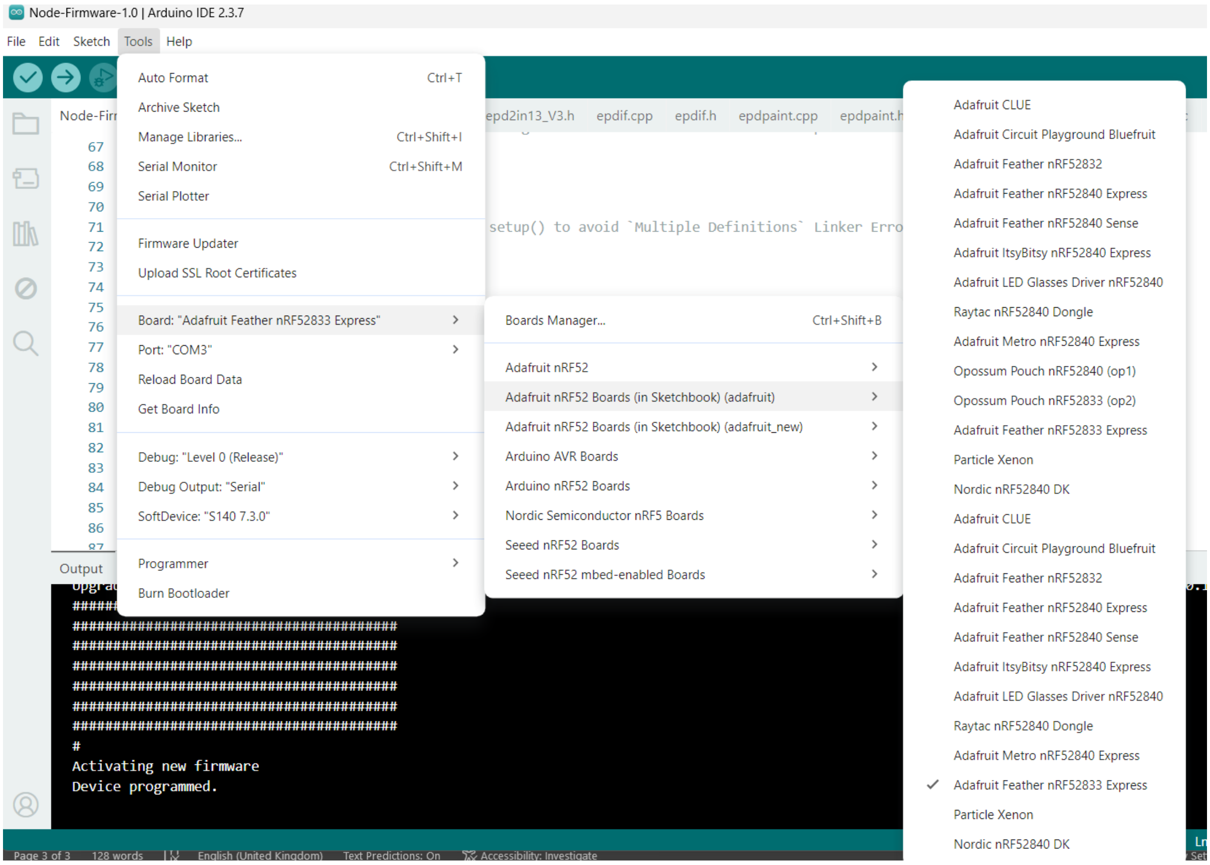
pip install -r requirements.txt

1. Install provided firmware (see folder "*Network Level Energy Measurement, Optimization and Prediction/Node-Minilamp-Firmware*") on Node and Mini Lamp (flash using Arduino IDE, Board Adafruit nrf82833 for node and Seeed Arduino nRF52840 for gateway. You may need to install the required libraries and hardware files which are available at: Arduino_hardware_libraries_needed.zip



Node-Firmware-1.0 | Arduino IDE 2.3.7

Board: "Adafruit Feather nRF52833 Express"

Port: "COM3"

Debug: "Level 0 (Release)"

Debug Output: "Serial"

SoftDevice: "S140 7.3.0"

```
upgra
#####
########################################
########################################
########################################
########################################
########################################
########################################
#
Activating new firmware
Device programmed.
```

File
Edit
Sketch
Tools
Help
Node-Fir
epd2in13_V3.h
epdif.cpp
epdif.h
epdpaint.cpp
epdpaint.h
setup() to avoid `Multiple Definitions` Linker Erro
Output
Auto Format Ctrl+T
Archive Sketch
Manage Libraries... Ctrl+Shift+I
Serial Monitor Ctrl+Shift+M
Serial Plotter
Firmware Updater
Upload SSL Root Certificates
Reload Board Data
Get Board Info
Programmer
Burn Bootloader
Boards Manager... Ctrl+Shift+B
Adafruit nRF52
Adafruit nRF52 Boards (in Sketchbook) (adafruit)
Adafruit nRF52 Boards (in Sketchbook) (adafruit_new)
Arduino AVR Boards
Arduino nRF52 Boards
Nordic Semiconductor nRF5 Boards
Seeed nRF52 Boards
Seeed nRF52 mbed-enabled Boards
Adafruit CLUE
Adafruit Circuit Playground Bluefruit
Adafruit Feather nRF52832
Adafruit Feather nRF52840 Express
Adafruit Feather nRF52840 Sense
Adafruit ItsyBitsy nRF52840 Express
Adafruit LED Glasses Driver nRF52840
Raytac nRF52840 Dongle
Adafruit Metro nRF52840 Express
Opossum Pouch nRF52840 (op1)
Opossum Pouch nRF52833 (op2)
Adafruit Feather nRF52833 Express
Particle Xenon
Nordic nRF52840 DK
Adafruit CLUE
Adafruit Circuit Playground Bluefruit
Adafruit Feather nRF52832
Adafruit Feather nRF52840 Express
Adafruit Feather nRF52840 Sense
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✓ Adafruit Feather nRF52833 Express
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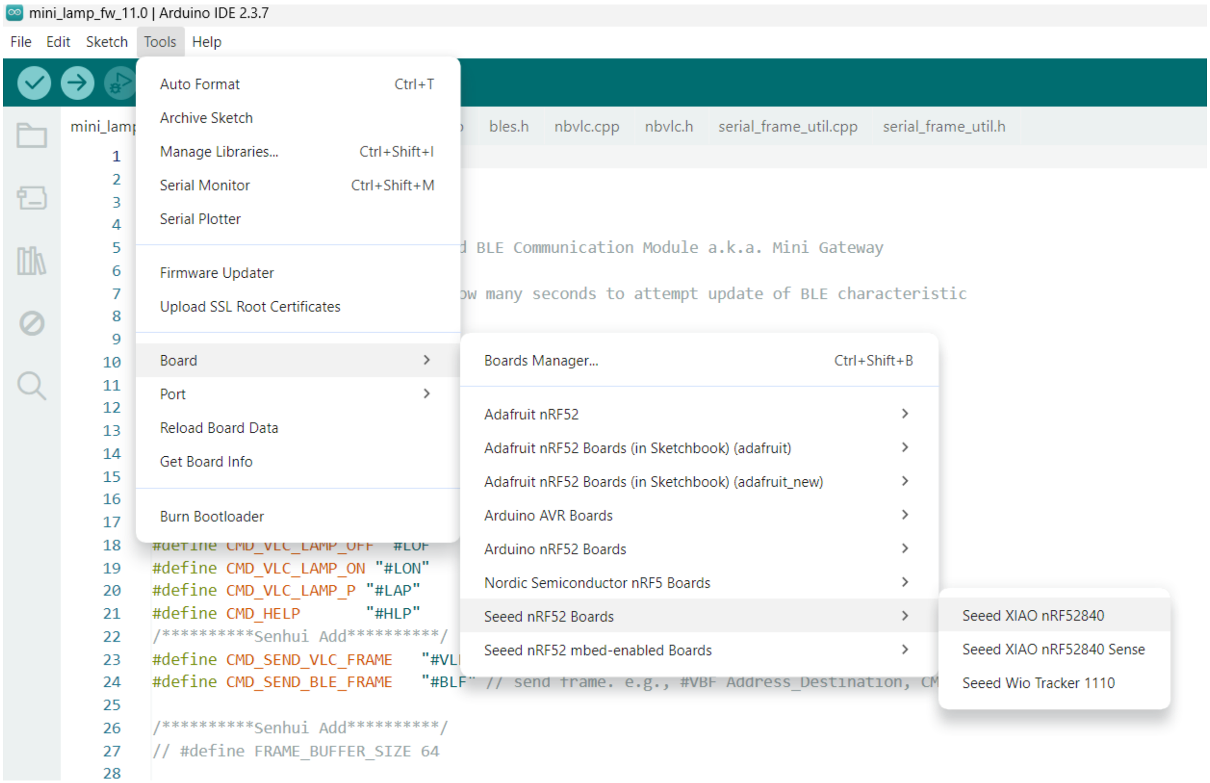
Page 3 of 3
128 words
English (United Kingdom)
Text Predictions: On
Accessibility: Investigate


mini_lamp_fw_11.0 | Arduino IDE 2.3.7
File
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Manage Libraries... Ctrl+Shift+I
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Seeed nRF52 mbed-enabled Boards
Seeed XIAO nRF52840
Seeed XIAO nRF52840 Sense
Seeed Wio Tracker 1110
mini_lamp
bles.h
nbvlc.cpp
nbvlc.h
serial_frame_util.cpp
serial_frame_util.h

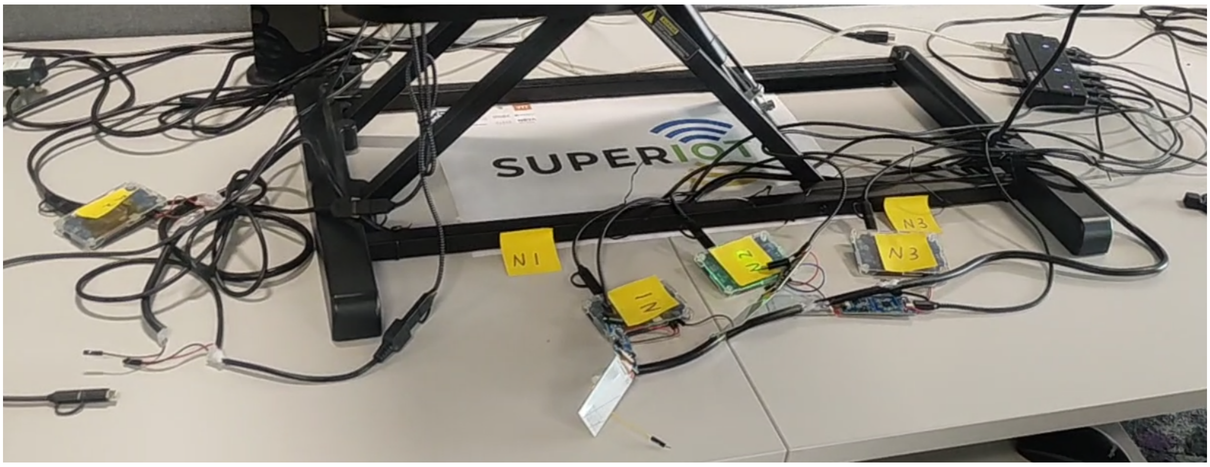
```
d BLE Communication Module a.k.a. Mini Gateway

ow many seconds to attempt update of BLE characteristic

#define CMD_VLC_LAMP_OFF  "#LOF"
#define CMD_VLC_LAMP_ON "#LON"
#define CMD_VLC_LAMP_P "#LAP"
#define CMD_HELP        "#HLP"
/**********Senhui Add**********/
#define CMD_SEND_VLC_FRAME    "#VL
#define CMD_SEND_BLE_FRAME    "#BLF" // send frame. e.g., #VBF Address_Destination, CM

/**********Senhui Add**********/
// #define FRAME_BUFFER_SIZE 64
```

2. Connect each node and each gateway to a PPK2 power profiler (using power and GND leads), and run USB cable from nodes and gateways to Hub using modified cabling setup, where the node and mini lamp are powered by PPKII. The USB cables connected to node or mini lamp do not provide power as per hardware modifications performed, only used for command transmission/reception. A common ground (GND) black cable is also connected to PPKIIs.
3. Connect PPK2 power profilers to USB as well.



In **VS code**, open directory.

select interpreter (Ctrl+ Shift + P)

→Python-select interpreter

→+create virtual environment

→Venv

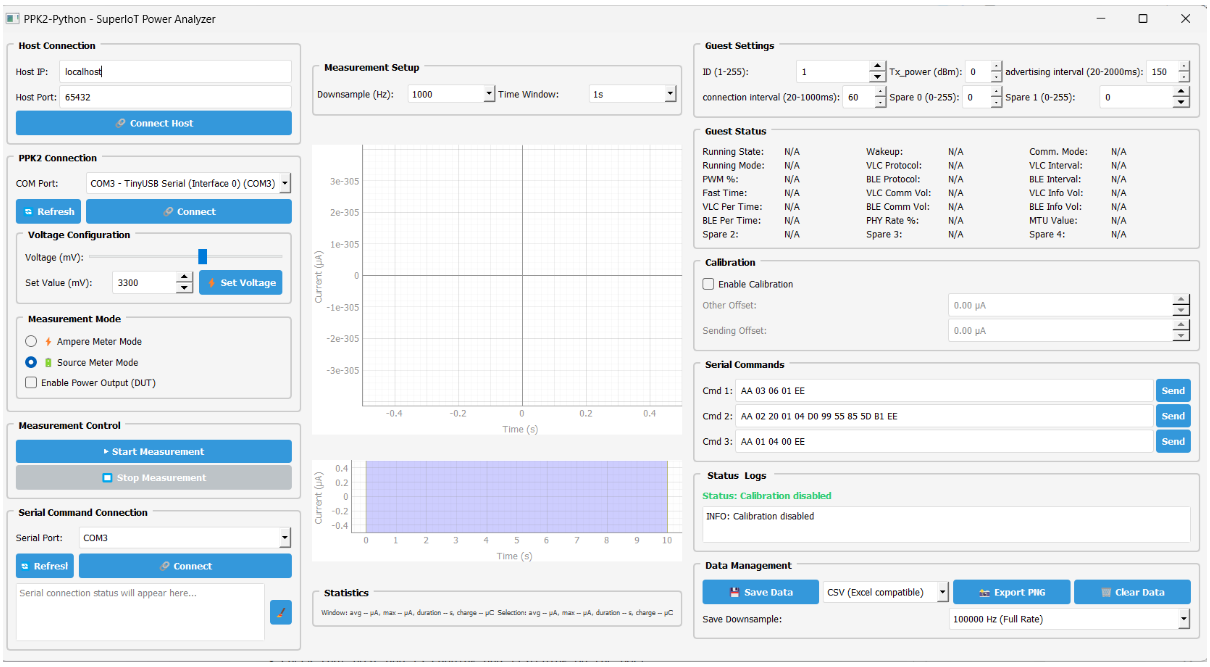
→Delete and Recreate

→Python 3.11 C:\****

→Select requirements.txt

TESTING FOR 1 NODE and 1 GATEWAY

Run ***python PPK2-Python.py*** in terminal (for **node** current measurements). Following window will appear. **For each node and mini lamp in your measurement setup, you will need to open a separate instance of the App**. Preferable to run all apps instances on the same PC via a USB Hub if many devices (for global time synchronisation).



PPK2-Python - SuperIoT Power Analyzer

Host Connection

Host IP: localhost

Host Port: 65432

PPK2 Connection

COM Port: COM3 - TinyUSB Serial (Interface 0) (COM3)

Voltage Configuration

Voltage (mV):

Set Value (mV): 3300

Measurement Mode

○ Ampere Meter Mode

● Source Meter Mode

□ Enable Power Output (DUT)

Measurement Control

Serial Command Connection

Serial Port: COM3

Serial connection status will appear here...

Measurement Setup

Downsample (Hz): 1000 Time Window: 1s

Statistics

Window: avg -- µA, max -- µA, duration -- s, charge -- µC Selection: avg -- µA, max -- µA, duration -- s, charge -- µC

Guest Settings

ID (1-255): 1 Tx_power (dBm): 0 advertising interval (20-2000ms): 150

connection interval (20-1000ms): 60 Spare 0 (0-255): 0 Spare 1 (0-255): 0

Guest Status

```
Running State:  N/A    Wakeup:         N/A    Comm. Mode:     N/A
Running Mode:   N/A    VLC Protocol:   N/A    VLC Interval:   N/A
PWM %:          N/A    BLE Protocol:   N/A    BLE Interval:   N/A
Fast Time:      N/A    VLC Comm Vol:   N/A    VLC Info Vol:   N/A
VLC Per Time:   N/A    BLE Comm Vol:   N/A    BLE Info Vol:   N/A
BLE Per Time:   N/A    PHY Rate %:     N/A    MTU Value:      N/A
Spare 2:        N/A    Spare 3:        N/A    Spare 4:        N/A
```

Calibration

□ Enable Calibration

Other Offset: 0.00 µA

Sending Offset: 0.00 µA

Serial Commands

Cmd 1: AA 03 06 01 EE

Cmd 2: AA 02 20 01 04 D0 99 55 85 5D B1 EE

Cmd 3: AA 01 04 00 EE

Status Logs

Status: Calibration disabled

```
INFO: Calibration disabled
```

Data Management

CSV (Excel compatible)

Save Downsample: 100000 Hz (Full Rate)

Suggestion:

IDs in **Guest Settings** usually set up as <10 for nodes, >10 for mini lamps (but user can define any IDs)

➔ Click **Refresh**, Select **COM Port** in "**PPKII Connection**") for PPKII power profiler connected to the node (e.g. COM5 – nRF Connect USB CDC ACM (COM5))

➔ Click **Connect**

➔ **Set Voltage** (3300 mV for **NODE**)

➔ **Source Meter Mode** (Check "**Enable Power Output (DUT)**")

➔ Click **Start Measurement (default resolution 100 kHz)**

➔ PPKII power profiler will turn RED

➔ Node will be running in an Idle mode at this point but is not activated until serial port is connected (that is, node's firmware is not activated).

➔ Click "**Connect**" serial port of node in "**Serial Command Connection**" (**Refresh** if needed, note, this is different Com port than the PPK2 connection port). When you click Connect, parameters in "**Guest Status**" will be updated as per node's current parameters configured in its firmware. Note, **before** you **Connect** you can also configure parameters like "Tx_power", "advertising interval", "connection interval", etc in the node's firmware first. However, you need to flash the firmware on the node (same for gateway) with desired parameters if you want to change parameters in Guest settings (else use default).

➔ Use **Serial commands** section in App for activating different node's operations. Check the "Commands_node.txt" and "Commands_minilamp.txt" files for list of commands you can send from node to gateway in uplink or from gateway to node in downlink. For, example on node's App, send command "AA 01 04 00 EE" for node to go to deep sleep (you will notice "Running State" in "Guest Status" has changed. After a while, the node will wake-up again (automatic as per firmware). Note: If you send deep sleep command to node, the node serial port will be disconnected (but not the current measurement). Then press **Connect** again in **Serial Command Connection** on the Node App after the node has woken up.

➔ **Save Data** (choose desired resolution) may take a while depending on amount of data logged.

➔ **Stop Measurement**

➔ **Clear Data**

For recording the measurement on the **mini lamp gateway**, open another terminal, and run ***python PPK2-Python-Minilamp.py***. The default ID is 10.

Note: For mini lamp set voltage to 5000 mV.

PARSING DATA FILES

###

1. When you click **Save Data** (raw) on App, it will be saved as several parts (suggestion: save data for each node and gateway/access point in separate folders)
2. Run "**plot_saved_raw_enhanced.py**" to refine/correct/realign the raw data. The new generated files will have the "*_refined*" text appended to the filenames. You may move the files to a new folder.
3. Preprocess the refined data in different steps using scripts provided in "**Predictor and Optimizer\Preprocess_dataset**" folder.