

UART Communications Guide

Communicating with Piera Sensors on an UART Serial Bus
6/17/21 - Version 1.0a

Summary of UART Mode

Piera's IPS Line of Particle Sensors default to UART/Serial mode of operating and this document will focus on communication with Piera IPS-Line of sensors specifically on UART/Serial bus

For customers that wish to evaluate Piera sensors for Particle Count capabilities and Air Quality Monitoring we recommend you evaluate the device using SenseiAQ Software on a Windows PC/Mac device using the USB Cable provided in the Piera Evaluation Kit.

Basics: UART Wiring for Piera sensors

The Piera IPS-Series must be wired properly to operate in I2C Mode, the default mode is UART as long as pins 4 and 5 are **not** grounded together. A cable is included in the Piera Evaluation Kit or alternatively the standard JST Connector is built using these parts

Connector Plastic Housing:

<https://www.digikey.com/en/products/detail/w%C3%BCrth-elektronik/648005113322/2508649?s=N4lgTCBcDaIGwBYAcAGFBWAjJgzDsEAugL5A>

Pre-crimped wires:

<https://www.digikey.com/en/products/detail/jst-sales-america-inc/ASZHSZH28K305/6009456?s=N4lgTCBcDaICwFYEFoDMAGAH05A5AliALoC%2BQA>

Hardware and Settings



Fig. 1. Interface connector I/O pins



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

Table 4. Interface connector I/O pin description

1.1. Default Settings

Features	Default Settings	Description
Auto Mode	On	IPS starts to readout data once power is on – Plug-and play.
Data Output Interval	1 second	IPS reads out all available bin data every 1 second interval.
PM Data Output	On	IPS reads out mass concentration (PM) data as well as particle counts (PC) data.
Serial Number Output	On	Device serial number is displayed at the end of each data string.
Network Serial Key Output*	On	Device network serial key is displayed at the end of each data string for IoT applications.
Auto Cleaning Mode	On, 1/week	IPS will initiate auto cleaning cycle every week for 10 seconds.
PC Data Output Unit	#/L	Displayed PC data is in number of particles per liter.
PM Data Output Unit	ug/m ³	Displayed PM data is in micrograms per cubic meter.
VSD Mode*	On	Vape/Smoke Detection feature is standard on IPS-7100 models, and the feature is enabled.

Table 5. Default settings for UART

*For if equipped models. Please refer to the Product Lineup section.

2. Communication Protocols

2.1. Physical Layer

The IPS has Rx and Tx lines with unipolar logic levels. Transmitted byte is shown in Fig. 2. The data speed is 115,200 Baud Rate. The IPS offers both a UART and I²C interface.

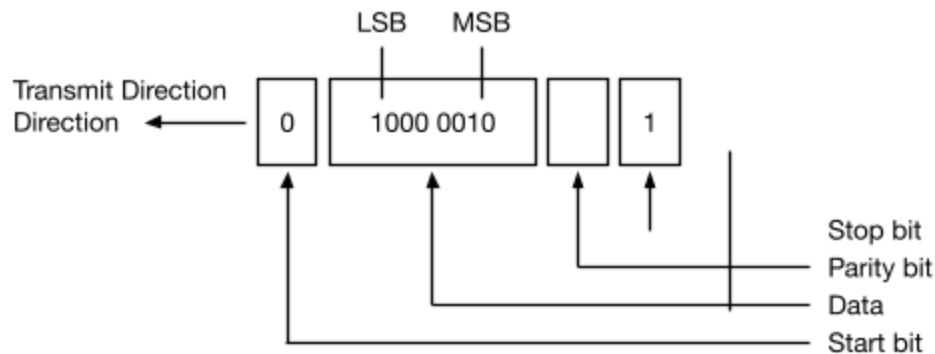


Fig. 2. UART (Universal Asynchronous Receiver Transmitter) data transfer

2.2. UART Interface

Fig. 3 shows the typical UART application circuit, which has 5 I/O pins; VDD, Rx, Tx, SEL, and GND. All commands for IPS (slave) are in printable ASCII strings for convenience. The IPS also replies in printable ASCII string format. Therefore, any serial communication program available on PC and application systems (master devices) can be used to download commands and see the results. An UART cable length should be less than 5m, or 16.5ft.

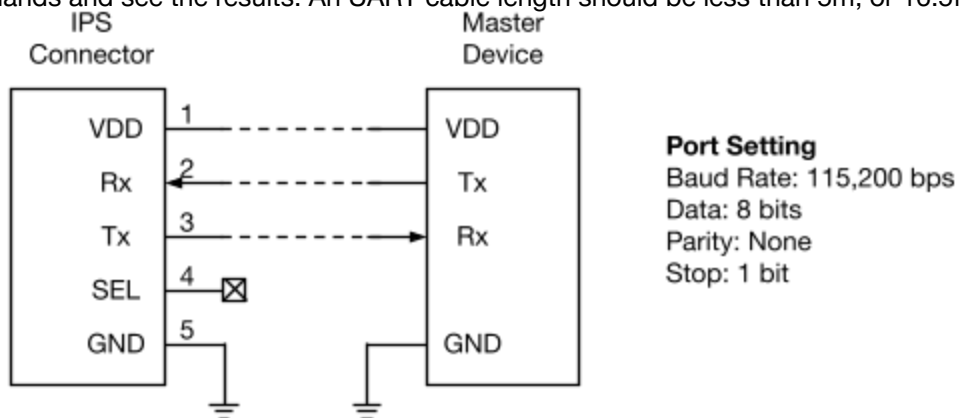




Fig. 3. Typical UART interfacing

2.2.1. Default Sensor Settings

By default, the IPS starts to send data automatically via UART every 1 second as the device is powered up: a series of data strings containing particle counts (PC) and mass concentration (PM) data followed by both device serial number and its network serial key. The PC data is in #/L, and the PM is in $\mu\text{g}/\text{m}^3$. Allow at least 5 seconds to obtain stable data. The IPS will run self-cleaning cycle for 10 seconds once a week by default.

If your device is equipped with the Vape/Smoke Detection (VSD) algorithm, the VSD mode is on by default. It is standard on IPS-7100 models.

Factory settings:

- | | |
|--|----------------|
| 1. Auto Mode | \$Wmodesel=0 |
| 2. 1 second Data Output Interval Time | \$Winterval=1 |
| 3. PM Data Output | \$Wpmd=1 |
| 4. Output Serial Number and Key Code | \$Wazure=1 |
| 5. Weekly Auto Cleaning | \$Wcinp=604800 |
| 6. Output Unit in #/L and $\mu\text{g}/\text{m}^3$ | \$Wunit=0 |
| 7. Vape-Smoke Detection Mode | \$Wvsd=1 |

To reset the sensor to default factory settings, use the following command.

```
$Wfactory=[CR][LF]
```

Note that ENTER key ([CR][LF]) must be followed by every command.

2.2.2. Operating Mode Setting – Manual or Automatic Mode

The IPS uses an easy-to-ASCII strings to communicate between the slave (IPS sensor) and the master device (application system). The internal blow fan is on as power is supplied.

Manual Mode: Sensor waits for the “Set Interval Time” command to start operation.

- Set Command Mode



`$Wmodesel=1[CR][LF]`

`$Wreset=[CR][LF]`

- b. Set Interval Time

`$Winterval=<n>[CR][LF]`, where n is interval in second ranging of 0 – 65,535s. Note that “0” doesn’t output any data.

Automatic Mode: Sensor starts operation and outputs data when the sensor is connected to power through USB connector. On this mode, the sensor outputs data automatically without the “Set Interval Time” command when plugged in a master system (like PC). The sensor outputs data according to the set Interval Time.

- a. Set Auto Mode

`$Wmodesel=0[CR][LF]`

`$Wreset=[CR][LF]`

- b. Change the Interval Time on Automatic Mode

`$Winterval=<n>[CR][LF]`, where n is interval in seconds, ranging from 1 to 65,535s.

2.2.3. Real-time Data Retrieving

The IPS offers a special mode for getting data (PCx and PMx) immediately at any time.

`$Rget=[CR][LF]` to retrieve a dataset for all PC and PM.

2.2.4. IoT Communication Mode

For models that are equipped with this feature, the IPS sends out its unique network serial key for IoT communication. When the IoT communication mode is enabled, device serial number and network key will be displayed at the end of each data string. The sensor memorizes the previous settings once the mode is set.

`$Wazure=1[CR][LF]` to enable IoT Communication Mode

`$Wazure=0[CR][LF]` to disable IoT Communication Mode

2.2.5. Fan Control and Cleaning Mode

The fan is automatically on when the power is supplied to the module. To turn on or off the fan manually, use the following commands as below:



\$Wfan=1[CR][LF] to turn on the fan

\$Wfan=0[CR][LF] to turn off the fan

\$Wcln=1[CR][LF] to initiate the cleaning cycle manually

\$Wcln=0[CR][LF] to stop the cleaning cycle manually

\$Wclnp=<n>[CR][LF] to set the auto self-cleaning interval where n is interval in second (604,800 by default)

\$Wclnp=0[CR][LF] to stop the auto self-cleaning mode

2.2.6. PC and PM Unit Change

To change measured data unit, use the following command:

\$Wunit=<n>[CR][LF] where n==0, 1, 2, or 3

1 for PC, PM values per ft^3 , 2 for PC, PM value per m^3 , 3 for PC, PM value per *liter*.

The default factory setting is n==0 for count number per *liter* and mass number per m^3 .

2.2.7. Power Saving Mode (PSM)

The IPS can hibernate to save energy depending on applications. The IPS will enter hibernation, disabling power to the sensor. The fan, laser diode will all be turned off, and the CPU also goes into deep-sleep mode (<67uA, <273uA for I²C). Any trigger pulse (1ms with 50%duty) will wake up the sensor. It will start gathering data normally.

\$Wpsm=1[CR][LF] to initiate PSM

2.2.8. Vape/Smoke Detection (VSD) Mode

If equipped, the IPS can function as a vape/smoke sensor. The device will detect any event of vaping or smoking, and it will send out alerts (print strings "Smoke Detected" or "Vape Detected") when the VSD is enabled. The device will continue to readout data normally even when the VSD Mode is on.

This feature is standard on every IPS-7100 models. Other models may be upgraded to access this feature on demand.

\$Wvsd=1 [CR][LF] to enable VSD Mode



$\$W_{vsd}=0$ [CR][LF] to disable VSD Mode

Warning: IPS is not meant for replacing standard indoor smoke/fire alarms.

2.2.9. Sensitivity and Detection Range Control

The IPS has two outstanding features for detecting various sized particulate matters. The user may customize the IPS depending on applications by adjusting sensitivity control voltage and/or detection range control voltage of the sensor. This feature is available for IPS-5100, IPS-5500, and IPS-7100.

Note: The user is required to calibrate for any particle size range that is not offered by standard IPS sensor output bins. Piera Systems does not guarantee the accuracy of the data obtained in this mode.

Contact Piera Systems for more details.

Sensitivity Control

The sensitivity control voltage of IPS is initially set to 1,800mV for general purpose operations. User can adjust the sensitivity of IPS when operating in special environments.

$\$W_{Vref}=1800$ [CR][LF] where 1800 means V_{ref} is set to 1,800mV

Detection Range Control

The IPS has 5 different equally spaced electrical bins to categorize the particulate matters by their sizes. The detection range control voltage of IPS is by default set to 2,500mV for typical measurement environment, which sets 5 internal threshold voltages (V_{th1} , V_{th2} , V_{th3} , V_{th4} , and V_{th5}). The parameter should be in between 1500 and 3000.

$\$W_{Vth}=2500$ [CR][LF] where 2500 sets the threshold voltages as follows:

$V_{th1}=0.5V$, $V_{th2}=1.0V$, $V_{th3}=1.5V$, $V_{th4}=2.0V$, and $V_{th5}=2.5V$.

2.2.10. Debugging Mode

The IPS offers a debugging mode for the advanced users who want to develop/modify the algorithm by getting the raw data from the sensor. The user can access to raw ASIC data by enabling debugging mode.

$\$W_{debug}=1$ [CR][LF], where $x==1$ for enabling the debugging mode, $x==0$ for disabling the debugging mode, which is the default.



When the command is sent to the module, raw data will be displayed as the following example:

```
$Won=1
Won=1
Turn on sensing for 200 [ms]
Init ...
N0[x],1,1,0,0,1,P[x],4,1,0,0,176,PC0.1, 32750000,PC0.3, 8492000,PC0.5,
4520500,PC1.0, 428500,PC2.5, 11500,PC5.0, 780,PC10, 268,PM0.1, 0.2736459,PM0.3,
0.21894411,PM0.5, 0.69106513,PM1.0, 0.90588760,PM2.5, 0.95394840,PM5.0,
0.98977848,PM10, 1.8606841
N0[x],1,2,0,0,2,P[x],5,6,0,0,22,
N0[x],0,0,0,0,0,P[x],0,0,0,0,0,
N0[x],1,0,0,0,2,P[x],5,0,0,0,47,
N0[x],1,1,0,0,2,P[x],1,7,0,0,40
N0[x],0,0,0,0,0,P[x],0,0,0,0,0,PC0.1, 41003000,PC0.3, 10631984,PC0.5, 5768158,PC1.0,
569905,PC2.5, 15295,PC5.0, 1037,PC10, 89,PM0.1, 0.3426046,PM0.3,
0.27411801,PM0.5, 0.87654443,PM1.0, 1.16225832,PM2.5, 1.22617918,PM5.0,
1.27381481,PM10, 1.30579169
N0[x],0,0,0,0,2,P[x],0,0,0,0,44,
```

Where, N0[x] means 5 bin counting numbers on Vth1, Vth2, Vth3, Vth4, and Vth5 respectively, and P[x] is pulse widths of corresponding bin on every 200ms @\$Won=1.

The sampling interval can be changed by: \$Won=2 for 500ms, \$Won=3 for 1,000ms, and etc.

Support information

Contact us <http://pierasystems.com/support>

Please be willing to provide the following information about your I2C Bus

- UART Controller Type, Cable Length, Use-Case information.

https://en.wikipedia.org/wiki/Universal_asynchronous_receiver-transmitter

Ordering information

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

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