Design and Implementation of a Function Generator

Freaky Friday

16 January, 2025 (Week 1)

Team Members

Table 1: SPOC

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11	Software	Niraj Agarwal	2022MT11921	mt1221921@iitd.ac.in	0.9
12	Software	Niranjan Rajeev	2022EE11766	ee1221766@iitd.ac.in	0.9
13	Software	Nobin Kidangan Benny	2022EE11154	ee1221154@iitd.ac.in	0.9
14	Documentation	Ojas Sharma	2022EE31746	ee3221746@iitd.ac.in	0.9
15	Documentation	Pratyush Sharma	2022MT61970	mt6221970@iitd.ac.in	0.9
16	Software	Praveen Lakhara	2022MT11280	mt1221280@iitd.ac.in	0.9
17	Hardware Design and Fabrication	Priyanshu Jindal	2022EE11668	ee1221668@iitd.ac.in	0.9
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22	Software	Sumit Sonowal	2022MT11296	mt1221296@iitd.ac.in	0.9
23	Software	Suneel Masarapu	2022MT11942	mt1221942@iitd.ac.in	0.9
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Balance sheet (Detailed record of talents)

Click *here* to view the Google Spreadsheet.

Contents

i. List of Tables

ii. List of Figures

iii. Abbreviations

Abbreviation	Meaning
ELP305	Systems and Design Lab
TC	Tribe Coordinator
IF	Involvement Factor
SPOC	Single Point of Contact
CAD	Computer-Aided Design
LCD	Liquid Crystal Display
USB	Universal Serial Bus
GND	Ground
TAM	Total Addressable Market
USP	Unique Selling Proposition
SLA	Service Level Agreements
MTBF	Mean Time Between Failures

iv. Glossary

Frequency: The rate at which an electrical signal oscillates.

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

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.

v. Mind Map

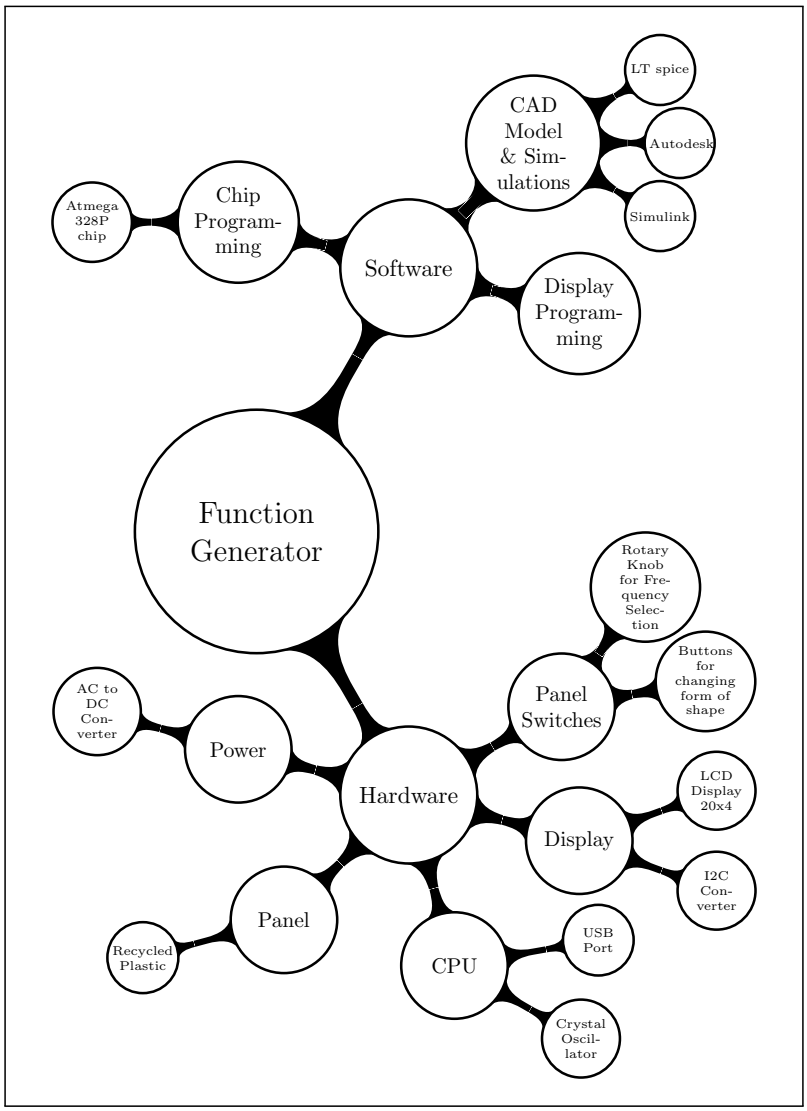

Figure 1: Mind Map of the Project

vi. Project Management Figures

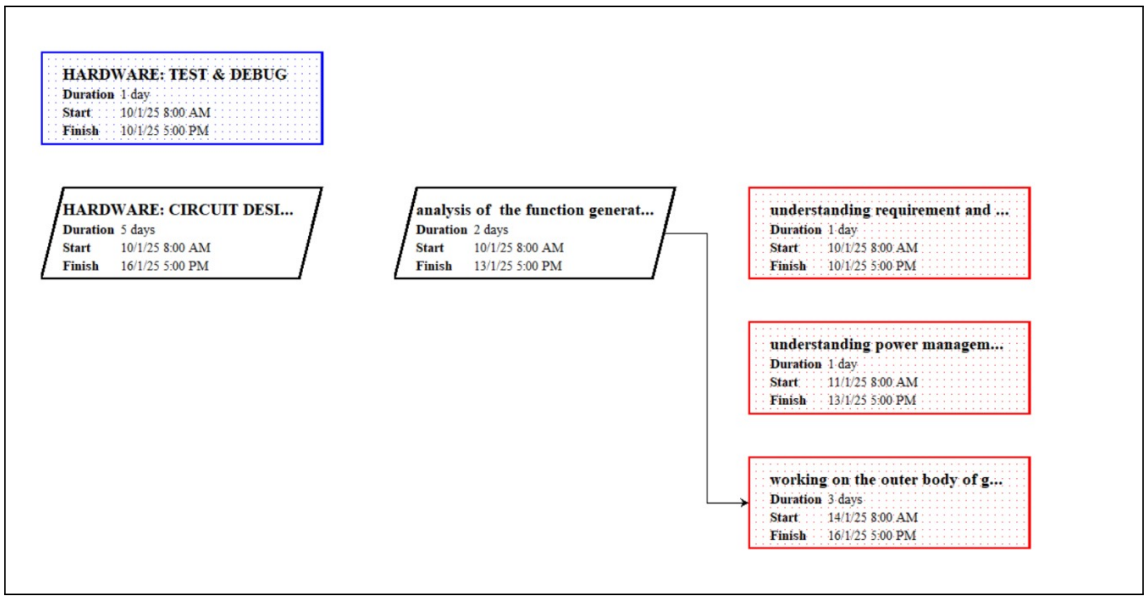

Figure 2: Hardware Test and Debugging Process

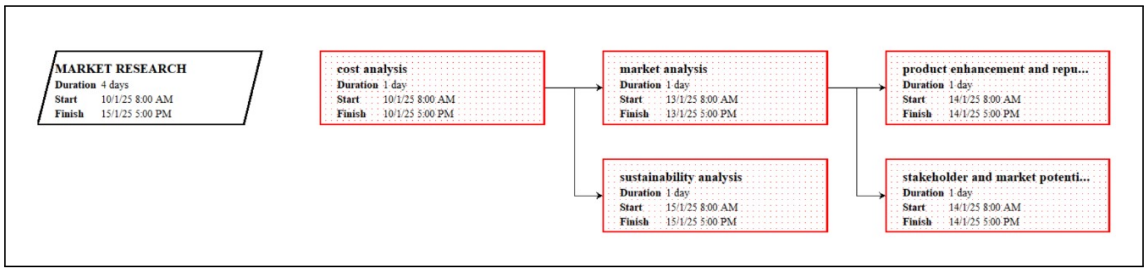

Figure 3: Market Research Analysis Workflow

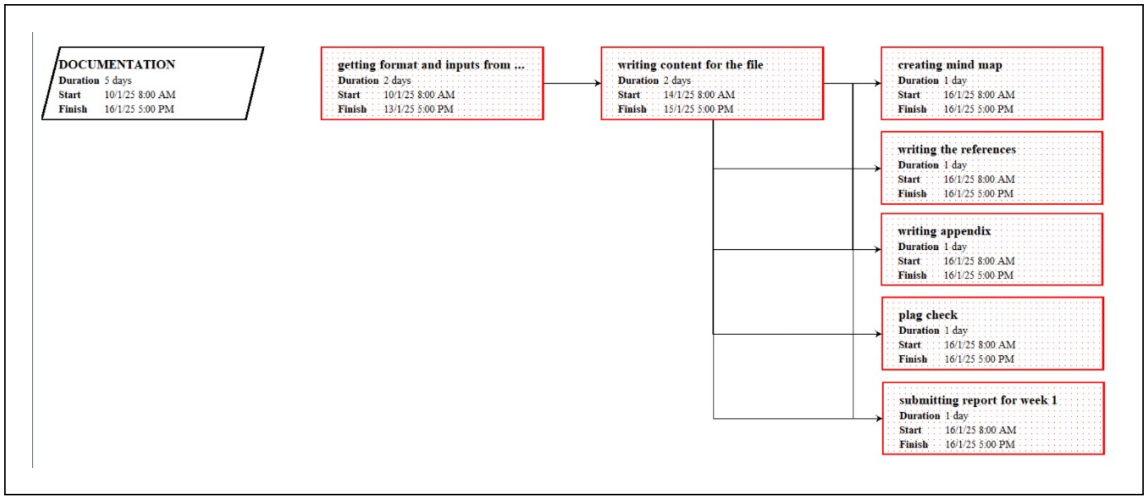

Figure 4: Documentation and File Writing Steps

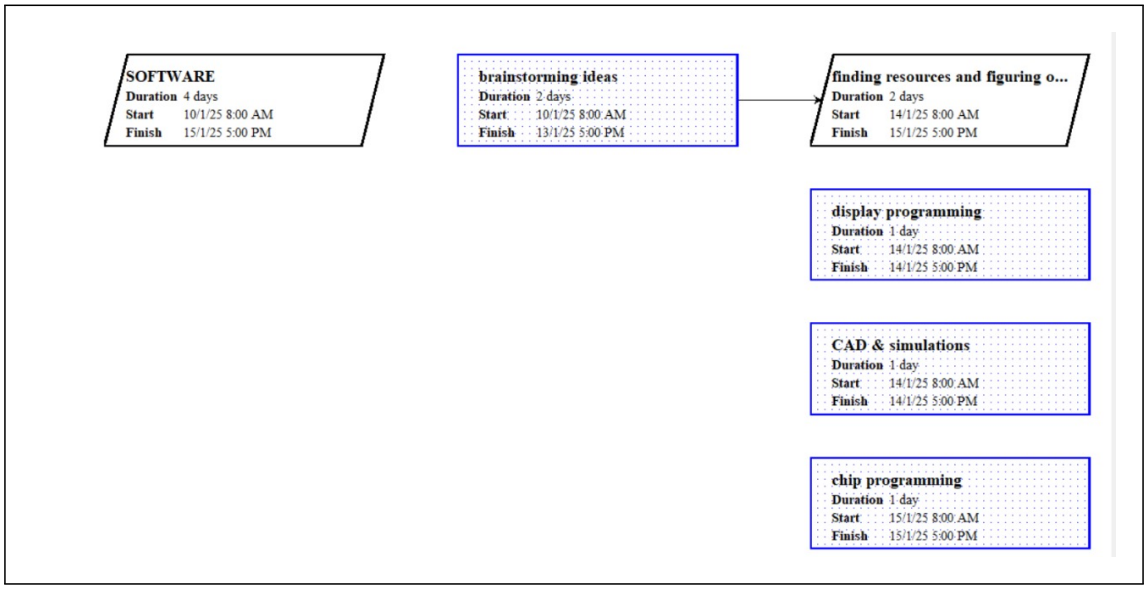

Figure 5: Software Development Flowchart

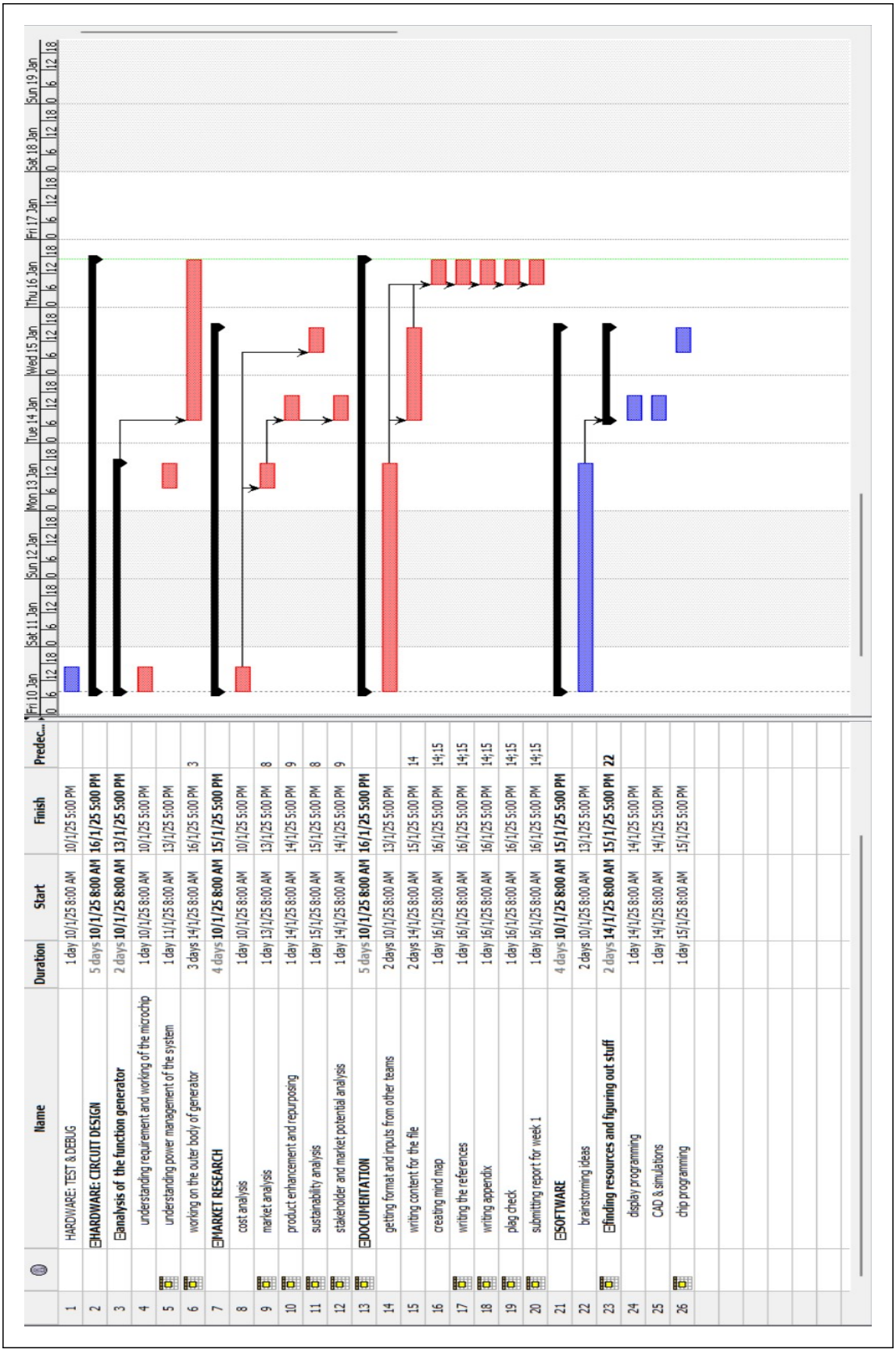

Figure 6: Project Timeline in Gantt Chart

vii. Project Statement

Design and development of a multifunctional signal generator for producing various waveforms with adjustable parameters for laboratory testing and experimentation.

viii. 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.

Chapter 1

Motivation

The development of an affordable and versatile **function generator** addresses a significant market opportunity in India's growing electronics and testing sector. Our product targets three primary **stakeholder segments**: **educational institutions** (including 25,000+ technical institutes) [9], **hobbyist communities** (approximately 50,000 active electronics enthusiasts), and **small businesses** (around 10,000 electronics firms). The **market size** analysis reveals promising potential, with estimates ranging from **Rs. 15 Lakhs** (worst-case) to **Rs. 1.6 Crore** (best-case) in revenue, based on projected sales of 1,500 to 16,000 units at **Rs. 1,000** per unit .We have estimated the total addressable market of Function generators in India to be **USD 2.35 Billion by 2030** servicable available market to be **USD 940 million by 2030.**[8]

The product's primary **Unique Selling Proposition** lies in its **competitive pricing** and **enhanced capabilities** compared to alternatives like the Techtonics XR2206, offering a superior **frequency range** (10 MHz vs. 1 MHz) at a comparable price point. This accessibility makes advanced signal generation technology available to budget-conscious institutions and individuals. Furthermore, the product incorporates **sustainable practices** through the use of recycled materials, appealing to environmentally conscious consumers.

A significant advantage lies in the product's **re-purposing potential**, particularly in the **audio and music sectors** [3]. The **signal generation technology** and **digital-to-analog converters** can be effectively utilized for **sound system calibration**, **audio equipment diagnostics**, and **professional studio monitoring**. Based on stakeholder expectations, the function generator delivers **multiple waveform generations** (sine, square, triangle, ramp, and pulse), adjustable **output signal amplitude** (Vpp), and **DC offset capabilities**.

The **development methodology** is tailored for small to medium-scale production, focusing on **quality control** and efficient assembly processes, suitable for the projected market size. The product maintenance strategy includes clear **Service Level Agreements** enforced through authorized service centers, ensuring a **24-hour response time** for technical support and repairs, thus maintaining customer satisfaction and product reliability in this competitive market segment.

Chapter 2

Requirements[1]

2.1 Inputs

1. **Display Module (20x4 LCD Display)**: [2]
   - 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.[10]
2. **Microcontroller**: ATmega328P chip, to be used with pseudo-Arduino.[11]
   - Requirements for pseudo-Arduino: Crystal oscillator and USB cable.[4]
3. **Frequency Range**:
   - For sine wave: 1mHz – 10MHz.
   - For other waveforms: 1mHz – 3MHz
   - Frequency resolution: Fine adjustments of the order of 1 mHz.
4. **Waveform Types**: Sine, square, triangular, pulse and ramp waves can be generated.
5. **Amplitude Settings**: Adjustable from 0 to 5 V (peak-to-peak) with a resolution of 0.01 V.
6. **Control Interfaces**:
   - Physical rotary knobs for coarse adjustments.[5]
   - Additional knob for finer adjustment of frequency values.[5]
7. **Modulation Inputs**:
   - Supports AM, FM, and PM modulation modes.
8. **Power Supply**:
   - Requires a standard AC input (220V/50Hz).

- Internal conversion to DC for stable operation.

9. **Additional Inputs**:
    - Toggle switches for function selection.[12]
    - 2/3-pin input connectors for external components.
    - A PCB, onto which components would be soldered.[7]

2.2 Outputs

1. **Output Impedance**: Configured to 50 Ω for compatibility with standard test equipment.
2. **Waveform Accuracy**: Less than 1% distortion across all frequencies and amplitudes.
3. **Signal Stability**: Output frequency drift not exceeding 0.01%.
4. **Voltage Offset**: Programmable DC offset adjustable between -5V to +5V.
5. **Frequency Precision**: Accuracy within 0.01% of the programmed value.
6. **Output Connectors**:
    - SMA connectors for signal output. [7]
    - Support for backlight connections with optional 220Ω resistor for current limiting.

2.3 Power Requirements

1. **Power Consumption**: Maximum 20 W under full load.

2.4 Logistical Requirements

1. **Portability**: Compact design with a weight of under 3 kg.
2. **Accessories**: Supplied with BNC cables, probes, knobs, and a user manual.

2.5 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. **EMI/EMC Compliance**: Meets electromagnetic interference and compatibility standards.

2.6 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.

2.7 Structural Requirements

1. **Chassis**: Durable recycled plastic enclosure.
2. **Control Panel**:
   - Intuitive layout with labeled controls.
   - Backlit buttons for visibility in low-light conditions.
3. **Protective Measures**:
   - Fuse for circuit protection.
   - Recycled plastic to shield internal components.

2.8 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.

2.9 Other Non-Functional Requirements

1. **Aesthetic Design**: Modern, sleek appearance.
2. **Safety**: Certified for safety under IEC 61010-1 standards.
3. **Serviceability**: Modular design for easy part replacement.
4. **Reliability**: Mean Time Between Failures (MTBF) of at least 10,000 operational hours.
5. **Weight**: Maximum weight of 3 kg to ensure portability.

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Appendix A

Document Statistics

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- Number of characters: 21841
- Readability Indices:
  - Readability Score(WebFx): 44.4
  - Flesch Reading Ease: 41.6
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  - Gunning Fog Index: 11.58
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Appendix 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/`

Appendix C

Document ID

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Appendix D

Minutes of the Meeting

The minutes of all meetings held between the tribe and its subtribes are documented in the following Google Doc. You can access the document by clicking *here*.