Design and Implementation of a Function Generator

Freaky Friday

16 January, 2025 (Week 2)

Team Members

Table 1: SPOC

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Table 2: List of Participants

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Table continues on the next page

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35	Hardware Design and Fabrication	Khushi Gupta	2022MT61973	mt6221973@iitd.ac.in	1.0
36	Testing and Debugging (Hardware)	Krish Singh	2022MT61303	mt6221303@iitd.ac.in	1.0
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39	Software	Manas Goyal	2022MT11918	mt1221918@iitd.ac.in	1.0
40	Software	Mukul Sahu	2022MT11939	mt1221939@iitd.ac.in	1.0
41	Hardware Design and Fabrication	Nagure Kalyani Paramanand	2022MT61983	mt6221983@iitd.ac.in	1.0
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55	Software	Punit Meena	2022EE11184	ee1221184@iitd.ac.in	1.0
56	Testing and Debugging (Hardware)	Rahul Rajoria	2022MT11947	mt1221947@iitd.ac.in	1.0
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58	Testing and Debugging (Hardware)	Ranjan Kumar Singh	2022MT61304	mt6221304@iitd.ac.in	1.0
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62	Hardware Design and Fabrication	Saksham Kumar Rohilla	2022EE11709	ee1221709@iitd.ac.in	1.0
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64	Software	Sarthak Gangwal	2022MT11275	mt1221275@iitd.ac.in	1.0
65	Market Survey and Research	Satvik Prasad S	2022MT11279	mt1221279@iitd.ac.in	1.0
66	Documentation	Shashwat Kasliwal	2022MT11915	mt1221915@iitd.ac.in	1.0
67	Documentation	Shivang Goyal	2022MT11269	mt1221269@iitd.ac.in	1.0
68	Software	Siddharth Saini	2022MT11283	mt1221283@iitd.ac.in	1.0
69	Market Research and Survey	Siya Gupta	2022MT11274	mt1221274@iitd.ac.in	1.0
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75	Hardware Design and Fabrication	Syna Rajvanshi	2022MT61974	mt6221974@iitd.ac.in	1.0
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77	Testing and Debugging (Hardware)	Taru Singhal	2022MT11922	mt1221922@iitd.ac.in	1.0
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80	Hardware Design and Fabrication	Tushar Goyal	2022MT11266	mt1221266@iitd.ac.in	1.0
81	Hardware Design and Fabrication	Umang Agarwal	2022EE11692	ee1221692@iitd.ac.in	1.0
82	Documentation	Utkarsh Dubey	2022MT61045	mt6221045@iitd.ac.in	1.0
83	Hardware Design and Fabrication	Vatsal Manish Sejpal	2022MT11926	mt1221926@iitd.ac.in	1.0
84	Hardware Design and Fabrication	Viha Singla	2022MT61972	mt6221972@iitd.ac.in	1.0
85	Documentation	Yuvraj Singh	2022EE11715	ee1221715@iitd.ac.in	0.2

Table 3: **List of Team Members with IF $<$ 1**

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2	Documentation	Yuvraj Singh	2022EE11715	ee1221715@iitd.ac.in	0.2

Balance sheet (Detailed record of talents)

Click *here* to view the Google Spreadsheet.

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Glossary

AC	Alternating Current	24
AM	Amplitude Modulation	23
DC	Direct Current	24
EMC	Electromagnetic Compatibility	24
EMI	Electromagnetic Interference	24
FM	Frequency Modulation	23
Hz	Hertz	29
IEC	International Electrotechnical Commission	25
LCD	Liquid Crystal Display	23
MHz	Megahertz	29
MTBF	Mean Time Between Failures	25
PCB	Printed Circuit Board	23
PM	Phase Modulation	23
SMA	SubMiniature Version A	24
THD	Total Harmonic Distortion	23

1. Introduction

1.1 Definitions

Frequency: The rate at which an electrical signal oscillates.

Amplitude: The height of the wave, indicating the strength of the signal.

Waveform: The shape of the periodic signal.

TAM: The overall revenue potential for function generators.

USP: The key distinguishing feature of the product.

SLA: Formal agreements that ensure customers receive timely technical support

DC Offset: A shift in the waveform along the voltage axis, allowing the signal to have a constant voltage added or subtracted from the waveform.

Vpp (Volts Peak-to-Peak): A measure of the amplitude of an alternating current (AC) signal, indicating the voltage difference between the highest and lowest points in the waveform.

MTBF: A reliability measure indicating that the product is expected to operate for at least 10,000 hours before failure.

Modular Design: A design feature that allows for easy replacement of individual components, improving serviceability.

Chassis: The outer protective housing of the device, made of durable recycled plastic.

SMA Connectors: A type of coaxial connector used for signal output, commonly used in electronics.

Signal Stability: The degree to which the output frequency remains constant, with drift limited to no more than 0.01

Readability Score (WebFx): A metric used to measure the readability of a text. A lower score indicates that the text is harder to read.

Gunning Fog Index: A readability test that estimates the years of formal education required to understand the text on a first reading.

Flesch Reading Ease,Flesch-Kincaid Grade Level: A Formula that evaluates the readability of text with higher scores indicating easier readability.

Coleman Liau Index: A readability test that uses characters per word and sentences per text to compute a U.S. school grade level.

ATmega328P A microcontroller from the AVR family, commonly used in embedded systems, including Arduino platforms, known for its flexibility and ease of use in controlling various digital and analog devices.

HD44780: A character LCD controller widely used in many types of digital devices for text display, providing a simple interface to control a 16x2 or 20x4 display with minimal components.

Potentiometer: A three-terminal variable resistor used to adjust voltage levels in a circuit by varying its resistance, often used for fine adjustments in settings like volume or brightness.

Crystal oscillator: An electronic oscillator that uses the mechanical resonance of a vibrating crystal to create a precise frequency signal, commonly used for clock generation in microcontrollers and communication devices.

Printed Circuit Board: A flat, rigid board used to mechanically support and electrically connect electronic components through conductive pathways etched from copper sheets, forming the backbone of most electronic devices.

Liquid Crystal Display: A flat-panel display technology that uses liquid crystals combined with polarizers to display images, commonly used in devices such as monitors, televisions, and digital clocks.

International Electrotechnical Commission: An international standards organization that prepares and publishes international standards for electrical, electronic, and related technologies.

Electromagnetic Compatibility: The ability of electrical equipment and systems to function correctly in their electromagnetic environment without causing or being affected by electromagnetic interference.

Electromagnetic Interference: Disturbance caused by electromagnetic radiation that affects the operation of electrical equipment, potentially degrading performance.

Direct Current: An electric current flowing in one direction only, as opposed to alternating current, commonly used in batteries and low-voltage applications.

Phase Modulation: A modulation technique in which the phase of the carrier signal is varied in accordance with the instantaneous amplitude of the message signal.

Total Harmonic Distortion: A measure of the distortion in a signal caused by harmonics, expressed as a percentage of the original signal's amplitude.

SubMiniature Version A: A type of high-frequency coaxial RF connector commonly used for signal transmission in compact electronic devices.

Frequency Modulation: A modulation technique in which the frequency of the carrier signal is varied in proportion to the amplitude of the message signal.

1.2 Mind Map

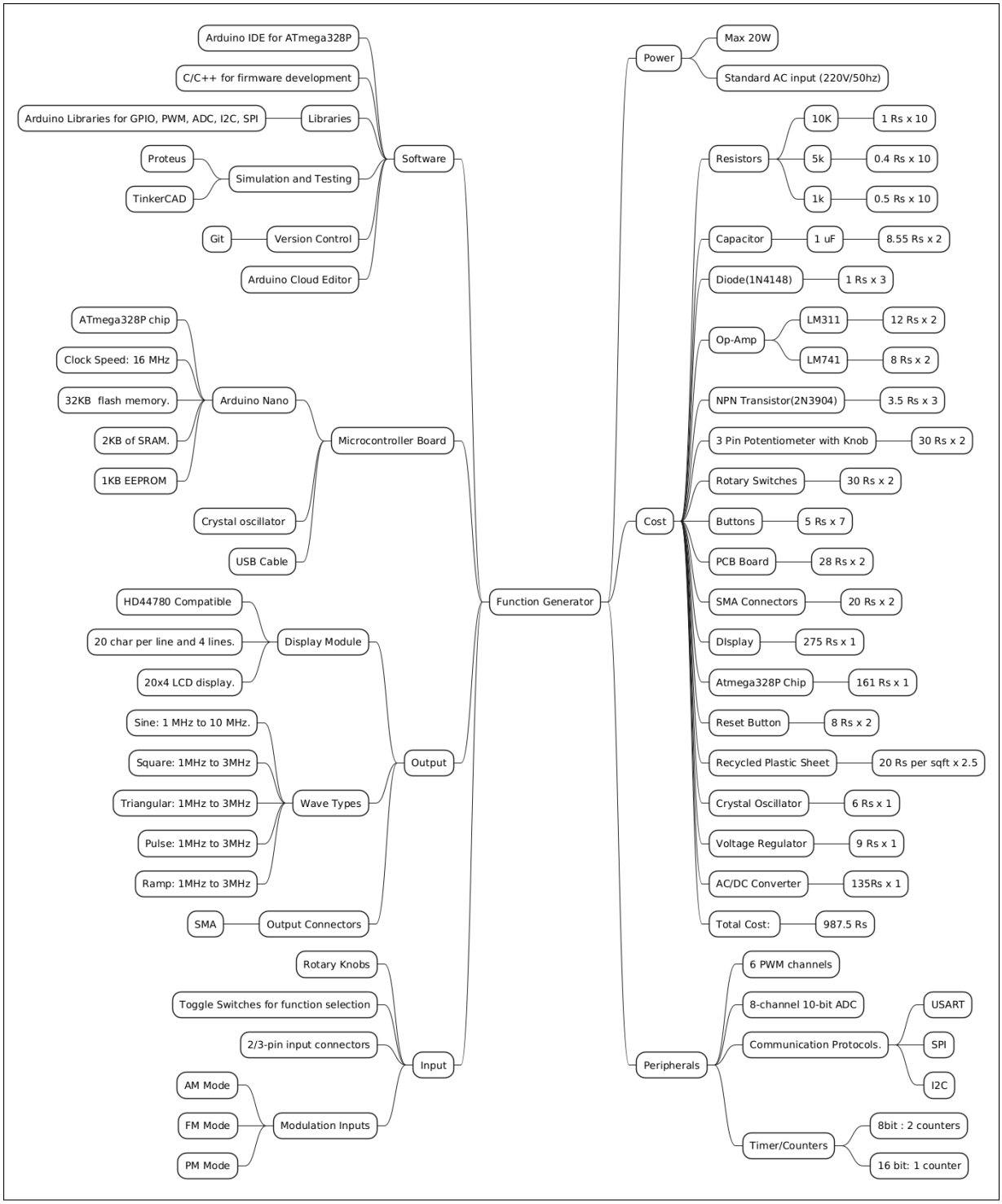


Figure 1.1: Mind Map of the Project

1.3 Project Management Figures

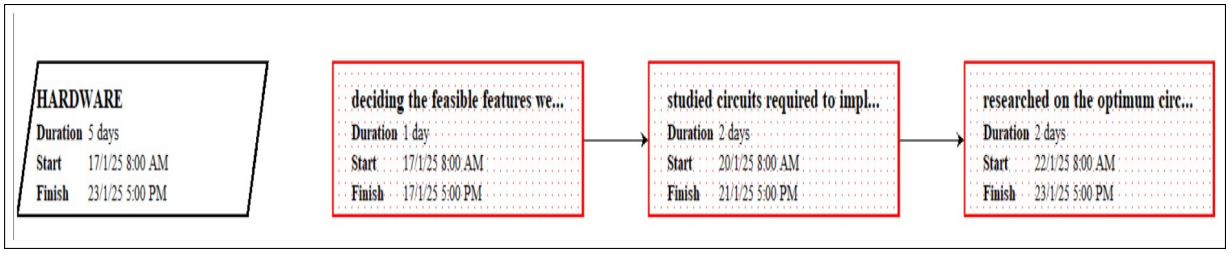


Figure 1.2: Hardware Test and Debugging Process

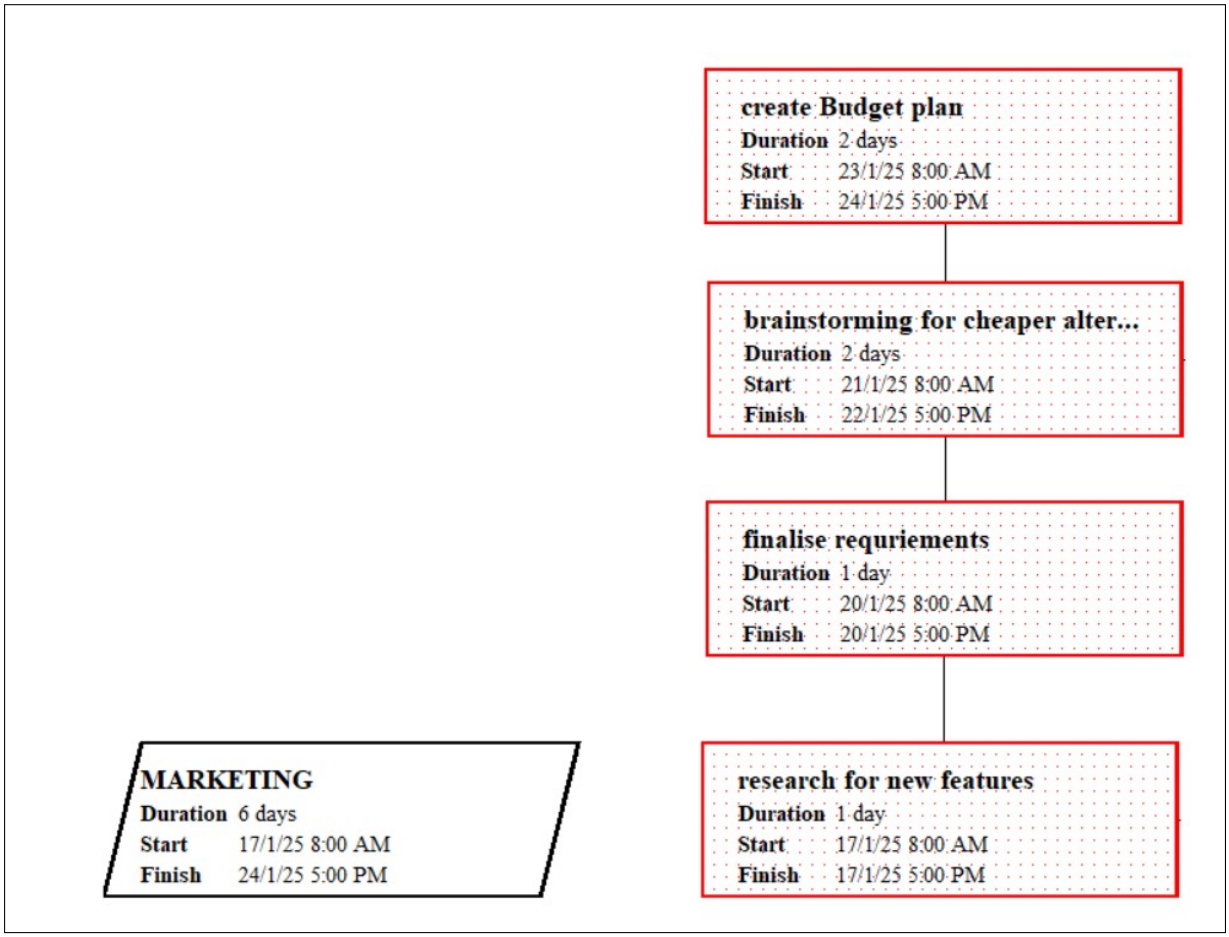


Figure 1.3: Market Research Analysis Workflow

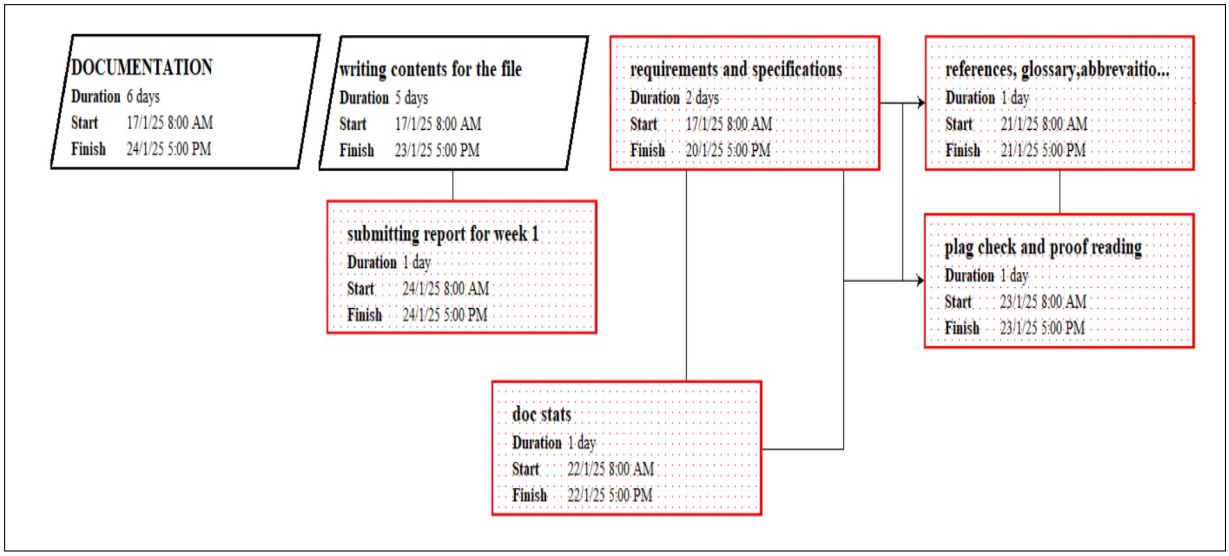


Figure 1.4: Documentation and File Writing Steps

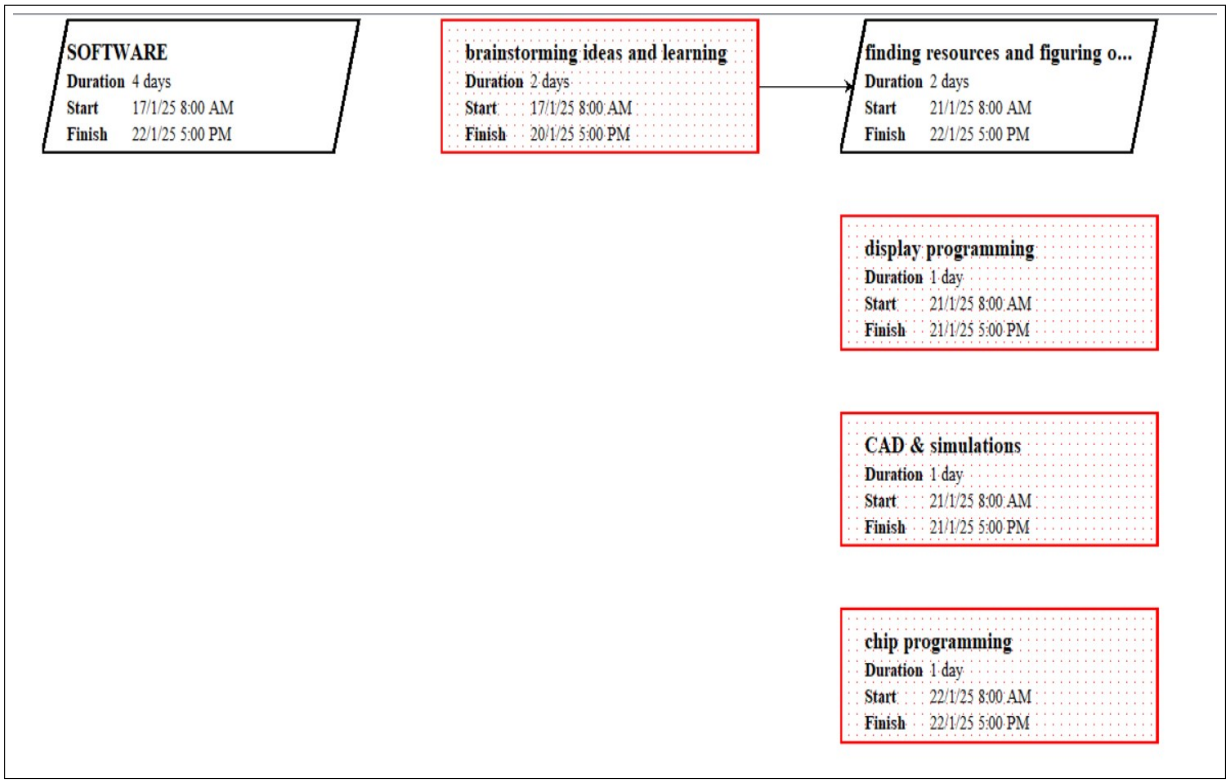
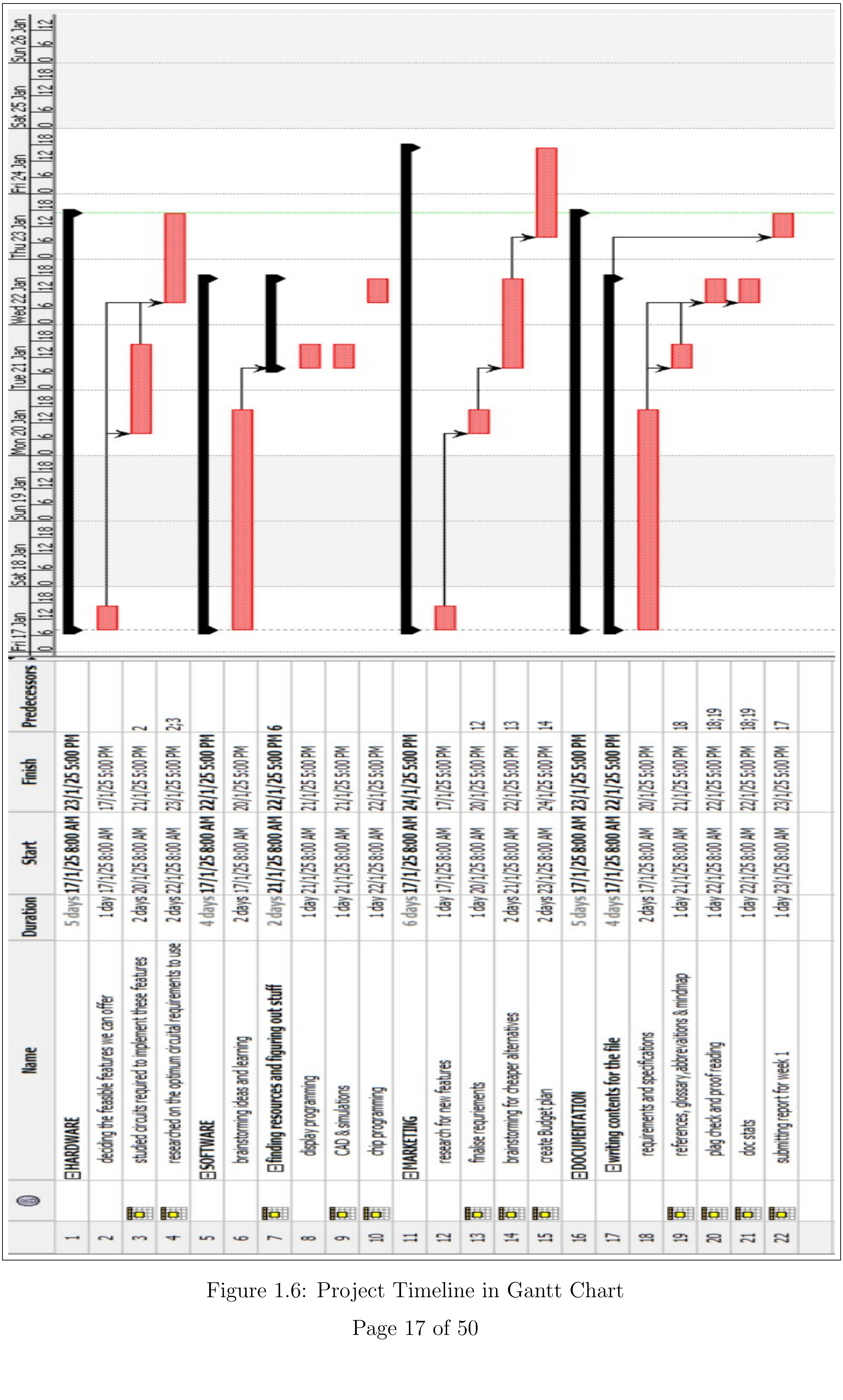


Figure 1.5: Software Development Flowchart



	Name	Duration	Start	Finish	Predecessors
1	HARDWARE	5 days	17/1/25 8:00 AM	23/1/25 5:00 PM	
2	deciding the feasible features we can offer	1 day	17/1/25 8:00 AM	17/1/25 5:00 PM	
3	studied circuits required to implement these features	2 days	20/1/25 8:00 AM	21/1/25 5:00 PM	2
4	researched on the optimum circuital requirements to use	2 days	22/1/25 8:00 AM	23/1/25 5:00 PM	2;3
5	SOFTWARE	4 days	17/1/25 8:00 AM	22/1/25 5:00 PM	
6	brainstorming ideas and learning	2 days	17/1/25 8:00 AM	20/1/25 5:00 PM	
7	finding resources and figuring out stuff	2 days	21/1/25 8:00 AM	22/1/25 5:00 PM	6
8	display programming	1 day	21/1/25 8:00 AM	21/1/25 5:00 PM	
9	CAD & simulations	1 day	21/1/25 8:00 AM	21/1/25 5:00 PM	
10	chip programming	1 day	22/1/25 8:00 AM	22/1/25 5:00 PM	
11	MARKETING	6 days	17/1/25 8:00 AM	24/1/25 5:00 PM	
12	research for new features	1 day	17/1/25 8:00 AM	17/1/25 5:00 PM	
13	finalise requirements	1 day	20/1/25 8:00 AM	20/1/25 5:00 PM	12
14	brainstorming for cheaper alternatives	2 days	21/1/25 8:00 AM	22/1/25 5:00 PM	13
15	create Budget plan	2 days	23/1/25 8:00 AM	24/1/25 5:00 PM	14
16	DOCUMENTATION	5 days	17/1/25 8:00 AM	23/1/25 5:00 PM	
17	writing contents for the file	4 days	17/1/25 8:00 AM	22/1/25 5:00 PM	
18	requirements and specifications	2 days	17/1/25 8:00 AM	20/1/25 5:00 PM	
19	references, glossary,abbreviations & mindmap	1 day	21/1/25 8:00 AM	21/1/25 5:00 PM	18
20	plag check and proof reading	1 day	22/1/25 8:00 AM	22/1/25 5:00 PM	18;19
21	doc stats	1 day	22/1/25 8:00 AM	22/1/25 5:00 PM	18;19
22	submitting report for week 1	1 day	23/1/25 8:00 AM	23/1/25 5:00 PM	17

Figure 1.6: Project Timeline in Gantt Chart

		Name	Type	Text1	Text2
1		**hardware**	**Work**		**days to finish**
2		Abhishek Singh	Work	Laser cutting	3
3		Adarsh Singh	Work	Laser cutting	3
4		Ajaypal Singh	Work	pcbdesign(LTM)	3
5		Ambhore Soham	Work	pcbdesign(LTM)	3
6		Arpit Mourya	Work	pcbdesign(LTM)	3
7		Deevyansh khadria	Work	circuit design	2
8		Jenit Jain	Work	circuit design	2
9		Khushi Gupta	Work	laser cutting	3
10		Nagure Kalyani	Work	laser cutting	3
11		Priyanshu Jindal	Work	circuit design	2
12		Saksham Kumar	Work	circuit design	2
13		Suhani Soni	Work	RDworks	2
14		Sushil Kumar	Work	icircuit design	2
15		Syna Rajvanshi	Work	RDworks	2
16		Tirth Punit Golwal	Work	RDworks	2
17		Tushar Goyal	Work	RDworks	2
18		Umang Agarwal	Work	pcbdesign(LTM)	3
19		Vatsal Manish Sejpal	Work	RDworks	2
20		Viha Singla	Work	RDworks	2
21		Madhav	Work	FreeCAD	1
22		Naman	Work	FreeCAD	1
23		**software**	**Work**		**days to finish**
24		Punit	Work	ChipProgramming	2
25		Nobin	Work	ChipProgramming	2
26		Sumit	Work	ChipProgramming	2
27		Lakshaya	Work	ChipProgramming	2
28		Praveen	Work	ChipProgramming	2
29		Dhruv	Work	ChipProgramming	2
30		Manas	Work	ChipProgramming	2
31		Yashwant	Work	ChipPorgamming	2
32		Suneel	Work	ChipProgramming	2
33		Srinivasa	Work	Chip Programming & Display ...	2
34		Shrenik	Work	ChipProgramming	2

Figure 1.7: Resource Breakdown, generated from ProjectLibre

		Name	Type	Text1	Text2
35		Arnav	Work	Simulations	2
36		Rijul	Work	Simulations	2
37		Niranjan	Work	Simulations	2
38		Niraj	Work	Simulations	2
39		Siddharth	Work	Simulations	2
40		Abhinav	Work	DisplayProgramming	2
41		Priyansh	Work	DisplayProgramming	2
42		Mukul	Work	DisplayProgramming	2
43		Sarthak	Work	Displayprogramming	2
44		Devansh	Work	Displayprogramming	2
45		**⊟Marketing**	**Work**		**days to finish**
46		Rahul Athipatla	Work	Cost Analysis & Research fo...	3
47		Siya Gupta	Work	Cost Analysis	2
48		Ayush Nayak	Work	Cost Analysis	2
49		Satvik Prasad	Work	Cost Analysis	3
50		Ashmit Nangia	Work	Research for new features	2
51		Gauri Agarwal	Work	Research for new features	2
52		Tanya Jain	Work	Cost Analysis	3
53		Kaneesha Jain	Work	Cost Analysis	2
54		Sanya Sachan	Work	Research for new features	2
55		Pratyush Shrivastava	Work	Research for new features	2
56		Aahna Jain	Work	Research for new features	2
57		**⊟documentation**	**Work**		**days to finish**
58		Utkarsh	Work	Project Libre	2
59		Kabir	Work	Mind Map	3
60		Keshav	Work	Requirements	2
61		Ishant	Work	Sofwares used	2
62		Shivaani	Work	References	2
63		Nilay	Work	Glossary and Abbreviations	2
64		Shivang	Work	Doc stats, ID, readability	2
65		Sachin	Work	Plag Check and Proof Reading	2
66		Pratyush	Work	General Formatting	2
67		Madhav	Work	Software Specs	2

Figure 1.8: Resource Breakdown (contd.)

		Name	Type	Text1	Text2
68		Ojas	Work	Hardware specs	2
69		Om	Work	MoM	2
70		shashwat	Work	Glossary formatting	2
71		Saiyam Jain	Work	cost specifications	2

Figure 1.9: Resource Breakdown (contd.)

1.4 Project Statement

Design and development of a function generator that, within a Rs 1000 budget, replicates the features, specifications, and layout of the generator used in ELP101.According to the requirements of our stakeholders the FG must support the same frequency range, waveform types, amplitude control, and other essential features as the "Scientech 4064S".

1.5 Abstract

As part of Project 1, we are creating a **Function Generator**—a highly adaptable electronic device designed to produce various periodic waveforms, including sine, square, triangular, and sawtooth waves. Our goal is to replicate the **Scientech 4064S Function Generator** that is used in the lab. This device allows users to adjust frequency, amplitude, and duty cycle, making it a perfect tool for tasks like electronics testing, debugging, and circuit design.

Key features of the Function Generator:

1. Precise frequency adjustments for accurate signal output.
2. Multiple waveform options to suit diverse testing needs.
3. A user-friendly interface for quick and efficient operation.

Function Generator is an essential tool for any electronics lab, offering flexibility and precision for a wide range of applications. The employment of cheap parts providing sufficient performances is foreseen within the frame of this project. The resulting design becomes a means of instruction for hands-on awareness of techniques of waveform generation in lab work.

1.6 Motivation

The development of an affordable and versatile function generator addresses a crucial need within foundational electronics education in India. While the broader electronics market is substantial, our initial focus is on equipping educational institutions, specifically those conducting introductory electronics laboratory courses similar to **ELP101.** These labs form the bedrock of electronics education, introducing students to fundamental circuit concepts and signal manipulation. Currently, many institutions rely on **older, less versatile** equipment or face budget constraints when acquiring modern function generators.

Our product aims to bridge this gap by offering a **cost-effective solution** with comparable capabilities compared to commonly used, basic function generators. While alternatives like the XR2206 exist, our product offers **a superior frequency range (10 MHz vs. 1 MHz) at a comparable or lower price point**, directly benefiting institutions with limited budgets. This improved performance allows students to explore a wider range of experiments and gain a deeper understanding of signal behavior.

This targeted approach to the educational market allows for efficient development and production scaling appropriate for the initial demand. While we acknowledge the potential for wider applications in hobbyist communities and small businesses in the long term, our primary objective is to provide a reliable and capable tool for foundational electronics education, starting with institutions conducting courses akin to **ELP101.** This focused strategy allows us to establish a strong foothold in a key segment before considering expansion into other markets. The product will still deliver multiple waveform generations **(sine, square, triangle, ramp, and pulse)**, adjustable output signal amplitude (Vpp), and DC offset capabilities, meeting the core requirements of these educational labs. Our maintenance strategy will prioritize rapid support for these educational institutions, ensuring minimal disruption to lab schedules.

2. Requirements

2.1 Functional Requirements

2.1.1 Input Requirements

1. **Control Interfaces**:
   - Physical rotary knobs for coarse adjustments.[17]
   - Additional knob for finer adjustment of frequency values.[17]
2. **Modulation Inputs**:
   - Supports Amplitude Modulation (AM), Frequency Modulation (FM), and Phase Modulation (PM) modulation modes.
3. **Additional Inputs**:
   - Toggle switches for function selection.[32]
   - 2/3-pin input connectors for external components.
   - A Printed Circuit Board (PCB), onto which components would be soldered.[14]

2.1.2 Output Requirements

1. **Display Module (20x4 Liquid Crystal Display (LCD) Display)**: [3]
   - HD44780 Compatible 20x4 LCD display.
   - Capable of displaying 20 characters per line and 4 lines.
   - Allows clear visualization of frequency, amplitude, and waveform type.
   - Contrast adjustable via a 10kΩ potentiometer.[29]
2. **Waveform Types**: Sine, square, triangular, pulse, ramp, TTL.
3. **Output Impedance**: Configured to 50 Ω for compatibility with standard test equipment.
4. **Waveform Accuracy**: Less than 1% Total Harmonic Distortion (THD) for sine waves.
5. **Waveform Symmetry**: Adjustable from 1% to 99% (duty cycle).

6. **Voltage Offset**: Programmable Direct Current (DC) offset adjustable between -5 V and +5V.
7. **Frequency Precision**: Accuracy within 0.01% of the programmed value.
8. **Frequency Resolution**: Fine adjustments of the order of 1 mHz.
9. **Signal Stability**: Output frequency drift not exceeding 0.01%.
10. **Amplitude Range**: Adjustable output from 0 to 5 V (peak-to-peak) with a resolution of 0.01V.
11. **Output Connectors**:
    - SubMiniature Version A (SMA) connectors for high-quality signal output.
    - Optional backlight connection via a 220Ω resistor for current limiting.

2.1.3 Power Requirements

1. **Power Consumption**: Maximum 20 W under full load.
2. **Voltage Compatability**: Requires a standard Alternating Current (AC) input (220 V/50 Hz).

2.1.4 Logistical Requirements

1. **Accessories**: Supplied with BNC cables, probes, knobs, and a user manual.
2. **Carry Case**: Optional carry case for portability.

2.1.5 Environmental Requirements

1. **Operating Temperature**: Functional from 0°C to 50°C.
2. **Storage Temperature**: Safe storage from -20°C to 70°C.
3. **Humidity Resistance**: Operates in environments with up to 80% relative humidity (non-condensing).
4. **Electromagnetic Interference (EMI)/Electromagnetic Compatibility (EMC) Compliance**: Meets regulatory standards such as FCC and CE compliance.

2.1.6 Site (Usage Site) Requirements

1. **Laboratory Use**: Designed for standard electronics laboratories with clean and stable workbenches.
2. **Power Outlet Compatibility**: Supports both EU and US power outlet standards with adapters.

2.1.7 Structural Requirements

1. **Chassis**: Durable recycled plastic enclosure with heat resistance.
2. **Control Panel**:
   - Intuitive layout with labeled controls.
   - Backlit buttons for visibility in low-light conditions.
3. **Protective Measures**:
   - Fuse for circuit protection.
   - Shielding to minimize interference and protect internal components.

2.1.8 Time Requirements

1. **Design Time Requirement**: Development and testing to be completed within 6 months.
2. **Time to Market Requirement**: Ready for commercial launch within 9 months from project initiation.
3. **Lifetime Requirements**: Guaranteed operational life of at least 5 years with proper maintenance.
4. **End of Life Requirements**: Must support recycling and environmentally safe disposal of components.

2.2 Non-Functional Requirements

2.2.1 Aesthetic Design

1. **Aesthetic Design**: Modern, sleek appearance with an ergonomic design.

2.2.2 Safety

1. **Safety**: Certified for safety under International Electrotechnical Commission (IEC) 61010-1 standards.

2.2.3 Serviceability

1. **Serviceability**: Modular design for easy part replacement.

2.2.4 Reliability

1. **Reliability**: Mean Time Between Failures (Mean Time Between Failures (MTBF)) of at least 10,000 operational hours.

3. Specifications

3.1 Hardware Specifications

The project utilizes the ATmega328P microcontroller, a widely used 8-bit microcontroller known for its efficiency and versatility. The key hardware specifications are as follows:

- **Processor:** ATmega328P, a high-performance, low-power 8-bit AVR microcontroller.
- **Memory:**
  - 32KB of in-system programmable flash memory.
  - 2KB of SRAM.
  - 1KB of EEPROM with 100,000 write/erase cycles.
- **Architecture:** Advanced RISC architecture with 131 instructions, most executed in a single clock cycle, enabling up to 16 MIPS throughput at 16 MHz.
- **Clock Speed:** Supports up to 16 MHz clock frequency.
- **Power Consumption:**
  - Active mode: 1.5mA at 4 MHz and 3V.
  - Power-down mode: As low as 1µA.
- **Operating Voltage Range:** 2.7V to 5.5V, suitable for automotive and industrial applications.
- **Peripherals:**
  - 6 PWM channels.
  - 8-channel 10-bit ADC.
  - USART, SPI, and I^2C communication protocols.
  - Three Timer/Counters: Two 8-bit and one 16-bit.
  - Interrupt and wake-up on pin change.
- **I/O Pins:** 23 programmable I/O lines.
- **Temperature Range:** Operates between -40°C and +125°C.
- **Programming:** In-system programming with onboard bootloader and SPI interface.

- **Quality Standards:** Manufactured according to ISO-TS-16949 and verified with AEC-Q100 Grade 1 standards [9].

3.2 Software Specifications

The software specifications for the project include:

- **Development Environment:** Arduino IDE for programming and uploading sketches to the ATmega328P microcontroller.
- **Programming Language:** C/C++ for firmware development.
- **Libraries:**
  - Standard Arduino libraries for GPIO, PWM, ADC, I^2C, and SPI.
  - Additional custom libraries for specific project needs.
- **Simulation and Testing Tools:**
  - Proteus or TinkerCAD for circuit simulation and debugging.
- **Version Control:** Git for source code management and collaboration.
- **Additional Features:** Integration with Arduino Cloud Editor for remote programming and debugging.

3.3 Comparative Analysis: Arduino Nano vs Arduino Uno

The Arduino Nano was selected for this project due to its compact design and cost-effectiveness. A comparison with the Arduino Uno is provided below:

- **Form Factor:** The Nano (45 x 18 mm) is significantly smaller than the Uno (68.6 x 53.4 mm), making it ideal for compact, breadboard-friendly applications. [8]
- **Core Functionality:** Both boards share the ATmega328P microcontroller, offering identical memory and processing capabilities.
- **Additional I/O:** Nano includes two extra I/O pins compared to Uno.
- **Cost Efficiency:** Nano is more cost-effective for compact and simpler applications, such as function generators or environmental monitoring projects.
- **Breadboard Integration:** Nano can be soldered or plugged into PCBs or breadboards, unlike the Uno. [7]

3.4 Space specifications

- **Outer casing:** The outer body of the function generator has dimensions of 20 cm x 7.5 cm x 27.5 cm.
- **Display:** The area occupied by the display screen is 7.5 cm x 2.5 cm on the front panel of the function generator.

3.5 Cost specifications

Component	**Quantity**	**Price per Unit (Rs)**	**Total(Rs)**	**Citations**
LM741	2	8	16	[26]
LM311	2	12	24	[25]
Resistor 10k	10	1	10	[28]
Resistor 5k	10	0.4	4	[5]
Resistor 1k	10	0.5	5	[14]
Capacitor 1 micro F	2	8.55	17	[22]
1N4148	3	1	3	[2]
2N3904	3	3.5	10.5	[4]
3 Pin Potentiometer with knob (>10k)	2	30	60	[11]
Rotary Switches	2	30	60	[16]
Buttons	7	1 to 5	30	[13]
PCB Board	2	28	56	[31]
SMA Connectors	2	20	40	[19]
20X4 lcd display with I2C	1	275	275	[17]
Atmega328P Chip	1	161	161	[15]
Reset button	2	8	16	[33]
Recycled Plastic Sheet	2.5 sqft	20 per sqft	50	
Crystal Oscillator	1	6	6	[12]
Voltage regulator	1	9	9	[27]
AC to DC Power Converter	1	135	135	[6]

Table 3.1: Components and Pricing

Total cost = Rs. 987.50

3.6 Performance specifications:

- **Waveforms:**
  - Sine wave: Frequency range of 1 mHertz (Hz)to 10 Megahertz (MHz).
  - Square wave: Frequency range of 1 mHz to 3 MHz.
  - Triangular wave: Frequency range of 1 mHz to 3 MHz.
  - Pulse wave: Adjustable duty cycle (1% –99%), frequency up to 3 MHz.
  - Ramp wave: Frequency range of 1 mHz to 3 MHz.
  - TTL wave: Frequency range of 1 mHz to 3 MHz.
- **Front panel:** Contains knobs and switches to alternate between modes, and set the parameters of the wave to be generated, through both coarse and fine tuning.

3.7 Milestone Specifications

Table 3.2: CAD Milestones and Subtasks

Milestone	**Description**	**Subtasks**	**Weightage**	**Total Weigh-tage**	**Date**
CAD	Outer casing of dimensions 20 cm x 7.5 cm x 27.5 cm	in (.CAD extension file)	3		
		Isometric view	0.5		
		Top view	0.5		
		Front view	0.5		
		Right view	0.5	5	
	Display of 7.5 cm x 2.5 cm	in (.CAD extension file)	3		
		Isometric view	0.5		
		Top view	0.5		
		Front view	0.5		
		Right view	0.5	5	

Milestone	Description	Subtasks	Weightage	Total Weigh-tage	Date
	4 poles for support, to provide an elevated platform for the function generator	in (.CAD extension file)	3		
		Isometric view	0.5		
		Top view	0.5		
		Front view	0.5		
		Right view	0.5	5	
	Buttons and knobs for setting frequency modes, fine and coarse tuning of wave parame-ters	in (.CAD extension file)	3		
		Isometric view	0.5		
		Top view	0.5		
		Front view	0.5		
		Right view	0.5	5	
	Consolidated CAD file	in (.CAD extension file)	5	5	04/02/25
			Total Weightage	**25**	

Table 3.3: Software Simulations Milestones and Subtasks

Milestone	**Description**	**Subtasks**	**Weightage**	**Total Weigh-tage**	**Date**
Software simulations	Chip programming	Code for generating different types of waves		14	05/02/25
		Sine wave	4		
		Square wave	2		
		TTL wave	2		
		Triangle wave	2		
		Pulse wave	2		
		Ramp wave	2		
	Display programming	Programming the display to show details of the set waveforms	5	5	
	Achieving milestones	Compilation of results from past weeks	6	6	
			Total weightage	**25**	

Table 3.4: Fabrication Milestones and Subtasks

Milestone	**Description**	**Subtasks**	**Weightage**	**Total Weightage**	**Date**
Fabrication	Container as described in the final CAD model, along with 4 poles at the bottom to stabilize the function generator body, having power supply ports and other ports for connection purposes.	Required size	4	16	
		Poles	4		
		Stable	4		
		Ports	4		
	The front panel has buttons and knobs for switching on, changing waveform, adjusting frequency, amplitude, and overall display.	Buttons	3	9	
		Knobs	3		
		Display	3		06/02/25
			Total Weightage	**25**	

Table 3.5: Demo Milestones and Subtasks

Milestone	**Description**	**Subtasks**	**Weightage**	**Total Weightage**	**Date**
DEMO	Similar display and front panel of FG as that in the lab		4	4	
	Button presses work as intended		4	4	
	All types of waves are generated of required frequencies and alternate on button press	Sine wave	2	12	
		Square wave	2		
		Triangular wave	2		
		Pulse wave	2		
		Ramp wave	2		
		TTL wave	2		
	Milestones 1, 2, and 3 are completed		5	5	07/02/25
			Total Weightage	**25**	

3.8 Man-hour specifications

3.8.1 Man-hours

Table 3.6: Man-hours invested

S.no	Role	Name	Entry No	Man-hours invested
1	Tribe Coordinator and Hardware Design and Fabrication	Saiyam Jain	2022MT11962	10.0
2	Deputy Tribe Coordinator and Documentation	Shivaani Hari	2022MT11273	10.0
3	Activity Coordinator-Hardware Design and Fabrication	Vagesh Mahajan	2022MT11260	10.0
4	Activity Coordinator-Software	Shrenik Mohan Sakala	2022MT11920	10.0
5	Activity Coordinator-Testing and Debugging (Hardware)	Madhav Maheshwari	2022MT61975	8.0
6	Activity Coordinator-Market Survey and Research	Rahul Athipatla	2022MT11277	8.0
7	Activity Coordinator-Documentation	Nilay Sharma	2022MT12007	10.0
8	Market Survey and Research	Aahna Jain	2022MT11930	6.0
9	Testing and Debugging (Hardware)	Abhishek Kumar Singh	2022MT11276	6.0
10	Hardware Design and Fabrication	Abhishek Singh	2022MT11934	8.0
11	Hardware Design and Fabrication	Adarsh Singh	2022MT11285	8.0
12	Testing and Debugging (Hardware)	Aditya Goyal	2022EE31761	6.0
13	Testing and Debugging (Hardware)	Aditya Raj	2022MT61980	6.0
14	Hardware Design and Fabrication	Ajaypal Kulhari	2022EE11711	8.0
15	Testing and Debugging (Hardware)	Aman Divya	2022MT11293	6.0
16	Hardware Design and Fabrication	Ambhore Soham Bhaskar	2022EE11713	7.0
17	Software	Arnav Tiwari	2022MT11267	8.0

Table continues on the next page

S.no	Role	Name	Entry No	Man-Hours
18	Hardware Design and Fabrication	Arpit Mourya	2022EE11728	8.0
19	Market Survey and Research	Ashmit Nangia	2022EE11989	6.0
20	Market Survey and Research	Ayush Nayak	2022MT11958	6.0
21	Testing and Debugging (Hardware)	Ayush Raj	2022MT11944	6.0
22	Software	Chintada Srinivasarao	2022MT11924	6.0
23	Hardware Design and Fabrication	Deevyansh Khadria	2022EE31883	7.0
24	Testing and Debugging (Hardware)	Dev Singh	2022MT11143	6.0
25	Software	Devansh Upadhyay	2022MT11931	7.0
26	Software	Dhruv Chaurasiya	2022MT11172	7.0
27	Software	Galla Yaswant Venkata Ramana	2022EE11687	6.0
28	Market Survey and Research	Gauri Agarwal	2021EE10715	5.0
29	Testing and Debugging (Hardware)	Ishan Bankal	2022EE31779	5.0
30	Documentation	Ishant Yadav	2022MT11397	7.0
31	Hardware Design and Fabrication	Jenit Jain	2022EE11690	10.0
32	Documentation	Kabir Uberoi	2022MT61202	9.0
33	Market Survey and Research	Kaneesha Jain	2022MT11929	6.0
34	Documentation	Keshav Rai	2022MT61968	7.0
35	Hardware Design and Fabrication	Khushi Gupta	2022MT61973	7.0
36	Testing and Debugging (Hardware)	Krish Singh	2022MT61303	5.0
37	Software	Lakshaya Jain	2022MT11933	7.0
38	Documentation	Madhav Biyani	2022EE11321	6.0
39	Software	Manas Goyal	2022MT11918	8.0
40	Software	Mukul Sahu	2022MT11939	7.0

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S.no	Role	Name	Entry No	Man-Hours
41	Hardware Design and Fabrication	Nagure Kalyani Paramanand	2022MT61983	7.0
42	Testing and Debugging (Hardware)	Naman Kale	2022MT11960	6.0
43	Software	Nimkar Abhinav Yashwant	2022MT11943	7.0
44	Software	Niraj Agarwal	2022MT11921	6.0
45	Software	Niranjan Rajeev	2022EE11766	6.0
46	Software	Nobin Kidangan Benny	2022EE11154	8.0
47	Documentation	Ojas Sharma	2022EE31746	7.0
48	Documentation	Om Goel	2022MT12071	8.0
49	Testing and Debugging (Hardware)	Parth Bhardwaj	2022MT11257	6.0
50	Documentation	Pratyush Sharma	2022MT61970	5.0
51	Market Survey and Research	Pratyush Shrivastava	2022EE11660	6.0
52	Software	Praveen Lakhara	2022MT11280	7.0
53	Software	Priyansh Prakash Mayank	2022MT11954	7.0
54	Hardware Design and Fabrication	Priyanshu Jindal	2022EE11668	7.0
55	Software	Punit Meena	2022EE11184	10.0
56	Testing and Debugging (Hardware)	Rahul Rajoria	2022MT11947	5.0
57	Testing and Debugging (Hardware)	Raman Jakhar	2022MT11941	6.0
58	Testing and Debugging (Hardware)	Ranjan Kumar Singh	2022MT61304	5.0
59	Software	Rijul Rudrax Barot	2022EE11664	6.0
60	Testing and Debugging (Hardware)	Rudranil Naskar	2022MT11287	5.0
61	Documentation	Sachin Hiren Trivedi	2022EE11190	6.0

Table continues on the next page

S.no	Role	Name	Entry No	Man-Hours
62	Hardware Design and Fabrication	Saksham Kumar Rohilla	2022EE11709	7.0
63	Market Survey and Research	Sanya Sachan	2022MT11286	6.0
64	Software	Sarthak Gangwal	2022MT11275	7.0
65	Market Survey and Research	Satvik Prasad S	2022MT11279	6.0
66	Documentation	Shashwat Kasliwal	2022MT11915	6.0
67	Documentation	Shivang Goyal	2022MT11269	7.0
68	Software	Siddharth Saini	2022MT11283	6.0
69	Market Research and Survey	Siya Gupta	2022MT11274	5.0
70	Testing and Debugging (Hardware)	Sparsh Jain	2022MT11917	5.0
71	Hardware Design and Fabrication	Suhani Soni	2022MT61981	6.0
72	Software	Sumit Sonowal	2022MT11296	7.0
73	Software	Suneel Masarapu	2022MT11942	6.0
74	Hardware Design and Fabrication	Sushil Kumar	2022EE31765	7.0
75	Hardware Design and Fabrication	Syna Rajvanshi	2022MT61974	8.0
76	Market Survey and Research	Tanya Jain	2022MT11935	7.0
77	Testing and Debugging (Hardware)	Taru Singhal	2022MT11922	6.0
78	Testing and Debugging (Hardware)	Tatsam Ranjan Sharma	2022MT61969	5.0
79	Hardware Design and Fabrication	Tirth Punit Golwala	2022MT11967	8.0
80	Hardware Design and Fabrication	Tushar Goyal	2022MT11266	6.0
81	Hardware Design and Fabrication	Umang Agarwal	2022EE11692	7.0
82	Documentation	Utkarsh Dubey	2022MT61045	7.0
83	Hardware Design and Fabrication	Vatsal Manish Sejpal	2022MT11926	6.0

Table continues on the next page

S.no	Role	Name	Entry No	Man-Hours
84	Hardware Design and Fabrication	Viha Singla	2022MT61972	7.0
85	Documentation	Yuvraj Singh	2022EE11715	3.0

3.8.2 Skillset

Table 3.7: Skillset acquired

S.no	Role	Name	Entry No	Skillset
1	Tribe Coordinator and Hardware Design and Fabrication	Saiyam Jain	2022MT11962	LaTex, soldering,
2	Deputy Tribe Coordinator and Documentation	Shivaani Hari	2022MT11273	LaTex, Zotero, soldering
3	Activity Coordinator-Hardware Design and Fabrication	Vagesh Mahajan	2022MT11260	RDWorks
4	Activity Coordinator-Software	Shrenik Mohan Sakala	2022MT11920	Arduino programming using TinkerCAD, SimulIDE
5	Activity Coordinator-Testing and Debugging (Hardware)	Madhav Maheshwari	2022MT61975	FreeCAD
6	Activity Coordinator-Market Survey and Research	Rahul Athipatla	2022MT11277	Stakeholder Analysis, Cost Optimisation
7	Activity Coordinator-Documentation	Nilay Sharma	2022MT12007	LaTex, Zotero
8	Market Survey and Research	Aahna Jain	2022MT11930	Cost analysis from different websites
9	Testing and Debugging (Hardware)	Abhishek Kumar Singh	2022MT11276	FreeCAD and Latex
10	Hardware Design and Fabrication	Abhishek Singh	2022MT11934	RDWorks, Laser Cutting
11	Hardware Design and Fabrication	Adarsh Singh	2022MT11285	RDWorks, Laser Cutting

Table continues on the next page

S.no	Role	Name	Entry No	Skillset
12	Testing and Debugging (Hardware)	Aditya Goyal	2022EE31761	FreeCAD
13	Testing and Debugging (Hardware)	Aditya Raj	2022MT61980	circuit building
14	Hardware Design and Fabrication	Ajaypal Kulhari	2022EE11711	Circuit Design
15	Testing and Debugging (Hardware)	Aman Divya	2022MT11293	FreeCAD
16	Hardware Design and Fabrication	Ambhore Soham Bhaskar	2022EE11713	Arduino functions like Analogwrite().RC Filters
17	Software	Arnav Tiwari	2022MT11267	TinkerCAD,SimulIDE
18	Hardware Design and Fabrication	Arpit Mourya	2022EE11728	PCB software LTM
19	Market Survey and Research	Ashmit Nangia	2022EE11989	Market Analysis
20	Market Survey and Research	Ayush Nayak	2022MT11958	Stakeholder Analysis, Cost Optimisation
21	Testing and Debugging (Hardware)	Ayush Raj	2022MT11944	market base analysis
22	Software	Chintada Srinivasarao	2022MT11924	Circuit Simulation in TinkerCAD and SimulIDE
23	Hardware Design and Fabrication	Deevyansh Khadria	2022EE31883	Circuit Simulation in SimulIDE
24	Testing and Debugging (Hardware)	Dev Singh	2022MT11143	Circuit Analysis
25	Software	Devansh Upadhyay	2022MT11931	Circuit Design
26	Software	Dhruv Chaurasiya	2022MT11172	Circuit Simulations in TinkerCAD
27	Software	Galla Yaswant Venkata Ramana	2022EE11687	Basics of Tinkercad
28	Market Survey and Research	Gauri Agarwal	2021EE10715	Stakeholder Analysis
29	Testing and Debugging (Hardware)	Ishan Bankal	2022EE31779	Circuit Analysis,GitHub

Table continues on the next page

S.no	Role	Name	Entry No	Skillset
30	Documentation	Ishant Yadav	2022MT11397	Latex
31	Hardware Design and Fabrication	Jenit Jain	2022EE11690	Circuit simulation in LTspice
32	Documentation	Kabir Uberoi	2022MT61202	LaTeX, PlantText
33	Market Survey and Research	Kaneesha Jain	2022MT11929	Cost analysis and optimization
34	Documentation	Keshav Rai	2022MT61968	LaTeX
35	Hardware Design and Fabrication	Khushi Gupta	2022MT61973	RDWorks, Laser Cutting
36	Testing and Debugging (Hardware)	Krish Singh	2022MT61303	Circuit Analysis
37	Software	Lakshaya Jain	2022MT11933	Circuit Simulations in TinkerCAD
38	Documentation	Madhav Biyani	2022EE11321	LaTex
39	Software	Manas Goyal	2022MT11918	Arduino programming using TinkerCAD, SimulIDE
40	Software	Mukul Sahu	2022MT11939	Circuit Simulations in Tinkercad, Wokwi, Basic Display Programming
41	Hardware Design and Fabrication	Nagure Kalyani Paramanand	2022MT61983	RDWorks, Laser Cutting
42	Testing and Debugging (Hardware)	Naman Kale	2022MT11960	FreeCAD
43	Software	Nimkar Abhinav Yashwant	2022MT11943	TinkerCAD,WOKWI circuit simulations for display programming using LiquidCrystal I2C
44	Software	Niraj Agarwal	2022MT11921	TinkerCAD
45	Software	Niranjan Rajeev	2022EE11766	TinkerCAD
46	Software	Nobin Kidangan Benny	2022EE11154	TinkerCAD, Wokwi
47	Documentation	Ojas Sharma	2022EE31746	LaTex
48	Documentation	Om Goel	2022MT12071	LaTeX, PlantText

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S.no	Role	Name	Entry No	Skillset
49	Testing and Debugging (Hardware)	Parth Bhardwaj	2022MT11257	LaTex
50	Documentation	Pratyush Sharma	2022MT61970	LaTex
51	Market Survey and Research	Pratyush Shrivastava	2022EE11660	Cost Optimization, Latex
52	Software	Praveen Lakhara	2022MT11280	Circuit Simulations in TinkerCAD
53	Software	Priyansh Prakash Mayank	2022MT11954	Circuit simulation in WOKWI and TinkerCAD for LiquidCrystal I2C display programming
54	Hardware Design and Fabrication	Priyanshu Jindal	2022EE11668	Altium, LtSpice Simulations
55	Software	Punit Meena	2022EE11184	TinkerCAD, Wokwi
56	Testing and Debugging (Hardware)	Rahul Rajoria	2022MT11947	TinkerCAD
57	Testing and Debugging (Hardware)	Raman Jakhar	2022MT11941	TinkerCAD
58	Testing and Debugging (Hardware)	Ranjan Kumar Singh	2022MT61304	using tools and techniques to find and fix problems in hardware and software.
59	Software	Rijul Rudrax Barot	2022EE11664	TinkerCAD
60	Testing and Debugging (Hardware)	Rudranil Naskar	2022MT11287	FreeCad, Latex
61	Documentation	Sachin Hiren Trivedi	2022EE11190	LaTex
62	Hardware Design and Fabrication	Saksham Kumar Rohilla	2022EE11709	Circuit Design
63	Market Survey and Research	Sanya Sachan	2022MT11286	Selecting the best market option based on quality, price, and specific needs

Table continues on the next page

S.no	Role	Name	Entry No	Skillset
64	Software	Sarthak Gangwal	2022MT11275	TinkerCAD,WOKWI circuit simulations for display programming using LiquidCrystal I2C
65	Market Survey and Research	Satvik Prasad S	2022MT11279	Analyzing components and It's evaluating market value .
66	Documentation	Shashwat Kasliwal	2022MT11915	LaTex
67	Documentation	Shivang Goyal	2022MT11269	LaTex
68	Software	Siddharth Saini	2022MT11283	TinkerCAD
69	Market Research and Survey	Siya Gupta	2022MT11274	Cost analysis
70	Testing and Debugging (Hardware)	Sparsh Jain	2022MT11917	FreeCAD
71	Hardware Design and Fabrication	Suhani Soni	2022MT61981	RDWorks, Laser Cutting
72	Software	Sumit Sonowal	2022MT11296	Circuit Simulations in TinkerCAD
73	Software	Suneel Masarapu	2022MT11942	Circuit Simulations in SimulIDE
74	Hardware Design and Fabrication	Sushil Kumar	2022EE31765	Circuit Design
75	Hardware Design and Fabrication	Syna Rajvanshi	2022MT61974	RDWorks, Laser Cutting
76	Market Survey and Research	Tanya Jain	2022MT11947	Optimal cost estimation techniques, research
77	Testing and Debugging (Hardware)	Taru Singhal	2022MT11922	LaTeXand FreeCAD
78	Testing and Debugging (Hardware)	Tatsam Ranjan Sharma	2022MT61969	3-D Modelling
79	Hardware Design and Fabrication	Tirth Punit Golwala	2022MT11967	RDWorks, Laser Cutting
80	Hardware Design and Fabrication	Tushar Goyal	2022MT11266	TinkerCAD

Table continues on the next page

S.no	Role	Name	Entry No	Skillset
81	Hardware Design and Fabrication	Umang Agarwal	2022EE11692	Circuit analysis
82	Documentation	Utkarsh Dubey	2022MT61045	LaTex, Project Libre
83	Hardware Design and Fabrication	Vatsal Manish Sejpal	2022MT11926	RDWorks
84	Hardware Design and Fabrication	Viha Singla	2022MT61972	RDWorks, Laser Cutting
85	Documentation	Yuvraj Singh	2022EE11715	

3.8.3 How Assignment was Done

We divided the assignments among the team members based on their individual strengths and preferences. This was achieved by documenting each member's skillset and areas of interest. We strategically assigned tasks, such as delegating the majority of hardware and debugging responsibilities to Electrical Engineering students, and assigning documentation and software development to Mathematics students respectively. This approach fostered a highly coordinated and efficient team where each member effectively contributed to the project's timely completion.

3.8.4 Surplus Manpower

To date, the project has progressed smoothly without encountering any instances of surplus manpower. Proactive resource allocation and regular progress reviews have ensured that team members are effectively utilized and their skills are aligned with the project's evolving needs. This proactive approach minimizes the risk of underutilization and allows for efficient and timely task completion.

3.8.5 TRL Description

Our design of the function generator is currently at Technology Readiness Level (TRL) 2. This indicates that the concept and application have been formulated but the technology is still in the early research and development stage. The design has not yet been prototyped or validated through testing and evaluation, and further research, prototyping and optimization is required to move it towards a more advanced prototype.

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- Readability Indices:
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  - Flesch Reading Ease: 50.3
  - Flesch-Kincaid Grade Level: 7.3
  - Gunning Fog Index: 9.936
  - Coleman Liau Index: 20.5
- A WebFX readability score of **48.8** indicates that the document should be easily read and understood by **14 to 15 year olds**.
- **Flesch Reading Ease** score of **50.3** and **Flesch-Kincaid Grade level** of 7.3 indicates that the text is **fairly difficult to read** and best understood by individuals with at least a **10th to 12th grade level of education**.
- A **Gunning Fog Index** of **9.936** suggests that the text requires a reading level equivalent to a **high school sophomore**.
- A **Coleman-Liau Index** score of **20.5** indicates that the text is written at a level appropriate for someone with at least **20 years of education**.

B. Softwares Used

The software(s) we used to prepare this report are as follows:

1. **LaTeX** - which is a high-quality typesetting system, commonly used for producing scientific and technical documents. It can be downloaded from:
    - LaTeX Project Website: `https://www.latex-project.org/get/`
2. **Zotero** - Which is a reference management software. Used to manage data and related research materials. It can be downloaded from:
    - Zotero Website: `https://www.zotero.org/download/`
3. **ProjectLibre** - Which is project management software system. It helps in planning, scheduling, and tracking projects. It can be downloaded from:
    - ProjectLibre Website: `https://www.projectlibre.com/`
4. **PlantUML** -Which is a open-source tool allowing users to create diagrams and mindmaps. It can be downloaded from:
    - PlantUML Website: `https://plantuml.com`
5. **Tinkercad** - Which is a free online 3D modeling program. It can be downloaded from:
    - Tinkercad Website: `https://www.tinkercad.com/`
6. **Microsoft 365/Microsoft Office** - Which is a collection of applications like Microsoft World, Excel and more. It is commonly used for document editing.
    - Access Microsoft 365: `https://www.microsoft365.com/`
7. **FreeCAD** - Which is an open-source parametric 3D modeler made primarily to design real-life objects. I can be downloaded from:
    - FreeCAD Website: `https://www.freecad.org/`

C. Document ID

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D. Minutes of the Meeting

- Week 1 (10/01/25 - 16/01/25)
- Week 2 (17/01/25 - 23/01/25)