School of Engineering and Applied Science (SEAS), Ahmedabad University

Sensors, Instrumental and Experimentation and Embedded Systems Design (ENR305 and ECE302)

Project - Digital Rain Measurement System Report - Group 4

Section - 3 & 2

Monsoon Semester - 2022

Submitted to faculty: Prof. Sanket Patel

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1. Introduction:

Background:

The water cycle cannot exist without rain, which is also the planet's primary source of freshwater. Simple terms, rain is precipitation in the form of water droplets that are heavy enough to fall to the ground due to the condensation of water vapor. Measurement of rainfall is essential for many fields, including forestry, hydrology, and others.

Motivation:

Since the time of the ancient Greeks, people have kept track of the amount of rain that has fallen, and the first measurements were performed using a rain gauge. This instrument was created in India in the fourth century. The simplest rain gauges consisted of a plain cylinder with markings to track the amount of precipitation over time. And they deliver readings that are extremely accurate. But the rain measurement system has evolved over time, just as everything else does. Traditional systems require you to manually log data yourself, which increases the likelihood of errors. In order to find out the readings, you must also go to the location where the cylinders are housed. And in some isolated regions, it is difficult. Additionally, you must wait until the rain stops before taking precise measurements. It also needs a lot of maintenance. The computerized rain measurement method was taken into consideration.

2. Literature Review:

These are the alternate designs from which we took reference from and these are used at industrial level.

Existing Model 1:

Tipping bucket rain gauge:

The bucket tips when precipitation of 0.01″, 0.2 mm, 0.5 mm or 1.0 mm has been collected. Each tip activates a reed switch closure which is detected by a data logger and/or telemetry system.

It’s also available with a larger collector measuring 11.1″ (282.8 mm) in diameter.

Receiver	200mm (8 inch) or 282.8 mm (11.1 inch) diameter with machined aluminum rim
Sensitivity	One tip at 0.2, 0.5, 1.0 mm or 0.01 inch
Measurements	Range: 0-700 mm/hour Accuracy: ± 2% 25-500 mm/hour, ± 1 tip from 1-25 mm/hour
Sensor	Tipping bucket with siphon
Siphon	0.4mm capacity of rainfall - made from brass with a non-hygroscopic outer body
Contacts	Type: dual reed-switch (make contact), momentary Rating:12 VA (0.5 amp max) Duration: 0.1 second
Physical dimensions	Height x diameter: 342 mm (13.5") x 229 mm 9" Weight: 3 kg (6.6 lbs)
Bucket	Chrome plated, injected molded non-hygroscopic ABS balanced ± 0.05 gms
Base	Die-cast aluminum
Mounting holes	Three (3) 10mm diameter mounting holes
Drain fittings	Able to attach 12 mm inside diameter tubing, to catch rainfall after passing through buckets
Pivots	Ground sapphire pivots with stainless steel shaft
Insect covers	Stainless steel mesh on all openings to prevent insects from entering gauge

Existing Model 2:

Industrial Level(cost: 15600):

It is a mechanical bistable structure. When one chamber receives water, the other chamber is waiting. When it rains, the rainwater collected by the water receiving port enters the metering bucket through the funnel. When the volume of the received rainwater reaches the predetermined value of 0.2mm, the chamber will overturn due to gravity and be waiting, and the other chamber will be in a state of receiving water

The stainless steel rain gauge is recognized to be the standard for measuring rainfall and other precipitation in hydrological and environmental testing. The internal tipping bucket structure provides high accuracy in various rainfall intensity ranges. Stainless Steel Rain Gauge Parameters Rain bearing

diameter: φ200mm

The sharp angle of cutting edge: 40 45°

Rain intensity range: 0mm 4mm/min (allowable maximum rain intensity 8mm/min)

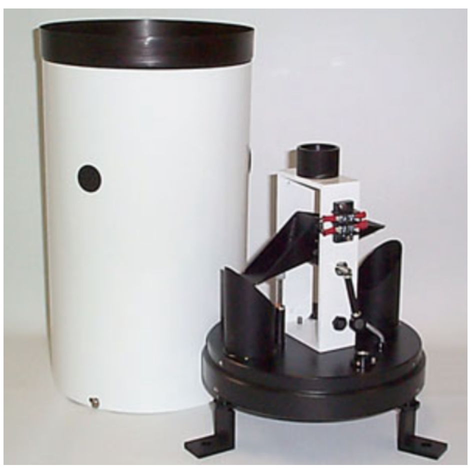
Power supply range: 4.5~30V

Maximum power consumption: 0.24W

Working temperature: 0 50

Working humidity: <95%(40)

Existing Model 3:



The 260-2500 Tipping Bucket Rain Gauges are dependable instruments used for measuring precipitation. Rainfall entering the 8" or 12" funnel collector is directed to the tipping bucket assembly. When an incremental amount of precipitation has been collected, the bucket assembly tips and activates a magnetic reed switch.

- Capacity: Unlimited
- Orifice:
    - 260-2500: 8" (20 cm)
    - 260-2500-12: 12" (30 cm)
- Calibration: 0.01", 0.25 mm, 0.5 mm, 1 mm
- Accuracy: ±1% at 2"/hr
- Output: 0.1 second switch closure
- Contact rating: 3 watts, 0.25 amps, 24 Vdc
- Size

- 260-2500: 8" x 17"
    - 260-2500-12: 12" x 20"
- Weight/Shipping
    - 260-2500: 7 lb/12 lb
    - 260-2500-12: 14 lb/18 lb

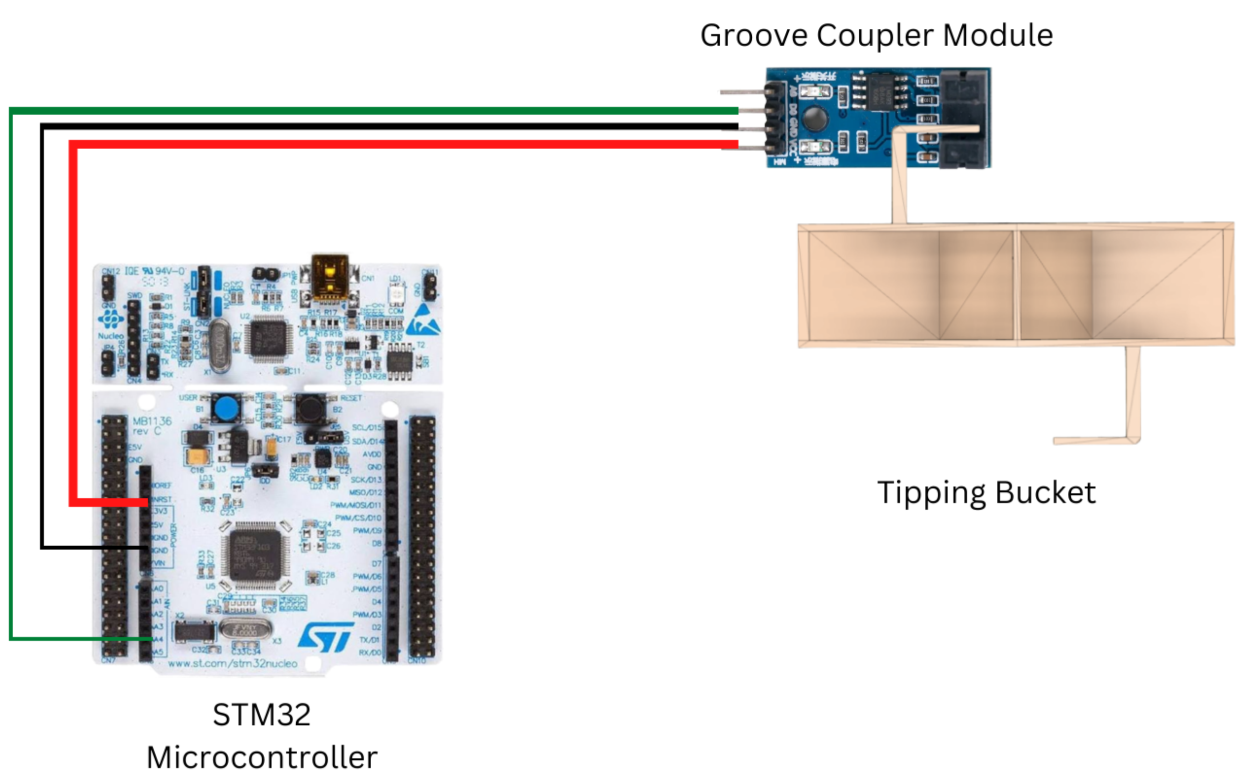
3. Methodology:

Product details:

Product Specifications:

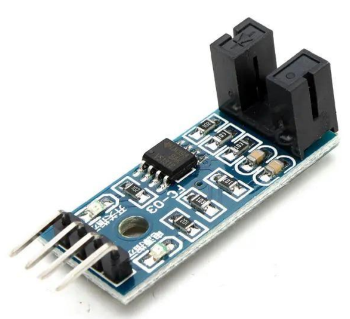
Our product contains a funnel of 8cm diameter (The standard size of the funnel is 16 to 21 cm), a tipping bucket, a base and a case. The tipping bucket is fixed in the base and placed in the case in such a way that the gap between the tipping bucket and the funnel's tip is 0.98mm.

Circuit Diagram:

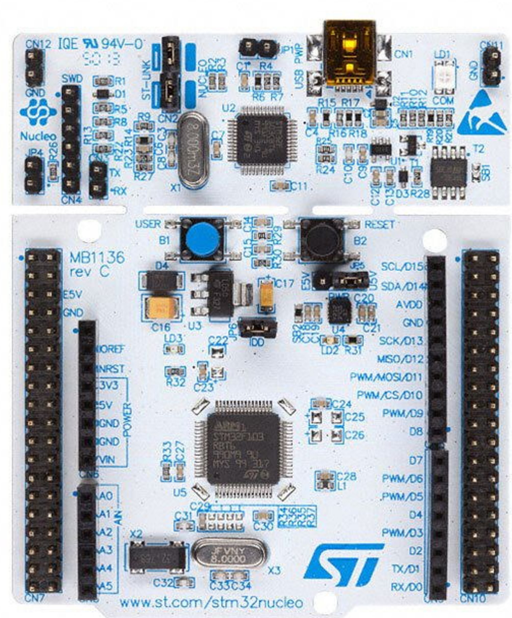


List of components:

Name	Price	Acquired From
3D - Printed Modules	-	Provided by the University
Groove Coupler Module (FC03)	Rs. 120	Delta Electronics
STM32 microcontroller	-	Provided by the University

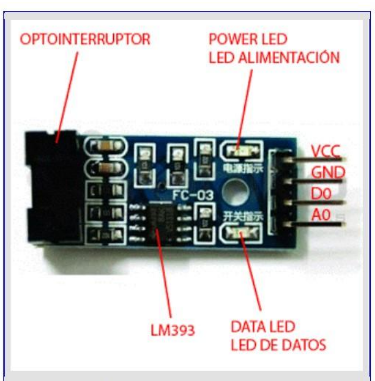


FC03 Sensor



STM32F070RBT6

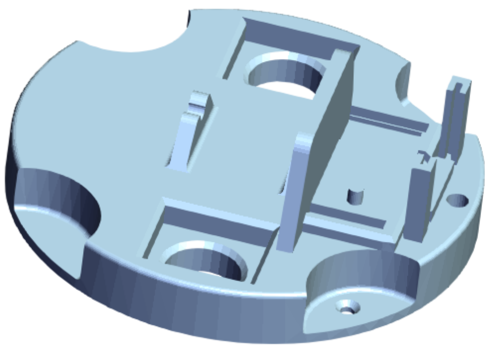
Sensor Details:



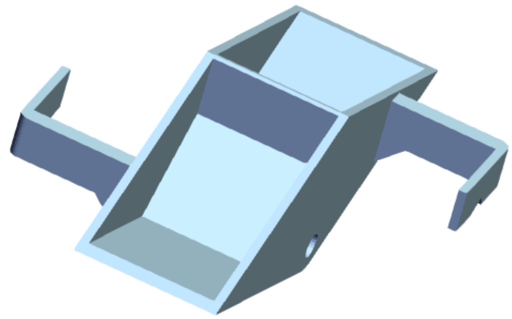
Main parts of the encoder

Operating Voltage(VDC)	3.3 to 5
Comparator	LM393
Output	Digital Switch Output (0 and 1)
Length (mm)	32
Width (mm)	14
Height (mm)	13
Weight (gm)	2

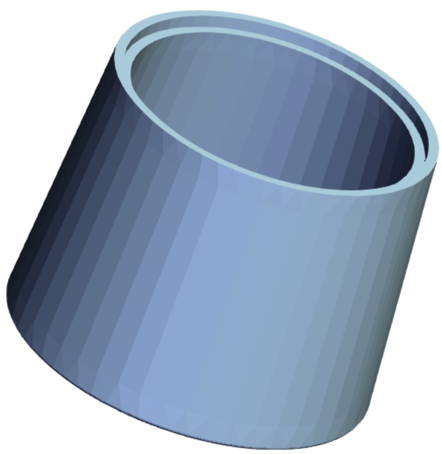
3D - Design Of Modul's Components



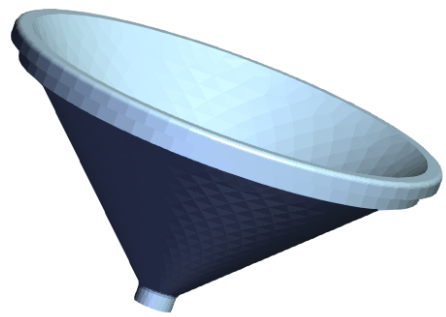
Base



Bucket



Case



Funnel

Mounting

Working of the product:

This digital rain measurement system will measure the amount of rain digitally rather than the traditional analog methods. Rain drops will accumulate on the top of the funnel and then steadily drop on the tipping bucket. When a certain amount of water will gather at one side of the bucket, it will tip and at that moment the water will flow out from the holes and the sensor will read the signal and increment the counter variable which is initialized to 0. Later when the rain is stopped, the microcontroller would have the total number of counts, which will then be multiplied to volume per count to get the volume of the rain. We need to have 3-4 modules of the product in a particular area to get an accurate measurement of rain.

Experimentation:

We experimented with the working of our product in a series of experiments. We poured many samples of 50 mL, 100 mL and 200 mL water and saw what was the output. Based on that we calculated the volume per count and the error in measurement. We maintained an Excel spreadsheet to record our results. By doing these experiments, we got the volume per count to be around 5.238 mL/count. Thus getting the following equation.

$$volume\ in\ mL\ =\ count\ *\ 5.238$$

$$volume\ in\ inches\ =\ volume\ in\ mL\ *\ 0.0393$$

A	B	C	D	E	F	G
Experiment No.	Total Counts	Input Water(ml)	Output Water(ml)	Difference (calculation)	Water per Count(ml)	Difference(we got)
17	19	100	95.6	4.4	5.031578947	4.4
18	19	100	96.3	3.7	5.068421053	3.7
19	18	100	96.4	3.6	5.355555556	3.6
20	18	100	95	5	5.277777778	5
21	18	100	96.35	3.65	5.352777778	3.65
Average	18.4		95.93	4.07	5.217222222	4.07
22	36	200	196.2	3.8	5.45	3.8
23	37	200	196.6	3.4	5.313513514	3.4
24	37	200	196.3	3.7	5.305405405	3.7
25	36	200	196.6	3.4	5.461111111	3.4
26	39	200	197.2	2.8	5.056410256	2.8
Average	37		196.58	3.42	5.317288057	3.42
27	9	50	46.2	3.8	5.133333333	3.8
28	9	50	47.5	2.5	5.277777778	2.5
29	9	50	46.8	3.2	5.2	3.2
30	9	50	47.5	2.5	5.277777778	2.5
31	9	50	45.2	4.8	5.022222222	4.8
Average	9		46.64	3.36	5.182222222	3.36
				Average	5.238910834	3.616666667

Technologies Used:

1) Fusion 360 for 3D printing.
2) FreeCAD for measuring dimensions.
3) STM32CubeMX and Keil µVision 5 for STM32F070RBT6 Microcontroller programming.

Code:

Only including variables and int main() part.

```
/* USER CODE BEGIN 0 */
int flag=1;
float count=0;
float rainAmt_mL=0;
float rainAmt_inch=0;
/* USER CODE END 0 */

int main(void)
    {
  /* USER CODE BEGIN 1 */

  /* USER CODE END 1 */

  /* MCU Configuration--------------------------------------------------------*/

  /* Reset of all peripherals, Initializes the Flash interface and the Systick. */
  HAL_Init();

  /* USER CODE BEGIN Init */

  /* USER CODE END Init */

  /* Configure the system clock */
  SystemClock_Config();

  /* USER CODE BEGIN SysInit */

  /* USER CODE END SysInit */

  /* Initialize all configured peripherals */
  MX_GPIO_Init();
  MX_USART2_UART_Init();
```

```
  /* USER CODE BEGIN 2 */

  /* USER CODE END 2 */

  /* Infinite loop */
  /* USER CODE BEGIN WHILE */
  while (1)
  {
    /* USER CODE END WHILE */

    /* USER CODE BEGIN 3 */
		if((HAL_GPIO_ReadPin(GPIOC, GPIO_PIN_1)) && flag)
		{
			count++;
			HAL_GPIO_WritePin(GPIOA,GPIO_PIN_5,GPIO_PIN_SET);
			rainAmt_mL=count*5.238;
			rainAmt_inch=rainAmt_mL*0.0393;
			flag=0;
		}
		else if(!HAL_GPIO_ReadPin(GPIOC, GPIO_PIN_1))
		{
			flag=1;
		}
		else
		{
			HAL_GPIO_WritePin(GPIOA,GPIO_PIN_5,GPIO_PIN_RESET);
		}
  }
  /* USER CODE END 3 */
}
```

4. Outcome:

The outcome of this project is measurement of rainfall by digital methods. We got the measurement of rain in Millilitres and inches. This project can replace the traditional analog way of measuring rainfall.

5. Technical problems faced:

We did face a few problems in our journey. First one was that our tipping bucket was not properly printed. We replaced that with a newly printed model of the bucket. It still wasn't so smooth because it was 3D printed. Second problem was balancing the load of the tipping bucket. As the model was not perfectly printed, its load was not uniformly distributed and that arose the problems in tipping. We solved that problem by applying uniform loads on both sides of the bucket. Third problem was water remaining in the bucket. Due to our design and the plastic material, water remained stored in the bucket after the last tip. To solve that, we first tried oiling the inside of the bucket. Then we applied aluminum foil. But those two didn’t work out well. So at last, we applied wax on the inside which made the surface smooth. Still, very little amount of water would be left but we added that in our error analysis. Last problem was that our wiring was a little loose which sometimes created problems like the sensor calculated false values of counts. We replaced them with new firm wires. These were the technical problems we faced in our project.

6. Possible improvements:

The material used in our project is plastic. We can use stainless steel or any other suitable metal to make load balancing better. This project contains some errors due to 3D printed design, which can be reduced by manufacturing it and can be made more accurate for better results by taking more experiments and calculating accurate errors. The system can be modified which doesn’t store water and kicks all the water out. Also, we can send the data collected to the cloud for more convenience.

7. Future Scope:

Digital rain measurement system’s scope in the future is pretty good as it will be more convenient to use because of the technologised lifestyle. Additionally, one doesn't have to take a trip to the isolated areas to measure the rainfall. Also, we don’t have to wait for the rain to stop to measure the amount of rainfall. Also, it doesn’t need a lot of maintenance and gives more accurate results.

8. Conclusion:

Thus, in this project we applied our basic understanding of sensors and microcontrollers along with applying some mechanical knowledge for implementing hardware of our project. By doing so we were able to make a system that can be useful for measuring rainfall. This project also contributed to the increase of our knowledge of sensors, microcontrollers and different ways to measure rain.

9. References:

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