TRUEYES

Carbon Dioxide (CO2) Gas Sensor

Rev. 2.5

TG100 User Manual

The TG100 measuring carbon dioxide (chemical formula CO2) is a NDIR (Non-Dispersive Infrared) gas sensor. As it is contactless, it has high accuracy and longer life than sensors having a different way. This sensor has been developed with standard gas and is efficiently calibrated using our state of the art gas sensor calibration technology. Furthermore, this sensor comes with Serial Communi cation (UART), I²C interface and Analog Output. So, CO2 density can be checked using these inter faces easily.

Features

- NDIR Gas Sensor
- High Precision
- Long Life span
- Compact size, 37 x 28 mm

Model : TG100 Series

Interfaces

- UART, 38400 Baud Rate
- I²C Interface
- Analog Output
- Status LED
- GPIOs for calibration.

Specifications

Table 1. Electrical Specifications

Parameter	Symbol	Min	Typ.	Max	Unit	Notes
Regulated DC Power Supply is used, Test Condition : $V_{DD} = 5\,V$						
Power Supply	V_{DD}	4.9	5	5.1	V	
Current Consumption	I_{DD}	12	-	25	mA	ready state
	I_{DD}	100	-	190	mA	while gas measurement

*** The noise on power supply may cause incorrect measurement.**

Table 2. Sensor Specifications

Parameter	Symbol	Min	Typ.	Max	Unit	Notes
Measuring Range		0	-	10k	ppm	
Accuracy		±5% ±30ppm				+degree C
		±7% ±50ppm				-degree C
Detection Limit		-	10	-	ppm	(Resolution @ 0ppm region)
Response Time	$t_{1/e}$	-	-	18	sec	
	t_{90}	-	-	30	sec	

Operating Temperature	T_O	$*T_{OL}$	-	$*T_{OH}$	℃	

*** T_{OL} and T_{OH} are mentioned at ordering guide on Page 16. Refer the ordering guide page.**

Storage Temperature	T_S	-30	-	70	℃	
Operating Humidity	H	0	-	95	%,RH	Non Condensing

Warming-Up Time	t_w	30	120	-	sec	for accuracy
Data Sampling Time	t_s	-	2	-	sec	Pulse Operation

Table 3. UART Interface Specifications

Parameter	Symbol	Min	Typ.	Max	Unit	Notes
Recommended Request Time	T_{UR}	0.5	1	-	sec	
Transmitted Time	T_{UT}	-	2	-	sec	
Acceptable TTL Signal High Level	V_{HU}	2.31	3.3	5	V	TXD, RXD
Acceptable TTL Signal Low Level	V_{LU}			0.99	V	TXD, RXD

Table 4. I²C Interface Specifications

Parameter	Symbol	Min	Typ.	Max	Unit	Notes
Operating Frequency	f_{I2C}	-	25	100	kHz	
Request Time	T_{I2C}	1	-	-	ms	
Acceptable TTL Signal High Level	V_{HI}	2.31	3.3	5	V	SCL, SDA
Acceptable TTL Signal Low Level	V_{LI}			0.99	V	SCL, SDA

Table 5. Analog Output Specifications

Parameter	Symbol	Min	Typ.	Max	Unit	Notes
Analog Output Range	V_A	10	-	4000	mV	10mV ≒ 25 ppm
Conversion Time	T_V	-	2	-	sec	

*** The range of analog output depend on maximum value of measured ppm.**

UART Interface

This sensor comes with a serial interface for user to read ppm values. Also, several commands are supported. About commands, refer to Table 9. Also, there are examples on next page.

To use UART interface, refer to serial communication configuration in Table 6.

Table 6. Serial Communication Configuration

Baud Rate	38,400 bps
Stop Bits	1 bit
Parity Check	None
Data Length	8 bits
TTL Level	3.3V or 5V

If the communication configuration is set correctly, user will get the protocol message as mentioned below.

Table 7. Protocol Format

Byte	1	1	1	1	1	1	1	1	1	1	1	1
Value	D6	D5	D4	D3	D2	D1	<SP>	'p'	'p'	'm'	<CR>	<LF>

Table 8. Protocol Format Explanation

Value	**Description**
D6 ~ D1	Gas density is indicated as string, Maximum length is 6 bytes.
<SP>	Space : 0x20
'ppm'	'ppm' : 0x70 0x70 0x6D
<CR>	Carriage Return : 0x0D
<LF>	Line Feed : 0x0A

The number of <SP> between D6 and D1 will be different for different gas densities. So, user will get 'ppm' values in ASCII format, shown below.

To write commands, Follow the important points below to keep in mind while sending serial commands and refer to the e xamples given on page 5 and page 6.

① This protocol format conforms to ASCII format.
② Before send command, Enter command mode.
③ To enter in command mode, Send ATTN<CR><LF> and to exit, Send RUN<CR><LF>.
④ All commands should be delimited by<CR><LF>.

Table 9. UART Command Table

Code	**Description**
ACAL	Period of automatic calibration can be changed.
MCAL	Manual Calibration is requested.

Getting Started with UART Commands

User can communicate with sensor using PC software / terminal program or another device. Which supports serial communication on same baud rate as mentioned in serial interface specification. If user has connected their serial device correctly, they will receive string message from sensor. The message will be transmitted at intervals of about two seconds.

Example

```
RX> <SP>643<SP>ppm<CR><LF>
```

Example 1. ASCII Code Message

Example

```
RX> 20 36 34 33 20 70 70 6D 0D 0A
```

Example 2. HEX Code Message

Entry Command Mode

To use any command, sensor should be entered in command mode.
To enter in command mode, user should send ATTN<CR><LF>. Otherwise, the commands will not recognized by the sensor.

Example

```
TX> ATTN<CR><LF>
RX> ATTN<CR><LF>
RX> <ACK>
```

Example 3. ATTN Message

Exit Command Mode

To exit from the command mode, user should send RUN<CR><LF>. When user is not using serial interface, to continue with normal running mode.

Example

```
TX> RUN<CR><LF>
RX> RUN<CR><LF>
RX> <ACK>
```

Example 4. RUN Message

Command Mode

ACAL<Value><CR><LR>

About automatic calibration, The information is on Page 12. Read the page before use this command.

The period of automatic calibration can be changed using this command. To use this command, the period should be selected one of 7 days or 30 days. Then, it should be put at the <Value>. Refer to Example 5.

Example

```
TX> ACAL07<CR><LF>
RX> ACAL07<CR><LF>
RX> ACAL_ONE_WEEK<CR><LF>
RX> <ACK>
```

Example 5. ACAL 7 days Message

MCAL=<Value><CR><LR>

At Page 13, There are instructions about manual calibration. Read the instructions before use this command.

When ppm value is put that user wants, Sensor will response like Example 6 message mentioned below. It means that manual calibration is started. And then when manual calibration is finished, sensor will response like Example 7 message.

Example

```
TX> MCAL=500<CR><LF>
RX> MCAL=500<CR><LF>
RX> MCAL<SP>ON<SP>:<SP>500<SP><CR><LF>
RX> <ACK><ACK>
```

Example 6. Starting MCAL Message

Example

```
RX> MCAL<SP>activated<CR><LF>
```

Example 7. Finishing MCAL Message

I²C Interface

This sensor communicates with the host controller, over a digital I²C interface. The 7-Bit base slave address is **0x31**.

Table 10. I²C Slave Address Byte

Bit	7	6	5	4	3	2	1	0
Data	0	1	1	0	0	0	1	R/W
* R/W : Read = 1, Write = 0								

Master I²C device communicates with our sensor, using a command structure. The commands are listed in, Table 11. Commands, other than those documented below are undefined and should not be sent to the device.

Table 11. I²C Command Table

Command	Data	Description
0x52	7 Byte	Read PPM and state of manual calibration
0x53	2 Byte	Request a manual calibration
0x55	2 Byte	Set a period of automatic calibration

Inside sensor, there are pullup resistors on each I²C line. Refer to the circuit below.

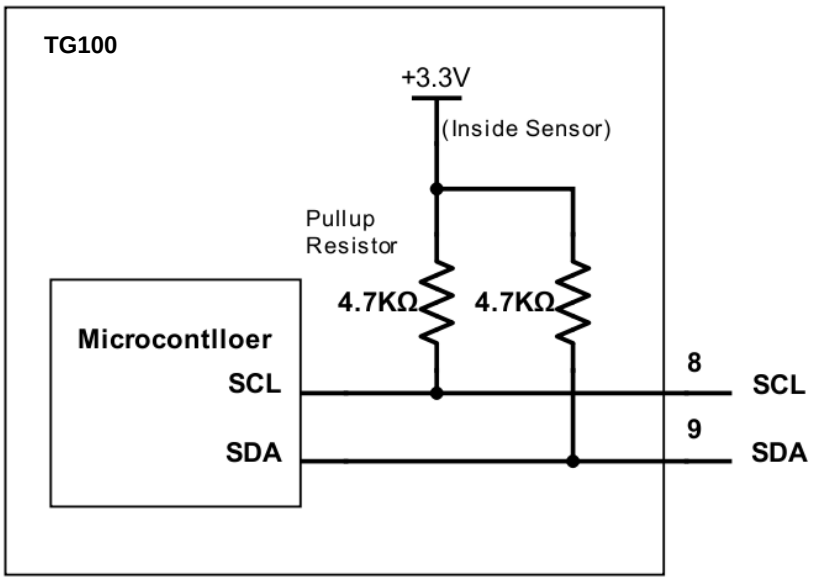


Figure 1. I²C Circuit Inside Sensor

Getting Started with I²C Commands

In the I²C sequence diagrams in the following sections, bits produced by the master and slave are color coded as shown :

Master	Slave

Table 12. I²C Bit Descriptions

Value	Symbol	Description
START	S	SDA goes low while SCL high
STOP	P	SDA goes high while SCL high
READ	R	Read bit = 1
WRITE	W	Write bit = 0
ACK	A	Acknowledge
NACK	NA	No acknowledge

I²C Sequence Diagrams

S	Slave Address	W	A	COMMAND	A	DATA n	NA	P

Figure 2. I²C Write Packet

S	Slave Address	R	A	COMMAND	A	DATA n	NA	P

Figure 3. I²C Read Packet

Data Read Mode

The write packet should be transmit before request the data packet. Then, it follow the I²C sequence diagrams above read pac ket format. Refer to the DATA packet below.

Table 13. Data Packet in the data read mode

DATA Number	0	1	2	3	4	5	6
Description	Configuration	PPM		Period ACAL	MCAL State	ACAL State	Reserved
Byte	0x80 (fixed)	0x0000 ~ 0x2710		0x07 (7days) 0x30 (30days)	0x00 (Ready) 0x01 (Run)	0x00 (Disable) 0x01 (Enable)	0x00 (Fixed)

The default value is **"0x30"**. It is unrelated to **"ACAL State"**.

The ACAL State can be changed using Hardware Pin, refer to Page 12.

Request Manual Calibration

At Page 13, There are instructions about manual calibration. Read the instructions before use this command.

This mode follows the write packet format on Page 8. And refer to the data packet below.
To run the manual calibration, Put value that user wants. Then, As read a data packet, user can check a state that whether manual calibration is running or not.

Table 14. Data Packet to set manual calibration

DATA Number	0	1
Description	Set ppm value	
Byte	0x0190~0x2710	

Set Period of Automatic Calibration

At Page 12, There are instructions about automatic calibration. Read the instructions before use this command.

This mode follows the write packet format on Page 8. And refer to the data packet below.

Table 15. Data Packet to write a period

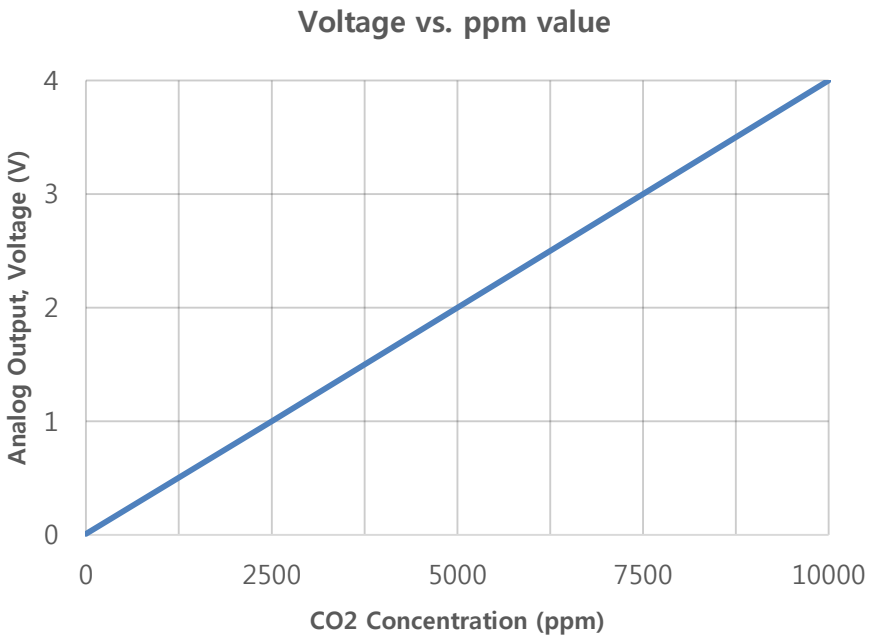
DATA Number	0	1
Description	Reserved	Period
Byte	0x00 (Fixed)	0x07 (7days) 0x30 (30days)

Analog Output

This sensor has analog output to read ppm value. To read ppm value, the analog voltage value should be convert to ppm value. Refer to Function 1.

$$ppm = 0.0004 \times V_{Analog\ Output}$$

Function 1. Voltage to ppm



Graph 1. I²C Write Packet

In case of analog output, the accuracy of ppm may be different when compared with other interface.

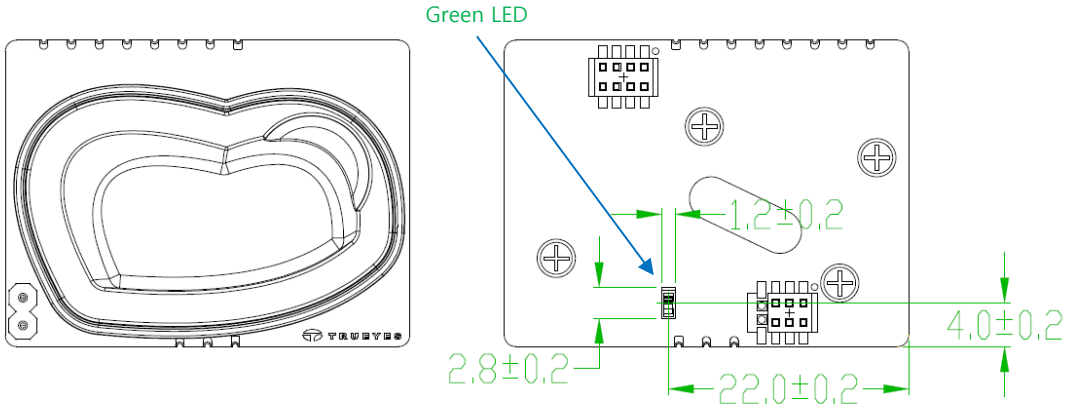
Check LED

This sensor has one led on the bottom. User can check the state of sensor easily. The led will be light up in mentioned situ ations below. Refer to the conditions.

- Conditions when the green led is light up.

① When sensor responses after receive any data trough UART, the led will be twinkled.
② When manual calibration is running, the led will be light up until finish the calibration.

As see the Dimension 1, user can know the location of green led.



Dimension 1. Green LED Position

ABC (Automatic Calibration)

This sensor was calibrated in a factory. But, it will be recalibrate monthly to get the accuracy of ppm. It mean if the ABC is enabled, sensor will have these operation. If user wants to disable the ABC, use a hardware pin. As use a hardware pin, the ABC can be disabled easily. Refer to instruction at Table 1 and Figure 4.

If UART or I²C is used, the period can be changed. In the initial state, the period is one month. It will be selected as one week or one month.

How to Enable and Disable the ABC function

Table 16. Hardware State vs ABC State

Hardware State	Description
Open	ABC is Enabled
Short	ABC is Disabled

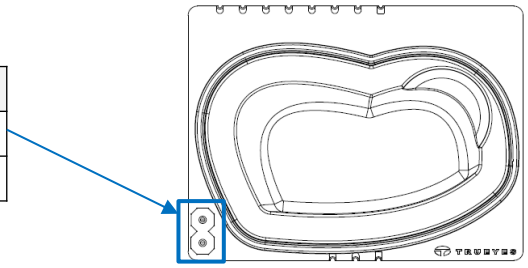


Figure 4. Hardware Pin Location

To change the period of ABC, use a UART or I²C at Page 6 (UART), Page 9 (I²C), there are instructions that how to use.

Table 17. ABC Period

Period
7 days
30 days (Default)

Manual Calibration

If user wants recalibrated data manually, this sensor can be calibrated as use a manual calibration function.
To use manual calibration, Please, Read all comments and cautions very carefully.

CAUTIONS

※ Please, Make sure that air conditions should be stabilized. It means that the CO2 density and temperature should be stabled in vicinity of sensor.

If manual calibration is run with unstable air conditions, calibration run time will be increased. Furthermore, the sensor data after finishing such manual calibration may be incorrect.

Manual Calibration Sequence

① Request a manual calibration command using Hardware Pin (Page 13) or UART (Page 6) or I²C (Page 9) interface.

② When sensor receives requested command, the manual calibration will be started. User can check it by watching Green LED glowing up during calibration process. Also, it can be checked through UART or I²C communication.

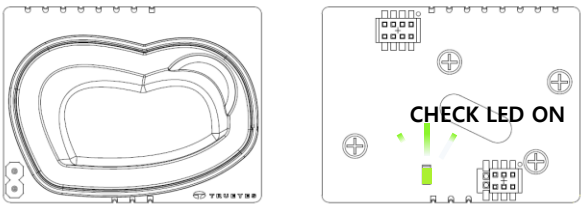


Figure 5. Green LED glowing up while manual calibration.

How to use Hardware Pin

At the moment, when the MCAL pin is connected to GND (at the falling edge), this sensor will start the manual calibration with set default value **(default value = 400 ppm)** and it will be ended automatically after calibration time. Which is depen dent on surrounding conditions.

So, in Figure 6, it is shown when the switch (SW) is pressed, the manual calibration will be started.

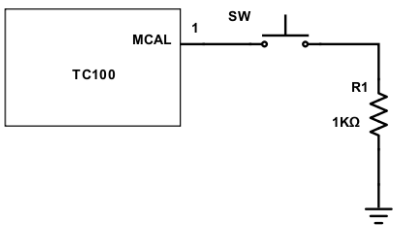
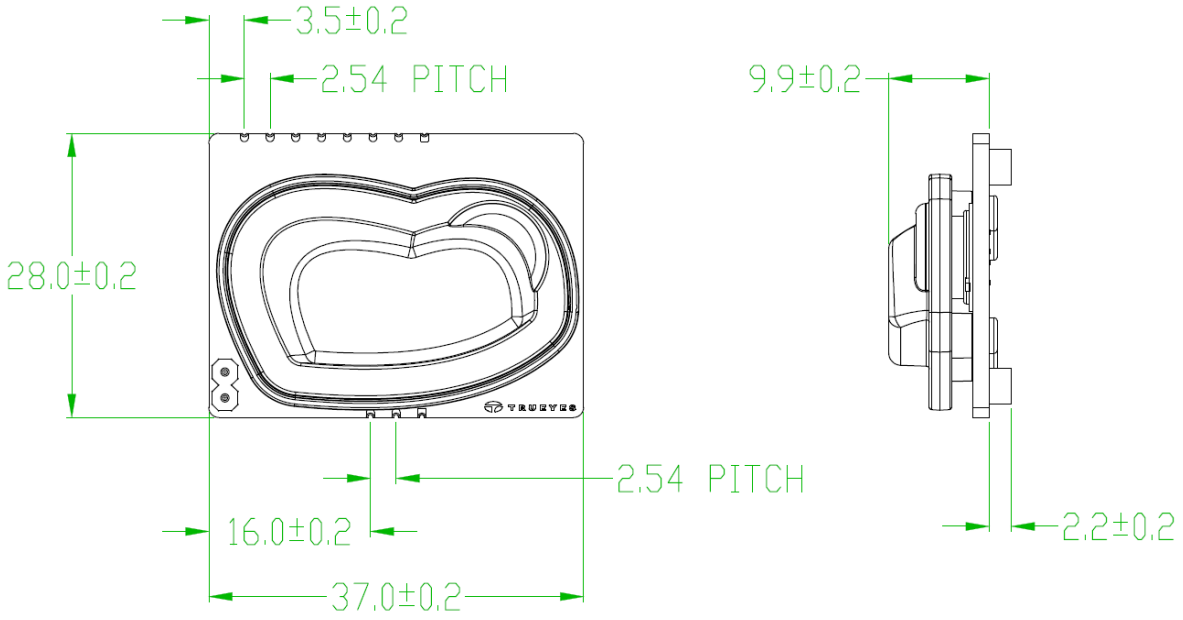


Figure 6. Manual Calibration Application Circuit, in case of using external hardware

Package Dimension



Dimension 2. Product Dimension

※ Caution : Do not attempt to reassemble or give physical stress while handling.

Pin Description - TOP

Table 18. Upper Pin Description

No.	Pin Assigned
1	Analog Output
2	GND
3	UART TXD →
4	UART RXD ←
5	I²C SDA
6	I²C SCL
7	GND
8	V_{DD}

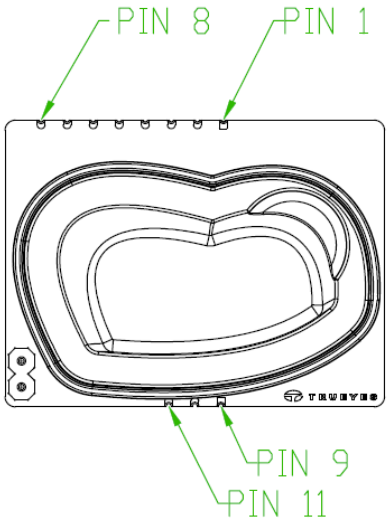


Figure 7. Assigned Pin on Top

Table 19. Lower Pin Description

No.	Pin Assigned
9	GND
10	GND
11	GND

Pin Description - BOTTOM

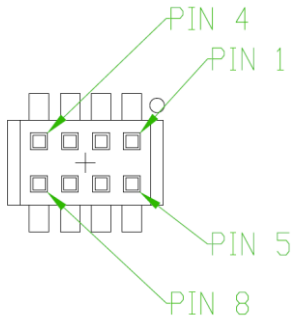


Figure 8. 4x2 Pin Header, 1.27mm SMD Type

Table 20. Upper Connector-1

No.	Pin Assigned
1	I²C SDA
2	I²C SCL
3	GND
4	V_{DD}

Table 21. Upper Connector-2

No.	Pin Assigned
5	UART RXD ←
6	UART TXD →
7	GND
8	Analog Output

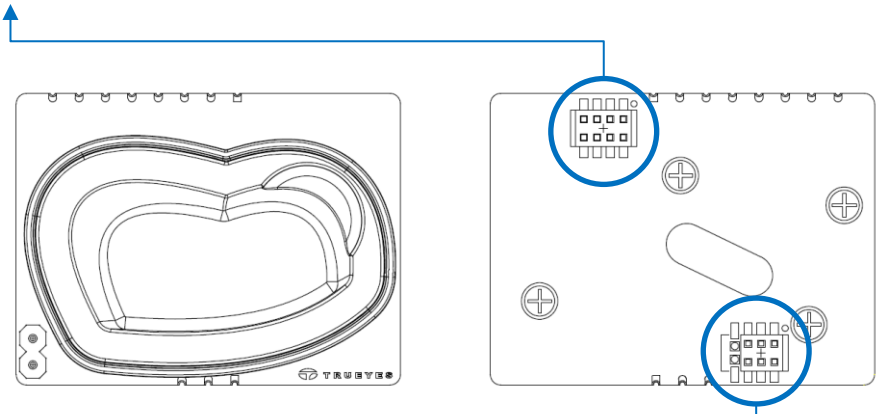


Figure 9. Assigned Pin on Bottom

Table 22. Lower Connector-1

No.	Pin Assigned
9	GND
10	*MCAL Pin
11	Reserved
12	NC

*MCAL : Manual Calibration

Table 23. Lower Connector-2

No.	Pin Assigned
13	Reserved
14	*ABC Pin
15	Reserved
16	NC

*ABC : Manual Calibration

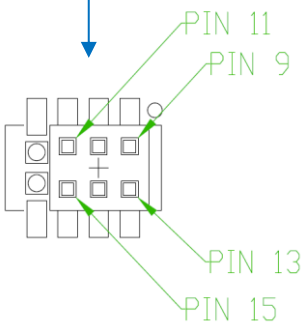


Figure 10. 3x2 Pin Header, 1.27mm SMD Type

※ Caution : Reserved pins should not be connected to anything.

Ordering Guide

Table 24. Ordering Guide

Model	Description	Supply Voltage (V_{DD})	Operating Range (℃)	
			T_{OL}	T_{OH}
TG100	NDIR Type CO2 Gas Sensor Module	5 V	0 ℃	50 ℃
TG100-R	NDIR Type CO2 Gas Sensor Module	5 V	-20 ℃	50 ℃
TG100-R2	NDIR Type CO2 Gas Sensor Module	5 V	-25 ℃	50 ℃
TG100-R3	NDIR Type CO2 Gas Sensor Module	5 V	-35 ℃	50 ℃

*** The "R" denotes what product can operate in temperatures below zero like a refrigeration system.**

Revision History

Table 25. Revision History

Revision	Description	Date	Author
2.3	Last Version	-	-
2.4	The previous version is destroyed because modified template and major parameters. Major changed contents : - Electrical Spec. was changed. - Details about interface, dimensions were added	January 5 2018	JH Yi
2.5	The pitch value at the dimension section was modified. - Changed : 2.5±0.2 ⇒ 2.54 PITCH Specific define for resolution (@0ppm)	January 8 2018	JH Yi

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