

Sensor Node Quick Start Guide

THINGY:AQ

Wildland Fire Real-Time Monitoring System
PROTOTYPE DRAFT

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1 Product Overview

Note: The Thingy:AQ real-time air quality monitoring and telemetry system described in this guide was designed and built to meet the requirements of the InnoCentive Wildland Fire Sensor Challenge - Challenge ID: 9933927

The system comprises of multiple Sensors Nodes and a Central Receiving Unit. Communications between the Sensor Nodes and the Central Receiving Unit utilize LoRa (Long Range Low Power) radio technology that offers a compelling mix of long range and low power consumption. The system has been designed to be lightweight and easily deployable by a single, non-specialist operator and to be suitable for harsh environments. The prototype Thingy:AQ systems contains two main system components:

Thingy:AQ Sensor Nodes. These battery-powered Sensor Nodes (SN) measure air pollutants including fine particulate matter $PM_{2.5}$, PM_{10} , carbon monoxide, carbon dioxide and ozone. The Sensor Nodes also measure air temperature, humidity and geo-location data. A unique System ID identifying the Sensor Node, latitude, longitude and System Error status are stored on the Sensor Node and are transmitted in real time over long distance utilizing a LoRa encoded radio link.

Thingy:AQ Central Receiving Unit. The central receiving unit (CRU), a physical system, receives and centrally records data from multiple remote Sensor Nodes and provides a USB port for interfacing into third party presentation platforms.

The Sensor Nodes include two 80um stainless steel particulate filters, one on the air inlet and one on the exhaust from the Sensor Node. These filters limit both the ingress of larger pollutant material and biological entities. To clean or replace the filters just turn the red filter housing counter-clockwise to remove. Reverse this process to replace the filters.

1.1 Sensor Node

1.1.1 Sensor Node Overview

The Sensor Node housing incorporates the data logger electronics, a microSD card used for logging the data, a GPS module for determining location information, a LoRa (Long Range) radio module and the sensors embedded in a flow chamber. The GPS and LoRa antennas are mounted directly to the top of the Sensor Node housing.

At the bottom of the Sensor Node housing (figure 1.1) are intake and exhaust filters for the airflow. Air flow passes through a three-stage bio-mas filter assembly (3mm, 80um, 20um), through the PM sensor into the sealed flow chamber where the airflow passes above the remaining gas sensors through to the exhaust filter. The intake is closest to the door and the exhaust is behind the intake (toward the enclosure back).

The solar/battery/wall power connector is one with the blue cap to the left of the air filters.



Figure 1.1 Thingy:AQ Sensor Node Housing with Inlet Air Filter

1.1.2 Sensor Nodes

The Sensor Nodes are designed to record and telemeter data with minimal or no operator intervention. Once the system has been turned on, it will start measuring sensors, logging the data and telemetering the data. The scan cycle time defines when the Sensor Node will start a scan cycle, which involves powering up the particulate matter and CO₂ sensors, waiting 15 seconds for the system to stabilize and then commencing a series of sensor measurements, reading each sensor every 2 seconds multiple times before filtering, averaging, and storing the data. At the end of the scan sequence, the Sensor Node powers down the sensors, powers up the radio transmitter, telemeters the data and powers down the radio. The Sensor Node enters a sleep state until the next scan cycle or input from the operator.

The only operator configurable variable is the Sensor Node Scan Interval (SI) cycle. The value is stored in non-volatile memory and can be configured for a 1, 2, 5, 15, 20, 30 or 60 minute scan interval. When the Sensor Node is powered on, it reads the scan interval configuration from its non-volatile memory and automatically commences operation based on this parameter. The operator can change this scan interval via the USB serial port on the Sensor Node. If the

operator changes the scan interval, the new value is stored in non-volatile memory and becomes the new power-on default value. The operator can interrogate system status, upload system logs and upload recorded data via the Sensor Nodes USB interface. The data on the Sensor Node is logged on the microSD card. The data can be read from this card without removing the card. When the microSD card is swapped or replaced the system will automatically commence logging to the media.

1.2 Sensor Node Front Panel

The front panel contains the logger's ON/OFF switch, a WAKE UP switch, the micro USB socket and three indicator LEDs; AWAKE, SYS ERROR and TX ERROR.



Figure 1.2 Prototype Sensor Node Front Panel

1.2.1 POWER SWITCH

Turns the Sensor logger on or off.

1.2.2 WAKE UP PUSH BUTTON

Wake the sensor up from deep sleep to enable configuration of the system, to upload data, delete the data and log files etc, When the system is in deep sleep it can be woken up using this push button by pushing the button for three seconds after which the AWAKE LED will flash continuously while the logger is awake.

1.2.3 AWAKE LED

The WAKE LED is blue and it provides an indication of three separate states. When the logger is turned on the blue LED will flash 6 times in rapid succession indication the processor is operational, after a few seconds, the Power LED will flash approximately 10 times at a slower rate indication the logger is initializing the hardware. When the initialization process is complete the Power LED will remain illuminated for several minutes until the system go into deep sleep.

1.2.4 SYS ERROR LED

The SYS Error LED indicates a problem with the logger. This indicates either a problem with the microSD card, a fault with one or more of the sensors or a low system voltage alarm.

1.2.5 TX ERROR LED

The TX ERROR LED will flash briefly in the event of an unsuccessful transmission of data via the radio.

1.2.6 MICRO USB CONECTOR

The micro USB connector provides a USB serial interface to the logger. The logger will send formatted data out of the serial interface at the end of the current scan interval. This interface provides the user / operator interface to enable the configuration and interrogation of the logger and to upload data and system log files from the logger to a terminal application.

2 Installing, Starting and Stopping the System

2.1 Powering up the system

2.1.1 External Battery Pack and Solar Charger

The Sensor Node Site Logger utilizes an external power supply enclosure (figure 2.1) which is mounted on the mast (not shown in the picture). This enclosure contains a sealed lead acid battery (SLA) and a solar charge controller. The battery is connected to the solar charger via a pair of in-line mating XT30 connectors. The system is shipped with the battery disconnected. To connect the battery, open the enclosure door and connect the XT30 connectors (see figure 2.2a).



Figure 2.1 Thingy:AQ Sensor Node Battery Enclosure



Figure 2.2a Thingy:AQ XC30 Connectors

2.1.2 Wall (AC) Power Option

The Sensor Node can also be powered with the supplied AC power supply and 2.1mm DC power connector (see figure 2.2b). In this case you will not use the external battery pack. Connect the supplied AC power supply (15VDC out to a 2.1mm barrel connector) to the power adapter labeled **WLF-Wall-Power**. Then attach the adapter to the sensor housing connector. The system is now ready to be powered on. *Note in this configuration the sensor will not operate without Wall power.*



Figure 2.2a Thingy:AQ XC30 Connectors

2.2 Preparing the Sensor Node for Deployment

1. Mount the battery housing to the mast (if required)
2. Open the battery housing, connect the battery, close the battery housing

3. Mount the Sensor Node enclosure with the provided mounting hardware on the collapsible mast
4. Raise the mast to the required height
5. Open the Sensor Node logger enclosure
6. Open the front panel
7. Install a newly formatted microSD card into the microSD card socket
8. Close the front panel
9. Plug in either the battery housing, if fitted, or an external power supply
10. Turn on the logger via the ON/OFF push button switch.
11. If necessary, connect to via the USB port and configure the desired scan interval
12. Close the enclosure cover

2.3 Connecting to the Sensor Node Logger

When the operator connects to the USB interface it will be enumerated on the PC as a Silicon Labs CP2102 USB-to-Serial port adapter. Modern operating systems, such as Windows 10, include the required driver to recognize the USB interface as a serial device and to create a logical serial port.

A quick way of determining the serial port in use on the PC is to inspect the PC's serial port table immediately before and immediately after plugging into the logger and noting the Comm port number (Comm xx) of the newly creates device. Figures 2.3 is a screen capture of Window's Device Manager on Windows 10 showing a newly created Comm port (in this case Comm20).

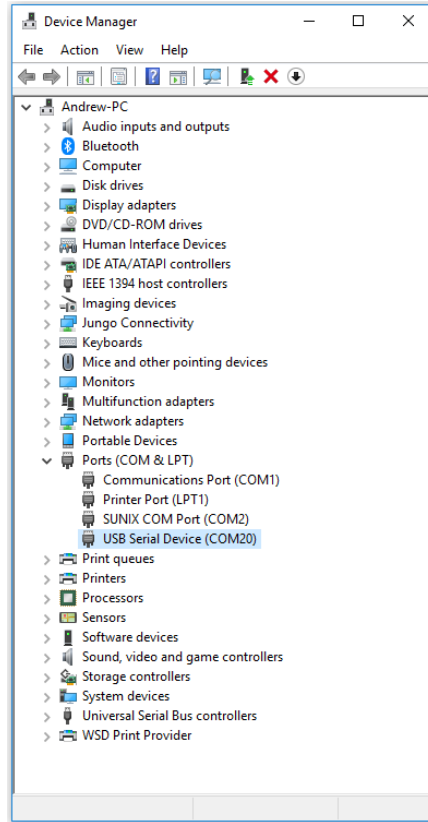
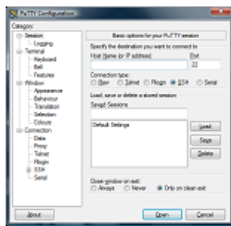


Figure 2.3 Windows Device Manager after plugging in the Sensor Node

2.3.1 Configuring the Terminal application

When using a PC, open your preferred terminal application and configure the terminal application to use the newly created serial port and to select **local echo** mode.

If you do not have a suitable terminal application these are several freeware terminal applications available. One example for Windows is PuTTY (figure 2.4) which can be downloaded here: www.putty.org



Download PuTTY

PuTTY is an SSH and telnet client, developed originally by Simon Tatham for the Windows platform. PuTTY is open source software that is available with source code and is developed and supported by a group of volunteers.

You can download PuTTY [here](http://www.putty.org).

Figure 2.4 Putty Terminal Program for Windows

When the terminal application on the PC is started, configure the serial interface attributes.

Set the Terminal to 57600 baud, 8 bit data, 1 stop, no parity, no flow control, local echo.

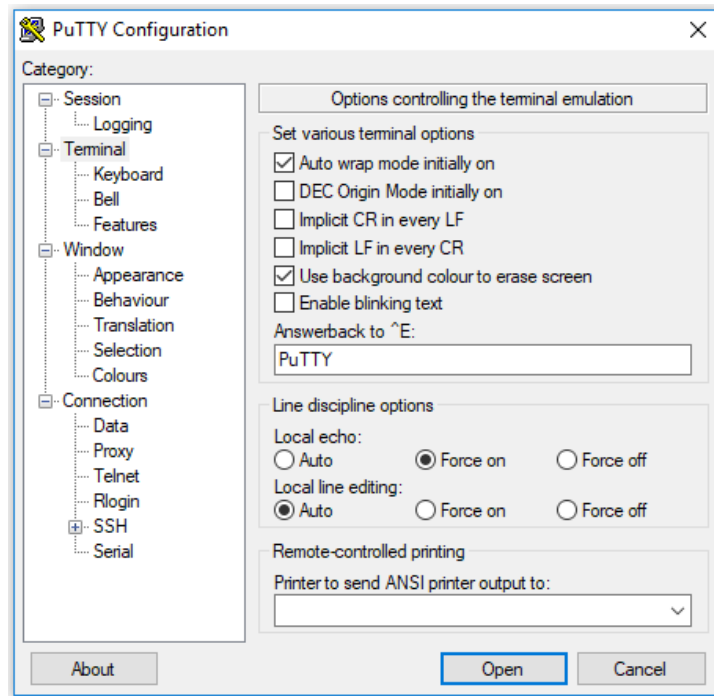
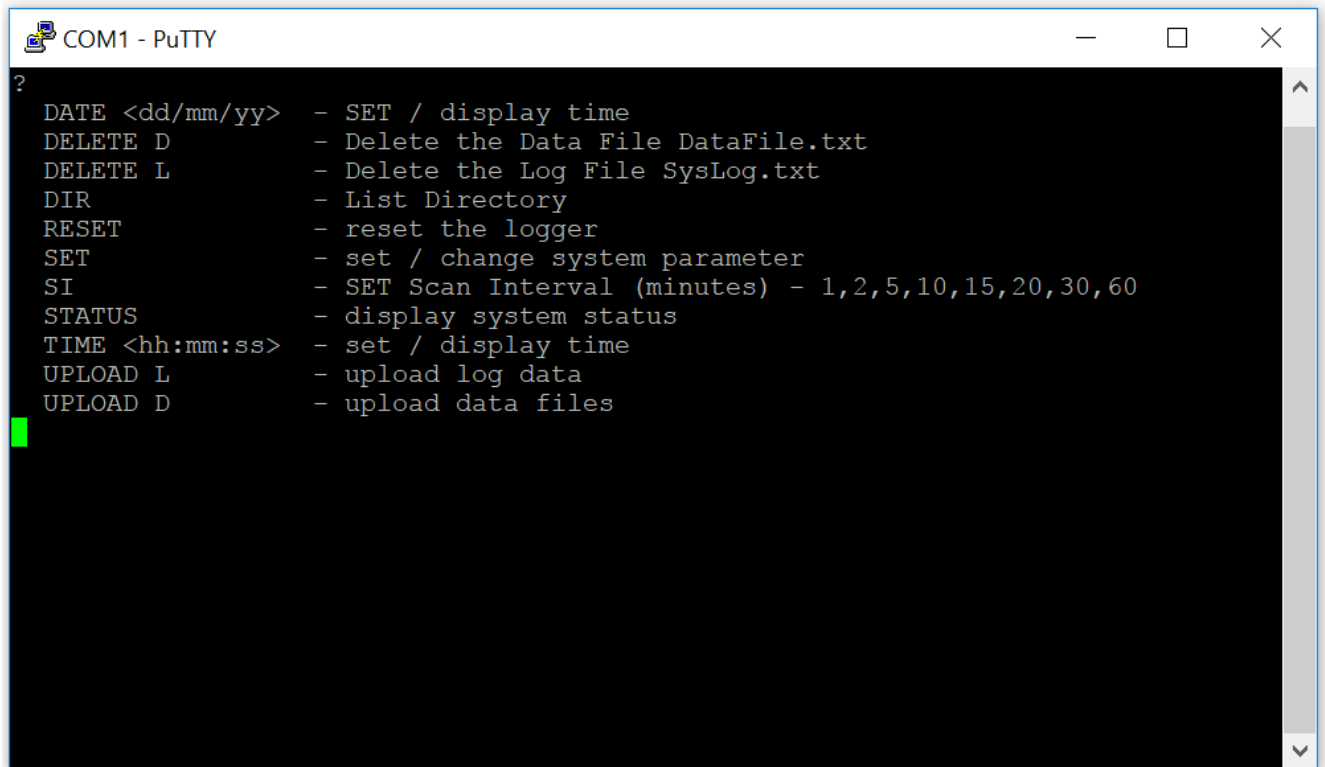


Figure 2.5 Putty Configuration Screen for Local Echo

2.4 User Interface

The logger provides a help screen. Help can be access using the short cut ? character followed by ENTER (carriage return / line feed).

A screenshot of a PuTTY terminal window titled "COM1 - PuTTY". The terminal displays a list of commands and their functions. The commands listed are: DATE, DELETE D, DELETE L, DIR, RESET, SET, SI, STATUS, TIME, UPLOAD L, and UPLOAD D. Each command is followed by a description of its function. A green cursor is visible at the end of the last line of the list.

```
?
DATE <dd/mm/yy> - SET / display time
DELETE D        - Delete the Data File DataFile.txt
DELETE L        - Delete the Log File SysLog.txt
DIR             - List Directory
RESET          - reset the logger
SET            - set / change system parameter
SI            - SET Scan Interval (minutes) - 1,2,5,10,15,20,30,60
STATUS         - display system status
TIME <hh:mm:ss> - set / display time
UPLOAD L       - upload log data
UPLOAD D       - upload data files
```

Figure 2.6 User Interface Help Output

2.4.1 Scan Interval

The scan interval determines the time interval between the logger sensor scan sequences and is configured using the SET SI command. Example: **SET SI 5** will set the scan interval to 5 minutes. The scan interval is stored in nonvolatile memory and becomes the power-on default value until changed again by the next SET SI command.

2.4.2 Status Command

The status command will display the logger's health status

2.4.3 Directory Listing

The directory contents of the logger's microSD card can be viewed using the DIR command.

2.4.4 Upload Commands and Delete

The upload commands are used to upload the status log file and the data file from the logger's microSD card to the terminal application. This data can then be logged to the PC via the terminal application's capture capability. The following screen capture shows the configuration of the Putty application to capture the console output.

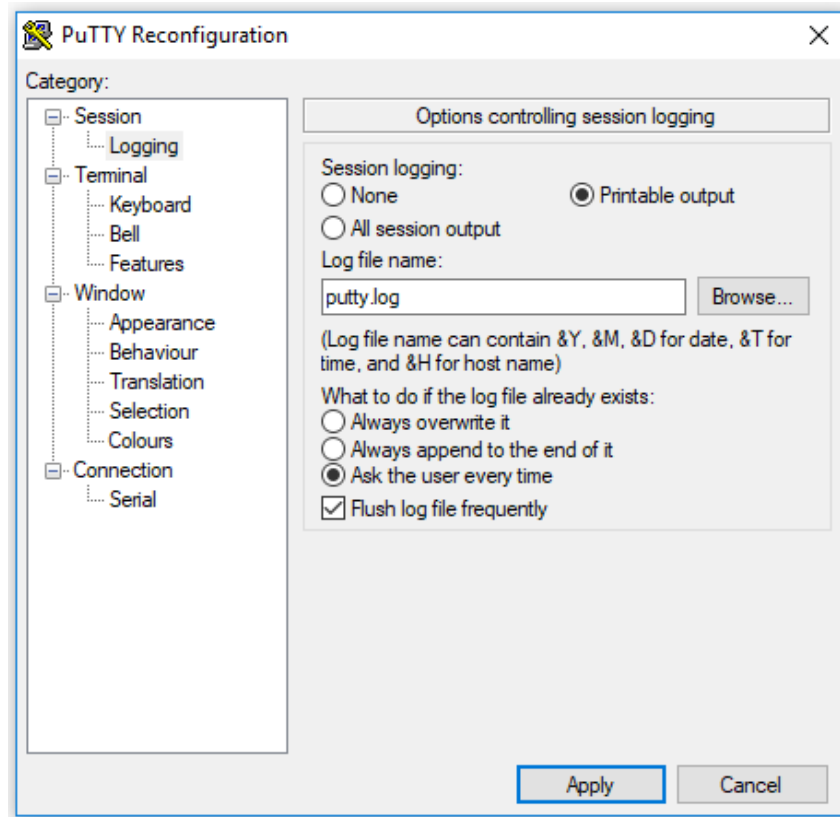


Figure 2.7 Configuring Logging (capture) with Putty Terminal Application

2.4.4.1 UPLOAD D

The data file can be uploaded using the **UPLOAD D** command.

2.4.4.2 DELETE D

Once the data has been uploaded via the terminal application and the user has confirmed the successful upload by viewing the contents of the uploaded file, the data file can be deleted from the logger via the **DELETE D** command.

2.4.4.3 UPLOAD L

The Sensor Node also produces status log records for the power on reset initialization of the logger. This file contains sensor configuration data extracted from the sensors. This file can be uploaded using the **UPLOAD L** command.

2.4.4.4 DELETE L

The log file can be deleted with the ***DELETE L*** command.

2.4.5 Reading the microSD card

Instead of uploading the data file via the terminal application, the user can instead to remove the microSD card from the logger and inserting it into the PC to read the file directly from the MicroSD card. The logger accepts MicroSD cards formatted as either FAT16 or FAT32.

2.5 Sample Data Format

Date	Time	Lat	Long	Type	ID	SI	Sys	TempC Deg C	RH %	PM2.5 µgm/m3	PM10 µgm/m3	CO2 ppm	CO ppm	O3 ppb	Battery voltage
2018/01/13T17:40		47.69445	-122.04355	Data	IDA3	02	60	23.0	42.0	0.6	1.9	885	4.9	8	12.0
2018/01/13T17:42		47.69445	-122.04355	Data	IDA3	02	60	23.0	41.5	0.6	1.2	892	4.7	8	12.0
2018/01/13T17:44		47.69445	-122.04355	Data	IDA3	02	60	23.0	42.0	0.5	0.6	879	4.7	9	12.0
2018/01/13T17:46		47.69445	-122.04355	Data	IDA3	02	00	23.0	42.0	0.7	2.2	865	4.6	8	12.0
2018/01/13T17:48		47.69445	-122.04355	Data	IDA3	02	00	23.0	42.0	0.6	1.5	870	4.6	9	12.0
2018/01/13T17:50		47.69445	-122.04355	Data	IDA3	02	00	23.0	42.0	0.6	4.8	850	4.5	10	12.0
2018/01/13T17:52		47.69445	-122.04355	Data	IDA3	02	00	23.0	42.4	0.8	3.6	852	4.6	10	12.0
2018/01/13T17:54		47.69445	-122.04355	Data	IDA3	02	00	23.0	42.5	0.5	1.5	867	4.5	9	12.0
2018/01/13T17:56		47.69445	-122.04355	Data	IDA3	02	00	23.0	42.5	0.8	2.5	867	4.5	9	12.0
2018/01/13T17:58		47.69445	-122.04355	Data	IDA3	02	00	23.0	42.5	0.4	0.4	854	4.5	9	12.0
2018/01/13T18:00		47.69445	-122.04355	Data	IDA3	02	00	23.0	42.5	0.7	2.1	870	4.5	8	12.0
2018/01/13T18:02		47.69445	-122.04355	Data	IDA3	02	00	23.0	42.5	0.9	2.2	859	4.6	8	12.0
2018/01/13T18:04		47.69445	-122.04355	Data	IDA3	02	00	23.0	42.0	0.6	1.3	868	4.7	8	12.0
2018/01/13T18:06		47.69445	-122.04355	Data	IDA3	02	00	23.0	41.5	0.7	4.2	859	4.6	8	12.0
2018/01/13T18:08		47.69445	-122.04355	Data	IDA3	02	00	23.0	41.5	0.6	3.5	854	4.6	8	12.0
2018/01/13T18:10		47.69445	-122.04355	Data	IDA3	02	00	23.0	41.5	0.5	1.1	856	4.6	8	12.0
2018/01/13T18:12		47.69445	-122.04355	Data	IDA3	02	00	23.0	42.0	0.7	0.7	854	4.6	8	12.0
2018/01/13T18:14		47.69445	-122.04355	Data	IDA3	02	00	23.0	42.0	0.5	0.8	853	4.5	9	12.0
2018/01/13T18:16		47.69445	-122.04355	Data	IDA3	02	00	23.0	42.0	0.7	1.4	853	4.5	9	12.0
2018/01/13T18:18		47.69445	-122.04355	Data	IDA3	02	00	23.0	42.0	0.6	0.8	849	4.5	8	12.0
2018/01/13T18:20		47.69445	-122.04355	Data	IDA3	02	00	23.0	42.0	0.6	0.6	849	4.4	8	12.0

Figure 2.8 Sample Data Upload