Microflow
Systems Inc.

February 8th 2010

Dr. Andrew Rawicz
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Functional Specification for Microflow's Networked Water Faucet System.

Dear Dr. Rawicz:

The attached document is intended to accurately describe all the functional specifications of the networked water faucet system that will be designed by Microflow Systems Inc. Included in the document are the specific requirements for each individual component of the system and an overview that contains all system requirements.

Appropriate requirements and specifications have been obtained through an analysis of each component's function with respect to the final working system. Our team has also researched different potential components and referenced many standards organizations to make sure our product will meet consumer safety standards. For the networked water faucet system to be consistent and unified in its purpose the enclosed functional specifications must be incorporated during design, modeling and production stages.

Microflow Systems Incorporated is a start up Technology Company made up of the following four members: Kwang-young Lee (CFO), Sonca Teng (CEO), Micheal Hou (COO) and Aaron Marcano (CTO). The team at Microflow will use the attached functional specifications as a reference to design, model and test the networked water faucet system. The enclosed functional specifications are subject to minor changes which will be updated as the company moves forward with development.

Sincerely,

Sonca Teng
Chief Executive Officer
Microflow Systems, Inc.

Enclosure: *Functional Specification for a Networked Water Faucet System*

Microflow Systems Inc.

Functional Specification for Microflow's Networked Water Faucet System

Submitted to: Dr. Andrew Rawicz – ENSC 440
Steve Whitmore – ENSC 305
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February 8th 2010

Executive Summary

The networked water conservation system functionality defined herein is a system unlike any other on the market today. Microflow's system will function in ways that will raise people's awareness with respect to their water consumption. By increasing awareness of water consumption homes and businesses can take steps to reduce their total water use, and conserve fresh water resources. Conservation is particularly important in areas of the world where there are limited fresh water resources.

The attached document contains the specifications describing the component/system functionalities as they pertain to the networked water conservation system being developed by Microflow Systems. The main goals of this set of functional specifications are to avoid inconsistencies in our product, document system configurations and to help estimate the amount of work and resources that are required for product development. The water faucet system's main functions include water monitoring for conservation, wireless communicating for data sharing, and water volume measuring for dispensing. The following list shows the main software and hardware development stages in which the functional specifications must be applied:

- Software – LCD, Flow Sensor, Transceiver (program - system implementation)
- Software – Transceiver (program - wireless communication)
- Software – PIC (program - system integration)
- Hardware – LCD, Flow Sensor, Faucet (mechanical/electrical connection)
- Hardware – Transceiver, PIC (electrical connection)

Throughout the project the Microflow development team members will refer to the functional specifications to make certain that all the requirements are being met. With this goal in mind this document will be frequently referenced during development stages such as design, modeling and software integration. The functional specifications will also be invaluable during product testing.

The functional specifications will be compliant with laws, bylaws, codes and acts in accordance with North American national and regional standards. This conformity will be achieved by approval from: the American National Standards Institute (ANSI), the Canadian Standards Association (CSA), the International Organization for Standardization (ISO), and the Canadian General Standards Board (CGSB). If our products become available outside of North America then Microflow plans to meet applicable product safety standards upheld abroad.

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Glossary

Flow Rate	Volume of fluid that flows past a cross section area of a pipe per unit of time
FDA	The United States Food and Drug Administration
FCC	The United States Government Federal Communications Commission
GPM	Gallons of fluid that flow through a cross section area per unit of time measured in minutes
ISM	Industrial, scientific and medical
KBPS	Kilobits per second
LPM	Liters of fluid that flow through a cross section area per unit of time measured in minutes
Networked Water Faucet System	The proprietary wireless system that Microflow is currently developing for use in place of regular water faucets
PSI	Pounds of fluid pressure per square inch of surface area when water is confined by the surface
R&D	Research and development
RoHS	Restriction of Hazardous Substances

1. Introduction

The networked water faucet system will work as a water conservation tool and an accurate dispenser of water. Measuring the total amount of water used by a system of faucets will achieve the most important step toward conservation, awareness. The requirements for the networked water faucet system are contained in the following sections.

1.1 Scope

This document is primarily intended for internal use to Microflow Systems to aid in the product development. Also, any third party company requiring the functional specifications of the networked water faucet system will have access to this document. To design and perform Microflow's system testing and regression testing no knowledge of the actual code logic or code design is required. However, the following specifications will provide quality assurance personnel with the central resource they need for the test case design process.

1.2 Intended Audience

The functional specifications are intended as a reference for Microflow's executives, technicians, marketing staff, and managers. They will be used during R&D, model testing and manufacturing. The external audience will be legal representation, for any sort of legal matter, manufacturing plants, licensees and contractors. In addition, external use of this document will include standards organizations so they can certify our system is sufficiently safe for public and private use.

1.3 Classification of Specifications

Functional Specifications will be identified by the following labels throughout the entire document.

[X.XX A] X.XX is the functional specification number, and A indicates model specification

[X.XX B] X.XX is the functional specification number, and B indicates production specification

[X.XX C] X.XX is the functional specification number, and C indicates both model and production specification

2. System Requirements

The requirements for the overall Microflow networked water faucet system are presented in this section.

2.1 System Overview

The Microflow networked faucet is a direct replacement for any regular household faucet. As such, we have specified our system to operate in exactly the same fashion as any user would be accustomed to. The user interface is identical to that of a traditional faucet save for a backlit LCD display which would show both water usage for the current session, and total water usage throughout the day across the faucet network.

A conceptual model of our faucet is shown below in Figure 1, as well as a high level system block diagram in Figure 2.

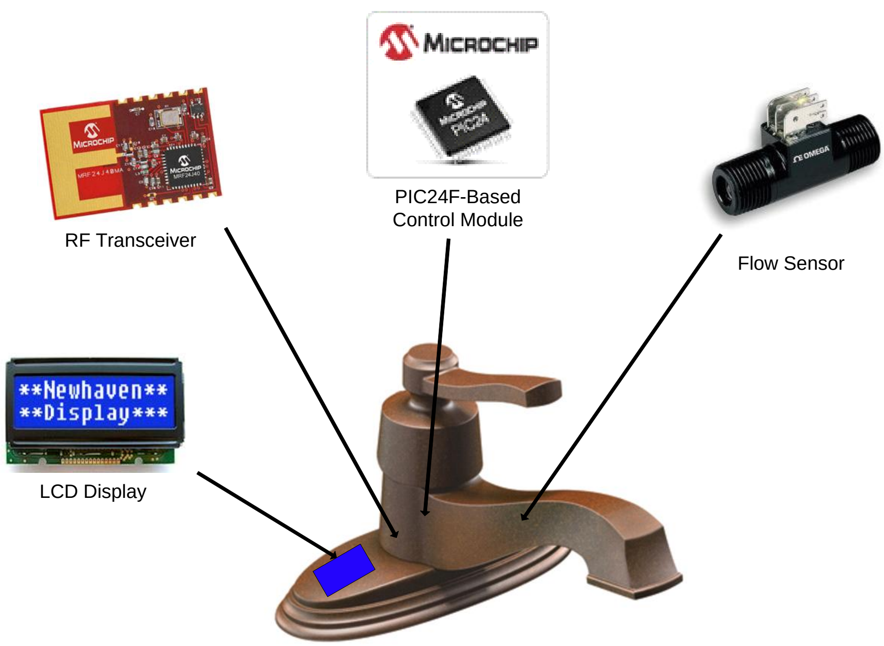

Figure 1 - Conceptual Model

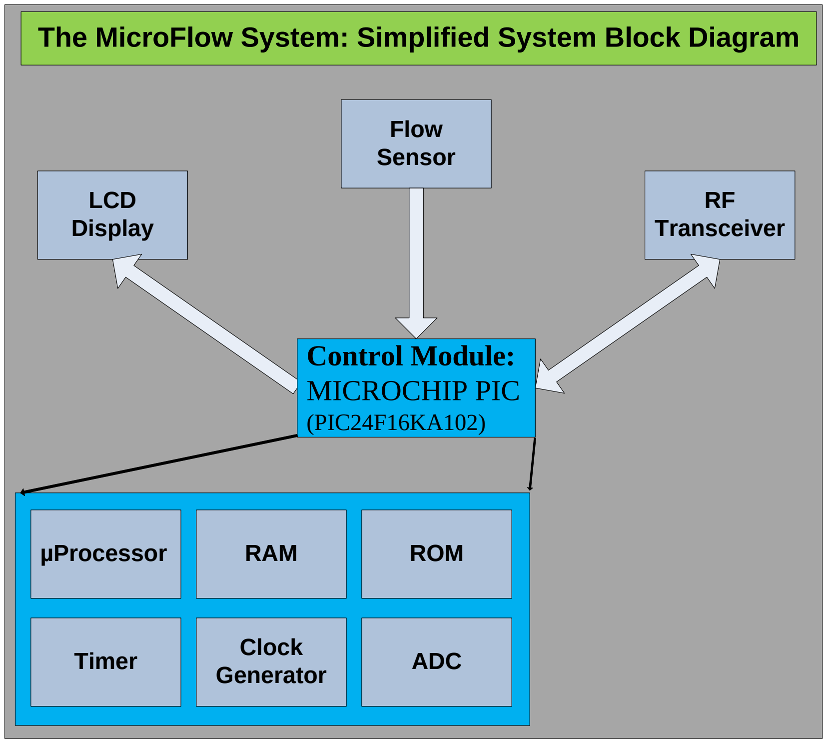

Figure 2 - System Block Diagram

When the user turns on the faucet, water flows as it would in a traditional faucet. However, with our faucet, there is an LCD that gives water usage information.

While the water is running, the LCD Display on our faucet would give a readout as shown in Figure 3, updating both figures in real time as the water runs. Current Usage reflects usage as currently being used by the faucet in use, and Network Usage denoting the total water used on the network of Microflow faucets in the building.

```
Current Usage:    0.2 L
Network Usage:   17.2 L
```

Figure 3 - LCD Display – Water Running

When the water is off, the LCD Display reverts to showing Total Usage by the faucet in question, while the Network Usage display shows the water use across the entire network, which updates in real time. This is shown as follows in Figure 4.

```
Total Usage:      2.8 L
Network Usage:   17.2 L
```

Figure 4 - LCD Display – Faucet Not in Use

As well, the LCD backlights turn on when the tap is on, and turn off when the tap is off.

Further enhancing our technology is the wireless capability made possible by our RF transceiver. A wireless network *automatically* forms between faucets installed into the home, and an illustration of this is shown below in Figure 5.

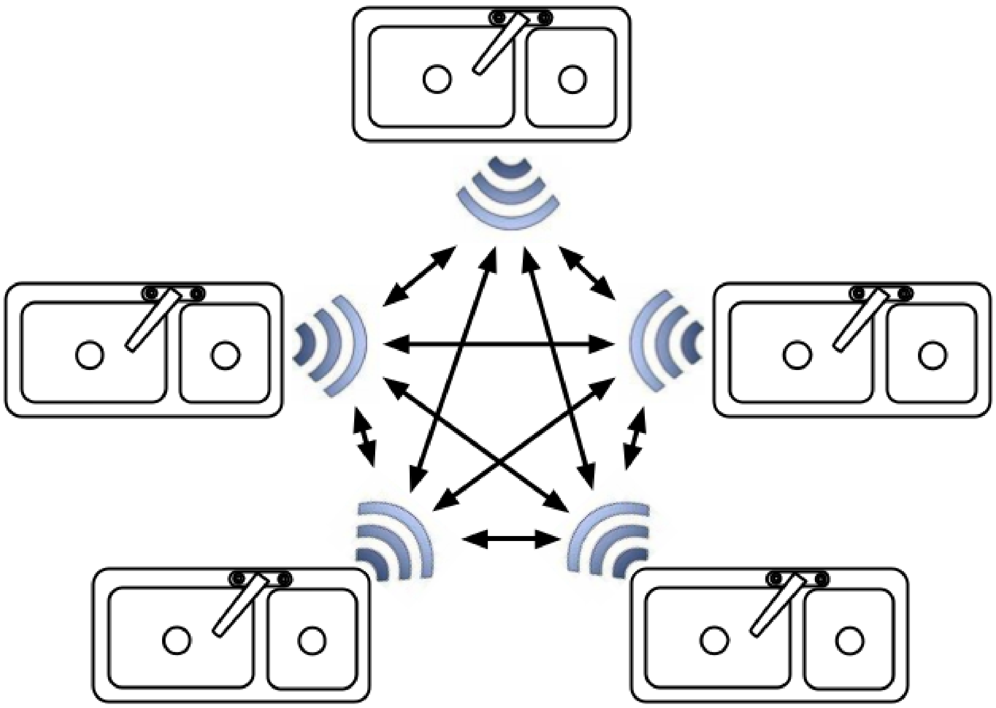

Figure 5 - Network Model

Once two or more Microflow faucets are present in the network, the individual Control Modules of each faucet process and calculate the total water usage on the network, and the LCDs of every faucet are able to display this information to the user. There is no need for user intervention to initiate this networking process.

The wireless network engages the MiWi communication protocol, using small, low-power radios, based on IEEE 802.15.4-2003 standards for wireless devices developed by Microchip Technology. It is provided fully free of charge and royalties for use with a Microchip PIC, and is a low development cost and low memory footprint alternative to competing IEEE 802.15.4 based protocols such as ZigBee [1].

2.2 General Requirements

[2.21 C] When the faucet is in use, the system shall display on the first line of the LCD, the amount of water used for the duration of the session.

[2.22 C] When the faucet is not in use, the system shall display on the first line of the LCD, the amount of water used for the duration of the session.

[2.23 C] The system shall remain on indefinitely.

[2.24 C] The display backlight shall light during faucet use, and turn off when not in use.

[2.25 C] At all times, the faucet shall display on the second line of the LCD, the total amount of water used for the day a across the network. In the absence of the network, the second line shall remain blank.

[2.26 C] The system shall not have an on/off switch; it will undergo normal operation when it is powered.

2.3 Physical Requirements

[2.31 B] The system shall be weather-resistant and will not incur cosmetic nor functional damage as a result of regular use.

[2.32 C] The system shall be impact resistant within the realm of reasonable regular use.

2.4 Electrical Requirements

[2.41 A] The system shall be powered by a 9V battery and draw current as needed.

[2.42 B] The system shall be powered by two rechargeable AA batteries, and draw current as needed. It shall run for six months under reasonable regular use without recharge.

[2.43 C] The system shall remain on indefinitely as long as there is a sufficient supply of power.

2.5 Mechanical Requirements

[2.51 C] The system shall take two 3/8" pipes carrying fluid input; one hot water, one cold.

[2.52 C] The system shall merge the two input pipes which will dump into the flow sensor.

[2.53 C] The system shall output the final water flow from the tap after the flow sensor terminates.

[2.54 C] The system shall feature either two handles or one that will allow the user to control the temperature of the water output.

2.6 Operating-Environment Requirements

[2.61 C] The system shall not be subject to impact forces, beyond reasonable regular use.

[2.62 C] The system shall not be subject to input fluid of any type but clean, debris-free water with neutral acidity.

2.7 Standards

[2.71 C] The system shall comply with FCC standards for unintended radiation [2].

[2.72 C] The system shall comply with RoHS standards.

[2.73 C] The system shall utilize MiWi protocols for wireless network communication.

2.8 Reliability Requirements

[2.81 C] The system shall be corrosion resistant to the extent of reasonable regular use over the expected lifespan of the unit.

[2.82 C] The system shall function electronically and mechanically in a satisfactory and predictable, expected manner for a period not less than three years.

2.9 Safety Requirements

[2.91 C] The system shall not emit harmful radiation.

[2.92 C] The system surface shall not contain sharp edges.

[2.92 C] The system shall not present a risk of electric shock.

[2.94 C] The system shall be able to turn off on demand.

2.10 Performance Requirements

[2.101 C] The system local usage display shall update at intervals of no more than 0.5 seconds.

[2.102 C] The system network usage display shall update at intervals of no more than 5 minutes.

[2.103 C] The system information display shall be accurate to within 0.05L.

2.11 Usability Requirements

[2.111 C] The system shall be useable to obtain water by any average user.

[2.112 C] The system shall be useable in its full capacity through minimal word-of-mouth training, or a technically savvy individual.

[2.113C] The system shall need no further input from a user to connect to a network other than to have batteries inserted.

3. LCD Display Requirements (NHD-0216K1Z-FSO-FBW-L)

The LCD component will display the amount of water currently being dispensed by the faucet in real time, and the total amount of water that has been used by the system of wireless faucets.

3.1 General Requirements

[3.11 C] The LCD shall be able to display two rows of sixteen characters.

[3.12 C] The LCD shall display both network and single faucet usage in real time.

[3.13 C] The LCD shall be able to turn on and off on demand.

3.2 Physical Requirements

[3.21 C] The LCD shall be 80mm x 36mm x 13.5mm (W x L x H) [3].

[3.22 B] The LCD shall be sealed in a water tight enclosure integrated into faucet.

[3.22 C] The LCD shall have 16 pins in total [3].

3.3 Electrical Requirements

[3.31 C] The LCD shall require +5V power supply [3].

[3.32 C] The LCD shall require 20mA current supply [3].

[3.33 C] The LCD shall require 11 pins for data flow [3].

[3.34 C] The LCD shall require +0.5V for contrast control [3].

3.4 Safety Requirements

[3.41 C] The LCD shall be RoHS compliant.

[3.42 C] The LCD shall not be bent.

[3.43 C] The LCD shall operate above -20 degree Celsius [3].

[3.44 C] The LCD shall operate below 70 degree Celsius [3].

[3.45 C] The LCD shall not operate more than 48 hours at -20 degree Celsius [3].

[3.46 C] The LCD shall not operate more than 160 hours at 70 degree Celsius [3].

[3.47 C] The LCD shall avoid static charge.

[3.48 C] The LCD shall be crushed and washed with solvents at end of functional life.

4. Flow Sensor Requirements (FTB2004)

The flow sensor will measure the amount of water flowing through the system.

4.1 General Requirements

[4.11 C] Water shall pass through the flow sensor in only one direction.

[4.12 C] Water passing through the flow sensor shall not exceed a temperature of 100°C [4].

[4.13 C] Water passing through the flow sensor shall not be lower than a temperature of -20 °C [4].

[4.14 C] Water passing through the flow sensor shall not flow faster than 4GPM, or 15 LPM [4].

[4.15 C] Water passing through the flow sensor shall not flow slower than 0.26GPM, or 1 LPM [4].

[4.16 C] Water passing through the flow sensor shall not exceed pressure of 200 PSI [4].

4.2 Physical Requirements

[4.21 C] The flow sensor shall have dimensions shown in Figure 6 below [4].

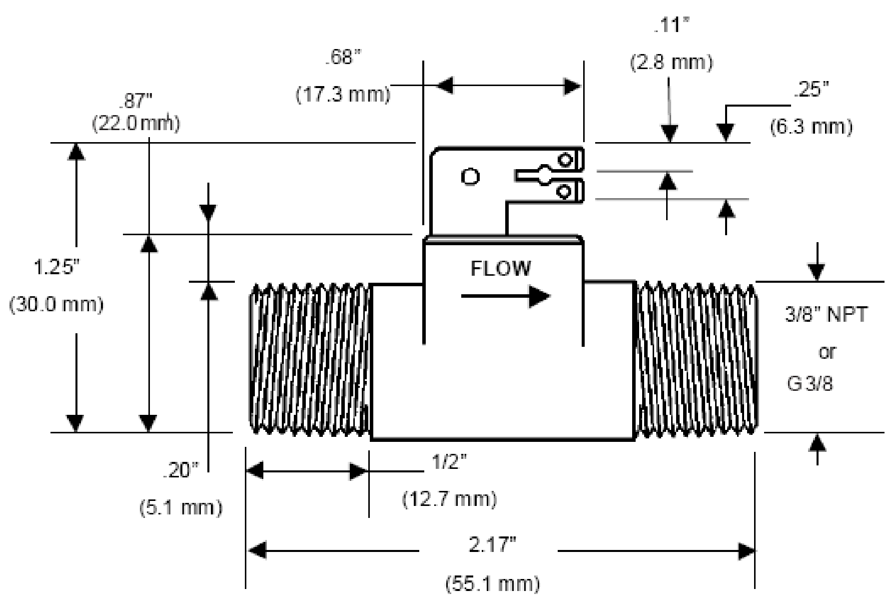

Figure 6 - Required Dimensions of the Flow Sensor Component, Model # FTB2004

[4.22 C] The flow sensor shall contain a hall-effect sensor.

[4.23 C] The flow sensor shall contain a turbine inline to water flow stream.

[4.24 C] The turbine shall be directly connected to the hall-effect sensor.

[4.25 C] The flow sensor shall have nodes to connect the hall-effect sensor to the micro-controller.

4.3 Electrical Requirements

[4.31 C] The flow sensor shall have a pull-up resistor connecting the power node with the signal wire in range of 1kΩ to 2.2kΩ [4].

[4.32 C] The flow sensor shall be supplied with DC voltage higher than 5V [4].

[4.33 C] The flow sensor shall be supplied with DC voltage lower than 24V [4].

[4.34 C] The flow sensor shall output 8300 pulses per gallon, or 2200 pulses per liter [4].

5. Microprocessor Requirements (PIC24F Series)

The microprocessor is the heart of the system, processing various inputs from sensors and sending the appropriate outputs to components in the system.

5.1 General Requirements

[5.11 C] The processor shall be able to switch between run and sleep mode.

[5.12 C] The processor shall support C programming [5].

[5.13 C] The processor shall have 16 kb of programming space [5].

[5.14 C] The processor shall have 512 bytes of EEPROM [5].

[5.15 C] The processor shall support 16bits architecture [5].

[5.16 C] The processor shall support real time clock and calendar.

[5.17 C] The processor shall be low power consumption.

5.2 Physical Requirements

[5.21 C] The processor shall be 10.9mm x 26.9mm x 9.4mm [5].

[5.22 C] The processor shall have 28 pins [5].

[5.23 B] The processor shall fit inside the enclosure with LCD.

5.3 Electrical Requirements

[5.31 C] The processor shall require 1.8V to 3.6V power supply [5].

[5.32 C] The processor shall require 8 µA current supplied in run mode [5].

[5.33 C] The processor shall require 20 nA current supplied in deep sleep mode [5].

5.4 Reliability Requirements

[5.41 C] The processor shall have minimum 10,000 write/erase EEPROM cycles [5].

[5.42 C] The Processor shall have minimum 10,000 flash cycles [5].

[5.43 C] The Processor storage shall have minimum 40 years data retention [5].

5.5 Safety Requirements

[5.51 C] The processor shall operate above -40 degree Celsius [5].

[5.52 C] The processor shall operate below 125 degree Celsius [5].

[5.53 B] The processor shall be sealed in a water tight enclosure with other parts.

6. Water Faucet Requirements

The water faucet will be installed in place of any ordinary faucet and will house the flow sensor component.

6.1 General Requirements

[6.11 B] Water shall flow through the faucet when hot, cold or both water supplies are on.

[6.12 B] The faucet shall have a serviceable filter upstream to the flow sensor component.

[6.13 C] Water shall be dispensed by the faucet only after it has flowed through the flow sensor.

[6.14 C] If a hot water supply line is to be connected to the faucet then the water temperature shall not exceed a temperature of 100 °C [4].

6.2 Physical Requirements

[6.21 C] The faucet shall have proper fittings to connect both hot and cold supply lines.

[6.22 C] The faucet will combine the hot and cold water to a single pipe before entering the flow sensor component of the system.

[6.23 C] The faucet shall be used with a total water pressure not exceeding 125 PSI static per ANSI and CSA requirements [6].

[6.24 C] The faucet shall be supplied with fluid not below a temperature of 0 °C.

[6.25 C] The faucet shall be supplied with fluid not exceeding a temperature of 100 °C.

[6.26 C] The faucet shall supply water to the flow rate sensor not below 0.26 GPM, or 1 LPM, for accurate flow rate measurement [4].

[6.27 C] The faucet shall supply water to the flow sensor at a rate not exceeding 4.0 GPM, or 15 LPM, for accurate water flow rate measurements [4].

6.3 Usability Requirements

[6.31 C] The faucet shall meet handicapped accessibility standards.

[6.32 C] The faucet shall conform to FDA, ANSI, ISO and CSA standards to protect the safety of all customers and end users.

6.4 Safety Requirements

[6.41 C] The faucet shall be used in a safe manner such that no damage is sustained to the device or the user.

[6.42C] The faucet must use the water supply system in accordance with any applicable regulations [7].

7. Transceiver Requirements (Model MRF24J40MA)

The transceiver will send and receive the water usage data to or from the rest of the faucets in the system.

7.1 General Requirements

[7.11 C] The transceiver shall be restricted to communicate over a radio frequency not below 2.405 GHz ISM Band [8].

[7.12 C] The transceiver shall be restricted to communicate over a radio frequency not exceeding 2.48 GHz ISM Band [8].

[7.13 C] The transceiver shall send and receive data at a bit rate not exceeding 250 KBPS [8].

7.2 Physical Requirements

[7.21 C] The transceiver shall be operated at a temperature not below -40 °C [8].

[7.22 C] The transceiver shall be operated at a temperature not exceeding 85 °C [8].

[7.23 C] The transceiver's antenna/transmitter shall remain clear of any metallic obstruction within a distance of 1.2" [8].

7.3 Electrical Requirements

[7.31 C] The transceiver shall be powered by a DC source not below 2.4V [8].

[7.32 C] The transceiver shall be powered by a DC source not exceeding 3.6V [8].

[7.33 C] The transceiver shall consume approximately 2 μA when transceiver is in sleep mode [8].

[7.34 C] The transceiver shall consume approximately 23 mA when consuming maximum power [8].

7.4 Safety Requirements

[7.41 C] "Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation" [8].

Caution

> "To satisfy FCC RF Exposure requirements for mobile and base station transmission devices, a separation distance of 20 cm or more should be maintained between the antenna of this device and persons during operation. To ensure compliance, operation at closer than this distance is not recommended. The antenna(s) used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter" [8].

8. User Document Requirements

User documents will be available on the internet and in hard copy to support our product distribution channels and end customers.

8.1 General Requirements

[8.11 B] The user document shall include detailed installation instruction.

[8.12 B] The user document shall include detailed operation instruction.

[8.13 B] The user document shall include technical specification of components.

[8.14 B] The user document shall be written in English, Spanish, French, and Mandarin.

[8.15 B] There shall be a website containing all the documents mentioned above.

9. System Test Plan

In order to test the system functionality, testers will use different techniques to complete the testing. Ad-Hoc testing will require the tester(s) to interpret the above stated system functionalities and then try to make the system fail. This technique will be reserved for less imperative features and require no test cases, just a report of any inconsistent results. Systematic testing will be driven by explicit quality assurance goals and the test cases will specify the expected results. Alpha and Beta testing will also be done near the completion of the project.

The networked water faucet system will have many functions and settings, and these will be tested throughout the entire development process. The functionality will eventually be tested both in a more systematic manner, and using ad-hoc methods. Test cases will be developed by quality assurance personnel following the ordered test case design process outlined below.

- Overall QA Planning
- Outline the Test Scenarios
- List Test Case Names
- Write Test Case Descriptions
- Write Selected Test Cases
- Evaluate Test Cases

Once the test cases have been evaluated, any issues or inconsistencies with respect to the system must be brought to the attention of the appropriate developer(s). Once the error(s) are corrected the component must undergo system testing and then the entire system must be regression tested. Once there are no active test case errors to report and fix, then alpha and beta testing may begin.

10. Conclusion

This document has specified all of the functional requirements for Microflow's networked water faucet system to function safely and correctly. Also included above are the requirements for the accompanying user documentation and a brief system test plan. With this document, Microflow Systems Inc. will be able to design, and build a functioning model based on the functionalities listed above. Microflow Systems will also undergo a functional verification process with the functioning model to bring it to market.

11. References

[1] "Microchip Wireless Design Center," 2009. [Online] Available: http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=2113&param=en520414, [Accessed: Feb. 8, 2010].

[2] "Compliance Guides," Nov. 30, 2007. [Online]. Available: http://www.fcc.gov/ocbo/complianceguides.html, [Accessed: Feb 7, 2010].

[3] "NHD-0216K1Z-FSB-FBW-L Data Sheet," May. 10, 2007. [Online]. Available: http://www.newhavendisplay.com/specs/NHD-0216K1Z-FSO-FBW-L.pdf, [Accessed: Feb. 1, 2010].

[4] "Flow sensor Data sheet, FTB2000 Series," [Online]. Available: http://www.omega.com/Manuals/manualpdf/M3236.pdf, [Accessed: Feb. 1, 2010].

[5] "Microchip PIC24F16KA102 Family Datasheet," 2009. [Online]. Available: http://ww1.microchip.com/downloads/en/DeviceDoc/PIC24F16KA102_Family_datasheet_39927b.pdf, [Accessed: Jan. 19, 2010].

[6] "Delta Electronic Faucet, DSP-591TRev.B.pdf," [Online]. Available: http://www.specselectonline.com/PDFs/DSP-591TRev.B.pdf, [Accessed: Feb. 6, 2010].

[7] "Drinking Water Protection Act," April 11, 2001. [Online]. Available: http://www.bclaws.ca/Recon/document/freeside/--%20D%20--/Drinking%20Water%20Protection%20Act%20%20SBC%202001%20%20c.%209/00_01009_01.x ml#!--%20#id=info%20--# [Accessed: Jan 22, 2010].

[8] "Transceiver MRF24J40MA Data Sheet," 2008. [Online]. Available: http://ww1.microchip.com/downloads/en/DeviceDoc/70329b.pdf, [Accessed: Feb. 3, 2010]. pp. 15-16.