Homework 3: Design Constraint Analysis and Component Selection Rationale

Due: Friday, February 10, at NOON

Team Code Name: _J-Team___________________________________ Group No. _10___

Team Member Completing This Homework: _Jonathan Chen__________________________

NOTE: This is the first in a series of four "professional component" homework assignments, each of which is to be completed by one team member. The completed homework will count for 10% of the team member's individual grade. It should be a minimum of five printed pages.

Evaluation:

Component/Criterion	**Score**	**Multiplier**	**Points**
Introduction	0 1 2 3 4 5 6 7 8 9 10	X 1	
Analysis of Design Constraints	0 1 2 3 4 5 6 7 8 9 10	X 3	
Rationale for Component Selection	0 1 2 3 4 5 6 7 8 9 10	X 3	
List of Major Components	0 1 2 3 4 5 6 7 8 9 10	X 1	
List of References	0 1 2 3 4 5 6 7 8 9 10	X 1	
Technical Writing Style	0 1 2 3 4 5 6 7 8 9 10	X 1	
		TOTAL	

Comments:

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1.0 Introduction

The RFID Xpr3ss system aims at improving the overall efficiency of the modern supermarket checkout system . The main goal is to replace the UPC labels with RFID tags to reduce scanning time of each item and greatly simplify the checkout process by introducing solely electronic payment options. Since this project is highly customer-oriented, our greatest constraints will be on the overall appearance of the finished product and also the ease of use and friendliness of the user interface. Additional design objectives include cost and PCB size minimization. With the customers in mind, visible parts such as the LCD and keypad were selected such that the look and feel of the product is generally pleasing. This will be discussed in further details below.

2.0 Design Constraint Analysis

The major design constraints of this project, as mentioned in section 1.0, will be the appearance and ease of use of the product, as well as minimizing cost and PCB size. It is imperative that customers find our product easy to use. This means that we cannot have dull LCD screens or keypads that are small and hard to press. Other constraints include the number of pins that will be required by the processor to interface with peripherals and external devices. We do need to interface with an RFID reader, an LCD, and a keypad encoder. The need to communicate with an external database requires us to have an Ethernet controller as well.

2.1 Computation Requirements

Most of our computational power will be used to operate the LCD, sending and receiving packets from a remote database through the Ethernet controller, and interpreting results gathered from the RFID reader. Other jobs, such as processing signals from the keypad will be trivial and require minimal computational power. None of these major functions are as complex as image or audio processing, and hence there is very little constraint on the processing power requirement of the microcontroller. The only time constraints we have identified seem to be trivial, such as handling a key-press interrupt, decoding an RFID tag, and promptly displaying a product's information to the LCD. While the number of instructions needed on the microcontroller is limited, most delay will likely result from accesses to the database through the Ethernet controller. Overall delay should be on the scale of milliseconds, and hence virtually undetectable by the user.

2.2 Interface Requirements

The finished product will not have any analog input or output, and thus all I/O will be digital. To interface with the LCD, 8 bi-directional pins and 5 output pins will be needed. These 13 pins are used to read from, write to, and control the LCD [1]. The LCD is provided power by the inverter, operating at 5 V with a maximum of 450 mA of current. It dissipates a considerable amount of power, 2.25 W max [2]. The LCD logic uses 5 V and 15 mA [1]. The keypad will be interfaced through a matrix encoder, and only 5 input pins and 1 output pin will be required on the controller side to receive data from the keypad at 4.5 V and .55 mA [3]. The RFID reader will be interfaced via RS232 communication and is only capable of transmission; hence, by using the Maxim IC MAX233A RS232 receiver, it will require only 1 input pin [4][5]. The total number of required I/O pins for these major components is 20. None of the pins in use on the microcontroller require optical isolation and have nominal sinking and sourcing requirements.

2.3 On-Chip Peripheral Requirements

One on-chip peripheral we are definitely going to use is the built-in Ethernet controller. Since the 9S12NE64 comes with only 64 KB of memory, it is not practical to embed the database of all items in the supermarket and customer information into each chip – whether on the basis of memory capacity or convenience of future modification to the database. Therefore, it is necessary for us to have an external database, and the best way we can communicate with such a database is through networking. Hence, a built-in Ethernet controller was a necessity when we chose our microcontroller. Another on-chip peripheral we will need to make use of is a Serial Communication Interface for use with the RFID reader[6]. These are two requirements that are necessary for our design project.

2.4 Off-Chip Peripheral Requirements

The off-chip peripherals that we will be using are a keypad encoder for our 16-button keypad and an RS232 level translator for our RFID reader. Our choice for the keypad encoder is a Fairchild matrix encoder, capable of reducing the necessary I/O pins required [7]. A Maxim MAX233A was chosen for the RS232 interface [5]. We will also have a PLD for general use and backup I/O expansion.

2.5 Power Constraints

Since this product is designed to be stationed in a supermarket where power supply should be abundant, there are no significant power constraints in our design, though power conservation still played a role in our component selection. There are, however, concerns about component heating within the case, especially the microcontroller and LCD, which has a backlight and a separate controller of its own [1]. Also taking into consideration that the product will likely remain powered for a prolonged period of time (days or even weeks), we will be implementing a cooling system in our design. We decided that, depending on the severity of the heating problem, a series of vents or fans could be used to circulate the air and adequately cool down the components.

2.6 Packaging Constraints

As mentioned before, the RFID Xpr3ss is a very customer-oriented product. To the least, none of the internal parts should be seen by the user. This implies that no wires, PCB or ports should be visible. Supermarkets already using UPC self-checkout machines should have more than enough room for our more compact solution. Hence there are no volume or shape constraints either. The keypad, LCD, and RFID reader are the only devices with which the user will directly interact, so these parts were carefully chosen to be able to withstand normal usage.

2.7 Cost Constraints

The primary cost constraint for RFID Xpr3ss is the minimization of production costs. This product is one of the first of its kind, and in order for it to have mass-market appeal to grocery stores around the world, it has to be an affordable, yet efficient, solution. We anticipate the prototype development to cost approximately $400, the bulk of which is due to the RFID reader with built-in antenna, keypad, and graphical LCD. However, subsequent production costs can be reduced by bulk ordering these items. For example, for our choice of LCD, a single purchase costs $112.63, while in bulk orders of 1000+ the unit cost drops to only $45.39.

Another factor in RFID Xpr3ss' mass-market appeal remains out of our hands and the scope of this project - that is the current price of RFID tags and the cost associated with overhauling the grocery industry and tagging all products with RFID labels. As RFID technology continues to improve, the cost of the labels will certainly decrease, making our solution an even more economical one for grocery chains worldwide.

RFID Xpr3ss is unique in that existing market solutions do not utilize RFID tags for identification of products; rather, similar machines like the NCR FastLane use UPC labels to identify products and deactivate RFID tags for security purposes. FastLane units have been installed anywhere from grocery stores in Germany to Home Depots across America. Due to confidentiality, security, and company policy, it is not possible for NCR to release pricing information for FastLane; therefore, our design has no competitive cost constraints. Regardless, because of the RFID implementation differences between RFID Xpr3ss and FastLane, it is apparent that RFID Xpr3ss will be the only solution like it on the market and faces no direct competition.

3.0 Component Selection Rationale

Microcontroller: Freescale MC9S12 NE64

The team compared this microcontroller with the TA neCore12 LAN DIP Module and the Rabbit RCM3750 RabbitCore Module. The design constraints require that there is an integrated Ethernet controller. All three choices have integrated Ethernet capabilities, but the later two came in packages which cost a lot more than the controller itself. Another design goal is to minimize board size, and the NE64 microcontroller is significantly smaller than either of the two modules, even considering the extra circuitry that will be required to integrate a separate Ethernet jack. This controller also operates at a low 3.3 V, as compared to the 5 V Rabbit microcontroller [6]. Moreover, Freescale's 9S12 offers up to 70 I/O pins, far more than our required 20 for major components, and thus allows for fast parallel communication with external devices. Comparing the price of the 9S12NE64 ($7.92) to the DIP module from TA ($79.00) and from Rabbit ($74.00), the choice is very clear.

RFID Reader: Intersoft USA Medium Range RFID Reader

The team compared this reader of choice with two other readers: the TI S4100 Multi-Function Reader Module and the Parallax RFID Reader Module. For the purpose of this design, long range is not required and is actually undesirable, since the reader might detect tags that weren't intended to be read yet. A medium range is ideal, as long as it doesn't require the tag to be immediately close to the reader. The TI Reader offers a very wide range in both low and high frequencies, but it doesn't come with an antenna. Separate antennas were unlikely to be gained as samples and increased the project cost by several hundred dollars. The Parallax reader offers a range of a mere three inches, which is sufficient for most small merchandise, but will be insufficient for larger ones like trash cans, requiring the customer to flip the object around to scan it, hence defeating the purpose of using RFID. The decision comes down to the Intersoft reader, with a decent maximum range of 19 inches, dependent upon tag size, and slim design with a built-in antenna, at a modest cost of $130.00 [4].

LCD: CrystalFontz CFAG240128D-FMI-T

The team had a wide range of choices for the LCD. A display was needed to show multiple lines of text, and preferably some graphics capability to make the checkout process more appealing. All of the available character LCDs had a maximum of four lines and would not be able to handle a reasonable display of items that had been scanned. Hence, character LCDs have been ruled out. Other comparable graphical LCDs either cost significantly more or did not have a high enough contrast. Also, the CFAG240128D does not have a wide viewing angle, meaning customer privacy is protected [1].

Keypad: Storm 6000 series PIN entry pad

Once again, there exists a very wide array of keypads to choose from, ranging from sealed, weather-proof, and customizable to back-lit, mounted, or conductive rubber. The choice will be based on two main concerns: an appealing appearance with a low cost, and an adequate number of keys to perform desired functions (PIN, Enter, Clear, Cancel). The Storm keypad has a very pleasing appearance and a nice ergonomic design. The team acquired a sample of a 4 x 4 Grayhill series 84 keypad with insertable keys. However, the buttons were too small and required that the user pressed very hard, and the unit itself wasn't aesthetically pleasing. Therefore, the team selected the Storm 6000 series keypad [3].

4.0 Summary

The components that will comprise the RFID Xpr3ss system were chosen specifically to operate within identified design constraints. The computational load on the microcontroller is relatively small, and the required I/O pins and on-board peripherals are not extraordinary and were easily satisfied with the selection of the MC9S12NE64, with its built-in Ethernet controller, low power consumption, small footprint, and cost-effectiveness. Minimizing power consumption is a general goal, considering the elongated runtime of the unit. Packaging constraints are not strict, but we intend to decrease the size and beat the cost of existing market solutions. Overall, the components selected for the RFID Xpr3ss meet the established design constraints and thus would be a good fit for our project.

List of References

[1] CrystalFontz CFAG240128D Graphic LCD
http://www.crystalfontz.com/products/240128d/CFAG240128DFMIT.pdf

[2] CrystalFontz CFAICCFL1 Inverter for backlit graphic modules
http://www.crystalfontz.com/products/240128d/CFAICCFL1.pdf

[3] Storm Interface 6000-210023 16 Key PIN entry keypad
http://www.alliedelec.com/catalog/pf.asp?FN=1086.pdf

[4] Intersoft Corp WM-RO-MR2 Medium Range RFID Reader
http://www.intersoft-us.com/dnload/WMROMR2.pdf

[5] Maxim IC MAX220 - MAX249 Multichannel RS232 Drivers/Receivers
http://pdfserv.maxim-ic.com/en/ds/MAX220-MAX249.pdf

[6] Freescale MC9S12NE64 Microcontroller
http://www.freescale.com/files/microcontrollers/doc/fact_sheet/MC9S12NE64FS.pdf

[7] Fairchild Semiconductor MM74C922 16 Key Encoder
http://www.fairchildsemi.com/ds/MM%2FMM74C922.pdf

Appendix A: Parts List Spreadsheet

Vendor	*Manufacturer*	*Part No.*	*Description*	*Unit Cost*	*Qty*	*Total Cost*
Freescale	Freescale	9S12NE64	16-bit microcontroller (80 pin)	7.92	1	7.92
Allied Electronics	Storm Interface	6000-210023	16 Key PIN Entry Keypad	112.71	1	112.71
CrystalFontz	CrystalFontz	CFAG240128D	240x128 Graphic LCD	112.63	1	112.63
CrystalFontz	CrystalFontz	CFAICCFL1	Inverter for backlit graphic modules	5.47	1	5.47
Intersoft Corp.	Intersoft Corp.	WM-RO-MR2	Medium Range RFID Reader	130.00	1	130.00
Mouser	Fairchild Semiconductor	MM74C922	16 Key Encoder	11.23	1	11.23
Maxim/Dallas Semiconductor	Maxim IC	MAX233A	RS232 Level Translator	7.80	1	7.80
				TOTAL		**$387.76**