November 20, 2011

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
8888 University Drive
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Design Specifications for SmartFlow

Dear Dr. Rawicz:

Please find the enclosed document describing the design specifications for our company's product: SmartFlow. Our team at Smart Remote Communications (SRC) Telemetry Incorporated is designing, implementing, and creating this product to allow clients the ability to control remotely located fluid tanks through the use of text messages via GSM enabled cellular phones.

The design specifications document enclosed provides a detailed description of the design implementations for the development of our product and also includes the overall design details of each of the major components used. Additionally, we provide a plan to describe the integration of each of the components used in the construction of our product. This document considers the design specifications that apply only to the proof-of-concept model; improvements in the design for future prototypes and releases of SmartFlow are discussed, but will not be implemented at this stage of the product development lifecycle.

This document will also be employed as a guiding source for our engineers throughout the design, construction, integration, testing, and debugging stages. SRC Telemetry is comprised of five undergraduate engineering students at Simon Fraser University: Yazan Shehadeh, Zhi-Yu (Mark) Zhou, Monir Pejgaleh, Shervin Asgari Pour, and Amit Verma. Should you have any questions or inquiries please do not hesitate to contact us at src.telemetry@gmail.com. Alternatively, you may contact me by phone directly at 778.838.4778.

Yours sincerely,

Amit Verma

Amit Verma
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Enclosure: *Design Specifications for SmartFlow*

Smart Remote Communications Telemetry Inc.

SmartFlow
Design Specifications

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Executive Summary

The engineering team at SRC proposes to design and to build this innovative and creative device in order to facilitate and assist its clients and to provide them with a cost effective and simple solution for the control and manipulation of remotely located systems or devices by the use of telemetry. The SmartFlow prototype unit will make use of the GSM (Global System for Mobile Communications) network and will allow SRC's clients the ability to send instructions and requests through the use of text messages to the SmartFlow unit. Upon the successful receipt of properly formatted messages from authorized customers, our product will perform the requested operations and notify the users of the resulting outcomes.

This document provides a technical description of the design specifications for SRC Telemetry's product: SmartFlow. The enclosed design specifications document illustrates the development lifecycle of the SmartFlow prototype unit from inception to completion. The required specifications outlined are necessary in order to provide additional insight and justification for the design choices made. Furthermore, they are also used as a means of ensuring and validating that all the requirements have been met for the proof-of-concept model.

Successful operation of the prototype SmartFlow unit requires that it meets the design requirements set within this document. The system is divided into the following separate essential components, each of which is absolutely vital for ensuring the proper functionality of the prototype device.

- Programmable Logic Controller (PLC)
- GSM Modem
- Water Level Sensors
- Water Pumps
- Emergency shut-off switches

The details of the design, implementation, and operation of these essential components, together with their integration with other non-core components (i.e. water tanks, pipes, float switches, etc.), are discussed in their respective sections of this document. Furthermore, the specifications that are presented here will adhere extensively with those that were set forth in the functional specifications document (marked with I or II). Upon the successful completion of the prototype SmartFlow unit, additional testing of the device will commence in order to ensure that finalized product prototype meets all the stated requirements.

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List of Acronyms

GND: Ground

GSM: Global System for Mobile Communications

LED: Light Emitting Diode

PLC: Programmable Logic Controller

SMA: Sub-Miniature version A RF Connector

SIM: Subscriber Identity Module

SMS: Short Message Service

1 Introduction

SmartFlow is a sophisticated, yet easy to use, product that aims to give its users the ability to control and to manipulate fluid levels in remotely located storage vessels and tanks through the use of text messaging over the GSM network.

A client initially sends an SMS text message containing the requested commands to the GSM modem component located within every SmartFlow device. For safety, security, and reliability purposes, the received text message is then checked for user authentication and for proper command formatting at the PLC. Validated messages are then converted into a string of instructions and transmitted to the pumps, which perform the requested actions. For proper functionality of the product, the team at SRC has also employed level sensors to ensure that the desired fluid levels can be easily obtained. Once the requested actions have been performed, an SMS text message is generated and transmitted to the client to inform them of the resulting outcome. The actual implementation requirements for the SmartFlow device, as proposed by SRC Telemetry Inc., are described in this design specifications document.

1.1 Scope

This document outlines the design specifications that must be achieved by SRC's upcoming SmartFlow unit. This in-depth document includes all the design requirements necessary to provide a complete description for a proof-of- concept model; it also partially details the final production model of a working SmartFlow prototype unit. These design requirements will closely adhere to those that were set forth in the functional specifications document and will be reflected extensively in SRC's finalized product.

1.2 Intended Audience

The design specifications presented in this document will be utilized by the engineering team at SRC in conjunction with the previously outlined functional specification requirements. Design engineers will use this document as a guideline for the construction of the SmartFlow prototype unit. Furthermore, test engineers will assess the similarities and differences between the constructed prototype and the criteria given here to ensure that adherence to the specified design requirements has been kept.

2 System Specification

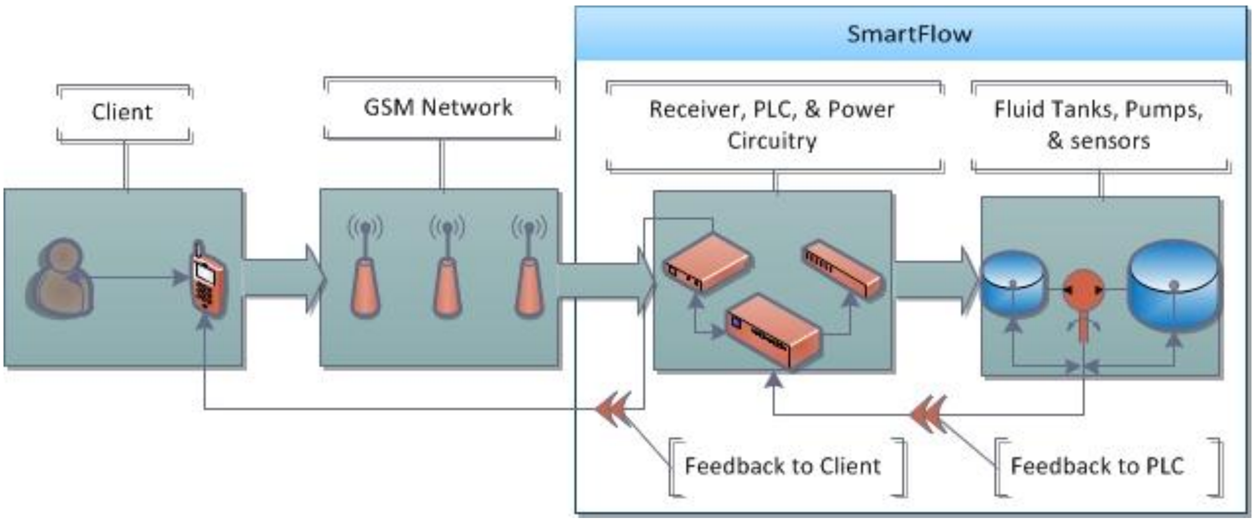

Figure 1 - SmartFlow System Specification

Figure 1 illustrates the high-level block diagram design of SRC Telemetry's SmartFlow device. As can be seen above, a SmartFlow prototype unit consists of the following core components:

- GSM Module
- Programmable Logic Controller
- Power circuitry
- Emergency shut off (incorporated into power circuitry)
- An in-flow fluid tank (smaller tank)
- A fluid storage tank (larger tank)
- Bi-directional water pump
- Level sensors for the fluid storage tank
- Float switch for the in-flow fluid tank
- Feedback system

It is expected that the finalized product will be employed in the oil industry for controlling remotely located oil tanks, these fluid vessels are assumed to be owned by companies or governments that wish to purchase the SmartFlow unit; as such, the tanks are only included in the prototype SmartFlow unit for proof-of-concept demonstration purposes. Furthermore, for proper operation of the device, it is also expected that a client has access to a GSM enabled cellular phone capable of transmitting and receiving text messages through the GSM network.

3 Overall System Design

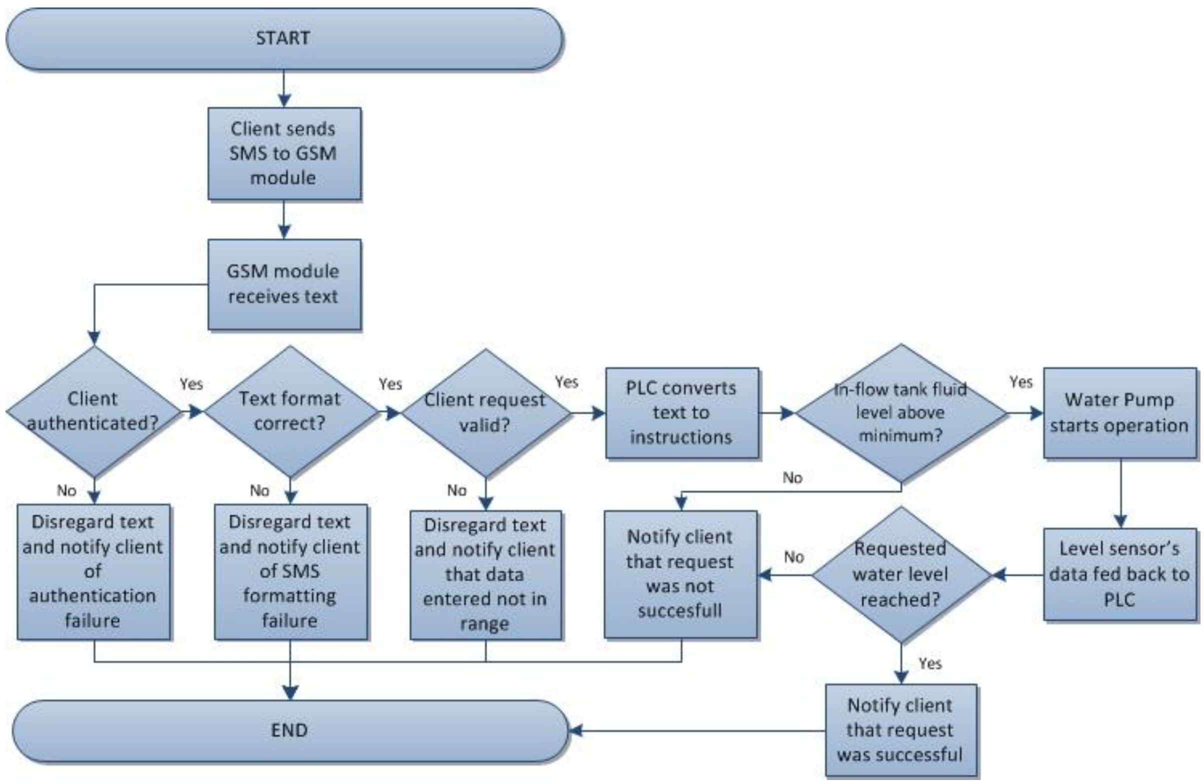

Figure 2 - Overall System Design Flowchart

Figure 2 illustrates the steps involved for processing and executing a client's request. As can be seen above, a client initially sends a text message with the requested actions on a GSM enabled cellular phone to the GSM module in SmartFlow. Internally, the SmartFlow unit will check the received text message for user authentication, proper formatting of the request, and for the validity of the user input data. If any of the above fails, SmartFlow issues a notification to the user informing them of the cause of the error and takes no further action.

If all three cases pass, the text message is converted into a string of machine readable instructions and is relayed to the water pump and the client's request is processed. Once the water level in the tanks starts to change, a level sensor installed in the storage tank sends a feedback signal to the PLC and informs it of the fluid level that has been reached. The pump continues to operate until the desired level has been reached and finally notifies the user that the request has been successfully executed. A float switch is also used in the in-flow tank to ensure pump safety; all pump operations will be stopped once the level of fluid in that vessel has reached its minimum point.

4 Programmable Logic Controller (PLC)

The PLC component will be an essential part of the system as it maintains and controls system level operations in either semi-automatic or full automatic mode. Its main purpose is to maintain and to operate the various electrical components in SmartFlow, and to ensure that the operation of the actuators and motors are within acceptable operating ranges. Furthermore, the PLC unit is also responsible for monitoring and responding to any internal or operator inputted commands.

4.1 Component Overview

4.1.1 Embedded Controller

The main component within the PLC is the programmable board with an embedded real-time control logic running.

4.1.2 Input Ports

The input port is responsible for monitoring all incoming sensor information such as that of the fluid level sensor voltage values and the fluid overflow indicator signal. It is also responsible for receiving simple text messages from the GSM modem module in which system operational commands are encapsulated.

4.1.3 Output Port

Output ports control the voltage signals to the electrical components including the pumps and the valves. It also controls the status LED lights indicating the current operating status such as normal operational mode or emergency stop operational mode.

4.1.4 GSM Communication Port

The GSM communication port is a special port designated to control and to monitor the status of the GSM modem module. This allows the PLC to use the port's capability to read and write instructions and feedback text messages for transmission through the cellular network using a SIM card reader.

4.2 Technical Specifications

To ensure all electrical components comply with values of those used by the PLC, all input and output values are confined to specific bounding voltages.

4.2.1 Input Ports

The following table lists the confined range of all input ports used for the PLC unit.

Table 1 - PLC Input Port Specifications

Port Number	Port Name	Maximum Value	Minimum Value	Default Value
$A1$	In-flow tank level sensor	$10.0V$	$1.0V$	$1.0V$
$A2$	Storage tank level sensor	$10.0V$	$1.0V$	$1.0V$
$A3$	Start button	$5.0V$	$0.0V$	$0.0V$
$A4$	Emergency stop button	$5.0V$	$0.0V$	$5.0V$

In Table 1 shown above, ports $A1$ and $A2$ are analog inputs where the voltages are continuous in value between specified bounds. Port $A3$ is a discrete voltage in either $5.0V$ or $0.0V$ representing TRUE or FALSE respectively. Port $A4$ is a discrete voltage in either $5.0V$ or $0.0V$ representing TRUE or FALSE respectively as well. The default status of $A3$ is FALSE and that of $A4$ is TRUE.

4.2.2 Output Ports

The following table lists the confined rage of all output ports used for PLC.

Table 2 - PLC Output Port Specifications

Port Number	Port Name	Maximum Value	Minimum Value	Default Value
$D1$	In-flow tank motor	$5.0V$	$0.0V$	$0.0V$
$D2$	Storage tank motor	$5.0V$	$0.0V$	$0.0V$
$D3$	Operation status LED	$2.0V$	$0.0V$	$0.0V$
$D4$	Emergency LED	$2.0V$	$0.0V$	$0.0V$

In Table 2 shown above, ports $D1$ and $D2$ are the output ports controlling motors for fluid transfer between the in-flow tank and storage tank. These two ports only supply control voltages, and no load voltage or current is provided to the motors. Ports $D3$ and $D4$ are the two status LED lights for each of the inputs $A3$ and $A4$ respectively.

4.3 Logic Diagram

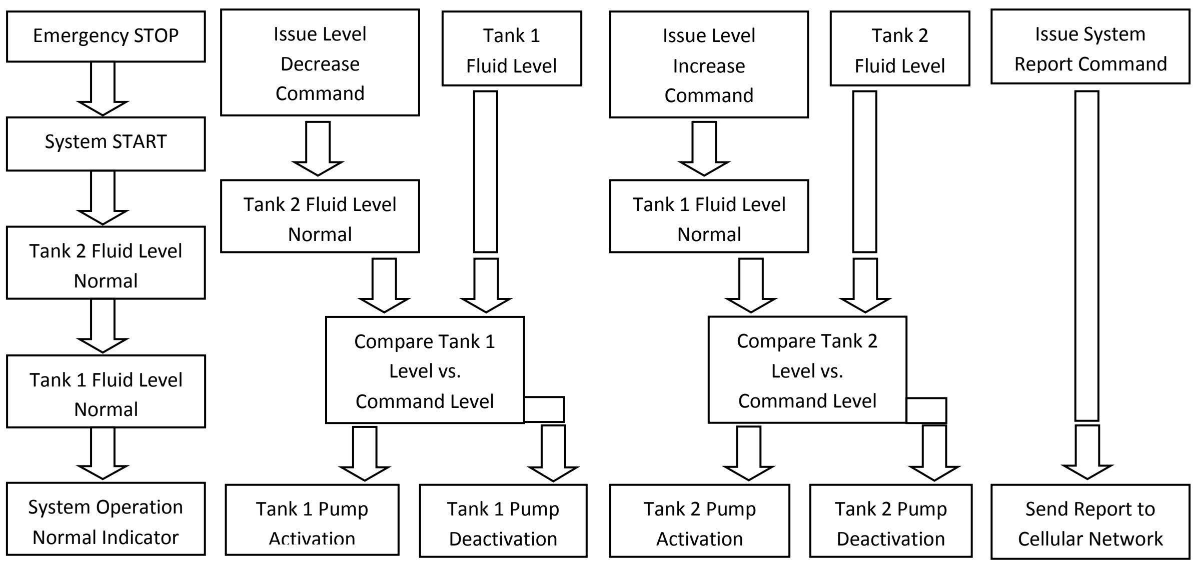

Figure 3 - PLC Logic Diagram

In the flowchart shown in Figure 3 above, the top row represents different sensor inputs and user command inputs; the bottom row represents the different system outputs or actuator/motor control outputs. Each column represents different concurrent threads running in parallel as part of the real-time embedded system.

Control system is operational only if the emergency button is not pressed and the start button is pressed while ensuring that the sensor input data is within operational range. The two motors controlling fluid flow between two tanks are controlled automatically. Additionally, a user can also query all system information including sensor data and operation status through cellular network module.

4.4 Unit Testing

To ensure that the functionality of the PLC is as designed, the following test plan outlines the basic requirements that need to be satisfied for each individual category.

4.4.1 Input Bound Testing

Under this test case, all inputs will be tested with various supplied voltage within the defined bounding range. Operation should be normal, and values should be accurate to within 5% of the actual value. Also, when input values are out-of-bound, values should be capped to the respective minimum or maximum bounding values.

4.4.2 Output Bound Testing

In this test plan, all output values are being compared between the actual and theoretical values, and accuracy should be within 5%. For $D3$ and $D4$, the LED status lights should only be on if the corresponding $A3$ and $A4$ input are contacted. For $D3$, the LED light should be ON when $A3$ is pressed once, and should remain to be ON until $A4$ is pressed. The $D4$ LED light should be ON if $A4$ is pressed once and remain to be ON until $A3$ is pressed once. By default, $A3$ and $A4$ are both OFF.

4.4.3 Embedded Software Testing

This test plan covers all testing on various aspects of the embedded software developed on the PLC. It covers all tests including converting analog to digital signals, analog comparator, read and write to internal registers, and external output ports. It also tests functionalities such as task scheduling and dispatching.

4.4.4 Critical Section Testing

Critical section testing is performed on the emergency stop function. Under all operational modes, full system stop must be achieved as soon as the emergency stop button is pressed.

5 Global System for Mobile Communications (GSM)

The GSM is of type Quad-Band operating at $900/1800\ MHz$. It is able to receive and transmit text messages from the client and controller. Figure 4 illustrates the GSM module unit used.

Figure 4 - GSM Module with all Supplied Parts [1]

The GSM Module shown in Figure 4 includes the following parts:

- DIN ($35\ mm$) Rail Mounting Clip
- 2 Mounting Brackets
- 2 Wire Cables with In-Line Fuse
- GSM Magnetic Antenna (SMA-M)
- Instructions Manual

5.1 Component Overview

5.1.1 GSM Modem – Front End

Figure 5 shows the front end of the GSM Modem.

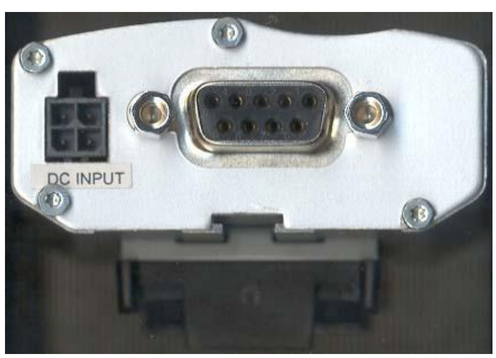

Figure 5 - GSM Modem Front End [1]

The front side of the GSM module includes the following:

- Connector Micro-Fit- 4-pins/M
- DIN ($35\ mm$) Rail Mounting Clip
- Connector Sub-D 9 pins/F

5.1.2 GSM Modem – Rear End

Figure 6 shows the front end of the GSM Modem.

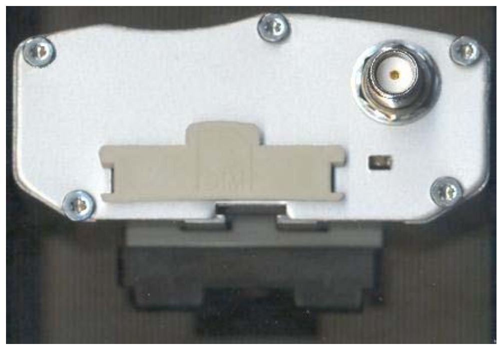

Figure 6 - GSM Modem Rear End [1]

The rear side of the GSM includes the following:

- SIM Card Cover
- GSM Antenna Connector SMA/F
- GSM Light Emitting Diode

The antenna connector is female impedance with 50Ω and allows for the connection of an external DC supply. As for the Connector Micro-Fit- 4-pins in the front side of the GSM, the upper pins are for +VDC and GND, and the lower two are for two NC signals [1].

The 9-pins Sub-D female connector pins are each used for a certain task. Figure 7 shows a schematic representing each of the pins.

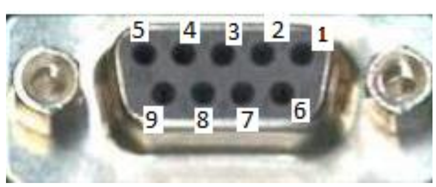

Figure 7 - Connector Sub-D 9 pins/F [1]

Table 3 explains what each of the above pins is used for and whether they are an input or an output pin.

Table 3- Pin Designation for the Connector Sub-D 9 pins/F

Pin Number	Designation	Input / Output
1	Detects the signal	Output
2	Data reception	Output
3	Transmission of data	Input
4	Data terminal ready	Input
5	GND	-
6	Data set ready	Output
7	Request to SEND	Input
8	Clear to SEND	Output
9	Ring indicator	Output

The GSM also comes with a cable that has the 4-pin Micro FIT connector connection to the modem. In it there is a black wire for the ground, $5mm$ tinned copper wire, a red wire for (+VDC), and a fuse $2.5A/250V$. The GSM magnetic antenna comes with a long wire and is for a vertical use. It must be put on a metallic support and is directly connected to the modem.

The modem automatically checks for an available valid network and the GSM LED gives the state of the modem. GSM and all the other devices in SRC have a rail mounting clip; they will all be hooked on a rack next to each other inside a box.

5.2 Unit Testing

To ensure the functionality of the GSM is as designed, the following test plans outline the basic requirements that need to be satisfied for each individual category.

5.2.1 Authentication Testing

The GSM modem is set to only accept authenticated numbers that are assigned in advance. In this testing plan, a text message will be sent to the GSM from a number that has not been authenticated and expect that it gets rejected by SRC's system.

5.2.2 Communication Problem Testing

Case 1: In the case where the modem returns nothing or random characters, the following steps need to be checked:

- if the modem is correctly powered
- if the serial cable is properly connected and cabled to the communication module
- If there are any other applications using the same port causing the conflict
- The configuration of the communications terminal

Case 2: In the case where the modem returns “NO CARRIER”, the following steps need to be checked:

- If the strength of the GSM signal is strong enough
- If the modem registered properly on the network
- If the antenna is properly connected
- If the command been sent out properly with the proper specifications
- If the SIM card is capable of doing the specified task

5.2.3 Modem States and LED Testing

Different actions should give different activities for the GSM LED. Testing the LED is done by the following test cases in order:

1. Power the modem without entering the PIN code or connecting the antenna so that the modem does not have network connection. This should result in the LED on and being fixed without flashing.
2. Power the modem with the PIN code active and the antenna connected. There is network connection and ready for use but in still idle mode. This should result in the LED on and flashing every 2 seconds.
3. Same as step 2 but no longer idle and there is communication. This should result in the LED on and flashing every second.
4. When RESET phase happens or the modem is not powered the LED should turn off.

6 Resistive Level Sensors

To measure and indicate the liquid level in tanks, resistive sensors have been used. The main purpose of the liquid level sensors is to indicate the level where the water reaches for a given input voltage obtained from the PLC. Furthermore, it is also used to indicate whether the liquid has reached the desired level, or to output an error message if it has not reached the requested level. The resistive sensors use different types of electrical components which are designed to give an output voltage within the acceptable range.

6.1 Sensor Placement

The liquid level sensors are designed to be located in a long stick which will be placed on the side of the tank as shown in Figure 8. For proper operation, the sensor stick must have the same length and depth as that of the tank. Additionally, the sensor must be scaled to 10 points in an output voltage range of $0V$ to $5V$ so that it can measure the level at each point and send back a signal to the PLC with the acquired information. At point "G" shown in Figure 8, there will be an alarm or a safety mechanism to ensure that water is not pumped in to the storage tank once this level has been reached. This is a necessary safety feature to guarantee that the fluid level does not exceed the vessel size and overflow.

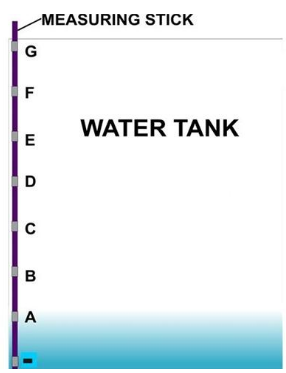

Figure 8- Water level sensor design and position [2]

Table 4 shows the necessary components and specifications required to build this level sensor.

Table 4 - Resistive Water Level Sensor Components

Components used	Component Specifications
Resistors	$1/_4\, Watts,\, 330\ k\Omega$
NAND Gates	2 nos. IC 4011
Capacitors	$0.1\ \mu F\ /\ 50V$
Transistor base resistor (BC547)	$150\ k\Omega$, 1 no
Buzzer Coil	1 no
Piezo Transducer (3 contact)	1 no
Power Supply (adapter)	$12\ V\ DC$

6.2 Circuit Diagram

The water level sensors that are being built for this project have a circuit diagram similar to the one shown in Figure 9. Each measuring position on the sensor, i.e. point “A” through to point “G” (as illustrated in Figure 8), is constructed using 2-input NAND gates; 8 of these 2-input NAND gates are utilized in the construction of this level sensor. The output of each gate will be connected to a control board, in such a way that a feedback signal is generated and transmitted to the PLC once any of the points have been triggered.

Furthermore, the NAND gates must be configured in a way that allows the sensing of logic differences at the input ports. Also, the level sensor circuit will be designed such that the two inputs ports of each gate are connected together and are shorted out. As a result, the 2 input ports of the NAND gate will act as an inverter and will be able to invert the difference in the logic level that will be sensed at the inputs [2]. The circuit figure shown below also indicates that the last point on the measuring sensor “point A” must be connected to the positive supply. The Peizo transducer connected to “point G” is used with the buzzer coil as a safety feature; once the coil starts to oscillates, it causes the transducer to vibrate and to alert the user that the maximum allowable water level has been reached. This step can also be easily replaced with an ON/OFF float switch that will trigger once the water reaches a chosen point.

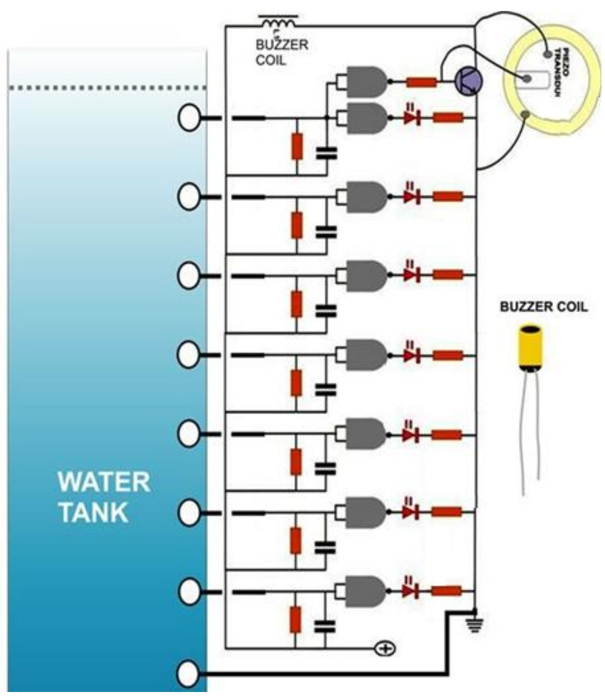

Figure 9 - Water Level Sensor Circuit Diagram [2]

6.3 Functionality and Output

The water level sensor needs a voltage supply of $12V$ DC for continuous discrete measurements. Furthermore, as mentioned previously, it has to provide an analog output voltage in the range of $0V$ to $5V$ to the PLC unit. Following the specifications given in Table 4, the resistors will be kept at logic high by the input resistors before pumping in any water [2].

6.4 Unit Testing

In the following section, the sensor will be tested to make sure that each part works properly and that the sensor gives the desired outputs and readings.

1. Place all components that are being tested in desired positions and make sure all are activated.
2. Provide enough supply voltage to each individual part and make sure that the voltage needed is being reached.
3. Start with an initial position of an empty tank, where the inputs of the gates are logic high.
4. Observe that the negative supply at the bottom of the stick connects with input points while the tank is being filled with water [2].
5. Monitor the sensor and observe that each set of NAND gates (points “A” to “G”) are sending the right signals to the control board.
6. Observe that the top point triggers an alarm system once the water level has reached that point.
7. Once water level has reached a steady state, the gate input signal right below it will be kept at logic high which will be then be transferred to the control board to give accurate readings [2].
8. Verify that the output signals are being passed correctly to the PLC.

7 Power Components

The power components will be the integral part of the SmartFlow and will be required for the construction and use of the overall unit. The following sub-sections will provide detailed design specifications of the components used in the overall unit.

7.1 Water Pump

The water pump will be used to draw fluid from one container to the other. Although, the overall unit can be implemented using any water pump (depending on the industrial requirement), for demonstration purposes SRC will make use of a water gardening pump. Figure 10 shows the Jebao submersible pump that will be utilized to draw water or fluid from one tank to another. A convenient feature of this pump lies in its ability to adjust the water flow rate without requiring any additional valves or any extra control equipment. This pump is impedance protected and carries a current of $0.195A$ at $120V$ with a frequency of $60Hz$.

Figure 10 - Jebao Water Pump

7.2 Float Switches

A float switch is a device used to detect the level of liquid within a tank. When used in SmartFlow's in-flow tank, the switch will detect the rising level of liquid in the tank and will energize an electrical pump which would then pump liquid out of the in-flow tank, until the level of the liquid has been substantially reduced. For safety and for security, the pump will be switched off once this minimum point has been reached.

SmartFlow will use two float switches; The Global Water WA100 liquid level float switch is easy to install, and can be fully submersed into the fluid. Additionally, it includes $20\ ft.$ of 22 AWG, PVC jacketed 2-conductor cable. The WA100 liquid level float switches are also self-weighted so they can be suspended in a tank, stilling well or as a standpipe without the need to tie the float switches off. The point at which the liquid level float switches actuate can be easily adjusted by adjusting the suspension depth as required. The liquid level float switch has a built-in slosh shield that prevents false tripping in turbulent conditions [3].

The low-cost liquid level float switch is ideally suited for sumps, dispenser pans, monitoring wells, tanks, or double-wall tanks where monitoring of leaks is essential. Another great feature of the WA100 liquid level float switch is that it can easily be changed from NC (Normally Closed) operation to NO (Normally Open) operation so that it may be used for high or low level applications [3]. Simply remove the bottom portion of the liquid level float switch's slosh shield and flip the float over to change the function. The liquid level float switch's slosh shield may also be removed for use in applications where there are heavy solids in the water.

Figure 11 - Liquid Level Float Switch

7.2.1 Float Switch Specifications

The following table illustrates the specifications of the liquid level float switch

Table 5- Liquid Level Float Switch Specifications

Liquid Level Float Switch Materials		Current/voltage ratings:	Operation:
Stem & extension:	Brass	$0.14\ A$ (resistive) @ $220\ VAC$	NC (Normally Closed): closes on low level
Float:	Buna-N- **Nitrile rubber**	$0.28\ A$ (resistive) @ $110\ VAC$	NO (Normally Open): closes on high level
Slosh shield:	PBT- **Polybutylene terephthalate**	$0.07\ A$ (resistive) @ $120\ VDC$	Weight: $0.4 Lbs\ (181 g)$
Cable:	20 ft. AWG **American wire gauge** 22 w/PVC jacket	$0.28\ A$ (resistive) @ $24\ VDC$	Dimensions: $1.44 in$ $(3.7 cm)$ Diameter x $4 in$ $(10 cm)$ Length

7.3 Contactors

For safe operation of the motors and to prevent any short circuit in the designed power circuit, SRC engineers will use a contactor switch which is similar to a relay switch except with higher current rating. A contactor is controlled by a circuit which has a much lower power level than the switched circuit. Contactors typically have multiple contacts, and those contacts are usually (but not always) normally-open, allowing the power to the load to be shut off when the coil is de-energized. Thus this component will be used to control the electric motor and to prevent it from short circuiting.

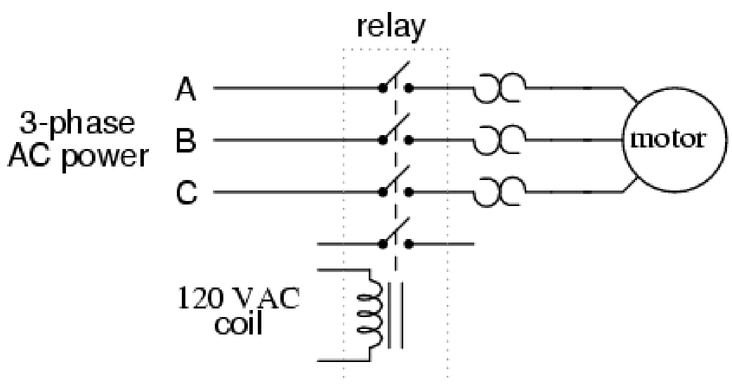

Figure 12 - Contactors Function in Motor Control

As illustrated in Figure 12, the top three contacts switch the respective phases of the incoming 3-phase AC power, typically at least $480V$ for motors with 1 Horsepower or greater. The lowest contact is an "auxiliary" contact which has a current rating much lower than that of the large motor power contacts, but is actuated by the same armature as the power contacts. The auxiliary contact is often used in a relay logic circuit, or for some other part of the motor control scheme, typically switching $120V$ AC power instead of the motor voltage.

Figure 13 - Magnetic Contactor

As shown in Figure 13, SRC engineers will be utilizing a magnetic contactor instead in the construction of the SmartFlow unit. The exterior of the magnetic contactor is square and boxlike. They are made of a heat-resistant, non-conductive plastic such as Bakelite, and have two metal contacts which fit into the contacts of their parent device. Internally, one contact leads to a small electromagnetic coil; while the other contact leads to a soft iron core which stays separated from the coil due to a spring. When electricity flows through the magnetic contactor, it will cause the electromagnet to generate a strong magnetic field. This field will pull the iron core into the coil, and thus create an electrical arc. Electricity passes in through one contact and into the contactor's parent device in this manner. To deactivate, the contactor can be physically pulled from the parent device, additionally, in the absence of electrical current, the spring pushes the core away from the coil, breaking the connection.

7.4 Motor Control Circuit Diagram

SRC is implementing a START/STOP self-holding circuit to make sure that the PLC has a two way control and will further use one of the PLC output relays (Normally Open) to energize the circuit (START) and will use the second output (Normally Closed) relay to STOP the motor by cutting the line voltage at point 1.

Figure 14 illustrates the way in which the motor operates. To start the motor, output 1 will be energized which will then connect the power between point 2 and 3. This will energize the power contactor (M) and the power will be held by self-holding contact (M) that remains powered until the PLC will de-energize the STOP input.

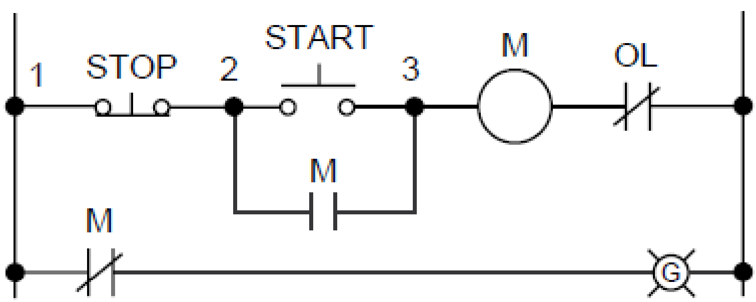

Figure 14 - Motor Control Circuit Diagram

7.5 Unit Testing

To confirm and to verify that all power components are working properly, the following tests must be performed.

1. Activate the motor and float switch only for the part that is being tested, leaving all other components disconnected.

2. With the float switch attached, start the motor and allow it to fill the tank with water and wait until the water level touches the base of float switch.
3. If the motor automatically turns off then the switch is working properly.
4. If the pump runs continuously, then the following could be the possible reasons:
    - Pump cord and float switch cord could be plugged in separately. Plug pump cord into piggyback connector on backside of the float switch plug. Put the combination into a single receptacle of an outlet.
    - The float switch is stuck. Inspect the pit for anything that could cause the float ball to get stuck and not settle to its “off” position. Remove any obstacle or relocate the pump or the switch to avoid obstacles.
5. To verify that the contactor is performing as desired, the following testing is conducted:
    - First do a quick check with a screw driver to center of the coil (solenoid valve only) and see if there is magnetism or at least some power to it.
    - Check both directly at coil and also check connections from terminals in electrical cabinet to include cable in case there is a short or open circuit.
    - Each coil contains 2 wires. One wire will be shared with the coil at the other end if it is a double solenoid control valve. Disconnect both wires from terminal at solenoid or in the electrical cabinet.
    - The meter usually read around 80Ω to 200Ω. If it is less than 20Ωs, the coil is most likely shorted. If it is above 500Ωs it is most likely open and should be replaced. If possible look for another solenoid to compare readings with.

8 Conclusion

The team at SRC Telemetry Incorporated is committed to the development of the SmartFlow unit. This document has provided and summarized the technical specifications for the design of the individual components of the device and includes the relevant test plans that need to be carried out to ensure that the prototype unit will adhere to the goals and requirements that were set forth in both the proposal and functional specifications documents. The engineering team at SRC is confident that the prototype unit will be finalized by mid-December 2011.

9 References

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