

# ECE 511 Project Group 11: MP3 Boombox

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Carlos R Araujo  
Divya Chinthapuri  
Leegia S Jacob  
Brian D Jarvis  
Shawn Wilkinson

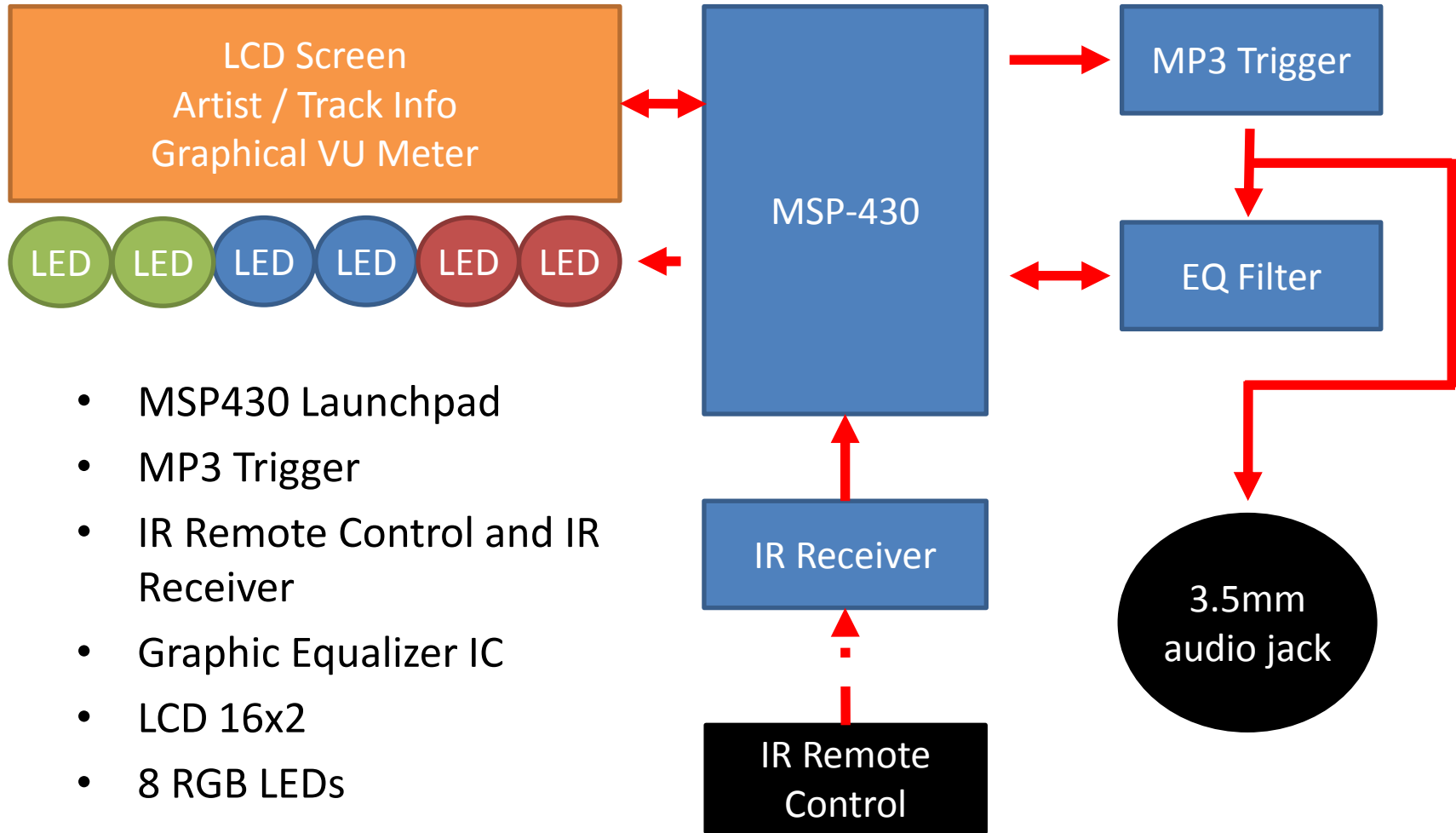
# Motivation

- A toy in the entertainment genre:
  - With the use of a single MSP430, we are able to do much more than just play MP3 files.
  - Advanced integrated features such as a fully functional graphic equalizer, remote control, LCD screen, and special lighting effects with RGB LEDs.
  - The artist name, track number and the output of the graphic equalizer are all displayed simultaneously on a 16x2 LCD.

# Overview

- Major Features:
  - **MP3 Trigger:** Decodes MP3 files stored on an SD card
  - **IR Remote Control:** Controls playback of songs, volume, and lighting effects
  - **Graphic Equalizer:** Analyzes seven frequency bands of the currently playing music
  - **16x2 LCD:** Displays the current artist, song title, and graphical VU meter simultaneously
  - Individually control **8 RGB LEDs** (24 LEDs total) for lighting effects

# Major Components: Block Diagram



- MSP430 Launchpad
- MP3 Trigger
- IR Remote Control and IR Receiver
- Graphic Equalizer IC
- LCD 16x2
- 8 RGB LEDs

# MSP430 Features used

- Digital IO
  - 1 trigger line out to control MP3 trigger board (on TXD) and 1 input coming from the trigger board (through RXD) to MSP430
  - 2 outputs to EQ filter for reset and strobe, 1 input from the EQ to MSP430
  - 7 outputs to LCD
  - 1 input from IR receiver
  - Remaining 3 GPIO pins to three cascaded shift registers to drive output to 24 individual LEDs
- USCI
  - UART communication with MP3 trigger board for command and control
  - UART debug output through USB port on LaunchPad
- ADC
  - 1 input from EQ filter
- External interrupt
  - Driven from IR receiver input
- Timers
  - Timer 0 used to drive state machine which controls EQ filter
  - Timer 1 used in capture mode to measure received IR signal pulse durations

# Hardware description:

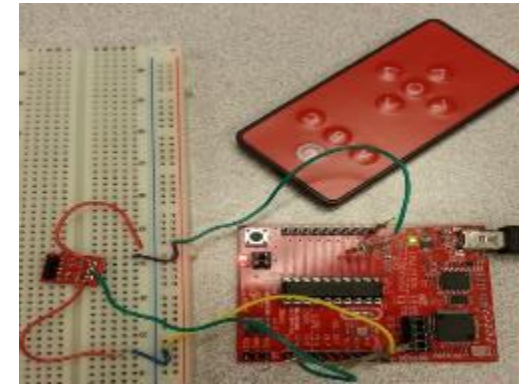
## Part 1.MP3 Trigger

- Embedded audio unit
- VS1063 MP3 audio codec IC
- Device Control
  - 13 Active low input
  - Full Duplex serial TTL Communication
- Available Commands
  - Play/stop, next track, previous track
  - Volume Up/Down
- uSD card (SPI)
  - File System: Fat16/Fat32



# Hardware description:

## Part 2. IR Remote and IR Receiver(TSOP38238)



**Purpose :** To operate the MP3 trigger remotely.

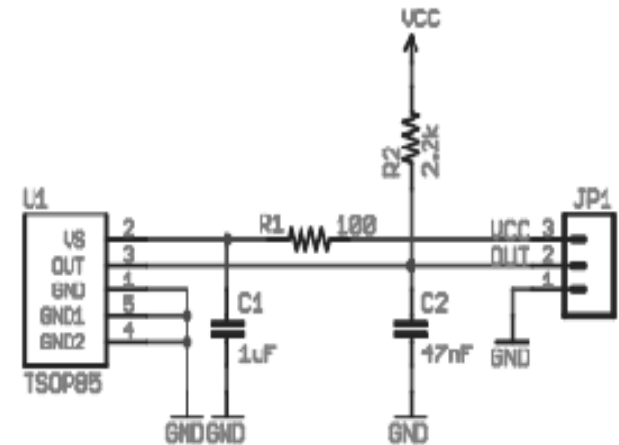
**Functions that are operated :** Play/Stop, Next Track, Previous Track, volume up/down.

### IR remote :

- Infrared LED emits a wavelength of 950nm.
- O/P is PCM modulated at 38kHz.
- 9 buttons-each emits 32 bit codes. Uses NEC protocol
- Detectable distance: 45m

### IR receiver breakout :

- Consists of IR demodulator (TSOP38238 ) and a 38kHz filter on board.
- TSOP38238 : PIN diode and a pre-amplifier.
- 2 lenses for high sensitivity
- Supply V : 2.5-5V.

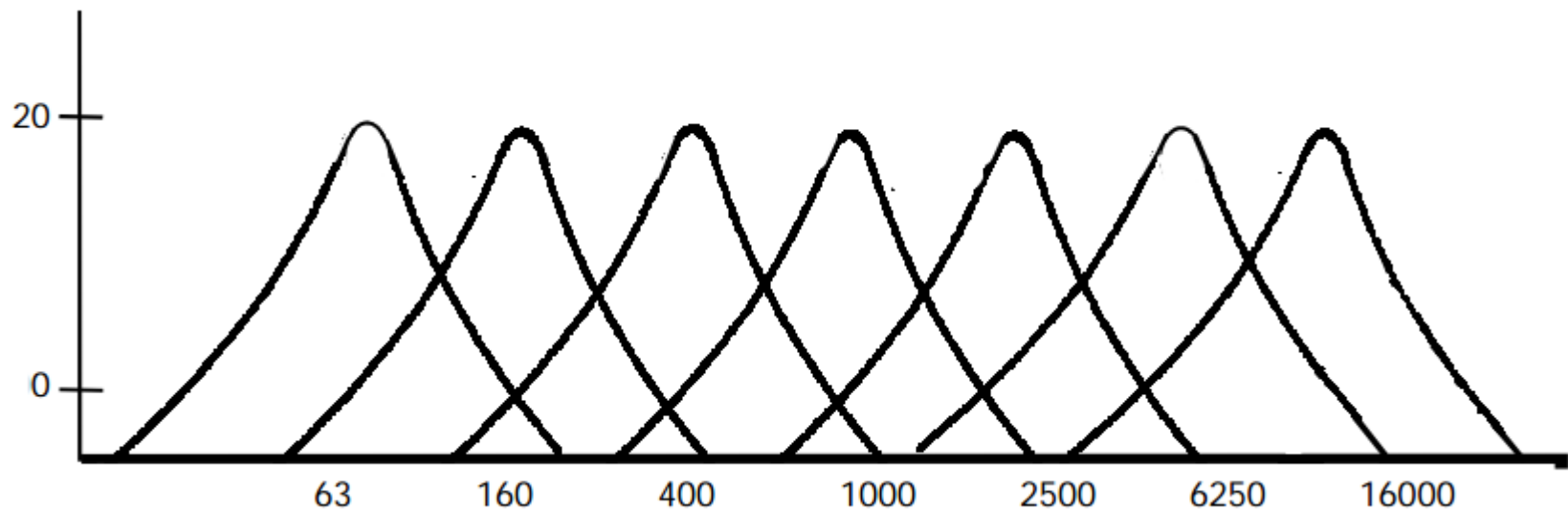


# Hardware description:

## Part 3: MSGEQ7



- Splits incoming audio signal into seven bands
- Each band is peak detected to find amplitude of each
- Amplitude levels are reported as a DC representation
- One pin used to output seven voltage levels by multiplexing
  - Each time a rising edge is driven on the strobe line, the chip provides the next frequency band's signal level on the DC out line.

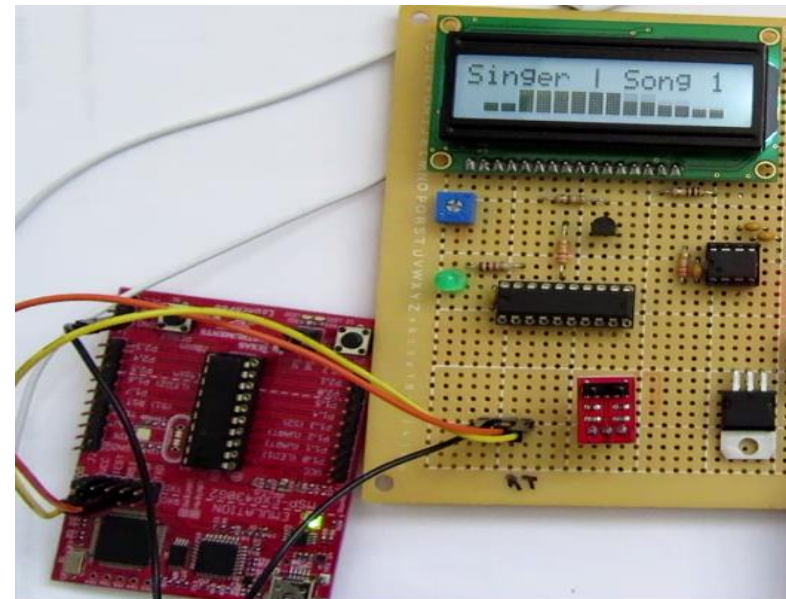
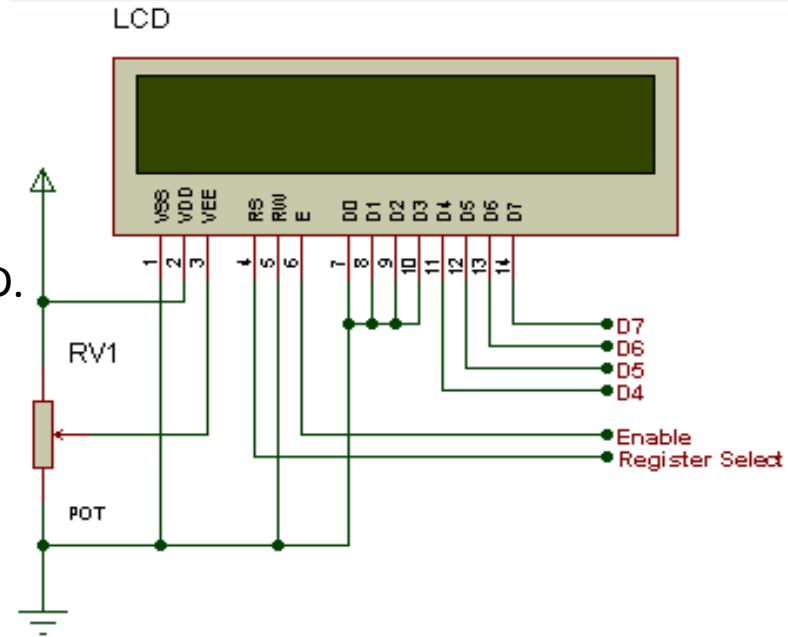




# Hardware description:

## Part 4: 16 × 2 LCD

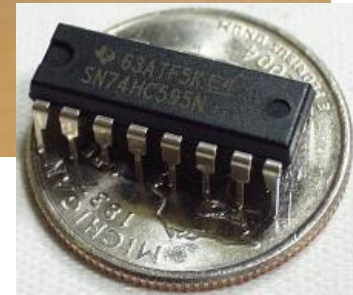
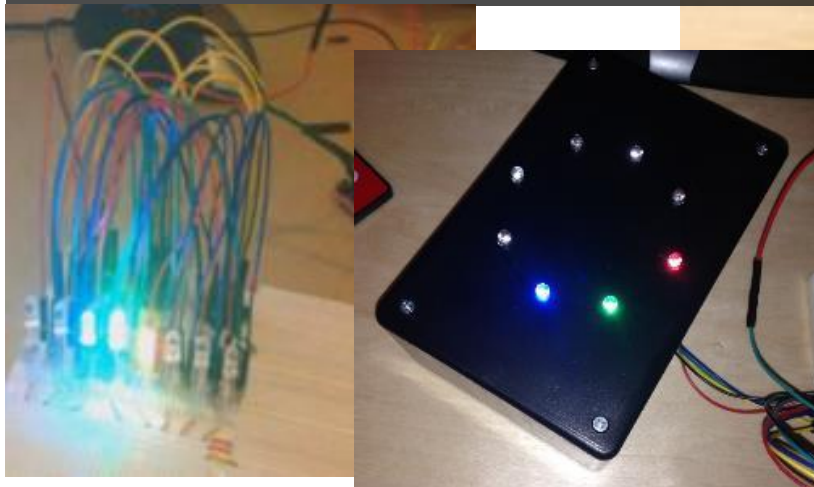
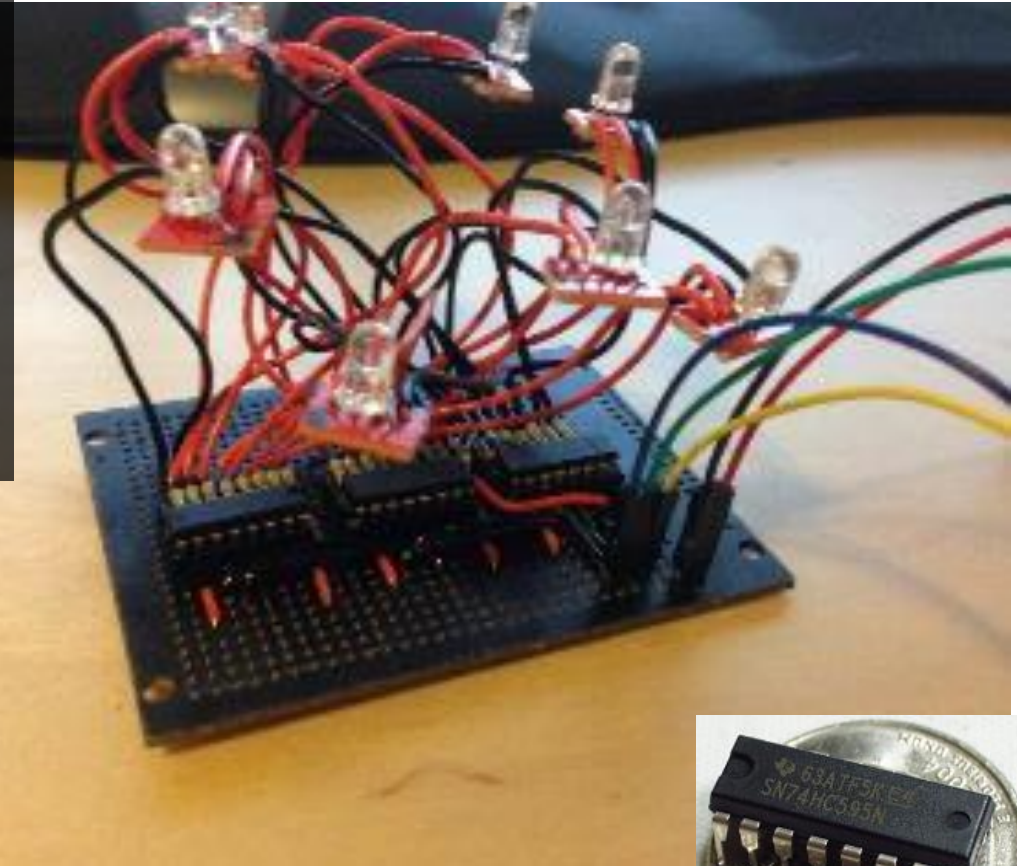
- **16 × 2 LCD** with Hitachi HD44780 controller.
- **Potentiometer:** to adjust the contrast of the LCD.
- Display song title and the artist on the top row.
- Display Equalizer bands on the bottom row.
- MSP430 chip pin utilization.
  - 4 pins for data.
  - Enable.
  - Register Select.
  - Vcc and Ground driven from MSP430 chip



# Hardware description:

## Part 5.RGB LEDs

- (8) RGB LED Housings
  - Contains 24 unique LEDs
- (3) 74HC595 Shift Registers
  - Each drives 8 LEDs
  - Cascaded
- Controlled by **three** digital output pins



# Software description

## Part 1: MP3 trigger

- Configured Hardware UART to work at 9600 8N1
- Created two interrupt driven functions for TXD, RXD
- Setup the MP3 trigger INI file in the uSD card to match the UART baud rate.
- Wrote functions to use the UART to send commands and receive status information from MP3 Trigger.
- Made a data structure to store information of the songs and position in the uSD card for playback and LCD display.

# Software description

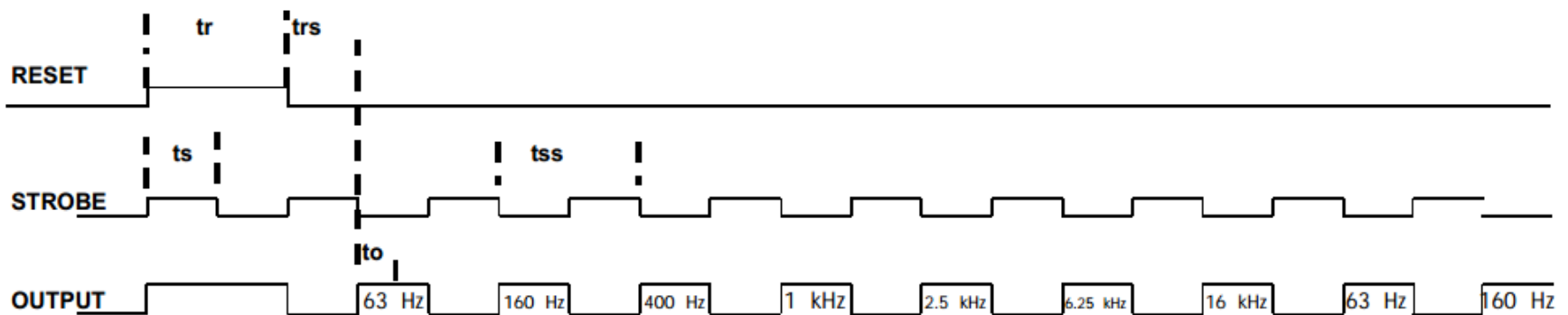
## Part 2: IR remote

- Triggers an interrupt routine to MSP430 on P2.4.
- Timer A1.2 in capture mode, **capture on both edges** and with **capture interrupt enabled**
- Upon interrupt, the control is transferred to detect the **pulse definitions of NEC protocol**(mark and space for header and data).
- When each set of these pulses match to the corresponding pulse definitions of remote buttons HEX values, the functions defined for those buttons are operated.



# Software description: Part 3, MSGEQ7

- Initialization:
  - Reset and Strobe pins configured as outputs
  - DC out from EQ Filter configured as input
  - Timer interrupt configured to fire every 72 us
  - Analog to Digital converter configured to read the input from EQ filter on request
- Timer interrupt service routine
  - State machine logic to control reset, strobe, and analog to digital conversions according to waveform
- ADC interrupt service routine
  - Saves converted values into an array for other software components to access.
- All seven bands displayed on LCD display as a graphical VU meter from main loop



# Software description

## Part 4: 16 x 2 LCD

- Display the song title and the artist on the top row.
- Display the Equalizer bands on the bottom row.
  - Takes the output from the equalizer (7 different frequencies).
  - Display the output as levels (8×5) for each band.
- LCD mode: 4-bit, 2 line, 5x8 pixels

### – Functions :

- LCD initialization.
- LCD trigger with enable set from P2.4 of MSP430 chip.
- Clear LCD display.
- Set cursor position.
- LCD write Data – RS = 1.
- LCD command – RS = 0.
- Print string.
- Draw frequency band levels using custom characters.
  - have 8 rows, 5 columns on each character on LCD.
  - Can store 8 custom characters in LCD.

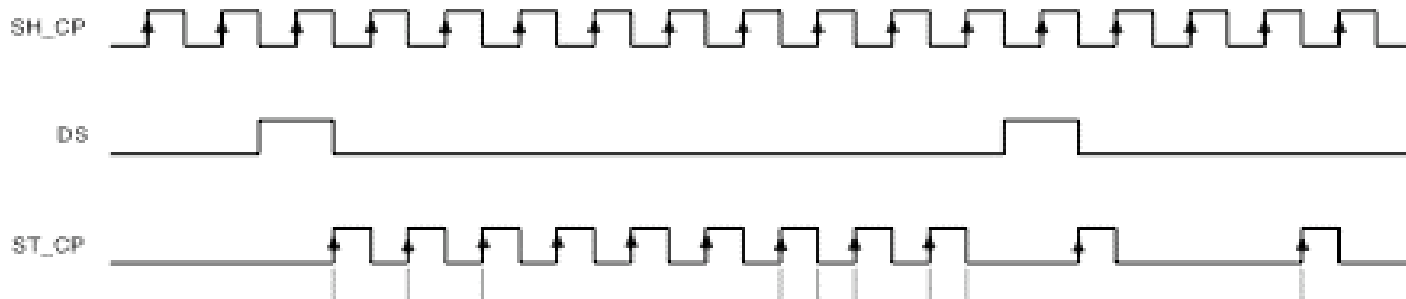


# Software description

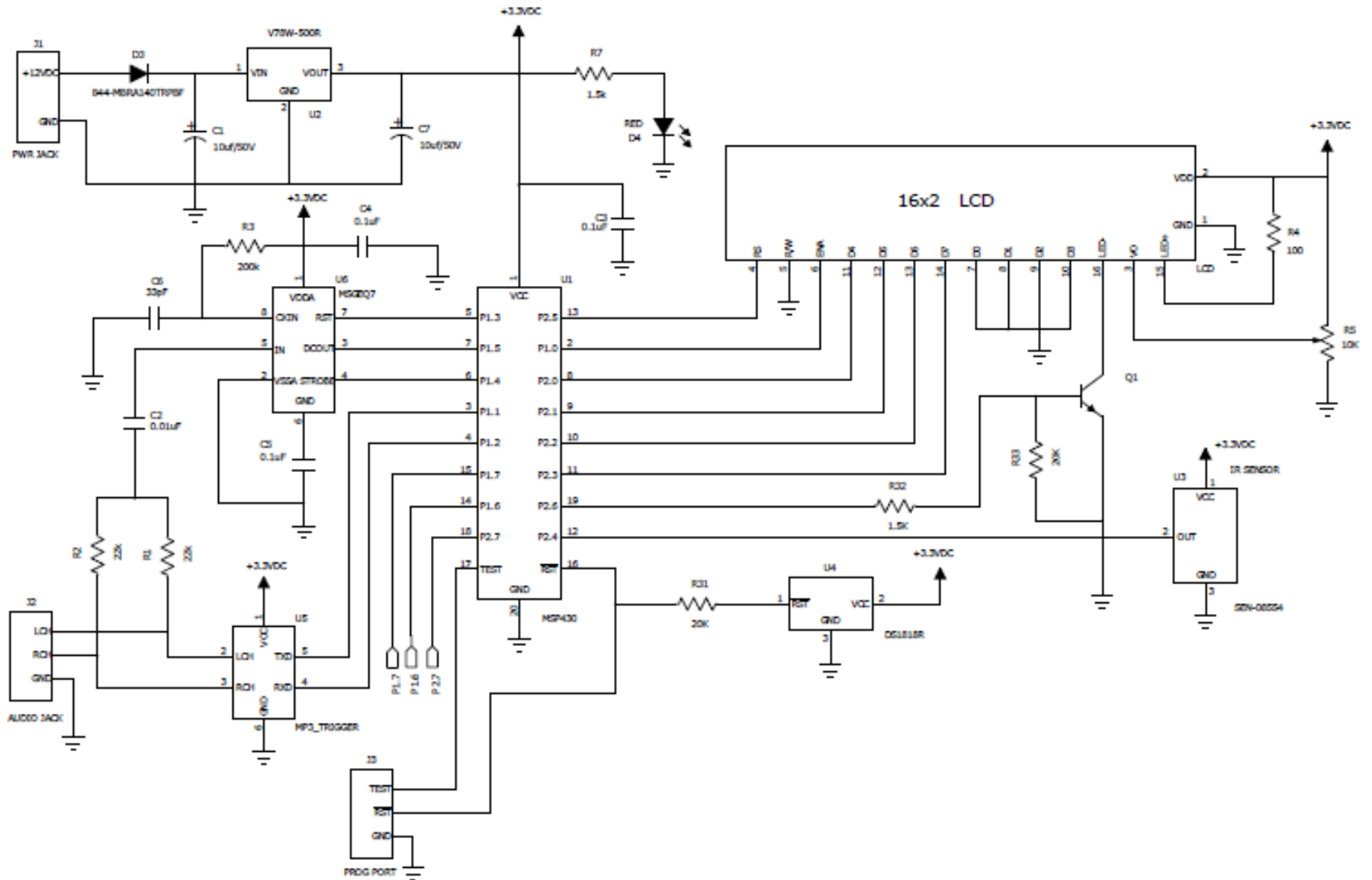
## Part 5: RGB LEDs

- Majority of program control dedicated to driving the shift registers and RGB LEDs.
- Incorporated the graphic equalizer code and MP3 trigger controls into the LED loop to ensure sharing of clock cycles.
  - 155 ms delay OR update the graphic equalizer
  - Poll global variables
- Upon interrupt from the remote control, turn the LEDs on/off or change the lighting pattern.

```
for(i=0;i<8;i++){  
    latchOff();  
    shiftOut(1 << i);  
    latchOn();  
    if(EQ_Mode == 1)  
        draw_levels();  
    else  
        delay(155);  
    if(new_cmd == 1)  
        MP3_sendCommand();  
}
```

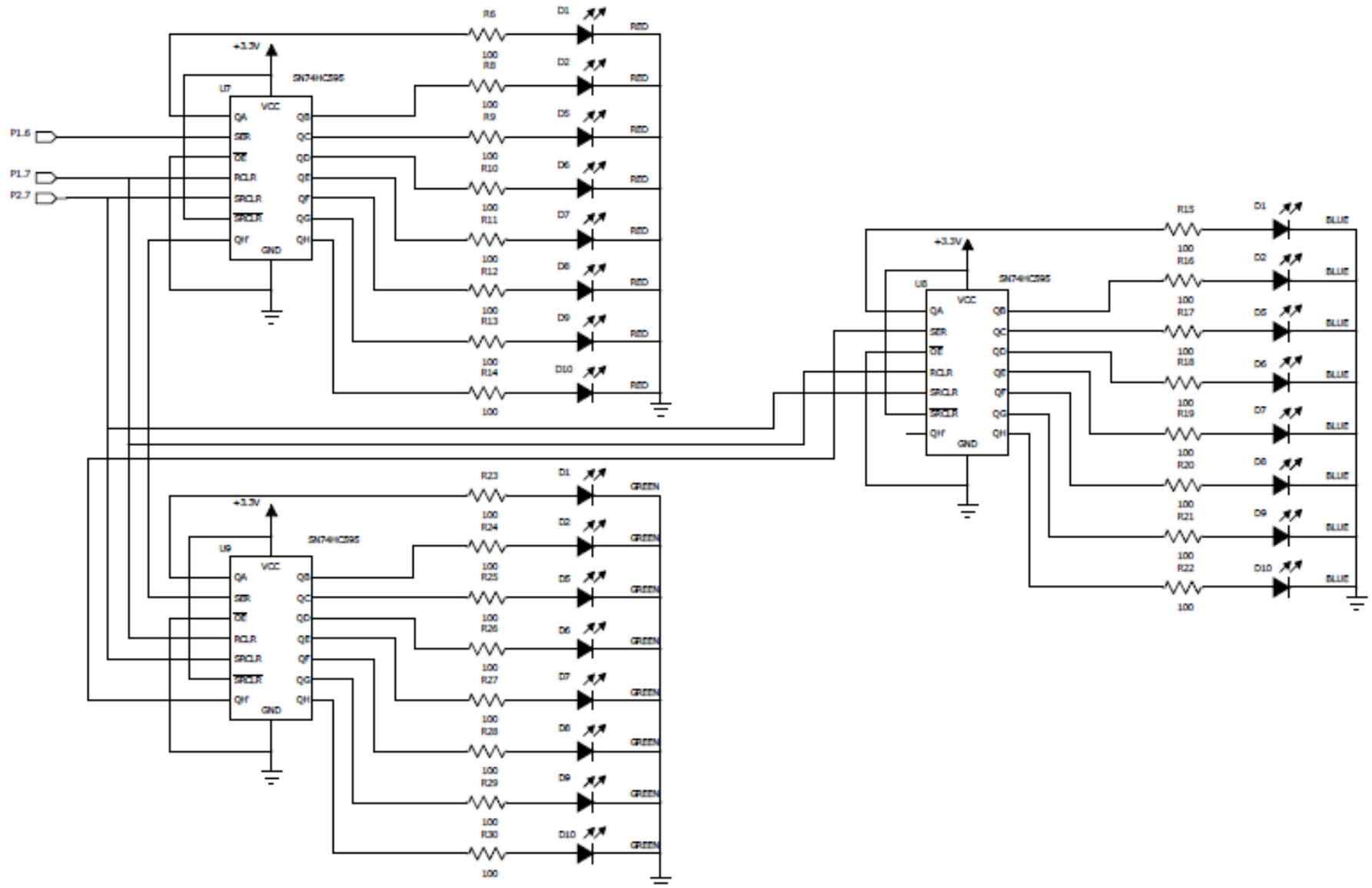


# Schematic

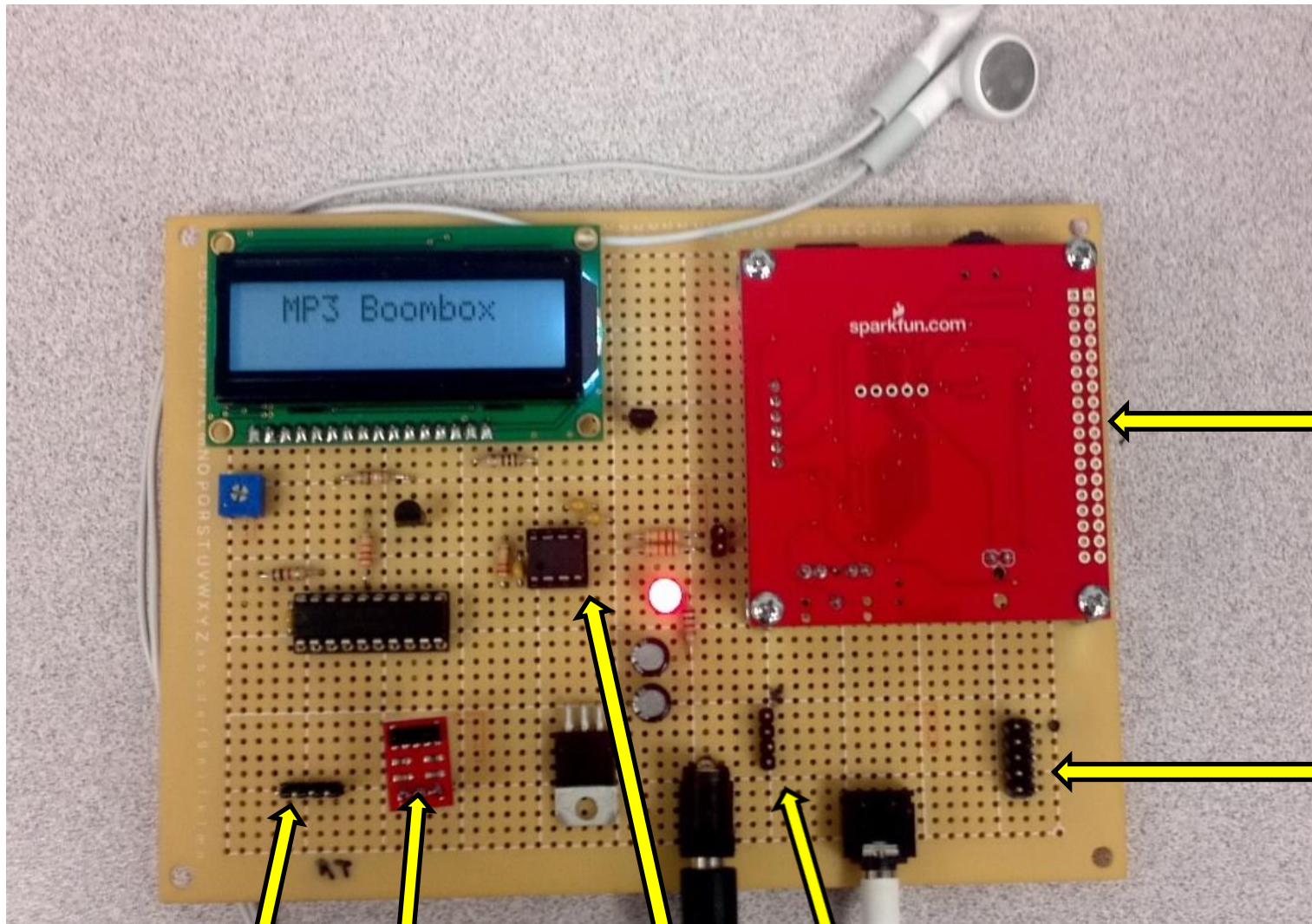




# Schematic(continued)



# Integration Platform



MP3  
Decoder

RGB LEDs  
PORT

Prog Port

IR recv

EQ

Comm port

# Integration Platform

- Hardware and software Integration
  - All modules were developed and tested independently, software and hardware are now integrated.
  - Threshold: Common integration platform using protoboard
    - All hardware modules either mounted on a single protoboard or connected using 0.1" male headers
- The Launchpad is used as a programming device for in System Programming (ISP) and debugging

# Results

- Using a divide and conquer approach, we partitioned a large project into five sub-modules that were independently coded and tested before integration.
- Using interrupts for time critical processes instead of polling when possible (i.e., IR decoding, EQ input, UART incoming data).
- Gained knowledge of a fair amount of the MSP430 modules (i.e., timers, GPIO, interrupts, ADC, UART).
- **An inexpensive MP3 Player using an inexpensive microcontroller**