University of Victoria

Department of Electrical Engineering

ELEC 399 FINAL REPORT:

DESIGN OF A RUGGEDIZED MARINE CATCH COUNTER

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EXECUTIVE SUMMARY

Long-line fishermen on the Pacific coast of Canada need an efficient and accurate way of recording and tracking their fish catch at sea. The existing systems are manual counting methods which can yield an error when fishermen rely on keeping track of counts in their mind. Knowing this, Archipelago Marine Research (AMR) presented University of Victoria several key issues that they were interested in pursuing a solution for. Our main goal for this project was to conceptually design something that allows fishermen to record their catch quantity for up to 16 species of fish. This ruggedized catch counter would be used in conjunction with existing observation technologies employed at sea as a method of validation of catch data.

The design that was decided on is a counter board, similar to a scoreboard but utilizing a microprocessor with RFID tagging and pushbutton manual input. Each species has its own square which has seven-segment displays that display the incremented count of each type of fish. Fishermen are able to add species to the board on the fly by scanning RFID tags laminated on Fish ID cards. A catalogue of Fish ID cards is kept on the boat with a vast species list, allowing the fishermen to tailor their counter board with the most commonly caught species. The fish counter will output a file to be used with spreadsheets, but also have the ability to communicate via RS-232 with existing observation equipment.

The system is explained in detail in the remainder of this report complete with a Bill of Materials detailing cost on the equipment proposed to be used.

1.0 INTRODUCTION

The following is the background, motivation and goals for designing a ruggedized marine catch counter.

1.1 BACKGROUND

Long-line fishermen on the Pacific coast of Canada need an efficient and accurate way of recording and tracking their fish catch at sea. Currently, it is personal preference as to how to record their catches. Present catch counting systems consist of several different manual methods which include:

- Hand-held counters with manual tally
- White board manual tracking
- Counting fish hooks associated with each species caught
- Rings or tokens hung on pegs or in a bucket for each species

Each of these presents their own advantages and disadvantages. These systems can be cumbersome and difficult to retain accurate counts. Inaccurate counts can yield penalties from the Department of Fisheries (DFO) in the way of fines or mandatory at-sea observation.

1.2 MOTIVATION

Archipelago Marine Research (AMR) presented University of Victoria several key issues that they were interested in pursuing a solution for. With consultation of the engineering staff at AMR, requirements were detailed and our team proposed a solution that was welcomed by the staff. This ruggedized catch counter would be used in conjunction with existing observation technologies employed at sea as a method of validation of catch data.

1.3 GOALS

This group's main goal for this project was to conceptually design something that allows fishermen to record their catch quantity. This is done based on the system requirements set fourth below.

We plan to learn more about the microprocessor and how many BCDs can be implemented with an RFID tagging system to create a system to increment the count. This system will also need to be integrated to any system using RS-232 communications.

2.0 DESIGN DETAILS

A design was obtained by focusing on the functions required to count fish on a long-line fishing vessel. The design takes into account the functions that are needed for a straightforward system that the fishing industry would be keen to implement as well as environmental factors that fishermen encounter with regards to sea conditions.

The premise of the design is a portable scoreboard that can be arranged to store the count of several species of fish. It houses a Programmable Interrupt Controller (PIC) which increments the count of the necessary species with human interaction. Human interaction is in the form of a number pad for numerical input and Radio Frequency Identification (RFID) tags for confirmation of incrementation. The data of this system would be stored in a Comma Separated Variable (.CSV) file format onboard a MicroSD card meanwhile offering RS-232 communications to any existing AMR observation equipment onboard the fishing vessel. Further details are below.

2.1 SYSTEM REQUIREMENTS

Requirements were set out by AMR necessary for this project to fulfill. The following is what was specified:

- Design a large, rugged and interactive control system which allow long-line fishermen to record their catch on the desk of their vessel
- System is to indicate each time that they have started and finished hauling a line
- Ability for fishermen to indicate that they have caught up to 12 species of fish
- Communicate with existing system- RS 232
- System has easy way to correct a mistake
- Feedback to confirm last entry and confirmation of successful input
- Waterproof and rugged system suitable for decks of fishing vessels
- Simple and quick to use system requiring few movements for quantity entry
- Ability to be used with gloves on in slippery surface conditions

The following design works towards satisfying these requirements.

2.2 PHYSICAL LAYOUT

The primary goal of the physical design is to house all of the components needed with a specific focus on waterproofness and ruggedness. A sketch of the design of the scoreboard is attached in Appendix A.

2.2.1 Case Design

The base of the counter board housing is going to be a 2 foot by 2 foot marine grade (5086-H32) aluminum case. The housing will contain all the electronics and should serve as a very good heat sink for the internal components of the design. The 7-segment displays will be viewable through a plexiglass top cover that will further seal the components from the sea water.

Between the aluminum housing and the plexiglass cover will be a waterproof gasket combined with a desiccant. The desiccant, consisting of silica gel, is used to help control the humidity and moisture within the case. These silica gel packages are replaced at regular intervals to ensure effectiveness at absorbing the moisture.

2.2.2 Fishsquares

Appendix A is a sketch of the main face of the counter board divided into 16 squares. Each of these “fishsquares” are intended for unique addressing of a specific species of fish. Each one has 3 seven-segment displays (SSD) which would display a count of up to 999 for each species.

Each square also has a metal binder clip attached to it for the purpose of clipping in a Fish Identification Card (Fish ID). This Fish ID is a laminated card that has a picture of the fish associated with the square as well as a unique RFID chip. In the top corner of each square is a number which identifies specifically to a square. This is intended for programming the Fish ID to the specific square in order to display the necessary count of each fish caught as entered by the user.

2.2.3 Counter Displays

Located on the top of the scoreboard are two SSDs which are labeled as Haul Count. Each group of catches are organized under a haul number, which can help to identify the breakdown of species caught based on the long-line number in which they were caught.

Next to the Haul Count is the user input SSDs labeled as Keypad Input. These consist of two SSDs that can display a number with a maximum value of 99. This Keypad Input will display the value entered on the keypad, prior to confirmation by user and incrementing the quantity of each fish species.

2.2.4 Number Pad

The number pad will be mounted to the side of the scoreboard in a case that is molded as part of the frame of the scoreboard. This will ensure minimal seams in which water can enter the case. The seams that do exist from the countersinking of the number pad in the mold will have a waterproof silicon gasket between the bottom side of the number pad and the flat edge of the case in which it mates to. The number pad is inherently waterproof.

2.2.5 RFID Components

Connected to the side of the scoreboard is the RFID wand which houses the RFID chip reader. When not in use the wand is stowed securely at the side. RFID tags are laminated on the Fish ID card which are then clipped onto the fishsquare, and associated to the counter display by entering the location number and scanning the Fish ID card.

2.3 ELECTRICAL DESIGN

The following are the various electrical components that comprise the counter board internals. The Electrical Block Diagram is seen below which outlines the interconnection of all of the components.

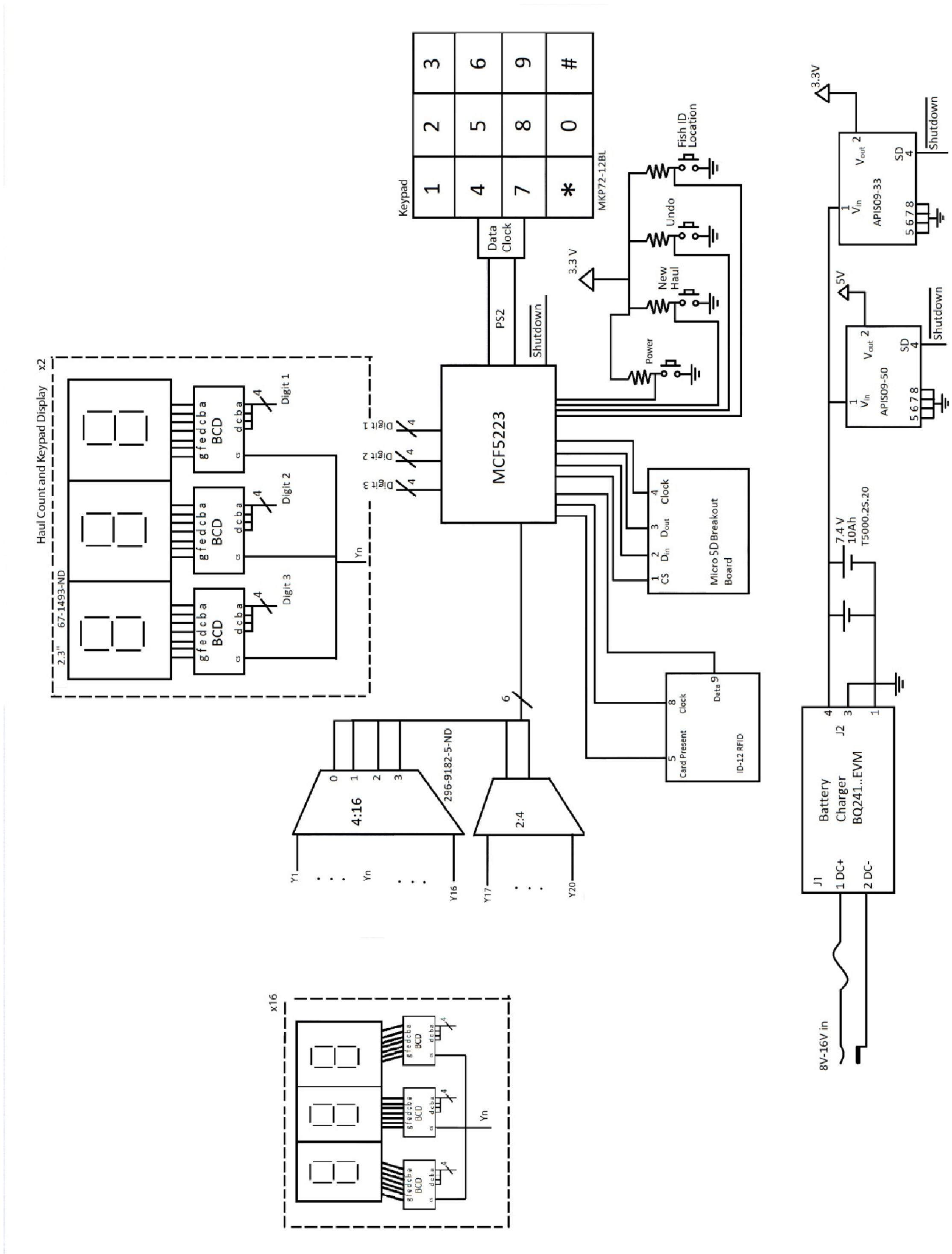

Figure 1: Electrical Block Diagram with Pinouts

2.3.1 Microprocessor Development board

The Coldfire microcontroller MCF52235 Development board due to its robust capabilities and familiarity to us. This 32-bit Development board has a fast clock rate of 25MHz and is capable of communicating with multiple serial devices. This is needed to utilize the RFID reader, Keypad, and MicroSD card interface. This will be done using the Queued Serial Peripheral Interface (QSPI) onboard feature. It has two interrupt controllers which in total accept up to 126 interrupts.

The MCF52235 has enough general input/output ports that will accommodate the use of the 6 to 20 demultiplexer, and a 12 bit data bus for the many, BCD 7-Segment Displays that are utilized.

The board is especially useful for this application due to its ability to communicate using RS-232 protocol. This protocol will be utilized to interface with any existing AMR system that may be onboard the fishing vessel. There is also an onboard ethernet controller which may be used to interface with advanced systems at a later date.

The MCF board will be powered via +5.0Vdc and also features low power modes which will enhance battery life. The MCF board will enter this low power mode when the power button is pushed. When this occurs, the active low shutdown line will go to 0v causing the 5V regulator and 3.3V regulator to turn off. These regulators power the 7-Segment displays and other integrated chips (ICs).

2.3.2 RFID system

On the side of the scoreboard is a weatherproof wand with an RFID reader attached to the end of it. It is wired to the microprocessor for the purpose of confirming value entry after inputting the numerical value via the numerical keypad. The weatherproof wand will be custom built with design outside of the scope of this project. However, it is specified to be waterproof with a sealed wire connection at the base. The main function is to provide portability of the RFID reader.

The RFID system is low-powered, utilizing a +5Vdc supply and operates using a 125KHz frequency to read the RFID tag. The card format is EM 4001 meaning that the output data structure consists of a 9 bit header, 40 data bits, 14 parity bits, with a stop bit to finish [1]. This output data is modulated using Manchester 64-bit coding [2].

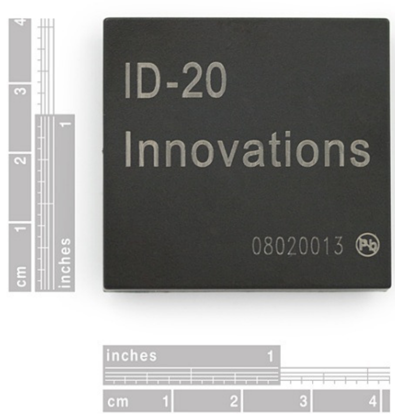

Figure 2: RFID reader [3]

The RFID tag is mounted on a Fish ID card. These cards can be mass produced using groups of similarly programmed RFID tags. A catalogue of Fish ID cards with all commonly caught species will be kept on board to add or swap new species on the counter board.

2.3.3 Keypad and Master Buttons
On the side of the scoreboard is a weatherproof numerical keypad with a 3x4 button arrangement and another 4 buttons used to enter various modes. All of these components have been rated under the IEC (International Electrotechnical Commission) 60529 standard as suitable for rugged environments.

The keypad will be the primary source of user input and will be used in conjunction with the RFID wand. This keypad is marine grade and will survive the elements once deployed. It is rated at IP65 (IEC 60529), which is dust tight and is capable of at least withstanding powerful water jets, projected by a nozzle at 12.5 litres per minute and pressure up to 30 kPa from 3 meters away.

Much like the keypad, the four master buttons are rated as IP67 (IEC 60529), which is dust tight and capable of at being immersed in water up to 1 meter for a duration of 30 minutes.

The following is the purpose of the master buttons:
- numeric keypad for quantity values
- incrementing haul count
- fish ID location
- universal undo button

2.3.4 Counter Displays
A total of 54, 7-Segment displays are used on this project to display various counts and totals. In order to utilize all of these 7-Segment displays individually, it would take 378 data lines or pins of a microprocessor.

378 = (7 bits to display a number) x (54, 7 Segment displays)

This would require either a very unique microprocessor or multiple microprocessors to accomplish such a task. With the use of Binary Coded Decimal (BCD) chips and a demultiplexer, this can be cut down to a 12 bit data bus and a 6 bit address bus. This brings the total amount of pins needed to uniquely use the 54 7-Segment displays to 18.

2.3.5 Memory System
An onboard memory card will be used as the primary means of storing data. To write to this card, an interface is needed between the microprocessor and the card. The MicroSD works using +5Vdc power supply to create a breakout between the traces of the MicroSD card to allow data to be written to it via the Interface lines [2]. The card can be written to with a max clock speed of 25MHz [4]. Figure 4 details the board while commenting for power options based on different voltage levels if needed.

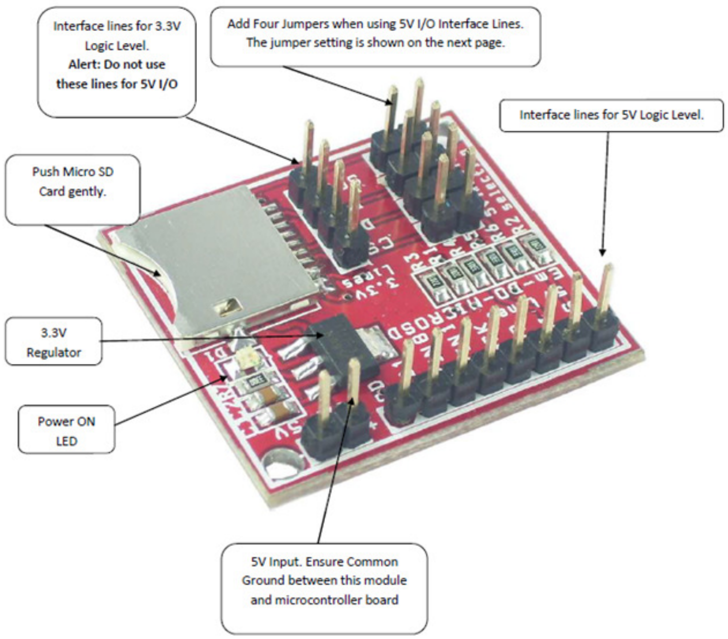

Figure 3: MicroSD card [2]

2.3.6 Battery System

The BQ24100EVM (24100) is an integrated Lithium-Ion and Lithium-Polymer charge management device. It offers an integrated synchronous Pulse-Width Modulation (PWM) Controller and high-accuracy current and voltage regulation, charge conditioning, charge status, and charge termination. The BQ24100EVM will charge the battery in three phases: conditioning, constant current, and constant voltage. By controlling the charging to the battery we are able to ensure that it is always charged in a manner that will minimize damage to the integrity of the cell.

The flexibility of allowing charge to be terminated based on user-selectable minimum current level makes for a reliable charger. A programmable charge timer provides a backup safety for charge termination. The BQ24100EVM automatically enters sleep mode when VCC supply is restored.

The 24100 can provide a continuous charging current of 2A for up to 2 cells and offers efficiency above 80% for charge currents up to 2A. It is adequate for a temperature range of -40degC to 125degC which is important for environmental conditions.

3.0 BILL OF MATERIALS

Table 1 is the Bill of Materials which detail individual components needed. The quantity, cost, and link to the source website to purchase these components is provided.

Name/Description	Part Number	Quantity	Price	Total	Available From
mcf52235	M52235EVB	1	$ 299.00	$ 299.00	http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=M52235EVB
4:16 Demux	296-9182-5-ND	1	$ 0.87	$ 0.87	http://www.digikey.ca/product-detail/en/CD74HC154M/296-9182-5-ND/376807
2:4 Demux	296-3782-1-ND	1	$ 0.50	$ 0.50	http://www.digikey.ca/product-detail/en/SN74LV139APWR/296-3782-1-ND/374664
BCD, 1 digit	296-31539-2-ND	54	$ 0.14	$ 7.78	http://www.digikey.com/product-detail/en/CD4543BM96/296-31539-2-ND/1691658
2.3" 1 digit, 7 seg, 10mA/led	67-1493-ND	6	$ 10.33	$ 61.98	http://www.digikey.com/product-search/en?mpart=LDS-AD16RI&vendor=67
0.8" 1 digit, 7 seg, 10mA/led	67-1477-ND	48	$ 2.12	$ 101.76	http://www.digikey.com/product-search/en?mpart=LDS-A814RI&vendor=67
RFID Reader ID-12 (125 kHz)	ID-12	1	$ 29.95	$ 29.95	https://www.sparkfun.com/products/8419
Micro SD card Interface Breakout Module	EM-BO-MicroSD	1	$ 2.85	$ 2.85	http://www.embeddedmarket.com/products/Micro-SD-card-Interface-Breakout-Module-for-3-3V-and-5V-Logic-Level/
12keys Metal Backlit Numeric Keypad	MKP72-12BL	1	$ 20.00	$ 20.00	http://kingleader.en.made-in-china.com/product/OvXndxUKEJcq/China-12keys-Metal-Backlit-Numeric-Keypad-MKP72-12BL-.html
HBJ19 series metal waterproof ip67 push button switch	HBJ19-A1RH1L	4	$ 5.00	$ 20.00	http://www.alibaba.com/product-gs/430516698/HBJ19_series_metal_waterproof_ip67_push.html?s=p
marine grade, waterproof case	N/A	1	$ 50.00	$ 50.00	http://www.protocase.com/
Binder clips 1"	14409-CA	16	$ 0.11	$ 1.83	http://www.staples.ca/ENG/Catalog/cat_sku.asp?webid=671985&CatIds=&AffixedCode=&=&=&=&cid=CSE:SBD:SHOPBOT:SE:671985_ENG
BQ24100EVM: 1 Cell Li-Ion/Li-Pol battery charger	296-17258-ND	1	$ 50.00	$ 50.00	http://www.digikey.com/scripts/DkSearch/dksus.dll?WT.z_header=search_go&lang=en&keywords=BQ24100EVM&x=0&y=0&cur=USD
Turnigy 5000mAh 2S 20C	T5000.2S.20	2	$ 15.34	$ 30.68	http://www.hobbyking.com/hobbyking/store/__9172__Turnigy_5000mAh_2S_20C_Lipo_Pack.html
5v regulator 2A	AP1509-50SGDITR-ND	1	$ 0.89	$ 0.89	http://www.digikey.ca/product-detail/en/AP1509-50SG-13/AP1509-50SGDITR-ND/1301328
3.3v regulator 2A	AP1509-33SGDITR-ND	1	$ 0.95	$ 0.95	http://www.digikey.ca/product-detail/en/AP1509-33SG-13/AP1509-33SGDITR-ND/1301327
			Total:	$ 677.20	

Table 1: Bill of Materials

4.0 SOFTWARE ALGORITHM

4.1 PROGRAMMING FLOWCHART

The software algorithm is demonstrated in Figure 3 with a programming flow chart. The process of incrementing the counters and storing the data is shown in a general step-by-step description.

The basis of operation is the utilization of a main routine and a interrupt service routine (ISR). The system is initialized with a catalogue of Fish ID cards programmed in, meaning that the commonly addressed RFID tag values are pre-programmed as variables used through the program.

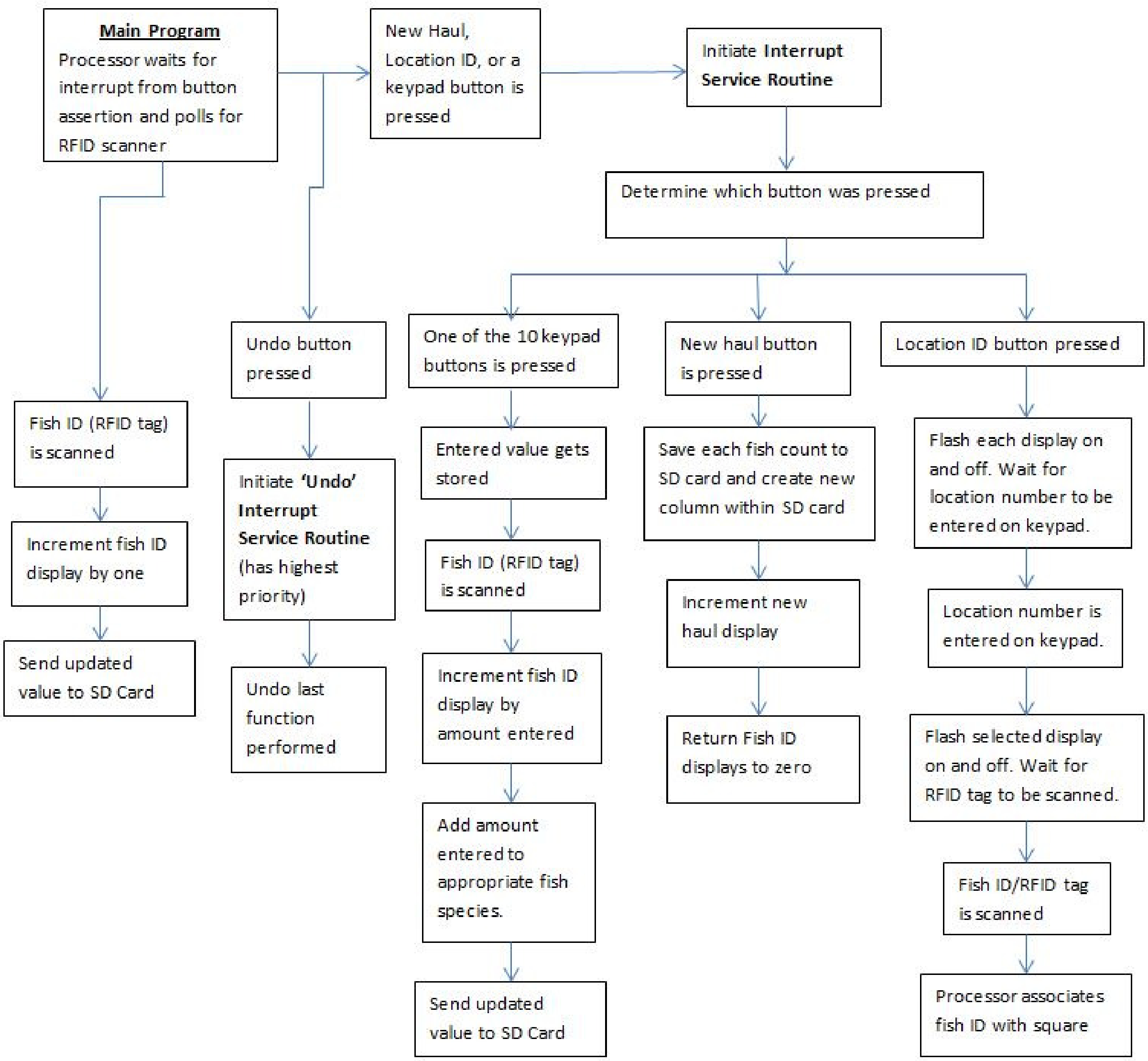

Figure 4: Programming Flowchart

The main routine polls for the RFID reader "Card Status" bit which initiates when an RFID tag is nearby. This is used for individual incrementing done by scanning an RFID Fish ID card. For other operations, one of four master buttons is pressed to enter one of two ISRs. The software algorithms are based on the modes of operation listed below.

4.2 MODES OF OPERATION

- A fisherman initiates a new haul count by asserting the master button 'New Haul'. The haul count display is then incremented and all fish count displays are reset to 000. The previous data is saved as a set, and associated to the previous haul count.
- A user catches a single fish of some species different than the majority being hauled in. Rather than inputting a number on the keypad, the user simply scans the appropriate Fish ID card with the RFID wand and the value is stored on the SD card.
- A user wants to enter a multiple quantity of fish via the keypad. When the user presses any button on the keypad, the value is displayed on the keypad counter display. The user then scans the Fish ID card which is the confirmation to the processor to go ahead and increment the corresponding counter display for that specific species. This correlation is determined by the RFID tag on the Fish ID card which is programmed to the specific counter display on that fishsquare.
- A user wants to add a specific fish species to the counter board for the purpose of keeping track of the quantity. The user presses the 'Location ID' master button causing each counter display to flash. A location ID of value 01 to 16 is entered on the keypad. This location ID is of the specific fishsquare whose counter display the user will utilize for record keeping is entered. The user then scans the Fish ID card of the new species and clips the card to the fishsquare. This process correlates the RFID tag on the Fish ID card to the counter display at that specific fishsquare.
- If a user completes an action such as entering an incorrect quantity and would like to undo their last entry. The user presses the undo button, starting the Undo ISR which reverses their last action.

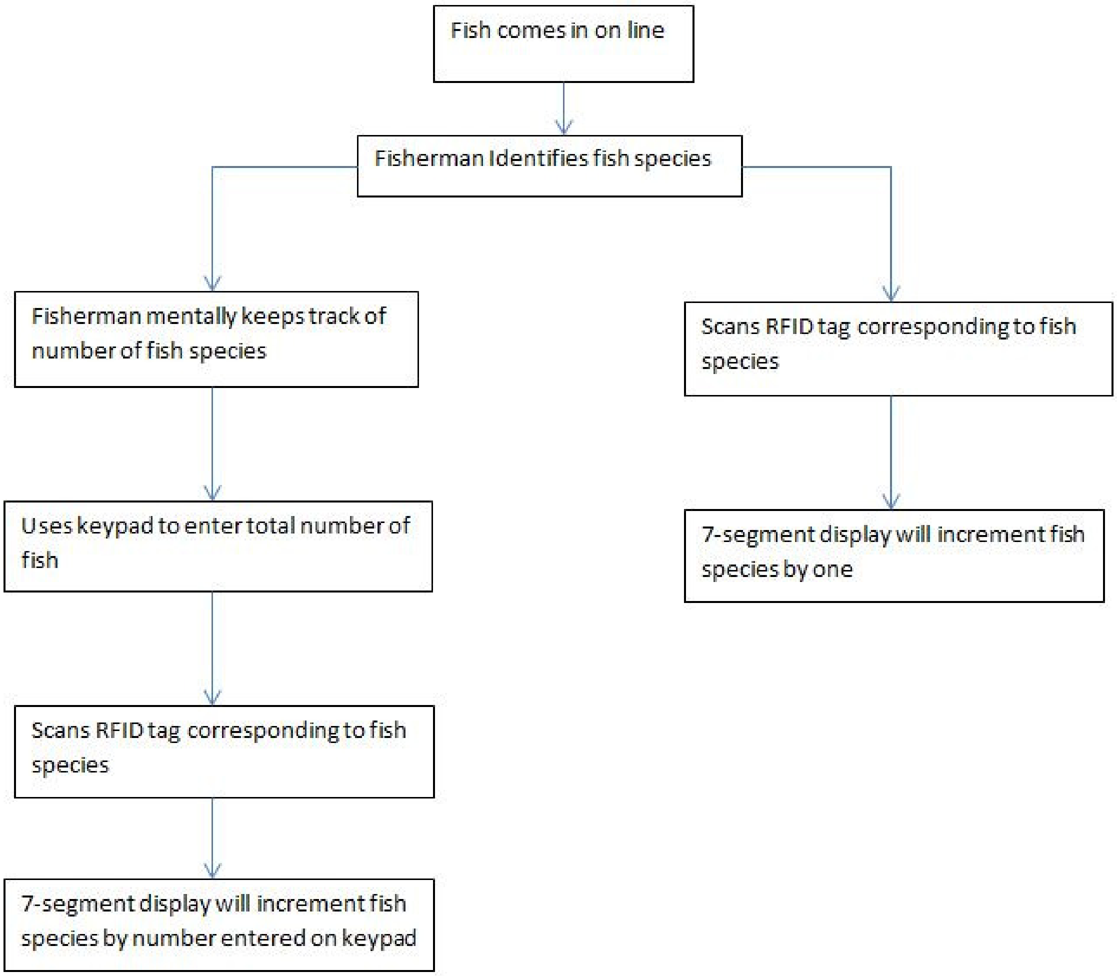

Figure 5: Mode of Operation

4.3 PROGRAM OUTPUT

The output of the algorithm will be saved to a Comma Separated Variable (.CSV) file. The .CSV format is a widely used standard for spreadsheet data collection. An example of what we expect the .CSV file to look like is shown below:

CSV format file:
"Species","Char","Trout","Grayling","Salmon","Whitefish","Cod","Dogfish","Tuna","Squid"
"Haul 1",5,10,45,87,1,54,350,0,2
"Haul 2",0,51,96,41,0,7,12,8,6
"Haul 3",45,3,48,1,7,68,453,34,9
"Haul 4",6,0,7,74,52,4,5,45,0

Microsoft Excel spreadsheet interpretation of CSV file:

Species	Char	Trout	Grayling	Salmon	Whitefish	Cod	Dogfish	Tuna	Squid
Haul 1	5	10	45	87	1	54	350	0	2
Haul 2	0	52	96	41	0	7	12	8	6
Haul 3	45	3	48	1	7	68	453	34	9
Haul 4	6	0	7	74	52	4	5	45	0

Table 2: Excel CSV output

5.0 PROJECT WORKLOAD

5.1 DISTRIBUTION

Throughout the project our group worked well to divide tasks and ensure even distribution of work. Our group held five meetings prior to completion of this project report and all group members were present and actively participating by presenting their ideas and opinions for the project.

The physical design was based on all of our input. The software algorithms encompassed different methodologies that we brainstormed together. The report was largely completed by Paul, Ian Colquhoun and Ryan, while the website was solely Ian Rusk's task as it was necessary for him to learn Cascading Style Sheets (CSS) web based programming.

5.2 ACHIEVEMENTS

The greatest achievement that we encountered was understanding the process of total system design. Having a practical motivation to create a system that solved an issue with the constraints that were given was a valuable lesson in real life project methodology.

More specifically, we learned much about the capabilities and limitations of the microprocessor, RFID systems, and Binary Counting systems. Ian Rusk learned much about CSS as well.

6.0 FUTURE CONSIDERATIONS

Cost reduction is a realistic possibility by gaining price break on components based on ordering greater quantities. A large cost of the project is the development board microprocessor. This processor was chosen as it was familiar to us and had the features we needed. A price break could be attained by choosing a different, more affordable processor that had similar I/O capability.

Portability could be further enhanced by introducing a wireless RF Xbee module board known as an Xbee WiFi module. These modules have a long-range reception up to 300m. To use this, an Arduino microprocessor board can be attached to the Xbee module.

7.0 REFERENCES

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[4] Kingmax Digital Inc. “SD Card Specification,” [Online.] Available: http://downloads.amilda.org/MODs/SDCard/SD.pdf

[5] Marine Grade Aluminum “Aluminum Alloys,” December 1, 2012. [Online.] Available: http://youboat.net/diy/metalBoats/aluminumAlloys.aspx (Marine Grade Aluminum)

8.0 APPENDICES

1. **Scoreboard Sketch**