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Xnode Smart Sensor Quick Start Guide

The Xnode Smart Sensors allow for wireless data collection from multiple sensor nodes through the Xnode gateway, which is connected to a PC via a USB-Serial connection using the provided USB cable. To operate the system:

- (optional) Connect Xnode sensors to solar panels or wall chargers using the 7-pin connector and the provided connector cables.
- Attach the provided 2.4GHz antennas to the Xnodes' antenna connector. For best results, antennas should be oriented perpendicular to the ground, and gateway and sensor node antennas should be parallel.
- For best results, elevate the Xnodes at least 1m above the ground.
- For large numbers of Xnodes, space the sensors at least 1m apart to minimize internal interference among the sensors. This is only relevant for large numbers of Xnodes that are in close proximity; e.g., 10 Xnodes next to each other on a table is not a problem.
- Turn ON the Xnodes sensors' power switch.
    - NOTE: the Xnode sensors operate on a power-saving 1-minute duty cycle, and there may not be an immediate indication that the node is on from the Xnode's LED (visible through the window in the clear lid). The LED will come on briefly once per minute. To force-reset the duty cycle, turn the switch ON, wait 2 seconds, turn the switch OFF, wait 2 seconds, and turn the switch ON again (ON-OFF-ON).
- Connect the provided USB cable to the Xnode gateway via the 7-pin connector, and plug the USB cable into the PC.
- Turn the gateway's power switch ON. The gateway's green LED should immediately turn on, indicating the gateway is ready for a connection from the PC. NOTE: the gateway node switch has opposite polarity from the sensor nodes: right = ON, left = OFF.

The Xnode gateway provides a USB-serial connection to the PC, which is supported by most operating systems with a general-purpose USB-serial device driver and a terminal interface application. The following instructions assume a Microsoft Windows operating system.

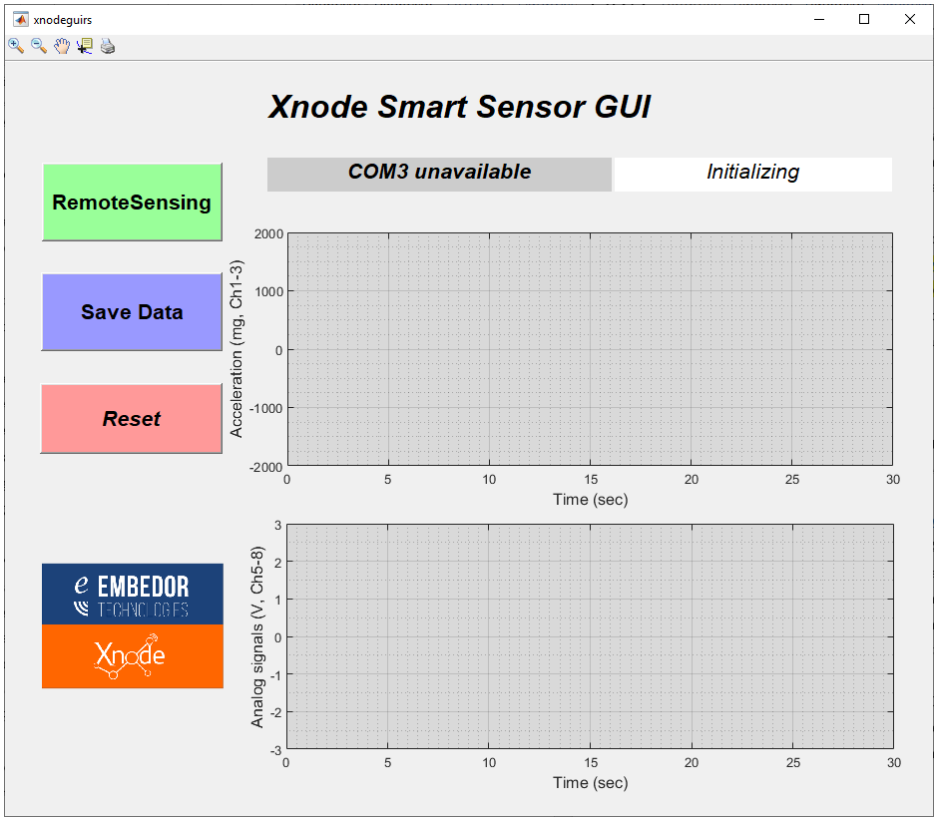
1. Installing the PC software

On recent versions of Microsoft Windows, the Xnode gateway will be detected automatically and an appropriate driver will be installed. Otherwise, a driver for Generic USB Serial Port Adapter or NXP USB Serial Device must be installed manually. Upon successful installation, a new serial port should appear under the "Ports (COM and LPT)" category in the Windows Device Manager (Control Panel -> Hardware and Sound -> Device Manager).

A terminal application is needed to interface with the Xnode gateway. We recommend TeraTerm.

- Download the software from http://www.embedortech.com/software/Xnode.zip
- Unpack the archive to a folder and run teraterm-4.103.exe.
- Launch TeraTerm, select File -> New Connection… -> Serial -> COMx (where COMx corresponds to the port assigned to the new device; can be checking in the Windows Device Manager).
- Press Enter if nothing is displayed on the screen. An application menu should appear.

2. Using the data acquisition GUI application



The graphical user interface (GUI) application facilitates the interactions between users and Xnode sensor network. Users can perform remote sensing, plots the acquired data in a zoomable graph, and export the results to a MATLAB file. To use this application, follow the instructions below:

- Download the software from http://www.embedortech.com/software/Xnode.zip.

- Unpack the archive to a folder and run XnodeInstaller.exe.

- Install the MATLAB Runtime (a required third-party component) when prompted.

- Connect the gateway with PC via USB cable. Make sure that the COM3 port is used (see Section 1).

- Turn on the gateway node, then start the GUI application from its install location.

- Before starting the application, make sure the notification bar in the GUI shows "ready".

- In the GUI, click *RemoteSensing* to start the application. Sensing parameters configured via the terminal application (see Section 3) are used for data acquisition.

- Data acquired is separated between acceleration (channels 1-3) and, optionally, analog voltage (external channels 4-8).

- After the notification bar shows "completed", click *Save Data*, to record the collected measurement data. The data file named "Xnodedata.mat" can be found in the folder where the application is installed.

- Finally, click *Reset* to restart the application.

3. Using the Xnode Smart Sensors.

Most of the options in the application menu are self-explanatory.

```
- Choose application to run:
- '1'  Remote sensing
- '2'  Autonomous monitoring
- '3'  Event-triggered sensing
- '4'  Retrieve sensor data
- '5'  Check sensor status
- '6'  Reset sensors
- '7'  Change configuration
- Xnode>
```

Option '1' starts the RemoteSensing application. The gateway node will wake up the remote Xnode Smart Sensors, synchronize their clocks, and perform data acquisition using the pre-configured parameters. The collected sensor data is stored on the gateway node's microSD card and is also printed on the screen, where it can be saved to a file using the File -> Log… option of TeraTerm.

Option '2' automatically performs a RemoteSensing run on a schedule:

```
- Choose period (hours):
- '1'  12
- '2'  24
- '3'  48
- Xnode>
```

Once AutoMonitor is running, it can be interrupted by pressing ‘x’, only when RemoteSensing data collection is not actively running.

Option '3' initiates event-triggered sensing. The Xnode smart sensors are instructed to collect data automatically whenever a pre-configured acceleration threshold is exceeded (see Option '7').

Option '4' allows for querying the Xnode sensors to retrieve previously collected datasets that have been stored locally at the sensors:

```
- Choose action:
- '1'  Get last (latest) not-yet-sent dataset of all nodes
- '2'  Get first (earliest) not-yet-sent dataset
- '3'  Get last N (latest) not-yet-sent datasets - Define:
- '4'  Get first N (earliest) not-yet-sent datasets – Define:
- '5'  Return
- Xnode>
```

Option '5' queries the status of the sensor nodes: whether the nodes are online, their battery voltage level, and charging current.

- Note that sensors plugged into a charger or solar panel will show the higher charging voltage, not the battery voltage, when charging is active.
- Note also that sensor node status information is automatically collected and displayed during RemoteSensing. It should never be necessary to run “Check sensor status” separately before running “Remote Sensing.”

Option '6' sends the reset command to sensors, putting them into low-power sleep state. This should not normally be necessary, as the sensor nodes automatically go to sleep upon successful completion of a command or after a period of inactivity. It may be needed, for example, when the Xnode gateway is disconnected from the PC while a command is running, causing the gateway node to reset.

- Note that Xnode sensors will not receive or process any commands while data acquisition is being performed, as the radio is turned off for the duration of this process.

Option '7' allows for changing the configuration parameters of the Xnode sensors and the Xnode gateway. These are split among sensing settings (sampling rate, duration, etc.), and event trigger settings, and communication settings (radio channel, rate, and transmission power).

```
- Choose action:
- '1'  Change sensing settings
- '2'  Change event trigger settings
- '3'  Change communication settings
```

```
- '4'  Return
- Xnode>
```

Sensing settings:

```
- Choose action:
- '1'  Restore defaults
- '2'  Change sampling time
- '3'  Change sampling rate
- '4'  Change node list
- '5'  Return
- Xnode>
```

Change sampling time:

```
- Enter sampling time (seconds):
```

Change sampling rate:

```
- Enter sampling rate (Hz):
```

Change node list

```
- Enter node list (e.g.: 1,2,3):
```

Event trigger settings:

```
- Choose action:
- '1'  enable trigger sensing
- '2'  disable trigger sensing
- '3'  Return
- Xnode>
```

Enable trigger sensing:

```
- Choose action:
- '1'  Restore defaults
- '2'  Change measurement range
- '3'  Change threshold for activity detection
- '4'  Change time for activity detection
- '5'  Change threshold for inactivity detection
- '6'  Change time for inactivity detection
- '7'  Change sampling time
- '8'  Change sampling rate
- '9'  Change channel number
- '0'  Return
- Xnode>
```

Communication settings (note: remote settings should be changed first, then local):

```
- Choose location to be changed:
```

```
- '1'  Local (gateway)
- '2'  Remote (sensor)
- Xnode>
```

Local (gateway):

```
- Choose action:
- '1'  Change local radio channel
- '2'  Change local radio power
- '3'  Change local radio rate
- '4'  Return
- Xnode>
```

Remote (sensor):

```
- Choose action:
- '1'  Change remote radio channel
- '2'  Change remote radio power
- '3'  Change remote radio rate
- '4'  Return
- Xnode>
```

Channel (local & remote):

```
- NOTE: range 11-26 with recommended values: 15, 20, 25, 26
- Enter channel:
```

Power (local & remote):

```
- NOTE: range 0-15, inverse scale: 0 = max, 15 = min
- Enter power:
```

Rate (local & remote):

```
- NOTE: supported rates are 1, 2, and 4 (lower = more stable, higher =
faster)
- Enter rate:
```

4. Event-triggered sensing

Event-triggered sensing is designed to monitor structures under sudden events such as earthquakes, impacts, vehicle crossings, etc. Xnodes will automatically start/stop data acquisition based on the user-defined parameters. The instructions for activating trigger sensing are as follows:

1) Enable event-triggered sensing
    - In main menu, select `'7' Change configuration` followed by `'2' Change event trigger settings`
    - Then, select '1' `enable trigger sensing`

- In a followed menu, define the desired parameter values.
- In main menu, select '3' `Event-triggered sensing`. Please confirm the parameters before initiating this step. The parameters will be sent to the remote nodes, and event-triggered sensing will be performed.

2) Disable event-triggered sensing
   - In main menu, select `'7' Change configuration` followed by `'2' Change event trigger settings`
   - Then, select '2' `disable trigger sensing`
   - In main menu, select '3' `Event-triggered sensing`

5. LED status indicator colors

The multi-color LED indicator on the top of the Xnode sensor and gateway nodes is used to provide visual feedback on what the Xnode is currently doing.

1) Sensor node
   - Low-power sleep mode: green light blinking briefly once per minute
   - Awake and ready to receive commands from the gateway: green
   - Time synchronization: purple
   - Sensing: blue-green
   - Data processing/storing data: yellow
   - Data transmission: blue

2) Gateway node
   - Ready for user commands: green
   - Sending commands to sensor nodes: blue
   - Data acquisition in progress: green
   - Data retrieval from sensor nodes: blue

6. (Optional) Configuring the Xnodes via configuration files on the microSD card

The recommended way to change configuration is via the application menu option. However, it is also possible to edit the configuration of the Xnode gateway and Xnode sensors directly by editing the configuration files located on the Xnode's microSD card. The SD card can be accessed by removing the Xnode's lid and disconnecting white 20-pin connector from the top board. The SD card slot is underneath. The SD card contains the configuration files governing the behavior of the

Xnode. The contents of the files differ between gateway and sensor nodes, and the parameters must be set appropriately. The configuration files are located in the 'Xnode' folder:

- Xnode.cfg (both sensor and gateway):

```
NODEID = 2
CHANNEL = 26
POWER = 0
RATE = 1
TRIG = 0
```

NODEID is the node id. Should be unique in the network (no two nodes with the same id). Valid range is 1- 65535 (0x0001 to 0xFFFE).

CHANNEL is the radio channel. Valid values are 11-26; the default 26 has minimal overlap with WiFi.

POWER is the radio power. Valid values are 0-15; using an inverse scale, meaning 0 is maximum power and 15 is minimum.

RATE is the radio rate (speed multiple). Valid values are 1, 2, and 4. Depending on communication conditions, faster transmission rates may incur higher error rates and reduced transmission range. In a lab setting, rate 4 generally works well.

TRIG is the flag of event-triggered sensing. Using 1 for event-triggered sensing, and 0 for periodic monitoring.

- Data.cfg (both sensor and gateway):

```
LAST = 0
```

LAST is the automatically updated number of the last stored data file. This is updated automatically by the software and should not normally be edited.

- AutoMonitor.cfg (gateway only):

```
AUTOMONITOR = 0
```

AUTOMONITOR indicates whether autonomous monitoring mode is active. This is updated automatically by the software and should not normally be edited.

- RemoteSensing.cfg (gateway only):

```
SAMPLINGTIME = 180
SAMPLINGRATE = 100
```

```
NUMCHANNELS = 3
NUMNODES = 10
NODEIDS = 1,2,3,4,5,6,7,8,9,10
```

SAMPLINGTIME is the length of sensing, in seconds
SAMPLINGRATE is the sampling rate, in Hz. Supported values are: 10, 20, 50, 100, 200, 333, 500
NUMCHANNELS is the number of channels to record. The first three channels correspond to the X, Y, and Z axes of the internal accelerometer, the other 5 channels sample external inputs on the 20-pin external connector.
NUMNODES is the number of sensor nodes in the network (excluding gateway).
NODEIDS is the comma-separated list of node ids.

- RemoteSensing_default.cfg (gateway only):
This is a copy of RemoteSensing.cfg, used for the "restore defaults" option in the application menu.

- TriggerSensing.cfg:

```
RANGE = 8
THRESHOLDACT = 60
TIMEACT = 2
THRESHOLDINACT = 40
TIMEINACT = 500
FIFONUM = 61
SAMPLINGTIME = 60
SAMPLINGRATE = 100
NUMCHANNELS = 3
```

RANGE is the measurement range of the trigger accelerometer, in g.
THRESHOLDACT is the threshold of activity detection, in mg.
TIMEACT is the time for activity detection, i.e. the required minimum number of data points above the threshold to start event-triggered sensing.
THRESHOLDINACT is the threshold of inactivity detection, in mg.
TIMEINACT is the time for inactivity detection, i.e. the required minimum number of data points below the threshold to stop event-triggered sensing.

FIFONUM is the number of data points saved in all the three axes from the trigger accelerometer before the node is woken up. 61 means 20 points for each axis, and the first data point is in x-axis.
SAMPLINGTIME is the length of sensing, in seconds.
SAMPLINGRATE is the sampling rate, in Hz. Suggested value is 100.
NUMCHANNELS is the number of channels to record. Currently default setup is 3 acceleration channels only.

- TriggerSensing_default.cfg:
This is a copy of TriggerSensing.cfg, used for the "restore defaults" option in the application menu.