Electrical Overview (Spring 2020)

Team: 8
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Assignment Evaluation:

Item	Score (0-5)	Weight	Points	Notes
Assignment-Specific Items				
Electrical Overview		x3		
Electrical Considerations		x3		
Interface Considerations		x3		
System Block Diagram		x3		
Writing-Specific Items				
Spelling and Grammar		x2		
Formatting and Citations		x1		
Figures and Graphs		x2		
Technical Writing Style		x3		
Total Score				

5: Excellent   4: Good   3: Acceptable   2: Poor   1: Very Poor   0: Not attempted

General Comments:
Relevant overall comments about the paper will be included here

1.0 Electrical Overview

- 16-bit, 68 pin low power microcontroller: Our choice of microcontroller will be used for general computing. In addition, there is a DSP unit built-in which will be used for 16-bit fixed point operations and for 16-point FFT. The resolution of the FFT may change based on performance considerations. The internal SRAM (8KB) is enough to store 16-bit audio words for our project but we may use the slower but larger (256KB) FRAM if required. The microcontroller is also responsible for interfacing between the peripherals. About the DSP module, as we receive 16-bit audio words, the data will be stored in the RAM. We probably must use DMA to transfer data to the DSP module, but we do not have this information yet.
    Data collected:
    - a. UART from Bluetooth that triggers an interrupt to change DSP parameters
    - b. I2S from Audio Codec that contains digitally sampled audio which also triggers DSP calculations
    - c. SPI from coulomb counter/PMIC registers which provides State of Charge information as well as battery voltage & temperature if required.
    Data transmitted
    - a. I2S to Audio Codec that transmits digital audio after audio effects processing.
    - b. PWM to LED that indicates State of Charge to end user based on data received from PMIC
    - c. GPIO to LED showing battery charge information
    - d. SPI to configure Audio Codec internal registers
    - a. SPI to coulomb counter/battery management to configure internal registers
- Low power Bluetooth chip/MCU: Low power Bluetooth MCU whose primary function is to receive Bluetooth data packets from an Android cell phone.
- Audio codec: 16-bit audio codec will be used for converting analog audio to digital data and vice-versa. There is a 16-bit DAC and 16-bit ADC as well as anti-aliasing filters which improves the quality of the conversion.
- PMIC: Used to monitor Li-ion State of Charge and communicates with the MCU using SPI.
- USB controller/battery charge management: Used to control Li-ion charging while providing a power supply to the system when plugged into a USB port (5V, 500mA max). This controller also switches power source back to the battery when external power is removed. No communication required with this peripheral
- Voltage regulator: Up to so far, we have decided to use an LDO for the power supply system. This allows us to use a single cell 3.7V Li-ion battery to get a stable output of 3.3V up to 300mA. The drop off voltage is very low at around 170mV which should not interfere with the power supply until the end of battery capacity (around 3.3V). Additionally, the LDO should also be able to work with 5V in when plugging in the system to external USB.

- Preamp: Used to amplify the audio signal from the Audio Codec. This circuitry will also ensure various speaker impedances do not damage our device.

Since this is primarily an audio system, careful consideration must be made to separate analog components, digital components, and wireless modules to prevent noise, inference and ground feedback loops. Ground nodes must be designed carefully which will also require plenty of decoupling capacitor on every IC and power supply.

2.0 Electrical Considerations

1. Operating frequency: Our chosen MCU operates at 16Mhz using an internal clock. However, we will be using a 16Mhz crystal to provide shared clock inputs to our MCU & Audio Codec to minimize jitter and maintain a standard 44.1Khz sampling rate to ensure professional quality audio.
2. Operating Voltage: All our components run on 3.3V using a single cell Li-ion. A single LDO power rail is required. We do not require high voltage because we are assuming that the external speaker system connected to our device does most of the amplification. We will only include pre-amplification which should be enough. However, if we notice clipping, we may need to add a second Li-ion cell and tweak the power circuitry.

Device	Operating Voltage	Current Consumption (max)	Power Consumption (max)
Microcontroller - MSP430FR5994	1.8V-3.6V	8mA	6.8mW
Bluetooth Interface	1.8V-3.6V	16mA	3.78mW
Audio Codec	2.4V-3.6V	24mA	72mW
RGB LED	2.2-3.3V	35mA	32mW
Red LED	2-2.4V	25mA	60mW
PMIC	2.7V-4.5V	100uA	0.42mW
RN4020	1.8V-3.6V	16mA	57.6mW

Maximum current consumption (approximately): 116mA
Maximum power consumption: 232.6 mW

3.0 Interface Considerations

UART: Interfacing between Bluetooth chip and DSP chip. Maximum Data Rate: 1 Mbps. This is used to receive data from the user about how the DSP should be configured.
I2S: Communication between codec and DSP chip. The sampling rate will be 44.1KHz, at 16 bit resolution the data rate would be 705 kbps.

4.0 Sources Cited:

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Appendix 1: System Block Diagram