Homework 3: Design Constraint Analysis and Component Selection Rationale

Team Code Name: Every1 DJ **Group No.** 2

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Evaluation:

SEC	DESCRIPTION	MAX	SCORE
1.0	Introduction (including updated PSSC)	10	
2.0	Design Constraint Analysis	-	
2.1	Computational Requirements	10	
2.2	Interface Requirements	5	
2.3	On-Chip Peripheral Requirements	10	
2.4	Off-Chip Peripheral Requirements	5	
2.5	Power Constraints	5	
2.6	Packaging Constraints	5	

2.7	Cost Constraints	5	
3.0	Component Selection Rationale	20	
4.0	Summary	5	
5.0	List of References	10	
App A	Parts List Spreadsheet	5	
App B	Updated Block Diagram	5	
	TOTAL	100	

Every1 DJ,
Comments:

1.0 Introduction

The Every1 DJ is an interactive DJ system that allows users to vote for songs they wish to be played. The song selections and voting process will take place on a web application developed in the Django framework. Vote tallies will continually be tabulated and the most requested song will be selected and played. The songs will be streamed over the Grooveshark API to the DJ system, which will feature an auxiliary port to connect to the external speakers. The system will also include LED's housed on the base of a disco ball that changes colors and strobes to the outputted music and rotates. The device will also house an LCD screen to display current song information as well as push buttons to skip or playback songs and control the volume. Some of the main design constraints of this system include the cost of the overall product, the size/packaging, and the heat dissipation.

Updated PSSC's:

1. An ability for a user-created webapp to communicate a selected song to the Rpi through an http request (API poll).
2. An ability for a computing PC (Rpi) to stream music through the Grooveshark API and communicate the song information with the microcontroller.
3. An ability to create a 'lights' show corresponding the the music beat, which will be sampled from the auxiliary out of the Rpi via the microcontroller ADC.
4. An ability to control the direction and rotation speed of the LED package through a motor controlled via the micro PWM peripheral.
5. An ability to utilize an LCD to display user-selected (via a control device) metadata (e.g. audio options, light settings, and track information)

2.0 Design Constraint Analysis

As mentioned in the introduction, the major design constraints that will be considered for this product are as follows:

1. **Size/Portability/Packaging:** The product's intent is to be "plug-and-play", so the design must adhere to an easily relocatable and portable form factor. It must be light enough to be lifted, carried, and transported easily by a single person.
2. **Cost:** The Every1 DJ cost should be kept as low as possible to appeal to the general public and to stay competitive with other similar party systems.
3. **Heat Dissipation:** Most of the system is housed at the base of the Every1 DJ system. This includes the Raspberry Pi, PCB, LCD and motor. With so many components running at the same time, there is potential for overheating of components. This product may need to utilize an in house cooling system to maintain proper temperature while running.

2.1 Computation Requirements

Overall, the computational requirements of the Every1 DJ are relatively small. The microcontroller ADC channels will be used to sample the audio output of the Rpi, which will not consume an inordinate number of CPU cycles, due to its peripheral location and interrupt-driven status. Some computation will be required to store song metadata received from the Rpi over UART, and a bit more will be necessary to convert that data into a readable format for the LCD. Motor control and LCD control panel operations will both be peripheral/interrupt driven as well.

2.2 Interface Requirements

The microcontroller selected for this project is responsible for driving the LED's, the LCD that will relay the selected song information, the motor, and the push buttons. With only using 4 LEDs coming out from the base shining onto the disco ball, there will be not a huge number of GPIO pins needed for the design. A tentative number of GPIO pins needed for the LEDs with the use of an LED driver is around 7, but may increase as our design varies throughout the design process. A serial shift register (or equivalent pin-expansion peripheral) will be used to expand the number of I/O pins if needed for the LEDs. The remainder of the I/O pins will be used for the LCD housed at the base of the device, the push buttons and the motor control. The microcontroller will interface with the LCD through a serial port and around 6 I/O pins will be needed. The microcontroller will interface with the Raspberry Pi auxiliary output jack to sample the sound through an ADC. Based on the frequency of the sound, the LED display will flash and the motor will spin the disco ball accordingly.

2.3 On-Chip Peripheral Requirements

The current design's microcontroller selection will require 2 channels 10-bit ADC for left and right channels of audio sampling. 2 channels of UART will also be necessary, one for micro-Rpi communication, and one for data transfer to the LCD. GPIO constraints are rather small - 4-6 pins for LCD control signald, 4-5 for LED and LED driver toggling, 1-2 for motor control (in addition to PWM), 5 for pushbutton sampling on the user control panel, and 3 for debug signals. Last, the microcontroller will need 2 channels of 8-bit PWM - one for motor control, one for rapid, accurately-timed LED pulsing.

2.4 Off-Chip Peripheral Requirements

The only selected off-chip peripheral that we see a need for is a level translator to switch from 3.3V to 5V for Raspberry Pi. All other peripherals will be taken care of on-chip. However, a change to a more complex, larger LCD could necessitate an LCD controller chip, which will also tie up 3-4 more GPIO pins.

2.5 Power Constraints

The Every1 DJ operates on A.C. power only, and has minimal heat dissipation requirements. Avoiding damage to electronic components is the only heat dissipation concern. One way for thedevice to dissipate heat is through a heat sink such as thermal resistance. The variance between the Raspberry Pi's 5V supply and the 3.3V supply of the remaining digital components will require the use of a level translation circuit. Another power constraint involves voltage regulation with supplying enough voltage to the motor. We have to make sure that we regulate the voltage to the other components so they do not blow up.

2.6 Packaging Constraints

The main packaging constraint associated with this product is how the LED's will be configured on the outside of the disco ball. The LED's must be mounted on the base of design on a pole that needs to be at the right angle and height to hit the disco ball correctly. Another packaging constraint includes the size of the LCD and motor, which will determine the size of the base where the disco ball will sit. Where the product will sit in user's homes is also a constraint that needs to be addressed when estimating the size of the base. This product is a tabletop design and therefore the product cannot be too bulky. One final constraint will be mounting the disco ball on the stepper motor to allow the ball to rotate freely without any resistance.

2.7 Cost Constraints

The Every1 DJ is cost-constrained by its consumer electronics market. There aren't any direct competitors, but consumers are only willing to pay a small, expendable amount on a device in the personal/social entertainment product line.

3.0 Component Selection Rationale

Microcontroller:

Research, based on the above stated on-chip and interface peripherals, was done to determine the correct microcontroller needed for the Every1 DJ. The two microcontrollers that stood out during the research are: the MSP430F47177IPZR and the PIC18F87J11. Below is a comparison of the two microcontrollers. These microcontrollers are almost identical, and both meet the needs of our design. They both have 68 I/O pins, which is more than enough to control the LED's, the LCD, the motor, and the push buttons. Both microcontrollers also have UART interfacing which is needed to interface with the Raspberry Pi and the LCD.

From all the research completed so far, the PIC line of microcontrollers seem to be the best option for the Every1 DJ. They offer enough I/O pins, more than enough program memory, the correct communication peripherals, on-chip ADC is offered and the price is reasonable to keep the cost of the product down. It will also be helpful that the PIC18F87J11 is available in the senior design lab for prototyping.

Model	**I/O Pins**	**Program Memory**	**Communication Peripherals**	**ADC**	**Price**
MSP430F47177IPZR [1]	68	92 KB	UART SPI I2C2		$11.26
PIC18F87J11 [2]	68	128 KB	2 - UART 2 - SPI 2 - I2C2	12 @10b	$4.67

LCD:

The LCD will display all song information as well as push button settings. It will be housed within the base of the design, so the user will be able to access information needed. The size of the screen is dependent on the size of our base, which is 4 inches in height. Therefore, the NHD-2.23-12832UCB3 seems sufficient for the design. The display is large enough for users and there is plenty of documentation.

Model	**Screen Size**	**Interface**	**Price**
NHD-2.23-12832UCB3 [3]	2.23 inches diagonal	Parallel / Serial	$27.65
F-55472GNBJ-LW-AGN [4]	69 x 36.5 mm	Parallel / Serial	$17.37

Onboard Computer:

The onboard computer will be interfacing with the internet and streaming audio through the Grooveshark API. The computer must be able to run a stable Linux distribution, communicate with the Microcontroller over serial connection, connect to the internet via Wi-Fi, and output line audio. With these constraints in mind the following were selected to be compared.

Model	**Wifi**	**RAM**	**CPU**	**Power Requirements**	**Price**
Raspberry Pi [5]	USB Dongle	512 Mb	700MHz Broadcom	300mA @5V	40.00
BeagleBone Black [6]	USB Dongle	512 Mb	1GHz Sitara™ ARM® Cortex-A8 processor	210-460mA@5V	45.00

The main criterion for the computer is cost and documentation. Since most of the computation will be light the RAM and CPU, either of the two devices will be sufficient. Both the Raspberry Pi and the BeagleBone have wireless capability via a USB Dongle and similar power requirements. Ultimately the Raspberry Pi was chosen because of the extensive amount of documentation available on the web.

4.0 Summary

The Every1 DJ will use the PIC18F87J11 microcontroller to handle motor control, audio sampling, LCD display, and user control signals. Audio streaming will be executed on an onboard Raspberry Pi computer. Song selection and tallying will be accomplished via a Django-framework webapp. An LED and motor-controlled “lights show” will accompany the audio playback. The device will draw power from a standard AC outlet and will provide audio output on a 3.5mm audio jack.

5.0 List of References

[1] "MSP430F47177IPZR." Internet: http://www.ti.com/lit/ds/symlink/msp430f47166.pdf, [Feb. 5, 2014].

[2] "PIC18F87J11." Internet: http://ww1.microchip.com/downloads/en/DeviceDoc/39778e.pdf, [Feb. 5, 2014].

[3] "NHD-2.23-12832UCB3." Internet: http://www.digikey.com/product-detail/en/NHD-2.23-12832UCB3/NHD-2.23-12832UCB3-ND/2640780, [Feb. 6, 2014].

[4] "F-55472GNBJ-LW-AGN." Internet: http://www.digikey.com/product-detail/en/F-55472GNBJ-LW-AGN/73-1351-ND/2270347, [Feb. 6, 2014].

[5] "Raspberry Pi" Internet: http://downloads.element14.com/raspberryPi1.html, [Feb, 6 2014].

[6] "BeagleBone Black" Internet: http://www.digikey.com/product-highlights/us/en/texas-instruments-beagleboard/685#beagleboneNext,[Feb. 6, 2014]

IMPORTANT: Use standard IEEE format for references, and CITE ALL REFERENCES listed in the body of your report.

Appendix A: Parts List Spreadsheet

Vendor	*Manufacturer*	*Part No.*	*Description*	*Unit Cost*	*Qty*	*Total Cost*
Digi-Key	Microchip	PIC18F87J11	Microcontroller : http://ww1.microchip.com/downloads/en/DeviceDoc/39778e.pdf	4.67	3	$14.01
Amazon	Raspberry Pi	RASPBERRY PI MODEL B 756-8308 Raspberry Pi B	R-Pi : http://www.amazon.com/RASPBERRY-MODEL-756-8308-Raspberry-Pi/dp/B009SQQF9C/ref=sr_1_1?ie=UTF8&qid=1391731289&sr=8-1&keywords=rpi	40.35	1	$40.35
Amazon	Edimax	EW-7811Un	Wireless adapter: http://www.amazon.com/Edimax-EW-7811Un-Wireless-Adapter-Wizard/dp/B003MTTJOY/ref=pd_bxgy_pc_text_y	9.99	1	$9.99
Amazon	SB Components	N/A	Raspberrry Pi Case: http://www.amazon.com/SB-Raspberry-Pi-Case-Clear/dp/B008TCUXLW/ref=pd_bxgy_pc_img_z	9.00	1	$9.00
Amazon	Kootek	N/A	R-Pi Power Supply: http://www.amazon.com/Kootek-Raspberry-Supply-Charger-Adapter/dp/B00FIFYQMA/ref=pd_sim_pc_3	9.50	1	$9.50

Amazon	Transcend	TS8GSDHC10E	8GB Flash Memory Card: http://www.amazon.com/Transcend-Class-Flash-Memory-TS8GSDHC10E/dp/B003VNKNEG/ref=pd_sim_e_5	8.95	1	$8.95
Digi-Key	Newhaven Display Intl	NHD-2.23-12832UCB3	LCD: http://www.digikey.com/product-detail/en/DSPIC33EP512MU814-I%2FPH/DSPIC33EP512MU814-I%2FPH-ND/2772	27.65	1	$27.65
Sparkfun	China Young Sun LED Technology Co., LTD	YSH-FRGBB-IA	3W RGB LED: https://www.sparkfun.com/products/8718	14.95	4	$59.80
	NXP	PCA9626	PCA9626 I2C LED Driver: http://www.nxp.com/products/interface_and_connectivity/i2c/i2c_led_display_control/series/PCA9626.html	4.90	1	$4.90
BeWild	N/A	N/A	12 inch disco ball: http://www.bewild.com/juxx12dimiba.html	$19.99	1	$19.99
AutomationDirect	SureStep	STP-MTR-23055	Stepper Motor: http://www.automationdirect.com/adc/Shopping/Catalog/Motion_Control/Stepper_Systems/Stepper_Motors_-z-_Cables/STP-MTR-23055?utm_source=google&utm_medium=product-search&gclid=CO6Mz7a0uLwCFSISMwodthkAGA	$35.50	1	$35.50

Digi-Key	Bud Industries	NBB-22241	Enclosure to hold hardware: http://www.digikey.com/product-detail/en/NBB-22241/377-2035-ND/3681224	33.70	1	$33.70
TOTAL						$273.34

Appendix B: Updated Block Diagram