Group7
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Design Constraint Analysis and Component Selection Rationale
(Homework 4)

Introduction:

Our design project consists of two parts. The first is a laser gun. It will fire a laser similar to what a laser pointer pen would use. The other part is, of course, the target. It will detect hits by the laser while keeping track of and displaying the current score as well as other information. In order to detect accuracy, the board will be divided into circles much like a dartboard. Each section will have to be routinely scanned by the circuitry of this target unit. The gun will be run off of batteries, and so power consumption will be a concern. Both of the gun and the target unit will use a lookup table in conjunction with a pulse width modulator to drive a speaker for sound effects.

Analysis of Design Constraints:

Computation Requirements:

For the target unit, the microcontroller will need to do the following: keep track of the current score, time left etc., receive input from the light detecting circuitry on the board, update the led displays, and feed a sound signal to an amplifier. Of all these, the only one that would come close to straining most any microcontroller would be the sound capability. This would require both a fast (or at least not slow) microcontroller as well as one with as much internal memory as possible. Since a lookup table with frequencies and a pulse width modulator will be used, the memory usage can be considerably less than if the usual sound format was used. Theoretically, this means that anywhere from a few bytes on up to Mbytes could be used to store the sound. Therefore, the more non-volatile memory the microcontroller has, the better. There is, however, no required minimum amount needed. A separate audio playback chip could be used for the sound generation.

Since a microcontroller is already being used for other functions, though, it would be a waist to use the extra chip.

The microcontroller located inside the gun, has just about the same computational requirements. It must receive input from the trigger button, send an output signal to the laser, and feed a sound signal to a speaker. Again, since the main function of this microcontroller deals with sound, the same considerations need to be taken for this processor as the one mentioned above.

Interface Requirements:

The plan for detecting laser strikes is to measure the voltage across either photo diodes or CDS cells using the microcontroller's Analog-to-Digital function. Since we will need perhaps two-dozen sensors, we will use analog multiplexers to feed the signals to the microcontroller. For the sound generation we plan on using the pulse width modulator. Since the human ear can detect sound in the range of 20 Hz to 20 kHz, the PWM will need to be able to output a signal throughout most of that frequency spectrum.

Power Supply Constraints:

The target unit will plug into a wall outlet, so it really shouldn't have a problem with power consumption. The gun, though, will use batteries for power. This means that all electrical components inside it must consume as little power as possible. Since the laser will only be firing for a fraction of a second, the main concerns are the microcontroller and the speaker. The PIC18F458 microcontroller that we are planning to use has a maximum power consumption of 1.0 W. ([2]) The speaker that we plan using on the gun has a maximum power rating of 400 mW. ([6]) With four AA batteries running at around 1.2V and 2000 mAh the gun should have no problem running for a few hours.

Packaging Constraints:

The packaging for the target unit will need to be fairly large to allow for the target board area. Also, since the target unit will probably sit, weight will not be of huge concern. The real challenge in packaging is with the gun. Here, size is going to be the

main concern. The microcontroller, PCB board, laser, batteries, and speaker must all be located inside the gun. Of course, the laser will be placed in the barrel, and the batteries will be stored in the handle. Luckily the PCB board needs to connect very few parts, and those parts require few traces.

Cost Constraints:

Since both parts of our project use the microcontroller to generate a decent sound signal, we cannot get away with using a very inexpensive part. Both microcontrollers under consideration are not excessively expensive though. The PIC16LF877A is $4.68, while the PIC18F458 is $6.25. ([9], [10]) The largest cost of the project, though, will be the light detecting devices. The photodiodes are $0.50 each and the CDS Cells are $1.00 apiece. ([6], [8]) We plan on using around 25 of these.

Rationale for Component Selection:

The microcontrollers are the brains of both the gun and the target unit. Therefore, it is important to make a wise choice as to which microcontroller to use. The requirements that we have for our microcontroller are that they have at least one Analog-to-Digital converter and a pulse width modulator. All three chips under consideration meet or exceed these requirements. Also, with all three chips running at about 8 MHz, they all have more than enough processing power to handle our needs. ([1], [2], [3])

The function that will strain the microcontrollers the most is generating the sound signal. Since all three run at more than adequate speeds, the main concern is the amount of flash memory on the chip. The first candidate is Microchip Technology's PIC16LF877A. It comes with 14.3 Kbytes of internal flash memory. ([1]) The other PIC under consideration is the PIC18F458. This one has 32 Kbytes of flash memory. ([2]) The third chip under consideration is the Motorola MC68HC912B32. It also has 32 Kbytes of flash memory. ([3]) More memory translates into either higher quality sound, or more total playtime. This makes the latter two chips look more attractive than the first.

Also of concern is pin count. Fewer pins means a less crowded PCB board. Since we are using analog multiplexers for the laser hit detection signals and multiplexers

for the LED displays, the target unit should need no more than 20 I/O pins. Both of the PICs have 40 pins while the Motorola has 63. ([1], [2], [3]) 63 pins is definitely overkill. This makes the Motorola chip look unappealing.

One advantage that the Motorola chip has is that it is a 16-bit processor while the PICs are 8-bit. ([1], [2], [3]) This really doesn't matter, though, since the extra computational power is not needed.

Having more memory than the PIC16LF877A and a lower pin count than the MC68HC912B32, the PIC18F458 seems to be our microcontroller of choice. This microcontroller will be used in both the target unit and the gun since they have similar requirements.

Figure 1: List of Major Components

Part	Vendor	Part Number	Unit Cost	Quantity	Total Cost
PIC18F458	Microchip	18F458	$6.25	2	$12.50
8mm Red Jumbo LED	Goldmine	G13530	$0.25	4	$1.00
Giant CDS Cell	Goldmine	G1296	$1.00	15	$15.00
Large Photo Diode	Goldmine	G13585	$0.50	16	$8.00
Flat Speaker	Goldmine	G13674	$0.20	5	$1.00
Large 7-Segment Display	Goldmine	G1586	$0.50	2	$1.00

List of References

[1] PIC16LF877A
http://ww1.microchip.com/downloads/en/DeviceDoc/39582b.pdf

[2] PIC18F458
http://ww1.microchip.com/downloads/en/DeviceDoc/41159c.pdf

[3] MC68HC912B32
http://courses.ece.uiuc.edu/ece385/class/bc32ts.pdf

[4] G13530 8mm Red Jumbo LED
http://www.goldmine-elec-products.com/prodinfo.asp?number=G13530&variation=&aitem=1&mitem=1

[5] G1296 Giant CDS Cell
http://www.goldmine-elec-products.com/prodinfo.asp?number=G1296&variation=&aitem=1&mitem=9

[6] G13674 Flat Speaker
http://www.goldmine-elec-products.com/prodinfo.asp?number=G13674&variation=&aitem=1&mitem=2

[7] G1586 Large 7-Segment Display
http://www.goldmine-elec-products.com/prodinfo.asp?number=G1586&variation=&aitem=1&mitem=1

[8] G13585 Large Photo Diode
http://www.goldmine-elec-products.com/prodinfo.asp?number=G13585&variation=&aitem=1&mitem=1

[9] PIC18 Microcontroller prices

http://buy.microchip.com/chart.aspx?branchID=1004&mid=10

[10] PIC16 Microcontroller prices

http://buy.microchip.com/chart.aspx?branchID=1002&mid=10