DATE 31 January, 2019
No. V-70033D-E

Messrs.

SPECIFICATION

Semiconductor Pressure Sensor

Model: AP4, AG4 Pressure Sensor

Project:

Distributor:

Distributed by:
Servoflo Corporation
75 Allen Street
Lexington, MA 02421
+1 781-862-9572
info@servoflo.com

Reference:

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

Fujikura Ltd.

Table of Contents

Table shown below is revision records of this specification

Rev. D	31 Jan., 2019	Y. Uchiumi	Added temperature data	D
Rev. C	18 Mar., 2015	Y. Uchiumi	Change arrangement of Slave address code and Custom ID	C
Rev. B	7 Jan., 2015	Y Uchiumi	Added 700kPa(700KG).	B
Rev. A	29 July, 2014	Y Uchiumi	Correction 10. Communication Interface	A
Est.	15 May, 2014	Y Uchiumi		
	Date	Name	Comment	Mark

1. General

This document describes the specifications of Fujikura Pressure Sensors, AP4 and AG4 series.

2. Principle

Fujikura Pressure Sensor is composed of a silicon piezoresistive 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 a high-level output signal that is proportional to the applied pressure.

3. Device Lineup

This device has the following lineup.

Model	Pressure Type	Supply Voltage	Accuracy	Pressure Range
AP4 AG4	Gauge	5.0 Vdc 3.3 Vdc 3.0 Vdc	±1.5 %FS	-100 (-15) -50 (-7) 0 25 (3) 50 (7) 100 (15) 200 (30) 500 (70) 700 (100) 1000 kPa (150) psi 025KG 050KG 100KG 200KG 500KG 700KG 001MG 050KV 100KV 100KW

Features

- ✓ Digital output
- ✓ Low power consumption
- ✓ High accuracy
- ✓ Package compatible with XFPM & XFGM integrated pressure sensor
- ✓ Modification available

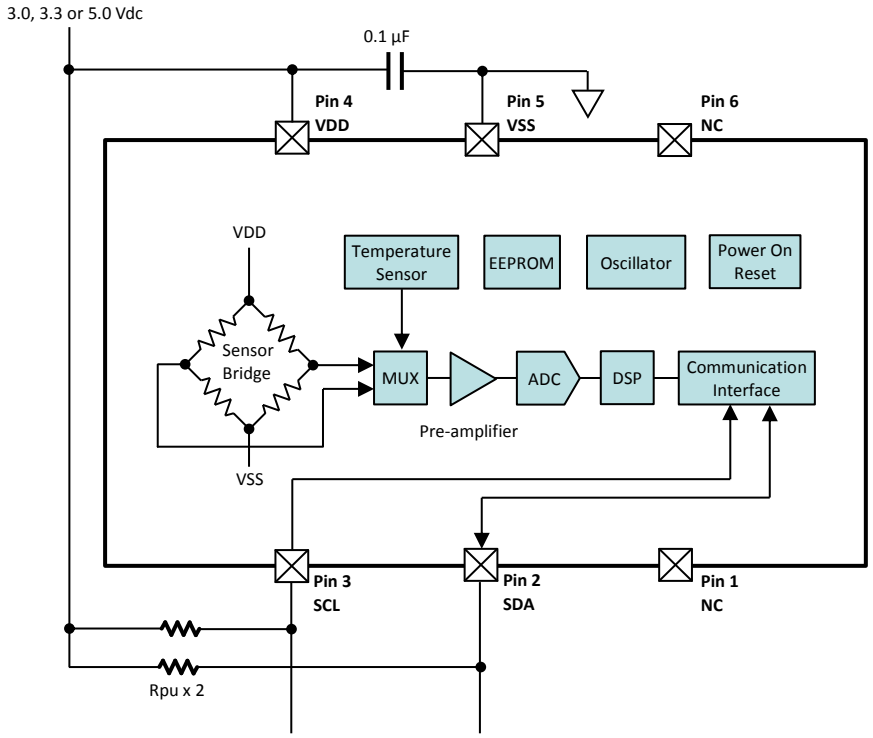
Applications

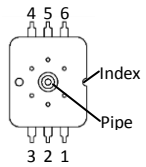
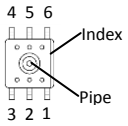
- ✓ Battery-operated devices
- ✓ Medical devices
- ✓ Industrial pneumatic devices
- ✓ Consumer devices

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	
AP4	AG4						
		1	NC	-	-	-	*2
		2	SDA	I/O	Digital	Serial bidirectional data	
		3	SCL	I	Digital	Serial clock input	
		4	VDD	-	-	Power supply connection	*1
		5	VSS	-	-	Common voltage connection	
		6	NC	-	-	-	*2

Notes:

*1) Put a 0.1 µF capacitor between Pin 4 (VDD) and VSS.

*2) Pin 1 and 6 must be open.

6. Device Name Code ⚠

The device name code is consisted of Sensor code, Pressure code, Slave address code and Packing style. For the exact ordering device number, please refer to Chapter 18 Ordering Information.

Sensor Code **Pressure Code**

AP4	0	N	-	025K	G	-	2		-	

Packing style	Blank:	Tray
	TP:	Tape & Reel
	STICK:	Stick
Custom ID		if applicable (3 characters)
Slave address code	**2:**	0x28
	⋮	⋮
	7:	0x78
Pressure type	**G:**	Gauge / Positive-pressure
	V:	Gauge / Negative-pressure
	W:	Gauge / Compound-pressure
Pressure value	**025K:**	25 kPa
	050K:	50 kPa
	100K:	100 kPa
	200K:	200 kPa
	500K:	500 kPa
	700K:	700 kPa
	001M:	1 MPa
Pin direction for AP4	**N**:	Normal
	R:	Opposite
Port length for AG4	**3**:	3 mm
	6:	6 mm
Supply voltage	**0:**	5.0 Vdc
	1:	3.3 Vdc
	2:	3.0 Vdc
Model	**AP4:**	DIP / Digital Output
	AG4:	SMD / Digital Output

7. Absolute Maximum Ratings

Item			Symbol	Rating			Unit	
				Min.	Typ.	Max.		
Load Pressure	Pressure Code	025KG	Pmax+	-	-	+50	kPa	
		050KG		-	-	+100	kPa	
		100KG		-	-	+200	kPa	
		200KG		-	-	+400	kPa	
		500KG		-	-	+1	MPa	
		700KG		-	-	+1.4	MPa	△B
		001MG		-	-	+1.5	MPa	
		050KV		-	-	+100	kPa	
		100KV		-	-	+200	kPa	
		100KW		-	-	+200	kPa	
Supply Voltage			VDDmax	-0.3	-	6	Vdc	
Voltage at Digital I/O pins			Vdiomax	-0.3	-	VDD+0.3	Vdc	
Operating Temperature			Topt	-40	-	+125	°C	
Storage Temperature			Tstg	-40	-	+125	°C	

Note: Absolute maximum ratings are the limits that the device will withstand without damage.

8. General Specifications

Item	Condition		Symbol	Rating			Unit	
				Min.	Typ.	Max.		
Supply Voltage	Sensor Code	AP40x, AG40x	VDD	4.75	5	5.25	Vdc	*1
		AP41x, AG41x		3.135	3.3	3.465		
		AP42x, AG42x		2.85	3.0	3.15		
Type of Pressure			-	Gauge pressure				*2
Pressure Media			-	Non-corrosive gases				*3
Pressure Range	Pressure Code	025KG	Popt	0	-	+25	kPa	*4
		050KG		0	-	+50	kPa	
		100KG		0	-	+100	kPa	
		200KG		0	-	+200	kPa	
		500KG		0	-	+500	kPa	
		700KG		0	-	+700	kPa	△B
		001MG		0	-	+1	MPa	
		050KV		-50	-	0	kPa	
		100KV		-100	-	0	kPa	
		100KW		-100	-	+100	kPa	
Compensated Temperature			-	0	-	+85	°C	*5
Operating Humidity	Non-condensing		Hopt	30	-	85	%RH	*6
Storage Humidity	Non-condensing		Hstg	30	-	85	%RH	*6
Dielectric Strength				-	-	1	mA	*7
Insulation Resistance				100	-	-	MΩ	*8

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.

*3) Ensure the pressure media contains no particulates. The device is not compatible with liquids.

*4) Pressure range is defined as the measurable pressure range of the device. Do not expose intentionally beyond minimum Popt and maximum Popt.

*5) Please also refer to Chapter 13 Transfer Function.

*6) Do not wet the device with dew.

*7) Dielectric strength is defined as the leakage current between all pins and the package with AC 500 V, 1 minute.

*8) Insulation resistance is defined as the resistance value between all pins and the package with DC 500 V.

9. Electrical Characteristics

Ambient temperature Ta = 25°C

Item	Condition		Symbol	Rating			Unit	
				Min.	Typ.	Max.		
Offset Pressure Data	Min. Popt, 050KV, 100KV: Max. Popt		Doff	598	819	1040	Count	*1, 2
Full Scale Pressure Data	Max. Popt, 050KV, 100KV: Min. Popt		Dfs	15344	15565	15786	Count	*3
Span Pressure Data	Min. to max. Popt		SD	-	14746	-	Count	*4
Accuracy	0 to 85°C		Error	-1.5	-	+1.5	%FS	*5, 6
Supply Current	VDD = 5 Vdc		Ic	-	-	4.5	mAdc	*7
	VDD = 3.3, 3.0 Vdc			-	-	3.5		
Response Time	for reference		tr	-	1	-	msec.	*8
Temperature Data	for reference	0°C	Dtemp	-	512	-	Count	*9
		+25°C		-	768	-		
		+85°C		-	1382	-		

Notes:

*1) Offset pressure data (Doff) is defined as the pressure data at minimum Popt. In case of 050KV and 100KV, 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 050KV and 100KV, Full scale pressure data (Dfs) is defined as the pressure data of minimum Popt.

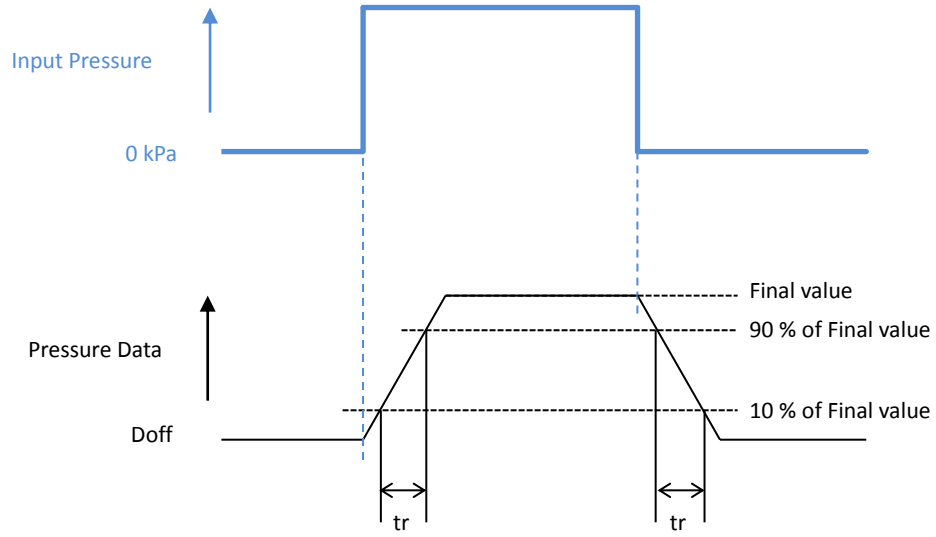
*4) Span pressure data (SD) is defined as the pressure data difference between Offset pressure data (Doff) and Full scale pressure data (Dfs).

*5) Accuracy consists of the following:
- Non-linearity
- Temperature errors over the temperature range 0 to 85°C
- Pressure hysteresis
- Calibration errors of sensitivity and offset

*6) The unit of Accuracy "%FS" is defined as a percent error by Span pressure data (SD).

*7) We can offer lower power mode products as modification line. Please ask to 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 referance.

10. Communication Interface ⚠

Ambient temperature Ta = 25°C

Item	Condition		Symbol	Rating			Unit	
				Min.	Typ.	Max.		
Interface					I^2C^{TM}			*1, 2
Input Low Voltage	Sensor Code	AP40x, AG40x	VIL	0	-	1	V	
		AP41x, AG41x		0	-	0.66	V	
		AP42x, AG42x		0	-	0.6	V	
Input High Voltage	Sensor Code	AP40x, AG40x	VIH	4	-	5	V	
		AP41x, AG41x		2.64	-	3.3	V	
		AP42x, AG42x		2.4	-	3	V	
Output Low Voltage	Sensor Code	AP40x, AG40x	VOL	-	-	0.5	V	
		AP41x, AG41x		-	-	0.33	V	
		AP42x, AG42x		-	-	0.3	V	
SCL clock frequency			f_{SCL}	100	-	400	kHz	
Start condition hold time relative to SCL edge			t_{HDSTA}	0.1	-	-	µsec.	
Minimum SCL clock low width			t_{LOW}	0.6	-	-	µsec.	*3
Minimum SCL clock high width			t_{HIGH}	0.6	-	-	µsec.	*3
Start condition setup time relative to SCL edge			t_{SUSTA}	0.1	-	-	µsec.	
Data hold time on SDA relative to SCL edge			t_{HDDAT}	0	-	-	µsec.	
Data setup time on SDA relative to SCL edge			t_{SUDAT}	0.1	-	-	µsec.	
Stop condition setup time on SCL			t_{SUSTO}	0.1	-	-	µsec.	
Bus free time between stop condition and start condition			t_{BUS}	2	-	-	µsec.	
Load Capacitance	Pin2 SDA, 400kHz		Cmax	-	-	200	pF	
Pull-up Resistor	Pin2 SDA, Pin3 SCL		Rpu	1	-	-	kΩ	
Slave address	7 bit			0x28 to 0x78				*4

Notes:

*1) I^2C^{TM} is a trademark of NXP Semiconductors.

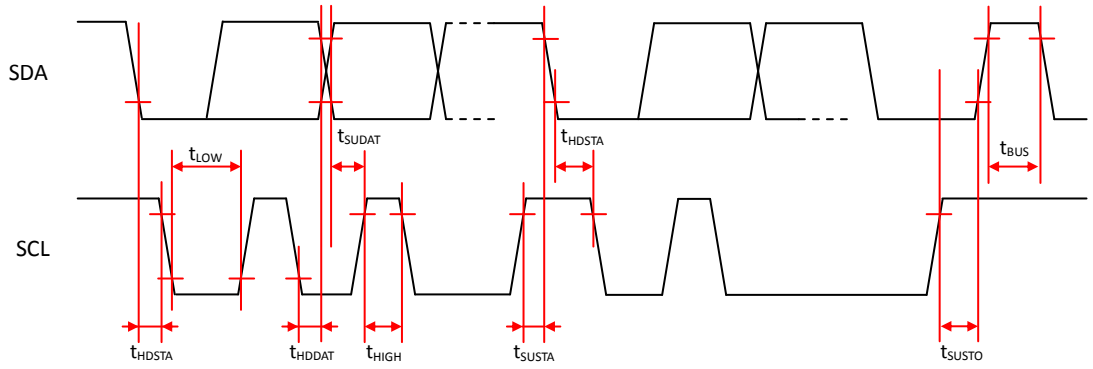
*2) There are three differences in this device protocol compared with the original I2C™ protocol:

- 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 I2C™ address with the first bit 0, SDA must be held low from the start condition through the first bit.

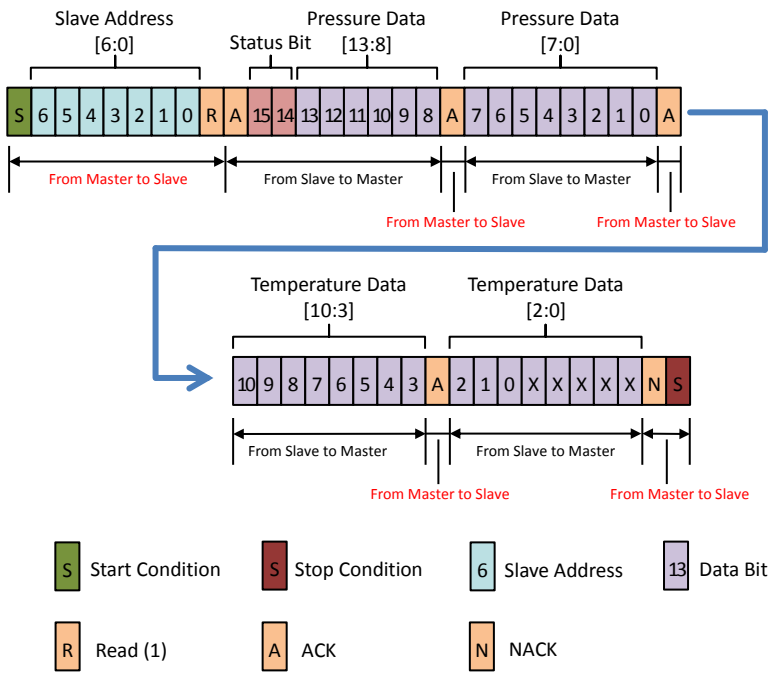
*3) Combined low and high widths must equal or exceed minimum SCLK period.

*4) Slave address is set by the factory. Please designate the slave address in the device name code. If you can accept any address, 0x28 is recommended.

Timing Diagram



11. Communication Protocol △D

Item		Measurement Packet	
Data Fetch			
Status bits	00	Normal operation , good data packet	
	01	Device in Command Mode	*1
	10	Stale data: Data has aleady been feched since the last measurement cycle.	*2
	11	EEPROM Error	*3

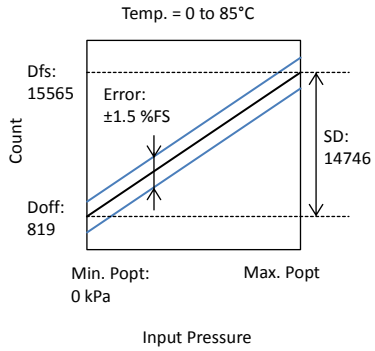
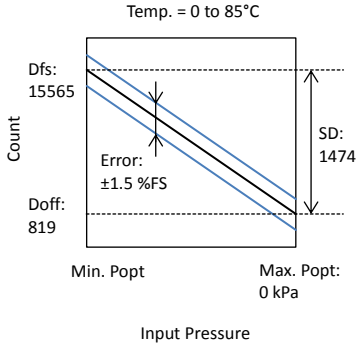
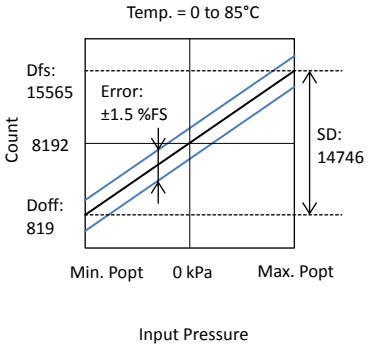
Note:

*1) If the status bits are 01, the device must be re-started to turn power supply off and on again.

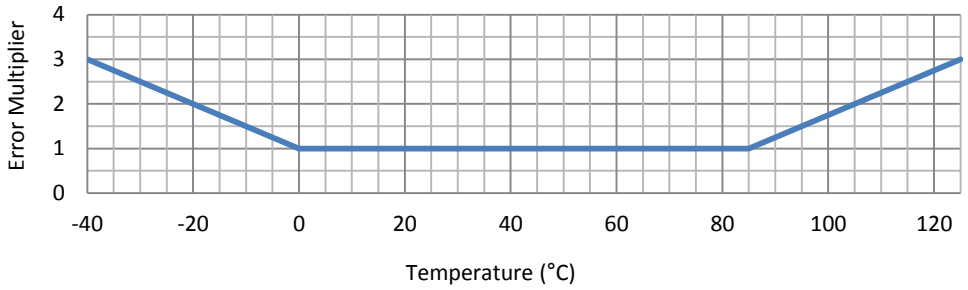
*2) If a data fetch is performed before or during the first measurement after power-on reset, then “stale” will be returned, but this data is actually invalid because the first measurement has not been completed.

*3) If the status bits are 11, do not use the device anymore.

12. Output versus Input Pressure

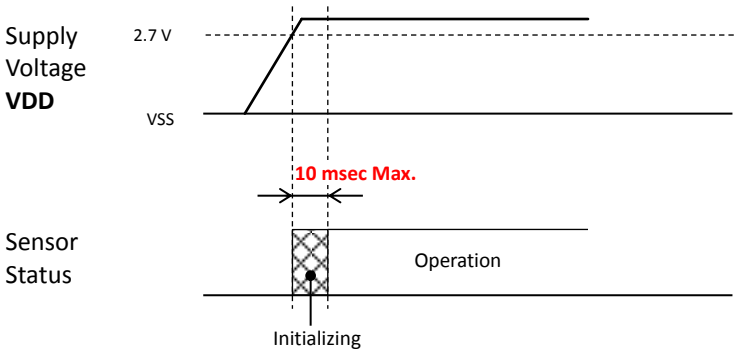
Pressure Code	Output vs. Input pressure
025KG 050KG 100KG 200KG 500KG 700KG 001MG	
050KV 100KV	
100KW	

13. Transfer Function

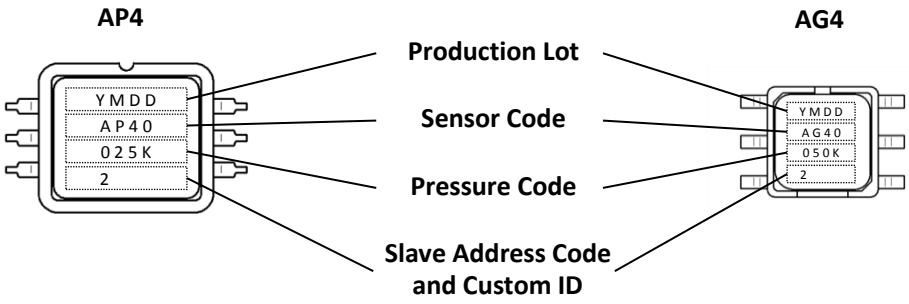
<table>
<tr><th>Item</th><th>Transfer Function</th></tr>
<tr><td>Pressure Data</td><td>
$$\text{Pressure Data (Count)} = P \times \alpha + \beta \pm (\text{Error} \times \text{Temperature Error Multiplier})$$
$$\Updownarrow$$
$$P\ (\text{kPa}) = \frac{\text{Pressure Data} - \beta \pm (\text{Error} \times \text{Temperature Error Multiplier})}{\alpha}$$
<table>
<tr><th>Pressure Code</th><th>P (kPa)</th><th>α</th><th>β</th><th>Error</th></tr>
<tr><td>025KG</td><td>0 to +25</td><td>14746/25</td><td>819</td><td>221</td></tr>
<tr><td>050KG</td><td>0 to +50</td><td>7373/25</td><td>819</td><td>221</td></tr>
<tr><td>100KG</td><td>0 to +100</td><td>7373/50</td><td>819</td><td>221</td></tr>
<tr><td>200KG</td><td>0 to +200</td><td>7373/100</td><td>819</td><td>221</td></tr>
<tr><td>500KG</td><td>0 to +500</td><td>7373/250</td><td>819</td><td>221</td></tr>
<tr><td>700KG</td><td>0 to +700</td><td>7373/350</td><td>819</td><td>221</td></tr>
<tr><td>001MG</td><td>0 to +1000</td><td>7373/500</td><td>819</td><td>221</td></tr>
<tr><td>050KV</td><td>-50 to 0</td><td>-7373/25</td><td>819</td><td>221</td></tr>
<tr><td>100KV</td><td>-100 to 0</td><td>-7373/50</td><td>819</td><td>221</td></tr>
<tr><td>100KW</td><td>-100 to +100</td><td>7373/100</td><td>8192</td><td>221</td></tr>
</table>


</td></tr>
<tr><td>△D Temperature Data</td><td>
$$\text{Dtmp (Count)} = \frac{2047}{200} \times (T + 50) \quad \longleftrightarrow \quad T\ (°C) = \frac{200}{2047} \times \text{Dtmp} - 50$$
</td></tr>
</table>

14. Operating Sequence



15. Device Marking



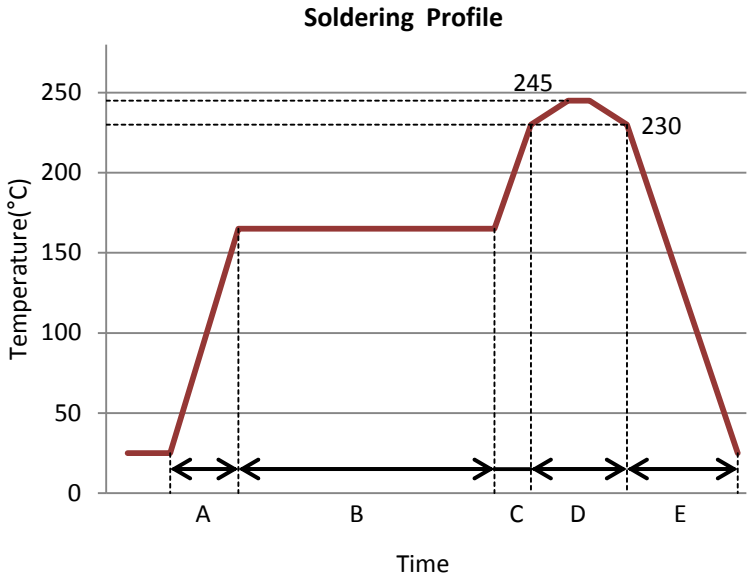
Items			Marking	
Production Lot				
	Y	Last digit of Production year	0 to 9	
	M	Production month	1, 2, 3 to 8, 9, X=Oct., Y=Nov., Z=Dec.	
	DD	Production date	01 to 31	
Sensor Code				*1
	AP40x		AP40	
	AP41x		AP41	
	AP42x		AP42	
	AG40x		AG40	
	AG41x		AG41	
	AG42x		AG42	
Pressure Code				
	025KG		025K	
	050KG		050K	
	100KG		100K	
	200KG		200K	
	500KG		500K	
	700KG		700K	
	001MG		001M	
	050KV		050V	
	100KV		100V	
	100KW		100W	
Slave Address Code				
	2		2	
	3		3	
	4		4	
	5		5	
	6		6	
	7		7	
Custom ID			If applicable	*2

Notes:

*1) Pin direction for AP4 or Port length for AG4 is not marked on the face plate.

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

16. Soldering

Process	Sensor code	Condition	
Hand Soldering	AP4xx	Soldering iron temperature: 350°C max. Soldering time: 3 seconds max.	*1, 2
Wave Soldering	AP4xR	Soldering bath temperature: 260°C max. Soldering time: 5 seconds max.	*1, 2
Moisture Sensitivity Level	AG4xx	Level 1	*3
Reflow Soldering	AG4xx		*1 *2 *4 *5

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.

Notes:

*1) NEVER wash the device with any washing liquid. NEVER wash the device with any ultrasonic washing machine.

*2) Do not put the solder and flux on the device's package.

*3) 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.

*4) Temperature means Surface temperature of the device's package.

*5) Do not reflow more than twice.

17. Dimensions and Weights

Refer to the following drawing as attached.

Sensor Code	Dimension Drawing	Weight
AP4xN	9-772-001	approx. 1.4 grams
AP4xR	9-772-002	
AG4x3	9-772-003	approx. 0.3 grams
AG4x6	9-772-004	approx. 0.4 grams

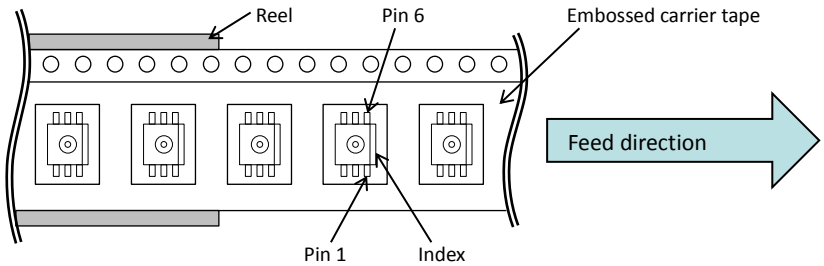
18. Ordering Information

Model	Package	Supply Voltage	Pin Direction	Packing	Ordering Device Number	Qty./Packing
AP4	DIP	5.0 Vdc	Normal	Tray	AP40N- [Pressure Code] -[Slave]	150 Pcs/Tray
				Stick	AP40N- [Pressure Code] -[Slave] -STICK	40 Pcs/Stick
			Opposite	Tray	AP40R- [Pressure Code] -[Slave]	150 Pcs/Tray
				Stick	AP40R- [Pressure Code] -[Slave] -STICK	40 Pcs/Stick
		3.3 Vdc	Normal	Tray	AP41N- [Pressure Code] -[Slave]	150 Pcs/Tray
				Stick	AP41N- [Pressure Code] -[Slave] -STICK	40 Pcs/Stick
			Opposite	Tray	AP41R- [Pressure Code] -[Slave]	150 Pcs/Tray
				Stick	AP41R- [Pressure Code] -[Slave] -STICK	40 Pcs/Stick
		3.0 Vdc	Normal	Tray	AP42N- [Pressure Code] -[Slave]	150 Pcs/Tray
				Stick	AP42N- [Pressure Code] -[Slave] -STICK	40 Pcs/Stick
			Opposite	Tray	AP42R- [Pressure Code] -[Slave]	150 Pcs/Tray
				Stick	AP42R- [Pressure Code] -[Slave] -STICK	40 Pcs/Stick
			Port Length			
AG4	SMD	5.0 Vdc	3 mm	Tray	AG403- [Pressure Code] -[Slave]	300 Pcs/Tray
				Tape & Reel	AG403- [Pressure Code] -[Slave] -TP	500 Pcs/Reel
			6 mm	Tray	AG406- [Pressure Code] -[Slave]	300 Pcs/Tray
				Tape & Reel	AG406- [Pressure Code] -[Slave] -TP	500 Pcs/Reel
		3.3 Vdc	3 mm	Tray	AG413- [Pressure Code] -[Slave]	300 Pcs/Tray
				Tape & Reel	AG413- [Pressure Code] -[Slave] -TP	500 Pcs/Reel
			6 mm	Tray	AG416- [Pressure Code] -[Slave]	300 Pcs/Tray
				Tape & Reel	AG416- [Pressure Code] -[Slave] -TP	500 Pcs/Reel
		3.0 Vdc	3 mm	Tray	AG423- [Pressure Code] -[Slave]	300 Pcs/Tray
				Tape & Reel	AG423- [Pressure Code] -[Slave] -TP	500 Pcs/Reel
			6 mm	Tray	AG426- [Pressure Code] -[Slave]	300 Pcs/Tray
				Tape & Reel	AG426- [Pressure Code] -[Slave] -TP	500 Pcs/Reel

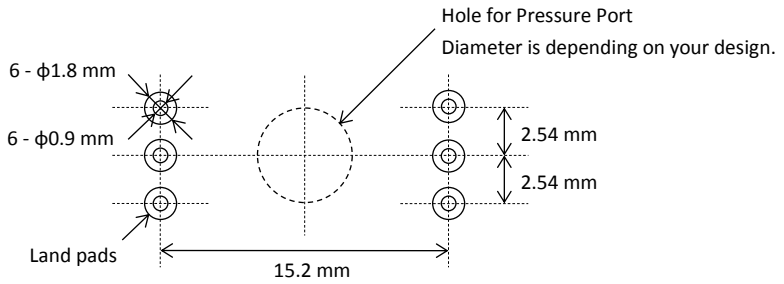
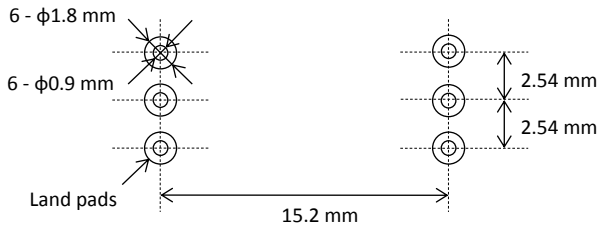
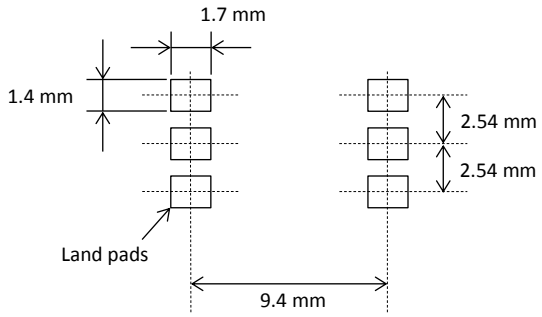
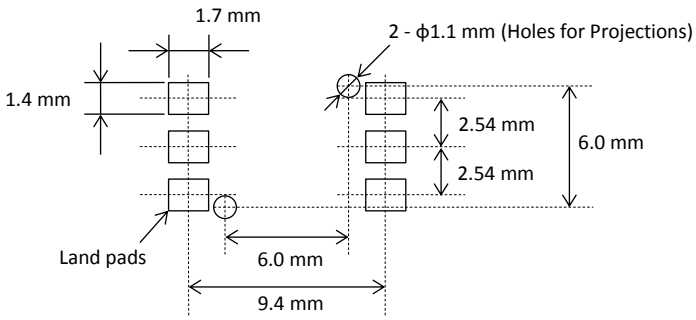
Pressure Range	Pressure Code
0 ~ +25 kPa	025KG
0 ~ +50 kPa	050KG
0 ~ +100 kPa	100KG
0 ~ +200 kPa	200KG
0 ~ +500 kPa	500KG
0 ~ +700 kPa	700KG
0 ~ +1 MPa	001MG
-50 ~ 0 kPa	050KV
-100 ~ 0 kPa	100KV
-100 ~ +100 kPa	100KW

Slave Address	Slave Address Code
0x28	2
0x38	3
0x48	4
0x58	5
0x68	6
0x78	7

19. Tape & Reel



20. Footprint for PCB designing (Reference)

Sensor Code	Footprint
AP4xN	
AP4xR	
AG4x3	
AG4x6	

Notes:

*1) These footprints are for reference. Please evaluate well these footprints, before your mass production.

*2) When designing your PCB, please also refer to the outline diagrams.

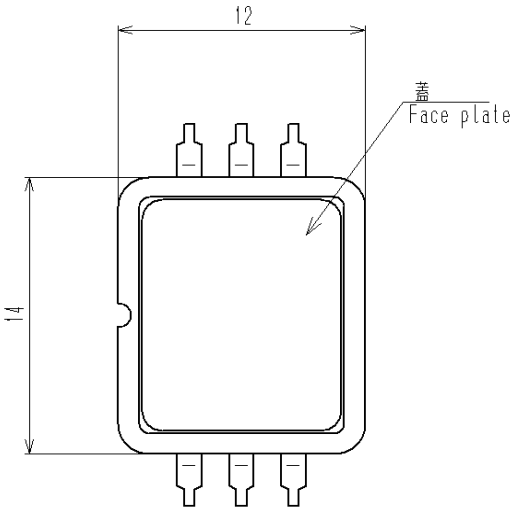
21. Handling Notes

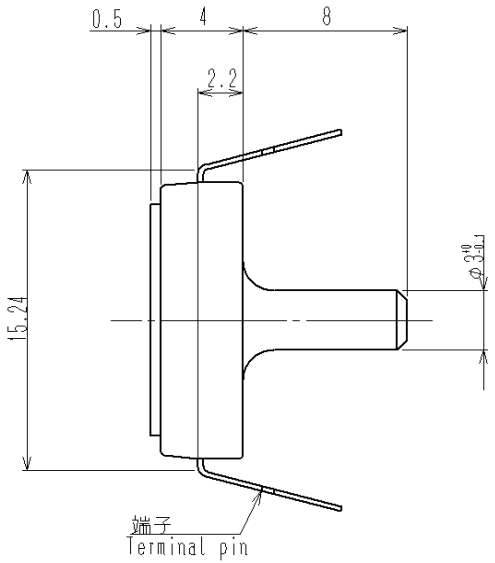
Plating of pins is silver (Ag). Silver has physical property that is discolored to black or brown by sulfur. There are notes for handling as below:

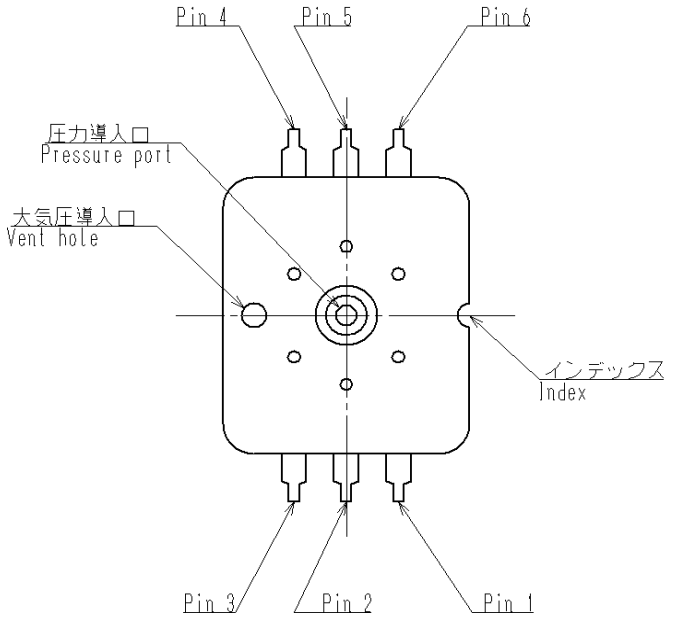
- To prevent discoloration of pins, please keep the devices sealed in static shielding bags before soldering.
- Do not solder the devices that have discolored pins.
- After soldering, pins would be discolored in black or brown in atmosphere. However it does not impact reliability of the device.

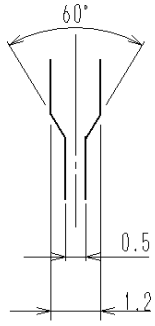
22. Notes

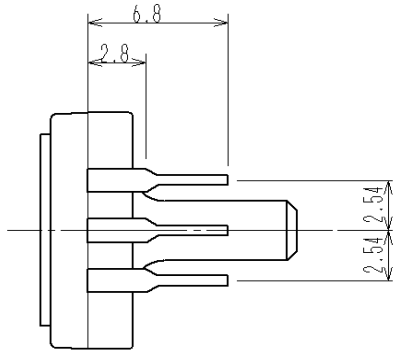
- Fujikura reserves all rights.
- This document is subject to change without notice.
- Limitation, usage, environment, standard warranty and so on are listed on Fujikura web site.
- Please refer to the latest specifications.







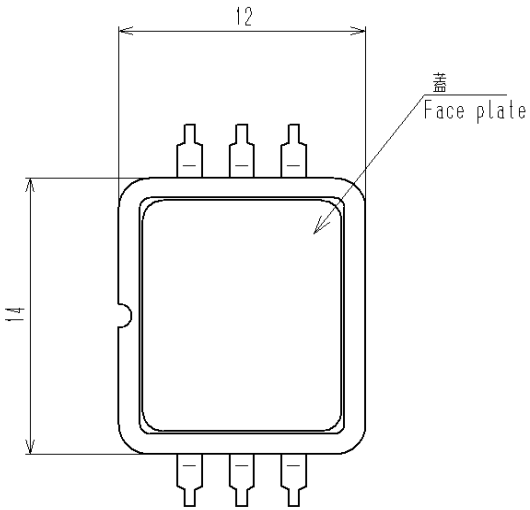


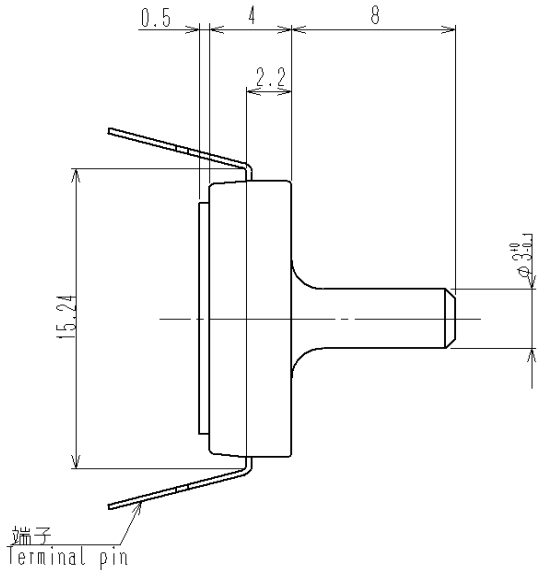


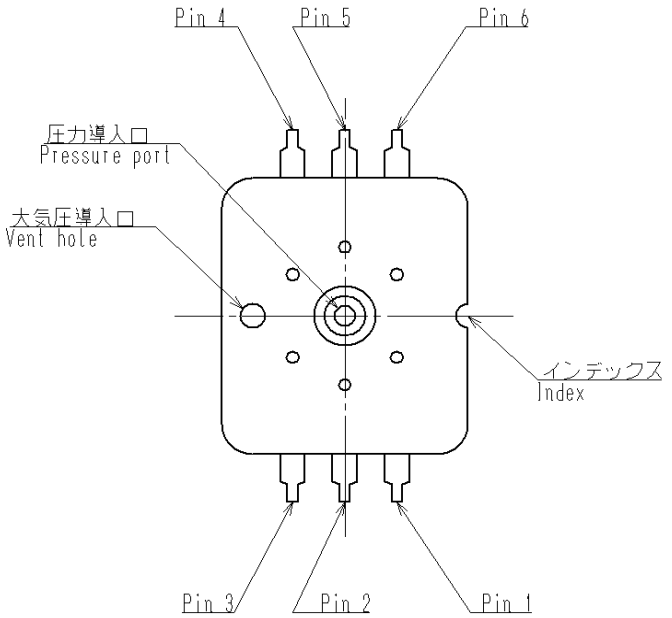
Unless otherwise specified, tolerance: +/-0.1mm

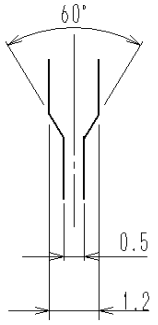
PART NO.	部品名 NAME OF PART	材質 MAT'L	個数 QTY.	摘要 REMARKS
PROJECT NAME:				
第３角法 3RD ANGLE PROJECTION	名称TITLE APxxN series Outline diagram			
単位UNITS mm				
尺度SCALE Free				
DATE OF ISSUE Oct/1/2013	図面番号DRAWING NO. _9-772-001_____			REV.MARK ◇

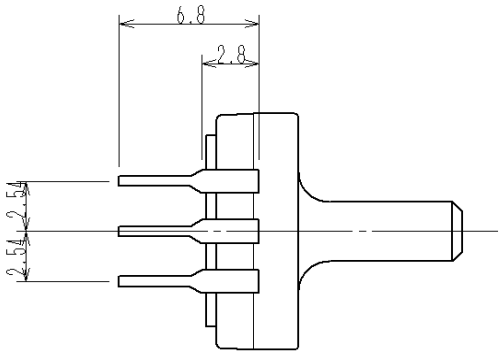
MARK	変更 REVISIONS	年月日 DATE
◇		







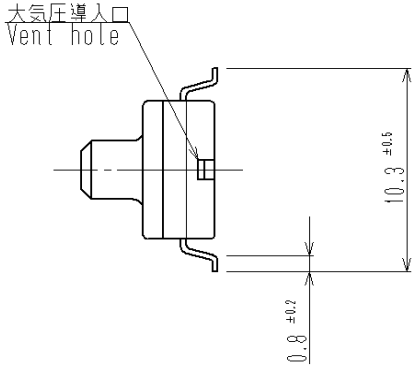


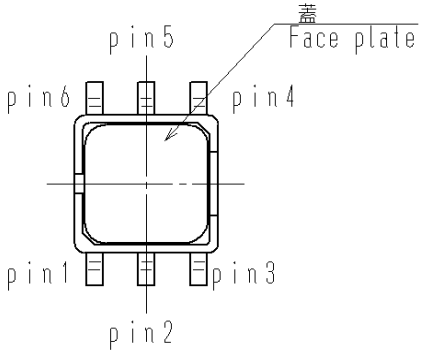


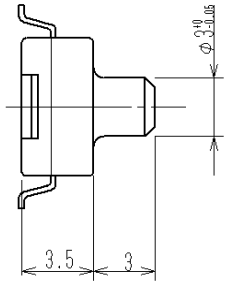
Unless otherwise specified, tolerance: +/-0.1mm

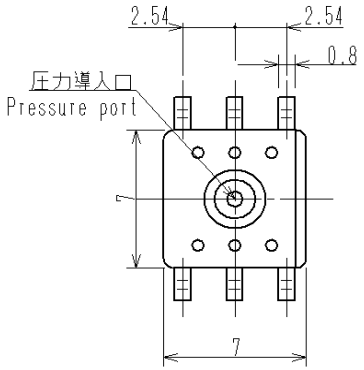
PART NO.	部品名 NAME OF PART	材質 MAT'L	個数 QTY.	摘要 REMARKS
PROJECT NAME:				
第３角法 3RD ANGLE PROJECTION	名称TITLE APxxR series Outline diagram			
単位UNITS mm				
尺度SCALE Free				
DATE OF ISSUE Oct/1/2013	図面番号DRAWING NO. 9-772-002			REV.MARK ◇

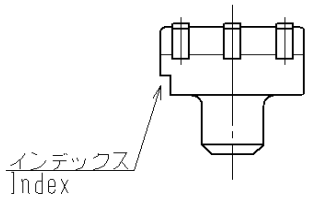
MARK	変更 REVISIONS	年月日 DATE
◇		







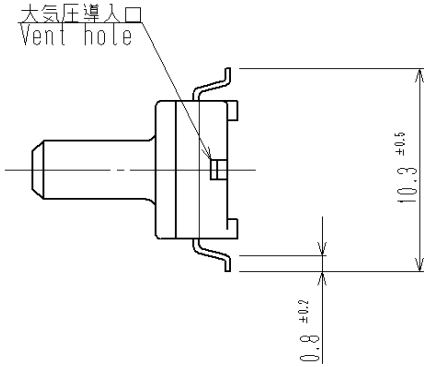


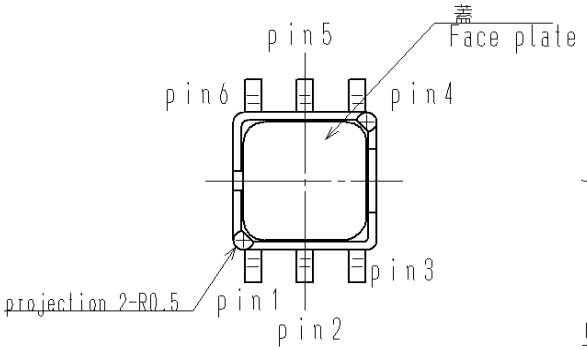


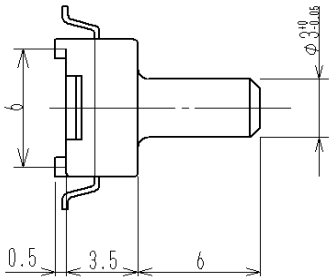
Unless otherwise specified, tolerance: +/-0.1mm

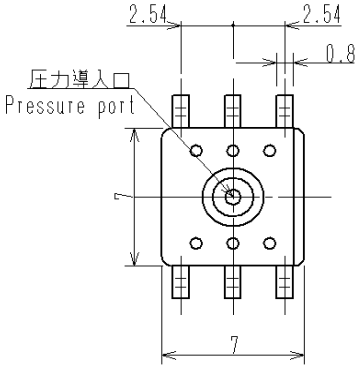
PART NO.	部品名 NAME OF PART	材質 MAT'L	個数 QTY.	摘要 REMARKS
PROJECT NAME:				
第３角法 3RD ANGLE PROJECTION 単位UNITS mm 尺度SCALE Free	名称TITLE AGxx3 series Outline diagram			
DATE OF ISSUE Oct/1/2013	図面番号DRAWING NO. 9-772-003			REV.MARK ◇

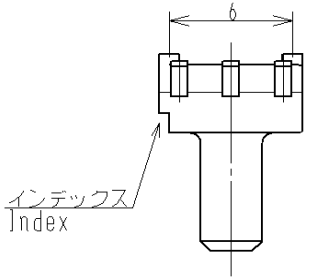
MARK	変更 REVISIONS	年月日 DATE
◇		











Unless otherwise specified, tolerance: +/-0.1mm

PART NO.	部品名 NAME OF PART	材質 MAT'L	個数 QTY.	摘要 REMARKS
PROJECT NAME:				
第３角法 3RD ANGLE PROJECTION	名称TITLE AGxx6 series Outline diagram			
単位UNITS mm				
尺度SCALE Free				
DATE OF ISSUE Oct/1/2013	図面番号DRAWING NO. 9-772-004			REV.MARK ◇

MARK	変更 REVISIONS	年月日 DATE
◇		