GMP106 Hermetic-Sealed Digital Pressure Sensor

General Introduction

GMP106 is a hermetic-sealed digital barometric pressure sensor especially designed for outdoor applications requiring precise pressure measurement. The gel protection and the stainless steel cap allow the use in 100m water resistance watch for measuring pressure.

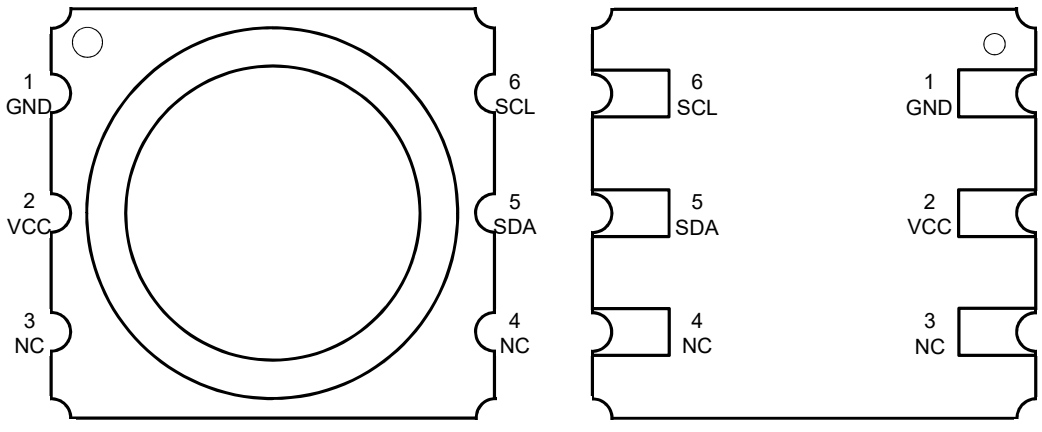
GMP106 includes both pressure and temperature sensors in a small 6.4×6.9×3.2 mm^3 module. The pressure sensor is based on the industry-recognized piezo-resistive technology featuring long-term stability and EMC robustness. A high-performance 24-bit ADC provides altitude resolution up to 20cm, and temperature resolution up to 0.004℃. The pressure sensor has a wide operating range from 300 to 1100hPa that covers all surface elevations on earth. Several operation options further provide flexible window for user optimization on the power consumption and resolution.

Features

- Operation range:
  - Pressure: 300~1100hPa (Absolute)
  - Extended Pressure: 10~2000hPa (Absolute)
  - Temperature: -40~+85℃
- Built-in 24-bit ADC:
  - Altitude resolution: up to 20cm
  - Temperature resolution: up to 0.004℃
- Digital interface:
  - I2C: standard and fast modes with clock up to 400kHz
- Calibrated P and T data output, no need for user calibration
- Operation mode:
  - T-/P-Forced and continuous mode
- Supply voltage:
  - VCC: +1.7V ~ +5.5V
- Power Consumption:
  - Standby ~ 1uA
- RoHS-compliance package:
  - 6-pin module, gel-sealed stainless cap
  - Footprint 6.4×6.9 mm^2, height 3.2 mm

Applications

Mobile altimetry and barometry, activity tracking for outdoor adventure



Top View **Bottom View**

Specifications

Table 1: Pin Descriptions

Pin#	Name	Description
1	GND	Ground pin
2	VCC	Power pin
3	NC	No connection inside
4	NC	No connection inside
5	SDA	I2C data I/O pin
6	SCL	I2C clock I pin

Table 2: Specification

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Operation voltage	VCC		1.7	—	5.5	V
Temperature range	Ta		-40	25	+85	°C
Pressure range	P	Full accuracy	300	—	1100	hPa
Extended pressure range	Pext	Linear range of ADC	10	—	2000	hPa
Operation current OSR=256 **OSR=1024 (default)** OSR=4096 OSR=16384 OSR=32768	ICC	VCC = 3.3V 20Hz P+T conversion	—	97 **120** 190 420 800	—	uA
Standby current	ICCSD	After POR or soft reset	—	1	—	uA
Relative accuracy pressure	PREL	Relative accuracy during pressure change between 700 to 950 hPa at any constant temperature between 25°C to 40°C	—	TBD	—	hPa
Offset temperature coefficient	TCO		—	TBD	—	Pa/K
Absolute accuracy pressure	PABS		—	TBD	—	hPa

Noise in pressure			—	TBD	—	Pa RMS
Absolute accuracy temperature	TABS	@25°C	—	TBD	—	°C
		-40 to 85°C	—	1	—	°C
Long term stability			—	TBD	—	hPa

Table 3: Absolute Maximum Rating

Parameter	Symbol	Min.	Max.	Unit
Power supply voltage	VCC	-0.3	6.5	V
Signal input voltage	VIS	-0.3	VCC + 0.3	V
Pressure	PMAX	0	20000	hPa
Storage temperature	TST	-40	+125	°C
ESD	HBM	—	±2	kV

Block Diagram and Connection

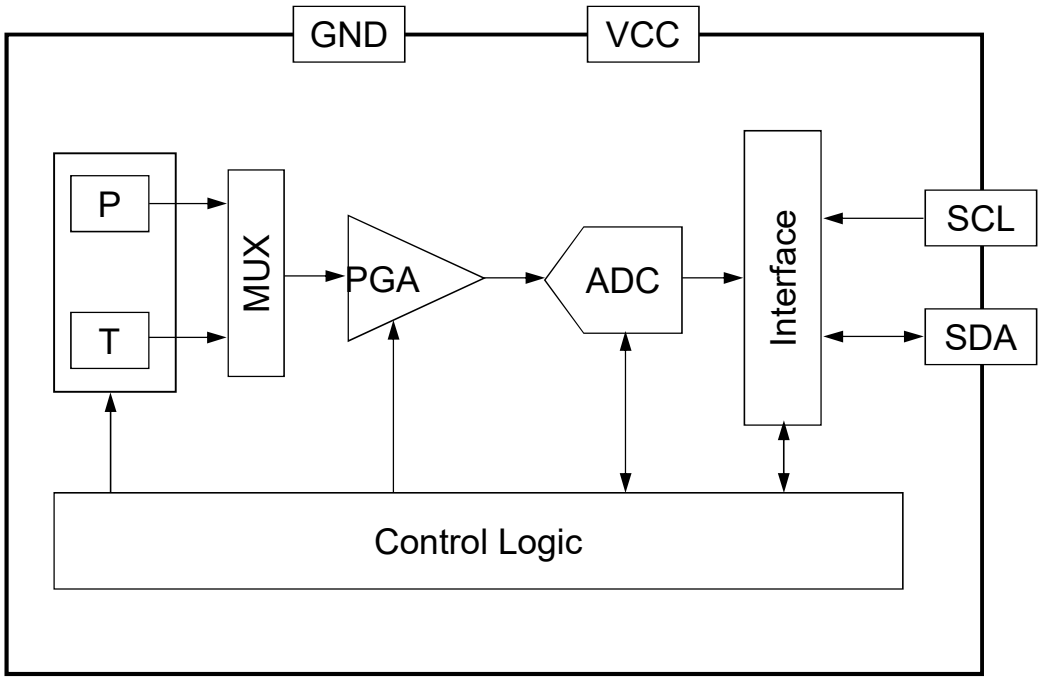


Figure 1: GMP106 Block Diagram

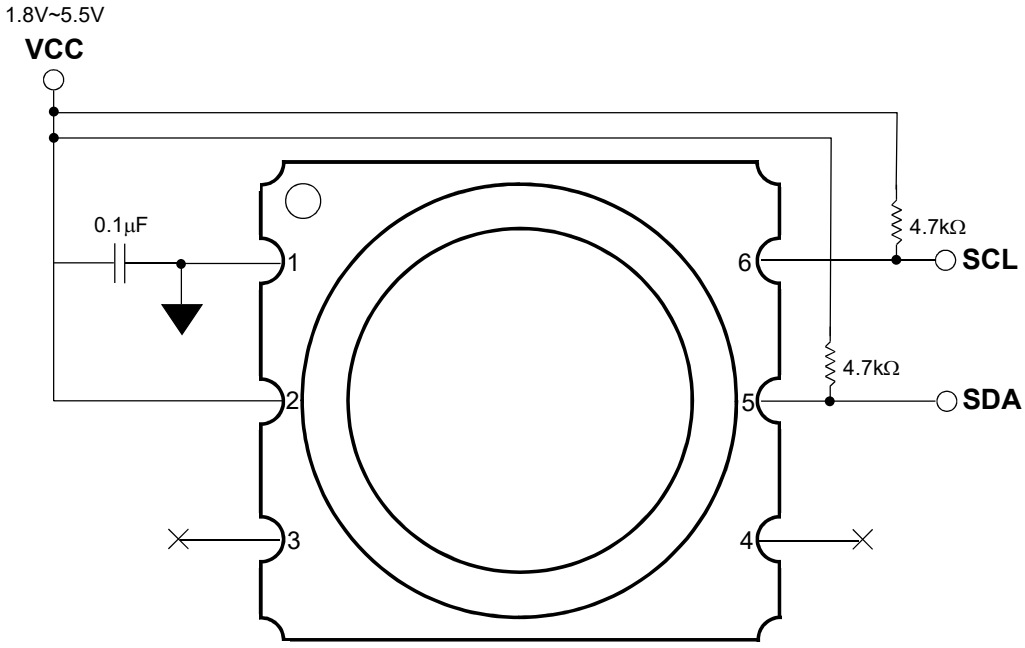


Figure 2: GMP106 I2C Connection Example

Functional Description

Power Management

GMP106 has one power supply pin VCC. When the power is connected to VCC, power-on reset (POR) circuit will be active to reset the internal circuits and registers. After the POR sequence, all registers will be initialized to the default values and GMP106 will transit to standby mode.

Reset Functions

GMP106 has two types of reset as summarized below:

- Power-on reset (POR): as described in the previous Power Management section.
- Soft reset: Set RESET register (00h) to 0x24 will trigger the device soft reset by resetting all register to default values.

Initialization

GMP106 will automatically initialize to standby mode upon power-up after POR. Or one can use soft reset for register initialization as required. There is nothing further to do except to set the power mode for operation. See below "Power Modes" section for description.

Power Modes

GMP106 offers four power modes, standby, P-Forced, T-Forced and continuous mode, by setting the 30h[3:0] (Measure_CTRL[3:0]) bits, see 30h register description for more detail.

The transitions between different modes are illustrated in Figure 3.

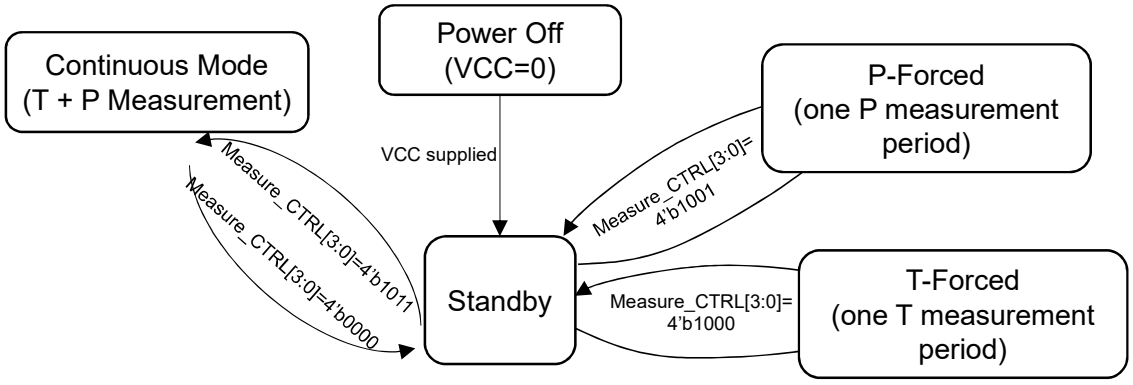


Figure 3: Mode transactions diagram

- Standby mode

GMP106 will enter standby mode after complete POR sequence or soft reset. Or user can enter standby mode at any time by set 30h = 0x00.

In this mode, data measurement stops and the power consumption is at the minimum. All registers, including PID data and control registers, are accessible.

- P-Forced mode

In P-Forced mode, GMP106 will take one-time pressure measurement and returns to standby mode automatically. The measurement results can then be obtained from the pressure data registers. Users need to set to P-Forced mode again to have another pressure measurement. The timing diagram of the P-Forced mode is illustrated in the following Figure 4.

Below summarized the single shot pressure conversion steps:

1. Set to the P-Forced mode by set 30h = 0x09.
2. Check 02h[0] (DRDY) bit and wait until its value is set. The data is available in the registers when DRDY = 1'b1.
3. Read the calibrated pressure data from the pressure data registers (06h~08h).
4. Divide the pressure data by 64 to get pressure in Pa.

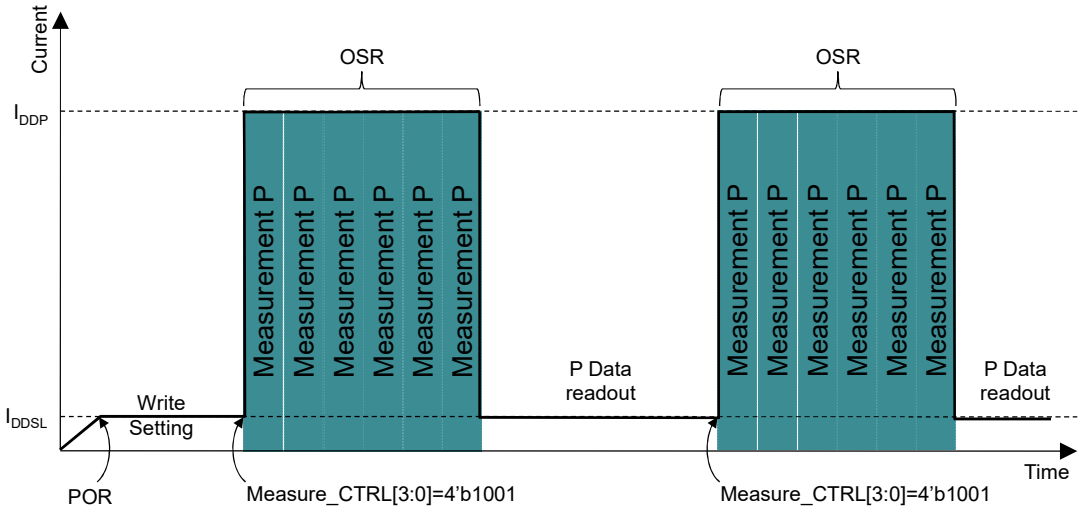


Figure 4: P-Forced mode timing diagram

- T-Forced mode

In T-Forced mode, GMP106 will take one-time temperature measurement and returns to standby mode automatically. The measurement results can then be obtained from the temperature data registers. Users need to set to T-Forced mode again to have another temperature measurement. The timing diagram of the T-Forced mode is illustrated in the following Figure 5.

Below summarized the single shot temperature conversion steps:

1. Set to the T-Forced mode by set 30h = 0x08.
2. Check 02h[0] (DRDY) bit and wait until its value is set. The data is available in the registers when DRDY = 1'b1.
3. Read the calibrated temperature output from the temperature data registers (09h~0Ah).
4. Divide the temperature data by 256 to get temperature in Celsius degree.

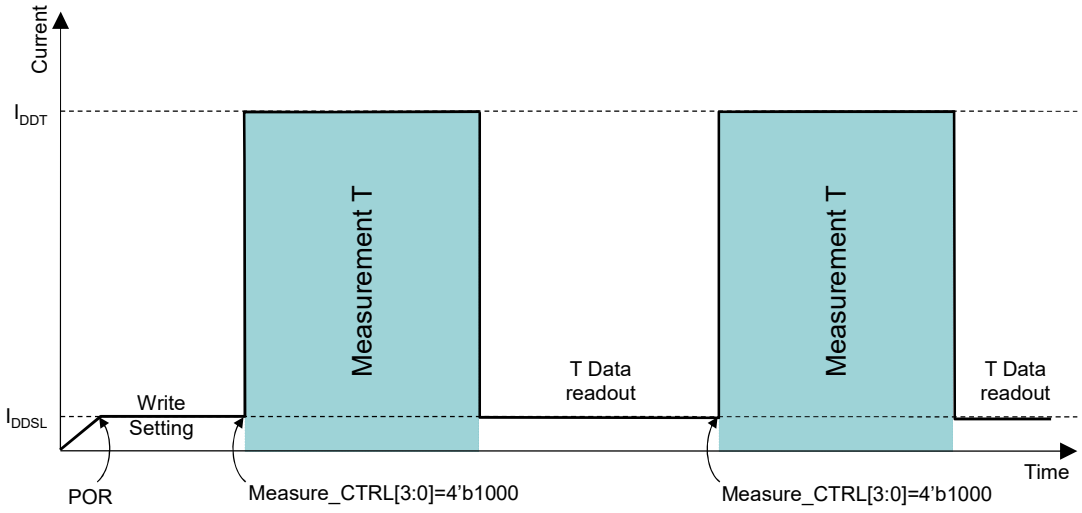


Figure 5: T-Forced mode timing diagram

- Continuous mode

In continuous mode, GMP106 will periodically power up and perform once temperature measurement, once pressure measurement, and then return to a sleep interval. The duration of the sleep interval is configured by the Standby_Time[3:0] bits of 30h register. The device will not get back to standby mode until manually set 30h = 0x00. The measurement results can be obtained from the data registers. The timing diagram of the continuous mode is illustrated in the following Figure 6.

Below summarized the continuous mode setup steps:

1. Set the sleep time interval by setting Standby_Time[3:0] bits of 30h register.
2. Set to the continuous mode by set 30h = 0x0B.

Calibrated temperature output can be read from the temperature data registers (09h~0Ah). Divide the temperature data by 256 to get temperature in Celsius degree.

Calibrated pressure output can be read from the pressure data registers (06h~08h). Divide the pressure data by 64 to get pressure in Pa.

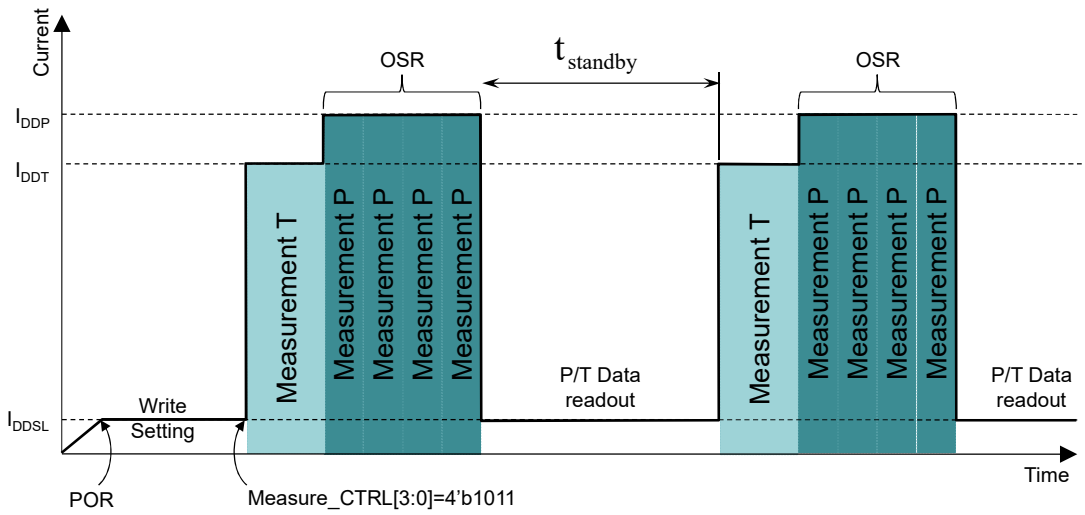


Figure 6: Continuous mode timing diagram

User Register Map

Table 4: User Register Map Table

Addr.	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
00h	RESET	Reserved		RST	0	0	RST	Reserved		RW	0x00
01h	PID	PID[7:0]								R	0x00
02h	STATUS	Reserved				0	0	0	DRDY	R	NA
06h	PRESSH	Pressure [23:16]								R	NA
07h	PRESSM	Pressure [15:8]								R	NA
08h	PRESSL	Pressure [7:0]								R	NA
09h	TEMPH	Temperature[15:8]								R	NA
0Ah	TEMPL	Temperature[7:0]								R	NA
30h	CMD	Standby_Time[3:0]				Measure_CTRL[3:0]				RW	0x00
A6h	CONFIG2	Reserved					OSR[2:0]			RW	0x20

Description of Registers

Register 00h: RESET Register

Addr.	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
00h	RESET	Reserved		RST	0	0	RST	Reserved		RW	0x00

Set RESET register (00h) to 0x24 to trigger the device soft reset. All register values will be reset to default. The RST bits will automatically return to 1'b0 when the soft reset complete.

Register 01h: PID Register

Addr.	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
01h	PID	PID[7:0]								R	0x00

PID is the product identification register and the value is fixed to 0x00. This register is available for reading after the device finished the power-on-reset.

Register 02h: STATUS Register

Addr.	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
02h	STATUS	Reserved				0	0	0	DRDY	R	NA

The DRDY bit will be set once the data conversion is complete. The output data is ready for reading from pressure or temperature data registers.

Register 06h~08h: Pressure Data Registers

Addr.	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
06h	PRESSH	Pressure [23:16]								R	NA
07h	PRESSM	Pressure [15:8]								R	NA
08h	PRESSL	Pressure [7:0]								R	NA

The pressure data output is encoded to a 24-bit value and stored across three bytes. Data representation is 2's complement, i.e. MSB (bit 23) is the sign bit with 1'b1 representing negative value.

The pressure data output has sensitivity of 64 LSB/Pa. The central value (0x00) stands for 0 Pa. Thus the pressure value can be converted from the pressure reading by the following conversion:

$$P\,(Pa) = \frac{Pressure[23:0]}{64}$$

Register 09h~0Ah: Temperature Data Registers

Addr.	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
09h	TEMPH	Temperature[15:8]								R	NA
0Ah	TEMPL	Temperature[7:0]								R	NA

The temperature data output is encoded to a 16-bit value and stored across two bytes. Data representation is 2's complement, i.e. MSB (bit 15) is the sign bit with 1'b1 representing negative value.

The temperature sensor has sensitivity of 256 LSB/℃. The central value (0x00) stands for 0℃. Thus the Celsius temperature can be converted from the temperature reading by the following formula:

$$T(℃) = \frac{Temperature[15:0]}{256}$$

Register 30h: CMD Register

Addr.	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
30h	CMD	Standby_Time[3:0]				Measure_CTRL[3:0]				RW	0x00

Measure_CTRL[3:0] control the signal conversion mode. For the T- or P-Forced mode, GMP106 will return to standby mode after each conversion. While in the continuous mode, the device will periodically power up and performs once temperature conversion, once pressure signal conversion and a standby interval defined by the Standby_Time[3:0] bits. Available setting is summarized in the following table.

Measure_CTRL[3:0]	Power Mode
4'b1000	T-Forced mode Make a single shot **temperature** conversion.
4'b1001	P-Forced mode Make a single shot **pressure** conversion
4'b1011	Continuous mode Periodically perform P and T conversion with an standby interval set by Standby_Time[3:0]
Others	Reserved

Standby_Time[3:0] control the standby interval between periodic conversions in the continuous mode, see Figure 6 for illustration. One code defined by Standby_Time represents 62.5ms. That is

$$t_{standby}\ (ms) = Standby\_Time[3:0] \times 62.5$$

Register A6h: CONFIG2 Register

Addr.	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access	Default
A6h	CONFIG2	Reserved					OSR[2:0]			RW	0x20

OSR[2:0] selects the oversampling ratio for the pressure data conversion as summarized in the following table.

OSR[2:0]	Conversion Time (ms)	Oversampling Ratio	Typical Resolution (ENOB)
3'b000	2.5	1024	17.8
3'b001	3.78	2048	18.2
3'b010	6.34	4096	18.7
3'b011	11.46	8192	19.1
3'b100	1.54	256	17
3'b101	1.86	512	17.3
3'b110	21.7	16384	19.4
3'b111	42.18	32768	19.7

Digital Interface: I2C

I2C Interface General Description

GMP106 7-bit device slave address is factory-settable to 0x6C or 0x6D. The default value is 0x6D.

The I2C interface is compliant with standard and fast I2C standard. The devices support the 7-bit control functions, and the SDA and SCL facilitate communication between GMP106 and master with clock rate up to 400kHz.

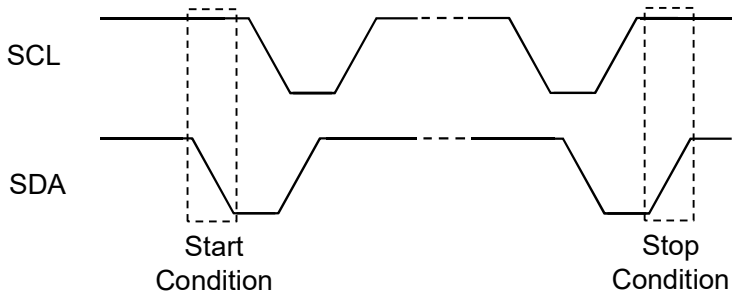
The I2C bus takes master clock through SCL pin and exchanges serial data via SDA. SDA is a bidirectional (input/output) connection. Both are open-drain connection and must be connected externally to VID via a pull-up resistor. The I2C interface supports multiple read and write. When using multiple read/write, the internal I2C address pointer will automatically increase by 1 for the next access.

I2C Access Format: Standard and Fast Mode

One data bit is transferred for each SCL cycle. The SDA must not change level when the SCL is high. The level changes in SDA while SCL is high are reserved control signals. The SDA and SCL remain high when I2C bus is idle.

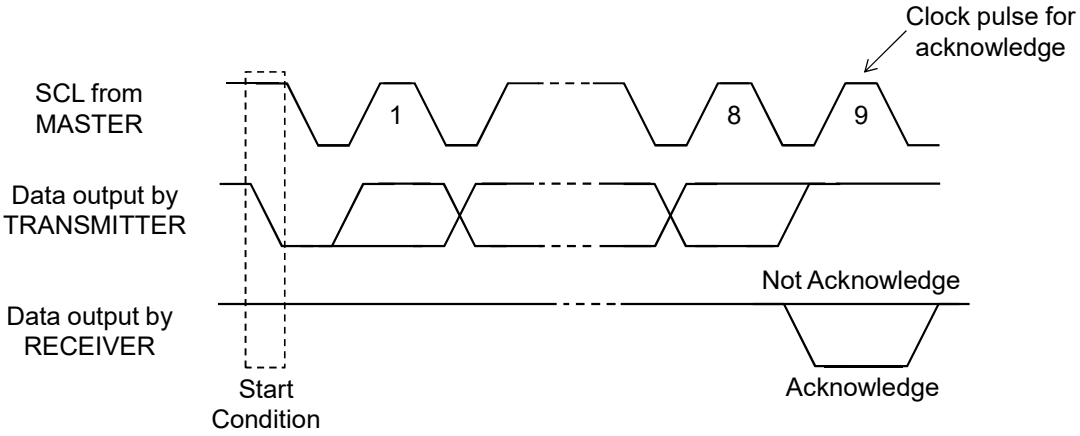
Data transfer begins by bus master indicating a start condition (ST) of a falling edge on SDA when SCL is high. The master terminates transmission and frees the bus by issuing a STOP condition (SP). Stop condition is a rising edge on SDA while SCL is high. The bus remains active if a repeated START (SR) condition is generated instead of a STOP condition. Figure 7 illustrates the START and STOP condition.

Figure 7: I2C START and STOP condition



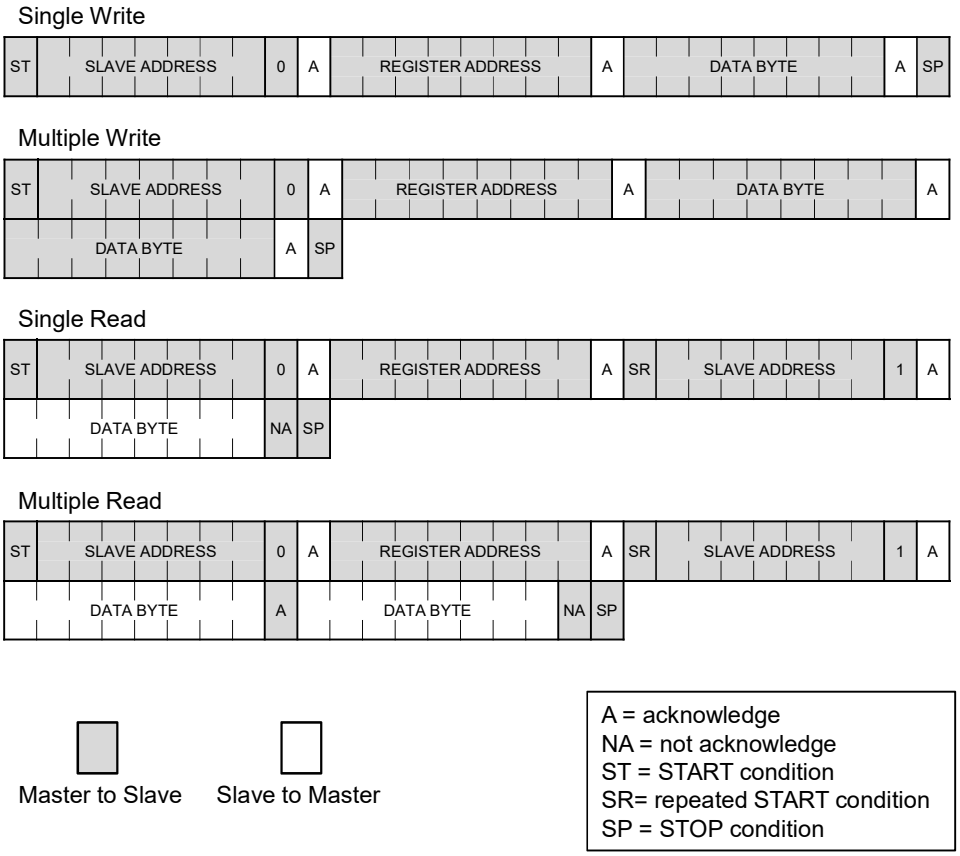
After a start condition (ST), the 7-bit slave address + RW bit must be sent by master. If the slave address does not match with GMP106, there is no acknowledge and the following data transfer will not affect GMP106. If the slave address corresponds to GMP106, it will acknowledge by pulling SDA to low and the SDA line should be let free by bus master to enable the data transfer. The master should let the SDA high (no pull down) and generate a high SCL pulse for GMP106 acknowledge. Figure 8 illustrates the acknowledge signal sequence.

Figure 8: Acknowledge signal sequence



A write to GMP106 includes transmission of a START condition, the slave address with R/W bit=1'b0, one byte of data to specify the register address to write, subsequent one or more bytes of data, and finally a STOP condition. "Single Write" and "Multiple Write" in Figure 9 illustrates the frame format of single and multiple write to GMP106 respectively.

Figure 9: I2C access format: standard and fast mode



A read from GMP106 starts with transmission of a START condition, the slave address with R/W bit=1'b0, and one byte of data to specify the register address to read. A repeated START condition and the slave address with R/W bit=1'b1 are transmitted subsequently. The slave address with R/W bit=1'b1 initiates a read operation. GMP106 acknowledge receipt of the read operation

command by pulling SDA low during the 9th SCL clock and begin transmitting the contents starting from the specified register address. The master must acknowledge all correctly received bytes except the last byte. The final byte must be followed by a not acknowledge from the master and the STOP condition. “Single Read” and “Multiple Read” in Figure 9 illustrates the frame format for reading single or multiple byte from GMP106.

I2C Specifications

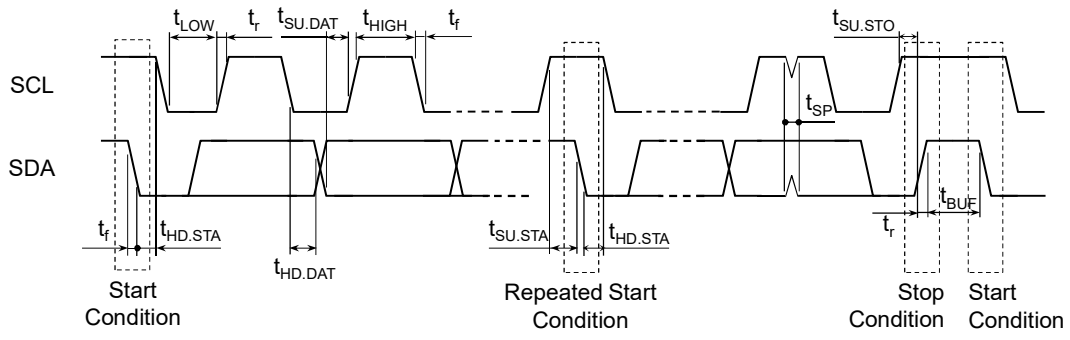
Table 5: I2C Timing Specification: Standard Mode

Parameter	Symbol	Minimum	Typical	Maximum	Unit
SCL clock frequency	f_{SCL}	—	—	100	kHz
Clock low period	t_{LOW}	4.7	—	—	µs
Clock high period	t_{HIGH}	4	—	—	µs
Start hold time	$t_{HD.STA}$	4	—	—	µs
Start setup time	$t_{SU.STA}$	4.7	—	—	µs
Data-in hold time	$t_{HD.DAT}$	0	—	—	µs
Data-in setup time	$t_{SU.DAT}$	250	—	—	ns
Stop setup time	$t_{SU.STO}$	4	—	—	µs
Rise time	t_r	—	—	1	µs
Fall time	t_f	—	—	0.3	µs

Table 6: I2C Timing Specification: Fast Mode

Parameter	Symbol	Minimum	Typical	Maximum	Unit
SCL clock frequency	f_{SCL}	—	—	400	kHz
Clock low period	t_{LOW}	1.3	—	—	µs
Clock high period	t_{HIGH}	0.6	—	—	µs
Bus free to new start	t_{BUF}	1.3	—	—	µs
Start hold time	$t_{HD.STA}$	0.6	—	—	µs
Start setup time	$t_{SU.STA}$	0.6	—	—	µs
Data-in hold time	$t_{HD.DAT}$	0	—	—	µs
Data-in setup time	$t_{SU.DAT}$	100	—	—	ns
Stop setup time	$t_{SU.STO}$	0.6	—	—	µs
Rise time	t_r	—	—	0.3	µs
Fall time	t_f	—	—	0.3	µs
Spike width	t_{SP}	—	—	50	µs

Figure 10: I2C Timing Diagram: Standard and Fast Mode



Package

Outline Dimension

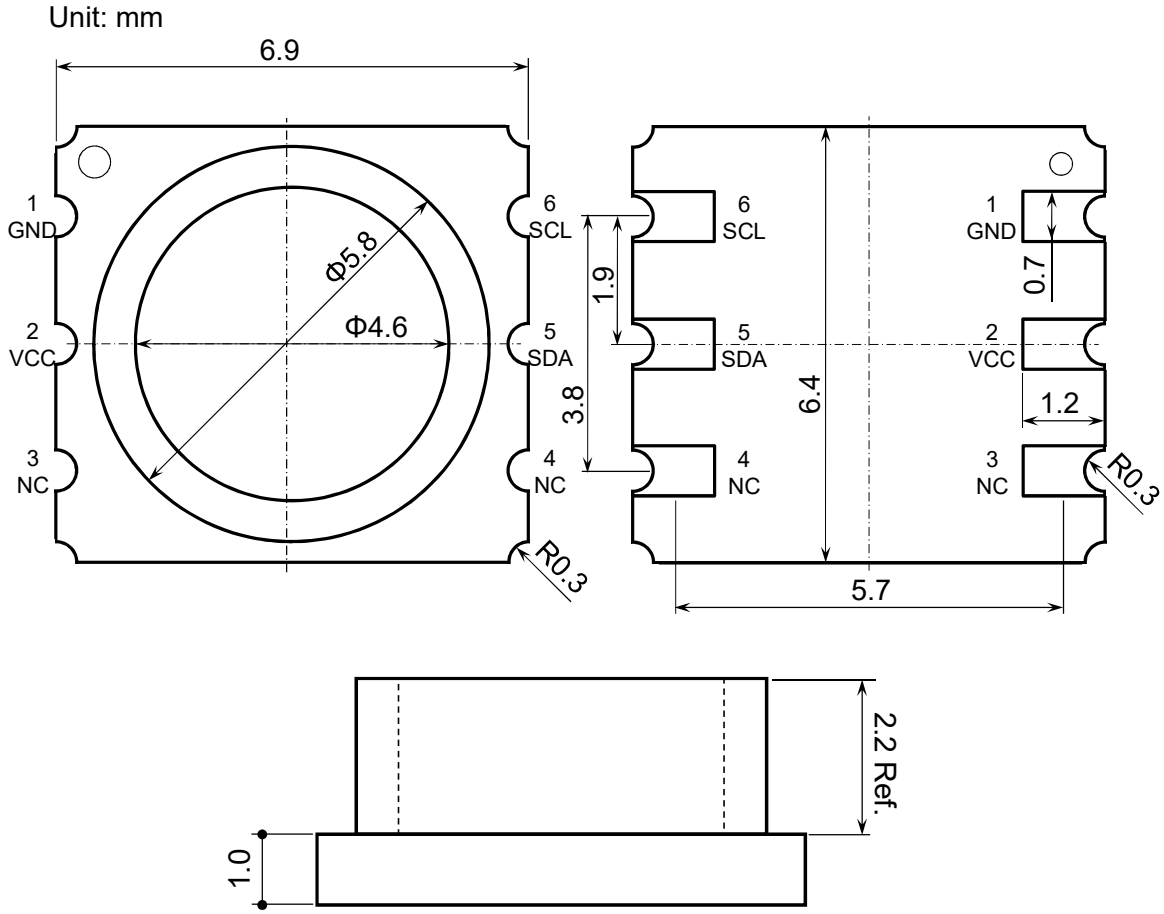


Figure 11: Package Outline Dimension

Recommended PCB Foot Print Layout

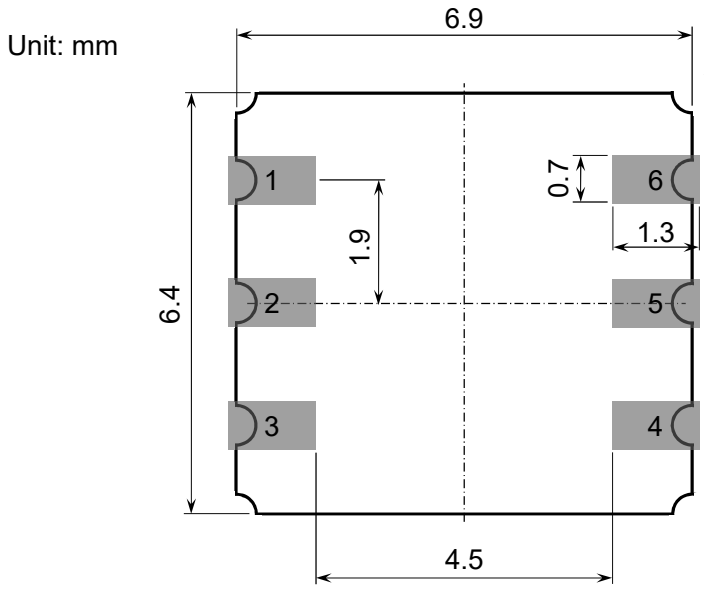


Figure 12: Layout Recommendation for PCB Land Pad

RoHS Compliance

GMP106 package is compliant with Restrictions on Hazardous Substances (RoHS), having halide-free molding compound (green) and lead-free terminations. Reflow profiles applicable to those processes can be used successfully for soldering the devices.

Moisture Sensitivity Level

GMP106 package MSL rating is Level 3.

Document History and Modification

Revision No.	Description	Date
V0.1	Preliminary first release	2018/2/7