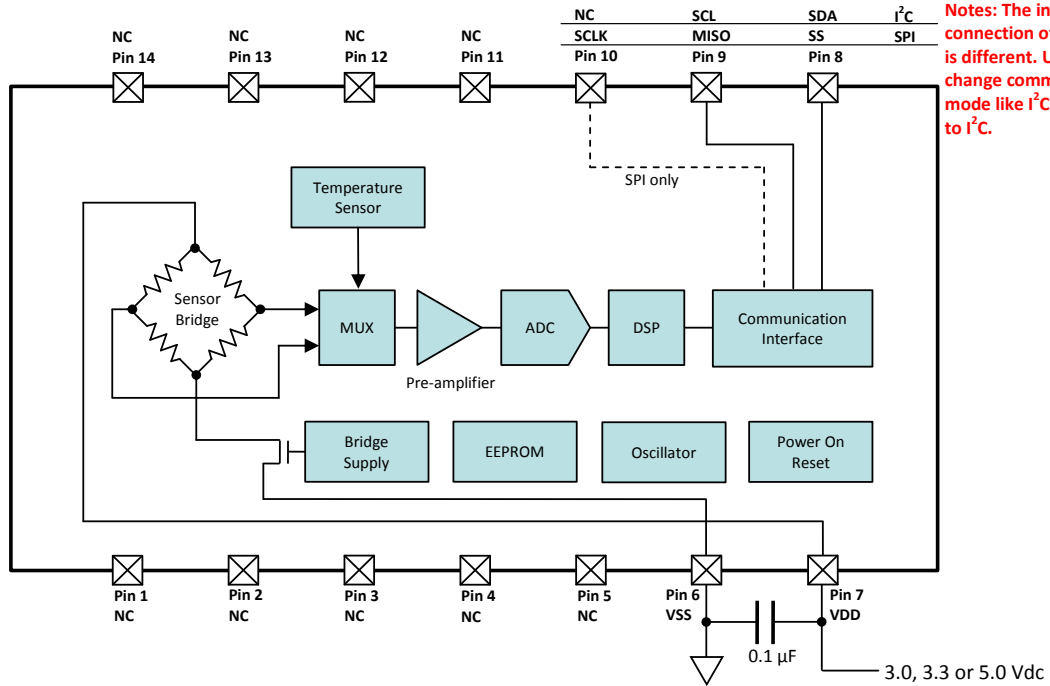
**Applications**

- ✓ Battery-operated devices
- ✓ Medical devices
- ✓ Industrial pneumatic devices
- ✓ Consumer devices

**4. RoHS**

This device is compliant with the Restriction of the use of certain Hazardous Substances in Electrical and Electronic Equipment (RoHS).

5. Block Diagram and Pin Connections



Pin Assignment	Pin No.	Pin Name	I/O	Type	Function		
	1	NC	-	-	No connect	*3	
	2	NC	-	-	No connect	*3	
	3	NC	-	-	No connect	*3	
	4	NC	-	-	No connect	*3	
	5	NC	-	-	No connect	*3	
	6	VSS	-	-	Common voltage connection	*1	
	7	VDD	-	-	Power supply connection	*1	
	8	I <sup>2</sup> C SDA	SDA	I/O	Digital	Serial bidirectional data	*2
		SPI SS	SS	I	Digital	Slave select	
	9	I <sup>2</sup> C SCL	SCL	I	Digital	Serial clock input	*2
		SPI MISO	MISO	O	Digital	Master-In-Slave-Out	
	10	I <sup>2</sup> C NC	-	-	-	No connect	*2
		SPI SCLK	SCLK	I	Digital	Serial clock input	
	11	NC	-	-	-	No connect	*3
12	NC	-	-	-	No connect	*3	
13	NC	-	-	-	No connect	*3	
14	NC	-	-	-	No connect	*3	

Notes:

- \*1) Put a 0.1µF capacitor between VDD Pin 7 and VSS.
- \*2) I<sup>2</sup>C or SPI is factory setting. User can not change communication mode.
- \*3) NC pins must be open.



## AL4 Series | V-70107-E

## 7. Absolute Maximum Ratings

Item	Condition	Symbol	Rating			Unit
			Min.	Typ.	Max.	
Proof Pressure	Port A	Pmax	-	-	+100	kPa *2
Burst Pressure	Port A	Pburst	+100	-	-	kPa *3
Supply Voltage		VDDmax	-0.3	-	6	Vdc
Voltage at Digital I/O pins		Vdiomax	-0.3	-	VDD+0.3	Vdc
Operating Temperature		Topt	-40	-	+85	°C
Storage Temperature		Tstg	-40	-	+85	°C

Notes:

- \*1) Absolute maximum ratings are the limits that the device will withstand without damage.
- \*2) Proof Pressure is defined as maximum applied pressure to the device without damage.
- \*3) The device will be damaged, if applied pressure is beyond Burst Pressure.

## 8. General Specifications

Item	Condition		Symbol	Rating			Unit	
				Min.	Typ.	Max.		
Supply Voltage	Sensor Code	AL40DB	VDD	4.75	5	5.25	Vdc *1	
		AL41DB		3.135	3.3	3.465		
		AL42DB		2.85	3.0	3.15		
Type of Pressure			-	Gauge pressure			*2	
Pressure Media			-	Non-corrosive gases			*3	
Pressure Range	Port A	Pressure Code	Popt	002KG	0	-	+2	kPa
				004KG	0	-	+4	kPa
				007KG	0	-	+7	kPa
				010KG	0	-	+10	kPa
				002KV	-2	-	0	kPa
				004KV	-4	-	0	kPa
				007KV	-7	-	0	kPa
				010KV	-10	-	0	kPa
				001KW	-1	-	+1	kPa
				002KW	-2	-	+2	kPa
				004KW	-4	-	+4	kPa
				007KW	-7	-	+7	kPa
010KW	-10	-	+10	kPa				
Compensated Temperature			-	-5	-	+65	°C *6	
Operating Humidity	Non-condensing, +65°C		Hopt	-	-	85	%RH *7	
Storage Humidity	Non-condensing		Hstg	30	-	85	%RH *7	
Dielectric Strength				-	-	1	mA *8	
Insulation Resistance				100	-	-	MΩ *9	

Notes:

- \*1) Supply voltage (VDD) should be constant.
- \*2) Gauge pressure is defined as the difference between applied pressure to the pressure port and atmospheric pressure of the device. Pressure must be applied to Port A, and Port B must be vented to atmospheric pressure.
- \*3) Ensure the pressure media contains no particulates. The device is not compatible with liquids.
- \*4) Pressure must be applied to Port A. Port B is a reference port. Do not apply pressure to Port B.
- \*5) Pressure range is defined as the measurable pressure range of the device. Do not expose intentionally beyond minimum Popt and maximum Popt.
- \*6) Please also refer to Chapter 17 Transfer Function.
- \*7) Do not wet the device with dew.
- \*8) Dielectric strength is defined as the leakage current between all pins and the package with AC 500 V, 1 minute.
- \*9) Insulation resistance is defined as the resistance value between all pins and the package with DC 500 V.

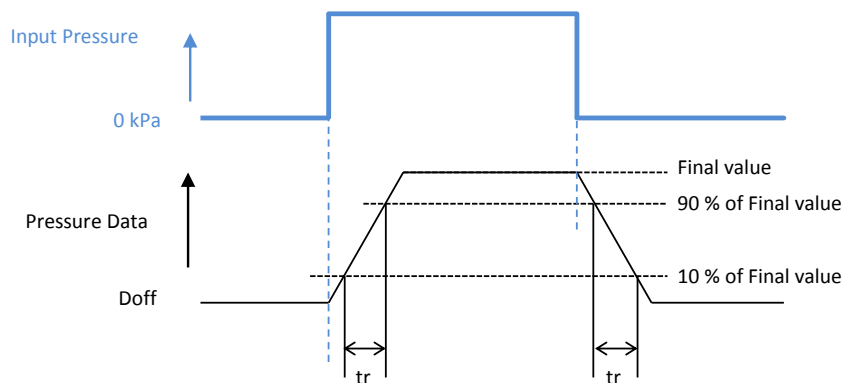
## 9. Electrical Characteristics

Ambient temperature  $T_a=25^\circ\text{C}$

Item	Condition		Symbol	Rating			Unit	
				Min.	Typ.	Max.		
Offset Pressure Data	Pressure type	G/W: Min. Popt	Doff	598	819	1040	Count	*1, 2
		V: Max.Popt						
Full Scale Pressure Data	Pressure type	G/W: Max. Popt	Dfs	15344	15565	15786	Count	*3
		V: Min.Popt						
Span Pressure Data	Min. to Max. Popt		SD	-	14746	-	Count	*4
Accuracy	-5 to +65°C		Error1	-1.5	-	+1.5	%FS	*5, 6
		Exclude Offset	Error2	-1.0	-	+1.0	%FS	*5, 6
Supply Current	VDD = 5 Vdc		Ic	-	-	4.5	mAdc	*7
	VDD = 3.3, 3.0 Vdc							
Response Time	for reference		tr	-	1	-	msec.	*8
Temperature Data	for reference	-5°C	Dtmp	-	461	-	Count	*9
		+25°C						
		+65°C						

Notes:

- \*1) Offset pressure data (Doff) is defined as the pressure data at minimum Popt. In case of 002KV to 010KV, Offset pressure data (Doff) is defined as the pressure data of maximum Popt.
- \*2) Offset error is calibration error of Offset pressure data (Doff) at production. It does not include Long term offset drift. It would be suggested that applications have Auto-zeroing function.
- \*3) Full scale pressure data (Dfs) is defined as the pressure data at maximum Popt. In case of 002KV to 010KV, Full scale pressure data (Dfs) is defined as the pressure data of minimum Popt.
- \*4) Span pressure data (SD) is defined as the pressure data difference between Offset pressure data (Doff) and Full scale pressure data (Dfs).
- \*5) The unit of Accuracy “%FS” is defined as a percent error by Span pressure data (SD).
- \*6) Accuracy of Error1 consists of the following:
  - Non-linearity
  - Temperature errors over the temperature range -5 to 65°C
  - Pressure hysteresis
  - Error1: Calibration errors of sensitivity and offset
  - Error2: Exclude Calibration error of offset (Auto-zeroing is required.)
- \*7) We can offer lower power mode products as modification product. Please ask Fujikura.
- \*8) Response time (tr) is defined as the time for the change in the pressure data from 10 % to 90 % or from 90 % to 10 % of its final value when the input pressure makes a step change.



- \*9) Temperature Data (Dtmp) is for reference.

## 10. Electrical Characteristics for I<sup>2</sup>C or SPI Interface

Communication interface (communication mode) of I<sup>2</sup>C or SPI is factory setting. User can not change communication mode like from I<sup>2</sup>C to SPI or from SPI to I<sup>2</sup>C.

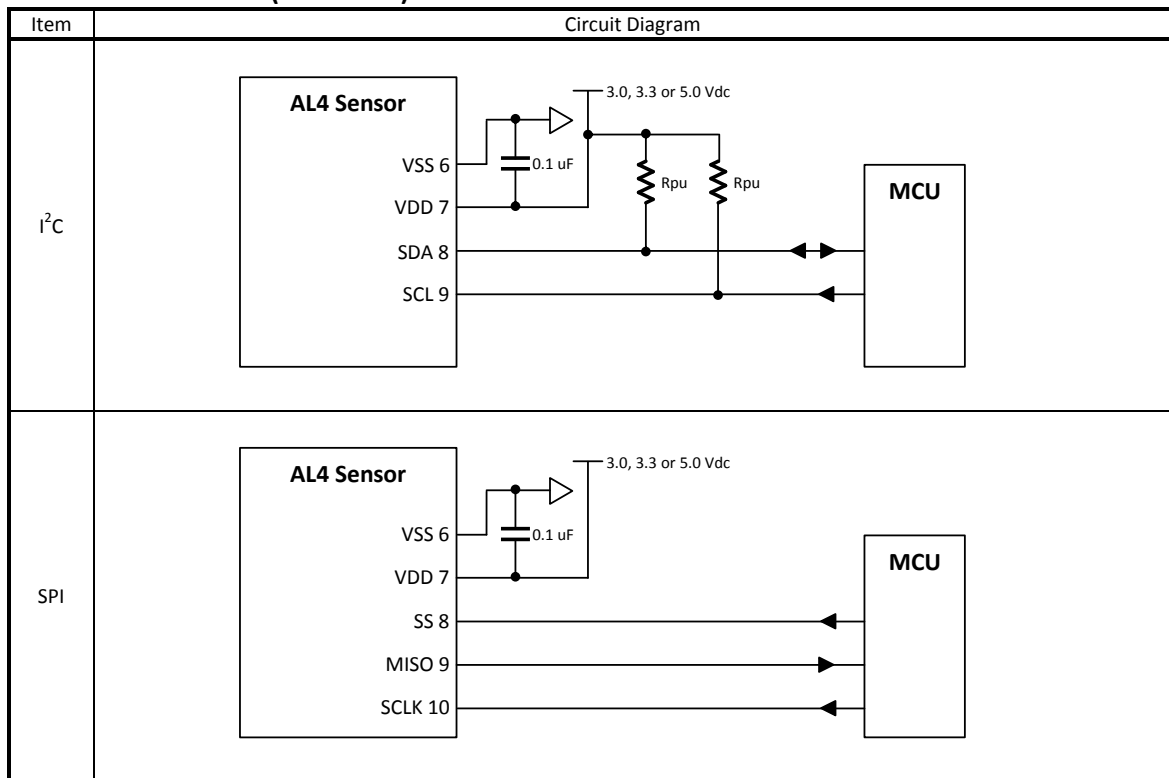
Ambient temperature Ta=25°C

Item	Condition	Symbol	Rating			Unit
			Min.	Typ.	Max.	
Interface			I <sup>2</sup> C or SPI			*1
Input Low Voltage	Sensor Code	AL40DB	0	-	1	V
		AL41DB	0	-	0.66	V
		AL42DB	0	-	0.6	V
Input High Voltage	Sensor Code	AL40DB	4	-	5	V
		AL41DB	2.64	-	3.3	V
		AL42DB	2.4	-	3	V
Output Low Voltage	Sensor Code	AL40DB	-	-	0.5	V
		AL41DB	-	-	0.33	V
		AL42DB	-	-	0.3	V

Notes:

\*1) I<sup>2</sup>C is a trademark of NXP Semiconductors.

## 11. I<sup>2</sup>C or SPI Circuits (Reference)





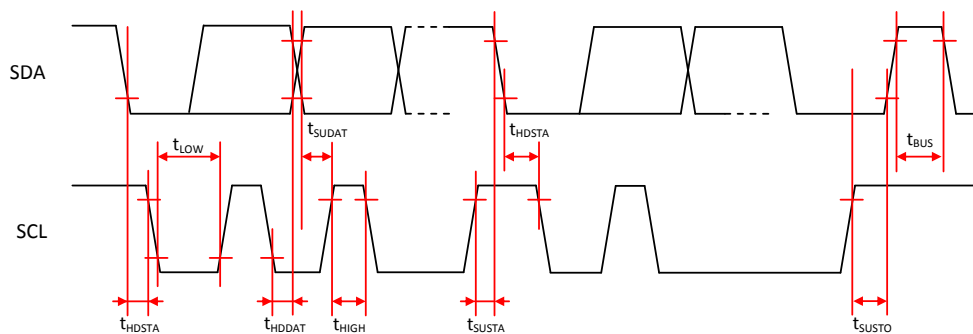
## 12. I<sup>2</sup>C Digital Interface

Item	Condition	Symbol	Rating			Unit
			Min.	Typ.	Max.	
SCL clock frequency		$f_{SCL}$	100	-	400	kHz
Start condition hold time relative to SCL edge		$t_{HDSTA}$	0.1	-	-	$\mu$ sec.
Minimum SCL clock low width		$t_{LOW}$	0.6	-	-	$\mu$ sec. *2
Minimum SCL clock high width		$t_{HIGH}$	0.6	-	-	$\mu$ sec. *2
Start condition setup time relative to SCL edge		$t_{SUSTA}$	0.1	-	-	$\mu$ sec.
Data hold time on SDA relative to SCL edge		$t_{HDDAT}$	0	-	-	$\mu$ sec.
Data setup time on SDA relative to SCL edge		$t_{SUDAT}$	0.1	-	-	$\mu$ sec.
Stop condition setup time on SCL		$t_{SUSTO}$	0.1	-	-	$\mu$ sec.
Bus free time between stop condition and start condition		$t_{BUS}$	2	-	-	$\mu$ sec.
Load Capacitance	Pin8 SDA, 400kHz	$C_{max}$	-	-	200	pF
Pull-up Resistor	Pin8 SDA, Pin9 SCL	$R_{pu}$	1	-	-	k $\Omega$
Slave address	7 bit, Factory setting		0x28 to 0x78			*3

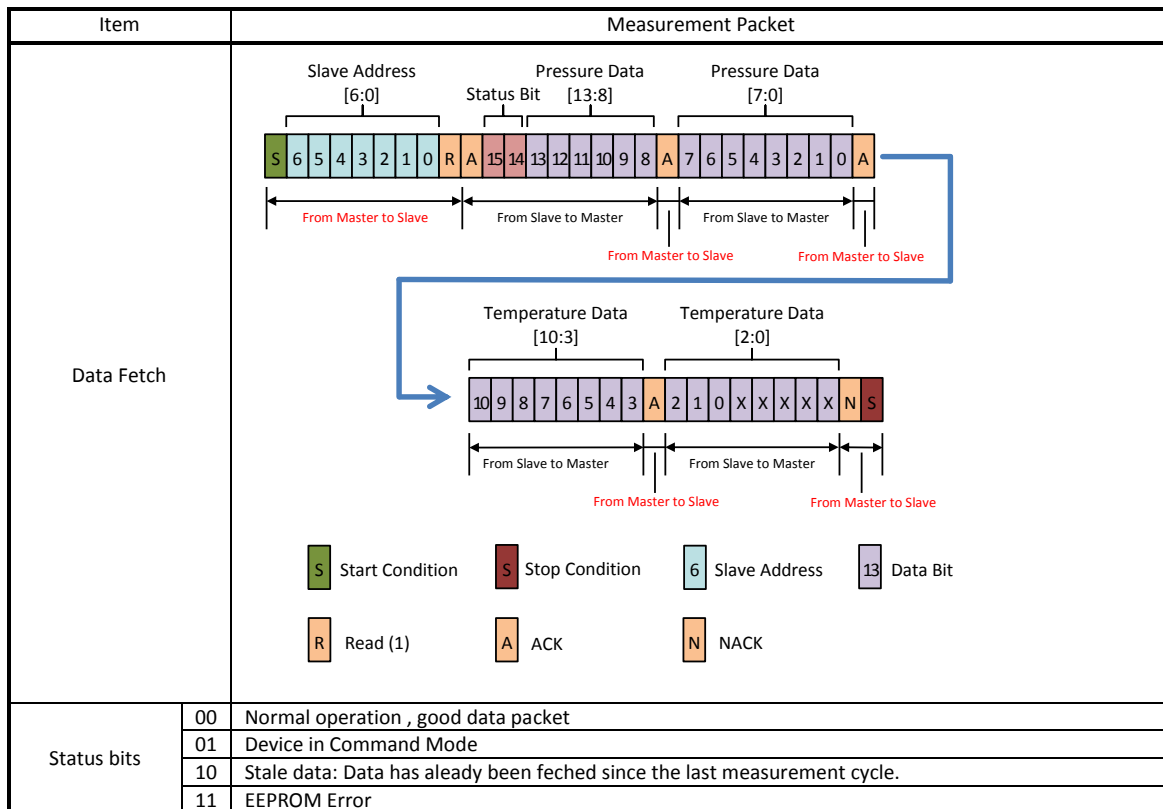
Notes:

- \*1) There are three differences in this device protocol compared with the original I<sup>2</sup>C™ protocol:
- Sending a start-stop condition without any transitions on the CLK line (no clock pulses in between) creates a communication error for the next communication, even if the next start condition is correct and the clock pulse is applied. An additional start condition must be sent, which results in restoration of proper communication.
  - The restart condition - a falling SDA edge during data transmission when the CLK clock line is still high - creates the same situation. The next communication fails, and an additional start condition must be sent for correct communication.
  - A falling SDA edge is not allowed between the start condition and the first rising SCL edge. If using an I<sup>2</sup>C™ address with the first bit 0, SDA must be held low from the start condition through the first bit.
- \*2) Combined low and high widths must equal or exceed minimum SCLK period.
- \*3) Slave address is factory setting. Customer can not change the slave address.

### Timing Diagram



### 13. I<sup>2</sup>C Communication Protocol



Notes:

- \*1) If the status bits are 01, the device must be re-started to turn power supply off and on again.
- \*2) If a data fetch is performed before or during the first measurement after power-on reset, then “stale” will be returned, but this data is actually invalid because the first measurement has not been completed.
- \*3) If the status bits are 11, do not use the device anymore.

### 14. SPI Digital Interface

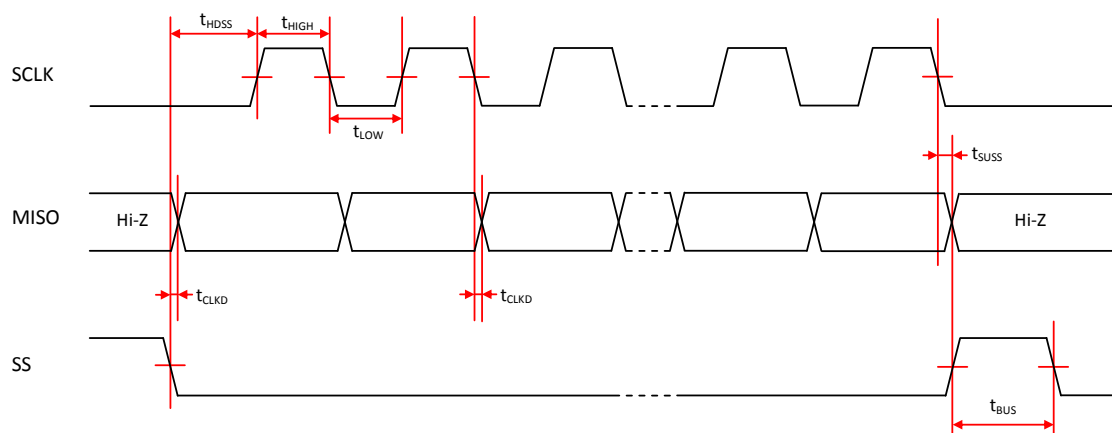
This mode is half duplex (read-only).

Item	Condition	Symbol	Rating			Unit
			Min.	Typ.	Max.	
SCLK clock frequency	4 MHz clock	$f_{SCL}$	50	-	800	kHz
SS drop to first clock edge		$t_{HDSS}$	2.5	-	-	$\mu$ sec.
Minimum SCLK clock low width		$t_{LOW}$	0.6	-	-	$\mu$ sec. *1
Minimum SCLK clock high width		$t_{HIGH}$	0.6	-	-	$\mu$ sec. *1
Clock edge to data transition		$t_{CLKD}$	0	-	0.1	$\mu$ sec.
Rise of SS relative to last clock edge		$t_{SUSS}$	0.1	-	-	$\mu$ sec.
Buss free time between rise and fall of SS		$t_{BUS}$	2	-	-	$\mu$ sec.

Notes:

\*1) Combined low and high widths must equal or exceed minimum SCLK period.

#### Timing Diagram

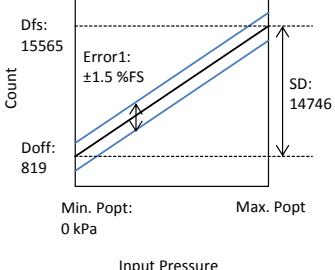
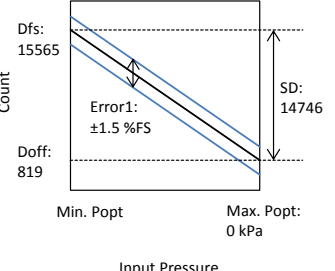
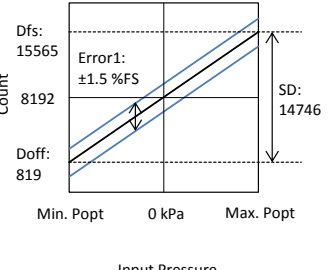


### 15. SPI Communication Protocol

The master should sample MISO on the rise of SCLK.

Item	Measurement Packet
Data Fetch	<p>SCLK </p> <p>MISO </p> <p>SS </p> <p>Packet = <math>\{S(1:0), B(13:8), \{B(7:0)\}, \{T(10:3)\}, \{T(2:0), xxxxx\}\}</math> Where                      S(1:0) = Status bits of packet (Normal, Command, Busy, EEPROM Error)                      B(13:8) = Upper 6 bits of 14-bit bridge data                      B(7:0) = Lower 8 bits of 14-bit bridge data                      T(10:3) = Corrected temperature data (if application does not require corrected temperature data, terminate read only.)                      T(2:0), xxxxx = Remaining bits of corrected temperature data for full 11-bit resolution                      Hi-Z = High impedance</p>

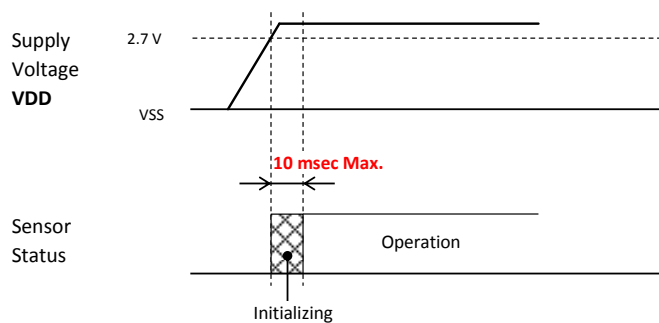
**16. Output versus Input Pressure**

Pressure Code	Output vs. Input pressure
<p>002KG 004KG 007KG 010KG</p>	<p style="text-align: center;">Temp. = -5 to 65°C</p>  <p style="text-align: center;">Input Pressure</p>
<p>002KV 004KV 007KV 010KV</p>	<p style="text-align: center;">Temp. = -5 to 65°C</p>  <p style="text-align: center;">Input Pressure</p>
<p>001KW 002KW 004KW 007KW 010KW</p>	<p style="text-align: center;">Temp. = -5 to 65°C</p>  <p style="text-align: center;">Input Pressure</p>

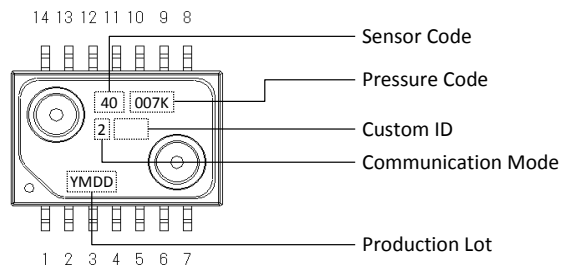
17. Transfer Function

Item	Transfer Function																																																																						
Pressure Data	$\text{Pressure Data (Count)} = P \times \alpha + \beta \pm (\text{Error1} \times \text{Temperature Error Multiplier})$																																																																						
	$P \text{ (kPa)} = \frac{\text{Pressure Data} - \beta \pm (\text{Error1} \times \text{Temperature Error Multiplier})}{\alpha}$																																																																						
	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Pressure Code</th> <th>P (kPa)</th> <th><math>\alpha</math></th> <th><math>\beta</math></th> <th>Error1</th> </tr> </thead> <tbody> <tr><td>002KG</td><td>0 to +2</td><td>7373</td><td>819</td><td>221</td></tr> <tr><td>004KG</td><td>0 to +4</td><td>7373/2</td><td>819</td><td>221</td></tr> <tr><td>007KG</td><td>0 to +7</td><td>14746/7</td><td>819</td><td>221</td></tr> <tr><td>010KG</td><td>0 to +10</td><td>7373/5</td><td>819</td><td>221</td></tr> <tr><td>002KV</td><td>-2 to 0</td><td>-7373</td><td>819</td><td>221</td></tr> <tr><td>004KV</td><td>-4 to 0</td><td>-7373/2</td><td>819</td><td>221</td></tr> <tr><td>007KV</td><td>-7 to 0</td><td>-14746/7</td><td>819</td><td>221</td></tr> <tr><td>010KV</td><td>-10 to 0</td><td>-7373/5</td><td>819</td><td>221</td></tr> <tr><td>001KW</td><td>-1 to +1</td><td>7373</td><td>8192</td><td>221</td></tr> <tr><td>002KW</td><td>-2 to +2</td><td>7373/2</td><td>8192</td><td>221</td></tr> <tr><td>004KW</td><td>-4 to +4</td><td>7373/4</td><td>8192</td><td>221</td></tr> <tr><td>007KW</td><td>-7 to +7</td><td>7373/7</td><td>8192</td><td>221</td></tr> <tr><td>010KW</td><td>-10 to +10</td><td>7373/10</td><td>8192</td><td>221</td></tr> </tbody> </table>	Pressure Code	P (kPa)	$\alpha$	$\beta$	Error1	002KG	0 to +2	7373	819	221	004KG	0 to +4	7373/2	819	221	007KG	0 to +7	14746/7	819	221	010KG	0 to +10	7373/5	819	221	002KV	-2 to 0	-7373	819	221	004KV	-4 to 0	-7373/2	819	221	007KV	-7 to 0	-14746/7	819	221	010KV	-10 to 0	-7373/5	819	221	001KW	-1 to +1	7373	8192	221	002KW	-2 to +2	7373/2	8192	221	004KW	-4 to +4	7373/4	8192	221	007KW	-7 to +7	7373/7	8192	221	010KW	-10 to +10	7373/10	8192	221
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010KW	-10 to +10	7373/10	8192	221																																																																			
Temperature Data	$\text{Dtmp (Count)} = \frac{2047}{200} \times (T + 50) \quad \longleftrightarrow \quad T \text{ (}^\circ\text{C)} = \frac{200}{2047} \times \text{Dtmp} - 50$																																																																						

18. Operating Sequence



19. Device Marking



Items		Marking
Production Lot		
Y	Last digit of Production year	0 to 9
M	Production month	1, 2, 3 to 8, 9, X=Oct., Y=Nov., Z=Dec.
DD	Production date	01 to 31
Sensor Code		
	AL40DB	40
	AL41DB	41
	AL42DB	42
Pressure Code		
	002KG	002K
	004KG	004K
	007KG	007K
	010KG	010K
	002KV	002V
	004KV	004V
	007KV	007V
	010KV	010V
	001KW	001W
	002KW	002W
	004KW	004W
	007KW	007W
	010KW	010W
Communication Mode		
	2	2
	3	3
	4	4
	5	5
	6	6
	7	7
	S	S
Custom ID		If applicable

Notes:

\*1) Port option is not marked on the package.

\*2) Custom ID will be added when product is customized for a customer.

**20. Soldering**

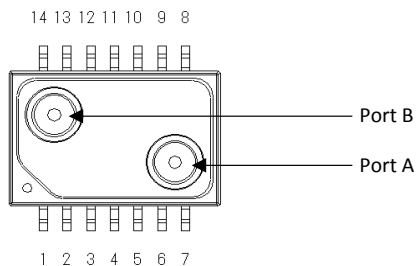
Items	Condition																		
Moisture Sensitivity Level	Level 1																		
Reflow Soldering	<p style="text-align: center;"><b>Soldering Profile</b></p> <table border="1" data-bbox="639 913 1326 1122"> <thead> <tr> <th>Phase</th> <th>Description</th> <th>Parameters</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>Ramp up</td> <td>2 to 4°C / sec.</td> </tr> <tr> <td>B</td> <td>Pre-heating</td> <td>150 to 180°C 60 to 120 sec.</td> </tr> <tr> <td>C</td> <td>Ramp up</td> <td>2 to 4°C / sec.</td> </tr> <tr> <td>D</td> <td>Heating</td> <td>Above 230°C, 45 sec. max. 245°C max., 10 sec. max.</td> </tr> <tr> <td>E</td> <td>Ramp down</td> <td>2 to 4°C / sec.</td> </tr> </tbody> </table>	Phase	Description	Parameters	A	Ramp up	2 to 4°C / sec.	B	Pre-heating	150 to 180°C 60 to 120 sec.	C	Ramp up	2 to 4°C / sec.	D	Heating	Above 230°C, 45 sec. max. 245°C max., 10 sec. max.	E	Ramp down	2 to 4°C / sec.
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\*1  
\*2  
\*3  
\*4  
\*5

Notes:

- \*1) This device is classified as moisture sensitivity level (MSL) 1 that is defined in Jedec standard J-STD-20. Floor life time is unlimited. However, the plating of pins is silver (Ag) that could be discolored to black or brown by sulfur in the environment. Discoloration of pins could impact soldering reliability. The device should be sealed in the embossed carrier tape before soldering.
- \*2) NEVER wash the device with any washing liquid. NEVER wash the device with any ultrasonic washing machine.
- \*3) Do not put the solder and flux on the device's package.
- \*4) Temperature means Surface temperature of the device's package.
- \*5) Do not reflow more than twice.

### 21. Pressure Port Connection



Pressure type	Port A	Port B
G: Gauge / Positive pressure V: Gauge / Negative pressure W: Gauge / Compound pressure	Pressure	Vent to atmospheric pressure

#### Recommended Tube (Reference)

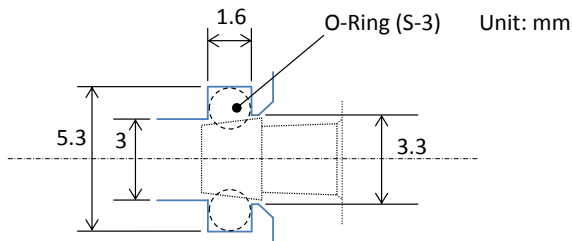
Flexible tubing is recommended. The following tubing is for reference. Please select appropriate tubing considering material, Durometer hardness and maximum pressure.

Manifold connection can also be available with O-ring or sealing fixtures.

I.D.	O.D.	Wall thickness
3/32 inch	7/32 inch	1/16 inch
2 mm	4 mm	1 mm

#### Manifold Connection (Reference)

Manifold connection can also be available with O-ring or sealing fixtures. There are parting lines on the surface of the pressure port at the base side. Top part of the pressure port (barbed part) is recommended for sealing with fixtures.



### 22. Dimensions and Weights

Refer to the following drawing as attached. 3D CAD model is available. Please ask Fujikura distributor.

Sensor Code	Dimension Drawing	Weight
AL4xDB	9-772-006	approx. 0.55 grams



### 23. Ordering Information

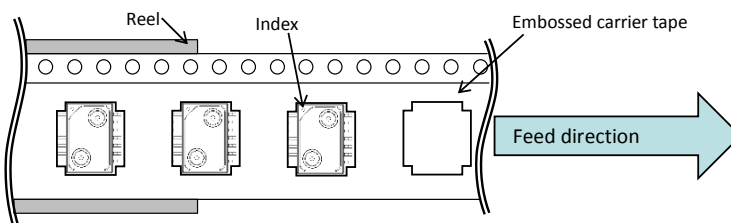
Model	Package	Supply Voltage	Packing	Ordering Device Number	Qty./Packing
AL4	SMD	5.0 Vdc	Tape & Reel	AL40DB-[Pressure Code]-[Com Mode]-TP	500 Pcs/Reel
		3.3 Vdc	Tape & Reel	AL40DB-[Pressure Code]-[Com Mode]-TP	500 Pcs/Reel
		3.0 Vdc	Tape & Reel	AL40DB-[Pressure Code]-[Com Mode]-TP	500 Pcs/Reel

Pressure Range	Pressure Code
0 to +2 kPa	002KG
0 to +4 kPa	004KG
0 to +7 kPa	007KG
0 to +10 kPa	010KG
-2 to 0 kPa	002KV
-4 to 0 kPa	004KV
-7 to 0 kPa	007KV
-10 to 0 kPa	010KV
-1 to +1 kPa	001KW
-2 to +2 kPa	002KW
-4 to +4 kPa	004KW
-7 to +7 kPa	007KW
-10 to +10 kPa	010KW

Communication Mode		
I <sup>2</sup> C Slave address	0x28	2
	0x38	3
	0x48	4
	0x58	5
	0x68	6
SPI		S

I2C or SPI is factory setting.  
User can not change the communication mode.

### 24. Tape & Reel Information



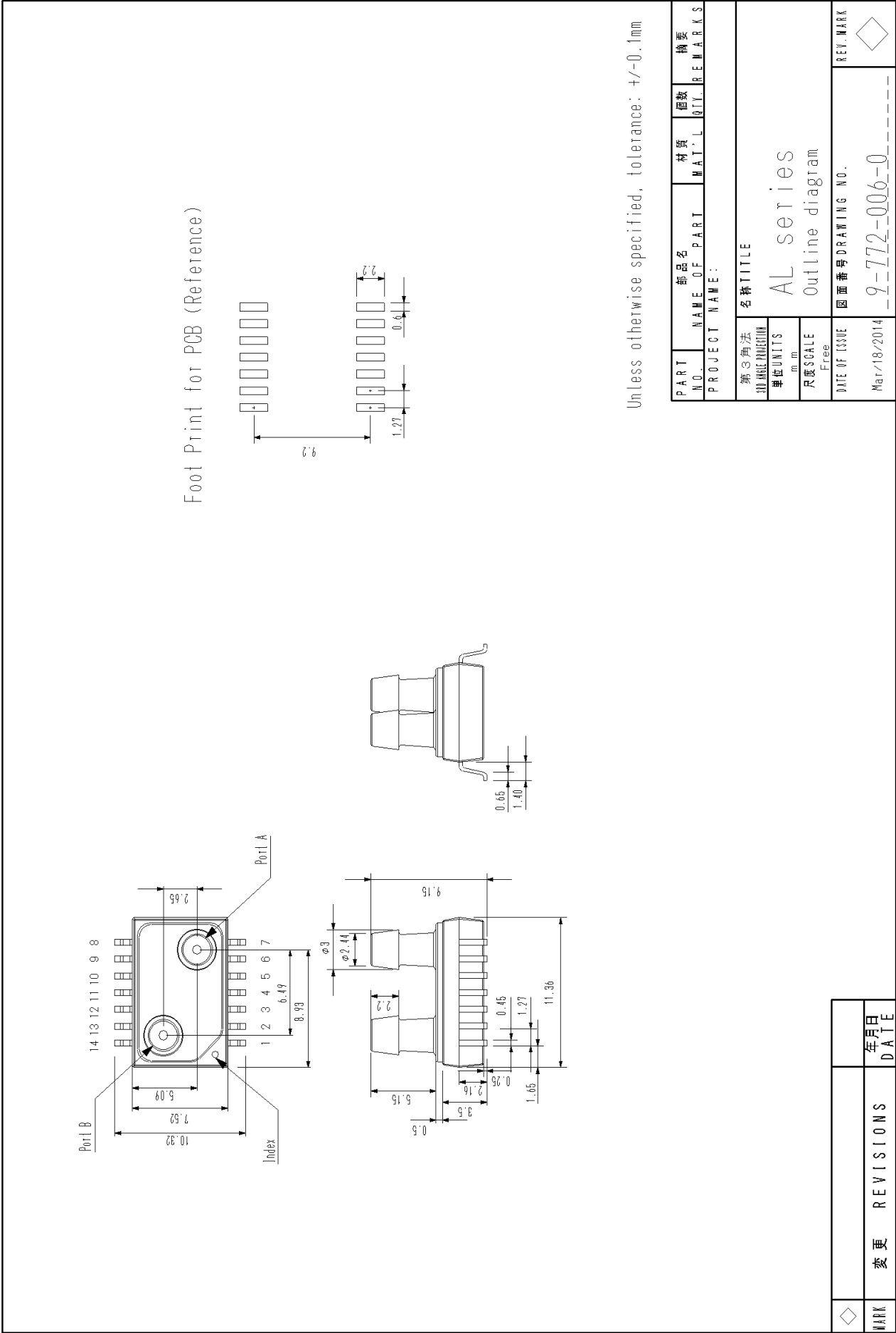
### 25. Handling Notes

Plating of pins is silver (Ag). Silver has physical property that is discolored to black or brown by sulfur. There are notes for handling as below:

- To prevent discoloration of pins, please keep the devices sealed in static shielding bags before soldering.
- Do not solder the devices that have discolored pins.
- After soldering, pins would be discolored in black or brown in atmosphere. However it does not impact reliability of the device.

### 26. Notes

- Fujikura reserves all rights.
- This document is subject to change without notice.
- Limitation, usage, environment, standard warranty and so on are listed on Fujikura web site.
- Please refer to the latest specifications.



PART NO.	部品名	材質	数量	摘要
NAME OF PART	MAT'L	QTY.	REMARKS	
PROJECT NAME:				
第3角法	名称TITLE			
3D MODEL FUNCTION	AL series			
单位UNITS	Outline diagram			
m				
尺度SCALE				
Free				
DATE OF ISSUE	图面番号DRAWING NO.			REV. MARK
Mar/18/2014	9-772-006-0			◇

MARK	变更	REVISIONS	年月日
◇			DATE

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SENSORS · POWER SOLUTIONS

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