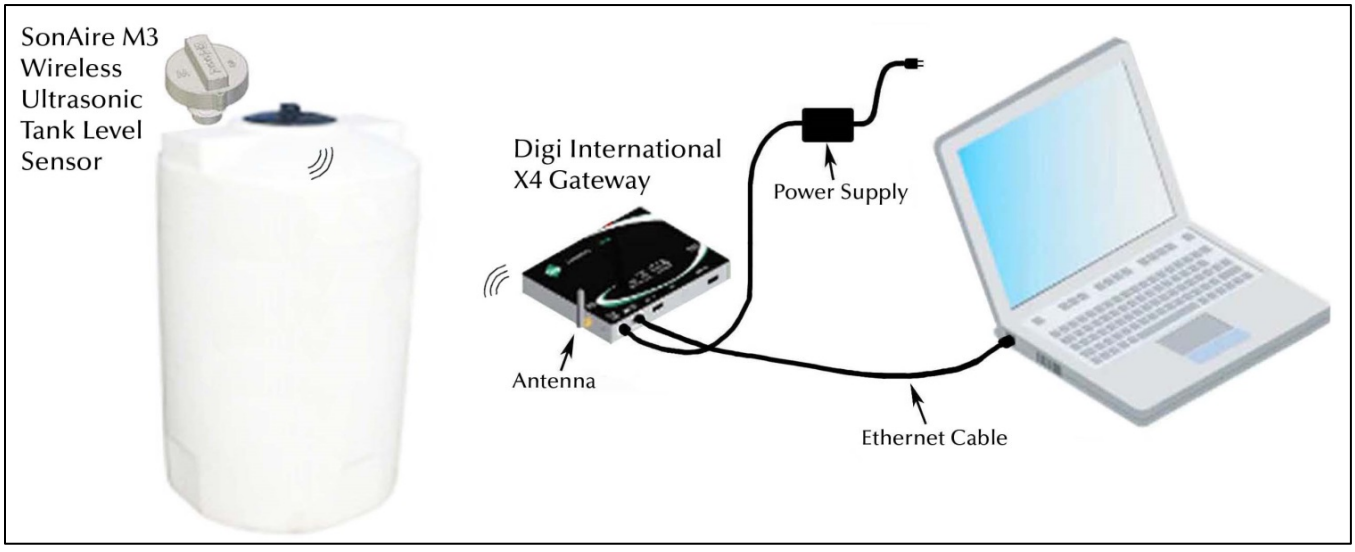
SonAire® M3 Wireless Ultrasonic Sensor Tank Level Monitoring Solution Evaluation Kit Using Gateway's Ethernet Port

Introduction

The MassaSonic® SonAire® M3 Wireless Ultrasonic Sensor Tank Level Monitoring Solution Evaluation Kit provides an easy method to evaluate the Massa/Digi wireless tank level monitoring solution. This includes establishing the wireless path, obtaining tank level and other data. This kit is preconfigured to get the sensor up and running quickly. Sensors are pre-programmed with a 1 minute sleep interval, which upon awakening will obtain range and status information that is sent to the gateway.

The MassaSonic SonAire M3 Wireless Ultrasonic Sensor Tank Level Monitoring Solution Evaluation Kit Includes:

1) MassaSonic SonAire M3/150 Wireless Ultrasonic Sensor is ideal for short tanks, and the SonAire M3/95 Sensor is ideal for taller tanks. In addition, other special order models are available for very tall tanks (please contact the factory). Supplied sensors are defaulted to sleep for one minute and upon awakening send status information.
2) Digi International X4 Gateway p/n X4-Z11-E-A (ZigBee to Internet) and power supply. The gateway is preconfigured with python files and autostart to log data in a status_log.txt file.
3) Ethernet cable to access gateway including python files and XBee settings.
4) Hardware including: a) 2" NPS nut, b) 2" gasket, c) 3 Energizer L91 batteries.
5) Compact Disk containing: a) MassaSonic SonAire M3 Application Software to view waveforms, b) Digi Device Discovery Software to find a gateway, c) SonAire M3 Manual, d) this guide e) SonAire M3 Application Software to view ultrasonic waveforms.



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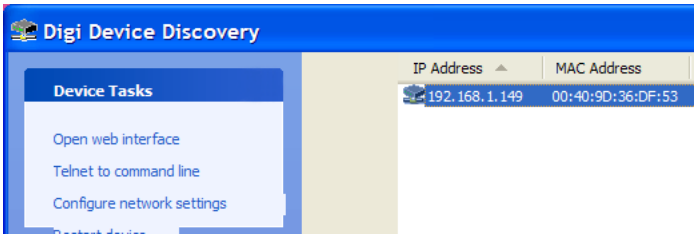
Quick Guide on Getting Started

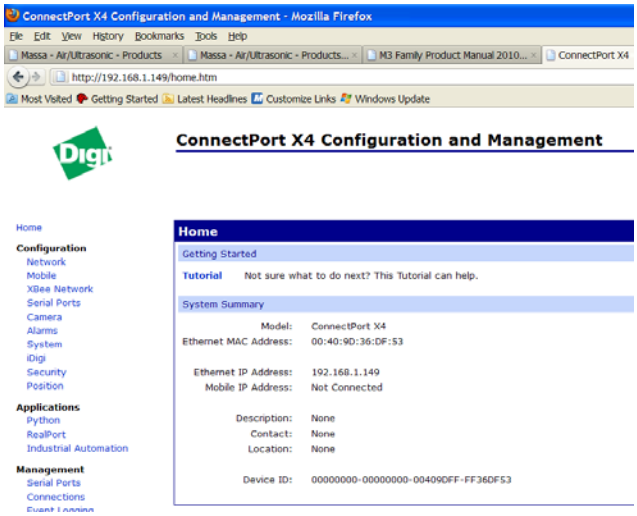
1) Install the Ethernet cable to your PC or router. Attach the gateway's antenna and power the gateway.
2) The X4 Gateway's Ethernet IP Settings are configured to *obtain an IP address automatically using DHCP*. If you plug the Ethernet cable directly to your PC, make sure the Local Area Connection TCP/IP set to obtain an IP address automatically. Contact your network administrator if you need additional support.
3) Run the Device Discovery utility supplied with the kit. To find the gateway as you see in the screen below, double click the IP address found to get to the Digi user interface (UI) web pages (see figures below).
4) The gateway is preconfigured to autostart and run Massa's python code that will record automated messages and stored in a file named "status_log.txt" located in the Python Files page. Note that it takes about a minute every time you power up the gateway for it to be ready to detect a sensor (Zigbee link light will be on when ready).
5) Install the 3 Energizer lithium AA batteries into the SonAire M3 Sensor in the direction indicated in the battery holder. The Sensor's green LED will blink 3 times followed by the red LED staying on for up to 50 seconds while the sensor searches for the gateway. Once the sensor is associated to the gateway (wirelessly connected), then the sensor's red LED will blink every 2 seconds.
6) The sensor's programmed awake period for this kit has been set to 31 seconds and typically should be set this way. The sensor's sleep period has also been preconfigured for 60 seconds. When the sensor wakes up, it will obtain range, temperature & other status information and send it to the gateway in which the gateway will store it to the status_log.txt file (see example below).

   Sample *status_log.txt* report:

Sensor 00:13:a2:00:40:54:da:6a!: Dist=26.5" Temp=20C Batt=4.8V UltrasonicStrength=75% RadioSignal=Strong Event=377 2012-12-12 09:41:16

7) After initial evaluation, it is suggested that you increase the sensor's sleep period if conducting a long term test. Typically 15, 30, 60 minutes is used. This will increase battery life. In the python files of the gateway, save the dia.yml file to your PC and edit the *sleep_interval_sec* setting to increase the time period. Upload this file to the gateway then reboot the gateway. For more information, see the SonAire M3 Manual.





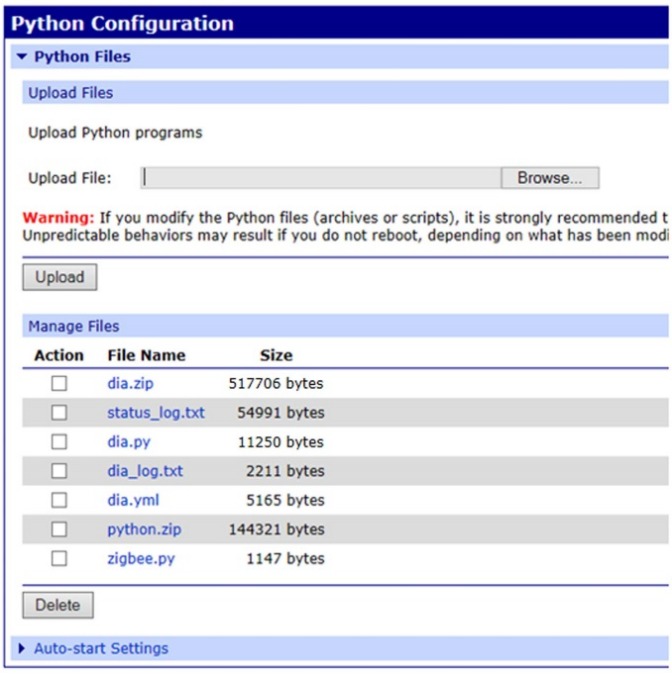
General Notes

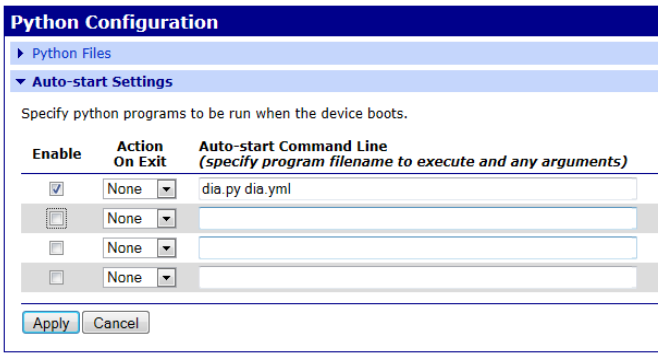
After successfully having the sensor associate with the gateway and having status information recorded in the python files in the gateway, the next step is to perform a site survey for locating the gateway for best RF performance. Typically the sensor is mounted in a fixed location on a tank so the gateway needs to be placed in a location where you are getting the best RF signal strength reports. After gateway and antenna placement, view the status_log.txt file. Ideally you want to see that the sensor is reporting "Strong" or "Very Strong" radio signal reports. If you are getting "Weak" reports, then move gateway to improve the signal strength. For more information on this subject, see the placement strategies section in this manual.

Sample *status_log.txt* report:

Sensor 00:13:a2:00:40:54:da:6a!: Dist=26.5" Temp=-3.6C Batt=4.8V UltrasonicStrength=75% RadioSignal=Strong Event=377 2012-12-12 09:41:16

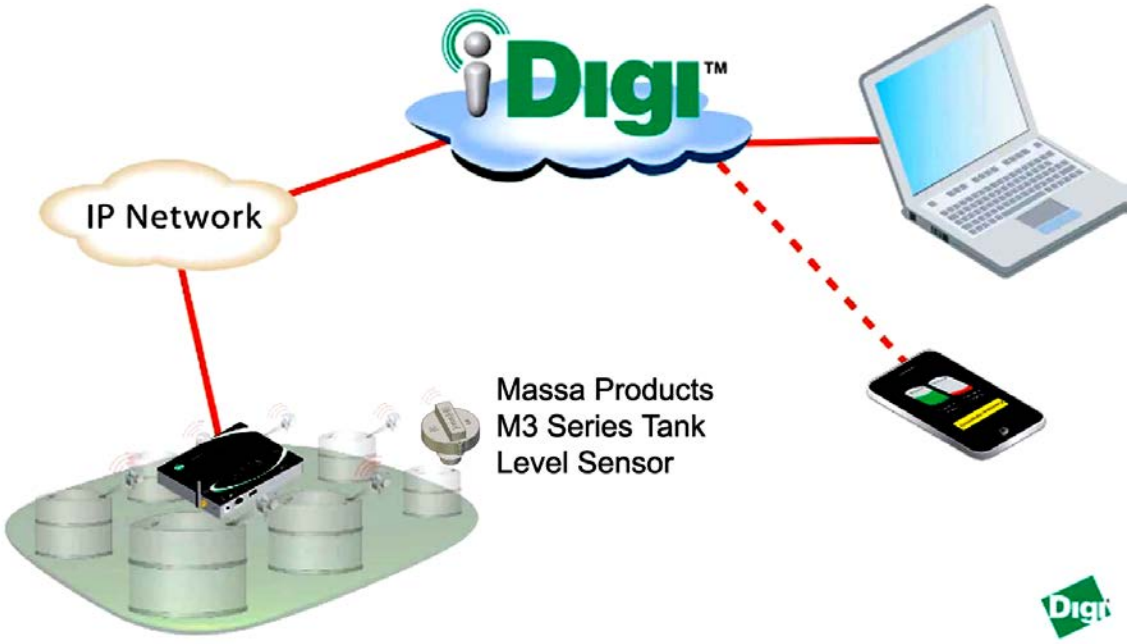
Application measurement issues do occur on occasion and may require using the diagnostic feature of the SonAire M3 Sensor to obtain ultrasonic waveforms. Typically issues that can occur include obstructions within a sensor mounted greater than 5 degrees off vertical, severe foaming on the surface, turbulence, and mounting in long standpipes. To diagnose an ultrasonic issue, enable the "obtain_diagnostic_data" setting in the dia.yml to obtain ultrasonic waveforms. For more information, see the MassaSonic SonAire Wireless Ultrasonic Sensor page on www.massa.com.





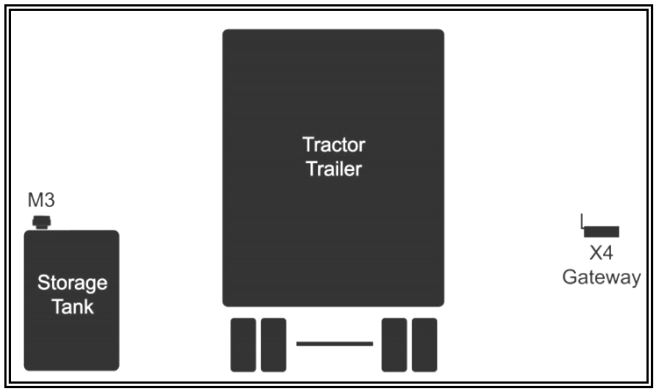
Wireless Tank Level Solution Beyond This Kit

The kit supplied contains the components necessary to evaluate a wireless tank level application including profiling a tank for any potential level measurement issues. The next step is to send sensor data to a hosting site such as iDigi Cloud. Then from the cloud, have service providers retrieve and deliver the data to PC or even a mobile device. For more information, contact Massa Products or Digi International for more information on this solution.

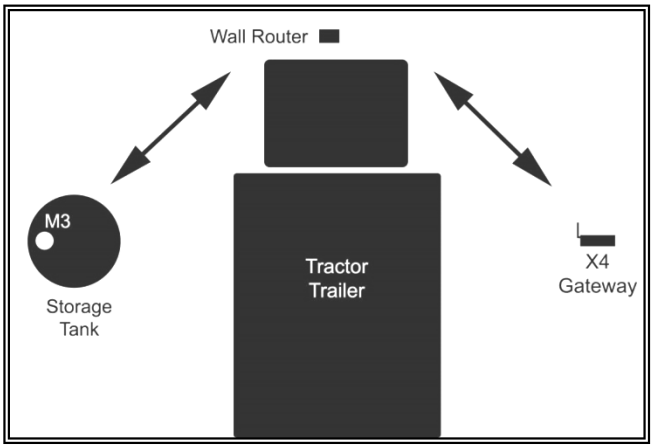


Digi Gateway & Massa SonAire M3 Sensor Placement Strategies

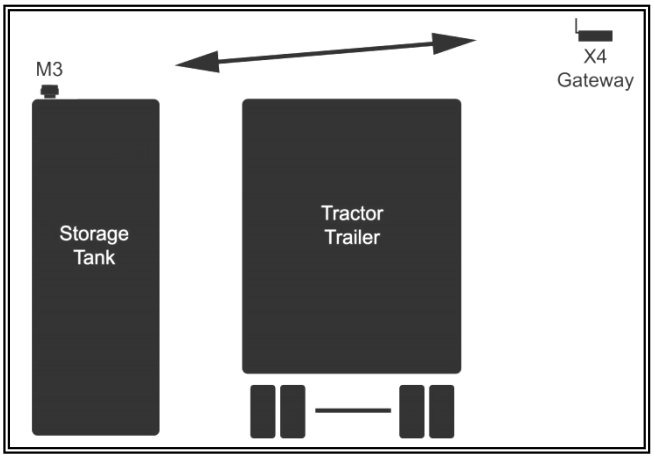
In this example, a tractor trailer truck is parked between a short storage tank and gateway. Radio signals may not be reliable.



Placing a Digi Wall Router as shown will allow another path around metal structures that could block the radio signal. Simply plug in the wall router and they should associate and be listed on the Xbee Network as a *router* Node Type. You may also use wall routers to extend the range between gateway and sensors.
NOTE: When using wall routers, it is recommended that you upgrade Massa Python code to version 1.14 or greater. Wall routers are not weatherproof, so they will require installation in an enclosure when placed outdoors. If a wall router does not appear to associate with the gateway, then press the button once which is located on the side of the housing. To have it leave a network and rejoin, press the button 4 times.



This example shows a much taller tank with a gateway placed high overhead. Here the tractor trailer does not impede the radio signals.

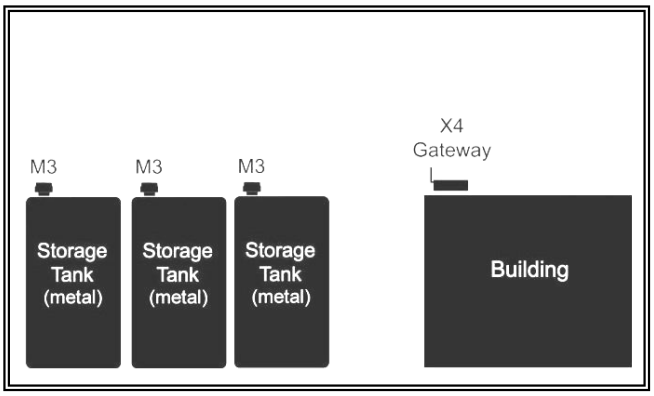


Challenging Sensor-Gateway Locations

In this scenario, a chain link fence is between sensor and gateway. A metal fence will significantly reduce the radio range. It is better to place the tank with sensor on the other side of the fence or place a router in a location possibly over the fence.

This scenario will also reduce the effective radio range. Place wall routers between the 2 points or place the gateway closer to the storage tanks. The radio signals here can bounce away from the sensor if the roof is metal.

This scenario has the gateway antenna at the same level as the SonAire M3 Sensor mounted on metal storage tanks. The RF signal may skip off the closer tanks and poor signal levels may occur at the further tanks. Raising the gateway's antenna will improve the signal to the further tanks.



APPENDIX A

Miscellaneous Sensor Information

LED Behavior

Following is the lookup table for the behavior of the LED:

LED Behavior	Description
OFF	No power, battery voltage too low, or sensor sleeping if powered
RED quick flash every 2 seconds	Sensor is joined with a ZigBee network, if stays in this mode, then Deep Sleep = 0.
RED quick flash every 2 seconds followed by an extended OFF period	Sensor is joined to a Zigbee network which then goes to sleep per programmed Awake setting and remains OFF for the programmed Deep Sleep setting.
RED 3 to 50 seconds steady ON	Un-associated state attempting to join ZigBee network.
RED quick flash once a minute	Sensor is not joined to a Zigbee network and the Deep Sleep Timer = 0. Once joined, sensor will quick flash every 2 seconds. May take up to 1 hour to join.
RED multiple blinking	Sensor was requested to read, write, obtain waveforms or other requests.
RED flash every ½ second for 30 seconds	Commission button pressed followed by other behaviors indicated above after 30 sec
GREEN 3 blinks followed by **RED**	Sensor was rebooted
RED 2 Hz flash, **GREEN** 1 Hz flash	Error: Application firmware not present

Rebooting Sensor Manually

To restart a sleeping sensor, remove battery and then press the commission button for several seconds. Reinstall battery.

APPENDIX B

Format for dia.yml

The controls for the Massa python driver are found in the dia.yml file. A file example is shown below. The **bold** text highlights the minimum settings that should be enabled when configuring a sensor for the first time. Values for the setting are typical for a 60 minute sleep time that will automatically send an automated message to the gateway. For detailed information on each setting, see the SonAire M3 Manual.

It is very important that the syntax is maintained with same spaces and no tabs as shown in this example. The "#" symbol and all that follows on a line are comments and are not processed. NOTE: Once a sensor has been configured, you can disable the "Sensor Settings" or "Xbee Settings" before the next gateway boot.

```
devices:
- driver: devices.xbee.xbee_device_manager.xbee_device_manager:XBeeDeviceManager
  name: xbee_device_manager
  settings:
    addr_dd_map: {}
    worker_threads: 1
#############################################################################################
# NOTE: If dia controls are left out or preceded with the '#' symbol (comment line), then the specific function
# will be ignored and not executed.  Enabling the xbee_program_awake setting will disable all other settings.
#############################################################################################
# Sensor #1 ###################################################################################
- name: M3-150-3b43
  driver: devices.vendors.massa.m3_driver:M3Driver
  settings:
# Main DIA related
    extended_address: '00:13:a2:00:40:48:3b:4e!'      # this is the sensor's MAC address
    xbee_device_manager: 'xbee_device_manager'
# Sensor Settings
    sleep_interval_sec: 3600              # units in seconds (shown here for a 60 minute sleep interval)
    awake_time_sec: 31                    # 20 sec min for most applications
    # data_collection_interval_sec: 0     # units in sec (inactive for outgoing msg modes 5 and 6)
    outgoing_message_mode: 5              # limit 0-6
    auto_message_length: 8                # limit 1-8
    sensitivity: 'normal'                 # 'normal', 'high', 'very high', 'low', 'very low', 'custom'
    # user_comment: ''                    # limit 32 ASCII characters
    # comm_fail_boot: 0                   # Reboot sensor on failed Zigbee Ack / Unassoc. limits: 0, 4 – 254 awake periods, default = 0
# XBee settings
    # for more information, see M3 Manual
# Routine control
    # obtain_diagnostic_data: 'true'      # 'true' to obtain diagnostic waveforms, 'false' to disable.
    log_status: 'true'                    # 'true' to output a 'status_log.txt' file that records autosend messages
    # log_dia: 'false'                    # 'true' to output a 'dia_log.txt' file that reports sensor settings and driver version
    # for additional Routine control settings, see M3 Manual
#############################################################################################
# For additional sensors on the gateway, copy the sensor controls as seen in Sensor 1 above and edit the new control
# extended_address line with sensor's MAC address and assign a new name (-name: ).
#############################################################################################
# For Loggers and Presentation settings, see M3 Manual.
```

APPENDIX C

Checklist for Reliable Sensor and Gateway Operation

- □ Sensor XBee firmware version 29A0, PO=0, CR=3. Scan channel (SC) set to 0x1ffe.
  - a) PAN ID = 0 for fixed sensor applications that don't ever expect another gateway in the vicinity or for roving sensors that need to associate with any gateway.
  - b) PAN ID = non-zero for fixed sensor applications that do expect, or have another gateway in the vicinity, in which the sensor is associated is to a specific gateway.
- □ Gateway XBee firmware version 21A0, poll rate setting dependent on application
  - a) Fixed sensor placement such as tank farm – SN=2880, SP=1000 (24 hours). If sensor set up to sleep 12 hours or more, set for at least 48 hour period or SN=5760, SP=1000.
  - b) Roving sensors that don't need to stay associated to gateway – SN=3, SP=1000 (30 seconds)
  - c) Scan channel (SC) set to 0x1ffe
  - d) PAN ID = 0 will randomly assign an operating PAN ID. It should not be used if more than one gateway is in the vicinity in fixed sensor applications.
  - e) PAN ID = non-zero for fixed sensor applications that do expect, or have another gateway in the vicinity, in which the sensor is associated is to a specific gateway.
- □ Gateway firmware up to date.
- □ Sensor settings:
  - a) Sleep setting must be non-zero value to output automated message upon awake
  - b) Awake Timer is recommended for 31 seconds initially for setup and evaluating period. Minimum 20 seconds once application has been validated if desired.
  - c) Data Collection Interval set to your application. This is disabled for Outgoing Message Modes 5 & 6
  - d) Outgoing Message Mode – 1 and 5 will send 1 message upon awake. Use Mode 2 or 6 so that 2 messages will be sent upon awake in situations where a message is lost due to a RF collision or other poor signal. If using a wall router, it is recommended to use Mode 2 or Mode 6. Use Mode 5 or 6 to synchronize the tank level measurement at the time the automated message is sent. For cellular gateways that want to minimize data usage, use Mode 1 or Mode 5.
  - e) Auto message length set your application. Default is 8.
  - f) Ultrasonic sensitivity set to normal. Consult factory for other settings in more difficult sensing applications.
- □ Application program "Notepad ++" is a very helpful in maintaining syntax for your dia.yml such as spaces and tabs are set properly. Make sure preferences are enabled for Python. Obtain this program from the web.
- □ Use dia.zip supplied by Massa which has been tested using DIA version 2.1.1.2
- □ The presentations in the dia.yml has the settings optimized so that data is sent to the cloud or cell network when sensor wakes up and sends status information. This includes settings: *interval:3600* (seconds) and *sample_threshold:7*. Sent *interval* longer than your sleep setting to avoid repeat of data sent to cloud as the *sample_threshold* is the trigger that sends the sensor information immediately to the cloud device.
- □ Massa python driver version 1.14 or greater. To verify driver number, see log file dia_log.txt when executed.
- □ Disable sleep and other register settings in the dia.yml by placing the # symbol in front (such as #*sleep_interval_sec*) once the sensor registers have been configured for the application. This will eliminate sensor them from being re-written on every gateway boot (thus saving some battery power). Also include disabling "log_status" and "log_dia" after an evaluation period since the gateway has limited memory.
- □ It is recommended to enable the *comm_fail_boot* setting which acts like a watchdog reset for any rare failures in RF communications. See the SonAire M3 User's Guide for details on this setting.

APPENDIX D – Troubleshooting Guide

Issue	Condition	Solution or work around
Missing data, sensor lost association.	- Gateway power cycle could lose association. - Gateway Xbee version less than version 21A0. - Poor RF link - Xbee firmware was updated	- Upgrade sensor firmware to version 32 which will detect unassociated state and attempt to rejoin gateway. - Upgrade gateway Xbee firmware to version 21A0. Sensor Xbee 29A0. - Upgrade Python to version 1.14. Disable sensor's sleep setting in dia.yml only after you have previously set all settings for application. - Consider the use of a XBee Wall Router. Otherwise, relocate gateway. - Sensor antenna not upright - Poor sensor/gateway placement - Low sensor battery voltage - For application reliability in marginal RF conditions, enable the *comm_fail_boot* setting.
Sensors do not rejoin gateway upon awake when it was previously joined	Gateway power cycle and Xbee "Number of remaining children" register full (NC=0)	Upgrade Massa Python driver 1.14 or greater which will perform a Xbee network reset upon gateway boot when NC=10. Sensor firmware must be ver. 32.x or greater which will allow the sensor to immediately rejoin the gateway upon its next awake cycle.
Sensor is not outputting automated messages	- Sensor's sleep setting is zero - The outgoing message mode is not set to 1, 2, 5 or 6.	- Sleep setting must be non-zero otherwise sensor is awake. Automated messages are only sent when the sensor wakes up from sleep. - Verify the outgoing message setting is set to 1, 2, 5 or 6.
Cannot upload sensor firmware	Gateway XBee version 21A7 and encryption is enabled	Disable encryption (EE=0) in both sensor and gateway's Xbee. If encryption required (EE=1), then upload gateway Xbee version 21A0.
Sensor appears joined with RED LED flashing every 2 seconds (when awake) but not seen on XBee network). *Case #1*	Sensor associated with another gateway when several gateways operating in same vicinity (with sensor PAN ID=0)	Use non-zero PAN ID's for gateway and sensor.
Sensor appears joined with RED LED flashing every 2 seconds (when awake) but not seen on XBee network). *Case #2*	Gateway encryption enabled with sensor encryption disabled.	Sensor will be allowed to associate with the gateway but will not be seen or enabled on the XBee network.
Driver not outputting data or changing sensor settings	Using dia.yml controls	Check syntax and spacing for sensor settings in the dia.yml. Also check MAC address is correctly entered.
Sensor does not join gateway	RED LED is on solid and does not blink.	Gateway out of range, poor RF signal strength, Gateway XBee child table full (NC=0), gateway/sensor PAN ID don't match with sensor non-zero PAN, gateway/sensor's encryption key doesn't match, gateway SC register 0x3fff (set to 0x1ffe).
Sensor has lost association after a time period of successfully being joined and reporting messages	No reported messages, sensor LED blink not normal blink every 2 seconds when awake.	Unknown rare event. It is strongly suggested to enable the setting *comm_fail_boot* for sensors that are placed in remote locations.
Sensor has to rejoin gateway every awake cycle	RED LED is on solid then blinks upon awake. This indicates gateway has dropped sensor from its XBee network.	Set gateway's SN/SP registers timing at least 3 times longer than the sensor's sleep register. Some applications will require gateway to intentionally drop sensors, so this will be normal LED operation as indicated in the "Condition" column.

APPENDIX D – Troubleshooting Guide *(continued)*

Issue	Condition	Solution or work around
Sensor blinking red/green.	No application firmware	Load gateway with SonAire M3 firmware (sensor model specific) and enable sensor firmware upload setting in dia.yml
Cellular data usage high	- dia.yml presentation settings set incorrectly - sensor sleep setting too short	- adjust dia.yml settings *interval=3600* and *sample_threshold=7* - set sleep settings to 1hour or more. - review all gateway mobile and other settings to minimize usage
PAN ID of sensor unknown to associate it with a gateway	- user accidentally programmed incorrect value or other reason for unknown PAN ID.	Press sensor's commission button 4 times quickly to reset XBee to factory defaults (with PAN ID=0). Then power cycle sensor. You must restore XBee registers SC=0x1ffe & LT=10 after power cycle.
Python stopped running (as seen in *Management-Connection*s)	- verify syntax in dia.yml - gateway rebooted (warm boot) with wall router present	- Check proper spacing & tabs, spelling, etc. in dia.yml - Intermittent operation may occur when using the *Administration-Reboot* button with a wall router present. So simply reboot again. No known issues with a gateway power cycle.
Incorrect measurement (full)	- reporting full when not	- Check for obstructions or if sensor is mounted in standpipe. Requires customized sensitivity adjustment. See section 3.1.11. Obtain waveforms for analysis. - Consult Massa Products for support with waveforms.
Incorrect measurement (empty)	- reporting empty when not	- Verify sensor is mounted vertically (less than a few degrees off angle) - Check for obstructions. Obtain waveforms for analysis and verify Sensitivity setting set so that detection occurs at furthest measurement level. If detection surface foaming with sensitivity set to highest levels (most sensitive), application may require lower frequency model sensor. -. Consult Massa Products for support with waveforms.
Incorrect measurement (midpoint)	- reporting a measurement that is closer than actual	- Obstruction in tank is detected when level falls below it. Sensors mounted closer to tank wall have a higher probability for false detection if such obstructions are present such as an internal ladder or intake pipe. Either move sensor to a new location or customize sensitivity setting so the threshold line is above the obstructed signal if possible. - Consult Massa Products for support with waveforms.
Incorrect measurement (overall)	vapors that have a different speed of sound from air	- Some products such as unleaded gasoline produce vapors that yield a slower speed of sound. Since the sensor bases its calculation for range detection to air, the user application will require multiplying a factor of the percentage of the sensor's reported range to obtain the proper distance to the actual level. One option is to scale the zero (empty) and span (full) distances to this vapor. - Consult Massa Products for support with waveforms.