



DesignNews

Understanding Sensors and Data Analysis Using the Arduino Nano 33 BLE Sense

DAY 3 : Sensor Programming

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Webinar Logistics

- Turn on your system sound to hear the streaming presentation.
- If you have technical problems, click “Help” or submit a question asking for assistance.
- Participate in ‘Attendee Chat’ by maximizing the chat widget in your dock.

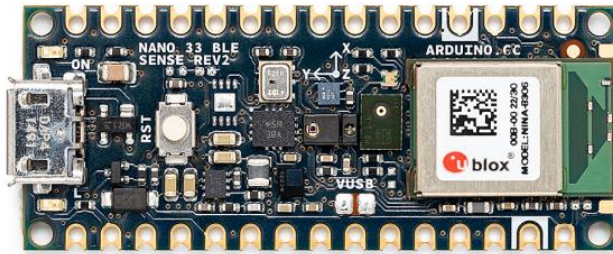


Dr. Don Wilcher

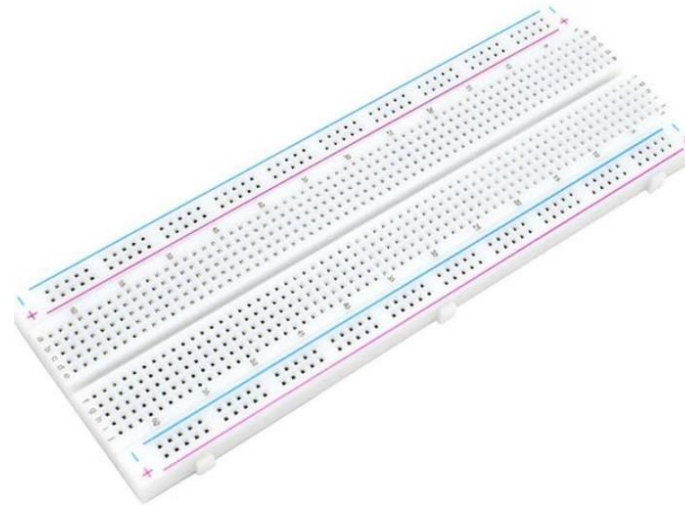
Visit 'Lecturer Profile' in your console for more details.

Course Kit and Materials

Arduino Nano 33 BLE Sense Board



Solderless Breadboard



Adafruit Parts Pal Kit

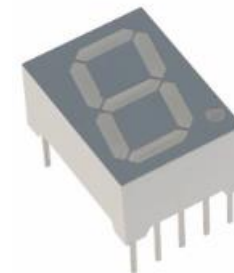


I2C OLED Display



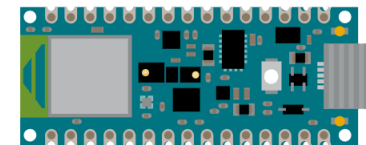
https://www.amazon.com/HiLetgo-Serial-128X64-Display-Color/dp/B06XRBYJR8/ref=sr_1_6?crid=1VC2UTZ2P8NWF&keywords=i2c%2Boled&qid=1700192985&srefix=I2C%2B%2Caps%2C108&sr=8-6&th=1

7 Segment LED Display, Common Cathode

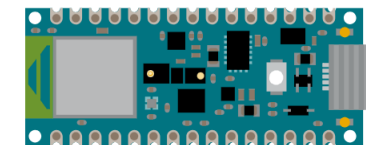


Agenda:

- Accessing On-board sensors
 - a) temperature
 - b) relative humidity
 - c) microphone
 - d) gesture sensor
- Logging sensor data
 - a) Tera Term
 - b) PuTTY
- Lab: Light Sensor OLED Demonstrator (Bricolage)



Research Perspective



“The Internet of Things, which has been quietly building and evolving over the past decade, now impacts many aspects of society.” (Chua & Storey, 2023).

Accessing On-board Sensors

Several onboard sensors can be accessed using code on the Arduino Nano 33 BLE sense board.

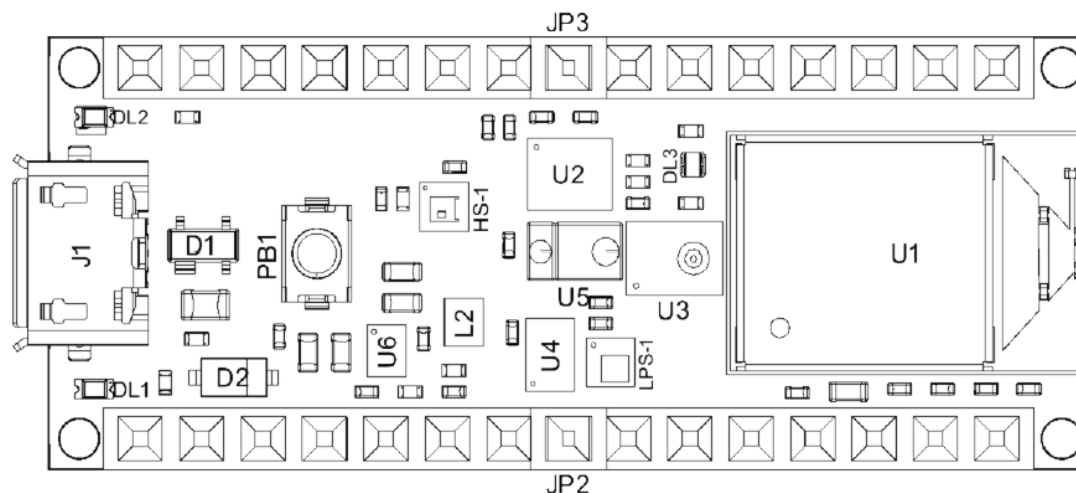
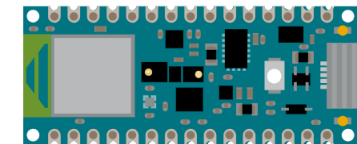
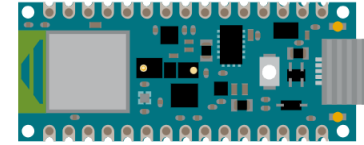


Illustration and table
courtesy of Arduino.cc

Ref.	Description	Ref.	Description
U1	NINA-B306 Module Bluetooth® Low Energy 5.0 Module	U6	MP2322GQH Step Down Converter
U2	LSM9DS1TR Sensor IMU	PB1	IT-1185AP1C-160G-GTR Push button
U3	MP34DT06JTR Mems Microphone	HS-1	HTS221 Humidity Sensor
U4	ATECC608A Crypto chip	DL1	Led L
U5	APDS-9660 Ambient Module	DL2	Led Power

Accessing On-board Sensors...



- These sensors can be accessed using the inter-integrated circuit (I2C) protocol.
- The I2C protocol allows multiple peripheral digital integrated circuits (ICs) to communicate with one or more controller ICs.
- The IC2 is only intended for short-distance communications with a single device.
- The IC2 requires two signal wires to exchange data.
- Communication digital circuits are labeled as **Controller** and **Peripheral**.
- The terms **Master** and **Slave** have been replaced with Controller and Peripheral.
- I2C can support up to 1008 peripheral devices.

Source:

<https://learn.sparkfun.com/tutorials/i2c/all>

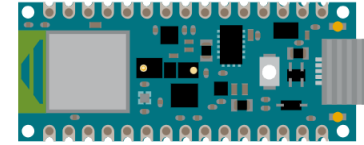
Question 1

The abbreviation of I2C stands for

- a) intra-integrated circuit**
- b) enter-integrated circuit**
- c) intered-integrated circuit**
- d) inter-integrated circuit**



Accessing On-board Sensors



Wiring configuration for I2C circuits

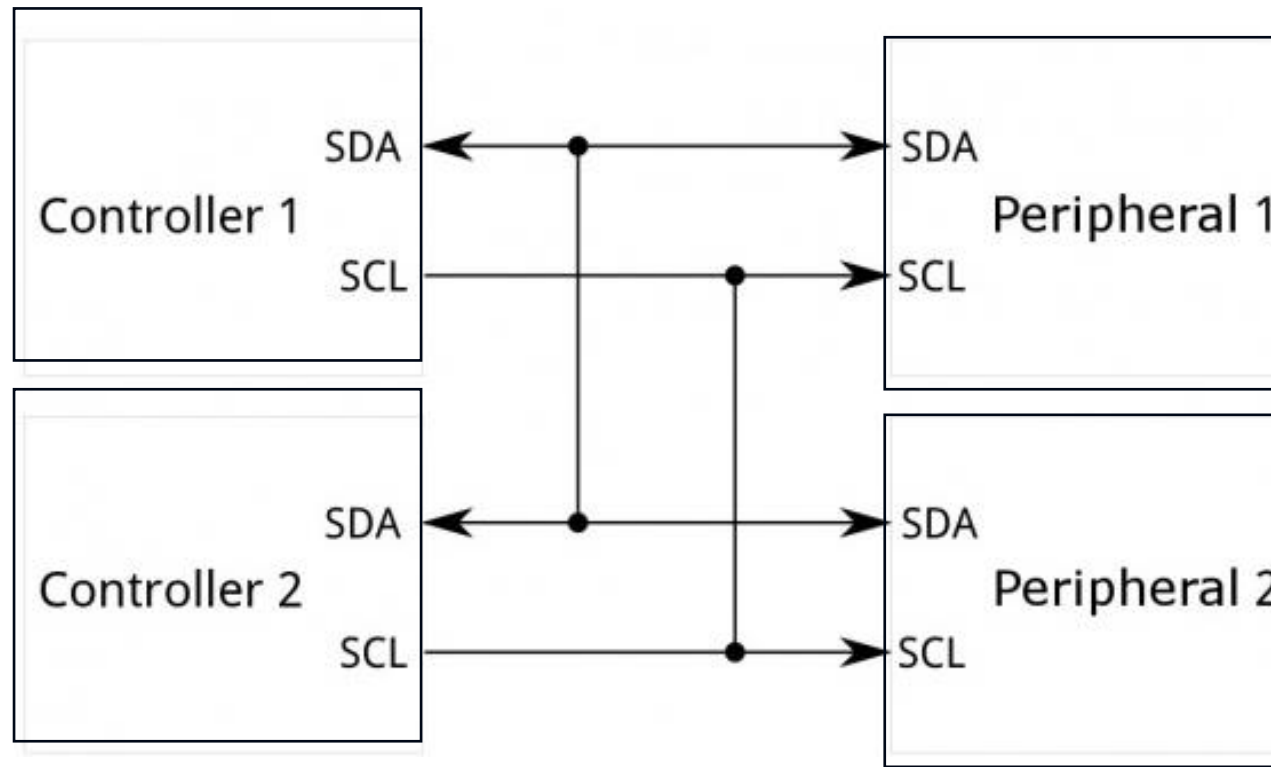


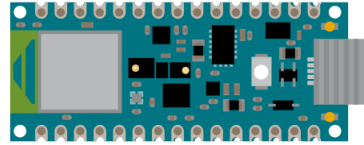
Diagram
courtesy of
Sparkfun

SDA is the Serial Data Line.
SCL is the Serial Clock Line. The
SCL is used to synchronize all
data transfers over the I2C bus.

Source:

<https://learn.sparkfun.com/tutorials/i2c/all>

Accessing On-board Sensors ...



Installing the Arduino_HTS221 Temperature Sensor Library.

LIBRARY MANAGER

Arduino_HTS

Type: All

Topic: All

ArduinoDMX by Arduino
Control DMX lights with your Arduino. Using RS485 shields, like the MKR 485 Shield. This...
[More info](#)
1.0.1 **INSTALL**

Arduino_HTS221 by Arduino
1.0.0 installed
Allows you to read the temperature and humidity sensors of your Nano 33 BLE...
[More info](#)

Click on More Info takes you here



Arduino_HTS221 Public

Watch 15 Fork 15 Star 13

master 1 branch 1 tag

Go to file Add file Code

per1234 Merge pull request #25 from arduino-libraries/dependabot/github_actio... b095d01 on Sep 5 34 commits

.github	Bump actions/checkout from 3 to 4	2 months ago
docs	added missing link (#11)	2 years ago
examples	Merge pull request #3 from KAbhijeet2105/master	2 years ago
src	Fixed hang due to consecutive read temperature	4 years ago
.codespellrc	Add CI workflow to check for commonly misspelled words	2 years ago
LICENSE.txt	Add license file	2 years ago
README.adoc	Add "smoke test" examples compilation CI workflow	2 years ago
keywords.txt	Initial import (based on MKRENV lib)	4 years ago
library.properties	Initial import (based on MKRENV lib)	4 years ago

About

HTS221 Library for Arduino

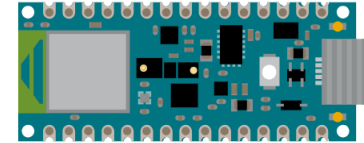
- Readme
- LGPL-2.1 license
- Activity
- 13 stars
- 15 watching
- 15 forks
- Report repository

Releases

1 tags

Packages

Accessing On-board Sensors...



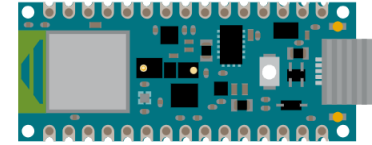
I2C Test Code

Upload the code to the
Arduino Nano 33 BLE
Sense Board.

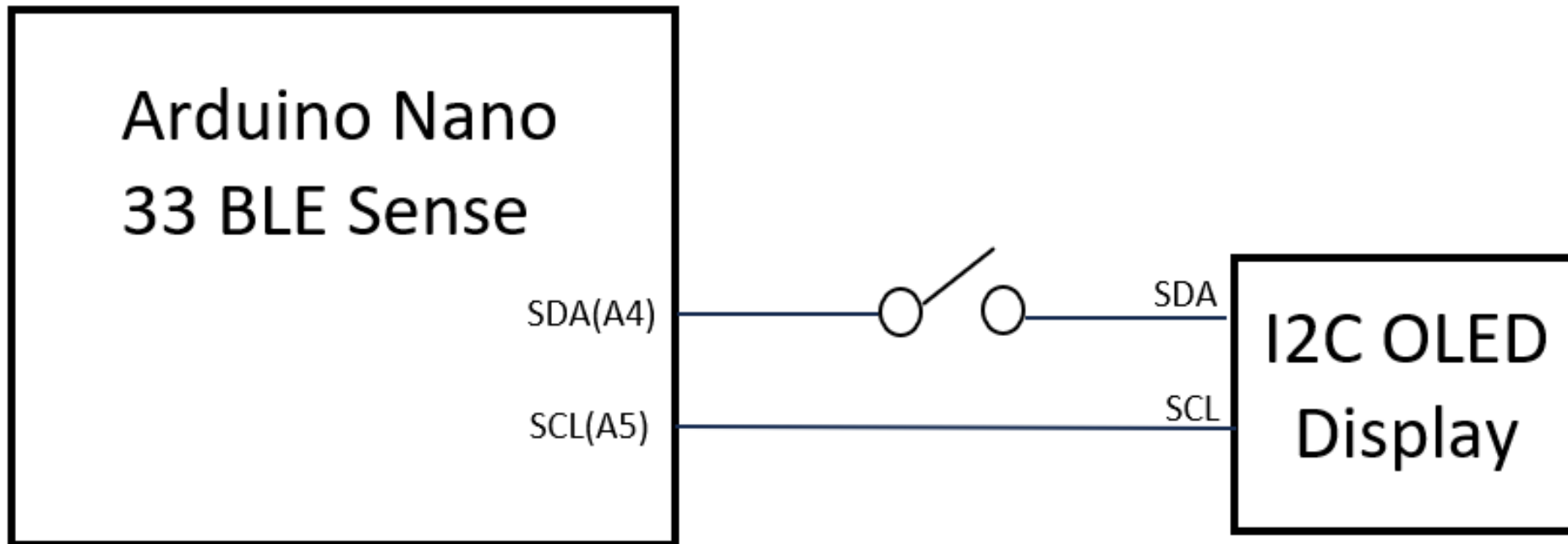
The code will display the
address of the connected
I2C device on the bus.

```
1  #include <Wire.h>
2  void setup() {
3      Serial.begin(115200);
4      Wire.begin();
5      Serial.println("\nI2C Scanner");
6  }
7  void loop() {
8      byte error, address;
9      int nDevices;
10     nDevices = 0;
11     for(address = 1; address < 127; address++) {
12         Wire.beginTransmission(address);
13         error = Wire.endTransmission();
14         if (error == 0) {
15             Serial.print("I2C device found at address 0x");
16             if (address < 16)
17                 Serial.print("0");
18             Serial.println(address, HEX);
19             nDevices++;
20         }
21     }
22     delay(5000);
23 }
24
```

Accessing On-board Sensors...

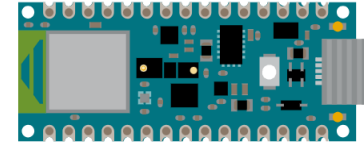


I2C Test Circuit

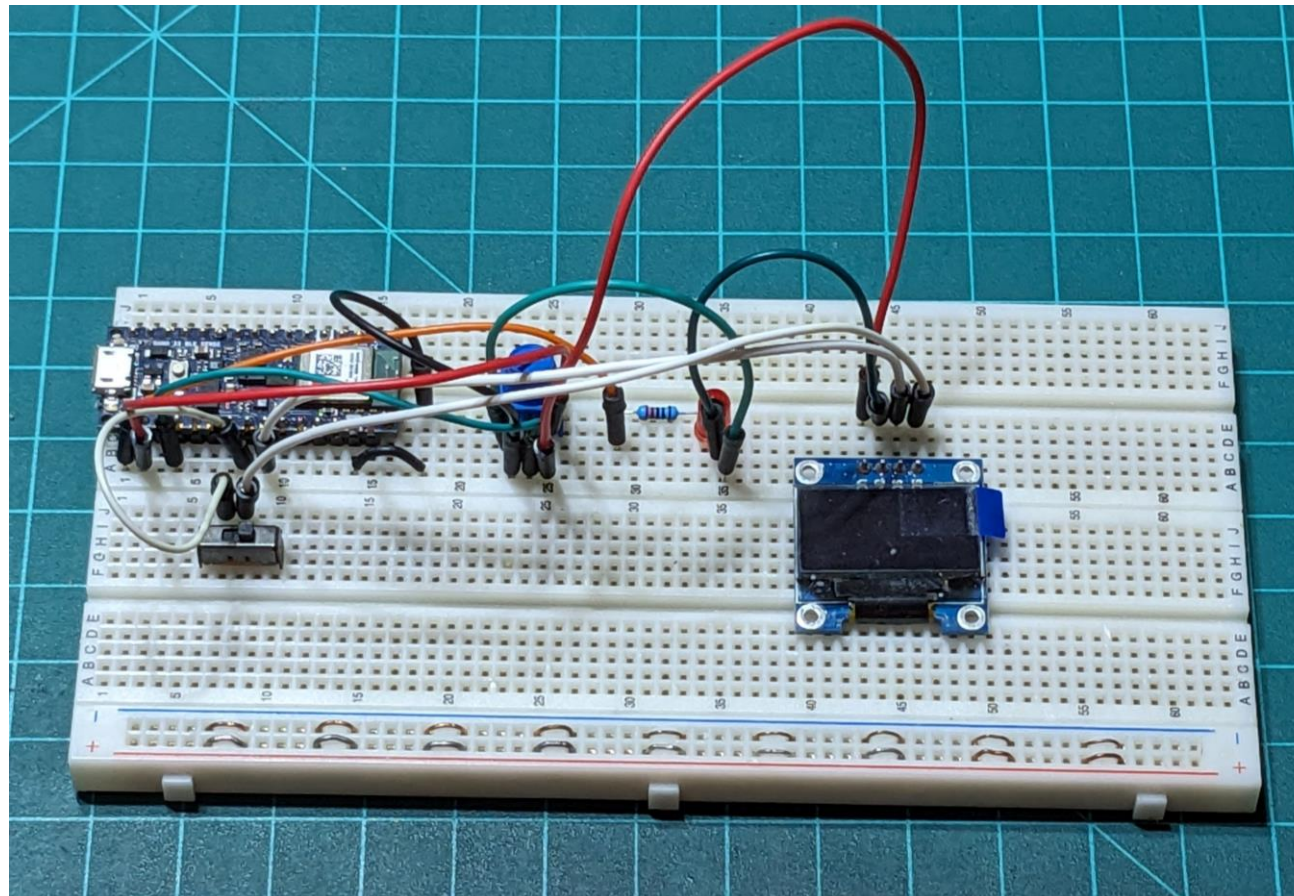


Accessing On-board Sensors... I2C Test Circuit

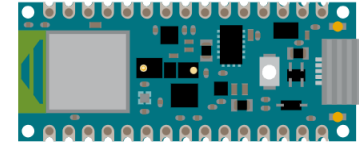
Switch wired
between A4
and SDA



The slide switch is wired
between A4(Arduino Nano 33
BLE Sense) and SDA (I2C OLED)
pins.



Accessing On-board Sensors...



Testing i2c_internalsensor
code

```
i2c_internalsensor.ino
4  wire.begin();
5  Serial.println("\nI2C Scanner");
6  }
7  void loop() {
8  byte error, address;
9  int nDevices;
10 nDevices = 0;
11 for(address = 1; address < 127; address++) {
12   Wire.beginTransmission(address);
13   error = Wire.endTransmission();
14   if (error == 0) {
15     Serial.print("I2C device found at address 0x");
16     if (address < 16)
17       Serial.print("0");
```

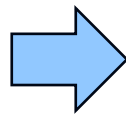
Output Serial Monitor x

Message (Enter to send message to 'Arduino Nano 33 BLE' on 'COM5') New Line 9600 baud

```
I2C device found at address 0x3C
I2C device found at address 0x3C
I2C device found at address 0x3C
I2C device found at address 0x3C
I2C device found at address 0x3C
```

Ln 1, Col 1 Arduino Nano 33 BLE on COM5 2

Line SDA closed



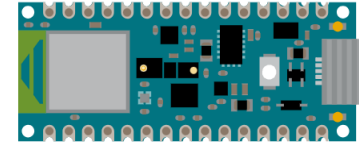
Question 2

In reviewing slide 15, what is the address for the I2C OLED?

- a) 0x2c**
- b) 0xbc**
- c) 0x4c**
- d) 0x3c**



Accessing On-board Sensors ...



Temperature and Humidity Sensor Code

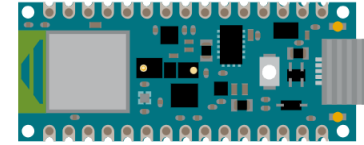


Image courtesy of
STMicro

Temperature_Humidity_Sensor.ino

```
1  #include <Arduino_HTS221.h>
2  void setup() {
3      Serial.begin(115200);
4      while (!Serial);
5      if (!HTS.begin()) {
6          Serial.println("Failed to initialize humidity temperature sensor!");
7          while (1);
8      }
9  }
10 void loop() {
11     float temperature = HTS.readTemperature();
12     float humidity    = HTS.readHumidity();
13     Serial.print("Temperature = ");
14     Serial.print(temperature);
15     Serial.println(" °C");
16     Serial.print("Humidity    = ");
17     Serial.print(humidity);
18     Serial.println(" %");
19     Serial.println();
20     delay(1000);
21 }
22
```

Accessing On-board Sensors ...



Upload the
Temperature_Humidity
Sensor code to the
Arduino Nano 33 BLE
Sense board

```
Temperature_Humidity_Sensor.ino
1  #include <Arduino_HTS221.h>
2  void setup() {
3      Serial.begin(115200);
4      while (!Serial);
5      if (!HTS.begin()) {
6          Serial.println("Failed to initialize humidity temperature sensor!");
7          while (1);
8      }
9  }
10 void loop() {
11     float temperature = HTS.readTemperature();
12     float humidity    = HTS.readHumidity();
13     Serial.print("Temperature = ");
```

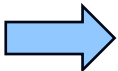
Serial Monitor ×

Message (Enter to send message to 'Arduino Nano 33 BLE' on 'COM5') New Line 9600 baud

```
Humidity    = 36.42 %
Temperature = 29.22 °C
Humidity    = 36.38 %
```

Ln 1, Col 1 Arduino Nano 33 BLE on COM5

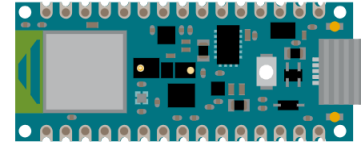
Output Results:
Readings from
Onboard
Sensors



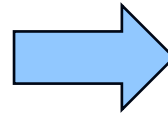
Accessing On-board Sensors ...

Onboard Digital
Microphone Code

Upload the Microphone Code to the Arduino Nano 33 BLE
Sense board

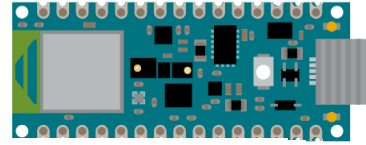


```
1 #include <PDM.h>
2 short sampleBuffer[256];
3 // number of samples read
4 volatile int samplesRead;
5
6 void setup() {
7     Serial.begin(9600);
8     //PDM.setGain(200);
9     while (!Serial);
10    // configure the data receive callback
11    PDM.onReceive(onPDMdata);
12    // one channel (mono mode) 16 kHz sample rate
13    if (!PDM.begin(1, 16000)) {
14        Serial.println("Failed to start PDM!");
15        while (1);
16    }
17 }
```



```
19 void loop() {
20     if (samplesRead) {
21         for (int i = 0; i < samplesRead; i++) {
22             Serial.println(sampleBuffer[i]);
23             delay(50);
24         }
25         // clear the read count
26         samplesRead = 0;
27     }
28 }
29
30 void onPDMdata() {
31     // query the number of bytes available
32     int bytesAvailable = PDM.available();
33     // read into the sample buffer
34     PDM.read(sampleBuffer, bytesAvailable);
35     // 16-bit, 2 bytes per sample
36     samplesRead = bytesAvailable / 2;
37 }
```

Accessing On-board Sensors ...



Onboard Digital Microphone Data

Serial Plotter

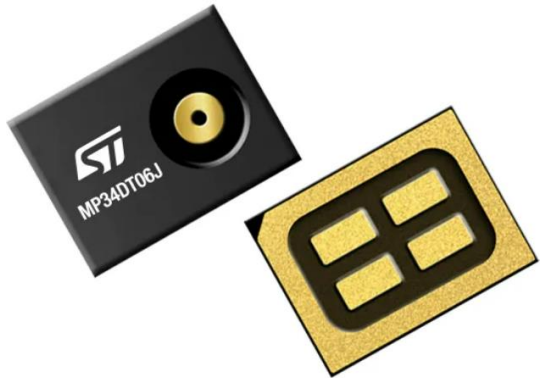
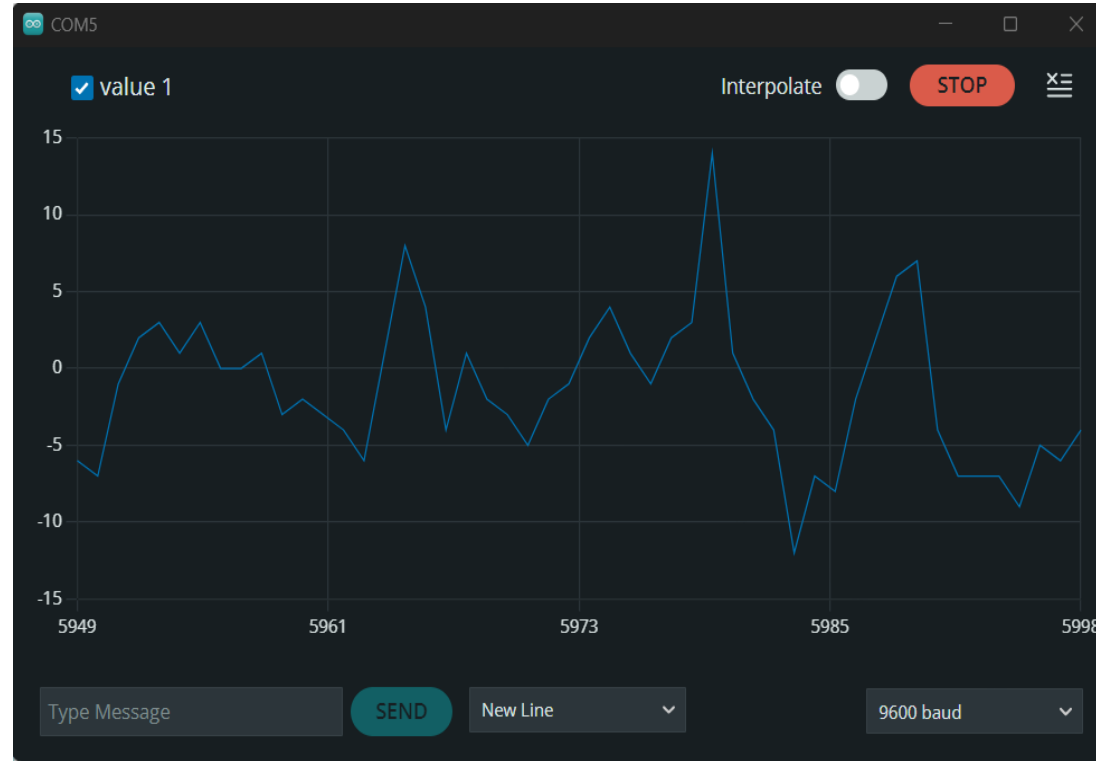


Image courtesy of STMicro



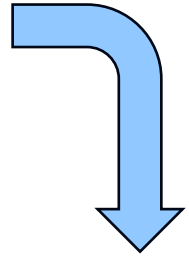
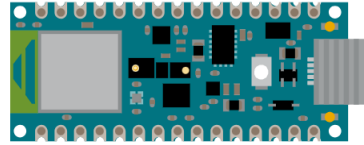
Serial Monitor

Accessing On-board Sensors ...

Onboard Gesture Sensor

About

A library for the APDS9960 sensor, allows you to read gestures, color, and proximity on your Arduino Nano 33 BLE Sense board and other boards with sensor attached via I2C.



LIBRARY MANAGER

Arduino_APDS

Type: All

Topic: All

Arduino_APDS9960 by Arduino

1.0.4 installed

A library for the APDS-9960 sensor allows reading gestures, color, and proximity on your Arduino Nano 3...

[More info](#)

1.0.4 REMOVE

Click on More Info takes you here



Arduino_APDS9960 Public

Watch 18 Fork 21 Star 23

master 1 branch 5 tags

Go to file Add file Code

dependabot[bot] Bump actions/checkout from 3 to 4 (#31) ✓ c193c0c on Sep 4 80 commits

.github	Bump actions/checkout from 3 to 4 (#31)	2 months ago
docs	added missing link	2 years ago
examples	Correct typos in comments	2 years ago
src	Fix CI build for megaavr by removing ambiguity for requestFrom call. (#...	2 years ago
.codespellrc	Fix spell check false positive by ignoring word	last year
LICENSE.txt	Add license file	2 years ago
README.adoc	Modernize library reference link	last year
keywords.txt	Update description and keywords.txt	4 years ago
library.properties	Release v1.0.4	2 years ago

About

A library for the APDS9960 sensor, allows you to read gestures, color, and proximity on your Arduino Nano 33 BLE Sense board and other boards with sensor attached via I2C.

Readme

LGPL-2.1 license

Activity

23 stars

18 watching

21 forks

Report repository

Releases 1

Question 3

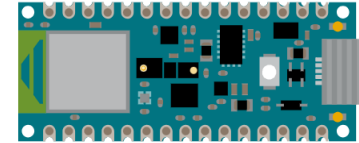
In reviewing slide 21, clicking the More Info button on the library module box takes you to a _____.

- a) website**
- b) an interactive website**
- c) Github page**
- d) webpage**



Accessing On-board Sensors...

Onboard Gesture Sensor



LIBRARY MANAGER

Arduino_APDS

Type: All

Topic: All

Arduino_APDS9960 by Arduino

1.0.4 installed

A library for the APDS-9960 sensor allows reading gestures, color, and proximity on your Arduino Nano 3...

[More info](#)

1.0.4 REMOVE

Click on More Info takes you here



Arduino_APDS9960 Public

Watch 18 Fork 21 Star 23

master 1 branch 5 tags

Go to file Add file Code

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library.properties	Release v1.0.4	2 years ago

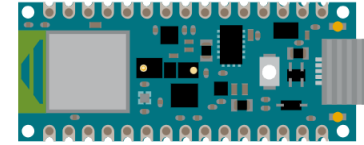
About

A library for the APDS9960 sensor, allows you to read gestures, color, and proximity on your Arduino Nano 33 BLE Sense board and other boards with sensor attached via I2C.

- Readme
- LGPL-2.1 license
- Activity
- 23 stars
- 18 watching
- 21 forks
- Report repository

Releases 1

Accessing On-board Sensors...



Onboard Gesture Sensor

```
1 #include <Arduino_APDS9960.h>
2 void setup() {
3   Serial.begin(115200);
4   while (!Serial);
5   pinMode(LED_BUILTIN, OUTPUT);
6   if (!APDS.begin()) {
7     Serial.println("Error initializing APDS9960 sensor!");
8   }
9   Serial.println("Detecting gestures ...");
10 }
11 void loop() {
12   if (APDS.gestureAvailable()) {
13     // a gesture was detected, read and print to serial monitor
14     int gesture = APDS.readGesture();
15     switch (gesture) {
16       case GESTURE_UP:
17         Serial.println("Detected UP gesture");
18         digitalWrite(LED_BUILTIN, HIGH);
19         break;
20       case GESTURE_DOWN:
21         Serial.println("Detected DOWN gesture");
22         digitalWrite(LED_BUILTIN, LOW);
23         break;
24       case GESTURE_LEFT:
25         Serial.println("Detected LEFT gesture");
26         digitalWrite(LED_BUILTIN, LOW);
27         break;
```



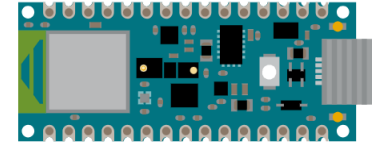
```
28     case GESTURE_RIGHT:
29       Serial.println("Detected RIGHT gesture");
30       digitalWrite(LED_BUILTIN, HIGH);
31       break;
32     default:
33       // ignore
34       break;
35   }
36 }
37 }
```

Upload the Gesture
Sensor code to the
Arduino Nano 33 BLE
Sense board



Image courtesy of
Mouser Electronics

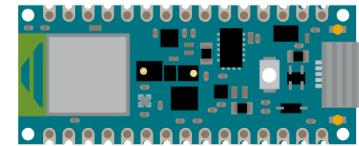
Accessing On-board Sensors



Onboard Gesture Sensor

```
Output Serial Monitor X
Message (Enter to send message to 'Arduino Nano 33 BLE' on 'COM5')
Detected DOWN gesture
Detected DOWN gesture
Detected UP gesture
Detected DOWN gesture
Detected DOWN gesture
```

Logging Sensor Data



- Using a terminal emulator (communication software), sensor data can be viewed and logged.
- Two common terminal emulators used to log data are:
 - a) Tera Term
 - b) PuTTY

Tera Term



Image courtesy of Tera Term

Download page:

https://download.cnet.com/tera-term/3000-2094_4-75766675.html

PuTTY

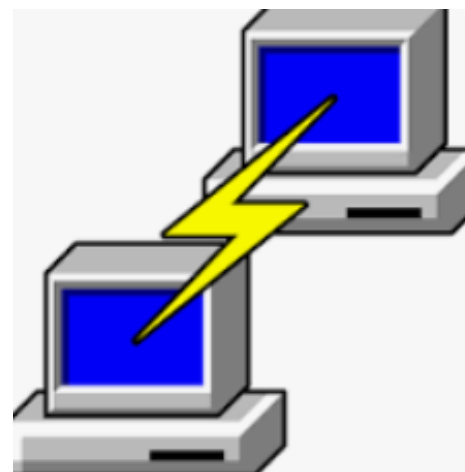
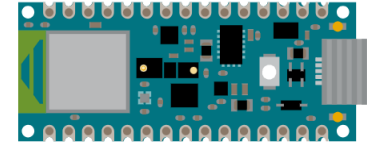


Image courtesy of PuTTY

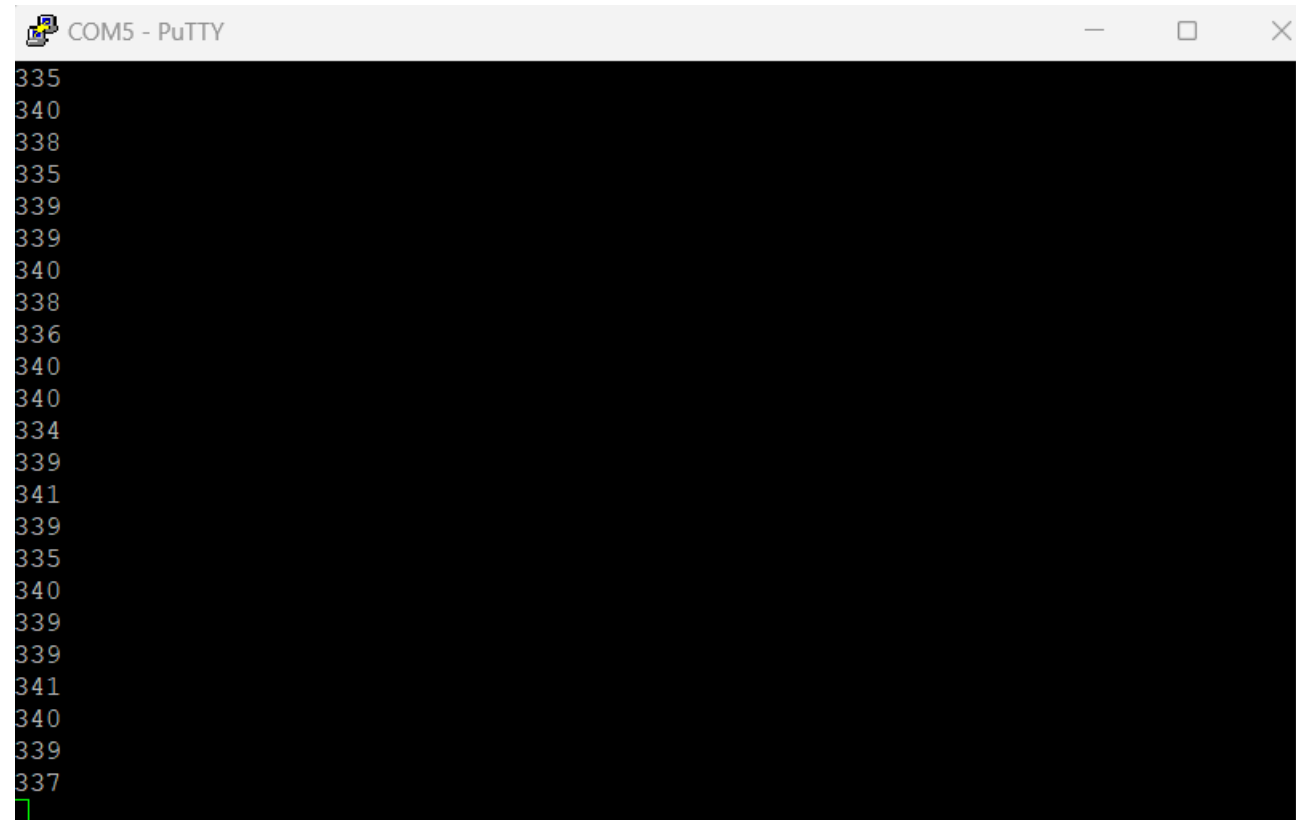
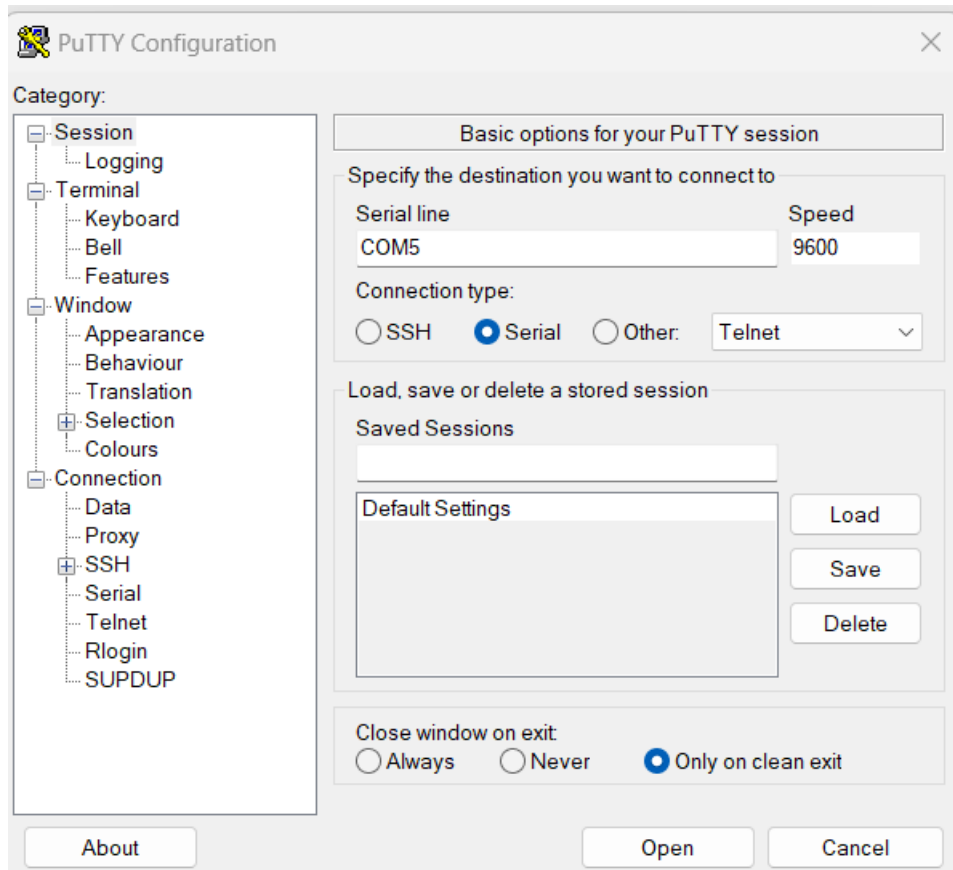
Download page:

<https://www.chiark.greenend.org.uk/~sgtatham/putty/latest.html>

Logging Sensor Data...

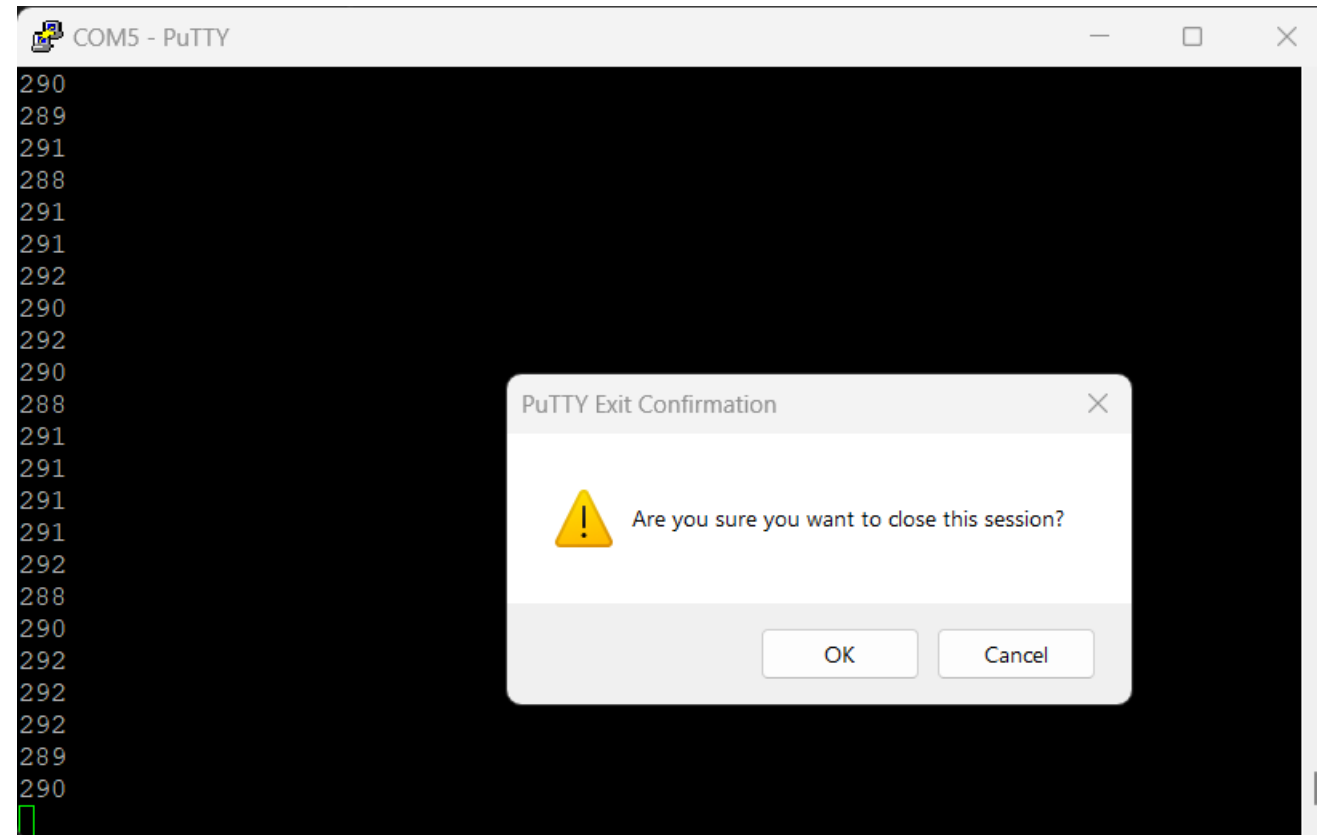
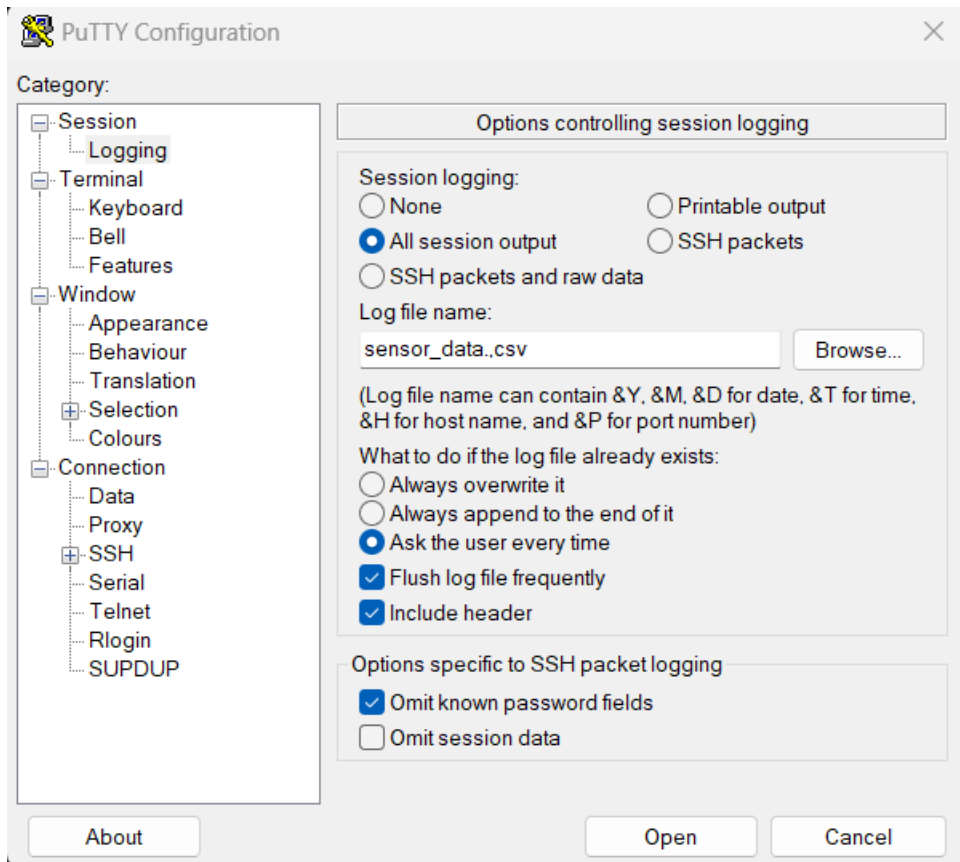
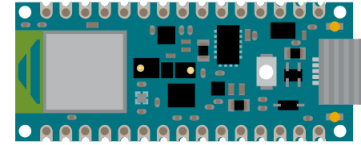


Setting Up PuTTY

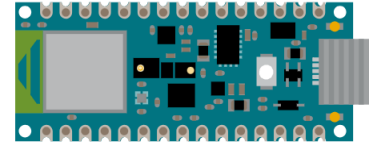


Logging Sensor Data...

Saving data – Log file saved by Clicking the OK button



Logging Sensor Data...



Setting Up Tera Term

Tera Term: New connection

TCP/IP

Host: 192.168.7.244

History

Service: Telnet TCP port#: 22

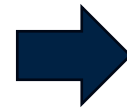
SSH SSH version: SSH2

Other IP version: AUTO

Serial

Port: COM5: USB Serial Device (COM5)

OK Cancel Help

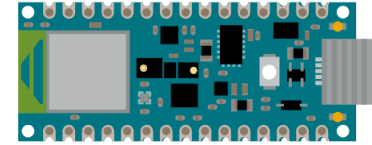


COM5 - Tera Term VT

File Edit Setup Control Window Help

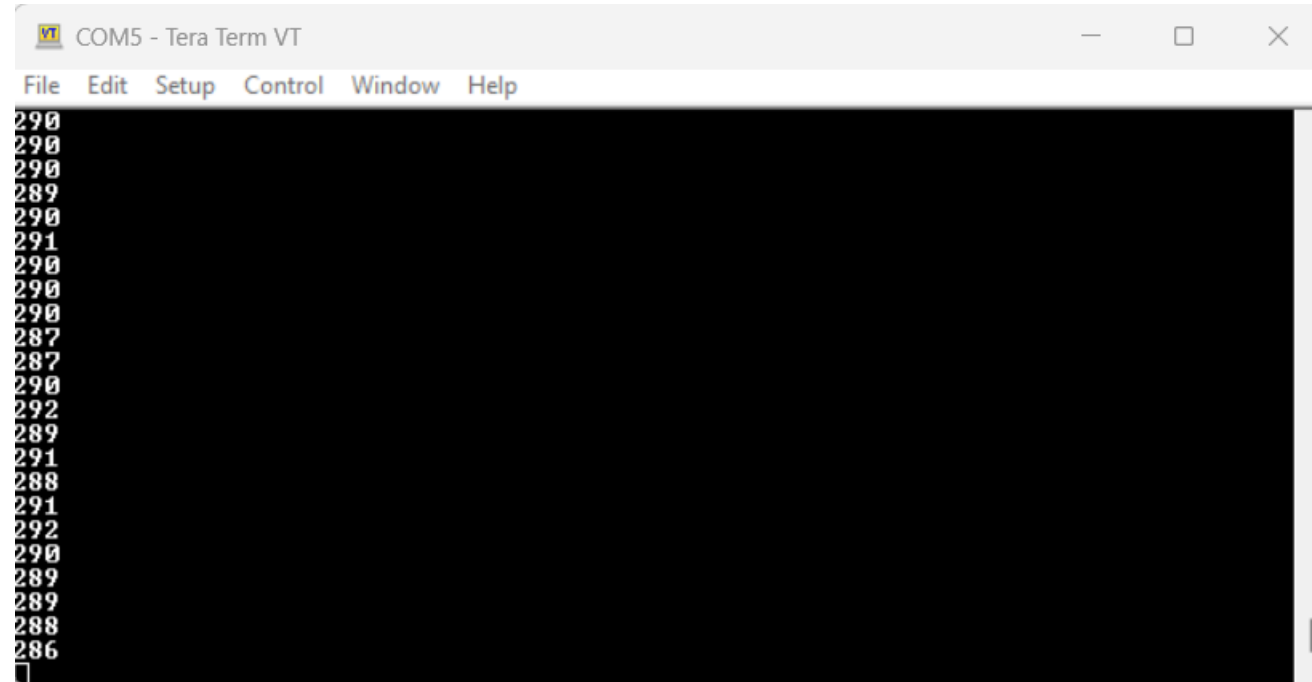
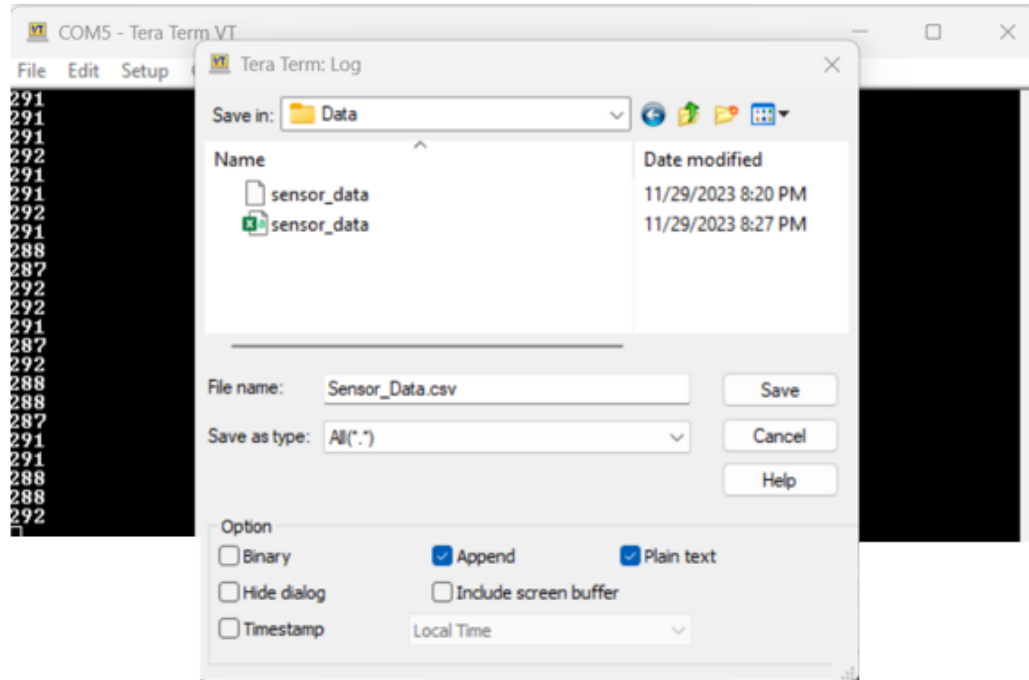
```
076
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077
```

Logging Sensor Data...



Saving data

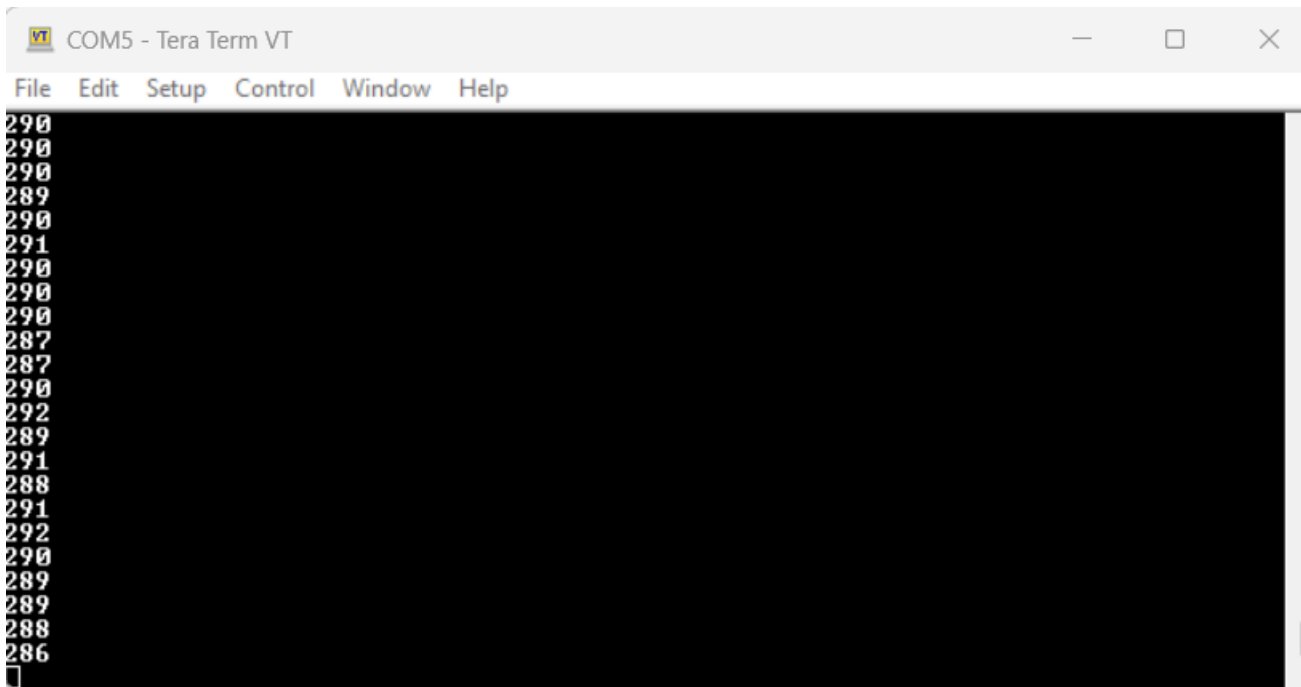
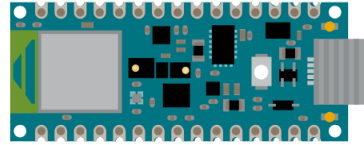
File>Log



Logging Sensor Data...

Saving data

Log file saved – Click the Close Button



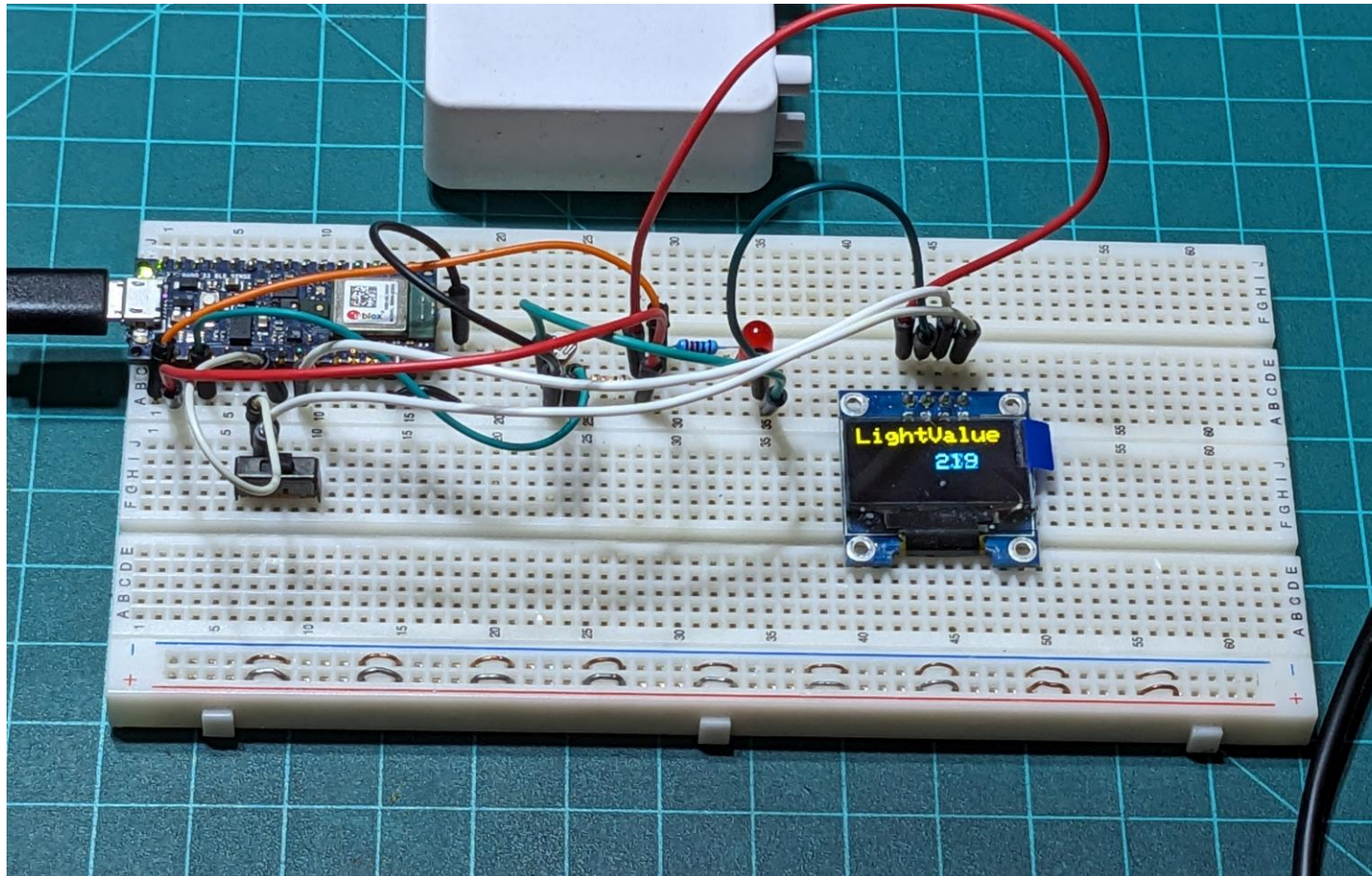
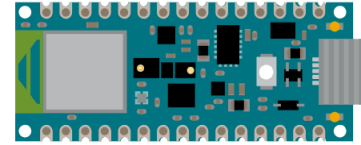
Question 4

There are three common terminal emulators used to log data.

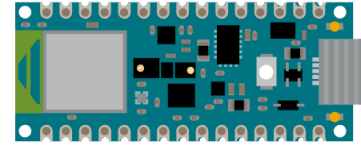
- a) True**
- b) False**



Lab: Light Sensor OLED Display (Bricolage)



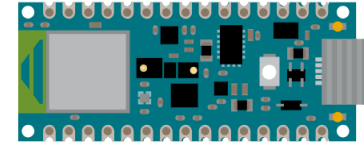
Lab: Light Sensor OLED Display (Bricolage)



Lab Objectives:

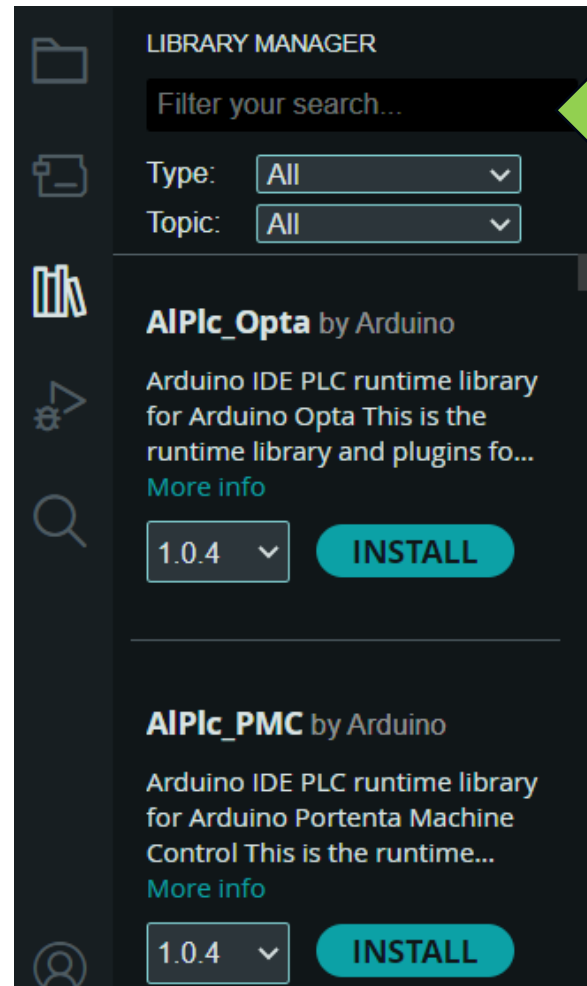
- Participants will learn to wire the Light Sensor OLED demonstrator circuit.
- Participants will learn to install libraries for the OLED display.
- Participants will learn to program the Arduino Nano 33 BLE Sense
- Participants will learn how to run the Light Sensor OLED Display

Setting Up The Libraries...



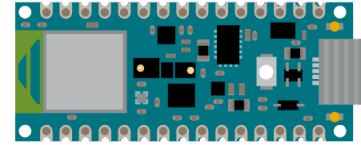
The libraries that will need to be installed are listed below.

- Adafruit GFX
- Adafruit SSD1306
- See Day 2 lecture slides for additional details and information

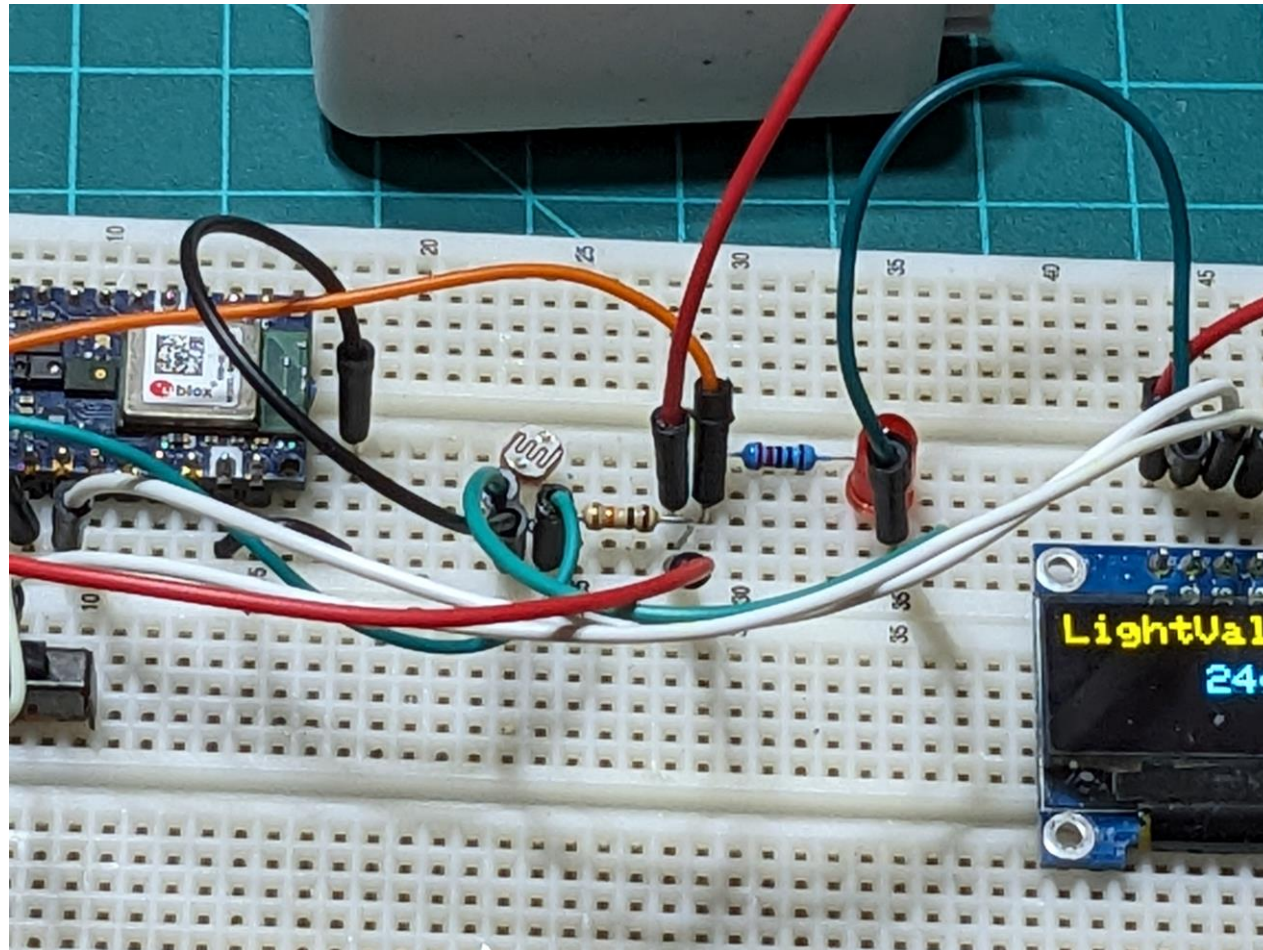


Type your Library searches here

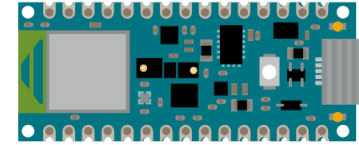
Lab: Light Sensor with OLED Display (Bricolage)...



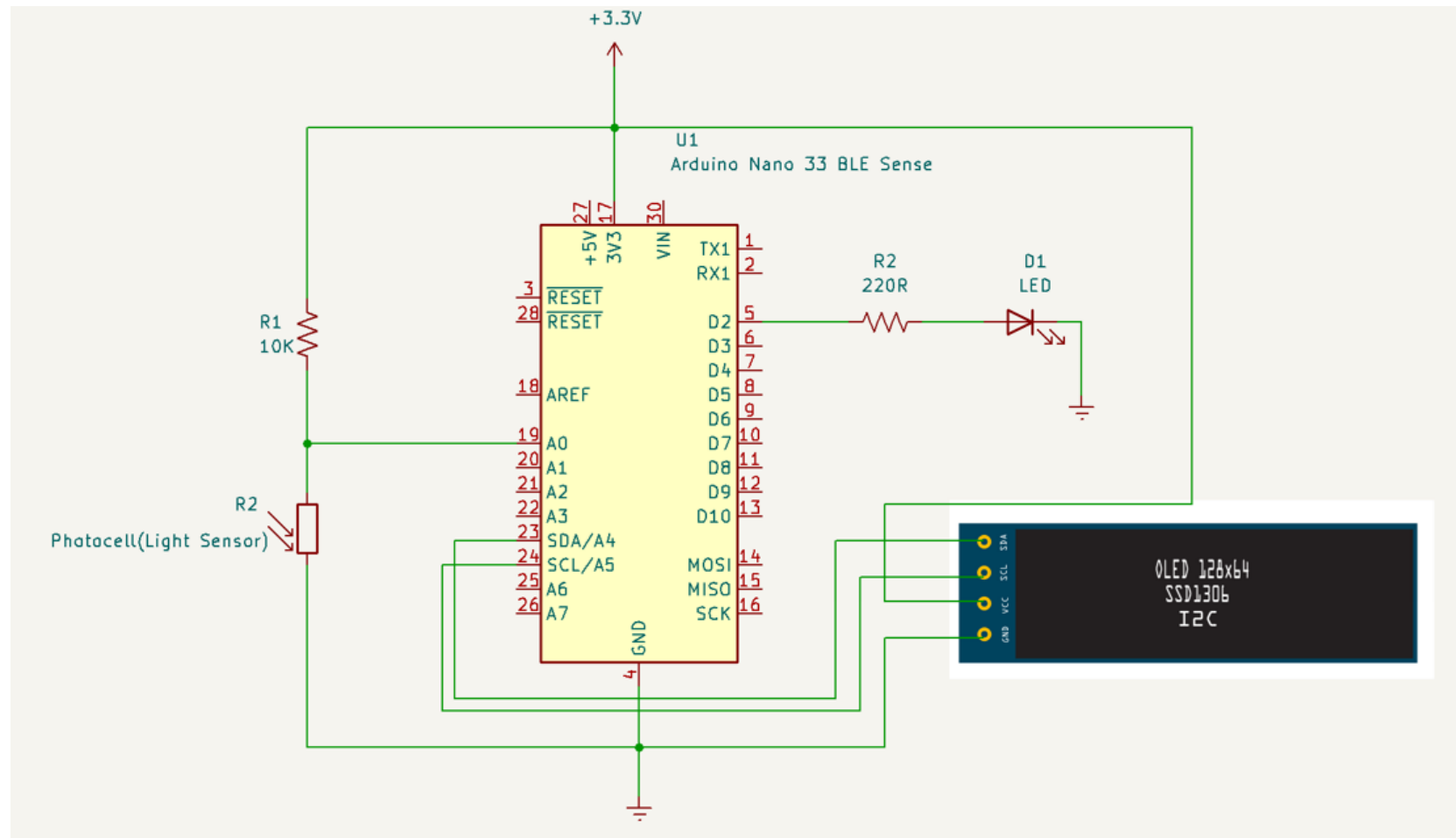
Replacement of 10K Ω
Potentiometer with
Light Sensor Circuit



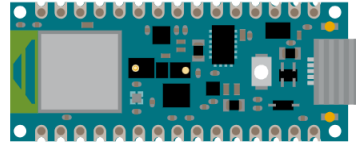
Lab: Light Sensor with OLED Display (Bricolage)...



Replacement of 10K Ω
Potentiometer with
Light Sensor Circuit:
**Electronic Circuit
Schematic Diagram**



Lab: Light Sensor OLED Display (Bricolage)...



```
1  #include <Wire.h>
2  #include <Adafruit_GFX.h>
3  #include <Adafruit_SSD1306.h>
4
5
6  //Adafruit_SSD1306 display(128, 64);
7
8  #define SCREEN_WIDTH 128
9  #define SCREEN_HEIGHT 64
10
11 #define OLED_RESET 4
12 Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, OLED_RESET);
13
14 const int lightsensorpin = A0; // Define the analog pin connected to the light sensor
15
16 void setup() {
17     Serial.begin(9600);
18     display.setTextColor(SSD1306_WHITE); // Set the color for the text
19
20     if(!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) {
21         Serial.println(F("SSD1306 allocation failed"));
22         for(;;);
23     }
24
25     // Set the background color to black
26     display.fillRect(0, 0, SCREEN_WIDTH, SCREEN_HEIGHT, SSD1306_BLACK);
27     display.display();
28     delay(2000);
29     display.clearDisplay(); // Clear the display after setting the background color
30 }
31 }
```

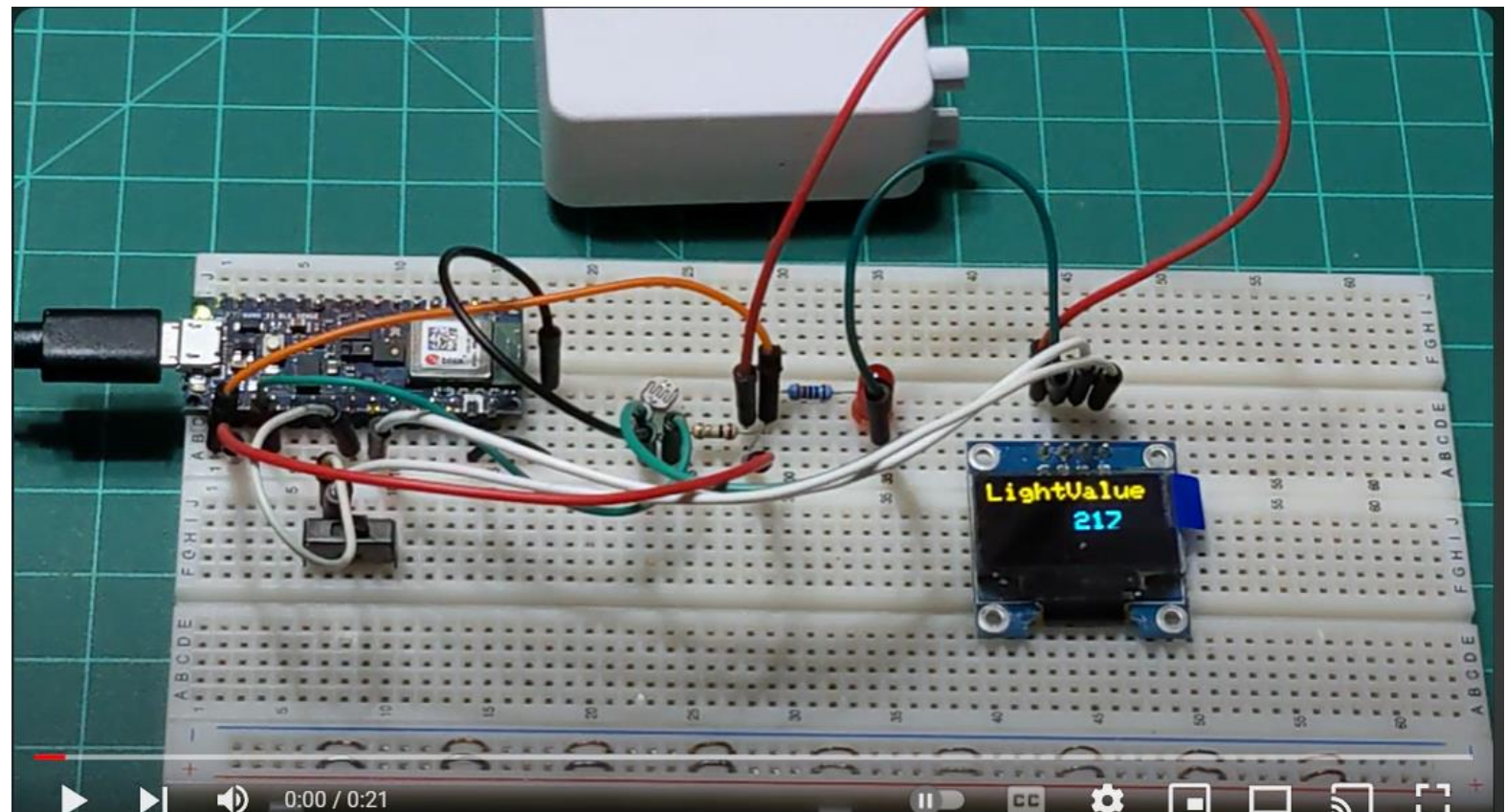
```
34 void loop() {
35     int lightValue = analogRead(lightsensorpin); // Read the light sensor value
36
37
38     // Display the light sensor value on the OLED disp
39     display.clearDisplay();
40     display.setTextSize(2);
41     display.setCursor(0, 0);
42     display.print("LightValue");
43     display.setTextSize(2);
44     display.setCursor(64,24);
45     display.print(lightValue);
46     Serial.println(lightValue);
47     delay(100);
48
49     // If the light sensor value is greater than 800, turn on the onboard LED
50     if (lightValue > 800) {
51         digitalWrite(LED_BUILTIN, HIGH);
52     } else {
53         digitalWrite(LED_BUILTIN, LOW);
54     }
55
56
57     display.display(); // Update the display
58 }
```

Lab: Light Sensor OLED Display (Bricolage)...

Running Light Sensor OLED Display on Solderless Breadboard

Click on the link to watch
the Hello World Demo

<https://youtu.be/QgXomLAnhs8>



Question 5

In reviewing slide 38, the 10K Ω potentiometer was replaced by what components?

- a) transistor-relay**
- b) diode-resistor**
- c) rheostat-resistor**
- d) resistor-photocell**



Thank you for attending

Please consider the resources below:

Chua, C.E., & Storey, V.C. (2022). A tutorial on prototyping internet of things device and systems: A gentle introduction to technology that shapes our lives. *Communications of the Association for Information Systems*, 51(34), 327-364.

https://www.researchgate.net/publication/360263045_A_Tutorial_on_Prototyping_Internet_of_Things_Devices_and_Systems_A_Gentle_Introduction_to_Technology_that_Shapes_Our_Lives

Kurniawan, A. (2021). *IoT projects with arduino nano 33 ble sense*. Apress.

https://link.springer.com/chapter/10.1007/978-1-4842-6458-4_3



Thank You

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