Piera-7100

Photon Counting Intelligent Particle Sensor for Accurate Air Quality Monitoring

Product Specification

Product Summary

The Piera-7100 is a photon counting readout based highly sensitive optoelectronic particulate sensor. Utilizing Piera's PCIC as a core processor, the Piera-7100 is compact and consumes low power while capable of fast data acquisition and readout, as well as categorizing particulates based on the size.

The Piera-7100 features an adjustable gain control that provides superior accuracy and versatility. Using a unique algorithm to identify different particulates, the Piera-7100 is suitable for true real-time precise airborne particulate matter monitoring such as vape, smoke, and noxious gas detection. Piera-7100 has been calibrated with GRIMM 11D.

Fig. 1. Piera-7100 (4.6cm x 4.15cm x 1.24cm)

Features

- Ultra-high sensitivity for detecting PM0.1 – PM10 airborne particulates
- Fast data acquisition and sampling
- 7 particle size bins
- High accuracy and reliability
- Supports UART and I2C
- Firmware update capability
- Adjustable sensitivity control for various applications
- Small, robust and long-term stability
- IoT/Network support
- Mounting screw holes

Applications

- Indoor air quality monitoring & management systems
- Ventilation systems
- Smoke/vape detection
- Submicron particle detection

1. Sensor Specifications

Parameter	Conditions	Value	Units
Particle count accuracy[1]	-	±10	%
Particle count resolution	-	1	#/CF
Particle count range	-	85 million	#/CF
Mass concentration range[2]	-	5,000	ug/m^3
Particle size range for particle count binning (differential)	PC0.1[4]	<0.1	um
	PC0.3	0.1 - 0.3	um
	PC0.5	0.3 - 0.5	um
	PC1.0	0.5 - 1.0	um
	PC2.5	1.0 - 2.5	um
	PC5.0	2.5 - 5.0	um
	PC10	5.0 - 10	um
Particle size range for mass concentration binning (cumulative)	PM0.1[4]	<0.1	um
	PM0.3	<0.3	um
	PM0.5	<0.5	um
	PM1.0	<1.0	um
	PM2.5	<2.5	um
	PM5.0	<5.0	um
	PM10	<10	um
Sampling time	-	>0.1	s
Start-up time	-	6 @0.2s sample time	s
Lifetime[3]	24h/day operation	>8	Years

Table 1. Piera-7100 Specifications

1. Deviation from reference counter (GRIMM 11D model year 2006) based on average readings over 3-minute period. The accuracy is verified after calibration using a Smoke Detector Tester Spray, SDI LLC. Ask Piera Systems for further details.
2. Mass concentration detection limit is estimated for PC2.5. May vary depending on size and density of particles.
3. Lifetime might vary depending on different operating conditions.
4. PC0.1 and PM0.1 are estimated by extrapolation.

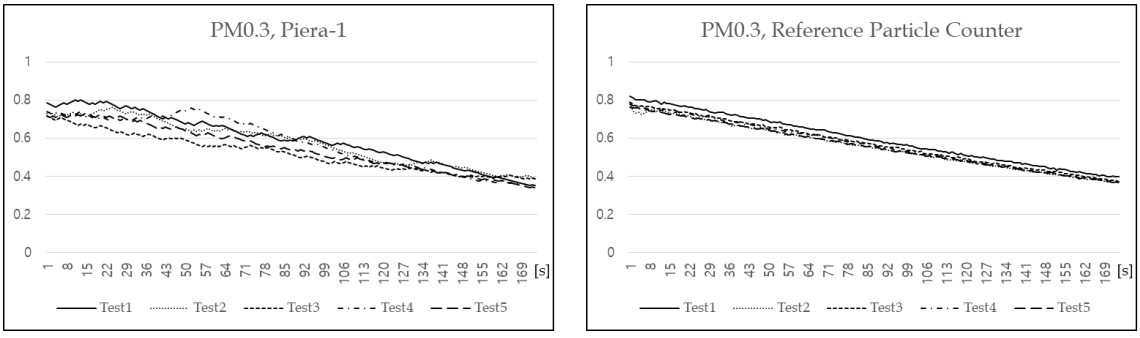


Fig. 2. Normalized number concentration: Piera-7100 vs. Reference Particle Counter @ 25°C, 50% RH

2. Electrical Specifications

2.1. Electrical Characteristics

Default conditions of 25°C and 5V supply voltage apply to values in the table below, unless otherwise stated.

Parameter	Conditions	Value	Units
Supply voltage	-	4.5 – 5.5	V
Average supply current	Measurement-mode	65	mA
Input high level voltage (V_{IH})	-	>2.31	V
Input low level voltage (V_{IL})	-	<0.99	V
Output high level voltage (V_{OH})	-	>2.9	V
Output low level voltage (V_{OL})	-	<0.4	V

Table 2. Electrical specifications

2.2. Absolute Minimum and Maximum Ratings

Operating beyond those ratings shown in Table 3 may cause damage to the device and is not guaranteed. (Exposure to the absolute maximum rating conditions may affect the reliability of the device as well.)

Parameter	Rating
Supply voltage VDD	-0.3 to 5.5 V
Interface Select SEL	-0.3 to 4.0 V
Rx, Tx I/Os	-0.3 to 3.3 (<5.5 V)
Operating temperature range	-10 to +60
Storage temperature range	-40 to +80
Operating humidity range	0 to 95% RH (non-condensing)
ESD CDM (Charge Device Model)	±4 kV contact, ±8 kV open air

Table 3. Absolute minimum and maximum ratings

2.3. Recommended Operation Conditions

The sensor best performs when operated within 10 – 40°C and 20 – 80% RH.

3. Hardware Interface Specifications

The interface connector and the description of the pin layout is shown in Fig. 3. The mating male connector should be 1.5mm-pitch. A sample connector info can be found here.

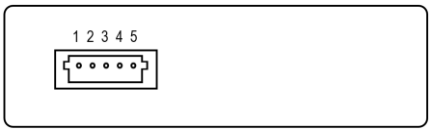


Fig. 3. Interface connector I/O pins

Pin	Name	Description	Comments
1	VDD	Supply voltage	5V ± 10%
2	Rx	UART: Receiving pin for communication	LVTTL 3.3V
	SDA	I²C: Serial data input/output	
3	Tx	UART: Transmitting pin for communication	LVTTL 3.3V
	SCL	I²C: Serial clock input	
4	SEL	Interface select	Floating: UART
			GND: I²C
5	GND	Ground	-

Table 4. Description of interface connector I/O pins

3.1. Physical Layer

The Piera-7100 has Rx and Tx lines with unipolar logic levels. Transmitted byte is shown in Fig. 4. The data speed is 115,200 Baud Rate.

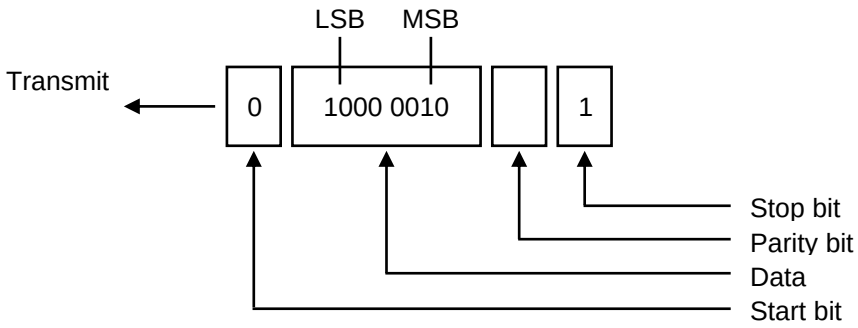


Fig. 4. UART (Universal Asynchronous Receiver Transmitter) Data Transfer

4. UART Interface

Fig. 5 shows the typical UART application circuit, which has 5 I/O pins; VDD, Rx, Tx, SEL, and GND.
The operation of Piera-7100 (slave) is quite simple. All the commands are printable ASCII strings so as to be easier to communicate and memorize. The reply from the Piera-7100 is also printable ASCII string. Therefore, any serial communication program available on PC and application systems (master devices) can be used to download commands and see the results.

The connection cable length should be less than 5m, or 16.5ft.

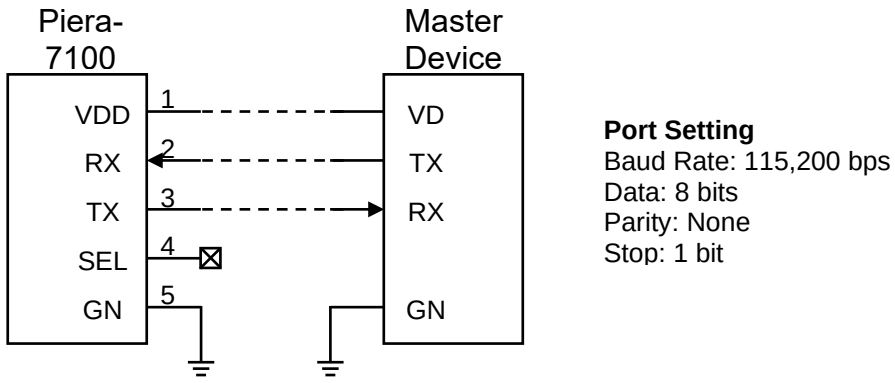


Fig. 5. Typical UART interfacing

4.1. Start Measurement

Piera-7100 uses an easy-to-ASCII strings to communicate between the slave (Piera-7100 sensor) and the master device (application system) start the sensor. The sensor module is in idling mode after powering up, and the fan turns on. The start of the measurement begins with the command line below:

$Won=200[CR][LF].

This is the default sampling time setting that allows Piera-7100 to collect data every 200[ms], and updates data every 1 second. The sampling time can be adjusted however, changing the sampling time will result in recalibration. Contact Piera Systems for more details.

The following command can be used to modify the sampling time:

$Wmsp=n[CR][LF] n=1 for 200ms, 2 for 500ms and 3 for 1000ms

When the default start command is sent to the sensor, the following result will be displayed:

```
$Won=200 IA: Won=200
Won=200
Turn on sensing for 200 [ms]
……
PM0.1,2259187,PM0.3,1882656,PM0.5,156888,PM1.0,6537,PM2.5,502,PM5.0,0,PM10,0
PM0.1,2281766,PM0.3,1901472,PM0.5,158456,PM1.0,6602,PM2.5,507,PM5.0,0,PM10,0
PM0.1,2258956,PM0.3,1882464,PM0.5,156872,PM1.0,6536,PM2.5,502,PM5.0,0,PM10,0
                                                    .
                                                    .
                                                    .
```

Note that it will not display measurement results for the first 6 seconds as an initial latency time for the stabilization of the sensor system.

4.2. Stop Measurement

To stop the measurement, download the following command line:

$Won=0[CR][LF]

Note that the fan still runs even though measurement is stopped unless the sensor is unplugged (powered off). To control the fan intentionally, use the following command line:

To turn on fan: $Wfan=1[CR][LF]

To turn off fan: $Wfan=0[CR][LF]

4.3. Gain and Threshold Voltage Control

Piera-7100 has two outstanding features for detecting particulate matters on size. By adjusting gain and/or threshold voltages of the sensor, the user can focus on any interesting particle size(s) to detect.

Gain Control

The gain control voltage (Vgc) of Piera-7100 is initially set to 1800[mV] for the typical measurement environment. User can increase of decrease the Vgc to get better performance depending on the application systems in different environments.

$WVgc=1800[CR][LF] where 1800 means Vgc is set to 1800mV.

When the command is sent to the module, the following result will be displayed:

```
$WVgc=1800A
WVgc=1800
Setting Vgc=1800
```

Threshold Voltage Control

Piera-7100 has 5 different threshold voltages to categorize the particulate matters by size. The threshold voltage (Vth) of Piera-7100 is initially set to 2500[mV] for the typical measurement environment, which sets 5 internal threshold voltages to Vth1 0.5V, Vth2 1.0V, Vth3 1.5V, Vth4 2.0V, and Vth5 2.5V.
To change each internal threshold voltage, user may enter the following command:

$WVth=2500[CR][LF]

Where 2500 means Vth5 is 2.5V, then Vth4 is set to 2.0V, Vth3 to 1.5V, Vth2 to 1.0, and Vth1 to 0.5 internally.

When the command is sent to the module, it will display the following result:

```
$WVth=2500
WVth=2500
Setting Vth=2500
```

4.4. Power Saving Mode

To save energy during idling, Piera-7100 provides the following command:

$Spwr=1[CR][LF]

This command will stop measurement and enter sleep mode cutting power to the sensor, fan and the laser diode. The CPU also goes hibernation.
To wake up the sensor, use the following command:

$Spwr=0[CR][LF]

4.5. Cleaning Mode

Piera-7100 also offers cleaning mode to clear out any accumulated dust within the air path to maintain the performance of the sensor. The fan can be controlled via the following command:

$Wfan=1[CR][LF]

To turn off the fan, use the following command:

$Wfan=0[CR][LF]

To clean the sensor module, use the following command:

$Wcln=1[CR][LF]

To clean the sensor module, use the following command:

$Wcln=0[CR][LF]

To enable auto cleaning mode with a set interval, use the following command:

$Wclnp=<n>[CR][LF] where <n> is the interval in second. The default value is set to 604800s, or 1 week.

To disable auto cleaning mode, use the following command:

$Wclnp=0[CR][LF]

4.6. Debugging Mode

For the advanced users who want to develop/modify the algorithm by getting the raw data from the sensor, Piear-1 offers a debugging mode. The user can get raw data other than the calculated PM numbers by turning on the debugging mode using the command of $Wdebug=x[CR][LF], where x=1. The debugging mode is off by default, x=0.

When the command is sent to the module, it will display the raw data as the following example:

```
$Won=200 IA: Won=200
Won=200
Turn on sensing for 200 [ms]
……
NP_MJA[0]=640714
N0[x],0,0,1,0,0,P[x],0,0,29,0,0,
N0[x],1,0,0,0,0,P[x],10,0,0,0,0,
N0[x],0,0,0,0,0,P[x],0,0,0,0,0,
N0[x],0,0,0,0,0,P[x],0,0,0,0,0,
N0[x],0,0,0,0,0,P[x],0,0,0,0,0,MA[30],13000,MJA,13000,PM0.1,249600,PM0.3,208000,PM0.
5,17333,PM1.0,722,PM2.5,55,PM5.0,0,PM10,0
N0[x],0,0,0,0,0,P[x],0,0,0,0,0,
N0[x],0,0,0,0,0,P[x],0,0,0,0,0,
N0[x],0,0,0,0,0,P[x],0,0,0,0,0,
N0[x],0,1,0,0,0,P[x],0,24,0,0,0,
N0[x],0,0,0,0,0,P[x],0,0,0,0,0,MA[30],21000,MJA,13261,PM0.1,254611,PM0.3,212176,PM0.
5,17681,PM1.0,726,PM2.5,56,PM5.0,0,PM10,0
```

Where, N0[x] means 5 bin counting numbers on Vth1, Vth2, Vth3, Vth4, and Vth5, respectively, and P[x] is average pulse width of each matched bin on every 200[ms] time interval.

Every fifth row, or 1 second interval, the raw data and PMx by Piera-7100 algorithm are displayed at the same time.

4.7. PC and PM Unit Change

Piera-7100 offers unit change feature, so the user may select desired display units for particle count and mass concentration. To set or change the displayed units, use the following command:

$Wunit=n where n==1 for /ft^3, n==2 for /m^3, or n==3 for /L

5. I^{2}C Interface

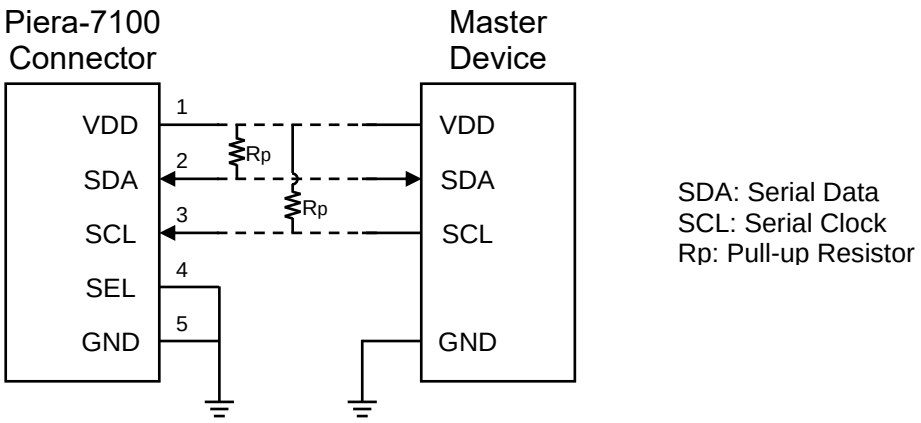


Fig. 6. Typical I^{2}C interfacing

SDA is serial data input/output pin and SCL is serial clock between Piera-7100 and master devices. The Rp is a pull-up resistor since the SDA and SCL are open drains.
The I^{2}C interfacing is generally used to communicate between short distance devices less than 10cm. Shielding for electromagnetic interference and crosstalk is needed for connection cables and/or PCB patterns.

I2C device ID is 0x93, and there are five types of data format:

Command without data

I2c address = 0x93

Ex. 0x40 command

Command with 1 parameter (1 byte)

Ex. 0x22, 0x23, 0x24, 0x25, 0x30 commands

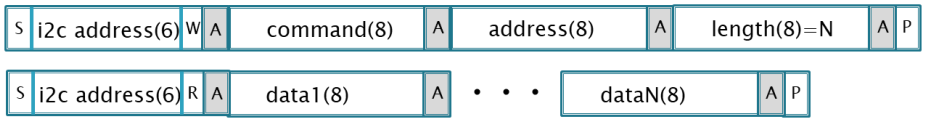
Command with 2 parameters (2 bytes)

Ex. 0x31, 0x32, 0x33, 0x34, 0x35 commands

Command expecting data from host

Ex. 0x21, 0x22 commands

Command to read N bytes from internal register memory



Ex. 0x41command

The following is the register map:

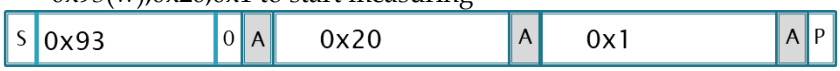
Register Address	Description
0x80	StatusByte (b0:fan on/off, b1: cleaning mode on/off, b2:PSM on/off) Each bit is 0 for off and 1 for on.
0x81	Measuring time, 1 for 200 [ms], default value, 2 for 500ms, and 3 for 1000ms
0x82 - 0x85	Auto cleaning interval, default = 604800 [s]
0x86 - 0x87	Vth value
0x88 - 0x89	Vgc value
0x90 - 0xc7	Measured PC data, 8 bytes each, PC0.1, …, PC10
0xc8 - 0xff	Measured PM data, 8 bytes each, PM0.1, …, PM10

The commands are defined in the following table:

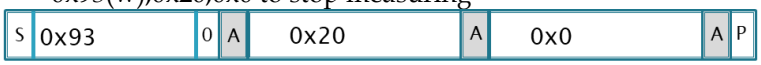
Command	Parameter(s)	Read/Write	Data description
0x20	1 or 0	Write	0x1: Start measuring, 0x0: Stop measuring
0x21	[n1],…,[n63]	Read	Read seven measured PC data {PC0.1,PC0.3,PC0.5,PC1.0,PC2.5,PC5.0,PC10} Each data has 8 bytes long, unsigned integer.
0x22	[n1],…,[n63]	Read	Read seven measured PM data {PM0.1,PM0.3,PM0.5,PM1.0,PM2.5,PM5.0,PM10} Each data has 8 bytes long. 1st 4 bytes for unsigned integer >0 and last 4 bytes for decimal places <0, thus last 4 bytes should be divided by 10000..
0x23	1 or 0	Write	0x01: Start cleaning, 0x0: Stop cleaning
0x24	1 or 0	Write	0x01: Start Power saving mode (PSM), 0x0: Stop PSM
0x25	1 or 0	Write	0x01: Start fan, 0x0: Stop fan
0x26	[n]	Read	Read StatusByte (b0:fan on/off, b1: cleaning on/off, b2:PSM on/off). Each bit is 0 for off and 1 for on.
0x30	[n=1,2,3]	Read/write	Measuring time reading/setting, 1 for 200ms,2 for 500ms and 3 for 1000ms
0x31	[n1],…[n4]	Read/write	Cleaning interval reading/setting 4 bytes are unsigned integer in second Default value = 604800s or 1 week
0x32	[n1], [n2]	Read/write	Vth reading/setting,[n1]x256+[n2]
0x33	[n1], [n2]	Read/write	Vgc reading/setting,[n1]x256+[n2]
0x34	[n=1,2,3]	Read/write	Measured data unit. As for PC data: 1 for binary number per ft^3 2 for binary number per m^3 *and* 3 for binary number per liter. As for PM data, 1st 4 bytes are unsigned integer >0, and last 4 bytes are unsigned integer <0, so this number should be divided by 10000. 1 for number per ft^3, 2 for number per m^3 *and* 3 for number per *liter*
0x40	None	Write	Reset the module
0x41	[addr],[n]	Read	Read [n] bytes from register map [addr]

For normal operation, users may use the following commands:

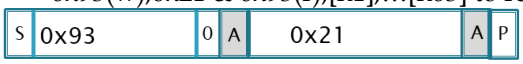
- 0x93(w),0x20,0x1 to start measuring



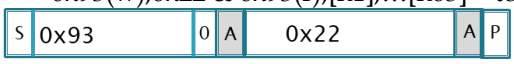
- 0x93(w),0x20,0x0 to stop measuring



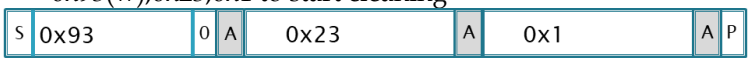
- 0x93(w),0x21 & 0x93(r),[n1],…[n63] to read measured PC data



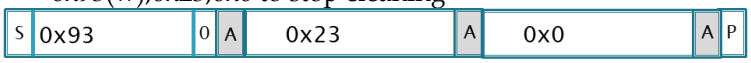
- 0x93(w),0x22 & 0x93(r),[n1],…[n63] to read measured PM data



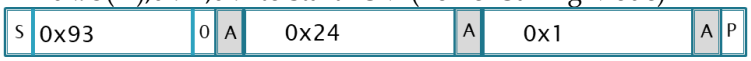
- 0x93(w),0x23,0x1 to start cleaning



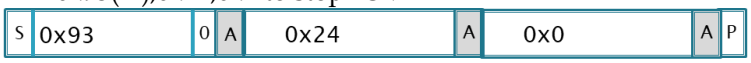
- 0x93(w),0x23,0x0 to stop cleaning



- 0x93(w),0x24,0x1 to start PSM (Power Saving Mode)



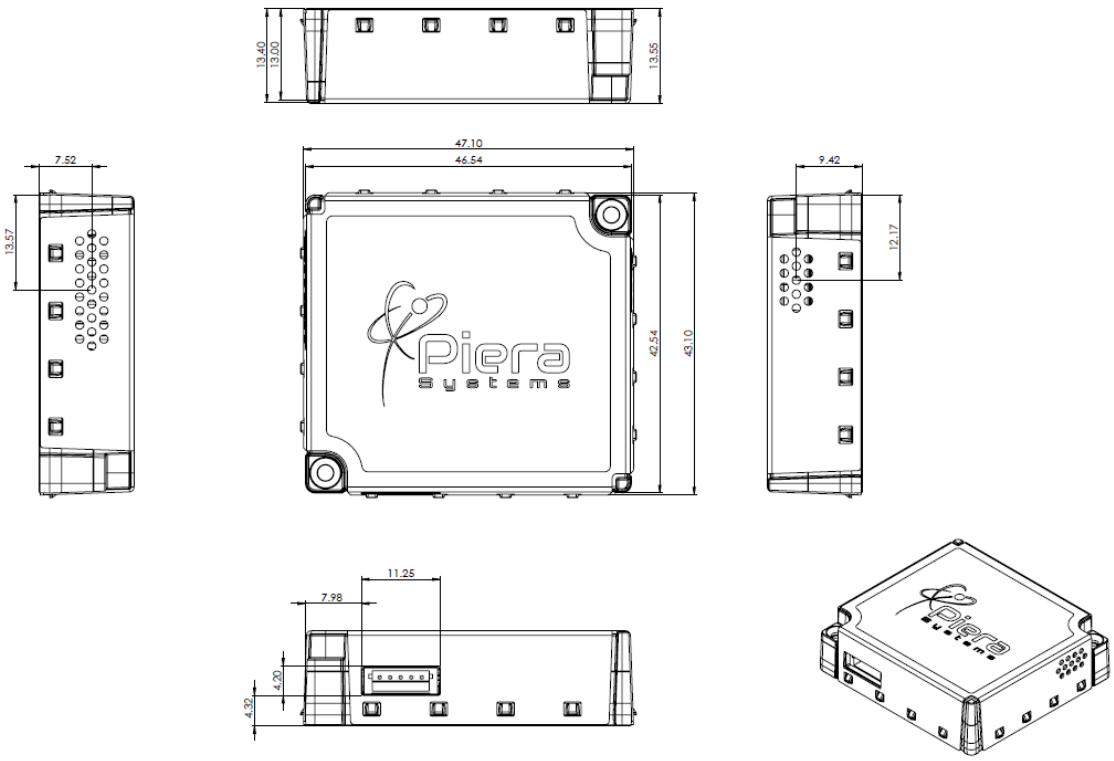
- 0x93(w),0x24,0x1 to stop PSM



6. USB Firmware Update

Any updates on Piera-7100's firmware can be uploaded to each Piera-7100 unit via UART/USB cable. Please contact Piera Systems for more detail.

7. Technical Drawings



Piera-7100 can be mounted by using M2 screws.

8. Ordering Information

Please visit www.pierasystems.com or email to info@pierasystems.com.

9. Important Notices

8.1 Warning, Personal Injury

Do not use this product as safety or emergency stop devices or in any other application where failure of the product could result in personal injury. Do not use this product for applications other than its intended and authorized use. Before installing, handling, using or servicing this product, please consult the data sheet and application notes. Failure to comply with these instructions could result in death or serious injury.

If the Buyer shall purchase or use PS-1 for any unintended or unauthorized application, Buyer shall defend, indemnify and hold harmless PIERA SYSTEMS and its officers, employees, subsidiaries, affiliates and distributors against all claims, costs, damages and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if PIERA SYSTEMS shall be allegedly negligent with respect to the design or the manufacture of the product.

8.2 ESD Precautions

The inherent design of this component causes it to be sensitive to electrostatic discharge (ESD). To prevent ESD-induced damage and/or degradation, take customary and statutory ESD precautions when handling this product.

See application note “ESD, Latch-up and EMC” for more information.

8.3 Warranty

Piera Systems warrants solely to the original purchaser of this product for a period of 12 months (one year) from the date of delivery that this product shall be of the quality, material and workmanship defined in Piera Systems’ published specifications of the product. Within such period, if proven to be defective, PIERA SYSTEMS shall repair and/or replace the product, in PIERA SYSTEMS’s discretion, free of charge to the Buyer, provided that:

- notice in writing describing the defects shall be given to PIERA SYSTEMS within 14 (fourteen) days after their appearance;
- such defects shall be found, to PIERA SYSTEMS’s reasonable satisfaction, to have arisen from PIERA SYSTEMS’s faulty design, material, or workmanship;
- the defective product shall be returned to PIERA SYSTEMS at the Buyer’s expense; and
- the warranty period for any repaired or replaced product shall be limited to the unexpired portion of the original period.

This warranty does not apply to any equipment which has not been installed and used within the specifications recommended by PIERA SYSTEMS for the intended and proper use of the equipment. EXCEPT FOR THE WARRANTIES EXPRESSLY SET FORTH HEREIN, PIERA SYSTEMS MAKES NO WARRANTIES, EITHER EXPRESS OR IMPLIED, WITH RESPECT TO THE PRODUCT. ANY AND ALL WARRANTIES, INCLUDING WITHOUT LIMITATION, WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, ARE EXPRESSLY EXCLUDED AND DECLINED.

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