University of Moratuwa
Faculty of Engineering
Department of Electronic & Telecommunication Engineering


# EN2160 - Electronic Design Realization

## **MP3 Player**
Design Report

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# Contents

# Abstract

**This report comprises detailed workings of my MP3 player design. The device takes music inputs from an SD card and it's being processed to output an analog output via a 3.5 mm audio outlet. Which can be connected to any wired music output (to a small speaker or to a headset)z.I have designed 3 inputs to control the device and an OLED display. The device can play up to 255 preloaded songs. Apart from the main design, ADDITIONALLY I chose a high-capacity battery pack to power the device instead of a traditional power pack in making the device also act as a power bank.**


# 1 Introduction

The mp3 player is a simple device that can play music stored in the device when connected to a headset. I have created my version of the device including the power bank functionality.

# 2 Design Specifications

## 2.1 Display

A standard 0.96 inch OLED display is used due to its compact size rather than a long LED display.

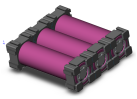
## 2.2 Control IC


Since I am planning to implement display and control buttons I need an IC that is capable of storing and executing the code I have written. I have chosen Atmega 328p as my IC and I went with SMD rather than the throughout IC to make the device compact.

## 2.3 SD card storage

I wanted to decode audio to output the analog waveform. Hence I have used a module named "DFPlayer mini" which has a built-in audio decoder in addition to an SD card slot.

## 2.4 Battery



Three 18650 3600mAh Li-ion batteries in parallel have been used to provide the power bank functionality and to play music for a longer period.

## 2.5 Boost converter

A boost converter is introduced to up the voltage from 3.7V to 5V in order to charge external devices.

## 2.6 Charging and regulation circuit

Since the device uses high-capacity li-ion batteries, Overcharging and over-discharging need to be accounted for. hence I have used a Li-ion battery charging IC, a Potection IC, and a Mosfet IC to ensure the safety of the batteries and the circuit. From many options i have selected TC4056 (Charging Management IC), DW01 (Protection IC) and for dual mosfet FS8205.
Selecting the DW01 battery protection IC, FS8205 power MOSFET, and TC4056 charging management IC for your charging circuit could provide a well-rounded solution with essential features and protections. Here are some reasons why you might choose these components:

- **DW01 (Battery Protection IC):**
  - **Overcharge Protection:** The DW01 provides overcharge protection by disconnecting the charging circuit when the battery reaches its maximum voltage level, preventing damage due to excessive charging.
  - **Overcurrent Protection:** DW01 safeguards the battery and charging circuitry from overcurrent conditions by detecting excessive currents during charging and cutting off the charging path.
  - **Short Circuit Protection:** It detects short circuits and interrupts the charging process to prevent further issues and ensure safety.
  - **Cell Balancing (Optional):** If you are using a multi-cell battery pack, some versions of the DW01 support cell balancing to ensure individual cells have similar charge levels, improving battery performance and longevity.

- **FS8205 (Power MOSFET):**
  - **High Current Handling:** The FS8205 is a dual power MOSFET package, capable of handling higher currents, which is beneficial for charging higher capacity batteries or multiple battery cells.
  - **Low On-Resistance (RDS(on)):** The FS8205 has low RDS(on), minimizing power dissipation and voltage drop across the MOSFET during charging, leading to higher charging efficiency.
  - **P-Channel MOSFET:** Being a P-channel MOSFET, it can easily be used as a low-side switch in the charging circuit, effectively controlling the charging current flow to the battery.
- **TC4056 (Charging Management IC):**
  - **Integrated Charging Solution:** The TC4056 is a complete linear single-cell Li-Ion battery charger, which simplifies the charging circuit design by providing most of the necessary charging functions in a single chip.
  - **Charging Current Control:** TC4056 allows you to set the charging current, which is useful when you need to charge the battery at a specific rate suitable for your application and battery capacity.
  - **Charging Indicator (Optional):** Some versions of TC4056 come with built-in charging status indicators, such as LED outputs, making it easier to provide visual feedback to the user about the charging process.
  - **Thermal Protection:** The TC4056 includes thermal protection to prevent the IC from overheating during charging or in case of abnormal conditions, ensuring safer operation.

By combining the DW01 battery protection IC, FS8205 power MOSFET, and TC4056 charging management IC, you create a charging circuit that includes necessary battery protection features, efficient charging, and controlled current delivery to the battery. However, always verify the compatibility of these components, check their datasheets for detailed specifications, and consider your specific application requirements before finalizing the design. Additionally, make sure to follow best practices for charging Li-Ion batteries to ensure safe and reliable operation.

# 3 Functionality Description

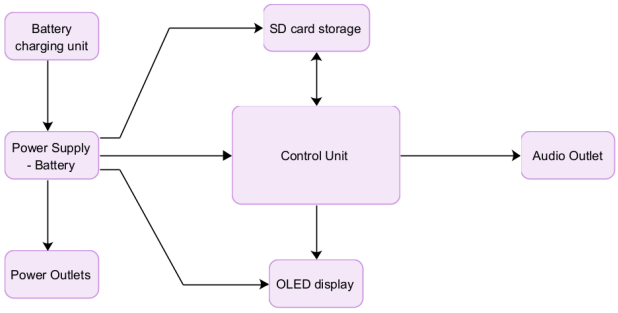



**Figure 1:** Block Diagram

Three inputs "prev", "next" and "select" has been used to navigate through songs and also change volume. When press play in the display song on the SD card will be converted to digital and outputted. Volume control can control the output volume from mute to max being 60db divided into 30 levels.

# 4 PCB Design

Schematic of the design is shown in 3 pages as follows.

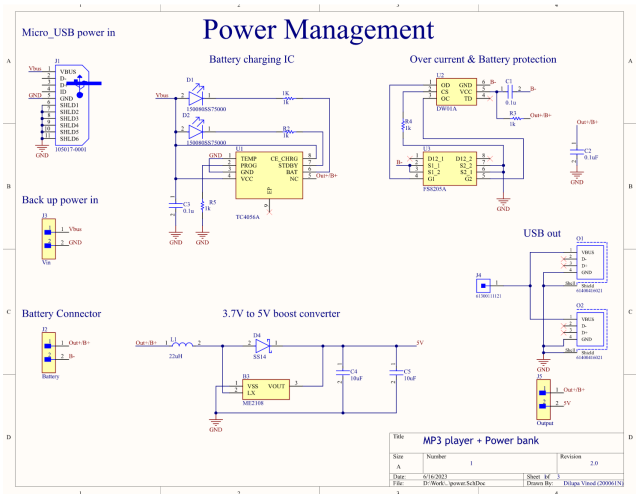



**Figure 2:** Page 1

This schematic shows how the power input is taken from a micro-USB inlet and how the battery protection explained earlier happened. There's a booster circuit to boost the voltage to output from the USB outlets. Two USB outlets are used to charge external devices.

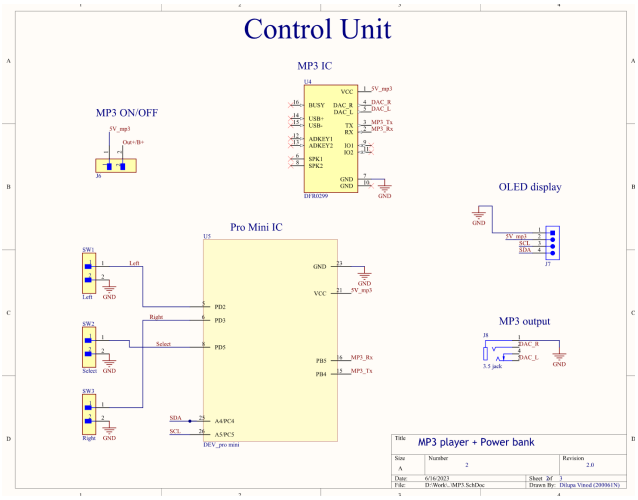



**Figure 3:** Page 2

This is the control structure of the MP3 player.

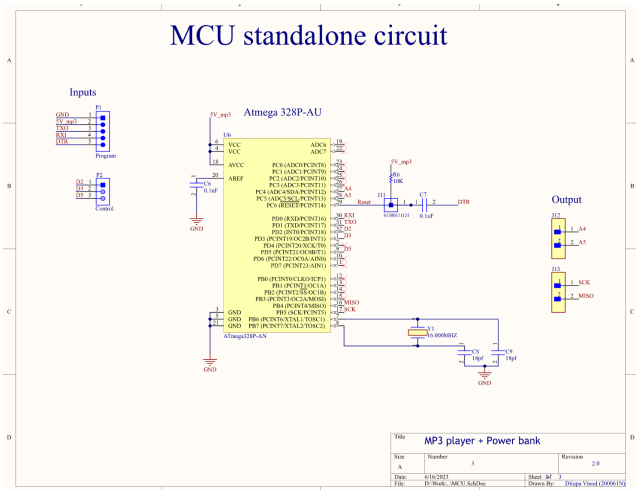



**Figure 4:** Page 3

This contains the expanded view of PRO Mini IC. The oscillator and internal connections.
After routing the PCB on two layers final output is as follows. Here the PCB is mainly routed on the top layer because mostly SMD components are used and through-hole components are placed on the bottom layer and meant to solder from the top.

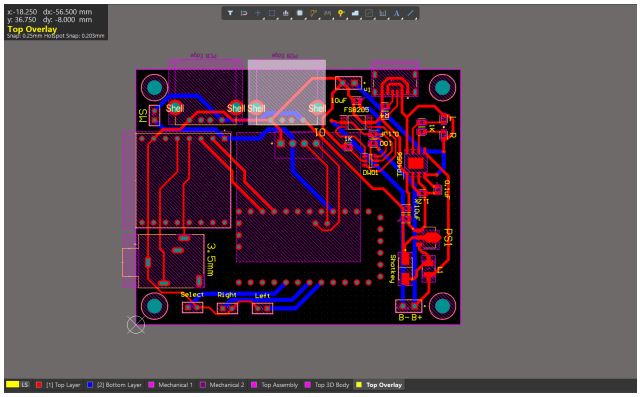


**Figure 5:** PCB

Final 3D view from altium viewer:

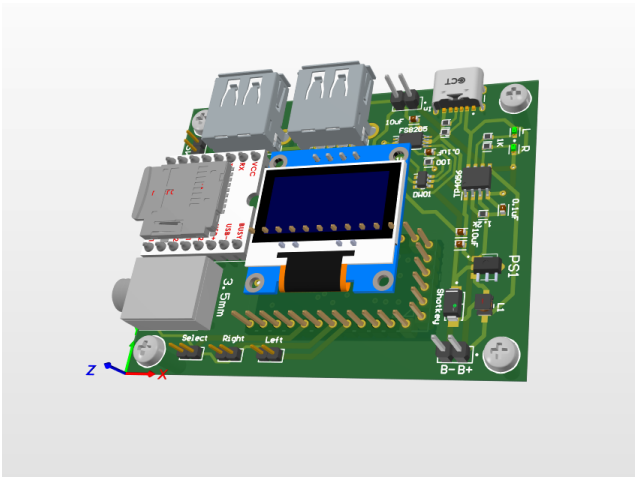



**Figure 6:** PCB-Altium

Fabrication outputs are attached in **Appendix II: Design Files**.

## 5 Components/BOM

All of the components were ordered from LCSC or Mouser and assembled here. The total cost for the components are given in **Appendix I: BOM**

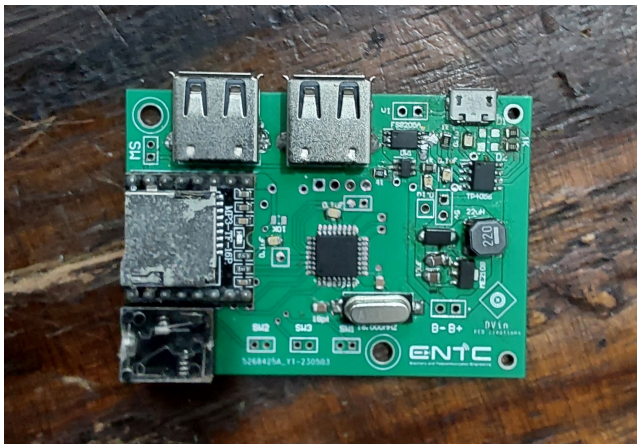
## 6 Enclosure Design

The enclosure was designed by Solidworks. Two halves are fitted with the lip and grove method in addition to three screws from the back. Holes are created for buttons, Audio-out, SD card, display, and power inlets and outlets.

**Figure 7:** Solidwork - 3D enclosure

## 7 Soldering and Testing

After receiving the PCB from china I have soldered the components into the PCB in order to test the device. Fully soldered PCB without the display is given below.



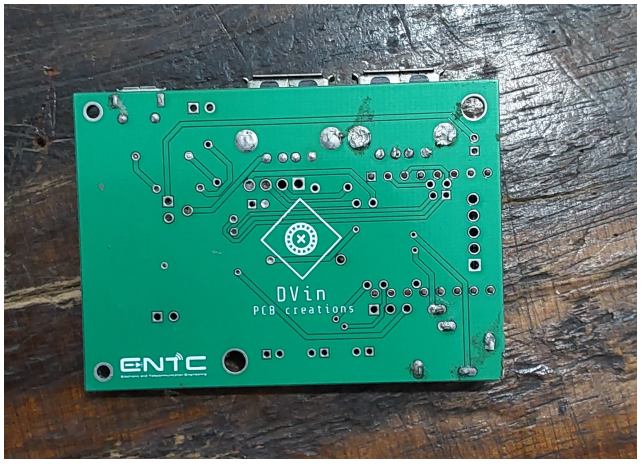
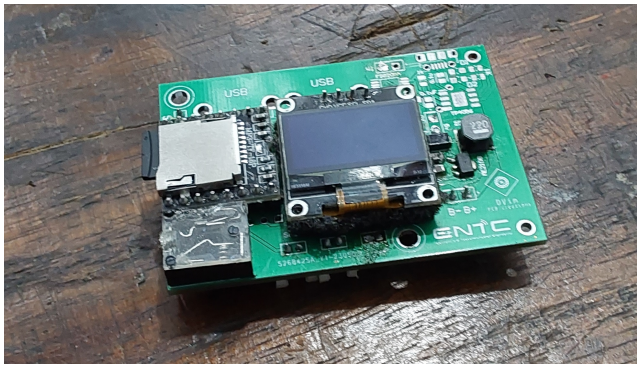



**Figure 8:** Soldered PCB

When testing found out that the FS8205 IC closest to the micro-USB outlet is burnt out and when removing some of the pad also came with it making it impossible to resolder. Hence I had to use another PCB where I bypass the battery protection externally and soldered the display also. I have used insulation behind the display to provide support and elevation and also protection from short-circuiting.



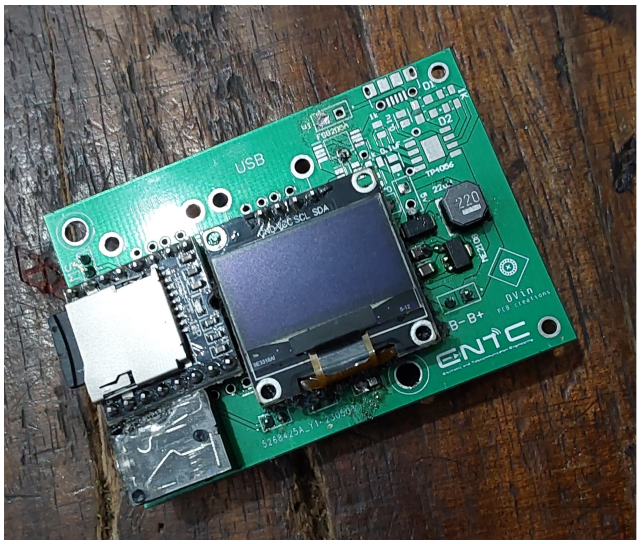



**Figure 9:** Soldered PCB

Now it worked fine except for the power output part which isn't soldered into the new PCB. The power boosting circuit worked well but as I used a high-capacity battery pack, that section of the PCB tends to heat up drawing high currents and eventually burning the boost converter. I tried to include a current controller which end up not giving enough power to turn on the SD card digital to analog converter. Hence I have to redesign my PCB with a method to control the heating. For now, the circuit works to some satisfactory extent, but not perfectly.

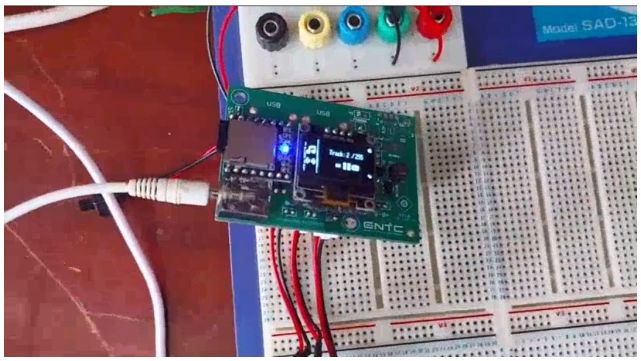


**Figure 10:** Functionality

The battery pack was also soldered as shown. The best way to do this is to use aluminum stripes and spark solder which I couldn't do due to lack of facilities.

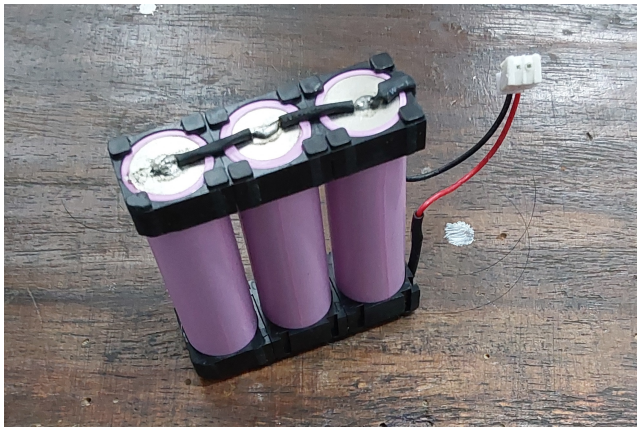


**Figure 11:** Soldered Battery pack

Then everything is assembled into the enclosure. JFT connectors used to wire everything together.

## 8 Final prototype

After I have received the printed enclosure, I fitted every part in with screws to fix them to the enclosure.

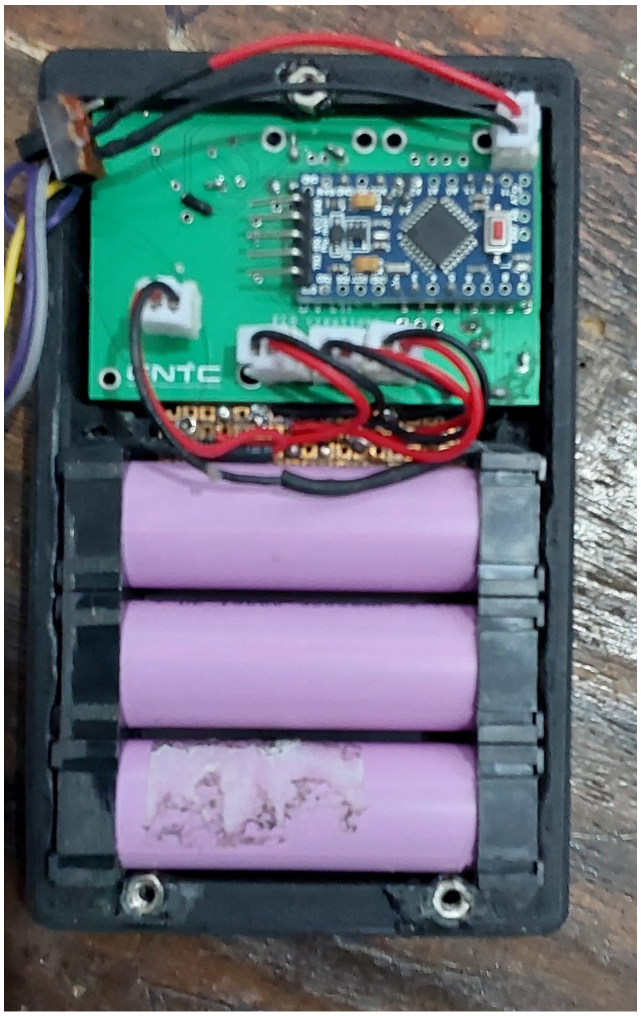


**Figure 12:** Assembled device

Progress from First prototype to final demonstrated prototype can be seen in **Appendix III: Final Product Assembly**

**Figure 13:** Final look

To close up the device screw in 3 screws in the back.

## 9 Instruction to use

First-time use, you first have to connect the device to external power via the charging port to reset the IC's logic levels. Thereafter charging is only necessary when the battery drains. Avoid contact with water as the device is not waterproof.

# Appendix I: BOM

**Table 1:** BOM

| Description | Designator | Supplier | Part Number | Unit Price | Subtotal |
|---|---|---|---|---|---|
| 6.5V 400mA SOT-23(SOT-23-3) DC-DC Converters RoHS | B3 | LCSC | ME2108A33PG | $0.09 | $0.09 |
| Cap Ceramic 100nF 16V X7R ±5% Pad SMD 0603 +125°C T/R | C1 | Mouser | CL10B104KO8NNNC | $0.10 | $0.10 |
| CAP CER 0.22UF 50V X7R 0805 | C2 | Mouser | C0805C224K5RAC | $0.02 | $0.10 |
| CAP CER 0.22UF 50V X7R 0805 | C3 | Mouser | C0805C224K5RAC | $0.02 | $0.10 |
| CAP CER 0.22UF 50V X7R 0805 | C4 | Mouser | C0805C224K5RAC | $0.02 | $0.10 |
| CAP CER 0.22UF 50V X7R 0805 | C5 | Mouser | C0805C224K5RAC | $0.02 | $0.10 |
| Chip Multilayer Ceramic Capacitors for General Purpose, 0805, 22uF, X5R, 15%, 20%, 6.3V | C6 | Mouser | 81-GRM21R60J226ME39L | $0.27 | $1.08 |
| Chip Multilayer Ceramic Capacitors for General Purpose, 0805, 22uF, X5R, 15%, 20%, 6.3V | C7 | Mouser | 81-GRM21R60J226ME39L | $0.27 | $1.08 |
| Chip Multilayer Ceramic Capacitors for General Purpose, 0805, 22uF, X5R, 15%, 20%, 6.3V | C8 | Mouser | 81-GRM21R60J226ME39L | $0.27 | $1.08 |

**Table 2:** BOM - Continued

| | | | | | |
|---|---|---|---|---|---|
| Chip Multilayer Ceramic Capacitors for General Purpose, 0805, 22uF, X5R, 15%, 20%, 6.3V | C9 | Mouser | 81-GRM21R60J226ME39L | $0.27 | $1.08 |
| LED RED CLEAR 0805 SMD | D1 | Mouser | 710-150080SS75000 | $0.19 | $0.38 |
| LED RED CLEAR 0805 SMD | D2 | Mouser | 710-150080SS75000 | $0.19 | $0.38 |
| DIODE SCHOTTKY 40V 1A DO214AC | D4 | Mouser | 625-SS14-E3 | $0.48 | $0.48 |
| Micro-USB B Receptacle, Right Angle, Bottom Mount, Surface Mount, with Solder Tabs, -30 to 85 degC, 5-Pin USB, RoHS, Tape and Reel | J1 | Mouser | 538-105017-0001 | $0.93 | $0.93 |
| 3.50mm (0.141", 1/8", Mini Plug) - Headphone Phone Jack Stereo (3 Conductor, TRS) Connector Solder | J8 | Mouser | 35RAPC2BH3 | $2.54 | $2.54 |
| Shielded Wirewound Inductor 22uH 20% 1.5A 0.1495 SMD | L1 | Mouser | 963-NR6045T220M | $0.41 | $0.41 |
| USB 2.0 Type A Receptacle WR-COM, Horizontal, THT | O1 | LCSC | C42642 | $0.04 | $0.07 |

**Table 3:** BOM - Continued

| | | | | | |
|---|---|---|---|---|---|
| Resistor | 1K | Mouser | 71-CRCW0805-0-E3 | $0.03 | $0.30 |
| Resistor | R2 | Mouser | 71-CRCW0805-0-E3 | $0.03 | $0.30 |
| Resistor | R3 | Mouser | 71-CRCW0805-0-E3 | $0.03 | $0.30 |
| Resistor | R4 | Mouser | 71-CRCW0805-0-E3 | $0.03 | $0.30 |
| Resistor | R5 | Mouser | 71-CRCW0805-0-E3 | $0.03 | $0.30 |
| Resistor | R6 | Mouser | 71-CRCW0805-0-E3 | $0.03 | $0.30 |
| Integrated Circuit | U1 | LCSC | C725790 | $0.07 | $0.07 |
| Integrated Circuit | U2 | LCSC | C35306 | $0.13 | $0.13 |
| MOSFET (N-Channel) | U3 | LCSC | C16052 | $0.21 | $0.21 |
| Dfplayer - a Mini Mp3 Player | U4 | Dfrobots | DFR0299 | $5.90 | $5.90 |
| 8-bit AVR Microcontroller, 32KB Flash, 1KB EEPROM, 2KB SRAM, 32-pin TQFP, Industrial Grade (-40°C to 105°C) | U6 | Mouser | 556-ATMEGA328P-AN | $2.80 | $2.80 |
| Crystal or Oscillator | Y1 | Mouser | 520-CSM491-20DN | $1.27 | $1.27 |
| 0.96 inch 4 pin | | Mouser | CS-ANAVI-DISPLAY-1 | $6.50 | $6.50 |
| | | | | **Total** | **$28.76** |

# Appendix II: Design Files

## Garber files

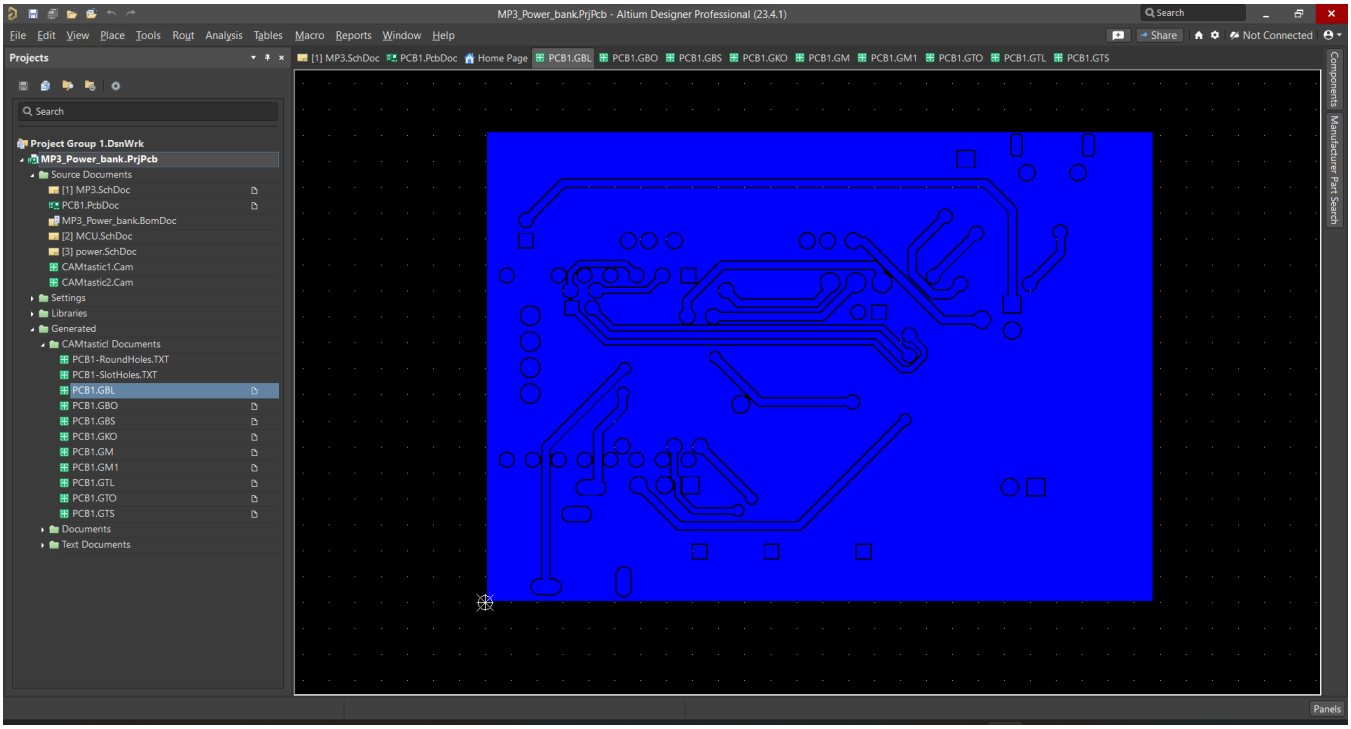



**Figure 14:** Bottom Layer - GBL

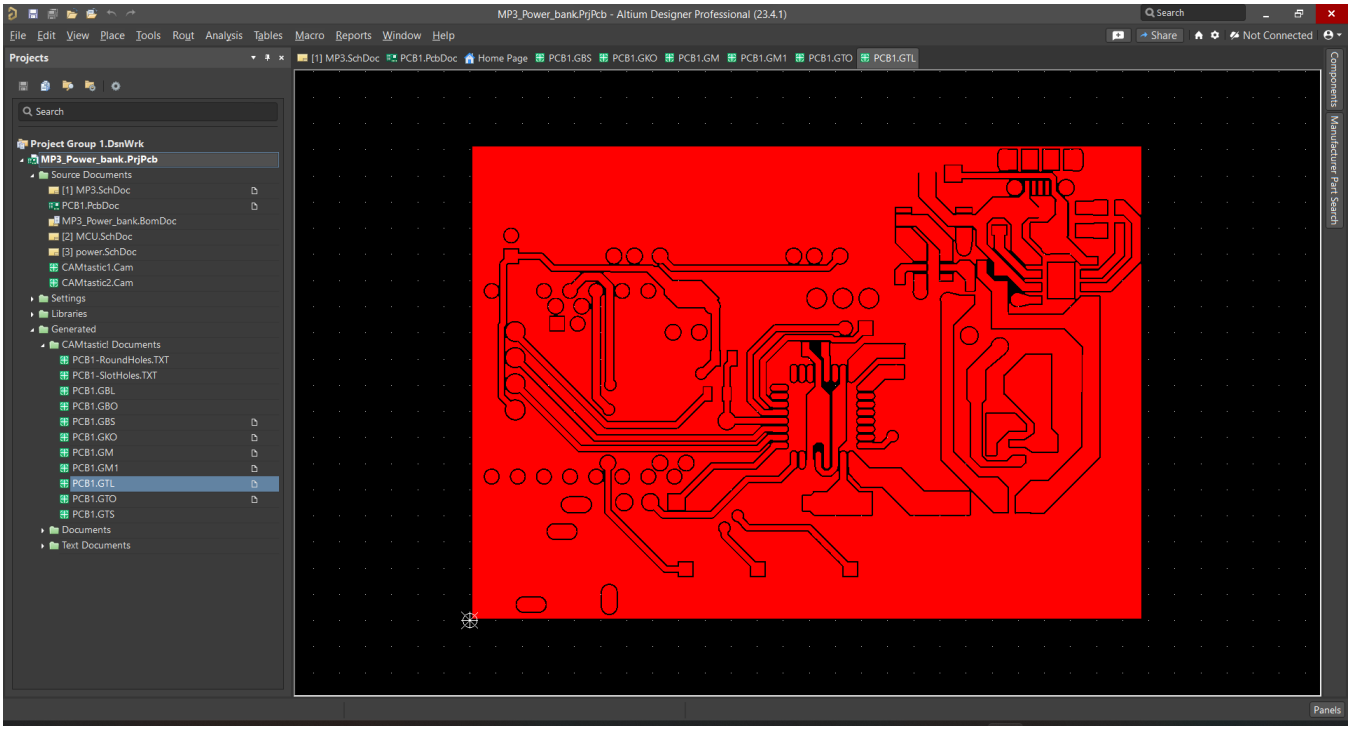



**Figure 15:** Top Layer - GTL

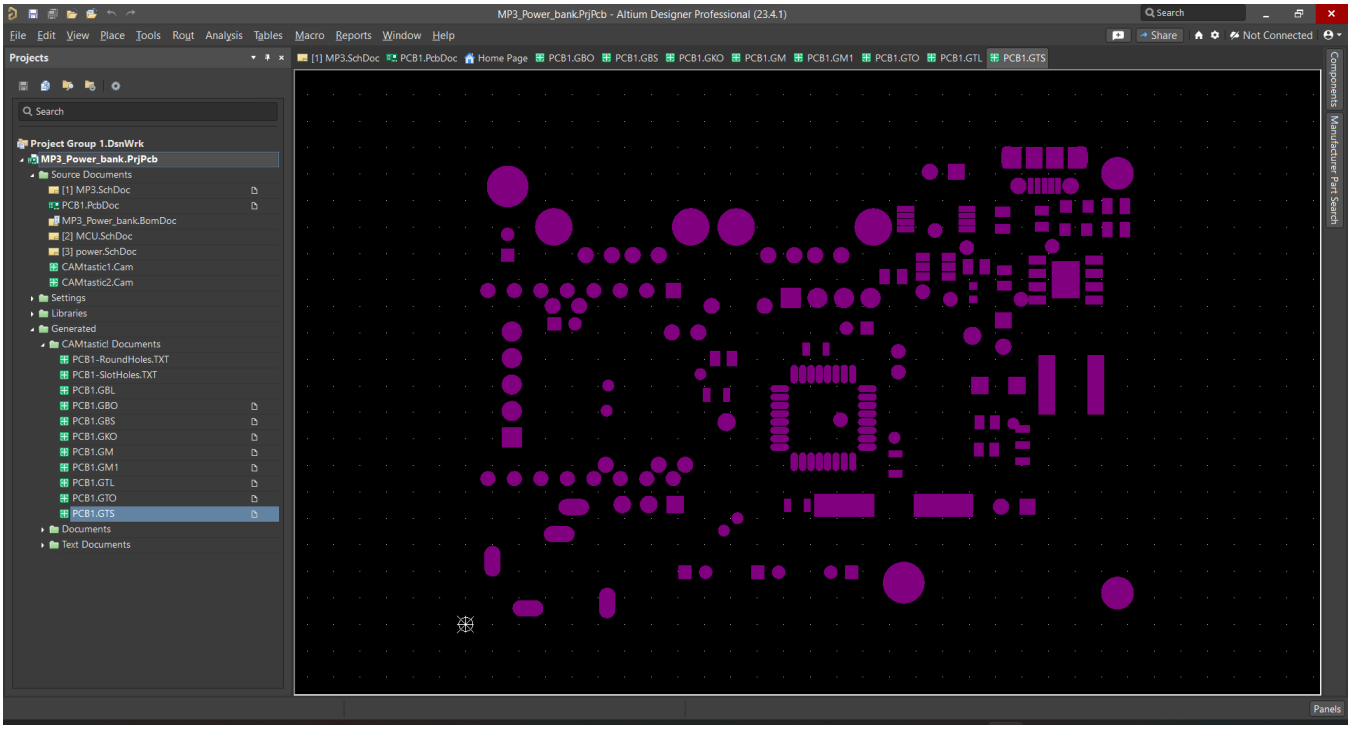



**Figure 16:** TOP solder - GTS

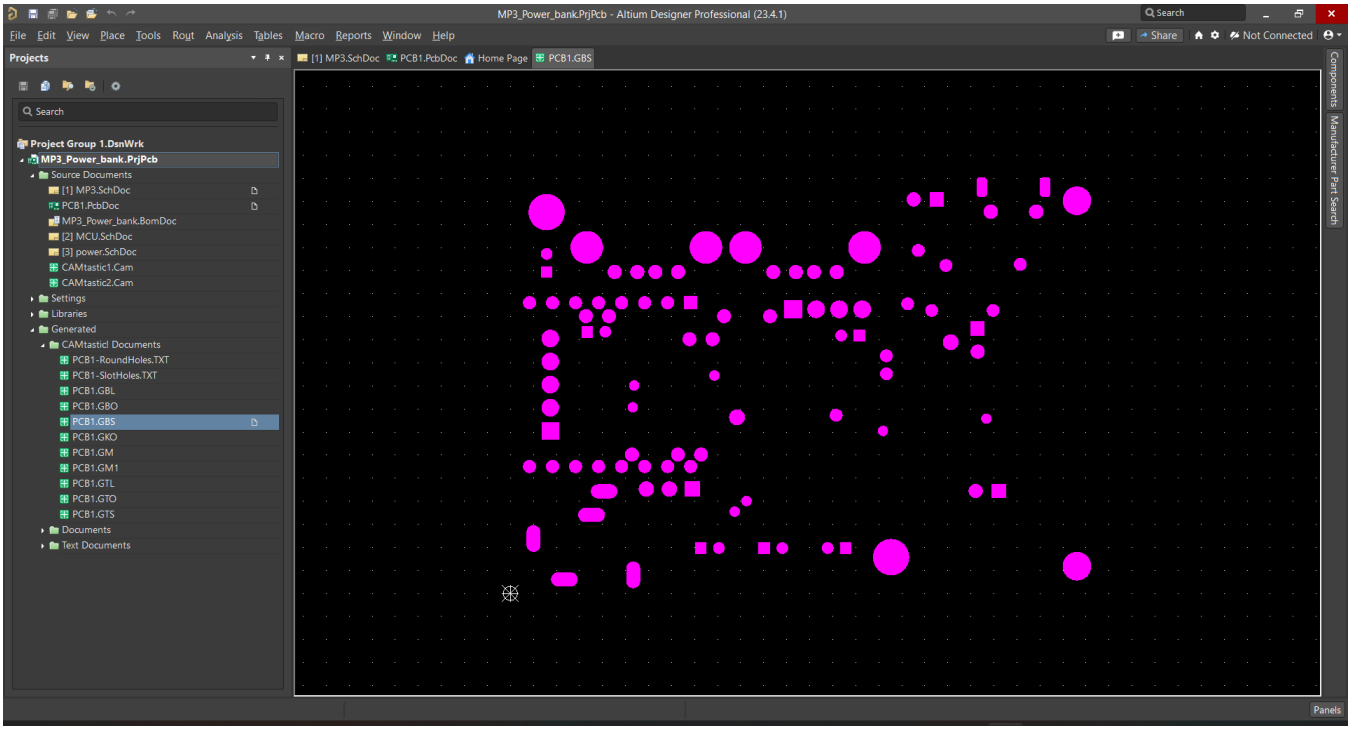



**Figure 17:** Bottom Solder - GBS

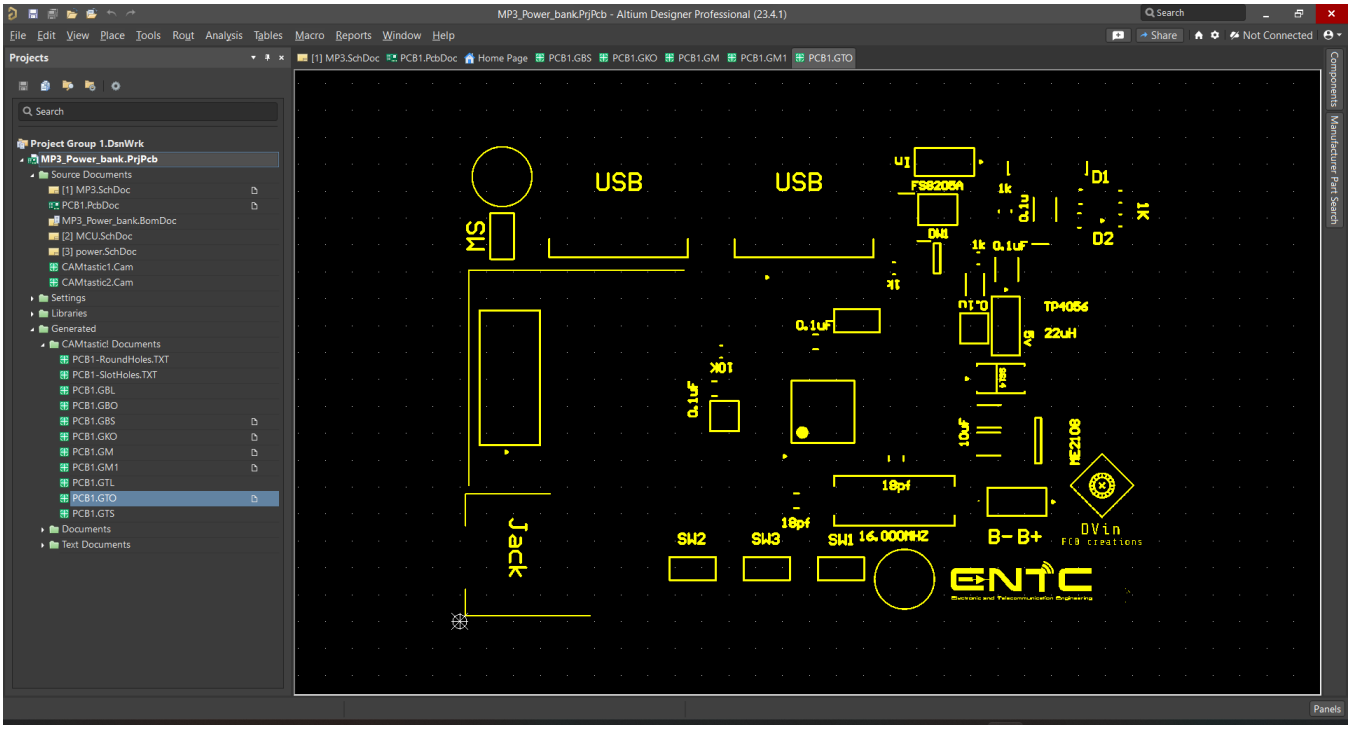



**Figure 18:** Top-overlay - GTO

The Bottom overlay(GBO), and the Keep out layer (GKO) are empty. The mechanical layer (GM1) only contains the frame. Hence not included here

## Enclosure with solidworks

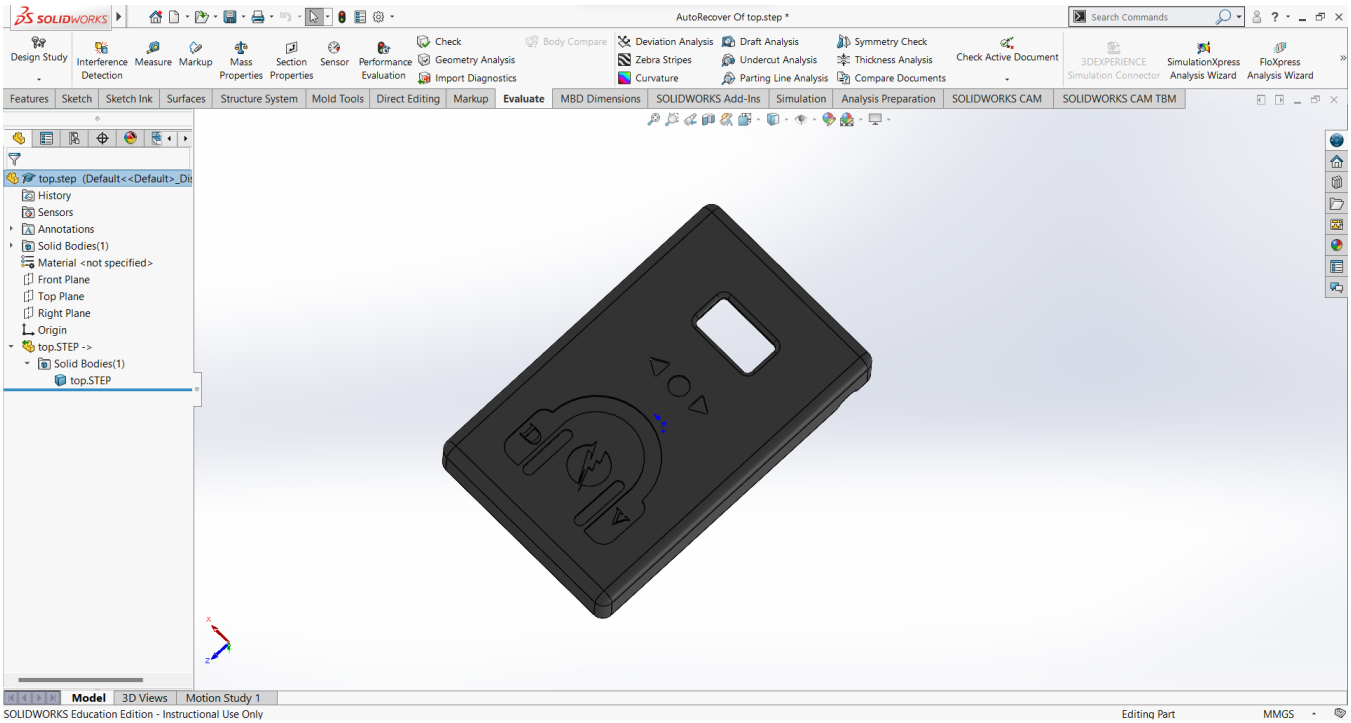



**Figure 19:** Top - Outside

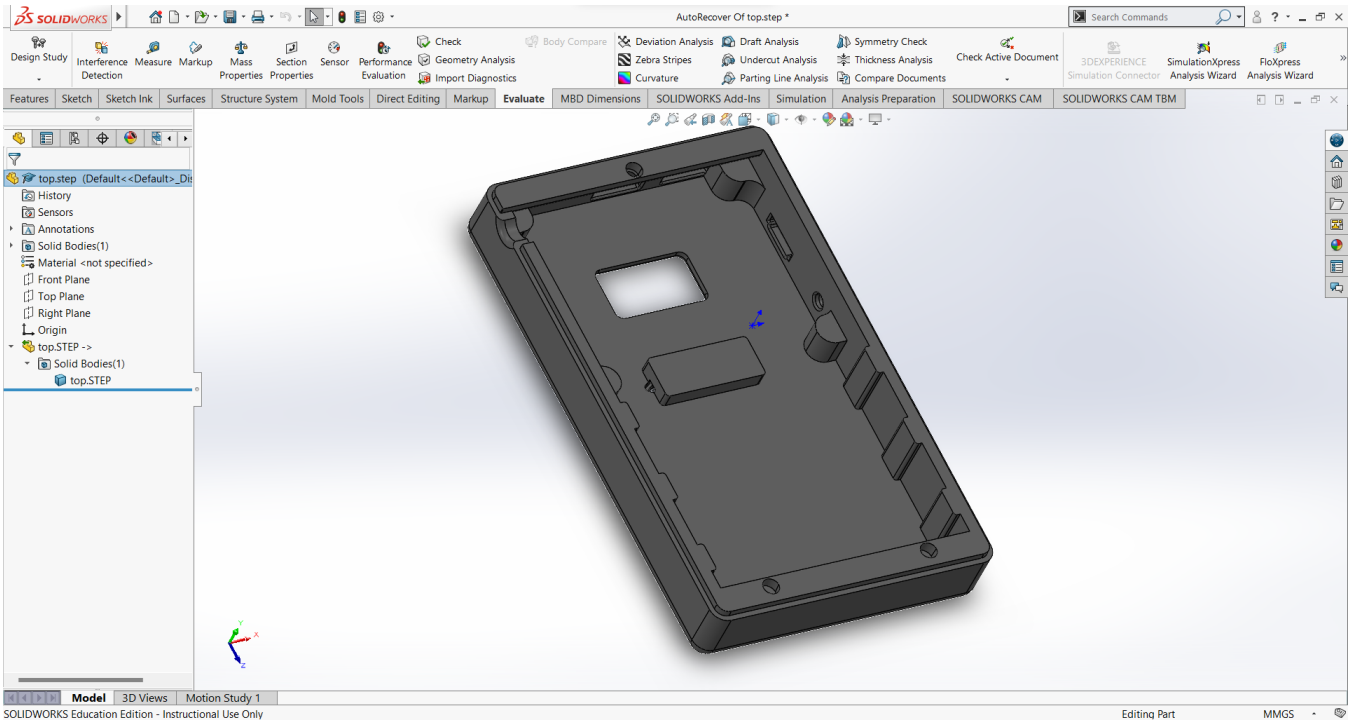



**Figure 20:** Top - Inside

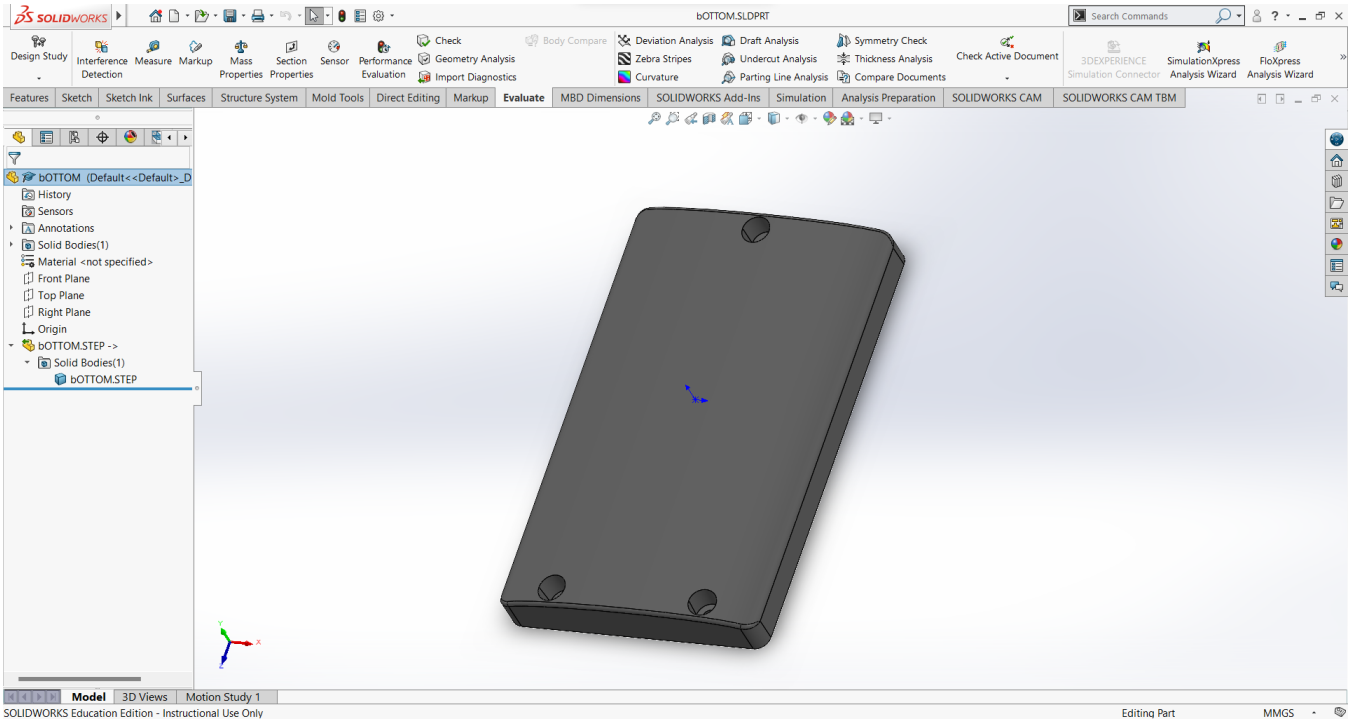



**Figure 21:** Bottom - Outside

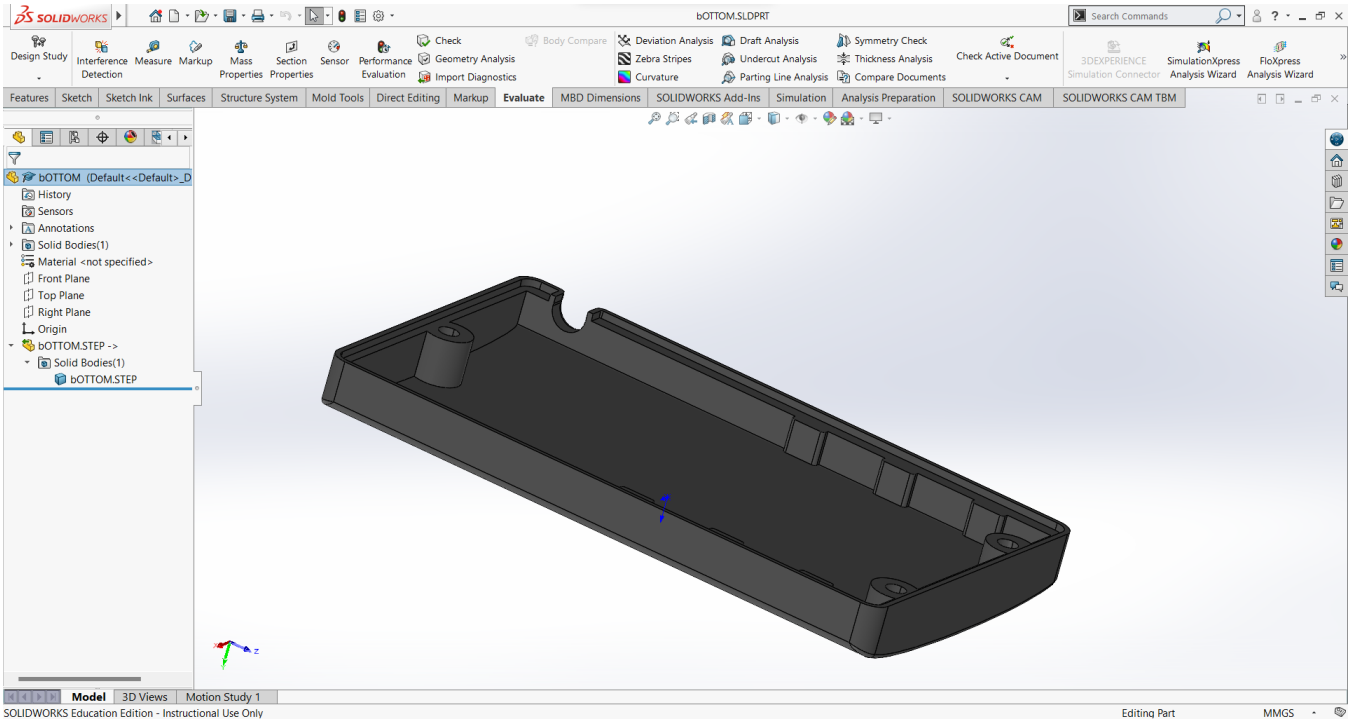



**Figure 22:** Bottom Inside

**Figure 23:** Assembly

## Appendix III: Final Product Assembly


**Figure 24:** First prototype

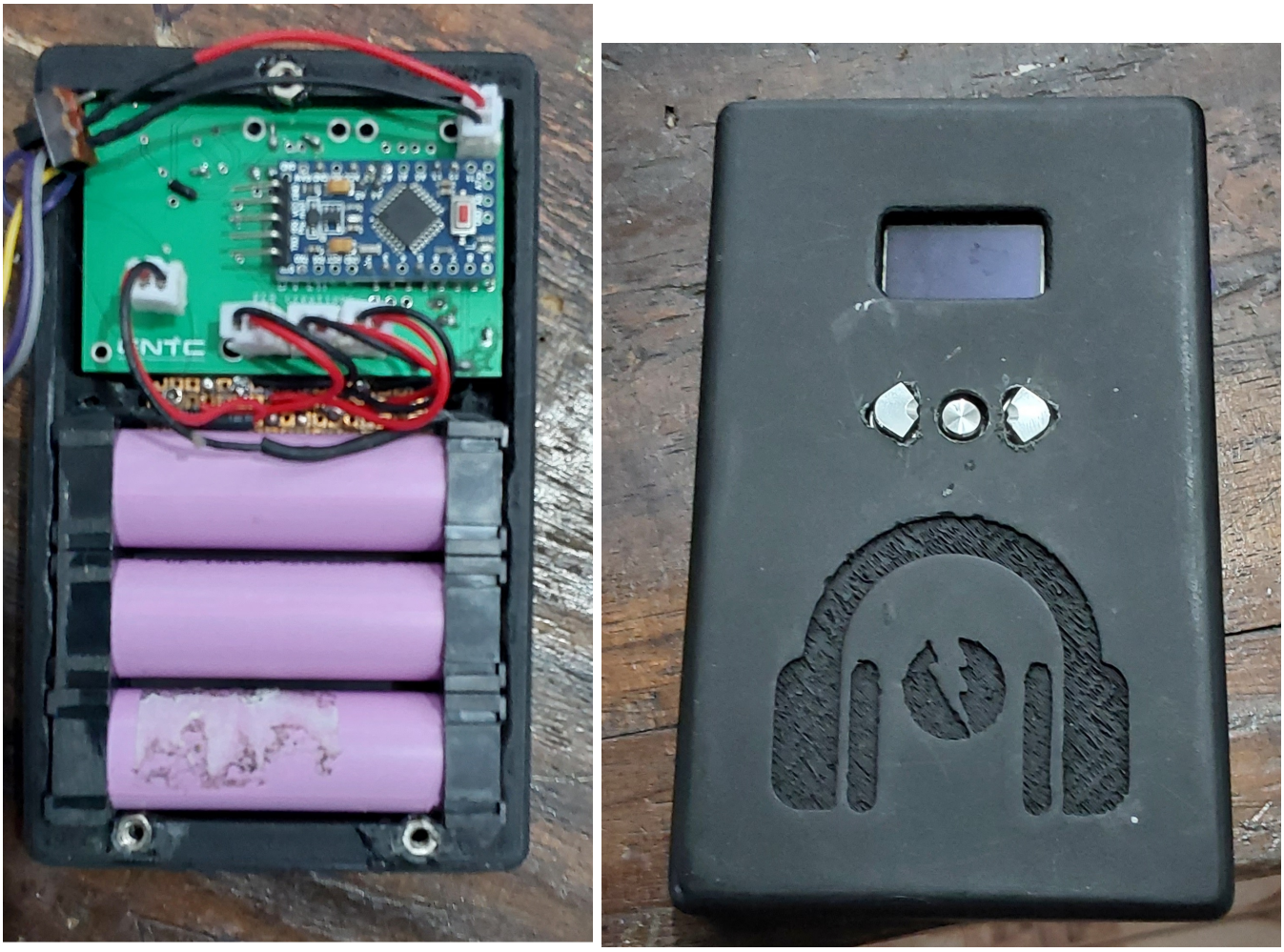


**Figure 25:** Final prototype

# Appendix IV: Display Code

## Main code

```
#include <Arduino.h>
#include <SoftwareSerial.h>
#include <DFRobotDFPlayerMini.h>
#include <U8g2lib.h>
#include <Wire.h>
#include <EEPROM.h>

SoftwareSerial customSoftwareSerial(12,13);
DFRobotDFPlayerMini myDFPlayer;

U8G2_SH1106_128X64_NONAME_F_HW_I2C u8g2(U8G2_R0, /* reset=*/ U8X8_PIN_NONE);

const uint8_t leftButton = 2;
const uint8_t selectionButton = 5;
const uint8_t rightButton = 3;

volatile uint8_t sMenuSelection = 2;
volatile uint8_t selection = 1;
volatile bool updateScreen = true;

boolean playing = false;
boolean inSideMenuSelection = true;

// Variables
uint8_t filecounts;                     // total number of files in current folder
uint8_t foldercounts;                   // total number of folders on sd-card

uint8_t volume = 20;                    // current volume (0 .. 30)
uint8_t folder = 1;                     // current sd-card folder
uint8_t file   = 1;                     // curent file in current folder
uint8_t eq = 0;

uint8_t batteryLevel = 0;
float resistor_ratio_factor = 3.91;
uint8_t mins = 0;
unsigned long lastTimepassed = 0;

void setup(void) {
    //Initializing u8g2 library
    Serial.begin(9200);
  u8g2.begin();
  u8g2.firstPage();
  do{
    flashPage();
  }while(u8g2.nextPage());
  pinMode(leftButton,INPUT_PULLUP);
  pinMode(rightButton,INPUT_PULLUP);
  pinMode(selectionButton,INPUT_PULLUP);

  attachInterrupt(digitalPinToInterrupt(leftButton),leftButtonISR, FALLING);
  attachInterrupt(digitalPinToInterrupt(rightButton),rightButtonISR, FALLING);

  //being hardware serial for debugging
  Serial.begin(9600);
  //Initializing software serial
  customSoftwareSerial.begin(9600);

  if (!myDFPlayer.begin(customSoftwareSerial)) {  //Use softwareSerial to communicate
    with mp3.
    Serial.println(F("Please insert the SD card!"));
  }
  volume = EEPROM.read(0);
  if(volume > 30)
```

```
  volume = 30;

  eq     = EEPROM.read(1);
  if(eq > 5)
  eq = 5;

  file   = EEPROM.read(2);
  if(file >= 255)
  file = 1;

  delay(1000);
  myDFPlayer.volume(volume);  //Set volume value. From 0 to 30
  delay(500);
  foldercounts = myDFPlayer.readFolderCounts();
  startFolderPlay();
//
}

void loop() {
  batteryReader();
//Selection button
  if(!digitalRead(selectionButton) && inSideMenuSelection)
  {
      inSideMenuSelection = false;
      updateScreen = true;
      delay(200);
  }
  else if(!digitalRead(selectionButton) && !inSideMenuSelection && sMenuSelection == 1)
  {
       if(selection == 1)
       {
        if(file > 1)
        {
         //previous audio
         myDFPlayer.previous();
         file--;
         if(!playing)
            playing = true;
         EEPROM.write(2, file);
        }
       }
       else if(selection == 2)
       {
         //pause / play
         if(playing)
         {
          myDFPlayer.pause();
         }
         else
         {
          myDFPlayer.start();
         }
         playing = !playing;
       }
       else if(selection == 3)
       {
          //next audio
          file++;
            myDFPlayer.next();
           if(!playing)
            playing = true;
            EEPROM.write(2, file);
       }
       else if(selection == 4)
       {
         //back to side menu
         selection = 1;
         inSideMenuSelection = true;
```

```
      }
      updateScreen = true;
      delay(200);
  }else if(!digitalRead(selectionButton) && !inSideMenuSelection && sMenuSelection == 2)
  {
     if(selection == 1)
     {
         selection = 2;
         myDFPlayer.volume(volume);
         EEPROM.write(0, volume);
     }
     else if(selection == 2)
     {
        selection = 4;
        myDFPlayer.EQ(eq);
        EEPROM.write(1, eq);
     }
     else if(selection == 4)
     {
         //back to side menu
         selection = 1;
         inSideMenuSelection = true;
     }
     updateScreen = true;
     delay(200);
  }

//Updating the dispaly
  if(updateScreen)
  {
    u8g2.firstPage();
    do {
      int ch = (sMenuSelection);
      switch(ch){
          case 1:
            player();
            break;
          case 2:
            settings();
            break;
          default:
            Serial.println(F("Default Screen"));
        }
      updateScreen = false;
      }while ( u8g2.nextPage() );
  }

   // check player status
  if (myDFPlayer.available()) {
    uint8_t type = myDFPlayer.readType();
    int value = myDFPlayer.read();

    switch (type) {
      case DFPlayerPlayFinished:
        if (file < filecounts) {
          file++;
          myDFPlayer.playFolder(folder, file);
          EEPROM.write(2, file);
          updateScreen = true;
        }
        break;
      default:
        break;
    }
  }
}
```

### audioplayer.ino

```
    // starts to play the actual file in the actual folder
void startFolderPlay() {
  filecounts = myDFPlayer.readFileCountsInFolder(folder);
  myDFPlayer.playFolder(folder, file);
  playing = false;
}

//Battery management
void batteryReader()
{
  if((millis() -  lastTimepassed) > 60000)
  {
  mins++;
  Serial.println("One min");
  lastTimepassed = millis();
  }

  if(mins > 5 || mins == 0)
  {
   /*Add battery logic here*/
  mins = 1;
  updateScreen = true;
  }
}
```

### input.ino

```
    void leftButtonISR()
{
 static unsigned long last_interrupt_time = 0;
 unsigned long interrupt_time = millis();
 // If interrupts come faster than 150ms, assume it's a bounce and ignore
 if (interrupt_time - last_interrupt_time > 150)
 {
  updateScreen = true;
  if(inSideMenuSelection && sMenuSelection < 2)
  {
   sMenuSelection++;
  }
  else if(selection < 4 && sMenuSelection == 1)
  {
     selection++;
  }
  else if(selection == 1 && volume < 30 &&sMenuSelection == 2 && !inSideMenuSelection)
  {
     volume++;
  }
  else if(selection == 2 && eq < 5 && sMenuSelection == 2 && !inSideMenuSelection)
  {
     eq++;
  }
 }
 last_interrupt_time = interrupt_time;
}

void rightButtonISR()
{
 static unsigned long last_interrupt_time = 0;
 unsigned long interrupt_time = millis();
 // If interrupts come faster than 150, assume it's a bounce and ignore
 if (interrupt_time - last_interrupt_time > 150)
 {
  updateScreen = true;
  if(inSideMenuSelection && sMenuSelection > 1)
```

```
  {
   sMenuSelection--;
  }
  else if(selection > 1 && sMenuSelection == 1)
  {
    selection--;
  }
  else if(selection == 1 && volume > 0 &&sMenuSelection == 2)
  {
     volume--;
  }
  else if(selection == 2 && eq > 0 && sMenuSelection == 2)
  {
     eq--;
  }
 }
 last_interrupt_time = interrupt_time;
}
```

### display.ino

```
    void settings()
{
   sideMenu();
   topMenu();
   u8g2.setFont(u8g2_font_glasstown_nbp_tf);

   u8g2.setCursor(65,17);
   u8g2.print(F("Setting"));

   u8g2.setFontMode(0);

   u8g2.setCursor(47,40);
   u8g2.print(F("Volume"));
   if(selection == 1 && !inSideMenuSelection)
    {
    u8g2.setFont(u8g2_font_open_iconic_arrow_1x_t);
    if(volume > 0)
    u8g2.drawGlyph(85,40,77);
    if(volume < 30)
    {
    if(volume < 10)
    u8g2.drawGlyph(100,40,78);
    else
    u8g2.drawGlyph(105,40,78);
    }
    }
   u8g2.setFont(u8g2_font_glasstown_nbp_tf);
   u8g2.setCursor(95,40);
   u8g2.print(volume);
   u8g2.setDrawColor(1);

   u8g2.setCursor(67,60);
   u8g2.print(F("EQ"));
   if(selection == 2 && !inSideMenuSelection)
    {
    u8g2.setFont(u8g2_font_open_iconic_arrow_1x_t);
    if(eq > 0)
    u8g2.drawGlyph(85,60,77);
    if(eq < 5)
    u8g2.drawGlyph(100,60,78);
    }
   u8g2.setFont(u8g2_font_glasstown_nbp_tf);
   u8g2.setCursor(95,60);
   u8g2.print(eq);
   u8g2.setDrawColor(1);
```

```
    if(selection == 4 && !inSideMenuSelection)
    {
    u8g2.setDrawColor(0);
    }
   u8g2.setFont(u8g2_font_open_iconic_arrow_1x_t);
   u8g2.drawGlyph(120,60,83);
   u8g2.setDrawColor(1);
}
void flashPage()
{
  drawIcon(u8g2_font_open_iconic_play_4x_t,u8g2.getDisplayWidth()/2-12,u8g2.
    getDisplayHeight()-22,64);
  u8g2.setFont(u8g2_font_glasstown_nbp_tf);
  u8g2.setCursor(50,63);
  u8g2.print(F("Soundpod"));
//  u8g2.drawStr(50,u8g2.getDisplayHeight()-5,"Soundpod");
}
void topMenu()
{
    u8g2.setFont(u8g2_font_open_iconic_play_1x_t);

    if(volume > 20)
    u8g2.drawGlyph(119,9,79);

    if(volume <= 20)
    u8g2.drawGlyph(119,9,80);

    if(volume < 10)
    u8g2.drawGlyph(119,9,81);
//
//    u8g2.setFont(u8g2_font_glasstown_nbp_tf);
//    u8g2.setCursor(25,9);
//    u8g2.print(batteryLevel);
//    u8g2.setCursor(35,9);
//    u8g2.print("%");
}
void sideMenu()
{
   const uint8_t menuListGlpy[2] = {77,64};
   const uint8_t *menuList[2] = {u8g2_font_open_iconic_play_2x_t,
    u8g2_font_open_iconic_mime_2x_t};

    u8g2.setFontMode(0);

    //Audio player selection
    if(abs(sMenuSelection) == 1 && inSideMenuSelection)
    {
    u8g2.drawRBox(0,12,20,21,3);
    u8g2.setDrawColor(0);
    }

    //Audio player
    drawIcon(menuList[0],2,30,menuListGlpy[0]);

    u8g2.setDrawColor(1);

    //About Selection
    if(abs(sMenuSelection) == 2 && inSideMenuSelection)
    {
    u8g2.drawRBox(0,33,20,19,3);
    u8g2.setDrawColor(0);
    }
    //About
    drawIcon(menuList[1],2,52,menuListGlpy[1]);
//    u8g2.setFont(menuList[1][1]);
//    u8g2.drawGlyph(2,52,menuList[1][0]);

    u8g2.setDrawColor(1);
```

```
    u8g2.drawLine(22,0,22,68);
}
void player()
{
  sideMenu();
  topMenu();

  u8g2_uint_t midOriginX = 64;
  u8g2_uint_t midOriginY = 44;

  u8g2.setFontMode(0);
  u8g2.setCursor(45,25);
  u8g2.setFont(u8g2_font_glasstown_nbp_tf);
  u8g2.print("Track : ");
  u8g2.setCursor(78,25);
  u8g2.print(file);
  u8g2.setCursor(88,25);
  u8g2.print('/');
  u8g2.setCursor(95,25);
  u8g2.print(filecounts);

  if(selection == 1 && !inSideMenuSelection)
    {
    u8g2.drawRBox(midOriginX-7,midOriginY-5,11,9,2);
    u8g2.setDrawColor(0);
    }
    u8g2.setFont( u8g2_font_open_iconic_play_1x_t);
    u8g2.drawGlyph(midOriginX-5,midOriginY+4,73);
    u8g2.setDrawColor(1);

    if(selection == 2 && !inSideMenuSelection)
    {
    u8g2.drawRBox(midOriginX+7.5,midOriginY-8.5,16.5,15,3);
    u8g2.setDrawColor(0);
    }
    u8g2.setFont(u8g2_font_open_iconic_play_2x_t);
    if(playing)
    {
      u8g2.drawGlyph(midOriginX+7.5,midOriginY+7.5,68);
    }
    else
    {
     u8g2.drawGlyph(midOriginX+7.5,midOriginY+7.5,69);
    }
    u8g2.setDrawColor(1);

    if(selection == 3 && !inSideMenuSelection)
    {
    u8g2.drawRBox(midOriginX+25,midOriginY-5,12,9,2);
    u8g2.setDrawColor(0);
    }
    u8g2.setFont(u8g2_font_open_iconic_play_1x_t);
    u8g2.drawGlyph(midOriginX+27,midOriginY+4,74);
    u8g2.setDrawColor(1);

     if(selection == 4 && !inSideMenuSelection)
    {
    u8g2.setDrawColor(0);
    }
    u8g2.setFont(u8g2_font_open_iconic_arrow_1x_t);
    u8g2.drawGlyph(120,60,80);
    u8g2.setDrawColor(1);
}
void drawIcon(const uint8_t* iconName,u8g2_uint_t  x,u8g2_uint_t  y,uint16_t  glyph)
{
    u8g2.setFont(iconName);
    u8g2.drawGlyph(x,y,glyph);
}
```

# Appendix V: Preliminary design approach

## Conceptual Design Process

Department of Electronic & Telecommunication Engineering
Faculty of Engineering
University of Moratuwa


EN2160 - Electronic Design Realization

Conceptual Design

Bandara D.M.D.V. 200061N

June 1, 2023

# Contents

# Proposed Design - Original Interpretation

The following design is my very own interpretation of a MP3 player with the additional charging functionality.

## Initial - Block Diagram

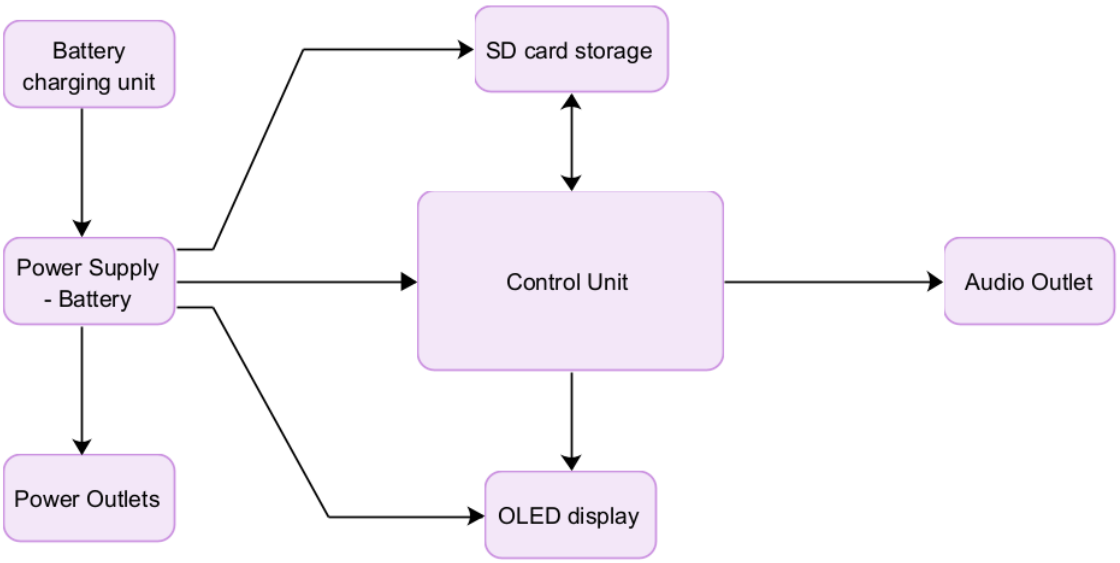



**Figure 1:** Initial - Block Diagram

## Initial - Sketch

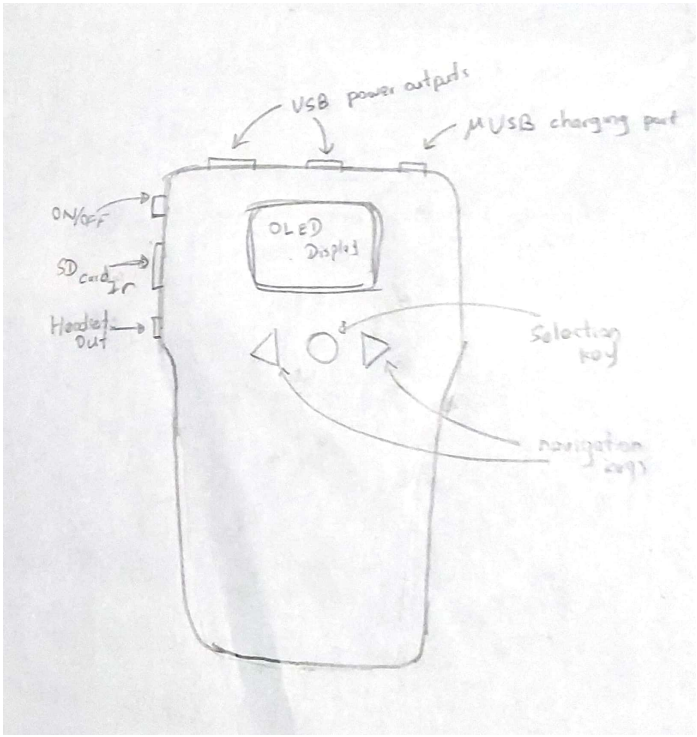



**Figure 2:** Initial - Sketch

## Proposed Specifications

- 9600mAh battery can ensure a longer period of non-interrupted music.
- Songs are stored in a SD card storage.
- 3.5mm Headset Outlet is used to give Sound output.
- USB outlet to charge two devices at the same time.
- 3 Buttons to navigate through songs and control Volume
- OLED display to show the soundtrack number, Volume.
- Micro_USB Inlet to recharge the device

Then this design was subjected to 3 iterations of design-driven innovation cycles which lead to 3 new designs which are included in this report. The group members who actively contributed to the design cycle are,

1. Bandara H.M.S.D. - 200064C
2. Chandira R.M. - 200082E
3. Hewavitharana M.I. - 200220D
4. Marasinghe M.M.H.N.B. - 200381U
5. Pramuditha A.A.H. - 200476P
6. Samarasekera A.M.P.S. - 200558U
7. Wijetunga W.L.N.K - 200733D

And together, we came up with the following three designs.

# Design-Driven Innovation

## Design 1

The first suggestion that everyone agreed upon was to change the traditional design of the enclosure. Disk shape was the one most agreed upon which allowed the design to be very thin and easy to carry( thin like a book ). Also, there is a slit to easily wind the earpiece wires and in the back a dent for the ends to be clipped in. I have to change to a thin LIPO battery to achieve these specifications.

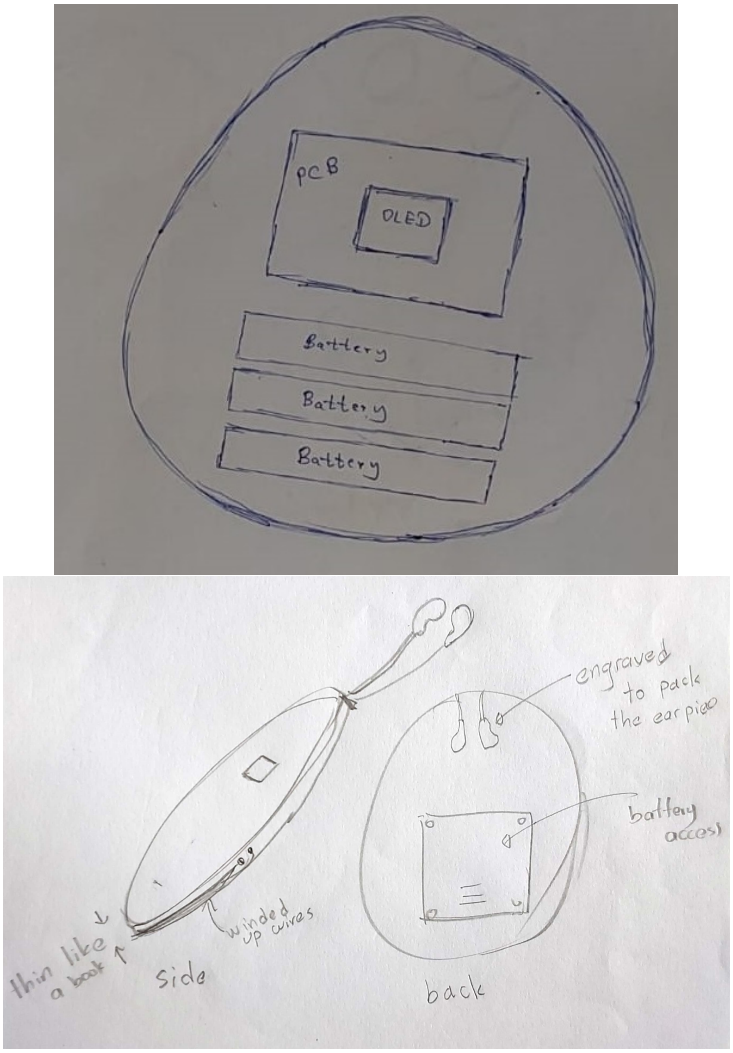



**Figure 3:** Design 02 - sketches

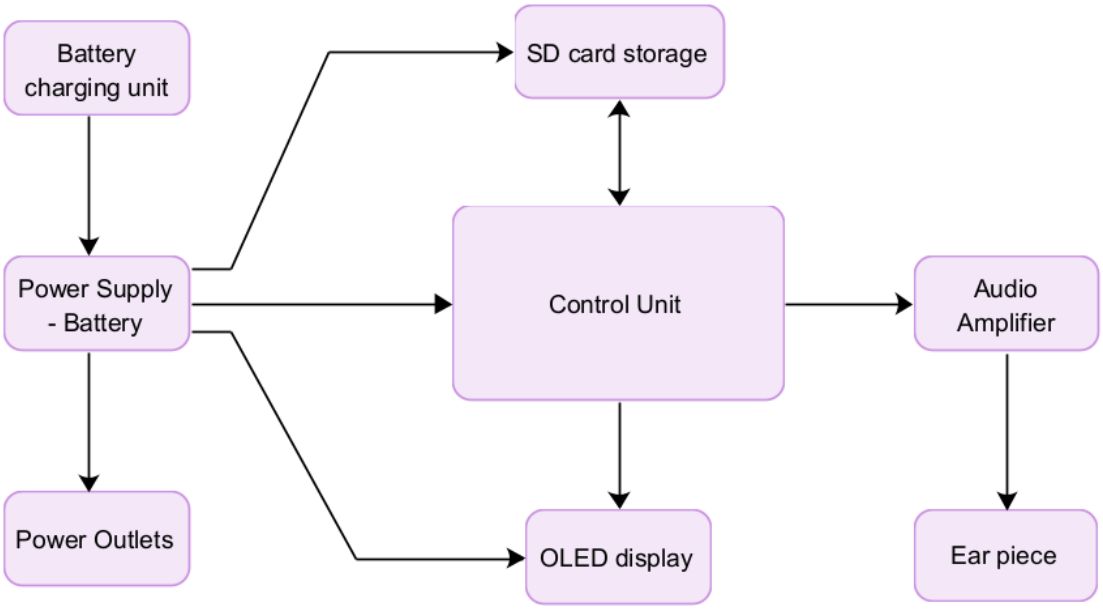
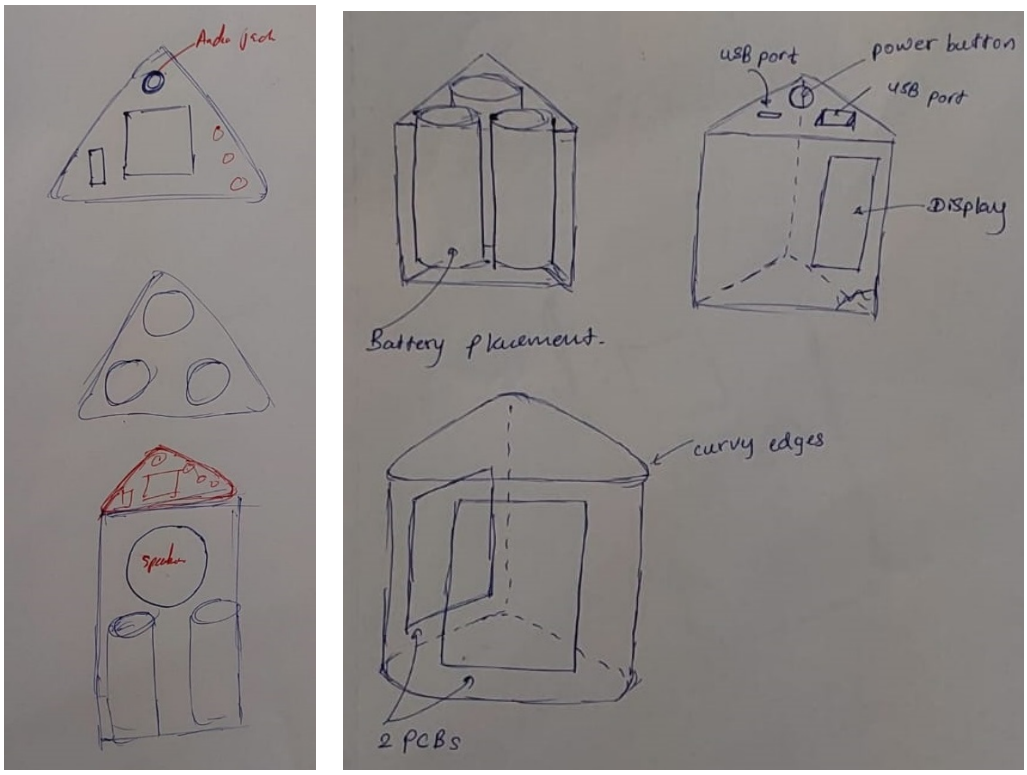



**Figure 4:** Design 01 - Block Diagram

## Design 2

In addition to the earpiece outlet, adding a speaker and making it in the shape of traingular prism. Two versions of designs were proposed one with side display and the other with the display on top.




**(a)** Version 1.0 **(b)** version 2.0

**Figure 5:** Design 02 - sketches

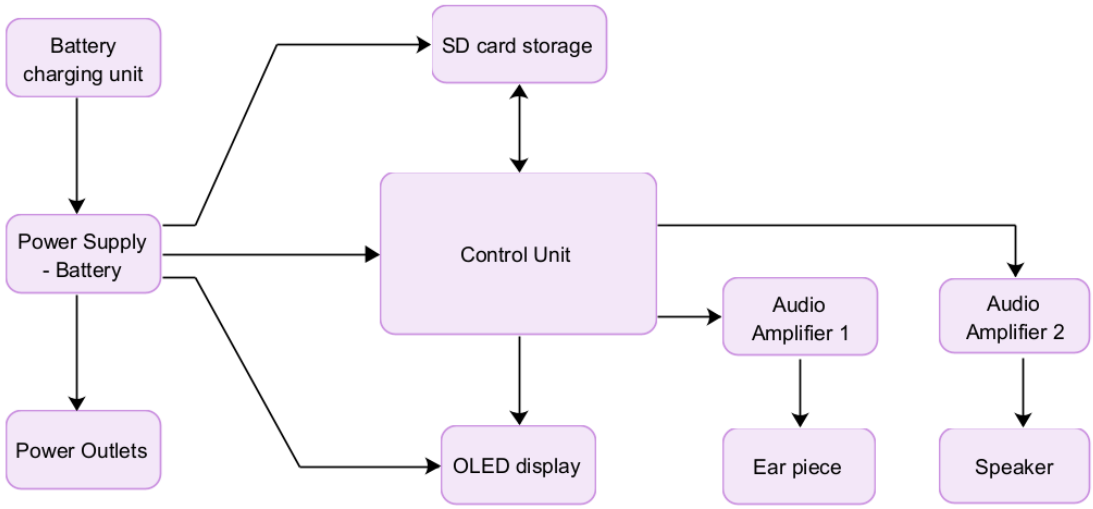



**Figure 6:** Design 02 - Block Diagram

### Design 3

Similar in design to the original but with an inbuilt speaker, Bluetooth functionality, and velcro/clip-on method to easily attach it to the flaps of common bags. This design should be designed to play high-quality music through its in-built speakers.

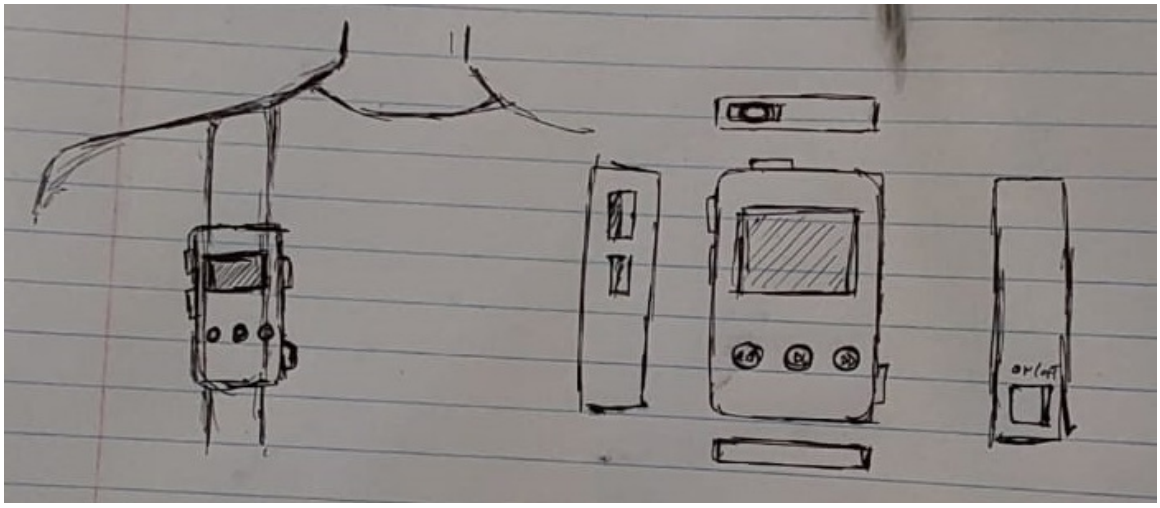


**Figure 7:** Design 03 - sketch

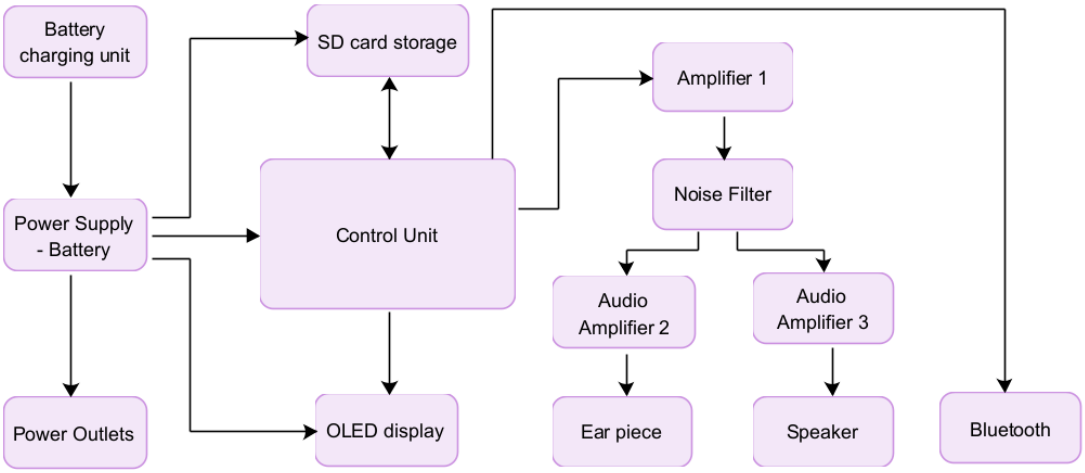



**Figure 8:** Design 03 - Block Diagram

## User-centered design

### User survey

With the initial design, we surveyed some of the other university undergraduates and outside personnel to get diverse user feedback and identify flows, and improvements they might expect. For this, we have created a questionnaire including the following questions.

Questionnaire

1. Your current profession?
2. Will you use or need something like this?
3. At what price point would you like to buy such an item?
4. On a scale of 1-5, how would you rate our product considering other similar products in the market as the midline (Rating 3)
5. What other specifications would you like to add to this design? How can we make this to your likeness?
6. Any other comments on the Product?

We received seven such completed question sets within the allocated period of two hours and the results per each question are summarized below.

### User Feedback

1. Our sample of users included a businessman, a School student, a Construction worker, a factory worker, and three undergraduates and one of which was a part-time musician.
2. Most did say that their mobile can play music but since this has an extended battery life and also can charge your mobile phone we received sufficient constructive feedback about the idea.
3. The average scaled rating we got was 4.143 Which is satisfactory.
4. Improvement wise there are a few suggestions which we have used below to improve our device as shown below.
5. Few said that the Mp3 players are a bit outdated and not using them anymore. Hence the market will be low.

With the suggestion of our sample users, we have short-listed the specifications as follows.

## Selected specifications

- Bluetooth compatibility to transfer music and connect to wireless earbuds/ headphones
- Battery size can be reduced using a lipo battery and overlaying it with the circuit, hence the whole device size can be reduced.
- Build an inbuilt speaker with quality sounds
- Touch-screen to navigate the system menu.

## Rejected specifications

We had to reject a few of the user specifications as those are not necessary and are used by anyone in this kind of device.

- Using a portable USB stick to store songs in addition to the SD card storage.
- Radio functionality

## Design 4

Following the design cycle specified in the reference, we were able to come up with the following design with the additional features we mentioned above.

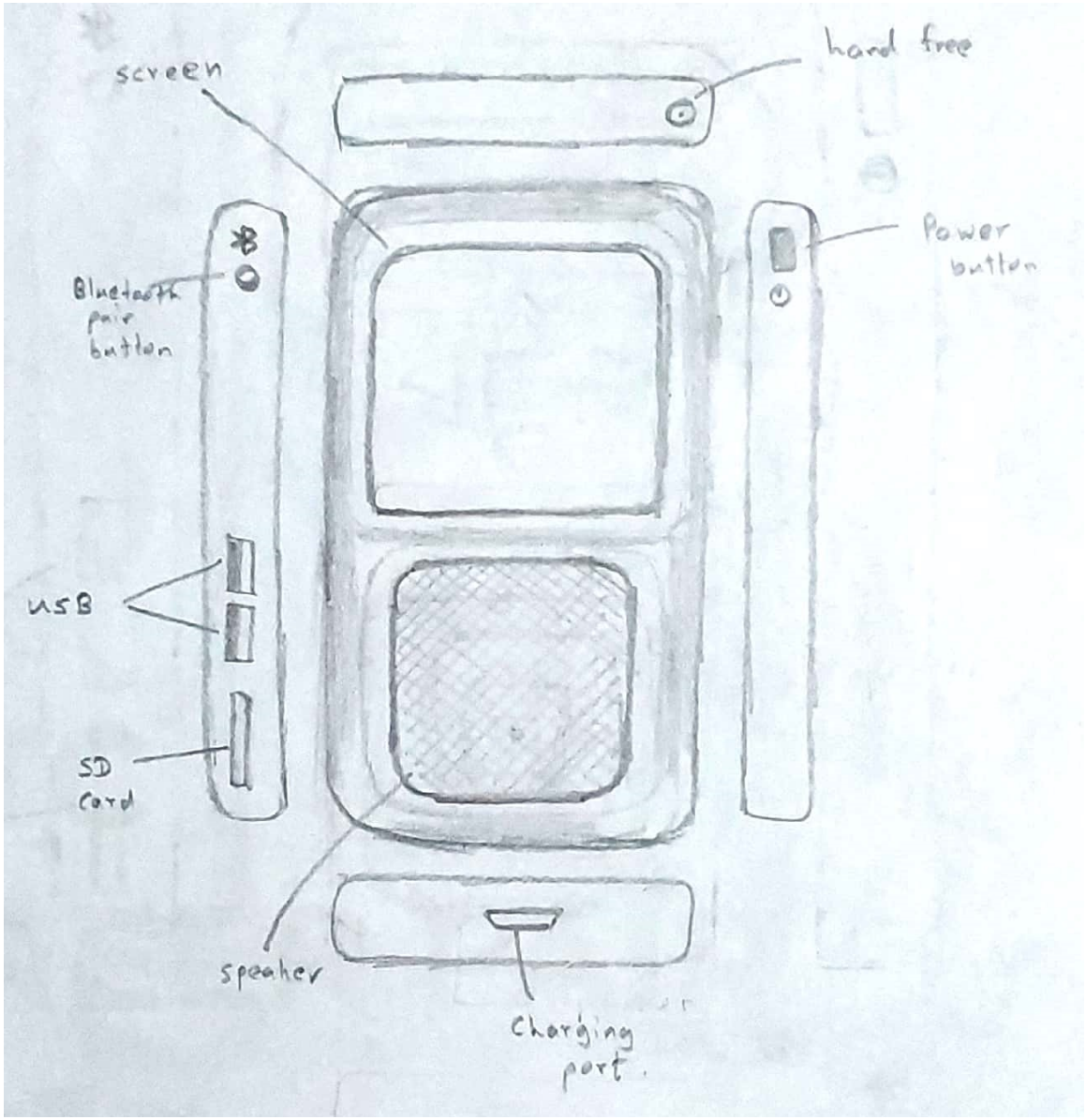



**Figure 9:** Design 04 - sketch

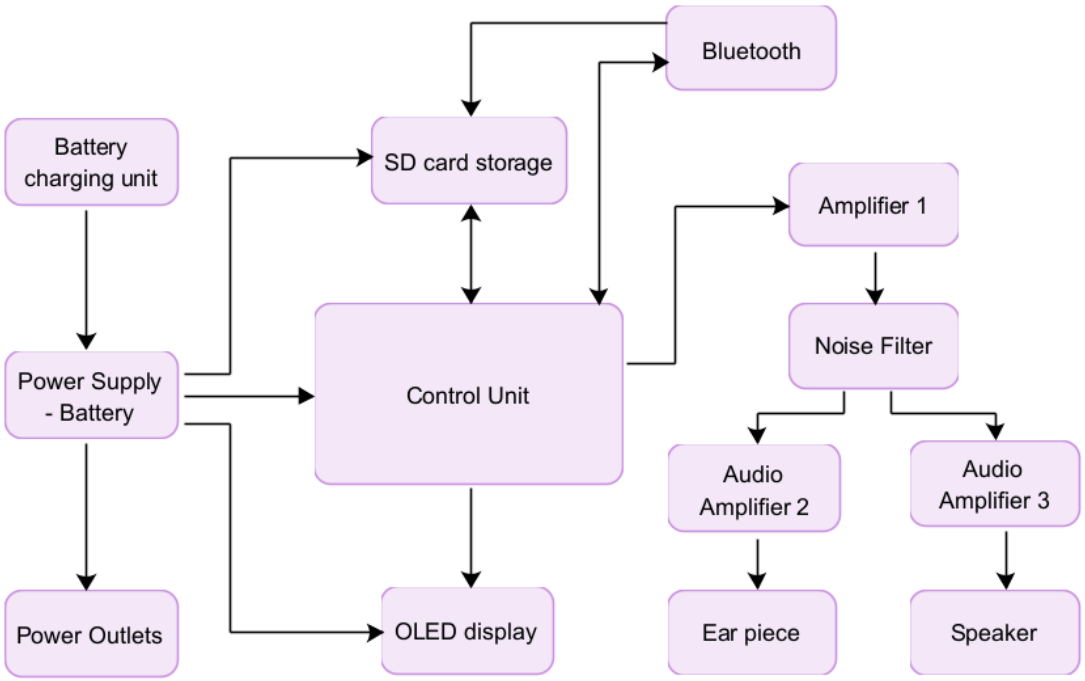



**Figure 10:** Design 04 - Block Diagram

# Selection Matrix

Taking the Initial Sketch as the Baseline ( 0 marks), the following matrix is used to select the best design.

## For Sketches

The criteria used for the selection of the best design sketch are,

1. Ergonomics - How well does the device fit in the user's hand?
2. User Safety - Is it safe to use?
3. Durability - Is the design going to last a long time or will it break?
4. Accessibility - Is the design easy to use, and easy to control?
5. Weight and portability - Is the design easy to carry around?
6. Manufacturing cost - Will the design be cheap?
7. Overall look - IS the finishing look appealing to the majority of users?

| Objectives | Weight | Design 01 | Design 02 | Design 03 | Design 04 |
|---|---|---|---|---|---|
| Ergonomics | 5 | -1 | +1 | 0 | 0 |
| User Safety | 10 | 0 | 0 | +1 | +1 |
| Durability | 10 | -1 | +1 | -1 | -1 |
| Accessibility | 7 | +1 | -1 | 0 | +1 |
| Weight and portability | 10 | +1 | 0 | +1 | 0 |
| Manufacturing Cost | 5 | -1 | -1 | 0 | -1 |
| Overall look | 3 | -1 | +1 | +1 | +1 |
| Final score - sketch | | -6 | 6 | 13 | 5 |

**Table 1:** Screening sketches

## For block diagrams

The criteria used for the selection of the best block diagram are,

1. Quality - Is the music quality better?
2. User-friendly interface - Is the user interface easy to use?
3. Functionality - Are the functions of the devices improved?
4. Accessories - Whether the supported amount of accessories such as headphones, and ear pieces have increased or not?
5. Manufacturing cost - Will the schematic design/parts be cheap?
6. Power efficiency - Will the battery last longer?
7. Scalability/Modularity - Will the design allow future improvements? Is it easy to replace certain parts separately?

| Objectives | Weight | Design 01 | Design 02 | Design 03 | Design 04 |
|---|---|---|---|---|---|
| Quality | 10 | 0 | 0 | +1 | +1 |
| User-friendly interface | 5 | 0 | 0 | 0 | +1 |
| Functionality | 10 | +0.25 | +0.5 | +0.5 | +1 |
| Accessories | 5 | 0 | 0 | +1 | +1 |
| Manufacturing cost | 4 | -1 | -1 | 0 | -1 |
| Power efficiency | 8 | -1 | 0 | 0 | -1 |
| Scalability/Modularity | 3 | 0 | 0 | 0 | -1 |
| Final score - Block Diagram | | -9.5 | 1 | 20 | 15 |

**Table 2:** Screening block diagrams

| Objectives | Design 01 | Design 02 | Design 03 | Design 04 |
|---|---|---|---|---|
| Sketch | -6 | 6 | 13 | 5 |
| Block diagrams | -9.5 | 1 | 20 | 15 |
| Total score | -15.5 | 7 | 33 | 20 |

**Table 3:** Results

# Conclusion

In conclusion the best design from the design cycles is the design 03 given in Figure 7 And 8.

# Reference


- Article : Inclusive Design Toolkit ,Concept design process, University of Cambridge

University of Moratuwa
Faculty of Engineering
Department of Electronic & Telecommunication Engineering


EN2160 - Electronic Design Realization

Report
Preliminary Design Part

Bandara D.M.D.V. 200061N

June 16, 2023

# Contents

# Schematic and Solid work design of the implemented design

## Schematic design

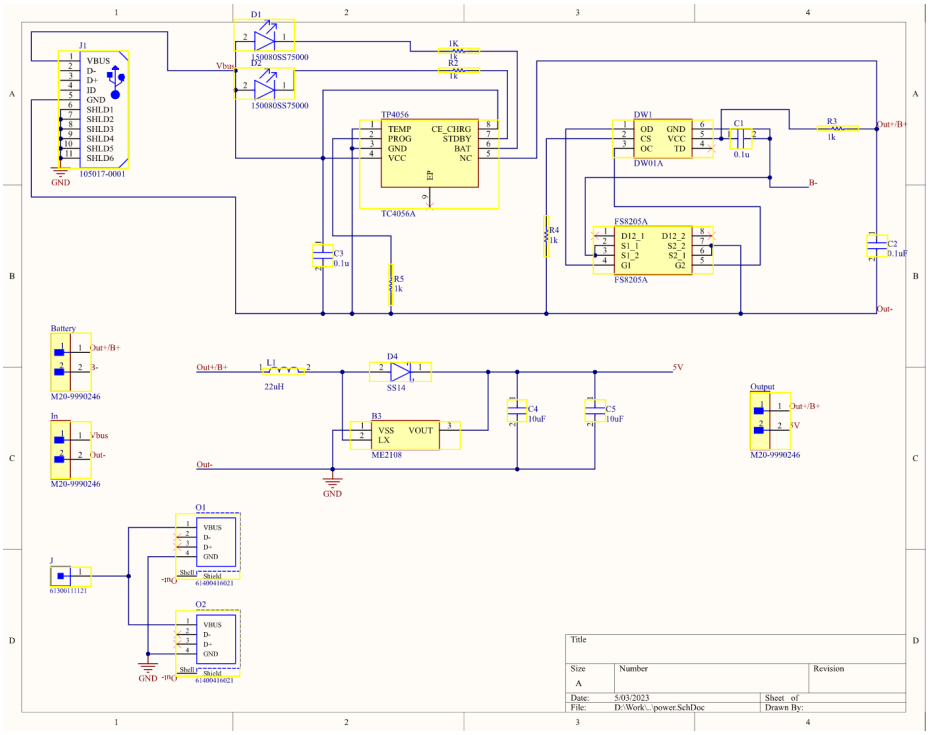



**Figure 1:** page 1

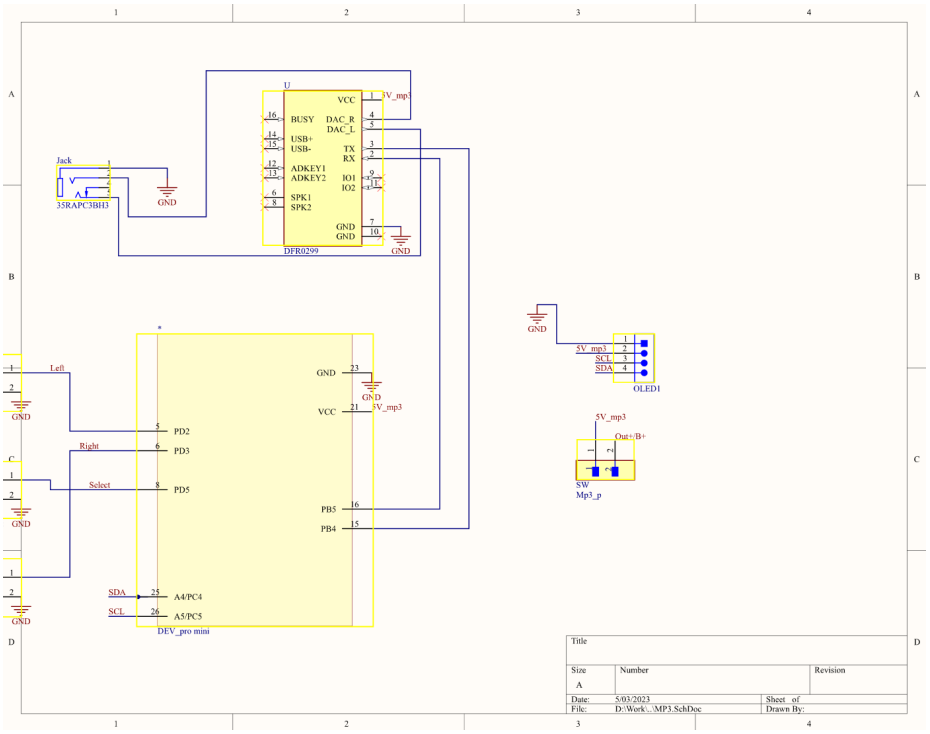



**Figure 2:** page 2

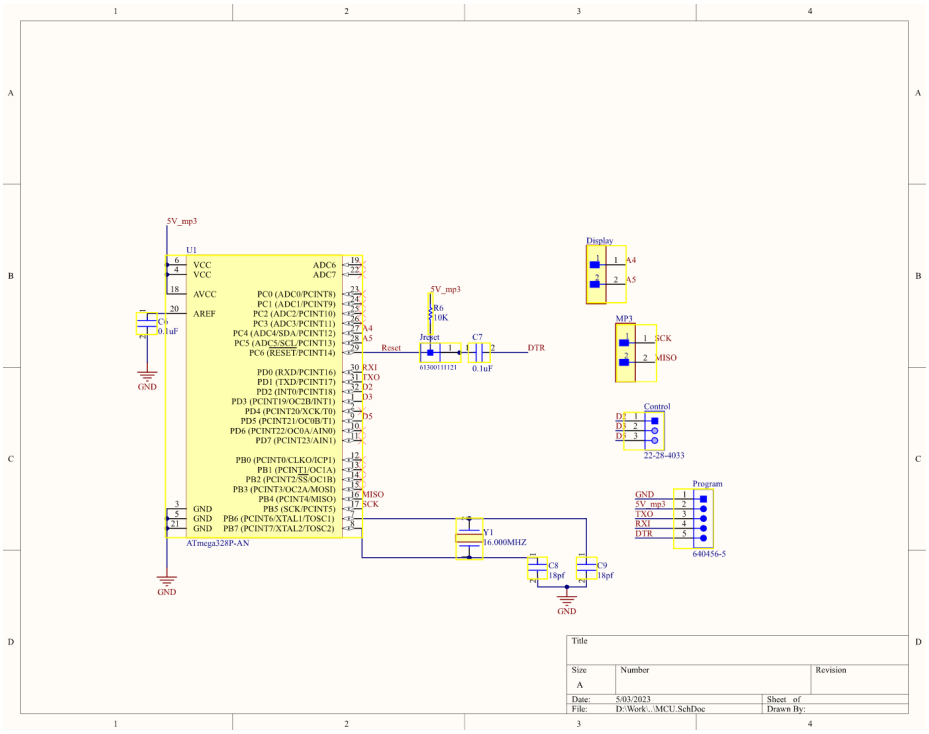



**Figure 3:** page 3

# Enclosure design

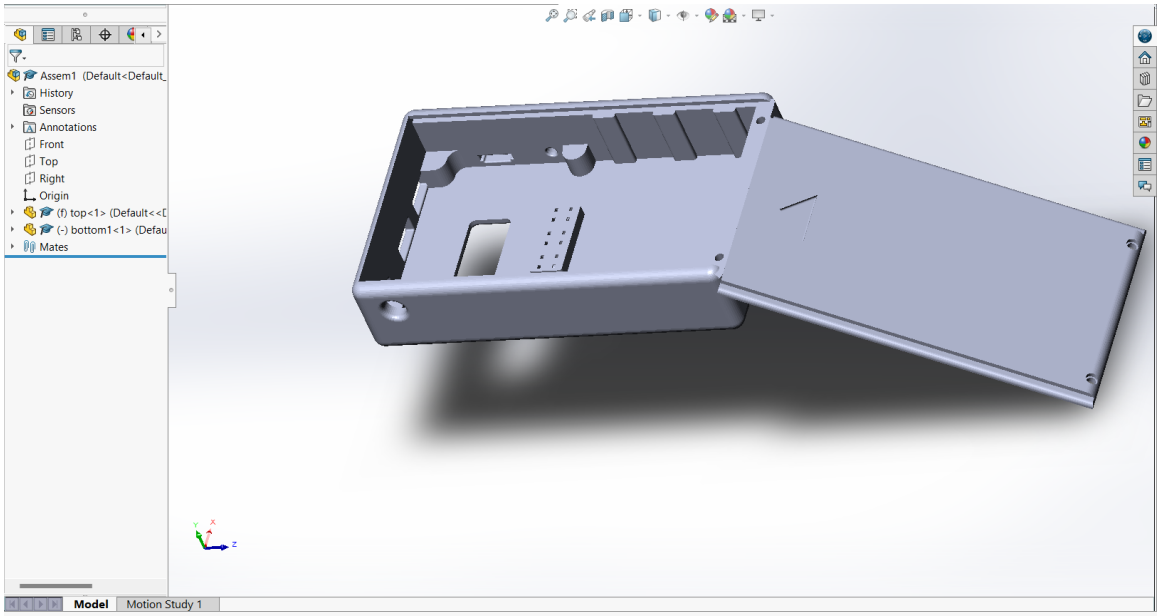



**Figure 4:** Initial enclosure

# Problems identified by you considering the course content delivered by Prof. Jayasinghe.

- Learned how to create a schematic document in the proper way, how inputs, outputs, and netlabels have to be used, and to make the schematic doc readable.
- Importance of filling the title box in each schematic pages.
- How to design a solidwork design that can mass produce (moldable design).
- How to design molds.
- Mold design process through a field visit.
- Adding curves and making the enclosure design aesthetic and sellable than using a box.
- Using 3 sketches and making a unique design rather than sketching and extruding.
- surfacing sketches and then converting them to a solid design.

# Design changes after his comments/guidance

## Schematic design

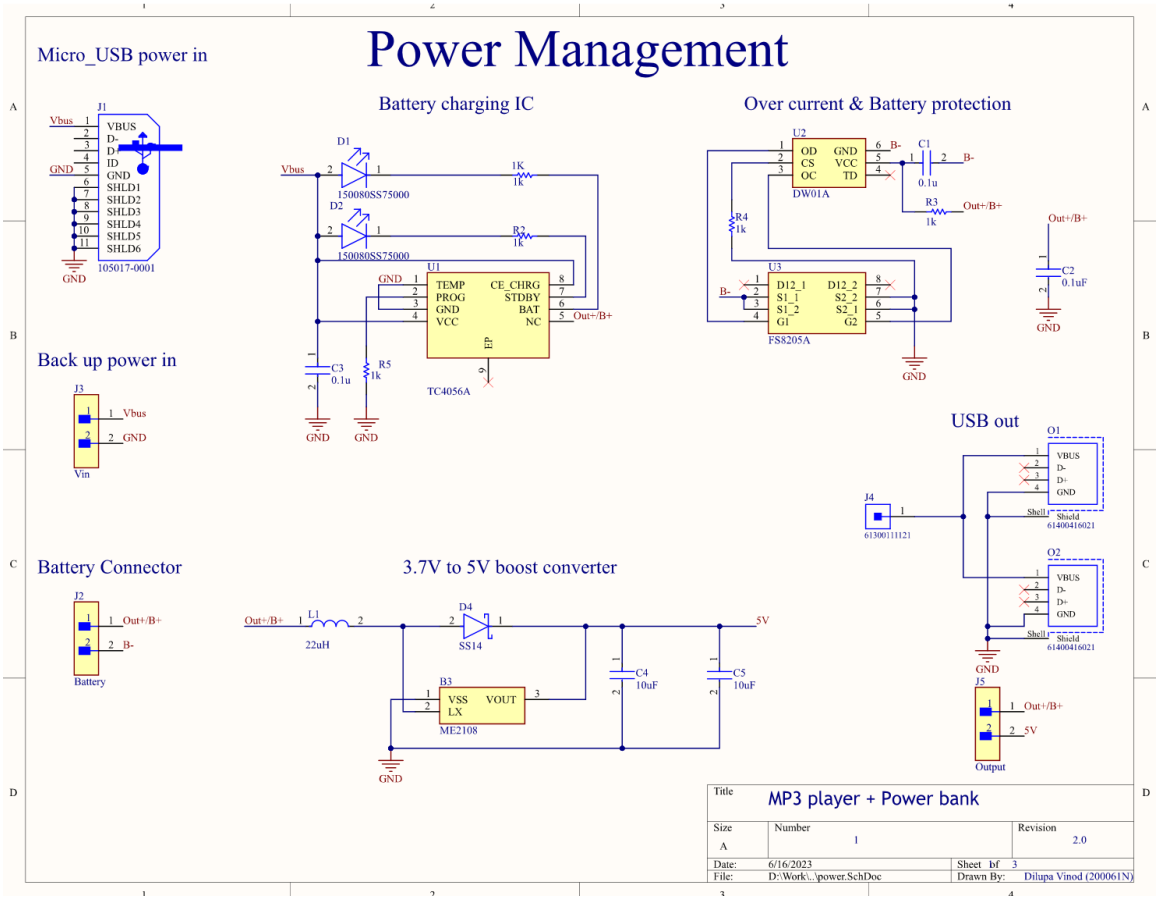



**Figure 5:** page 1

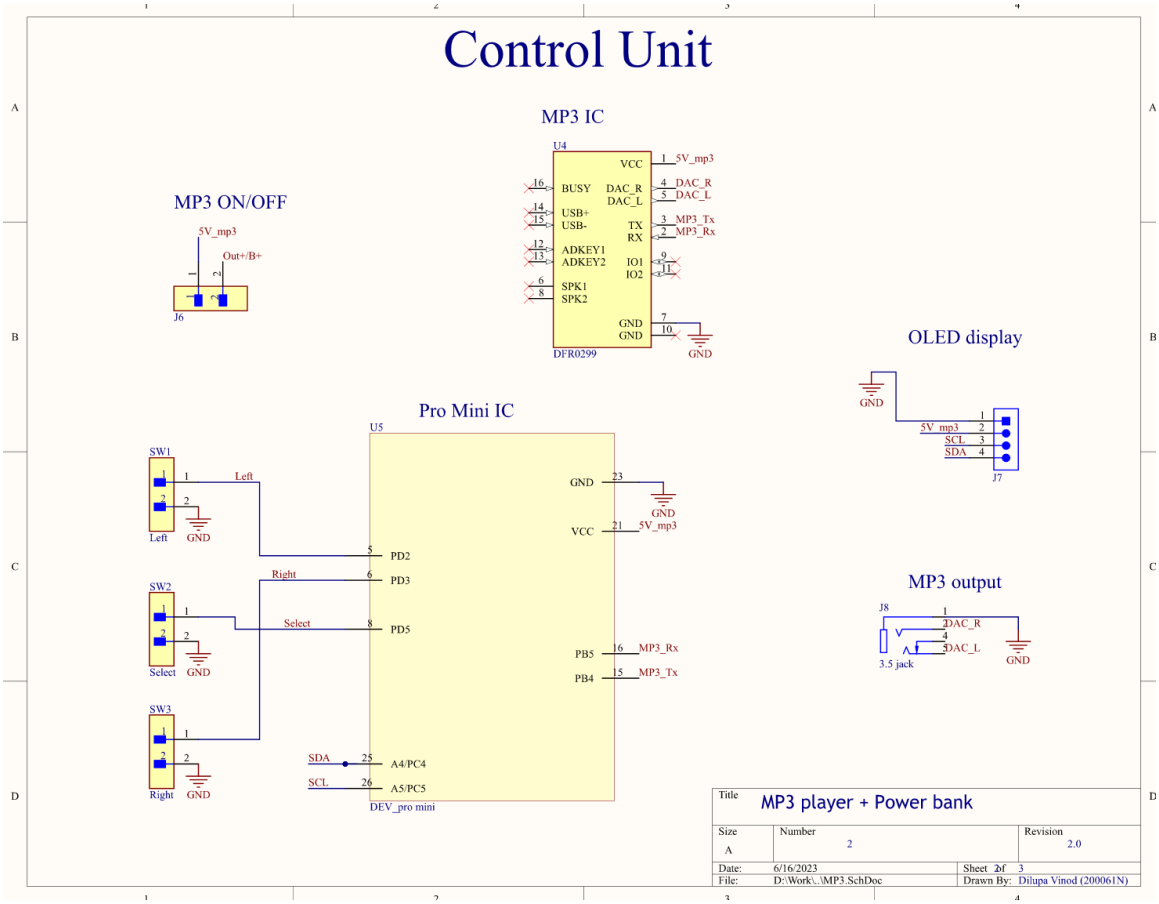



**Figure 6:** page 2

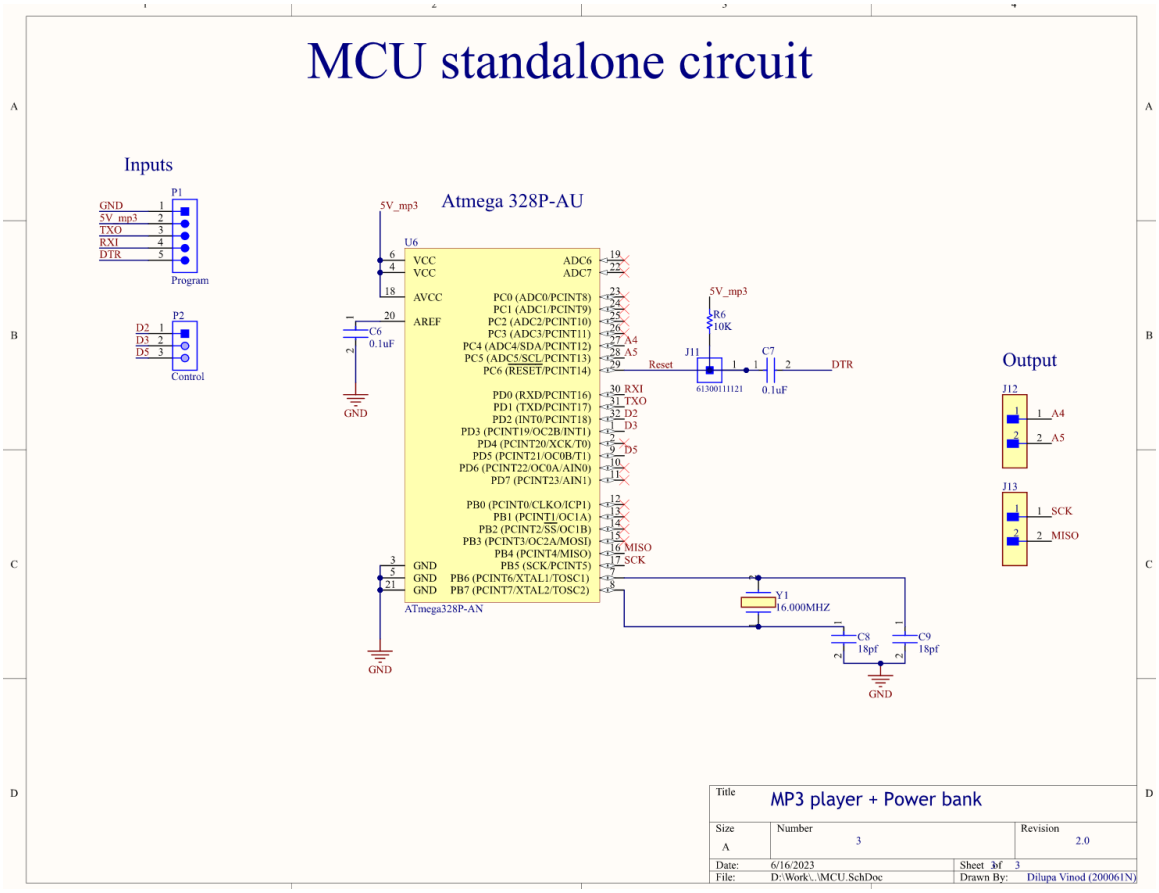



**Figure 7:** page 3

### Enclosure design

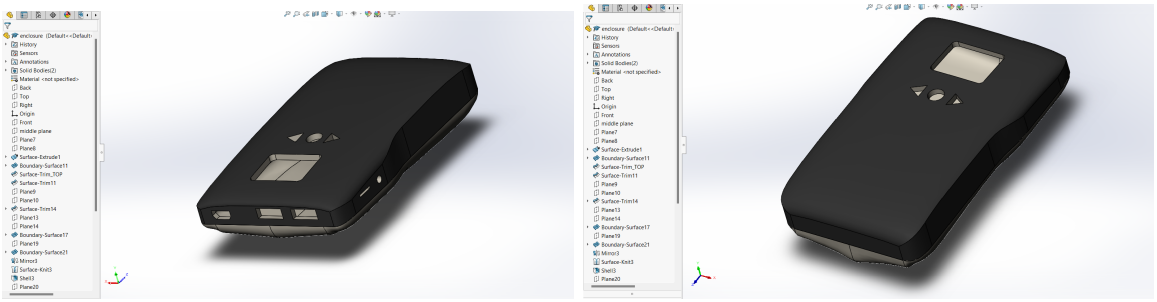


**Figure 8:** Initial enclosure

## Problems/Improvements identified/proposed by members of your group.

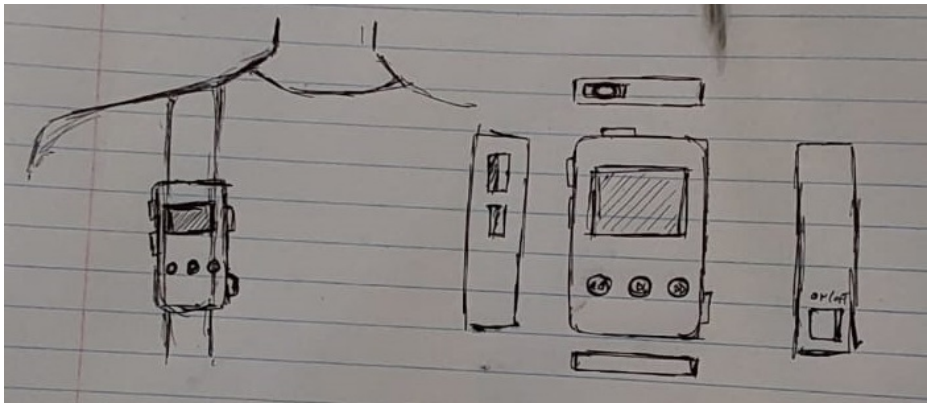
- Using a lipo battery as they are compact and reliable.
- Making the device Bluetooth accessible as most accessories nowadays connected via Bluetooth.
- Adding a speaker
- Making it wearable rather than the traditional design.

## Problems/Improvements identified/proposed by users.

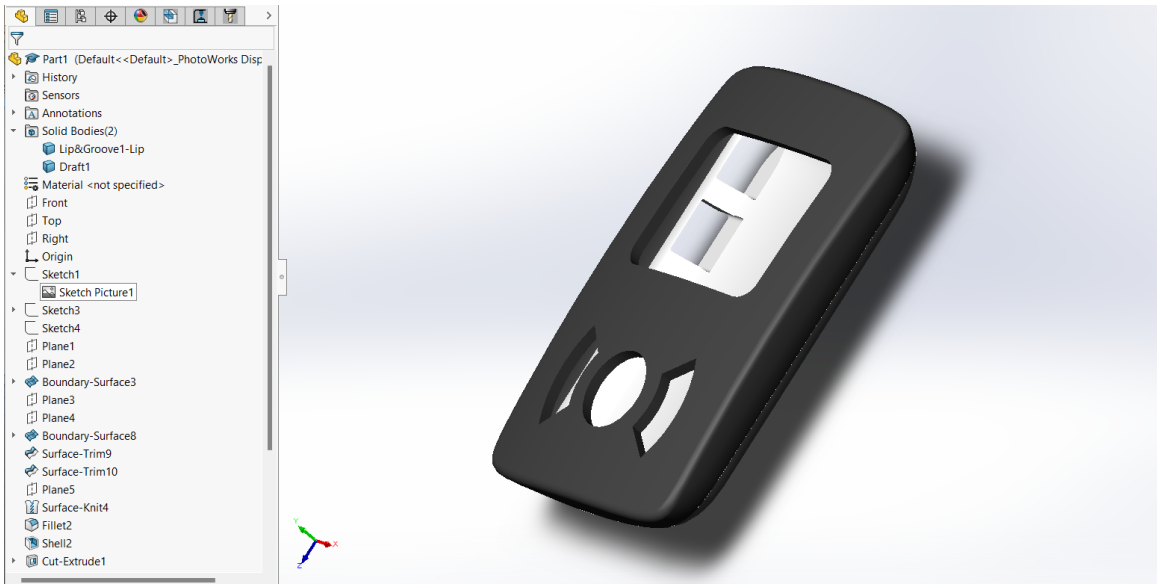
- As mp3 players are extinct and mostly replaced by mobile phones, including a speaker can increase the product's marketable approach.
- Rather than using 3 buttons, a touch screen can improve the user interface.

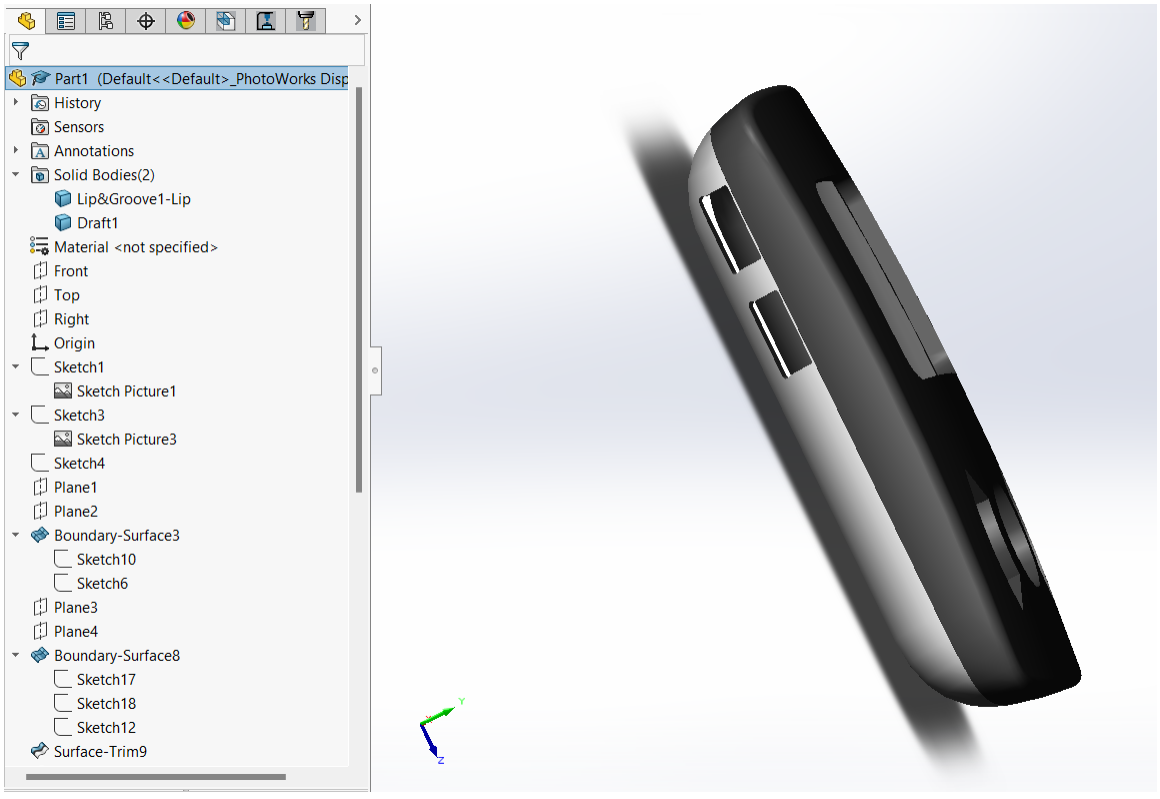
## Schematic and Solid work design of the improved design.

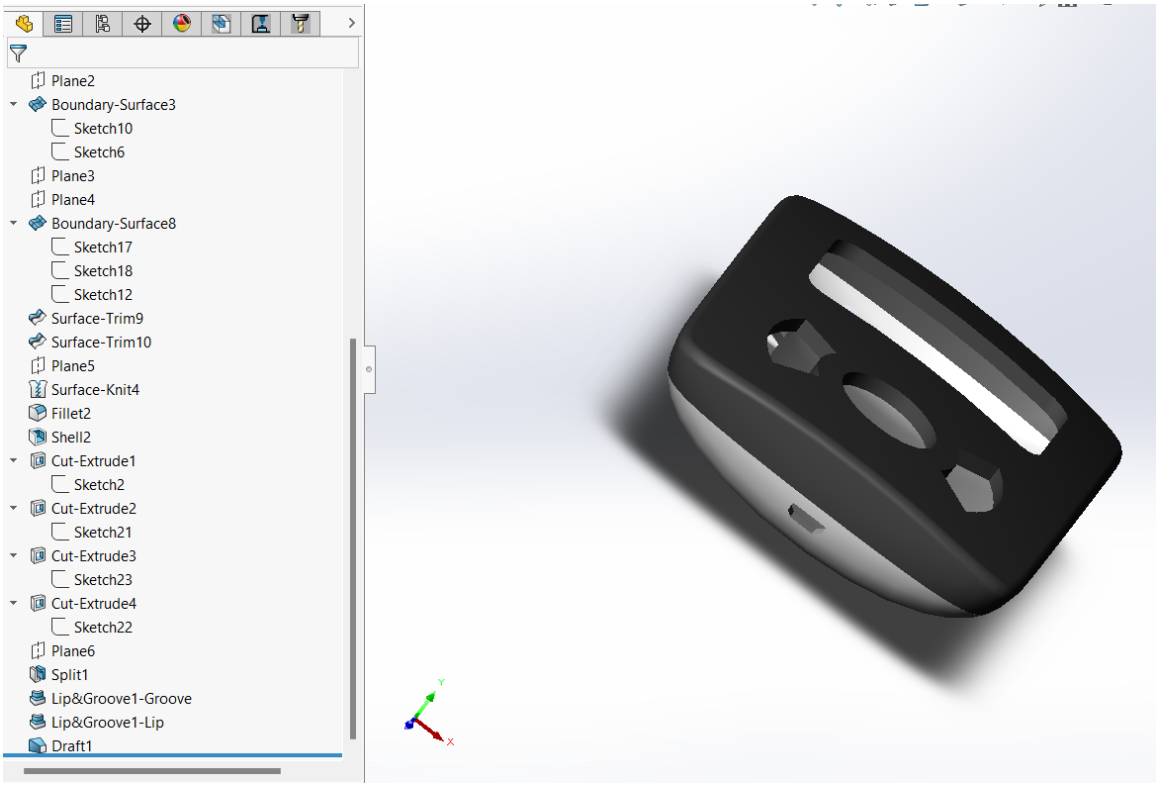
### Output from the conceptual design process

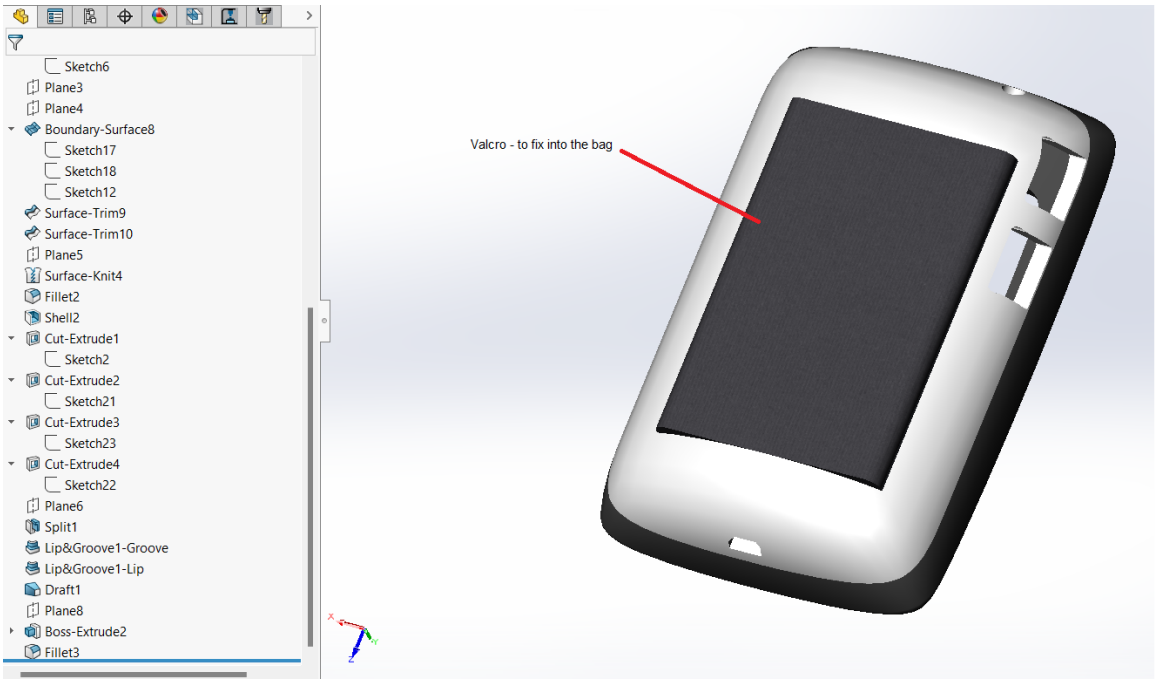


# Solidwork design

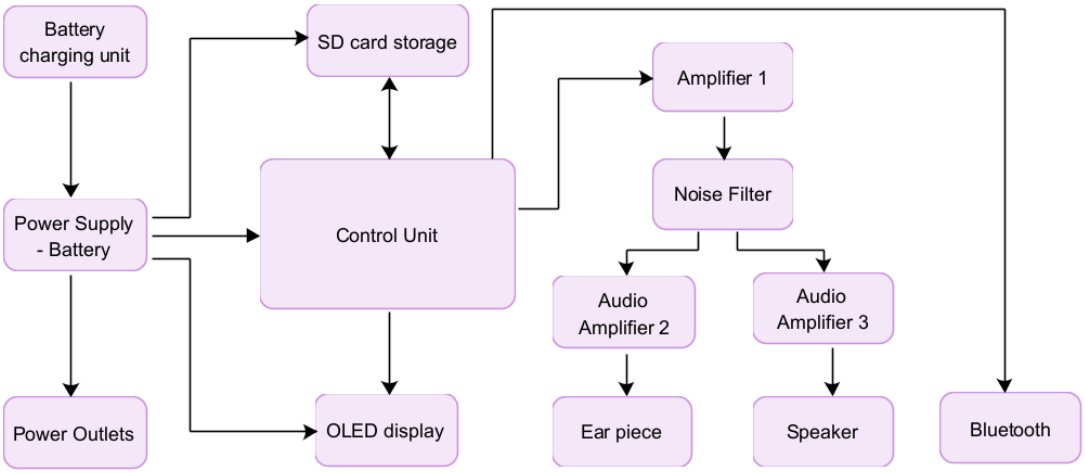


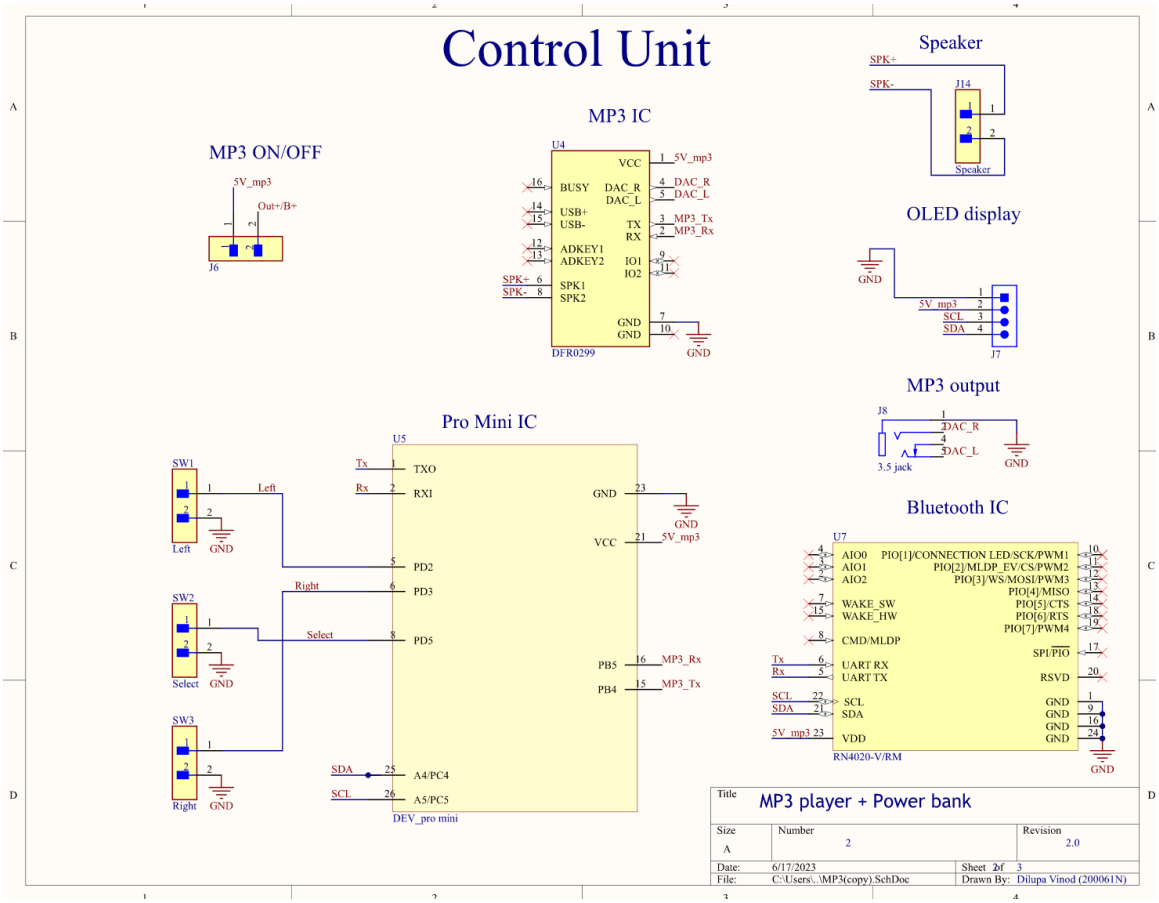

Plane2
Boundary-Surface3
Sketch10
Sketch6
Plane3
Plane4
Boundary-Surface8
Sketch17
Sketch18
Sketch12
Surface-Trim9
Surface-Trim10
Plane5
Surface-Knit4
Fillet2
Shell2
Cut-Extrude1
Sketch2
Cut-Extrude2
Sketch21
Cut-Extrude3
Sketch23
Cut-Extrude4
Sketch22
Plane6
Split1
Lip&Groove1-Groove
Lip&Groove1-Lip
Draft1


Sketch6
Plane3
Plane4
Boundary-Surface8
Sketch17
Sketch18
Sketch12
Surface-Trim9
Surface-Trim10
Plane5
Surface-Knit4
Fillet2
Shell2
Cut-Extrude1
Sketch2
Cut-Extrude2
Sketch21
Cut-Extrude3
Sketch23
Cut-Extrude4
Sketch22
Plane6
Split1
Lip&Groove1-Groove
Lip&Groove1-Lip
Draft1
Plane8
Boss-Extrude2
Fillet3
Valcro - to fix into the bag

## schematic design




No change has been done to the power schematic and MCU standalone circuit in figures 7 and 5. The control unit schematic in figure 6 will change as follows.




Here I have added a Bluetooth IC and a Speaker. Digital amplification can be done by the main IC and the main connections are established as shown above.