Pressure Sensor series

Pressure Sensor IC

BM1390GLV-Z

General Description

BM1390GLV-Z is piezo-resistive pressure sensor.
BM1390GLV-Z performs temperature compensation for MEMS inside chip internally, so it's very easy to get pressure information. BM1390GLV-Z realizes waterproof by potting gel inside to protect.
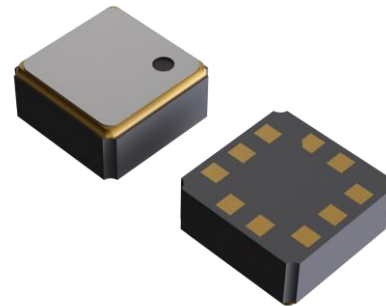
Features

- Piezo-resistive pressure sensor
- Pressure range is from 300 hPa to 1300 hPa
- Built-in temperature compensation function.
- I^{2}C bus interface (f/s mode support)
- Built-in FIFO
- Small package
- Waterproof

Applications

- Smartphone, Healthcare, Mobile device (e.g. game).

Key Specifications

- Pressure Range: 300 hPa to 1300 hPa
- Relative Pressure Accuracy: ±0.06 hPa(Typ)
- Absolute Pressure Accuracy: ±1 hPa(Typ)
- Operating Temperature Range: -40 °C to +85 °C

Package

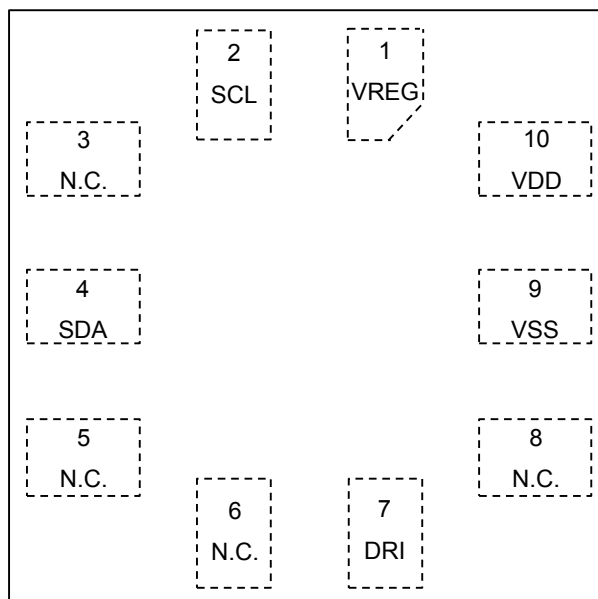| Package	W (Typ) x D (Typ) x H (Max)
RLGA10VG020T	2.0 mm x 2.0 mm x 1.0 mm

Typical Application Circuit and Block Diagram
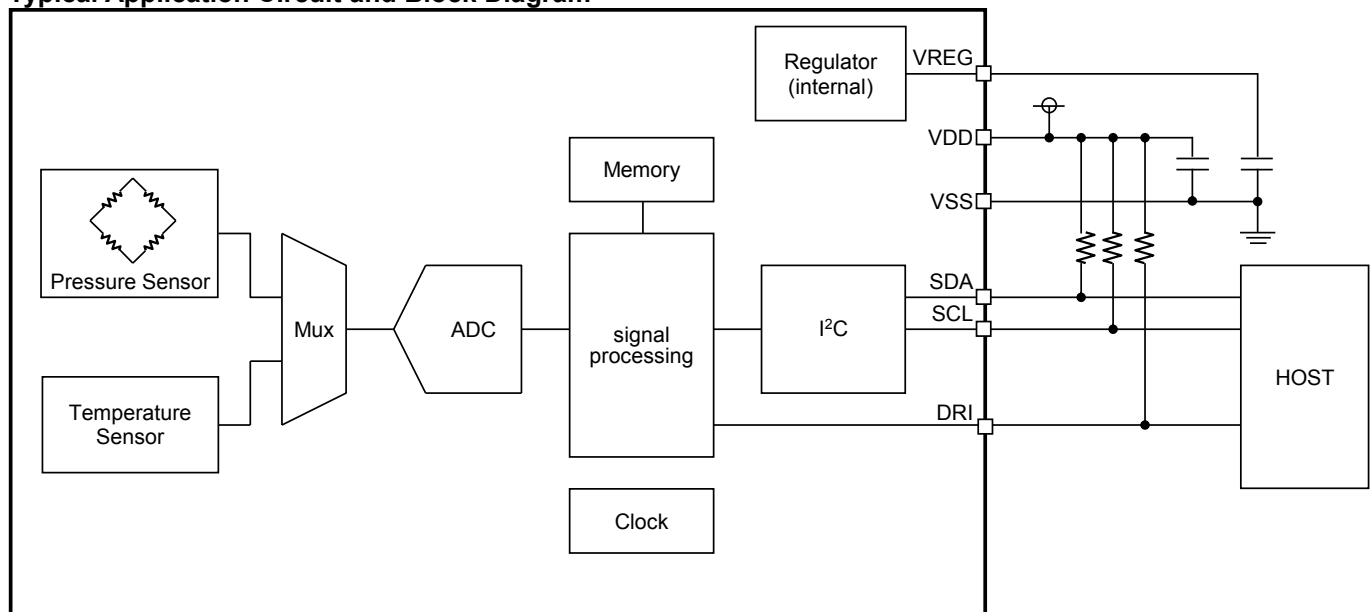
○Product structure : Silicon integrated circuit   ○This product has no designed protection against radioactive rays.

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Contents

Pin Configuration

Top View

Pin Description

Pin No.	Pin Name	Function
1	VREG	Internal power supply pin[Note 1]
2	SCL	I2C serial bus clock pin [Note 2]
3	N.C.	No connection (Set to open)
4	SDA	I2C serial bus data pin [Note 2]
5	N.C.	No connection (Set to open)
6	N.C.	No connection (Set to open)
7	DRI	Interrupt notice output pin[Note 2]
8	N.C.	No connection (Set to open)
9	VSS	Ground pin
10	VDD	Power voltage pin[Note3]

(Note 1) Dispose a bypass capacitor as close as possible to the IC.
Dispose a bypass capacitor of 0.1 µF between VREG and VSS.
Do not use this pin for external power source.
(Note 2) When there is other device which is connected to the SDA, the SCL or the DRI pins and its signal falls sharply,
that might generate undershoot and the pin voltage might go below ground. When such undershoot occurs,
a measure like disposing a capacitor near the pins of the device must be taken.
(Note 3) Dispose a bypass capacitor as close as possible to the IC.

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Absolute Maximum Ratings (Ta = 25°C)

Parameter	Symbol	Rating	Unit
Power Supply	V_{DD}	4.5	V
Input Voltage1 [(Note 1)]	V_{IN1}	-0.3 to +4.5	V
Input Voltage2 [(Note 2)]	V_{IN2}	-0.3 to (V_{DD}+0.3) or +4.5 whichever is less	V
Storage Temperature Range	Tstg	-40 to +125	°C
Maximum Junction Temperature	Tjmax	125	°C
Pressure	P_{OVR}	20000	hPa

(Note 1) DRI, SCL, SDA pin
(Note 2) except DRI, SCL, SDA pin
Caution 1: *Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.*
Caution 2: *Should by any chance the maximum junction temperature rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. In case of exceeding this absolute maximum rating, design a PCB with thermal resistance taken into consideration by increasing board size and copper area so as not to exceed the maximum junction temperature rating.*

Thermal Resistance [(Note 3)]

Parameter	Symbol	Thermal Resistance (Typ)		Unit
		1s [(Note 5)]	2s2p [(Note 6)]	
RLGA10VG020T				
Junction to Ambient	θ_{JA}	289.5	151.4	°C/W
Junction to Top Characterization Parameter [(Note 4)]	Ψ_{JT}	73	62	°C/W

(Note 3) Based on JESD51-2A(Still-Air)
(Note 4) The thermal characterization parameter to report the difference between junction temperature and the temperature at the top center of the outside surface of the component package.
(Note 5) Using a PCB board based on JESD51-3.
(Note 6) Using a PCB board based on JESD51-7.

Layer Number of Measurement Board	Material	Board Size
Single	FR-4	114.3 mm x 76.2 mm x 1.57 mmt

Top	
Copper Pattern	Thickness
Footprints and Traces	70 μm

Layer Number of Measurement Board	Material	Board Size
4 Layers	FR-4	114.3 mm x 76.2 mm x 1.6 mmt

Top		2 Internal Layers		Bottom	
Copper Pattern	Thickness	Copper Pattern	Thickness	Copper Pattern	Thickness
Footprints and Traces	70 μm	74.2 mm x 74.2 mm	35 μm	74.2 mm x 74.2 mm	70 μm

Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Power Supply	V_{DD}	1.7	1.8	3.6	V
Input Voltage [(Note 7)]	V_{IN1}	0.0	-	3.6	V
I²C Clock Input Frequency	f_{SCL_I2C}	-	-	400	kHz
Operating Temperature	Topr	-40	+25	+85	°C

(Note 7) DRI, SCL, SDA pin

Electrical Characteristics (Unless otherwise specified V$_{DD}$ = 1.8 V Ta = 25 °C)

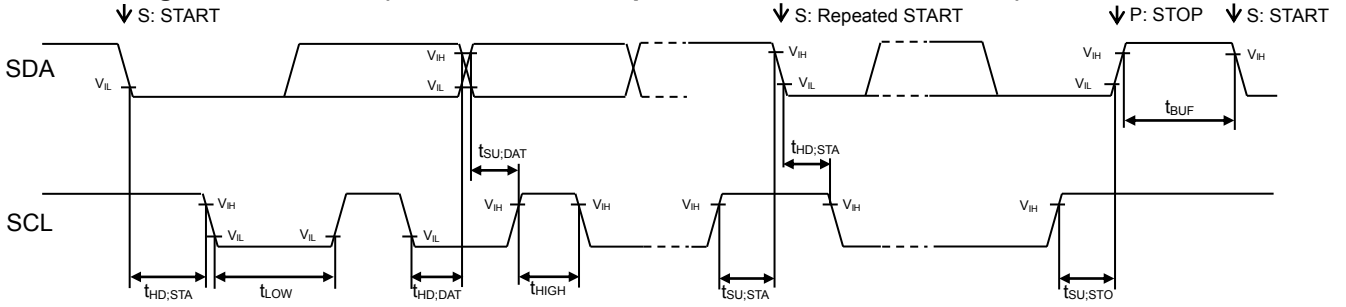| Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Current Consumption						
Power Down Mode Current	I$_{SS}$	-	1	5	µA	PWR_DOWN = 0, RSTB = 0
Logic						
L Input Voltage[Note 1]	V$_{IL}$	-	-	0.3 x V$_{DD}$	V	
H Input Voltage[Note 1]	V$_{IH}$	0.7 x V$_{DD}$	-	-	V	
L Input Current[Note 1]	I$_{IL}$	-10	-	-	µA	V$_{IL}$ = GND
H Input Current[Note 1]	I$_{IH}$	-	-	10	µA	V$_{IH}$ = V$_{DD}$
L Output Voltage 1[Note 2]	V$_{OL1}$	-	-	0.2 x V$_{DD}$	V	IL = -0.3 mA
L Output Voltage 2[Note 3]	V$_{OL2}$	-	-	0.2 x V$_{DD}$	V	IL = -3 mA
Pressure characteristics						
Pressure Detection Range	P$_R$	300	-	1300	hPa	0 °C to 65 °C
Relative Pressure Accuracy[Note 4]	P$_{REL}$	-	±0.06	-	hPa	950 hPa to 1050 hPa 10 hPa step
Absolute Pressure Accuracy	P$_{ABS}$	-	±1	-	hPa	1000 hPa
Temperature Accuracy	T$_{ABS}$	-	±2	-	°C	25 °C to 85 °C
Measurement Time[Note 5]	t$_M$	-	-	20	ms	AVE_NUM = 011

(Note 1) SDA, SCL pin
(Note 2) DRI pin
(Note 3) SDA pin
(Note 4) Target values
(Note 5) Measurement time is changed by average number of measurement data. It is written in Measurement time more detail.

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I²C Bus Timing Characteristics (Unless otherwise specified V$_{DD}$ = 1.8 V, Ta = 25 °C)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
SCL Clock frequency	f$_{SCL}$	0	-	400	kHz	
'L' Period of the SCL Clock	t$_{LOW}$	1.3	-	-	µs	
'H' Period of the SCL Clock	t$_{HIGH}$	0.6	-	-	µs	
Setup Time for Repeated START	t$_{SU;STA}$	0.6	-	-	µs	
Hold Time for START	t$_{HD;STA}$	0.6	-	-	µs	
Data Setup Time	t$_{SU;DAT}$	100	-	-	ns	
Data Hold Time	t$_{HD;DAT}$	0	-	-	µs	
Setup Time for STOP	t$_{SU;STO}$	0.6	-	-	µs	
Bus Free Time between STOP and START	t$_{BUF}$	1.3	-	-	µs	

I²C Bus Communication

1. Write Format
   (1) Indicate register address

S	Slave Address	W 0	ACK	Register Address	ACK	P
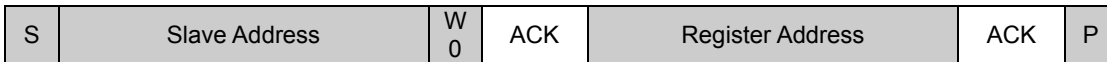
   (2) Write data after indicating register address

S	Slave Address	W 0	ACK	Register Address	ACK

Data specified at register address field	ACK	· · ·	ACK	Data specified at register address field + N	ACK	P
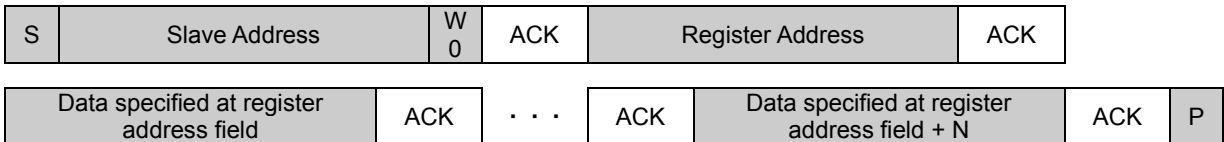
2. Read Format
   (1) Read data after indicating register address

S	Slave Address	W 0	ACK	Register Address	ACK

S	Slave Address	R 1	ACK	Data specified at register address field	ACK

Data specified at register address field + 1	ACK	· · ·	ACK	Data specified at register address field + N	NACK	P
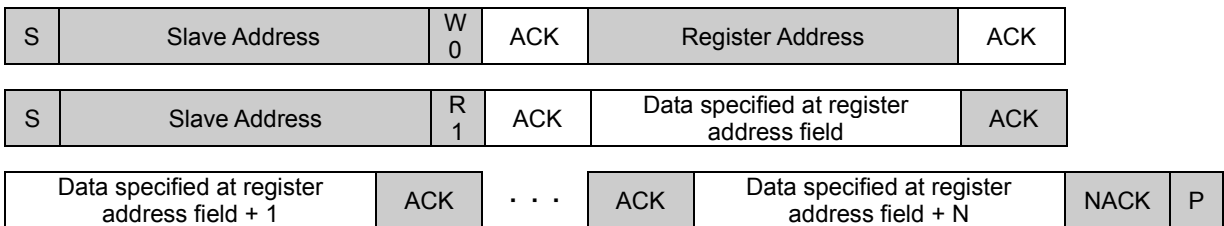
   (2) Read data from the specified register

S	Slave Address	R 1	ACK	Data specified at register address field	ACK

Data specified at register address field + 1	ACK	· · ·	ACK	Data specified at register address field + N	NACK	P

	from master to slave		from slave to master
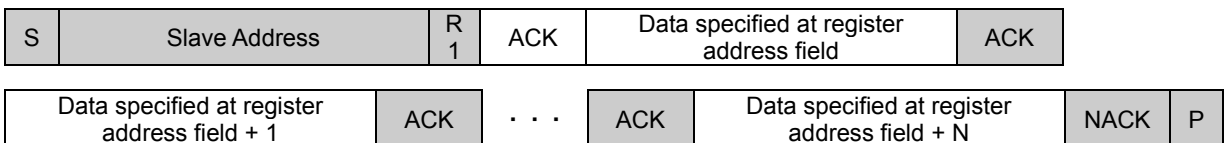
I²C bus Slave Address
The slave address is "1011101".

Register Map [Note 1]

Register Address	Register Name	R/W	D7	D6	D5	D4	D3	D2	D1	D0
0x0F	MANUFACTURER ID	R	MANUFACTURER ID [7:0]							
0x10	PART ID	R	PART ID [7:0]							
0x12	POWER_DOWN	RW	0	0	0	0	0	0	0	PWR_DOWN
0x13	RESET	RW	0	0	0	0	0	0	0	RSTB
0x14	MODE_CONTROL	RW	AVE_NUM[2:0]			DR_EN	FULL_EN	WTM_EN	MODE[1:0]	
0x15	IIR, FIFO CONTROL	RW	FIFO_EN	WTM_LEVEL	0	0	0	0	IIR_MODE[1:0]	
0x18	FIFO data	R	0	0	0	0	0	FIFO_LEV[2:0]		
0x19	STATUS	R	0	0	0	0	0	RD_FULL	RD_WTM	RD_DRDY
0x1A	PRESSURE	R	PRESS_OUT[15:8]							
0x1B		R	PRESS_OUT[7:0]							
0x1C		R	PRESS_OUT_XL[5:0]						0	0
0x1D	TEMPERATURE	R	TEMP_OUT[15:8]							
0x1E		R	TEMP_OUT[7:0]							

(Note 1) Do not write any commands to other addresses except above. Do not write '1' to the fields in which value is '0' in above table.
Address from 0x14 to 0x1E registers can be accessed only when PWR_DOWN = 1 and RSTB = 1. (In other case Write: Ignored, Read: 0xXX)

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Register Map – continued

(0x0F) MANUFACTURER ID

Fields	Function
MANUFACTURER ID [7:0]	Manufacturer ID: 0xE0

(0x10) PART ID

Fields	Function
PART ID [7:0]	Part ID: 0x34

(0x12) POWER_DOWN

Fields	Function
PWR_DOWN	0: power down 1: active

default value 0x00

(0x13) RESET

Fields	Function
RSTB	0: Measurement control block is reset 1: Measurement control block is active

default value 0x00

Register Map – continued

(0x14) MODE_CONTROL

Fields	Function
AVE_NUM[2:0]	Seting of the averaging number of measurement data 011: 8 times, 100: 16 times, 101: 32 times, 110: 64 times, other: Prohibited
DR_EN	DRI pin Enable for Data Ready Details are written in Interrupt. 0: DRI pin Disable, 1: DRI pin Enable
FULL_EN	DRI pin Enable for FULL Details are written in Interrupt. 0: DRI pin Disable, 1: DRI pin Enable
WTM_EN	DRI pin Enable for Water Mark Details are written in Interrupt. 0: DRI pin Disable, 1: DRI pin Enable
MODE[1:0]	Measurement mode setting (Pressure and Temperature are measured at one rate) 00: Standby, 01: One shot, 10: Continuous, 11: Prohibited

default value 0x00

(0x15) IIR, FIFO CONTROL

Fields	Function
FIFO_EN	FIFO mode setting Details are written in FIFO. 0: Bypass mode, 1: FIFO mode
WTM_LEVEL	Water Mark level setting Details are written in FIFO. 0: Water Mark interrupt occur when FIFO memory is 2 or above. 1: Water Mark interrupt occur when FIFO memory is 3 or above.
IIR_MODE[1:0]	IIR filter enable and coefficient setting 00: IIR OFF, 01: IIR ON (weak) 10: IIR ON (middle), 11: IIR ON (strong) When using IIR filter, set 110 to "AVE_NUM" and 10 to "MODE".

default value 0x00

Measurement time and RMS noise against number of average

AVE_NUM	IIR_MODE	Measurement time t_M max[ms]	Measurement cycle t_I max[ms]	RMS noise [hPa]
011	00	20	25	0.032
100	00	40	50	0.023
101	00	76	100	0.016
110	00	152	200	0.011
110	01	152	200	0.0072
110	10	152	200	0.0034
110	11	152	200	0.0016

RMS noise is calculated as standard deviation of 32 data points (1σ).
RMS noise is a reference value and it's not the value with guarantee.
Condition V_{DD} = 1.8 V, Ta = 25 °C

Register Map – continued

Measurement time

One shot mode performs one measurement. Measurement data is updated when measurement completed, so it should be read more than t_M after measurement start.
Continuous mode repeats measurement in every measurement cycle t_I. The latest measurement data which is completed is read.
Measurement time t_M and measurement cycle t_I is determined by number of average.
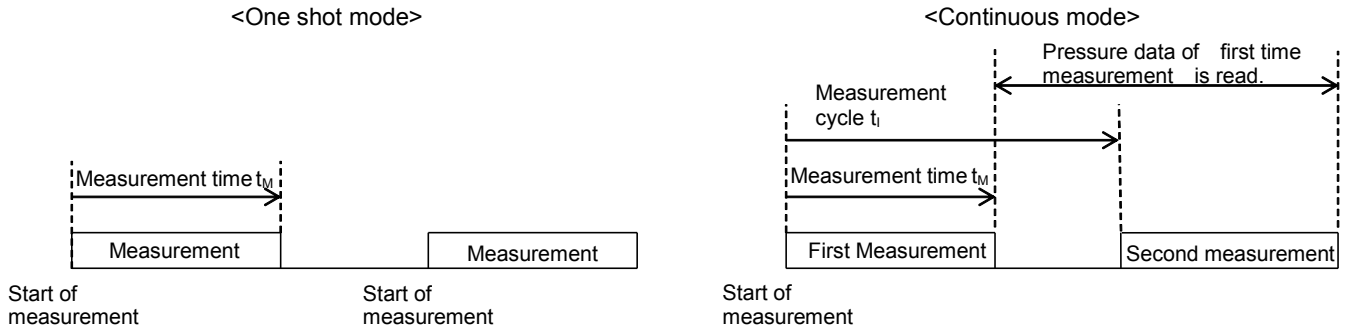
IIR filter

RMS noise can be reduced by setting IIR filter in addition to the setting of number of averaging. When IIR filter is ON and pressure input fluctuates, a response time t_R to reach a target value delays.
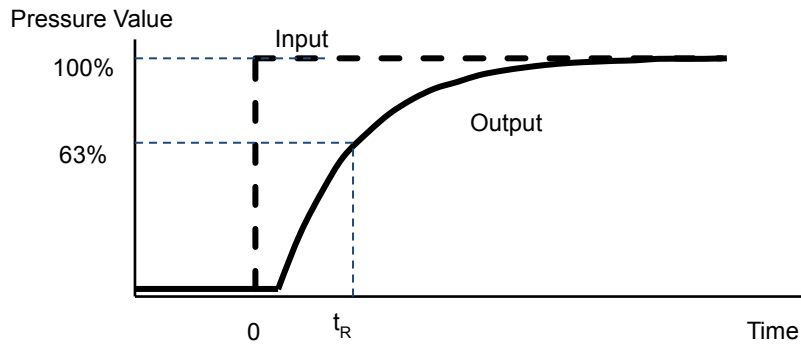
Response time against IIR coefficient

AVE_NUM	IIR_MODE	Response time t_R [ms]
110	01	352
110	10	952
110	11	3352

Response time is a reference value and it's not the value with guarantee.
Condition V_{DD} = 1.8 V, Ta = 25 °C, MODE = 10

Register Map – continued

Operation mode transition
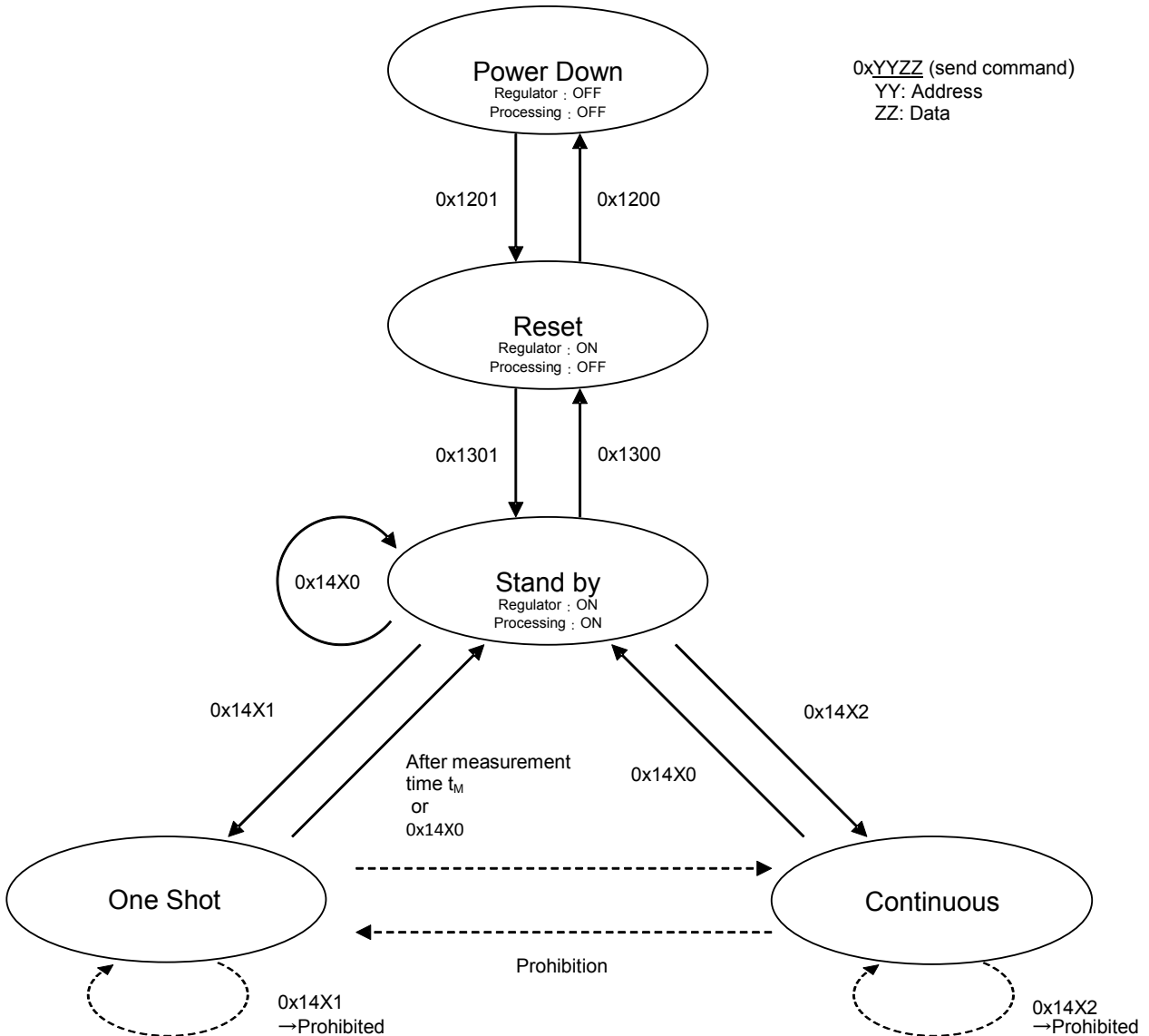
Operation mode transition is like the chart below.

Power down mode is the smallest current consumption mode due to circuit is OFF. Set this mode when reducing current consumption. Measurement is not available in this mode, so the measurement is performed after switching to standby mode.

In reset mode, regulator for internal blocks is active and measurement control block is reset. Register is initialized in Reset mode. Measurement command is acceptable when "1" is written in "RSTB"

There are 2 measurement modes. One shot mode and Continuous mode. They are transferred from standby mode. Then, set "AVE_NUM" register at the same time.
Write "00" in "MODE" (address = 0x14) when transferring to standby mode again.

In one shot mode, a single measurement is performed when "01" is written in "MODE". After the measurement completes, it is transferred to standby mode automatically. When "00" is written in "MODE" before end of measurement, mode is switched to standby immediately but pressure value is not updated.
Transition to the other measurement mode during measurement in one shot mode is forbidden.

In Continuous mode, when "10" is written in "MODE", measurement starts and it continues until "00" is written in "MODE". Transition to the other measurement mode from Continuous mode is forbidden.

```
                          ┌───────────────────┐
                          │    Power Down     │
                          │  Regulator：OFF    │
                          │  Processing：OFF   │
                          └───────────────────┘       0xYYZZ (send command)
                             ↓          ↑              YY: Address
                          0x1201     0x1200            ZZ: Data
                          ┌───────────────────┐
                          │      Reset        │
                          │  Regulator：ON     │
                          │  Processing：OFF   │
                          └───────────────────┘
                             ↓          ↑
                          0x1301     0x1300
                          ┌───────────────────┐
                   0x14X0 │    Stand by       │
                   (loop) │  Regulator：ON     │
                          │  Processing：ON    │
                          └───────────────────┘
                   0x14X1    ↓  ↑        ↑  ↓    0x14X2
                     After measurement   0x14X0
                     time t_M
                      or
                     0x14X0
        ┌───────────┐                        ┌───────────┐
        │ One Shot  │ - - - - - - - - - - →  │ Continuous│
        │           │ ← - - - - - - - - - -  │           │
        └───────────┘       Prohibition      └───────────┘
         0x14X1                                0x14X2
         →Prohibited                           →Prohibited
```

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Register Map – continued

(0x18) FIFO data

Fields	Function
FIFO_LEV[2:0]	Number of sample in FIFO

default value 0x00

FIFO_LEV[2:0]

D2	D1	D0	Description
0	0	0	FIFO empty
0	0	1	Number of sample in FIFO = 1
0	1	0	Number of sample in FIFO = 2
0	1	1	Number of sample in FIFO = 3
1	0	0	FIFO FULL

(0x19) STATUS

Fields	Function
RD_FULL	FIFO overrun (FULL) status This register is cleared when this is read. RD_FULL is not updated unless data are read. 0: FIFO is not full; 1: FIFO is full.
RD_WTM	FIFO threshold (Water Mark) status This register is cleared when FIFO memory become less than threshold level. 0: Number of sample in FIFO is lower than threshold level. 1: Number of sample in FIFO is equal or higher than threshold level.
RD_DRDY	Pressure and temperature measurement data ready bit This register is cleared when '1' is read. Do not care RD_DRDY in FIFO mode (FIFO_EN = 1). 0: data is not updated 1: data is updated

default value 0x00

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Register Map – continued

(0x1A / 0x1B / 0x1C) PRESSURE

Fields	Function
PRESS_OUT[15:0] PRESS_OUT_XL[5:0]	pressure data

default value 0x000000

Conversion to pressure value is below.

Pressure counts = PRESS_OUT[15:8] x 2^{14} + PRESS_OUT[7:0] x 2^6 + PRESS_OUT_XL[5:0] [counts] (dec)
Pressure value [hPa] = Pressure counts [counts] / 2048 [counts/hPa]

Data registers (0x1A, 0x1B, 0x1C) should be read by burst read.
Data is updated at the timing of measurement completion.
If they are not read by burst read, data might be mixed up with the data of different measurement.

(0x1D / 0x1E) TEMPERATURE

Fields	Function
TEMP_OUT[15:0]	temperature data

default value 0x0000

Conversion to temperature value is below. Note that TEMP_OUT is data with sign (two's complement).

Temp counts = TEMP_OUT[15:8] x 2^8 +TEMP_OUT[7:0] [counts] (dec)
Temperature value [°C] = Temp counts [counts] / 32 [counts/°C]
       (in case of positive number)

Data registers (0x1D,0x1E) should be read by burst read.
Data is updated at the timing of measurement completion.
If they are not read by burst read, data might be mixed up with the data of different measurement.

FIFO

This IC embeds a 4-slot FIFO to store the pressure and temperature output values.
FIFO has Bypass mode (FIFO_EN = 0) and FIFO mode (FIFO_EN = 1).
In FIFO mode, the pressure output data are stored in FIFO when measurement is completed.
The data is read from oldest data. Temperature output data are not stored in FIFO.
Interrupt for WTM and FULL is available in FIFO mode.
WTM interrupt is enable when WTM_EN is set to '1'. In this mode, when FIFO memory reach the number set in WTM_LEVEL, RD_WTM goes to '1'.
FULL interrupt is enable when FULL_EN is set to '1'. In this mode, when 4 data are stored in FIFO, RD_FULL goes to '1'.
FIFO_LEV is the number of sample in FIFO.
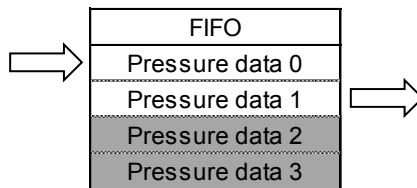FIFO is only available in Continuous mode.

<Bypass mode>
FIFO is not operational in Bypass mode (FIFO_EN = 0).
New data is overwritten to old data due to only the first slot of FIFO is in use.
FIFO and FIFO_LEV are initialized in Bypass mode.

FIFO
Pressure data 0
Pressure data 1
Pressure data 2
Pressure data 3
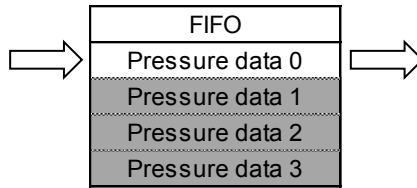
<FIFO mode>
FIFO is operational in FIFO mode (FIFO_EN = 1).
Pressure data is read from the address 0x1A, 0x1B and 0x1C.
The data is read from oldest data. FIFO stops storing data when FIFO is FULL.
The latest temperature data is read from the address 0x1D and 0x1E.

FIFO
Pressure data 0
Pressure data 1
Pressure data 2
Pressure data 3

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FIFO – continued

Water Mark interrupt

Water Mark interrupt occur when stored data in FIFO is equal to or more than the number set in WTM_LEVEL.
Water Mark level is selectable from 2 (WTM_LEVEL = 0) and 3 (WTM_LEVEL = 1).
RD_WTM goes to '1' when Water Mark interrupt occur
Water Mark interrupt keep active state while FIFO_LEV is equal to or more than WTM_LEVEL. And it is released, when FIFO_LEV go below WTM_LEVEL.
The DRI pin status is determined by Water Mark interrupt, when WTM_EN is '1'.

Case of Water Mark occurs at 2 of Water Mark level

FIFO
Pressure data 0
Pressure data 1
Pressure data 2
Pressure data 3
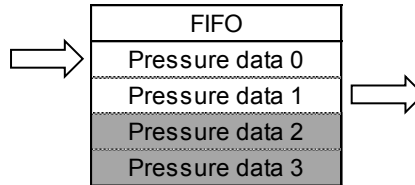
FULL interrupt

FULL interrupt occur when stored data in FIFO is 4. RD_FULL goes '1'.
RD_FULL goes '0' when RD_FULL is read.
FIFO and RD_FULL are not updated by measurement after FULL interrupt occur. Then FIFO_LEV is fixed to 4.
The DRI pin status is determined by FULL interrupt, when FULL_EN is '1'.

Case of FULL occurs

FIFO
Pressure data 0
Pressure data 1
Pressure data 2
Pressure data 3

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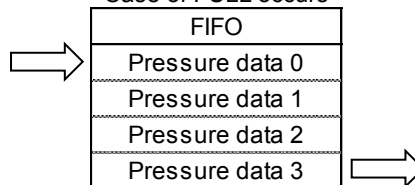
Interrupt Function

Interrupt factor is Data Ready, FIFO FULL and FIFO WTM.
The condition is listed below.
The status register is always operational.
The status register goes '1' when interrupt occur.
When the DRI pin enable register for each factor is '1', the DRI pin status is determined by the interrupt state of factor.
When interrupt occur, the DRI pin output 'L'.
The status register and the DRI pin keeps the state until the interrupt is cleared.
FIFO FULL and FIFO WTM are not available in Bypass mode (FIFO_EN = 0)
Do not care Data Ready in FIFO mode (FIFO_EN = 1).

Interrupt factor

Factor	Status Register	Interrupt Condition	Interrupt Clear Condition
Data Ready	RD_DRDY	Measurement completion	Read RD_RDRY
FIFO FULL	RD_FULL	FIFO is Full	Read RD_FULL
FIFO WTM	RD_WTM	FIFO_LEV ≥ WTM level	FIFO_LEV < WTM level

Relation between factor and the DRI pin enable

Factor	DRI Pin Enable
Data Ready	DR_EN
FIFO FULL	FULL_EN
FIFO WTM	WTM_EN

The DRI pin is Nch open drain so this pin should be pull-up to voltage source by an external resister.
The DRI pin is high impedance just after VDD is supplied.
The DRI pin becomes inactive (High impedance) by reading RD_DRDY register or setting reset mode.
VDD current (approximately 6 μA at V_{DD} = 1.8 V) is consumed during DRI is active.
When disabling interrupt function, it has to be done after clearing interrupt.

<Example of Data Ready interrupt: 1shot mode>

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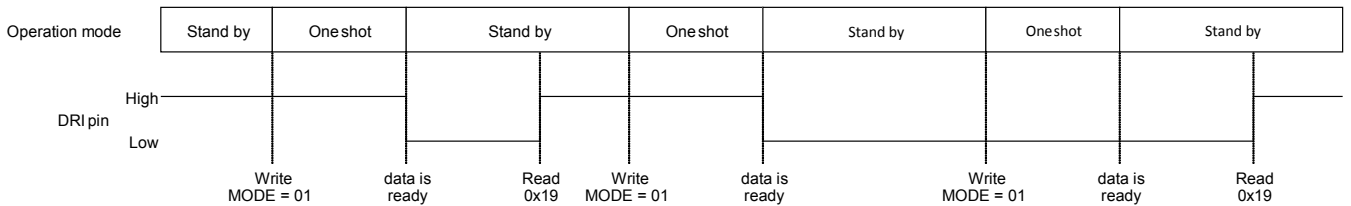
Typical Performance Curves
(Reference data)
(Unless otherwise specified V_{DD} = 1.8 V Ta = 25 °C)

Figure 1. Power Down Mode Current vs Supply Voltage
(PWR_DOWN = 0, RSTB = 0)
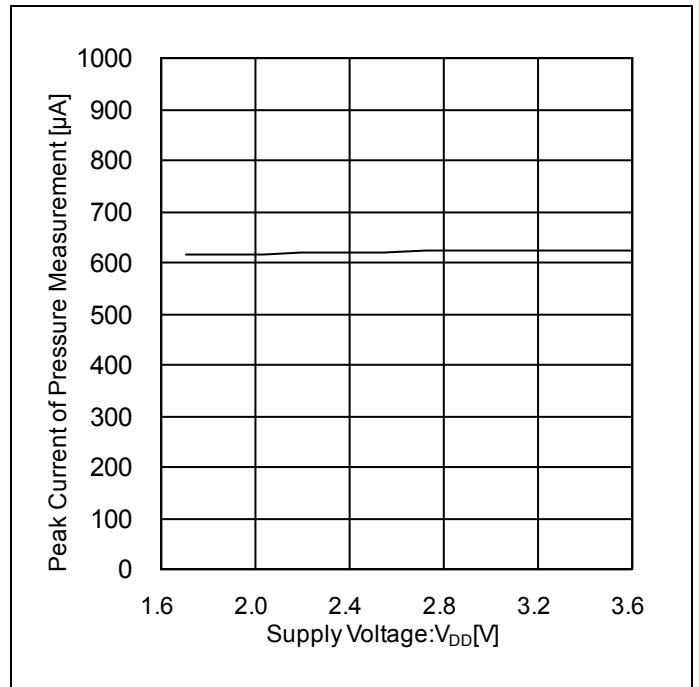
Figure 2. Peak Current of Pressure Measurement vs
Supply Voltage
(During measurement)

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Control Sequence

1. Power-on Sequence

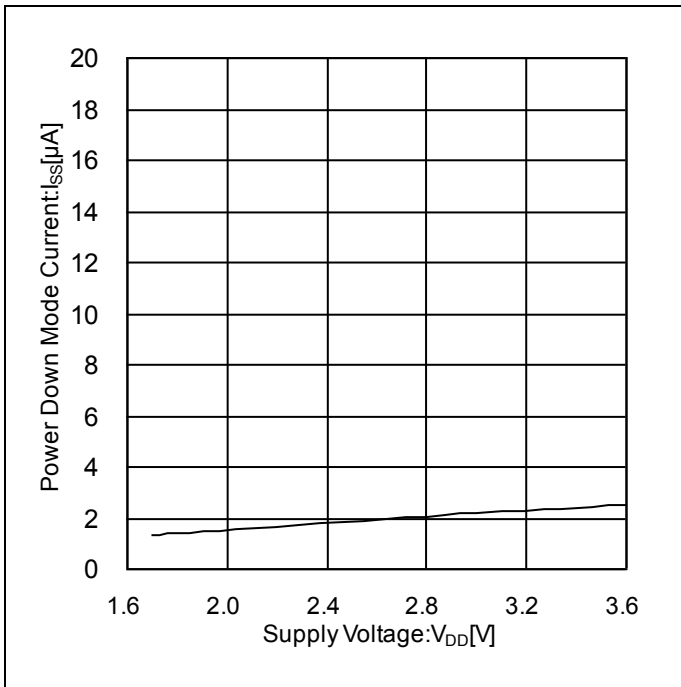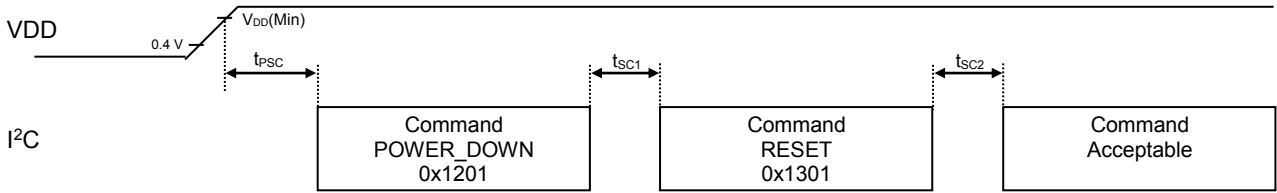| Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Command input time after power-on	t_{PSC}	100	-	-	µs	
Reset cancel wait time	t_{SC1}	1	-	-	ms	VREG: 0.1 µF
Measurement command wait time	t_{SC2}	100	-	-	µs	

t_{PSC} after VDD power-on, command can be input.
Send reset cancel command (RSTB = 1) more than t_{sc1} after regulator for internal blocks become active (PWR_DOWN = 1).
Send measurement command more than t_{sc2} after reset cancel command.

2. Power-off sequence
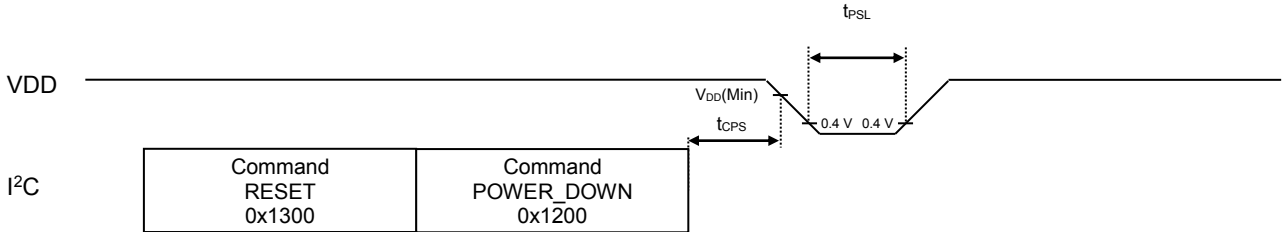
Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Wait time from power down command	t_{CPS}	0	-	-	µs	
Power supply OFF time	t_{PSL}	1	-	-	ms	

Send reset command (RSTB = 0) to turn regulator for internal blocks off (PWR_DOWN = 0) t_{CPS} before the VDD power-off.
Keep VDD Low (V_{DD} < 0.4 V) more than t_{PSL} before VDD power-on

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Control sequence – continued

3. Starting sequence

```
┌─────────────┐
│ power supply│
└─────────────┘
       │
       ▼
  ╱─────────────╲
 ╱ wait for more ╲
 ╲  than 0.1 ms  ╱
  ╲─────────────╱
       │
       ▼
┌─────────────────┐
│ POWER_DOWN setting │      : release Power down
│  Write:0x1201   │
└─────────────────┘
       │
       ▼
  ╱─────────────╲
 ╱ wait for more ╲
 ╲   than 1 ms   ╱
  ╲─────────────╱
       │
       ▼
┌─────────────────┐
│  RESET setting  │      : release Reset mode
│  Write:0x1301   │
└─────────────────┘
       │
       ▼
  ╱─────────────╲
 ╱ wait for more ╲
 ╲  than 0.1 ms  ╱
  ╲─────────────╱
       │
       ▼
┌─────────────────┐
│  Completion of  │      : Completion of operation preperation
│ starting sequence │
└─────────────────┘
```

4. Measurement sequence: One Shot Mode

```
          ┌─────────────┐
          │  Starting   │
          │  sequence   │
          └─────────────┘
                 │
                 ▼
   yes      ╱─────────────╲      no
 ◄──────── ╱  Enable DRI？  ╲ ────────►
          ╲─────────────╱
     │                         │
     ▼                         ▼
┌──────────────────────┐  ┌──────────────────────┐
│ MODE_CONTROL setting │  │ MODE_CONTROL setting │   : measurement mode setting. it starts pressure
│    Write:0x14XX      │  │    Write:0x14XX      │     and temperature measurement.
│ (DR_EN = 1, MODE = 01)│  │ (DR_EN = 0, MODE = 01)│
└──────────────────────┘  └──────────────────────┘
     │                         │
     ▼                         ▼
  ╱─────────╲  H          ╱───────────────╲  no
 ╱  DRI pin  ╲◄─────     ╱ wait for the end of ╲ ────►
 ╲           ╱          ╲   measurement   ╱
  ╲─────────╱            ╲───────────────╱      : wait interrupt(DRI = 'L') or measurement end
     │ L                      │ yes
     ▼                        │
┌──────────────────┐          │              check interrupt status
│  read STATUS     │          │            : The DRI pin is set to 'H' by reading.
│  Read:0x19       │          │
└──────────────────┘          │
     │                        │
     └────────────┬───────────┘
                  ▼
        ┌──────────────────────────┐
        │     read PRESSURE        │
        │ Read:0x1A to 0x1C(Note 1) │
        └──────────────────────────┘
                  │
                  ▼
        ┌──────────────────┐
        │   Measurement    │
        │   complestion    │
        └──────────────────┘
```
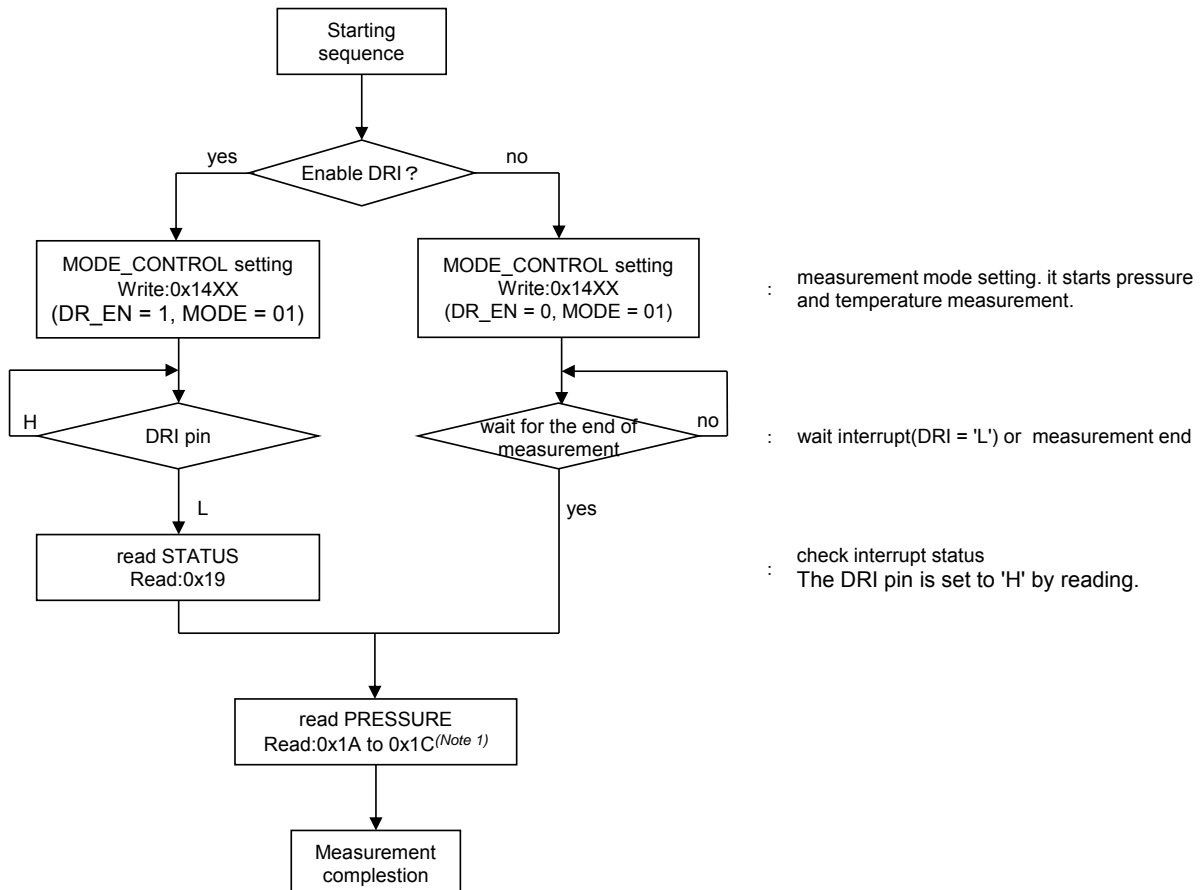
(Note 1) Data registers (0x1A, 0x1B, 0x1C) should be read by burst read.

Control sequence – continued

5. Measurement sequence: Continuous Mode (25 ms/50 ms/100 ms/200 ms)

```
                          ┌──────────────┐
                          │   Starting   │
                          │   sequence   │
                          └──────────────┘
                                 │
                          ◇ Enable DRI？ ◇
                   yes  /                 \  no
```

MODE_CONTROL setting Write:0x14XX (DR_EN = 1,MODE = 10)	MODE_CONTROL setting Write:0x14XX (DR_EN = 0,MODE = 10)

:   measurement mode setting. it starts pressure and temperature measurement.

```
        H ◇ DRI pin ◇                    ◇ wait for the end of   no
              │ L                            measurement ◇
```

:   wait interrupt(DRI = 'L') or measurement end

read STATUS Read:0x19	

:   check interrupt status
    The DRI pin is set to 'H' by reading.

read PRESSURE Read:0x1A to 0x1C(Note 1)	read PRESSURE Read:0x1A to 0x1C(Note 1)

:   read Pressure data

```
   no ◇ measurement            ◇ measurement    no
          stop？ ◇                  stop？ ◇
            │ yes                     │ yes
```

:   end judgement of Continuous mode

MODE_CONTROL setting Write:0x14X0

:   shift to Stand-by mode. At the timing of setting the command it stops measurement and shifts to Stand-by mode.

Measurement complestion

(Note 1) Data registers (0x1A, 0x1B, 0x1C) should be read by burst read.
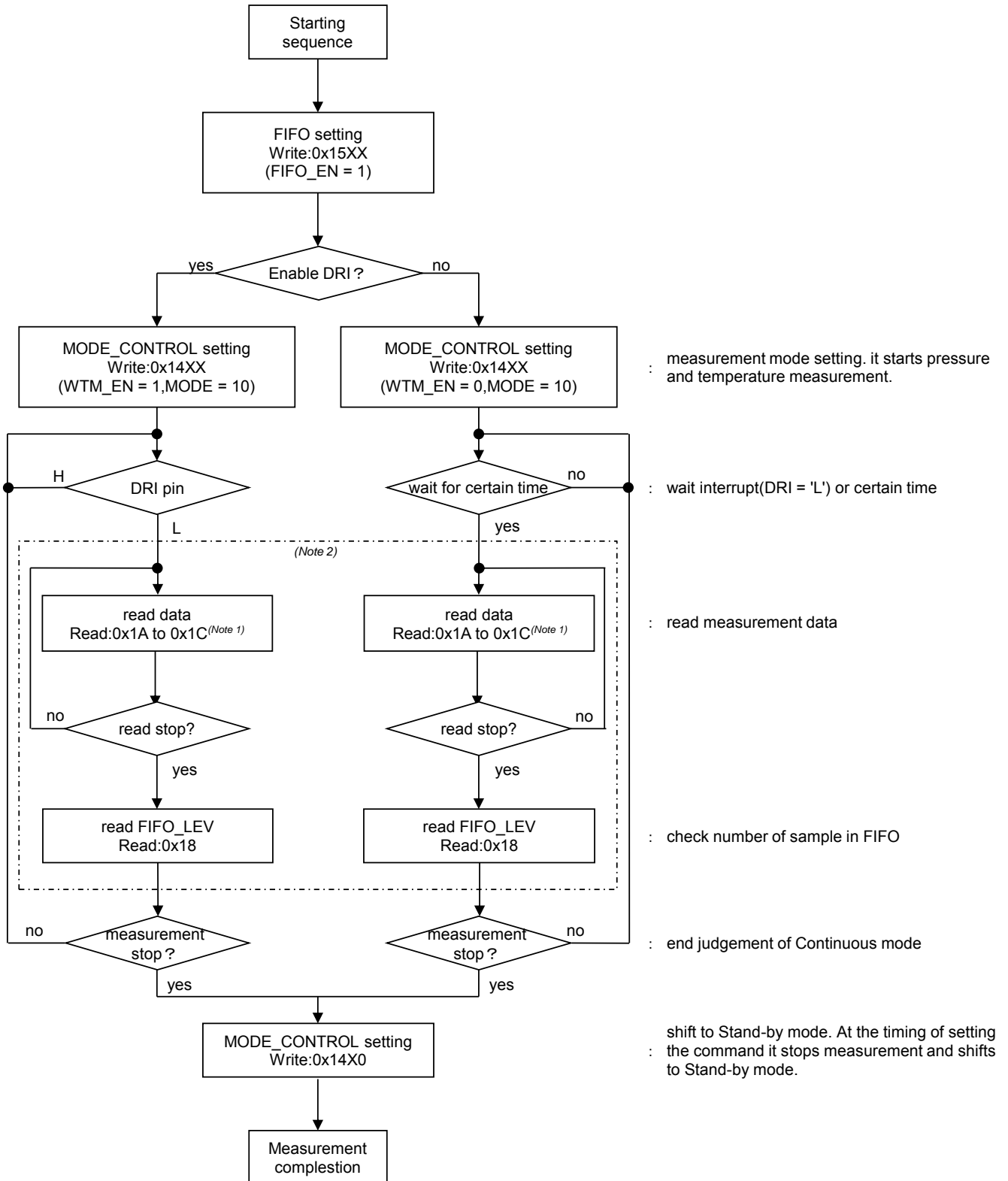
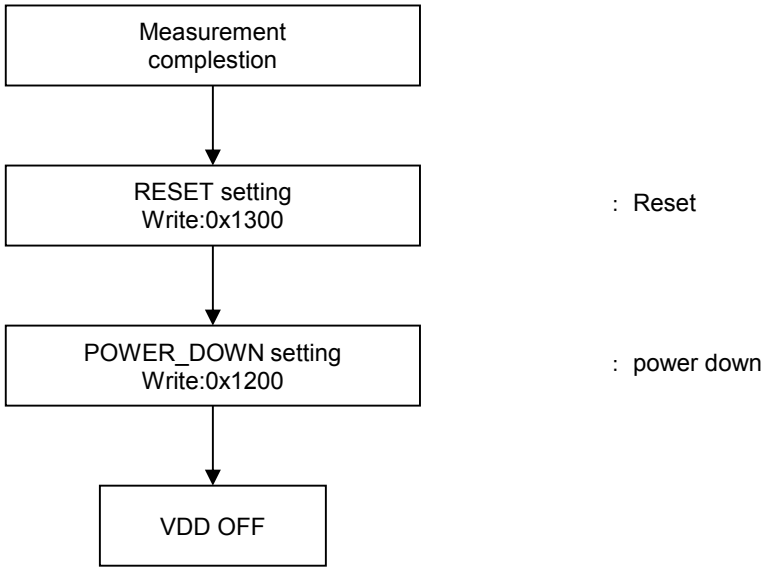## Control sequence – continued

6. Measurement sequence: Use case of FIFO

```
                        ┌──────────────────┐
                        │    Starting      │
                        │    sequence      │
                        └──────────────────┘
                                 │
                        ┌──────────────────┐
                        │   FIFO setting   │
                        │  Write:0x15XX    │
                        │  (FIFO_EN = 1)   │
                        └──────────────────┘
                                 │
               yes      ◇ Enable DRI？ ◇      no
```

| MODE_CONTROL setting Write:0x14XX (WTM_EN = 1,MODE = 10) | MODE_CONTROL setting Write:0x14XX (WTM_EN = 0,MODE = 10) | : measurement mode setting. it starts pressure and temperature measurement. |

- DRI pin — H / L
- wait for certain time — no / yes — : wait interrupt(DRI = 'L') or certain time

(Note 2)

| read data Read:0x1A to 0x1C *(Note 1)* | read data Read:0x1A to 0x1C *(Note 1)* | : read measurement data |

- read stop? — no / yes
- read stop? — no / yes

| read FIFO_LEV Read:0x18 | read FIFO_LEV Read:0x18 | : check number of sample in FIFO |

- measurement stop？ — no / yes
- measurement stop？ — no / yes — : end judgement of Continuous mode

| MODE_CONTROL setting Write:0x14X0 | : shift to Stand-by mode. At the timing of setting the command it stops measurement and shifts to Stand-by mode. |

```
                        ┌──────────────────┐
                        │   Measurement    │
                        │   complestion    │
                        └──────────────────┘
```

(Note 1) Data registers (0x1A, 0x1B, 0x1C) should be read by burst read.

(Note 2) During a period form a start of FIFO reading (write to address 0x1A) to FIFO_LEV reading (write to address 0x18), do not communicate with this device. When communicating with this device during FIFO reading, read FIFO_LEV and finish FIFO read sequence before other communication. If don't read FIFO_LEV before other communication, there is a possibility to lose FIFO data.

Control sequence – continued

7. Ending sequence

```
┌─────────────────────────┐
│      Measurement        │
│      complestion        │
└─────────────────────────┘
              │
              ▼
┌─────────────────────────┐
│     RESET setting       │            :  Reset
│     Write:0x1300        │
└─────────────────────────┘
              │
              ▼
┌─────────────────────────┐
│   POWER_DOWN setting    │            :  power down
│     Write:0x1200        │
└─────────────────────────┘
              │
              ▼
       ┌──────────────┐
       │   VDD OFF    │
       └──────────────┘
```

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Application Example
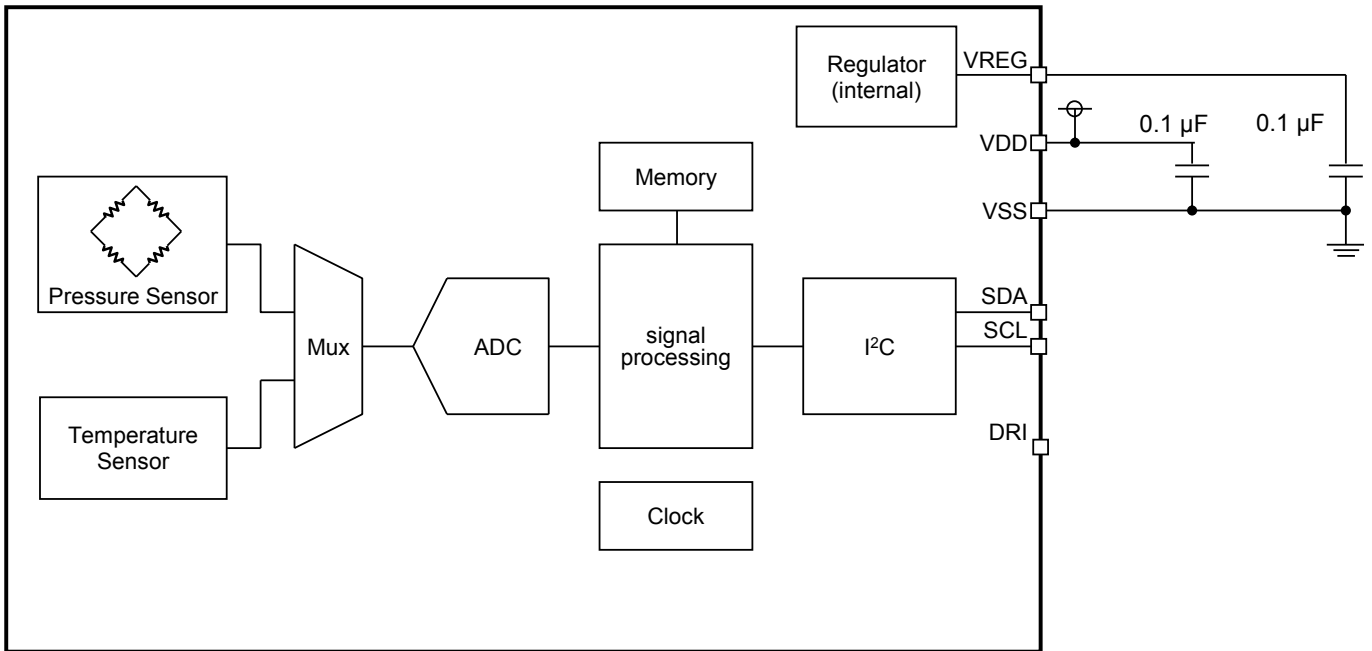
I/O Equivalent Circuits

Pin Name	Equivalent Circuit	Pin Name	Equivalent Circuit
SCL		SDA	
DRI		VREG	

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Operational Notes

1. **Reverse Connection of Power Supply**
   Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC's power supply pins.

2. **Power Supply Lines**
   Design the PCB layout pattern to provide low impedance supply lines. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

3. **Ground Voltage**
   Ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition.

4. **Ground Wiring Pattern**
   When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

5. **Recommended Operating Conditions**
   The function and operation of the IC are guaranteed within the range specified by the recommended operating conditions. The characteristic values are guaranteed only under the conditions of each item specified by the electrical characteristics.

6. **Inrush Current**
   When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

7. **Testing on Application Boards**
   When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

8. **Inter-pin Short and Mounting Errors**
   Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.

9. **Unused Input Pins**
   Input pins of an IC are often connected to the gate of a MOS transistor. The gate has extremely high impedance and extremely low capacitance. If left unconnected, the electric field from the outside can easily charge it. The small charge acquired in this way is enough to produce a significant effect on the conduction through the transistor and cause unexpected operation of the IC. So unless otherwise specified, unused input pins should be connected to the power supply or ground line.
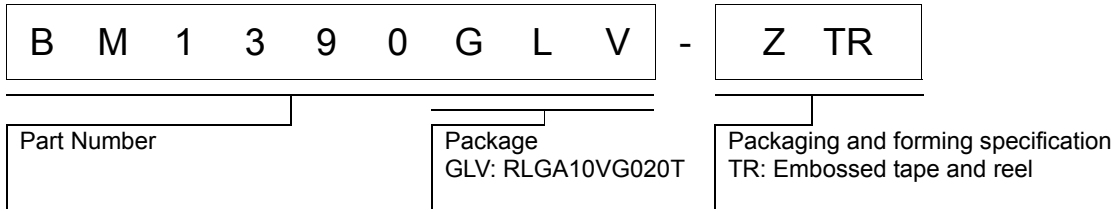
10. **Regarding the Input Pin of the IC**
    In the construction of this IC, P-N junctions are inevitably formed creating parasitic diodes or transistors. The operation of these parasitic elements can result in mutual interference among circuits, operational faults, or physical damage. Therefore, conditions which cause these parasitic elements to operate, such as applying a voltage to an input pin lower than the ground voltage should be avoided. Furthermore, do not apply a voltage to the input pins when no power supply voltage is applied to the IC. Even if the power supply voltage is applied, make sure that the input pins have voltages within the values specified in the electrical characteristics of this IC.
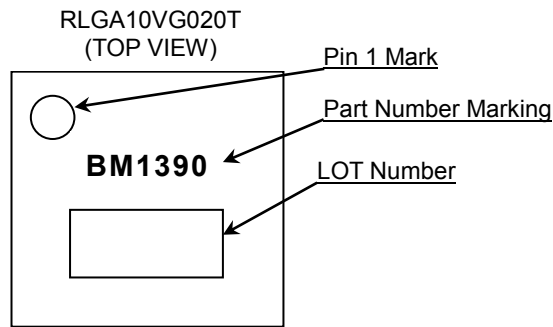
11. **Ceramic Capacitor**
    When using a ceramic capacitor, determine a capacitance value considering the change of capacitance with temperature and the decrease in nominal capacitance due to DC bias and others.
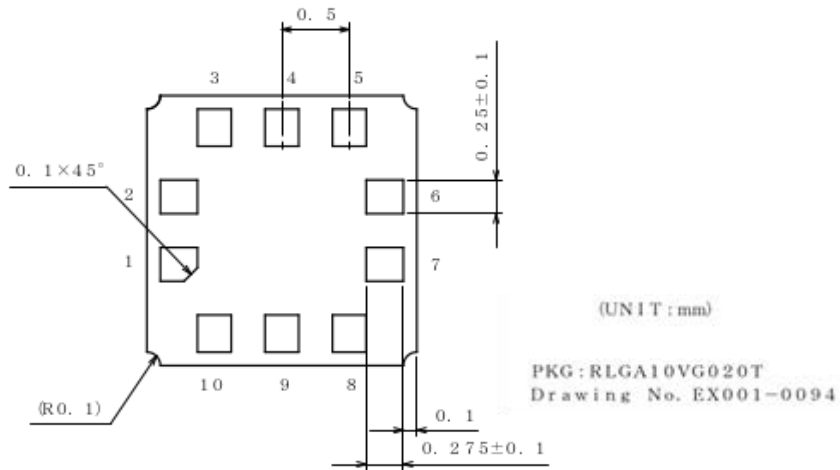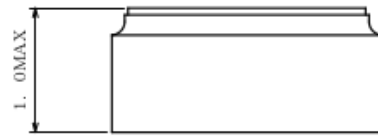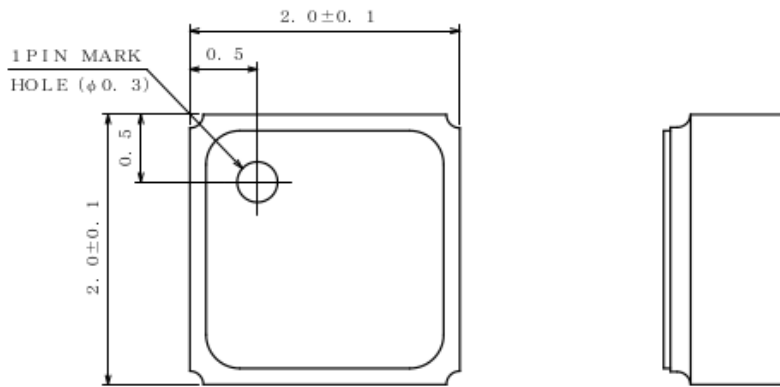
Ordering Information

| B | M | 1 | 3 | 9 | 0 | G | L | V | - | Z | TR |

Part Number

Package
GLV: RLGA10VG020T

Packaging and forming specification
TR: Embossed tape and reel

Marking Diagram

RLGA10VG020T
(TOP VIEW)

Pin 1 Mark

Part Number Marking

BM1390

LOT Number

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Physical Dimension and Packing Information

Package Name	RLGA10VG020T

(UNIT : mm)

PKG : RLGA10VG020T
Drawing No. EX001-0094

< Tape and Reel Information >

Tape	Embossed carrier tape
Quantity	3000pcs
Direction of feed	TR
	The direction is the pin 1 of product is at the upper right
	when you hold reel on the left hand and you pull out the tape on the right hand

Direction of feed

Pocket Quadrants

Reel
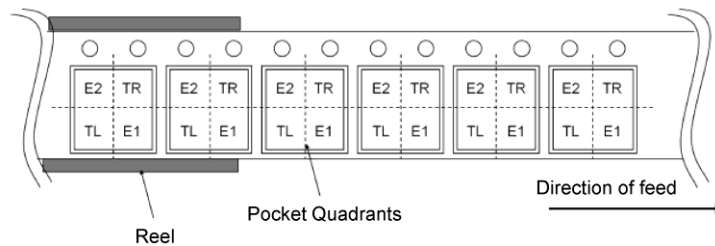
Revision History

Date	Revision	Changes
30.Sep.2020	001	New Release

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JAPAN	USA	EU	CHINA
CLASSⅢ	CLASSⅢ	CLASSⅡb	CLASSⅢ
CLASSⅣ		CLASSⅢ	

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   [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
   [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
   [f] Sealing or coating our Products with resin or other coating materials
   [g] Use of our Products without cleaning residue of flux (Exclude cases where no-clean type fluxes is used. However, recommend sufficiently about the residue.) ; or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
   [h] Use of the Products in places subject to dew condensation

4. The Products are not subject to radiation-proof design.

5. Please verify and confirm characteristics of the final or mounted products in using the Products.

6. In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse, is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.

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8. Confirm that operation temperature is within the specified range described in the product specification.

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   [b] the temperature or humidity exceeds those recommended by ROHM
   [c] the Products are exposed to direct sunshine or condensation
   [d] the Products are exposed to high Electrostatic

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