ZG09 CO2 Module

User Manual

Issued

Version	Date	Author	Description
1	Oct 2 2018	JamesHuang	Review by Radiant.

Contents

1 General Description

This document describes the user guide of ZG09 Series.
This is a preliminary specification, any update might without notification.

2 Abbreviations and Terminology

EEP	Electrically-Erasable Programmable Read-Only Memory
REG	Register
RMS	Root Mean Square
PWM	Pulse Width Modulation
I^2C	Inter-Integrated Circuit
HVAC	heating, ventilation and air conditioning
RDU	Remote Terminal Unit

3 Features of Design

使用雙光束 NDIR 感測器

氣體採樣兼容擴散式與通氣式
超越室內空氣品質需求，量測範圍可達 0-10000ppm
支援 UART、RS485、I^2C、PWM、DAC 輸出格式

4 Specification

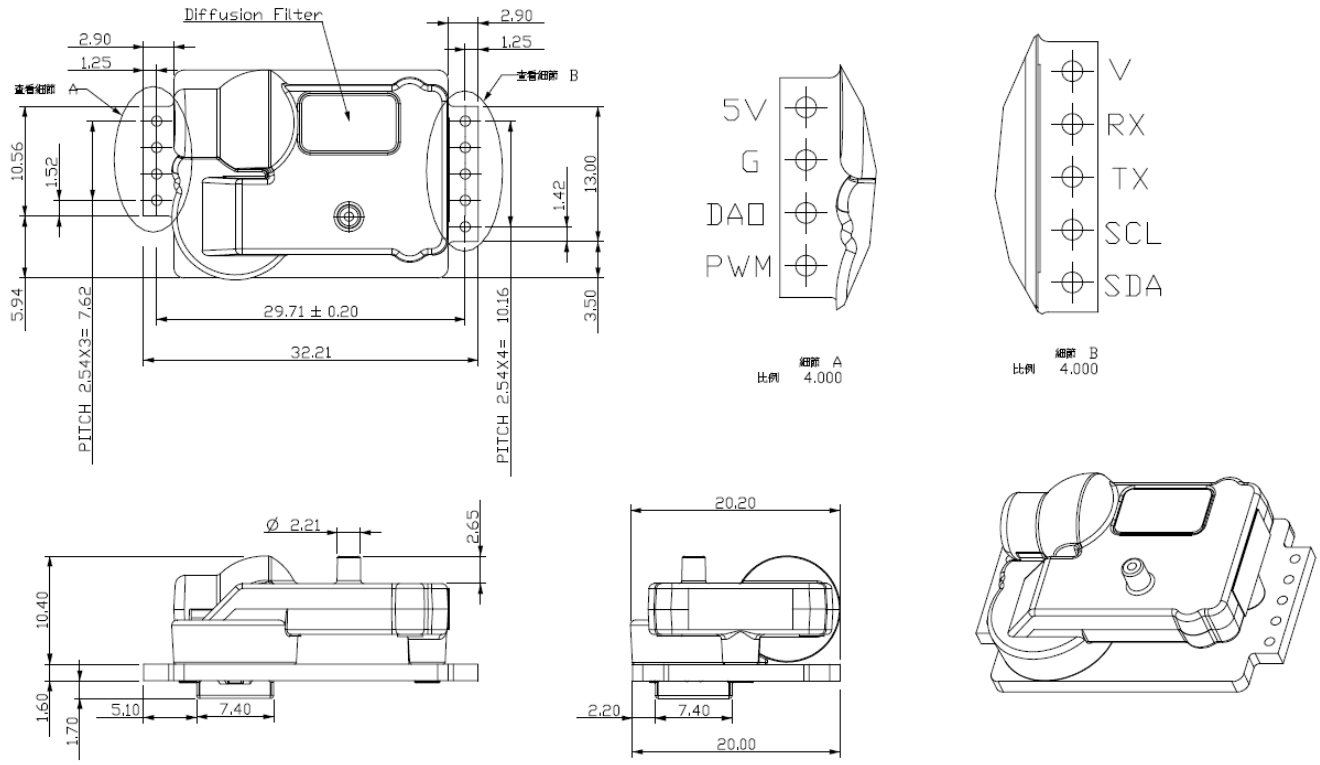
CO2 量測範圍	0-10000 ppm
量測周期	2 sec
CO2 精度(Accuracy)	±50 ppm ± 3% of reading
CO2 RMS 雜訊	<10 ppm @ 400 ppm <20 ppm @ 1000 ppm
CO2 再現性(Repeatability)	±20 ppm
解析度(Resolution)	1ppm
響應時間	擴散式約 1min (90% Rise Time)
Pressure Dependence	0.13% of reading per mm Hg
暖機時間(冷啟動) @ 25°C	30 sec
供應電壓	5.0 VDC ±0.5 supply

最大耗電流(0.8 ms 截取測試)	<190 mA
紅外線關閉平均耗電流	<10 mA
整體平均耗電流	<34 mA
操作溫度	0~50°C
儲存溫度	-20~60°C
操作濕度	0-95% RH
儲存濕度	0-95% RH
外觀尺寸	32.2mm x 20.2mm x 10.4mm

通訊

UART	3.3V level Modbus RTU protocol
RS485	SCL pin for 485 R/T control pin
I^2C	Max. clock 400 kHz
PWM	3.3V level at 1 kHz
DAC output	0-1V = 800-1200 ppm

ZG09 接腳尺寸圖



注意：圖片尺寸僅供參考，實際尺寸以標示為主

Fig1. 模組外觀尺寸圖

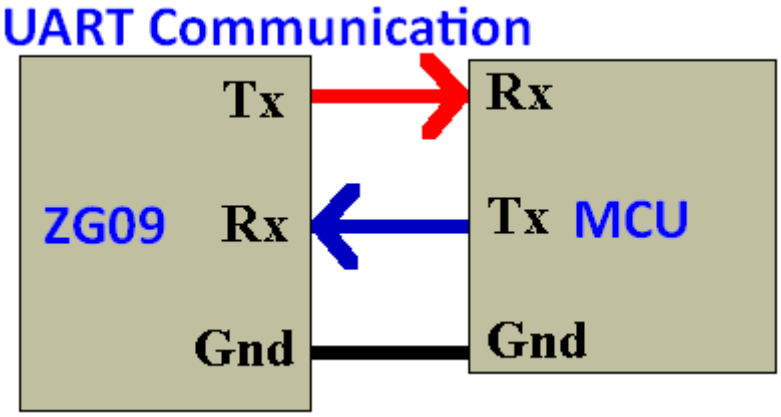
接腳說明

接腳名稱	功能
PWM	CO2 ppm PWM output
DAO	DAC output
G	Ground
5V	Power input +5V
SDA	I2C Data pin、0/400ppm calibration pin
SCL	I2C Clock pin or 485 R/T control pin
TX	UART TX
RX	UART RX
V	3.3V output 僅給小功率電路使用，如影響量測精度請額外提供 3.3V 電源。

5 UART

UART 預設 default

BPS: 9600、Data Bit: 8、Parity bit: None、Stop bit: 1



通訊協定(protocol)

ZG09 series UART 使用的是 Modbus RTU 協議，指令結構分成發送(Send)與接收(Receive)，如下：

發送(Send)

ID 編號 (1 Byte)	Function code 功能碼 (1 Byte)	Starting 起始位址 (2 Bytes)	Quantity 讀取資料量 (2 Bytes)	CRC 檢查 (2 Bytes)
0FEH	03H	000BH(註 1)	0001H	XXXX

发送:FE 03 00 0B 00 01 E1 C7

接收:FE 03 02 01 C8 AC 56　　CRC=56AC

接收(Receive)

ID 編號 (1 Byte)	Function code 功能碼 (1 Byte)	Byte count 讀回資料量 (1 Byte)	Register value 資料內容 (N Bytes)	CRC 檢查 (2 Bytes)
0FEH	03H	06H (註 2)	6 * 8 bit (註 3)	XXXX

Example: CO2 read sequence in Function 3

Master Transmit:

Function code	1Byte	0x03
Starting Address	2Bytes	0x0000 to 0xFFFF
Quantity of Registers	2Bytes	1 to 125 (0x7D)

<ID> <Function code> <Starting address $byte_0$ + Starting address $byte_1$> <$data\_byte_0$ + $data\_byte_1$> <CRC $byte_0$ + CRC_byte_1>

<FE> <03> <00> <0B> <00> <01> <E1> <C7>

Slave Reply:

Function code	1Byte	0x03
Byte count	1Byte	2 x N*
Register value	N* x 2 Bytes	

*N = Quantity of Registers

<ID> <Function code> < Byte count $byte_0$> <$data\_byte_0$　$data\_byte_n$> <CRC byte0 + CRC byte1>

<FE> <03> <02> <02> <8D> <6D> <55>

028Dh=653ppm

Error:

Error code	1Byte	0x83
Exception code	1Byte	01 or 02 or 03 or 04

註 1：起始位址 = 想要讀取該筆資料的位址，例如：CO2 值 = 0x0B (參見起始位址表)
註 2：讀回資料量 = 資料內容的長度(N)
註 3：接收的資料內容的長度(N) = 發送的讀取資料量 x 2
0x03 Read hold register
0x04 Read input register
0x06 Write

CRC 程式範例:

檢查碼

```
unsigned int Crc16(unsigned char * data, unsigned char length)
{
   int      j;
   unsigned int reg_crc=0xFFFF;
   while(length--)
   {
         reg_crc       ^= *data++;
         for(j=0;j<8;j++)
         {
               if(reg_crc & 0x01) /* LSB(b0)=1   */
                     reg_crc=reg_crc     >>1    ^ 0xA001;
               else
                     reg_crc=reg_crc     >>1;
         }
   }
   return reg_crc;
}
```

檢查碼 (查表法)

```
unsigned int Crc(unsigned char *ucTx, unsigned int Len)
{
if    (Len && ucTx)
      {
      unsigned char *ucPtr=ucTx;
      unsigned char ucCRCHi = 0xff;
      unsigned char ucCRCLo = 0xff;
      unsigned uIndex;
      while(Len--)
          {
          uIndex = ucCRCHi ^ *ucPtr++;
          ucCRCHi = ucCRCLo ^ ucCRCHigh[uIndex];
          ucCRCLo = ucCRCLow[uIndex];
          }
      return (unsigned int)(ucCRCLo << 8) | (unsigned int)ucCRCHi;
      }
   else
      return 0;
}

unsigned char ucCRCHigh[] =
{
   0x00,0xc1,0x81,0x40,0x01,0xc0,0x80,0x41,0x01,0xc0,0x80,0x41,0x00,0xc1,0x81,
   0x40,0x01,0xc0,0x80,0x41,0x00,0xc1,0x81,0x40,0x00,0xc1,0x81,0x40,0x01,0xc0,
   0x80,0x41,0x01,0xc0,0x80,0x41,0x00,0xc1,0x81,0x40,0x00,0xc1,0x81,0x40,0x01,
   0xc0,0x80,0x41,0x00,0xc1,0x81,0x40,0x01,0xc0,0x80,0x41,0x01,0xc0,0x80,0x41,
   0x00,0xc1,0x81,0x40,0x01,0xc0,0x80,0x41,0x00,0xc1,0x81,0x40,0x00,0xc1,0x81,
   0x40,0x01,0xc0,0x80,0x41,0x00,0xc1,0x81,0x40,0x01,0xc0,0x80,0x41,0x01,0xc0,
   0x80,0x41,0x00,0xc1,0x81,0x40,0x00,0xc1,0x81,0x40,0x01,0xc0,0x80,0x41,0x01,
```

```
    0xc0,0x80,0x41,0x00,0xc1,0x81,0x40,0x01,0xc0,0x80,0x41,0x00,0xc1,0x81,0x40,
    0x00,0xc1,0x81,0x40,0x01,0xc0,0x80,0x41,0x01,0xc0,0x80,0x41,0x00,0xc1,0x81,
    0x40,0x00,0xc1,0x81,0x40,0x01,0xc0,0x80,0x41,0x00,0xc1,0x81,0x40,0x01,0xc0,
    0x80,0x41,0x01,0xc0,0x80,0x41,0x00,0xc1,0x81,0x40,0x00,0xc1,0x81,0x40,0x01,
    0xc0,0x80,0x41,0x01,0xc0,0x80,0x41,0x00,0xc1,0x81,0x40,0x01,0xc0,0x80,0x41,
    0x00,0xc1,0x81,0x40,0x00,0xc1,0x81,0x40,0x01,0xc0,0x80,0x41,0x00,0xc1,0x81,
    0x40,0x01,0xc0,0x80,0x41,0x01,0xc0,0x80,0x41,0x00,0xc1,0x81,0x40,0x01,0xc0,
    0x80,0x41,0x00,0xc1,0x81,0x40,0x00,0xc1,0x81,0x40,0x01,0xc0,0x80,0x41,0x01,
    0xc0,0x80,0x41,0x00,0xc1,0x81,0x40,0x00,0xc1,0x81,0x40,0x01,0xc0,0x80,0x41,
    0x00,0xc1,0x81,0x40,0x01,0xc0,0x80,0x41,0x01,0xc0,0x80,0x41,0x00,0xc1,0x81,
    0x40
};

unsigned char ucCRCLow[] =
{
    0x00,0xc0,0xc1,0x01,0xc3,0x03,0x02,0xc2,0xc6,0x06,0x07,0xc7,0x05,0xc5,0xc4,
    0x04,0xcc,0x0c,0x0d,0xcd,0x0f,0xcf,0xce,0x0e,0x0a,0xca,0xcb,0x0b,0xc9,0x09,
    0x08,0xc8,0xd8,0x18,0x19,0xd9,0x1b,0xdb,0xda,0x1a,0x1e,0xde,0xdf,0x1f,0xdd,
    0x1d,0x1c,0xdc,0x14,0xd4,0xd5,0x15,0xd7,0x17,0x16,0xd6,0xd2,0x12,0x13,0xd3,
    0x11,0xd1,0xd0,0x10,0xf0,0x30,0x31,0xf1,0x33,0xf3,0xf2,0x32,0x36,0xf6,0xf7,
    0x37,0xf5,0x35,0x34,0xf4,0x3c,0xfc,0xfd,0x3d,0xff,0x3f,0x3e,0xfe,0xfa,0x3a,
    0x3b,0xfb,0x39,0xf9,0xf8,0x38,0x28,0xe8,0xe9,0x29,0xeb,0x2b,0x2a,0xea,0xee,
    0x2e,0x2f,0xef,0x2d,0xed,0xec,0x2c,0xe4,0x24,0x25,0xe5,0x27,0xe7,0xe6,0x26,
    0x22,0xe2,0xe3,0x23,0xe1,0x21,0x20,0xe0,0xa0,0x60,0x61,0xa1,0x63,0xa3,0xa2,
    0x62,0x66,0xa6,0xa7,0x67,0xa5,0x65,0x64,0xa4,0x6c,0xac,0xad,0x6d,0xaf,0x6f,
    0x6e,0xae,0xaa,0x6a,0x6b,0xab,0x69,0xa9,0xa8,0x68,0x78,0xb8,0xb9,0x79,0xbb,
    0x7b,0x7a,0xba,0xbe,0x7e,0x7f,0xbf,0x7d,0xbd,0xbc,0x7c,0xb4,0x74,0x75,0xb5,
    0x77,0xb7,0xb6,0x76,0x72,0xb2,0xb3,0x73,0xb1,0x71,0x70,0xb0,0x50,0x90,0x91,
    0x51,0x93,0x53,0x52,0x92,0x96,0x56,0x57,0x97,0x55,0x95,0x94,0x54,0x9c,0x5c,
    0x5d,0x9d,0x5f,0x9f,0x9e,0x5e,0x5a,0x9a,0x9b,0x5b,0x99,0x59,0x58,0x98,0x88,
    0x48,0x49,0x89,0x4b,0x8b,0x8a,0x4a,0x4e,0x8e,0x8f,0x4f,0x8d,0x4d,0x4c,0x8c,
    0x44,0x84,0x85,0x45,0x87,0x47,0x46,0x86,0x82,0x42,0x43,0x83,0x41,0x81,0x80,
    0x40
};
```

Function code 3 hold register:

Address	Name	REG/EEP	Function	Description
00H (0x00)	SlaveID	EEP、R/W	ModBus ID	ID 設定 出廠預設 0x01 1~249 for slave 250 (0xFA) and 254 (0xFE) 為廣播預留，無法設定
01H	BPS	EEP、R/W	Baud rate	Uart Parity 設定(需要 reset 或重新上電才會套用) 0x00 : 9600 (default) 0x01 : 19200 0x02 : 38400 0x03 : 57600
02H	SET	EEP、R/W	Uart Parity	Uart Parity 設定(需要 reset 或重新上電才會套用) 0x00:n82 0x01:n81 (default) 0x02:e81 0x03:o81
04H	Filter	EEP、R/W	數位濾波器	0 Enable
05H	Control mode[2]	EEP、R/W	控制模式	0:Polling mode 預設 1:Stream mode

				2:Hold mode→Off Lamp 停止量 CO2
06H	I2C ID[6]	EEP、R/W	I2C 位置選擇	1~127(07FH) for I2C slave ID，255 0FFH for SDA calibration in I/O operating and 485 R/T control pin ，0FFH (default)
07H	AtmComp	EEP、R/W	氣壓補償	1=Enable
09H	Command select	REG、W	命令選項	0:Echo 0x1234 1:Reset
0AH	Sys status	REG、R	系統狀態	Read only: 00:Starting 04:Ambinet over operating Temperature 12:CO2 low limit 13:CO2 High Limit 14:Raw Data Error 15Parameter check sum error
0BH	CO2 Value	REG、R	CO2 讀值	Read only
0CH				
0DH	湿度			
0EH	温度			
0FH	Atm Value[1]	REG、R/W	mmHg 氣壓輸入	760.0mmHg(default)
10H	Atm Meter[1]	REG、R/W	高度輸入	0meter(default)
11H	Atmhpa[1]	REG、R/W	Hpa 氣壓輸入	1013hpa (default)
14H	Control mode[2]	REG、R/W	控制模式(暫存)	0:Polling mode 1:Stream mode 2:Hold mode
15H	AL1[3]	EEP、R/W	Lower limit concentration for alarm signal	0~10000ppm
16H	AL2[3]	EEP、R/W	Upper limit concentration for alarm signal	0~10000ppm
1BH	SN0	EEP、R	序號 MSB	16bits Hex code
1CH	SN1	EEP、R	序號 LSB	16bits Hex code
1DH				
1EH	ABC co2 Target	EEP、R/W	環境 CO2 值	0~1000ppm，400ppm(default)
1FH	ABC Day Set	EEP、R/W	ABC 調整週期	0-30days 建議設置為 8(default)
20H	CO2 offset	EEP、R/W	CO2 Offset adjustment	新讀值=現在 CO2 值±1000ppm，0ppm(default)
21H	CO2 Gain	EEP、R/W	Gain range =0.7~1.3	數學公式：新讀值=現在 CO2 值*Gain 增益(21H)+offset 偏移(20H) 0.7=7000 1.0=10000(default) 1.3=13000
28H	Cali Set[4]	REG、W	Any concentration of Gas calibration	0-1000ppm
29H	Calln Value Set1[5]	EEP、R/W	400ppm calibration by SDA pin	SDA=0，5-8sec for 400ppm offset
2AH	Calln Value Set2[5]	EEP、R/W	0ppm calibration by SDA pin	SDA=0，>16sec for 0ppm
2FH	ABC Tune Speed[7]	EEP、R/W	每次 ABC 調整範圍	100ppm/day (default)，1~300ppm
7FH	RhOffset			
80H	AmbOffset			

Note1: 氣壓 mmHg、hpa、高度擇一輸入，ZG09 會採用最後一次傳入的值做為計算使用，因此不論輸入任一種單位或高度，ZG09 都會轉換為內部計算所需的值。

(1) Air pressure input Air Pressure(mmHg)、Altitude mode(meters)、Air pressure input (hPa)

(a) Read Air Pressure(mmHg) default 760mmHg

Master Transmit:

<FE> <03> <00> <0F> <00> <01> <A0> <06>

Slave Reply:

<FE> <03> <02> <1D> <B0> <A4> <B4>

1DB0=7600=760.0mmHg

(b) Write Air Pressure(mmHg) Example input: 730mmHg

Master Transmit:

<FE> <06> <00> <0F> <1C> <84> <A5> <65>

Slave Reply:

<FE> <06> <00> <0F> <1C> <84> <A5> <65>

當寫入 Air pressure (0FH) 730mmHg 同時計算與轉換並存入相對的 Altitude mode(10H) meters、Air pressure input (11H) hPa

Read (10H) check Altitude meter value

Master Transmit:

<FE> <03> <00> <10> <00> <01> <91> <C0>

Slave Reply:

<FE> <03> <02> <0C> <EA> <28> <DF>

0CEA=3306=330.6meters

Read (11H) check Air Pressure hpa value

Master Transmit:

<FE> <03> <00> <11> <00> <01> <C0> <00>

Slave Reply:

<FE> <03> <02> <03> <CD> <6D> <35>

03CD=973hpa

Note2:

Control mode set has two way, use Addr=5(0x05) Set will set to EEPROM,Power Reset will Keep the Set.

Use addr =20 (0x14) Set will only set to Register,Power Reset will clearn the set.

(2) Control mode write into EEPROM

(c) 0: Polling mode: 就是一問一答為 ModBus 標準模式

Polling mode operating sequence

Master Transmit:

<FE> <06> <00> <05> <00> <00> <8D> <C4>

Slave Reply:

<FE> <06> <00> <05> <00> <00> <8D> <C4>

Make sure the settings are correct and the device is running in polling mode.

(d) Stream mode: 主動發送每 2sec 發送一次

ID 編號 (1 Byte)	Function code 功能碼 (1 Byte)	Byte count 起始位址 (1 Bytes)	CO2 data 讀取資料量 (2 Bytes)	Amb data 讀取資料量 (2 Bytes)	CRC 檢查 (2 Bytes)
00H	64H	04H	0291H	0B85H	7422H

Stream mode operating sequence:

Master Transmit:

<FE> <06> <00> <05> <00> <01> <4C> <04>

This command is written to the EEPROM power off is not canceled must be written to the polling mode

Slave Reply:
<FE> <06> <00> <05> <00> <01> <4C> <04>
Make sure the settings are correct and the device is running in Stream mode.

After the command is confirmed, the CO2 value and the Sensor temperature value are returned every 2 seconds.
<00> <64> <04> <02> <91> <0B> <85> <74> <22>
0291=657ppm
0B85=29.49℃，收到 Sensor 溫度需除 100 才為實際溫度(單位為 1/100 ‘C)

(e) Hold mode: CO2 暫停量測，恢復量測需重設為 Polling 或 stream mode。
Hold mode operating sequence:
Master Transmit:
<FE> <06> <00> <05> <00> <02> <0C> <05>
This command is written to the EEPROM power off is not canceled must be written to the polling mode

Slave Reply:
<FE> <06> <00> <05> <00> <02> <0C> <05>
Make sure the settings are correct and the device is running in hold mode. At this time, the lamp is off and the CO2 is not measured. The power will not be canceled. Only the CPU waits for the stream or polling mode command to start the lamp and measure CO2 again.

(3) Control mode write into Register

(a) Stream mode operating sequence:
Master Transmit:
<FE> <06> <00> <14> <00> <01> <1C> <01>
This command is written to the Register

Slave Reply:
<FE> <06> <00> <14> <00> <01> <1C> <01>
Make sure the settings are correct and the device is running in Stream mode.

After the command is confirmed, the CO2 value and the Sensor temperature value are returned every 2 seconds.
<00> <64> <04> <02> <91> <0B> <85> <74> <22>
0291=657ppm
0B85=29.49℃，收到 Sensor 溫度需除 100 才為實際溫度

(b) Hold mode: CO2 暫停量測，恢復量測需重設為 Polling 或 stream mode or power off。
Hold mode operating sequence:
Master Transmit:
<FE> <06> <00> <14> <00> <02> <5C> <00>
This command is written to the Register

Slave Reply:
<FE> <06> <00> <14> <00> <02> <5C> <00>
Make sure the settings are correct and the device is running in hold mode. At this time, the lamp is off and the CO2 is not measured. The power will be canceled. Or the CPU waits for the stream or polling mode command to start the lamp and measure CO2 again.

Note3: AL1 and AL2 for Alarm level setting : **一般 HVAC 使用**為環境 CO2 濃度大於 AL2 1200ppm(可自訂)啟動通風。當通風後環境 CO2 濃度降至 800ppm(可自訂)停止通風。**植物栽種使用** AL1>AL2 的方式設定，當植物環境 CO2 濃度低於 400ppm(可自訂)增加植物環境 CO2 濃度，植物環境 CO2 高於 AL2 1200ppm(可自訂)時停止供應 CO2。
AL1 and AL2 的動作影響 PWM and DAV 的輸出，如為 CO2 讀值使用 AL1 設為 0，AL2 設為 3000 或其他範圍，輸出電壓動作範圍就會由 0~3000 表示或其他直範圍表現。參看 7 PWM 輸出說明。

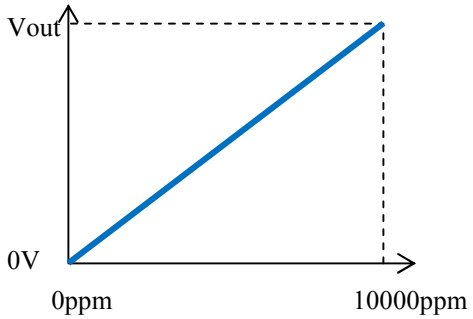
(1) Set AL1 and AL2 sequence: 0~10000ppm for full range

Master Transmit: AL1 0ppm
<FE> <06> <00> <15> <00> <00> <8C> <01>
This command is written to the Register

Slave Reply:
<FE> <06> <00> <15> <00> <00> <8C> <01>

Master Transmit: AL2 10000ppm
<FE> <06> <00> <16> <27> <10> <66> <3D>
This command is written to the Register

Slave Reply:
<FE> <06> <00> <16> <27> <10> <66> <3D>
Vout:
The PWM :0-VCC
DAV output: 0-1V

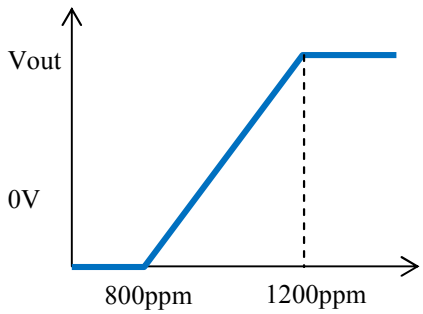


(2) Set AL1 and AL2 sequence: 800~1200ppm for HVAC
Master Transmit: AL1 800ppm
<FE> <06> <00> <15> <03> <20> <8D> <29>
This command is written to the EEPROM

Slave Reply:
<FE> <06> <00> <15> <03> <20> <8D> <29>

Master Transmit: AL2 1200ppm
<FE> <06> <00> <16> <04> <B0> <7F> <75>
This command is written to the Register

Slave Reply:
<FE> <06> <00> <16> <04> <B0> <7F> <75>
Vout:
The PWM :0-VCC
DAV output: 0-1V



(3) Set AL1 and AL2 sequence: 1400~400ppm for Green Hours

Master Transmit: AL1 1400ppm

<FE> <06> <00> <15> <05> <78> <8F> <73>

This command is written to the Register

Slave Reply:

<FE> <06> <00> <15> <05> <78> <8F> <73>

Master Transmit: AL2 400ppm

<FE> <06> <00> <16> <01> <19> <7D> <FD>

This command is written to the Register

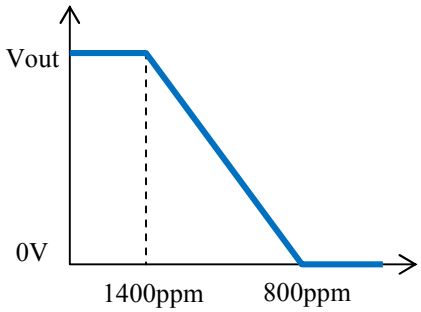
Slave Reply:

<FE> <06> <00> <16> <01> <19> <7D> <FD>

Vout:

The PWM :0-VCC

DAV output: 0-1V



Note4: Cali Set 動作說明，ZG09 可直接輸入任一氣體標準氣體濃度校正，使用方法為位置 28H 寫入已知標準氣體濃度，範圍為現在讀取的濃度±1000ppm(20H) 解析度 1ppm，當 ZG09 接收確認後會立即動作並反應傳回的 CO2 讀值。ZG09 只有一個 offset 存放的位置，因此 ABC、Span、Cali Set 都是存放在(20H)，如果 ZG09(20H)有之前校正的記錄，再次校正 ZG09 會重新計算與存入新的 offset 值。

Cali Set sequence: Any concentration of Gas calibration

如果您知道 ZG09 的環境 CO2 濃度,您可以直接寫入期望的值於位置 28H,ZG09 會幫您計算出正確的 offset 值存入 20H.

If you know the ambient CO2 concentration of ZG09, you can directly write the desired value to position 28H. ZG09 will help you calculate the correct offset value and store it in 20H.

由 ZG09 本身計算 offset 偏差量，使用者只要輸入期望值.

(1) Provide 1000ppm CO2 to ZG09 (Flow rate 100CC/minute)

圖(提供標準氣體)

(2) 寫入 28H 期望值 1000ppm

Master Transmit:
<FE> <06> <00> <28> <03> <E8> <1D> <73>

Slave Reply:
<FE> <06> <00> <28> <03> <E8> <1D> <73>

(3) 校正後讀校正後的結果是否接近 1000ppm
Master Transmit:
<FE> <03> <00> <0B> <00> <01> <E1> <C7>

Slave Reply:
<FE> <03> <02> <03> <E9> <6D> <2E>
3E9=1001ppm

ZG09 也可放置於戶外以 400ppm 做為標準，人員不要靠近呼吸同時放置 10 分鐘後，依照下述方式進行 400ppm 校正。
(1) 如已經放置 10 分鐘，寫入 28H 期望值 400ppm
Master Transmit:
<FE> <06> <00> <28> <01> <90> <1C> <31>

Slave Reply:
<FE> <06> <00> <28> <01> <90> <1C> <31>

(2) 校正後讀校正後的結果是否接近 400ppm
Master Transmit:
<FE> <03> <00> <0B> <00> <01> <E1> <C7>

Slave Reply:
<FE> <03> <02> <01> <90> <AD> <AC>
190h=400ppm

自已計算 offset 存入 20H 的程序:
如已知 CO2 的標準氣體是 1000ppm 圖(提供標準氣體)
(1) 清除 ZG09 內部的 offset value
Master Transmit:
<FE> <06> <00> <20> <00> <00> <9C> <0F>

Slave Reply:
<FE> <06> <00> <20> <00> <00> <9C> <0F>

(2) 讀 ZG09 CO2 值為 1050ppm 多了 55ppm
Master Transmit:
<FE> <03> <00> <0B> <00> <01> <E1> <C7>

Slave Reply:
<FE> <03> <02> <04> <1F> <EF> <58>
41F=1055ppm

(3) 將-55ppm 的 offset 存入 ZG09
Master Transmit:
<FE> <06> <00> <20> <FF> <C9> <1D> <A9>

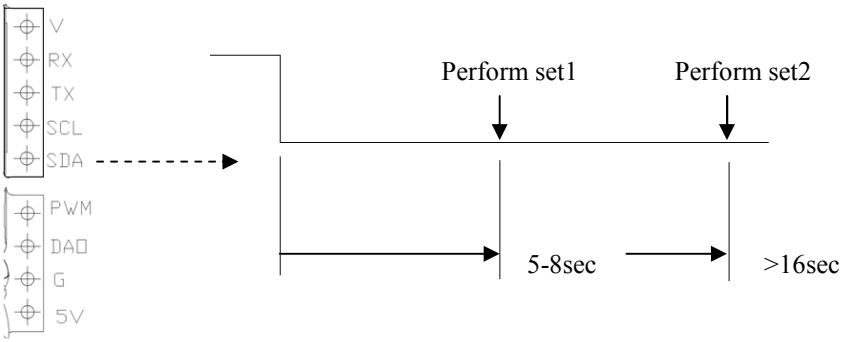
Slave Reply:
<FE> <06> <00> <20> <FF> <C9> <1D> <A9>

(4) 校正後讀校正後的結果是否接近 1000ppm
Master Transmit:

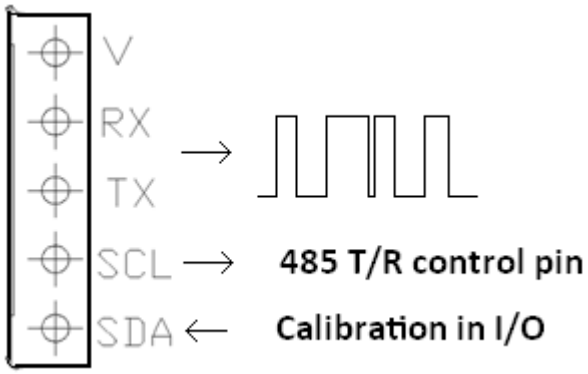
<FE> <03> <00> <0B> <00> <01> <E1> <C7>

Slave Reply:
<FE> <03> <02> <03> <E9> <6D> <2E>
3E9=1001ppm

Note5: Calln Value Set1and 2，Calibration in value setting 1 為 400ppm (default) 的設定值，可依使用環境需要來設置，Calibration in value setting 2 為 0ppm (default) 的設定值，也是可以依需要來設置。



Note6:
Address 06H: 0FFH (default) for calibration in I/O operating and 485 R/T control pin



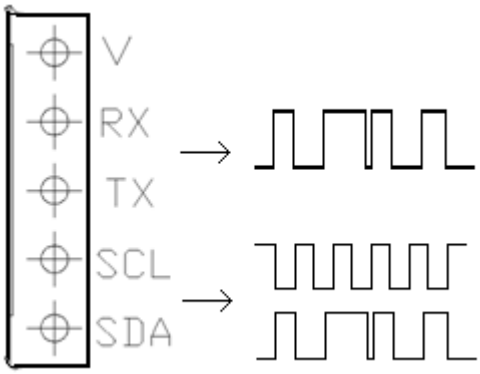
Write in to 1~127 for ID，(07FH) for I2C slave ID，128~254 no use，設置後必須關電重啟才會動作或 Reset。
(1) 設置 I2C ID 下例 ID=68h
Master Transmit:
<FE> <06> <00> <06> <00> <68> <7C> <2A>

Slave Reply:
<FE> <06> <00> <06> <00> <68> <7C> <2A>

(2) Reset or Re-Power 下例為 Reset
<FE> <06> <00> <09> <00> <01> <8C> <07>

Slave Reply:
<FE> ……Reset 過程中也會停止傳送。

UART 與 I2C ID=68h 同時動作，使用者可以使用 UART 或 I2C ID=68h



(1) 關閉 I2C

Master Transmit:

<FE> <06> <00> <06> <00> <FF> <3D> <84>

Slave Reply:

<FE> <06> <00> <06> <00> <FF> <3D> <84>

(2) Reset or Re-Power 才會改變，下例為 Reset

<FE> <06> <00> <09> <00> <01> <8C> <07>

Slave Reply:

<FE> ……Reset 過程中也會停止傳送。

Note7:

ABC 調整預設是關閉

ABC Tune Speed。是指每日 ABC 自動調整的上限(預設是 100ppm 每天調整量)。防止 ABC 的過度調整

ABC It is recommended to re-open in a well-ventilated environment. This function is not recommended for greenhouses, wine cellars, confined or poorly ventilated spaces, which will affect accuracy.

Function 4 input register:

Address	Name	REG/EEP	Function	Description
00H	SYS Status	REG、R	系統狀態	Read only: 00:Starting 04:Ambinet over operating Temperature 12:CO2 low limit 13:CO2 High Limit 14:Raw Data Error 15Parameter check sum error
03H	CO2 Value	REG、R	CO2 讀值	Read only
04H	CO2 AMB	REG、R	CO2 sensor temperature	Read only

Example: CO2 read sequence in Function 4

Master Transmit:

Function code	1Byte	0x04
Starting Address	2Bytes	0x0000 to 0xFFFF
Quantity of Input Registers	2Bytes	0x0001 to 0x007D

<ID> <Function code> <Starting address $byte_0$ + Starting address $byte_1$> <$data\_byte_0$ + $data\_byte_1$> <CRC $byte_0$ + CRC $byte_1$>

<FE> <04> <00> <03> <00> <01> <D5> <C5>

Slave Reply:

Function code	1Byte	0x04
Byte count	1Byte	2 x N*

Input Registers	N* x 2 Bytes	

*N = Quantity of Registers

<ID> <Function code> < Byte count $byte_0$> <$data\_byte_0$ $data\_byte_n$> <CRC byte0 + CRC byte1>

<FE> <04> <02> <02> <D6> <2D> <DA>

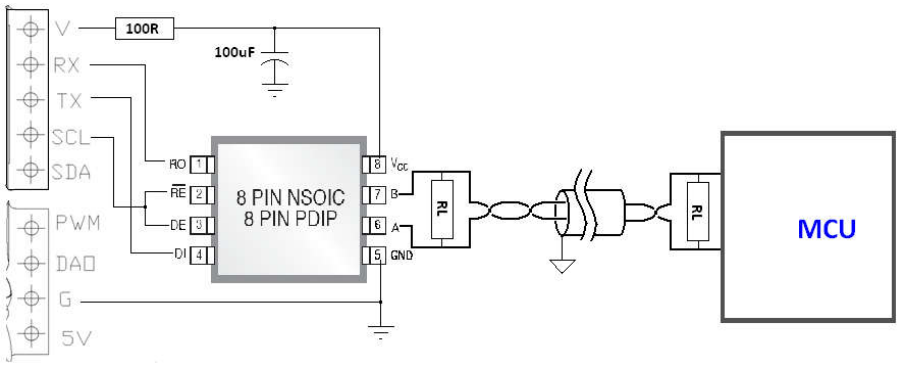
02D6h=726ppm

Error:

Error code	1Byte	0x84
Exception code	1Byte	01 or 02 or 03 or 04

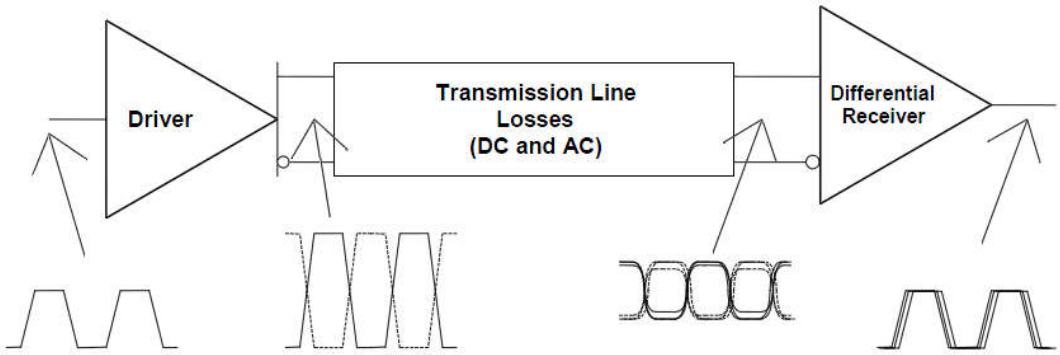
6 RS485 通訊

運用電路



圖一

外接 RS-485/RS422 收發晶片(SP3072)可長距離監測環境 CO2 濃度，距離拉長必須使用隔離絞線，收發晶片可使用 ZG09 的 3V 輸出電源，如上圖(圖一)方式連接，接線盡可能縮短，RL 依照實際上的需要設置，通訊協定依照 ModBus 格式(參閱 4.UART)。



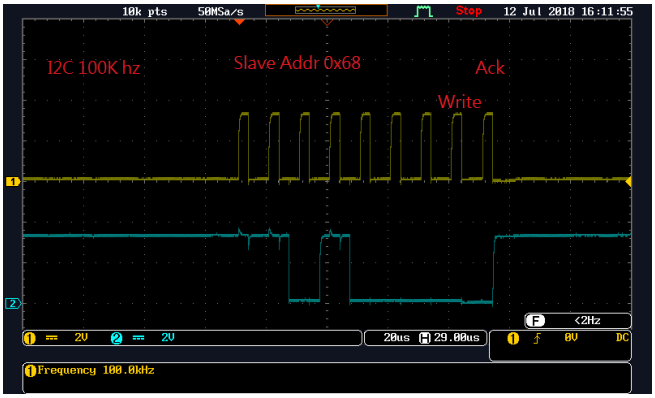
RS-485 Data Transmission System

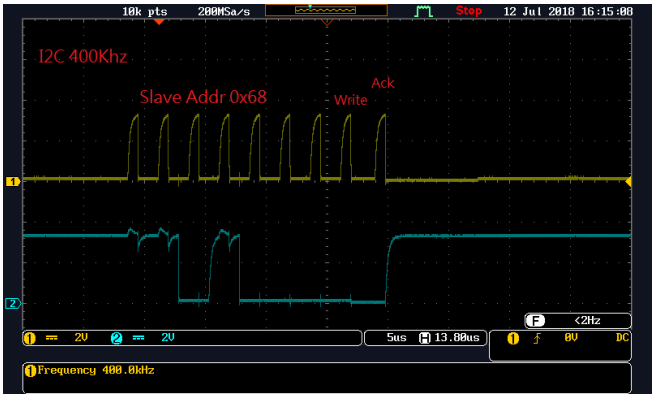
Because many RS-485 application involve relatively long cable lenghts, the bus lines are often modeled as a transmission line, rather than a “lumoed” connection. This implis that the signal takes a non-negligible amount of time to propagate through the cable. Usually, the attenuatuin(reductuin in signal amplityde)must also be considered for RS-485 systems, Therefore, the choice of RL is set for the stability of communication, and the longer the line is, the smaller the impedance of RL.

由於許多 RS-485 應用涉及相對較長的電纜長度，因此總線通常被建模為傳輸線，而不是“集總”連接。 這意味著信號需要不可忽略的時間來通過電纜傳播。通常，RS-485 系統也必須考慮衰減（信號放大器中的還原），因此 RL 的選擇是為了通訊的穩定而設置，當線越長時，減少 RL(終端電阻)阻抗。

7 I2C 通訊

I2C 界面具有 100KHz 以上至 400KHz 的通訊速率。





(1) 使用電腦、樹莓等，透過介面來通訊，需注意 I/O 的電位 0-3.3V，但最高不要超過 3.5V。
(2) 使用 CPUs 等不同廠家產品，均可。
(3) 通訊頻率，100KHZ or 400KHz，某些電腦在 100KHz 的通訊頻率時會有不穩定現象，請改至 400KHz 通訊。

Data Sheet of UART 4 位置 06H 寫入 1~127 給 I2C ID 使用，設定完成需重上電。
(1) 1~127(07FH) for I2C slave ID，128~254 沒有定義。
(2) 設為 255(0FFH 預設)是給 SDA 腳做為手動氣體校正(calibration in I/O operating)或 485 R/T 控制腳，同時關閉 I2C。
(3) 確認 SCL and SDA 串列訊號線有 pull-up resistors ，如沒有請加入如下圖的電路，Rp 建議使用 2.2K。

The ZG09 supports a bi-directional, 2-wire bus and data transmission protocol. A device that sends data onto the bus is defined as a transmitter and a device receiving data as a receiver. The device that controls the message is called a master. The devices that are controlled by the master are referred to as slaves. The bus must be controlled by a master device that generates the serial clock (SCL), controls the bus access, and generates the START and STOP conditions. The ZG09 operates as a slave on the 2- wire bus. A typical bus configuration using this 2-wire protocol is show in Figure 7-1.

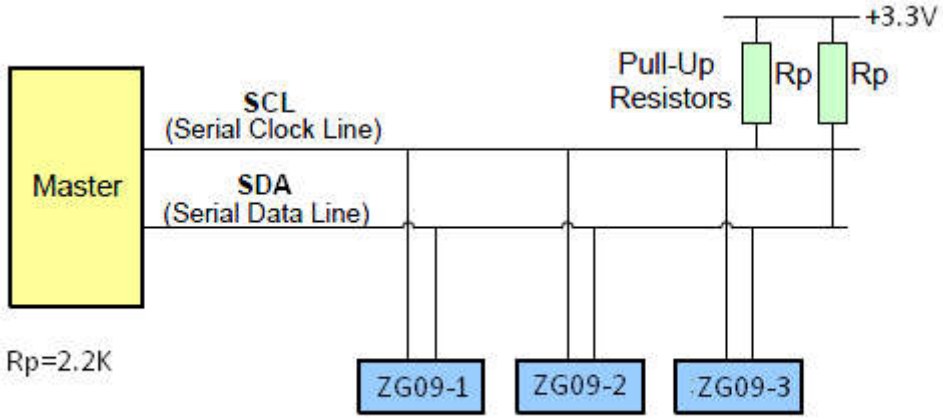


Figure7-1: 2-WIRE BUS CONFIGURATION

圖二 Data transfer sequence for random Read command

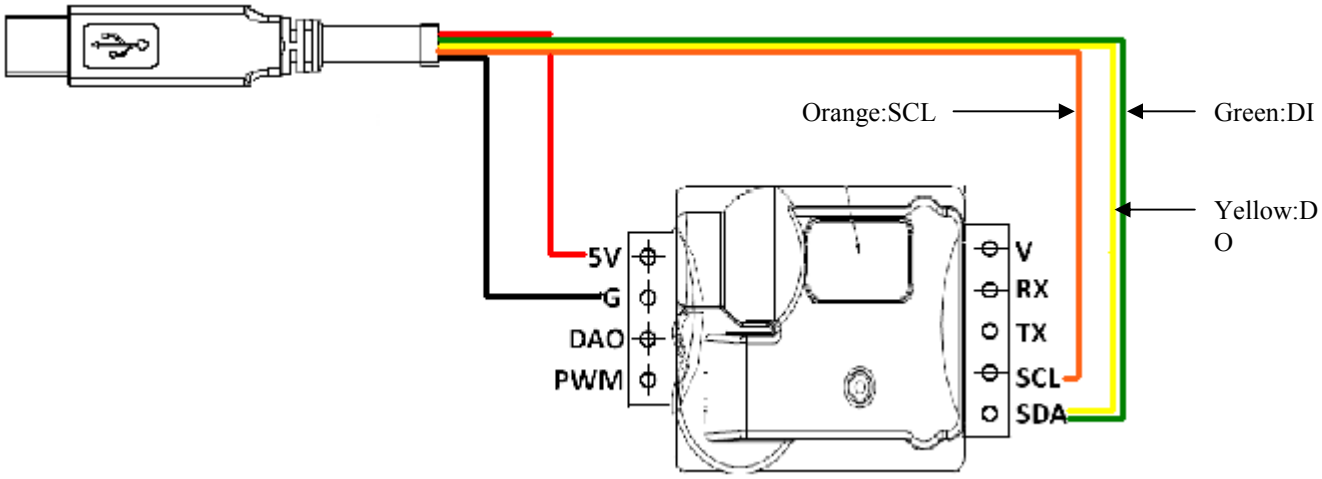
Address	Name	REG/EEP	Function	Description
00H	Reset Set	REG、W	Sofware reset	Resets the module
01H	Sys Status LSB	REG、R	Status register LSB	Monitors the operating status--read-only
02H	Sys Status MSB	REG、R	Status register MSB	Monitors the operating status--read-only
03H	CO2 Value LSB	REG、R	Low-order CO2 concentration data	Read only
04H	CO2 Value MSB	REG、R	High-order CO2 concentration data	Read only
09H	Atm (hpa)	REG、R/W	Atmospheric pressure (Hpa)	Value*10+800hpa

0AH	Meter	REG、R/W	Altitude (Meter)	Value*10
0BH	Atm (mmHg)	REG、R/W	Atmospheric pressure (mmHg)	Atm=Value+520mmHg
0CH	Alarm H	EEP、R/W	Upper limit concentration for alarm signal	ppm=Value *10
0DH	Alarm L	EEP、R/W	Lower limit concentration for alarm signal	ppm= Value*10
0EH				
0FH	Filter Set	EEP、R/W		0=Enable
10H	ABC Day	EEP、R/W	ABC cycle time	0-30 days
11H	ABC Target	EEP、R/W	Target CO2 for ABC	(30~120)*10;300ppm~1200ppm
12H	Cali Set[1]	EEP、R/W	Any concentration of Gas calibration	Write:(0~120)*10;0ppm~1200ppm，set 255 for clear Read for check offset value: 12H for LSB、13H for MSB

Note1: Cali Set 動作說明，ZG09 可直接輸入任一氣體標準氣體濃度校正，使用方法為位置 12H 寫入已知標準氣體濃度，範圍 0ppm~1200ppm 解析度 10ppm (0~120、00H~78H)*10ppm，當 ZG09 接收確認後會回傳兩筆 offset 的值:12H for LSB and 13H for MSB，清除校正值 12H 寫入 255 (FFH)。

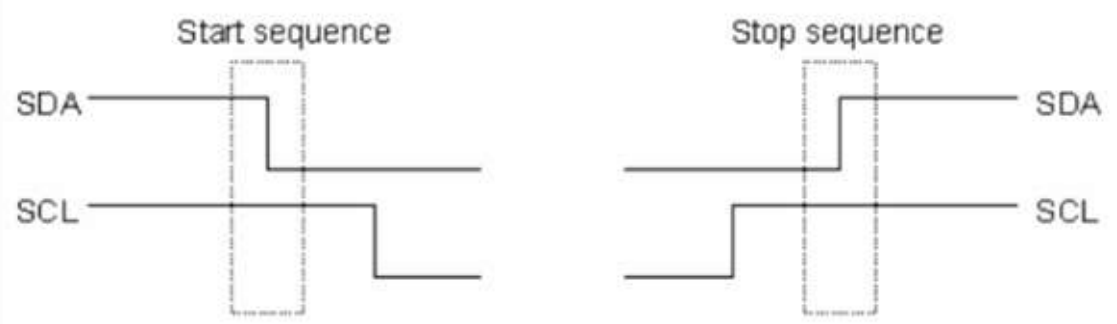
UART and IC2 測試可以使用 FTDI Cable: 10 條 I/O 介面含 5V 輸出電源(注意電流輸出需大於 200mA 的容量)，通訊與控制使用。參看:DS_C232HM_MPSSE_CABLE.PDF

FTDI 以 IC2 的方式與 ZG09 連接

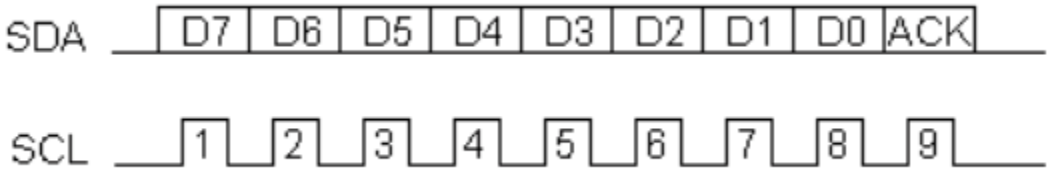


Colour	Pin Number	Name	Type	Description
Orange	2	SCL	Output	Serial Clock
Yellow	3	SDA	Input/Output	Serial data signal shorted together to create bidirectional data(both yellow and green wires need to be shorted together)
Green	4			

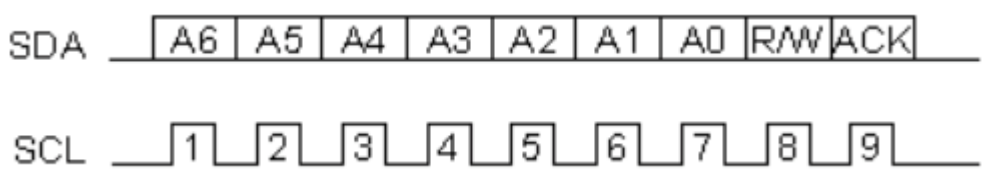
Master 跟 Slave 之間要如何溝通呢



簡單的來說，在每次開始的第一步，就是要送 Start sequence 到 slave 然後在要結束前送 stop sequence Data 是 8bits 傳輸 是由 MSB 開始傳輸 每八個 bit 傳輸完以後會有一個 acknowledge bit 所以會有 9 個 pulse。 如果收到的 ACK bit 是 low 的話 就代表 device 已經可以準備接收下一筆 data, 但是如果收到的 ACK bit 是 high 的話 就表示不能再接收任何資料 此時 mater 應該要結束傳輸(傳送 stop sequence)



我們馬上可以想到一個問題就是 I2C 可以傳輸多快呢？ 一般來說 I2C 的標準是 100 KHz, faster speed mode 可以傳輸高達 400 KHz,利用 I2C 溝通的時候還要特別注意到一件事情 那就是 Slave Address:每一個 I2C device 都會有自己的 address (7 bits or 10 bits) 通常使用 7 bits, 10 bits 很少見,在 7bits 的情況下的話 代表我們最多可以連接 128 個 device 此外我們在傳送的 mater slave 的資訊的時候還必須在最後面多加上個 bit R/W 所以送出去的總共還是八個 bits 比如說我們要送 write to address 為 21 (10101) -> 42 (101010) and if you want to read the data from this address -> 43 (101011)



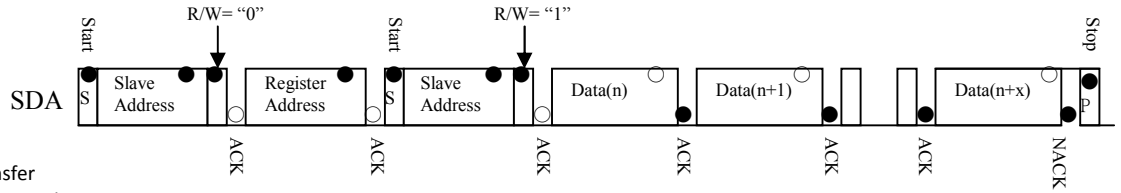
如果我們要進行寫入(Write)的動作的話 我們依照下列的做法:

1. Send a start sequence
2. Send the I2C address of the slave with the R/W bit low (even address)
3. Send the internal register number you want to write to
4. Send the data byte
5. [Optionally, send any further data bytes]
6. Send the stop sequence.

如果我們要進行讀取(Read)的動作的話 我們依照下列的做法: 在讀取的部分稍微複雜一些，因為在讀取之前我們必須要先告訴slave那個internal address我們想要讀取 所以在讀取之前 我們必須要先做一個寫入的動作。

1. Send a start sequence
2. Send I2C address with the R/W bit low (even address)
3. Send Internal address of the bearing register
4. Send a start sequence again (repeated start) (with LSB=1)
5. Send I2C address with the R/W bit high (odd address)
6. Read data byte from ZG09
7. Send the stop sequence.

●Data transfer from Master side:
○Data transfer from Slave side:

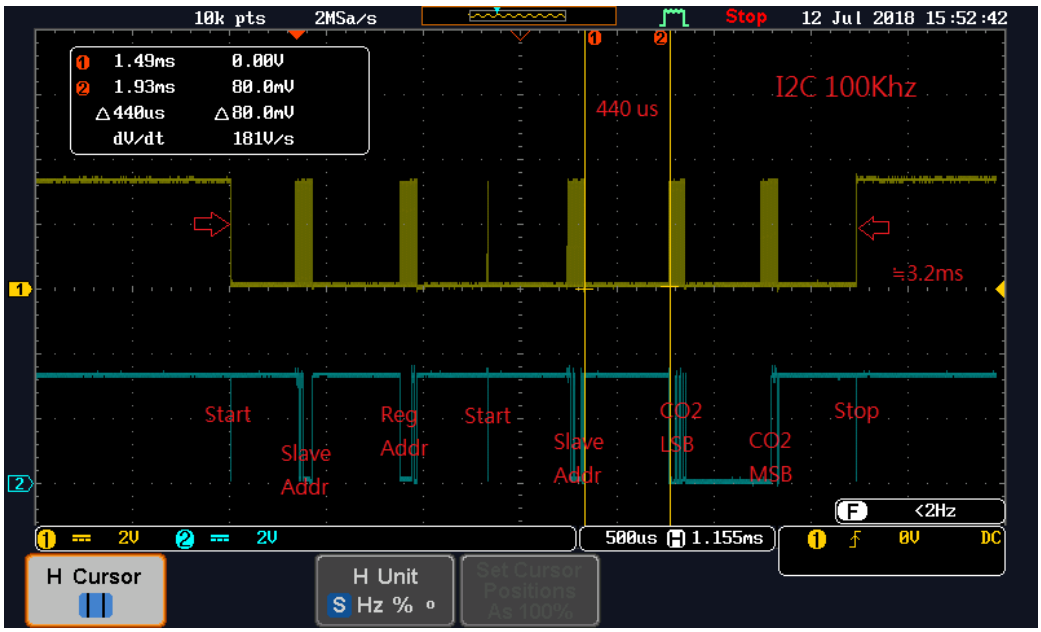


Data transfer
from Master side : 11010000 00000011 11010001

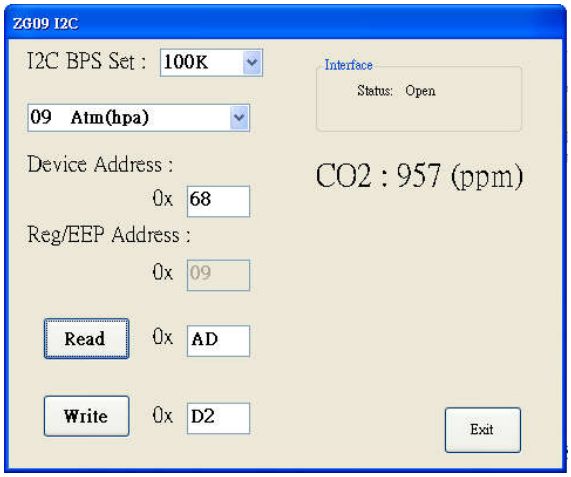
Data transfer
Slave side : 1001000 (97H) 00000001 (01H)

Register 03H-LSB 04H-MSB

Concentration 01 97H=407ppm

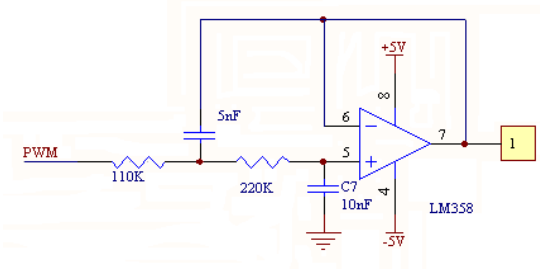


Reference document: http://www.robot-electronics.co.uk/i2c-tutorial
Demo communication program: ZG09_I2C_Demo_SoureCode.7z



8 PWM 輸出

可自訂 CO2 濃度範圍的 PWM VCC (3.0~3.3V) level at 1 kHz 輸出 0~10,000ppm，運用電路如下圖(圖二)，AL1=0~10,000ppm AL2=0~10,000ppm 如 AL1<AL2 可使用於 HVAC，運用 AL1>AL2 可使用於農業,如使用於氣體濃度輸出 0~10,000ppm AL1=0ppm、AL2=10,000ppm



圖二

運用	AL1 0~10,000ppm	AL2 0~10,000ppm	說明
監測 CO2 濃度	0ppm (0V)	10,000ppm (VCC)	
HVAC	800ppm 初設 (<800ppm=0V)	1200ppm 初設 (>1200ppm=VCC)	Note1
農業	自訂	自訂	Note2

Note1: 一般 HVAC 使用為環境 CO2 濃度大於 AL2 1200ppm(可自訂)啟動通風。當通風後環境 CO2 濃度降至 800ppm(可自訂)停止通風。

Note2: 植物栽種使用 AL1>AL2 的方式設定，當植物環境 CO2 濃度低於 400ppm(可自訂)增加植物環境 CO2 濃度，植物環境 CO2 高於 AL2 1200ppm(可自訂)時停止供應 CO2。

AL1 and AL2 之間的間隔為 100ppm

9 DAV 輸出

DAV 輸出是可用戶控制輸出使用，不建議做為高精密度 CO2 量測使用，輸出 0-1V = 初設 800-1200 ppm(~210 階)可藉由 AL1 與 AL2 來控制範圍，運用端可以使用比較器來控制繼電器，AL2>AL1 可運用於 HVAC，AL1>AL2 運用於農業，當 AL1 設置為 800ppm 此時讀值達 800ppm 時 DAV 輸出 0V，如希望全範圍輸出可將 AL1 設置為 0ppm、AL2 設置為 10000ppm。

10 響應時間

(表一)顯示環境 CO2 改變多久時間可以平衡，讀值與環境氣體濃度一至，測試方式由 1000ppm 放至 10 分鐘，快速移至 400ppm 環境與 400ppm 放至 10 分鐘，快速移至 1000ppm 環境。

(表一)

測試項目	Time
400ppm to 1000ppm	~60sec (90%上升時間)
1000ppm to 400ppm	~120sec (90%下降時間)