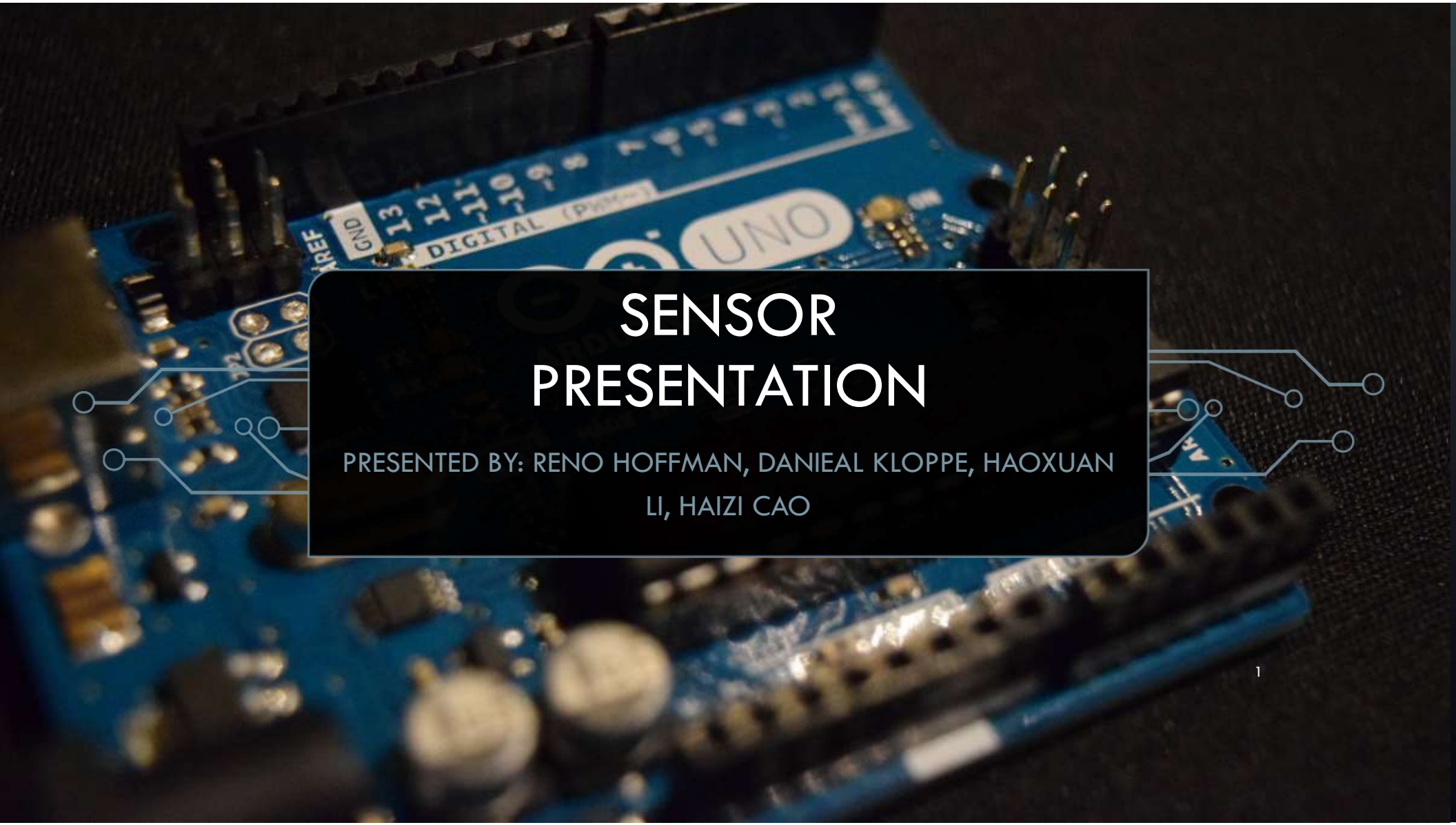


SENSOR PRESENTATION

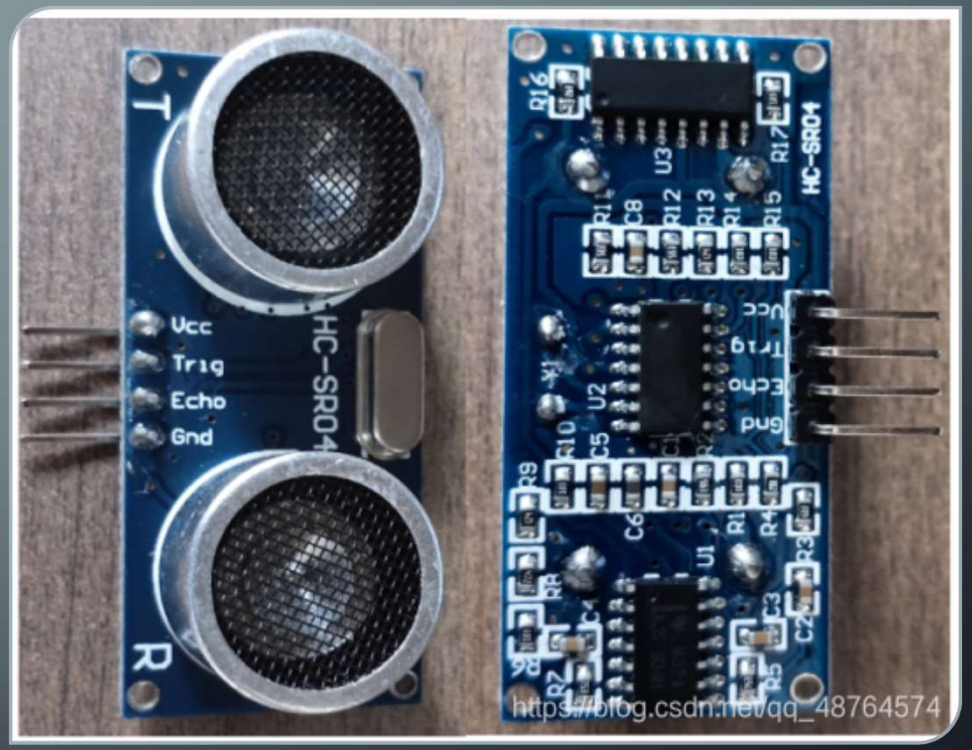
PRESENTED BY: RENO HOFFMAN, DANIEAL KLOPPE, HAOXUAN LI, HAIZI CAO

ULTRASONIC RANGING MODULE

Speaker：Haizi Cao， Haoxuan Li

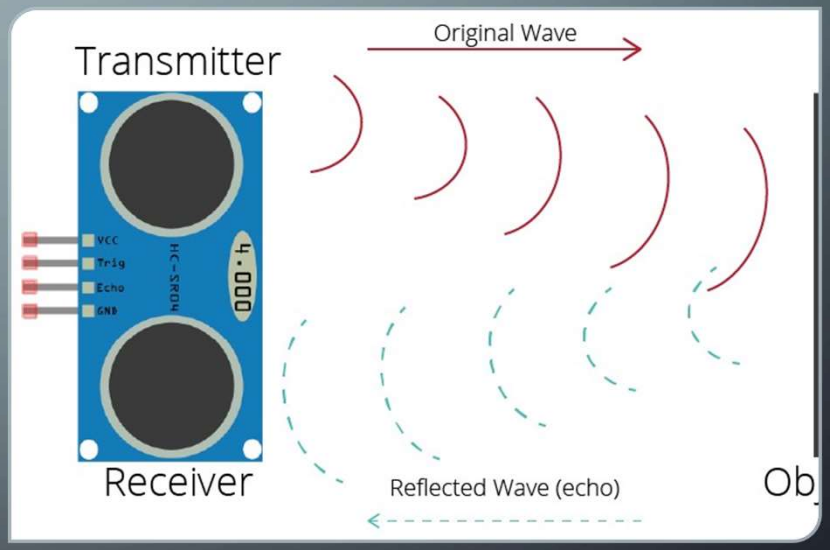
WHAT IS AN ULTRASONIC SENSOR?

- Ultrasonic sensors are piezoelectric transducers that can convert electrical signals into mechanical vibrations and convert mechanical vibrations into electrical signals. Generally speaking, we use it as a transceiver to measure its distance from an object.



WORKING PRINCIPLE OF ULTRASONIC SENSORS

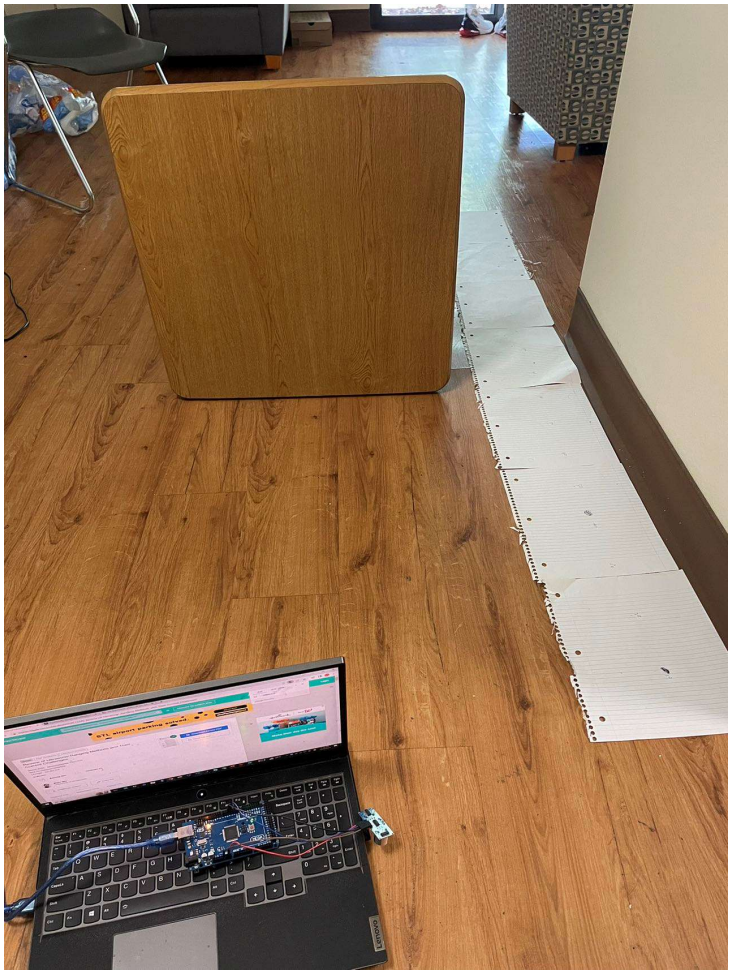
- Ultrasonic sensors can measure distance and detect the presence of objects without actual contact. They achieve this by generating and monitoring ultrasonic echoes. According to the characteristics of sensors and objects, the effective distance in the air is between a few centimeters and a few meters. Ultrasonic sensors (or transducers) generate and emit ultrasonic pulses, which are reflected back by objects in the sensor's field of view.



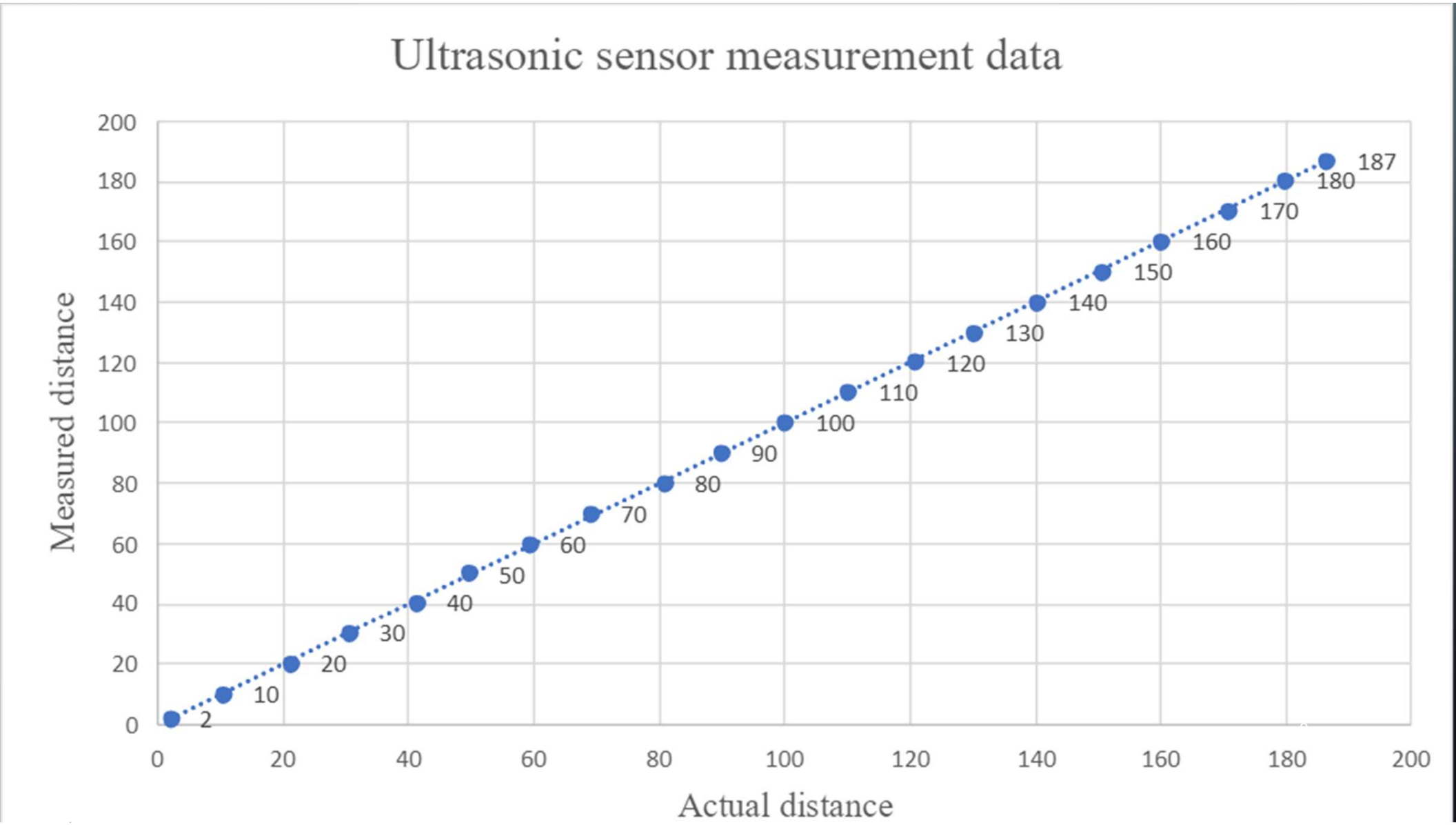
THE IMPORTANT CHARACTERISTIC OF ULTRASONIC RANGING MODULE

- There are several important characteristic of ultrasonic ranging module: Range, static error, precision, resolution and sensitivity.
- **Range:** Range of the ultrasonic ranging module is determined by the allowed lower and upper limits of its input or output.
- **Static Error**: Errors that are always present even in unchanging system and therefore are not a function of time or frequency.
- **Precision:** Precision is a statistical measure. It is usually indicated by the standard deviation (or variance) of a set of readings of the sensor for the same input.

Power Supply	+5V DC
Quiescent Current	<2mA
Working Current	15mA
Effectual Angle	<15°
Ranging Distance	2cm - 400 cm/1″ - 13ft
Resolution	0.3 cm
Measuring Angle	30 degree
High Precision	Up to 3mm
Trigger Input Pulse width	10uS
Dimension	45mm x 20mm x 15mm



	2.12	9.97	20.19	29.91	42.74	48.74	59.28	69.64	80.34	90.21	99.71	109.71	121.72	129.84	140.1	150.02	160.55	170.64	179.84	186.33
	2.12	9.97	20.79	29.9	40.52	49.74	59.36	69.66	80.53	89.86	100.1	109.69	121.26	129.95	140.03	148.86	160.43	170.67	179.59	186.34
	2.12	11.84	20.69	30.41	42.72	49.34	59.38	63.26	80.69	89.93	99.69	109.9	121.28	130.02	140.02	150.59	160.45	170.72	179.53	186.05
	2.02	13.6	22.09	30.43	42.28	49.74	59.24	69.52	80.79	89.86	100.05	109.79	121.33	129.93	139.97	150.28	159.91	170.69	179.52	186.26
	2.12	13.48	20.79	30.41	42.62	49.34	59.38	69.62	81	89.76	99.81	110	121.26	130.1	139.95	150.67	159.79	170.78	179.95	186.09
	2.12	9.6	20.79	30	42.71	49.33	59.14	69.74	81.09	89.64	100.12	109.97	121.41	130.03	140.03	150.81	160.29	170.76	179.57	186.19
	2.12	9.6	20.81	30	41.24	48.95	59.38	69.64	81.24	89.66	99.5	110.02	121.71	129.95	140.12	150.84	160.03	170.62	179.57	185.97
	2.02	9.72	20.79	29.9	40.86	48.95	59.28	69.64	81.22	89.76	99.97	109.88	121.66	130.6	140.09	150.87	159.67	170.67	179.64	186.87
	2.12	9.62	20.79	30.41	40.78	48.95	59.24	64.36	80.88	89.74	99.59	110.09	121.45	130.03	140.1	150.74	160.22	170.64	179.64	185.83
	2.12	9.6	20.79	30.43	40.4	48.95	59.14	69.64	80.79	89.76	99.97	109.53	121.6	130.1	140.03	150.72	160.29	170.64	179.55	186.91
	2.12	9.72	20.69	30.43	40.33	49.95	59.38	70.07	80.81	89.83	99.31	110	121.6	130.05	140.14	150.81	160.21	170.62	179.64	186.79
	2.02	9.71	20.79	30.41	40.41	49.14	59.38	70.05	80.72	89.83	99.79	109.81	121.26	130.03	140.07	150.84	160.33	170.69	179.91	186.36
	2.12	9.6	20.79	30.43	40.31	50.1	59.34	69.93	80.79	89.83	99.97	109.98	121.09	130.12	140.05	150.84	160.34	170.6	179.67	186.86
	2.12	13.14	20.69	30.41	41.34	49.74	58.97	69.95	80.79	89.74	99.97	109.86	120.88	130.12	140.14	150.72	160.31	170.64	179.57	186.36
	2.12	13.14	20.81	30.95	41.22	49.33	59.26	69.93	80.9	89.72	99.86	109.91	120.74	130.05	140.1	150.74	160.29	170.55	180.05	186.29
	2.02	13.14	20.79	30.53	41.81	49.74	59.38	70.38	80.97	89.64	99.86	110	120.81	130.12	140.47	150.74	159.88	170.62	179.57	186.38
	2.12	11.14	20.79	30.53	41.31	49.74	59.28	69.64	80.88	89.67	99.95	110	120.72	130.05	140.02	150.41	160.34	170.62	179.62	186.34
	2.14	11.12	20.79	31.05	41.34	49.33	59.38	70.07	80.97	89.66	99.59	109.95	120.62	130.4	140.09	150.83	160.33	170.62	180.03	186.22
	2.12	9.26	20.79	31.05	41.81	49.33	59.28	61.71	80.98	89.67	100.24	109.98	120.6	130.48	140.47	150.29	160.33	170.53	179.69	186.47
	2.02	9.26	21.78	30.97	42.6	49.34	59.38	70.07	80.98	89.67	99.95	109.95	120.69	130.48	140.05	150.29	160.34	170.72	179.64	187.1
	2.12	13.24	23.02	30.95	41.79	49.34	59.38	70.09	80.81	89.67	100.26	109.98	120.53	130.02	140.45	150.74	160.36	170.69	180	186.74
	2.12	9.71	21.66	31.47	41.69	49.34	59.41	70.09	80.88	89.69	100.21	110	120.88	130.05	140.1	150.84	160.29	170.72	179.67	186.62
	2.12	9.6	20.79	30.97	42.72	49.33	59.38	70.4	80.9	89.57	100.16	109.98	120.86	130.1	140.1	150.43	159.93	170.69	179.66	186.79
	2.02	9.67	22.91	30.95	42.16	50.29	59.41	69.66	81	89.76	100.14	110	120.55	130.12	140.12	150.76	160.33	170.72	180.03	186.59
	2.12	9.71	20.79	30.95	40.88	50.29	59.5	70.07	80.91	89.93	99.69	110.07	120.62	130.36	140.07	150.74	160.36	170.71	179.52	186.16
	2.12	9.6	23.02	30.95	41.33	50.28	59.28	70.05	80.84	90.1	100.07	110.05	120.43	130.05	140.1	150.31	159.81	170.6	179.64	186.6
	2.12	9.6	23.03	30.95	41.79	50.28	59.38	70.07	80.71	90.21	100.03	109.71	120.41	130.03	140.5	150.83	159.88	170.6	179.53	186.52
	2.02	9.71	20.79	30.43	41.79	50.29	59.38	70.07	80.72	90.19	100.03	110.09	120.43	130.38	140.09	150.86	159.9	170.64	179.64	186.53
	2.12	9.62	21.64	30.95	42.62	50.28	59.38	70.09	80.91	90.12	99.86	109.98	120.43	130.12	140.09	150.71	160.22	170.64	179.52	186.26
		9.62	20.48	30.95	42.72	49.93	59.38	70.09	80.91	90.21	99.97	109.98	120.41	129.93		150.71	159.9	170.59	179.59	187.17
		9.72	21.76	30.95	40.53	49.95	59.28	70.07	80.81	90.12	99.67	110.02	120.47	130.12		150.76		170.62	179.6	186.36
		9.62	20.47	30.95	40.62	49.95	59.5	70.1	80.83	90.21	99.67	110.07	120.36			150.47		170.67		186.24
AVERAGE y/(cm)	2.096551724	10.4890625	21.1746875	30.624375	41.5621875	49.60375	59.3284375	69.2928125	80.8621875	89.850625	99.89875	109.9359375	120.9396875	130.1203226	140.1262069	150.5959375	160.177	170.6540625	179.6835484	186.4559375
	0.043333181	1.445982277	0.798475048	0.40127093	0.829532	0.467143915	0.103745764	2.028528152	0.170399061	0.203407496	0.225343488	0.127936981	0.446888439	0.177772669	0.145564627	0.378985977	0.232151531	0.05611703	0.166453488	0.316848341
PRECISION/(cm)	0.982607369	0.137856198	0.037708941	0.013102992	0.019958815	0.009417512	0.001748668	0.029274727	0.002107277	0.002263841	0.002255719	0.001163741	0.003695135	0.001366218	0.001038811	0.002516575	0.001449344	0.000328835	0.00092637	0.00169932
STATIC ERROR/(cm)	0.044100199	1.469119463	0.81125146	0.407691673	0.842805355	0.474618692	0.105405802	2.060986664	0.173125619	0.206662222	0.228949213	0.129984103	0.454039109	0.180711259	0.148141192	0.385050138	0.236120221	0.05701496	0.169204972	0.321918236
y1/(cm)	2.140651924	11.95818196	21.98593896	31.03206667	42.40499286	50.07836869	59.4338433	71.35379916	81.03531312	90.05728722	100.1276992	110.0659216	121.3937266	130.3010338	140.2743481	150.9809876	160.4131202	170.7110775	179.8527534	186.7778557
y2/(cm)	2.052451525	9.019943037	20.36343604	30.21668333	40.71938214	49.12913131	59.2230317	67.23182584	80.68906188	89.64396278	99.66980079	109.8059534	120.4856484	129.9396113	139.9780657	150.2108874	159.9408798	170.5970475	179.5143434	186.1340193
x/(cm)	2	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	187


Ultrasonic sensor measurement data
Measured distance
Actual distance
0
20
40
60
80
100
120
140
160
180
200
2
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
187

MPU-6050

Speaker: Daniel Kloppe

FUNDAMENTALS

- The MPU-6050 is an accelerometer which uses inertial reactions in tandem with piezo-electric effects. These effects are utilized in the form of capacitance.
- Capacitance is monitored and converted to an acceleration.

IMPORTANT CHARACTERISTICS

- Range
- Sensitivity
- Drift

Voltage Supply	3.3-5VDC
Logic Level	3.3V
Degrees of Freedom	6x
Interface	I²C
Built-in Chip	16-bit AD converter
Pins	8x
Pin Spacing	2.54 mm
Accelerator Measurement Range	± 2, ± 4, ± 8, ± 16 g
Accelerator Sensitivity	16384 LSB/g ±2g, 8192 LSB/g ± 4g, 4096 LSB/g ± 4g, 2048LSB/g ±16g
Gyroscope Measurment Range	± 250. ± 500, ± 1000, ± 2000 ° /s
Gyroscope Sensitivity	131 LSB/dps ± 250 dps, 65,5 LBS/dps ± 500 dps, 32,8 LBS/dps ± 1000 dps, 16,4 LBS/dps ± 2000 dps
Dimensions	25 x 20 x 7 mm
Weight	1 g

RANGE

- The sensor was subjected to increasingly large accelerations in different directions until the reading could not increase.
- The maximum and minimum values were recorded.

SENSITIVITY

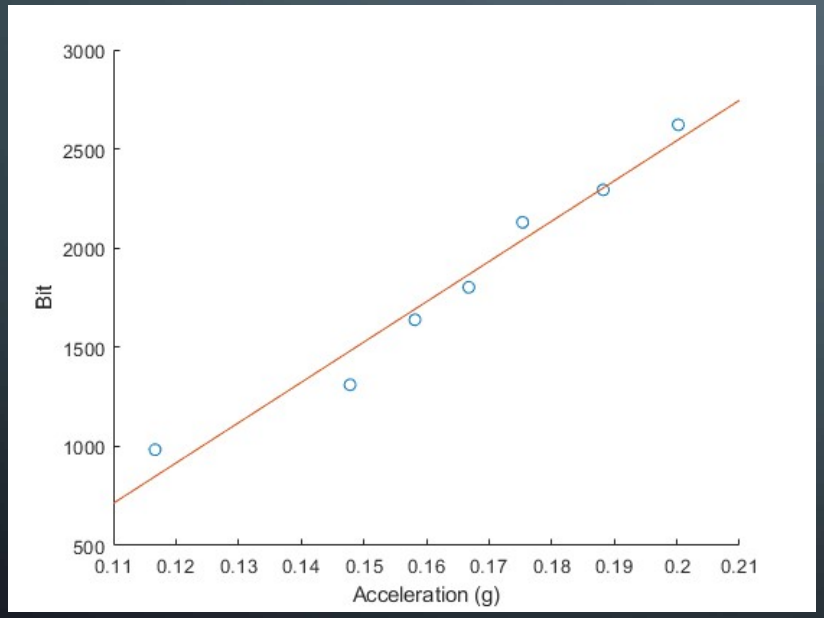
- The sensor was subjected placed on a level surface and rotated in small increments around the x and y axes until a change in reading was registered.
- A T-bevel was used to monitor the angle and a level was used to ensure the surface was level.
- The changes in least significant bit were divided by the changes in acceleration and averaged.

DRIFT

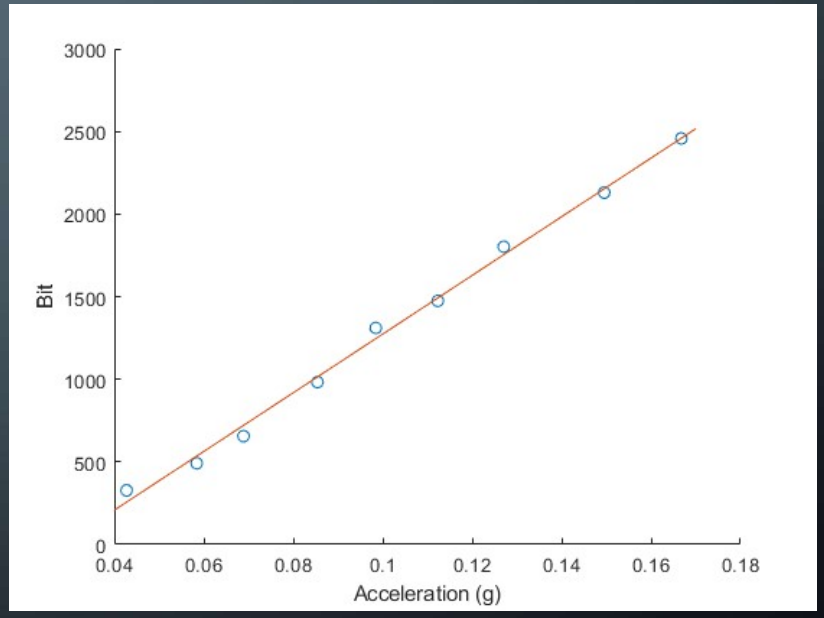
- The sensor was rotated from a level position in 5-degree increments around the x and y axes.
- The initial output was recorded and then the output was recorded again after a 2 minute period.

RESULTS

Bit vs. Acceleration in x



Bit vs. Acceleration in y

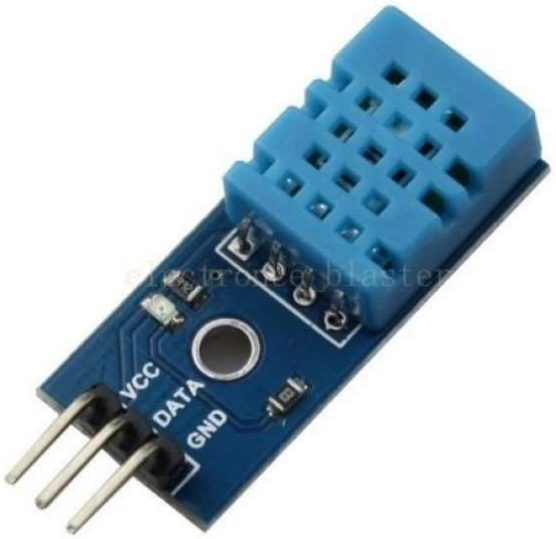


RESULTS

	Sensitivity (LSB/g)	Range (x)	Range (y)	Range (z)	Drift
Experimental Value	20287	-2.01 - 1.99	-2.00 - 2.00	-1.98 - 2.02	0.0039
Percent Error	23.82%	0.5%	0%	1%	0.4624%

DHT-11 SENSOR

Speaker- Reno Hoffman



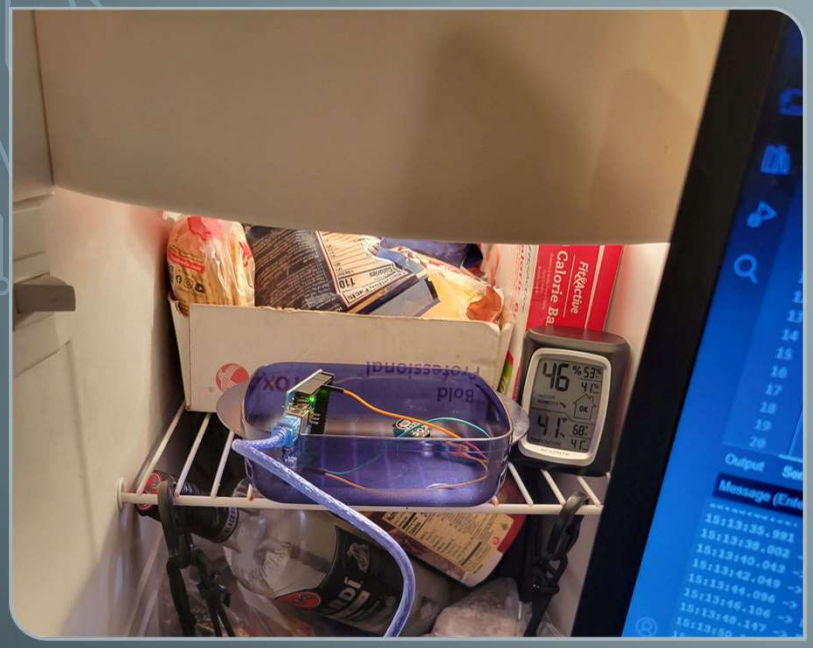
BASIC OVERVIEW

- Humidity based on capacitance
- Temperature based on thermistor

CHARACTERISTICS TO TEST

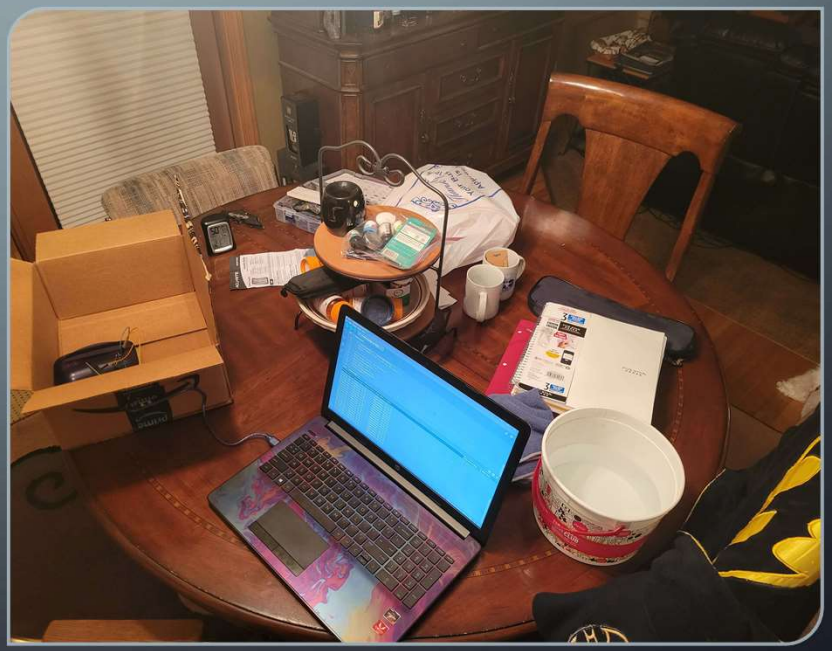
- Linearity _ Graph
- Resolution _ Code/Change
- Sensitivity _ Slope of best linear fit
- Accuracy _ Comparison to Control

Parameters	Conditions	Minimum	Typical	Maximum
Humidity				
Resolution		1%RH	1%RH	1%RH
			8 Bit	
Repeatability			±1%RH	
Accuracy	25℃		±4%RH	
	0-50℃			±5%RH
Interchangeability	Fully Interchangeable			
Measurement Range	0℃	30%RH		90%RH
	25℃	20%RH		90%RH
	50℃	20%RH		80%RH
Response Time (Seconds)	1/e(63%)25℃, 1m/s Air	6 S	10 S	15 S
Hysteresis			±1%RH	
Long-Term Stability	Typical		±1%RH/year	
Temperature				
Resolution		1℃	1℃	1℃
		8 Bit	8 Bit	8 Bit
Repeatability			±1℃	
Accuracy		±1℃		±2℃
Measurement Range		0℃		50℃
Response Time (Seconds)	1/e(63%)	6 S		30 S



TESTING METHODS

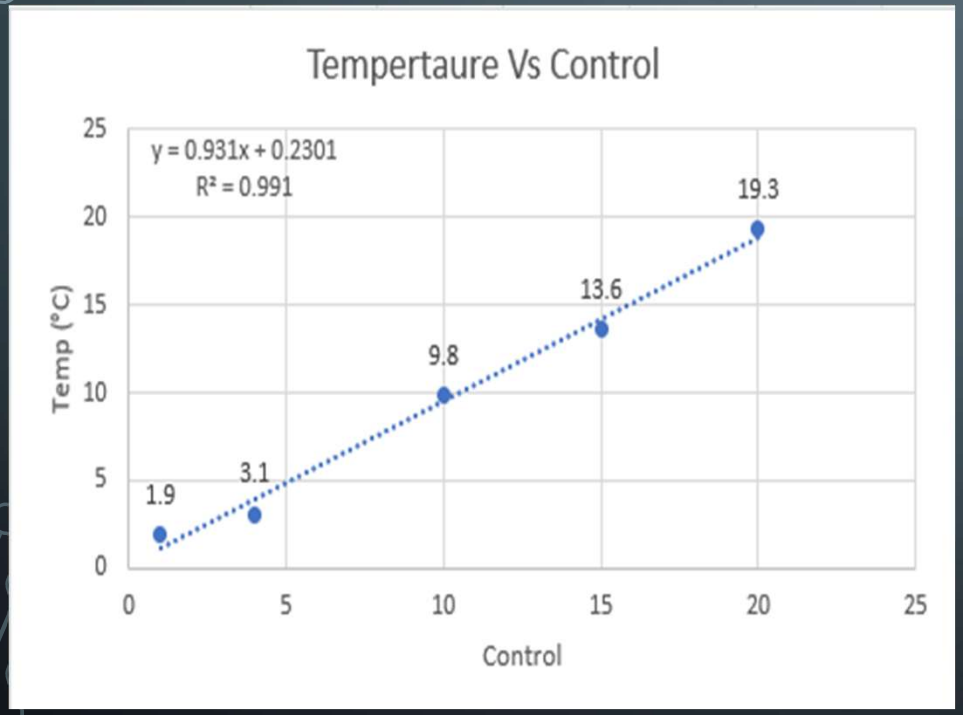
- Temperature – Cooling compared to control
- Acurite indoor humidity and temperature measurement



- Humidity – Higher Humidity

TEMPERATURE RESULTS

GRAPH

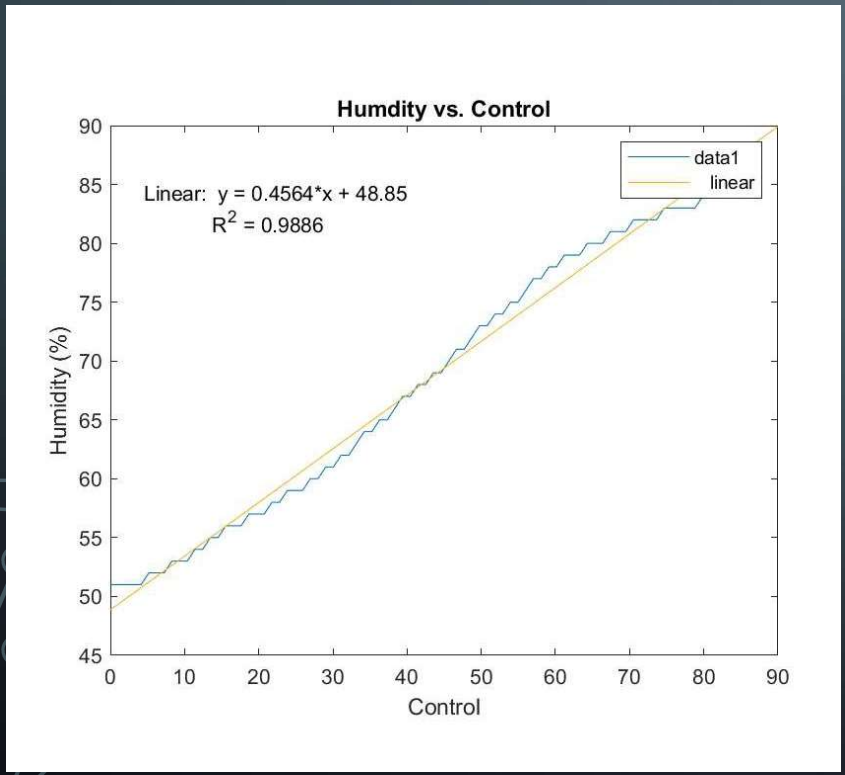


CHARACTERISTICS

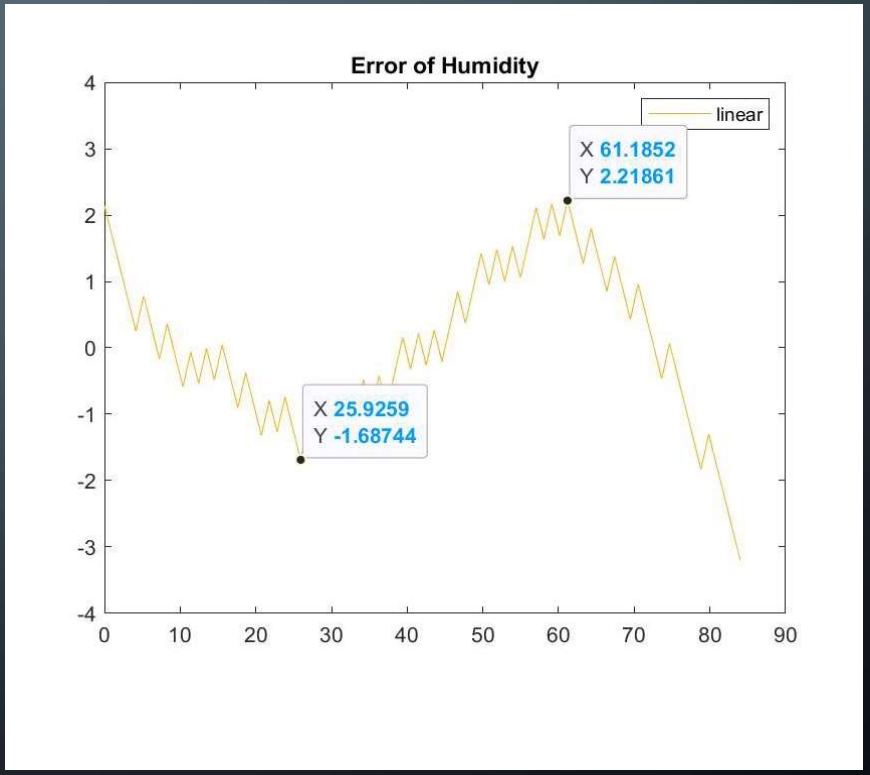
- Sensitivity
- Linearity
- Resolution

HUMIDITY RESULTS

HUMIDITY



ERROR HUMIDITY



SUMMARY

Testing Character	Resolution	Sensitivity – Linear Fit	Linearity	Accuracy
Temperature	0.1°C (8-bit)	0.931	Yes	+-1.5°C Max
Humidity	1%(8-bit)	0.4564	NO	+-4.2% Max

QUESTIONS?