Western Washington University

Electrical Engineering Technology

Etec 471

Professor Morton

Senior Hardware Description

Automated Aquarium

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Introduction

The Automated Aquarium Controller is a system that monitors and controls a large fish aquarium. The block diagram for this project is Figure 1 on page 1. It shows that the microprocessor will receive inputs from the two sensors, temperature and pH. Each signal will go though signal conditioning of op-amps and a low-pass filter into the microcontroller's A/D converter. The user input will allow the operator to change many settings, such as: current time, lighting times, feeding amount, pH range, water temperature, and water change reminders (warnings.)

This project will control feeding and remind the owner to change the water at a scheduled time or if the ph of the water changed to outside acceptable programmed range. Over feeding is harmful to aquarium water quality, bad for filtration, and stressful for fish. This project would control feeding as well as turn off the filter during feeding to increase life of filters.

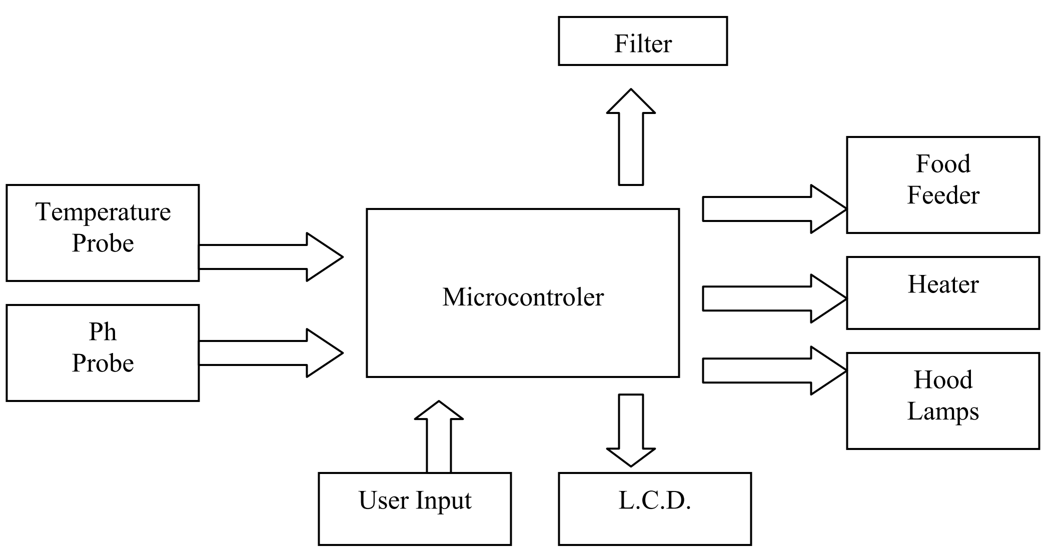

Figure 1: Basic System Block Diagram

Chassis

The hardware for this prototype project will be enclosed in 2 aluminum box from Hammond Manufacturing. The control box will be 6" x 6" x 4". This will be large enough to house the LCD display, 3 LEDs (heat on, change water, and AC power loss), a (8x2) matrix keypad, the microcontroler, and all other 5 volt DC devices. The input lines from my sensors will come into this box for signal conditioning and processing. Wires exiting this box will be control lines for the stepper motor and relays. This control box will be supplied by a 6 Volt DC uninterruptible AL6246C housed in the external power box. It will supply a continuous 6V at 1.2A. If power is lost due to a power failure it will ensure that vital user settings will not be lost. The control lines for the relays will enter the external power box on the floor. This box will 10" x 8" x 4" and house the DC UPS AL6246C, relays, and the plug-ins for the heater, filter, and hood lamps. To energize common heaters, filters, and hood lamps, 120 volts AC will supply this box.

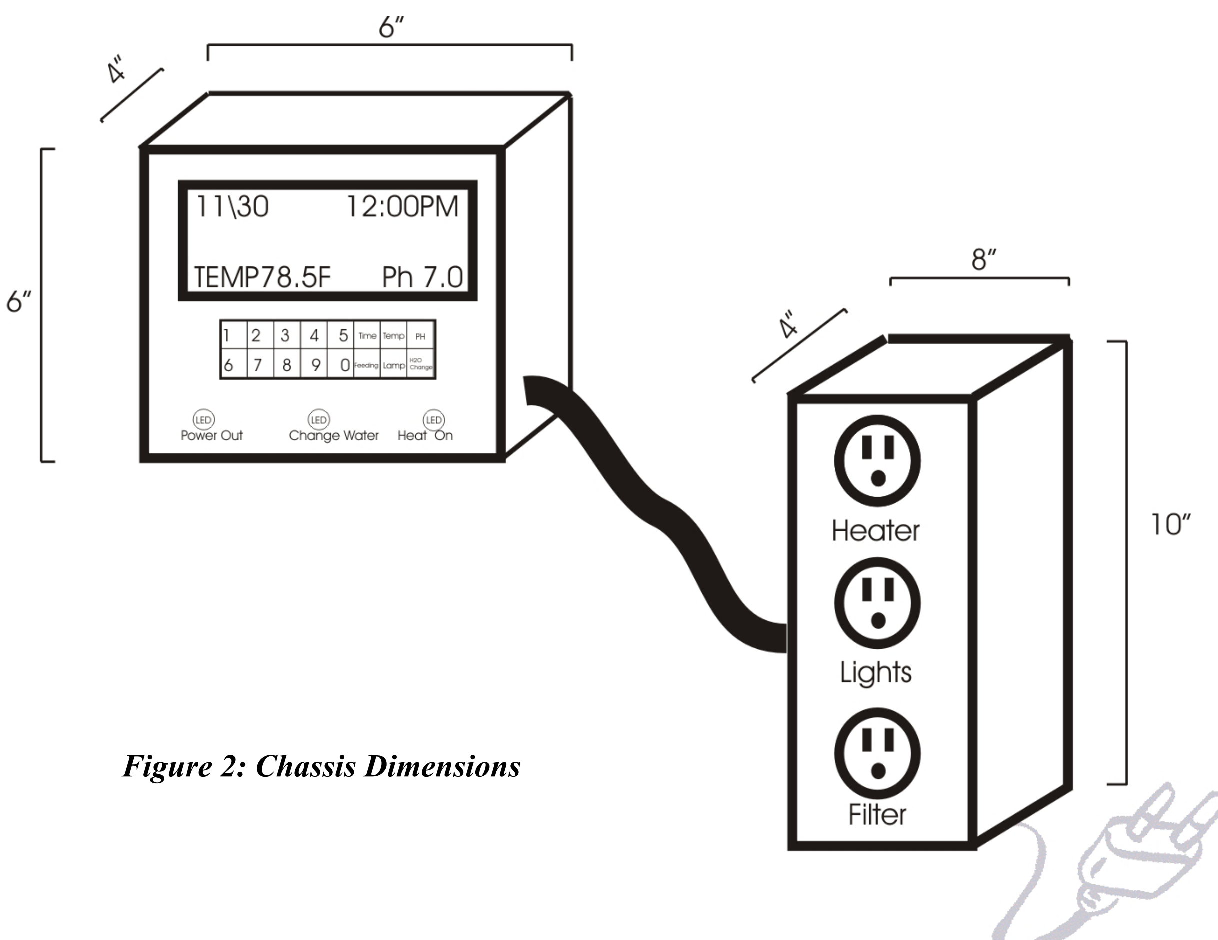

Figure 2: Chassis Dimensions

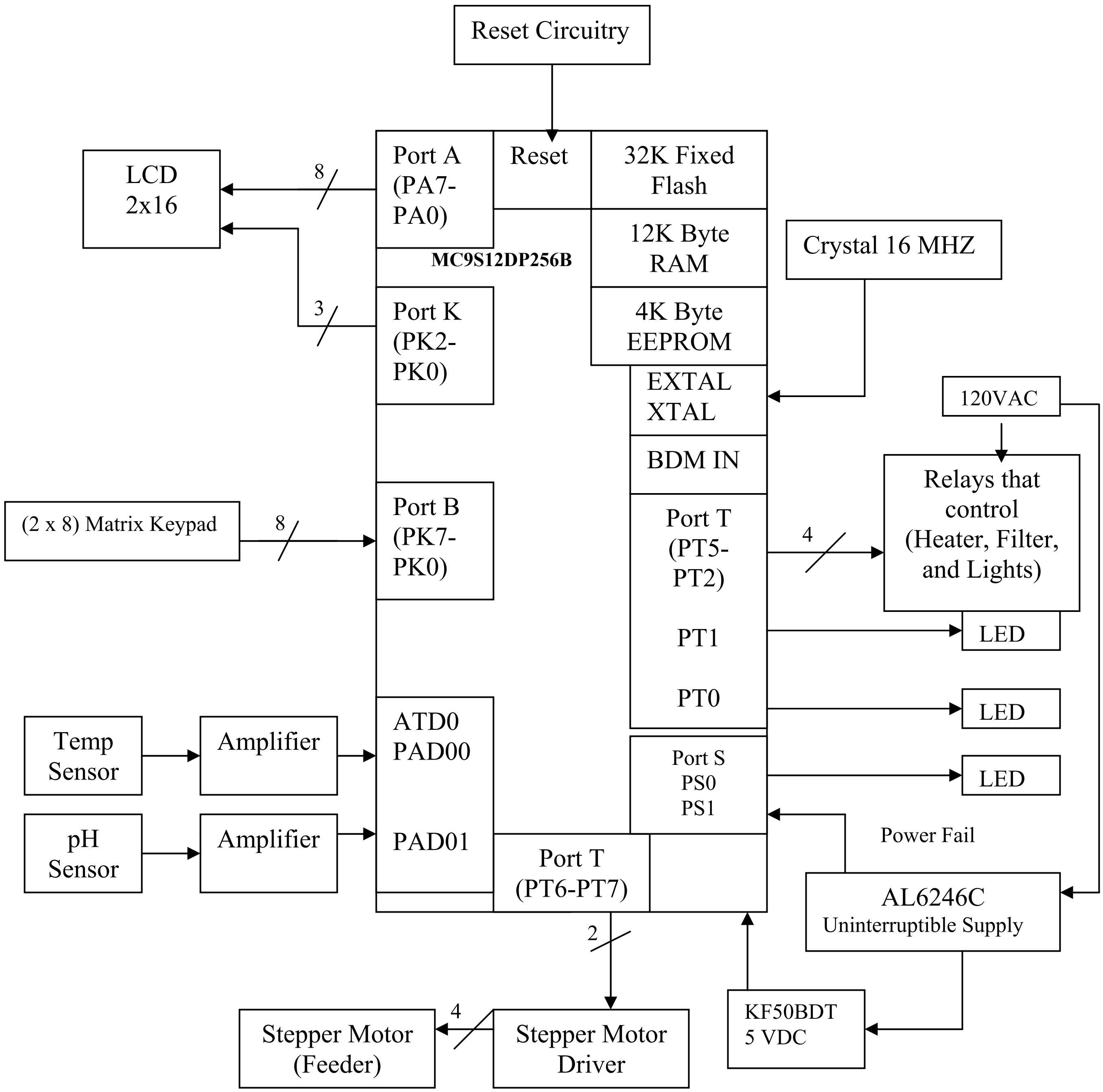

Figure 3: Functional Hardware Diagram

Hardware Overview

The Function Hardware Diagram for this project is Figure 3 located on page 3. The Automated Aquarium Controller is composed of two circuit boards. One is used for all user interface components in the control box the other is for the relays and power sources and is located in the external power box. We will now into look into the hardware components in more detail.

Power Supply

This project will be supplied with 120VAC into the power box. This is required the power conventional lights, heater, and filters. The AC line will power plug ins for light, filter, and heater directly through a relay. The AC line will also plug into the AL6246C which will regulate it into 6VDC @ 1.2A uninterruptible. The AL6246C is a battery backed DC supply it will supply 6VDC even if the AC line power is lost. This will allow the microcontroller and DC devices to continue running if there is a power outage. If the AC line is lost, a power fail signal is set high for to microcontroller to illuminate a power out LED. The battery will back up this project for over 2 hrs. and will be recharged when power is restored. The 6VDC out put is than regulated by the KF50BTD to 5V.

If the battery backed power supply AL6246C is not available, this circuit (Fig. 4), is an alternative method of achieving a battery backed uninterruptible DC supply using a conventional DC wallwort. It will do the same as the AL6246C including an power fail signal to microcontroller.

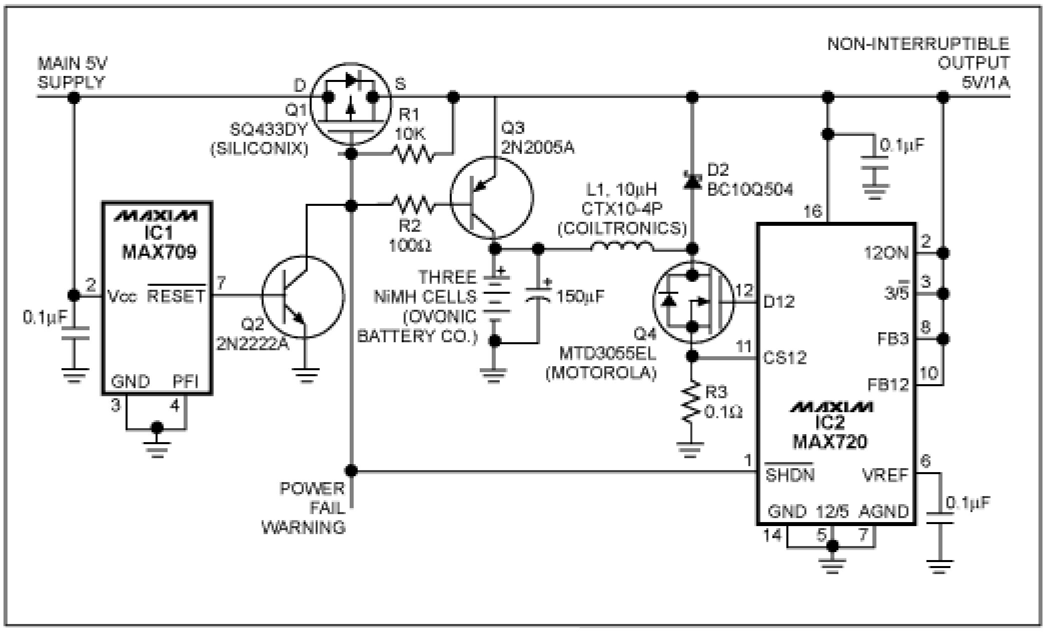

Figure 4: AL6246C Alternative Circuit

Microcontroller

The Automated Aquarium Controller is based on the Motorola MC9S12DP256B (U1) microcontroller configured to operate in standalone mode. It has 256K of Flash EEPROM, 12K of RAM, and 4K of EEPROM. This project will use Ports A, B, S ,T, and K. Also it will use the PAD0 for A/D conversions on 2 channels.

Reset Circuitry

The MAX6314 (U3) is a low-power microprocessor that monitors the power supply. The chip will reset the microcontroler if the supply voltage to it drops below 4.6V.

BDM

J1 is a 10 pin BDM header used to communicate with the S12 microcontroller. This is connects to BKGD along with the ECLK. It will allow for future updates to this system.

Relays

Also in the power box are the relays to energize the heater, lights, and filter. These relays control power going to the plug ins to the respective light, heater, and filter. I am using a SSRQ-240-D20 (K1) relay. This is a quad relay that has one line to control each relay. The microcontroler then controls when to energize each plug in affect turning that device on. The relays control lines will run from microcontroler in the control box to the relays in the power box.

Steeper Motor

The Steeper Motor (M1) is controlled by the microcontroller with 2 bits. One is an enable bit, and one is a clock. The clock and enable bit are hooked up to a L297 (U5) steeper motor controller. This chip will receive my clock pulses and generate steeping code on outputs A, B, C, and D which will go to a Darlington pair driver chip the ULN2003AN (U4). The Driver chip is then hooked up to the steeper motor. With this setup all I need to do to steep to motor is enable the enable bit and send a clock pulse for every steep I desire. The Stepper Motor is connected to an auger that I designed to dispense food.

Sensors

Temperature Probe

I am using a Vernier temperature probe DCT-DIN (J2). This temperature probe is supplied with 5VDC and outputs (0.01 volts/degree F). The signal is buffered and amplified by 4 with a MAX 494 (U2) op-amp. Then the signal is inputted into the A/D on the microcontroller. By amplifying the signal by 4, the quantized value can then be multiplied by 5 to achieve the correct temperature with the desire resolution of .5 degrees F. For example, 62.5 degrees is 0.625V. With a DC gain of 4 that's 2.5V. 2.5V quantized is 128, multiplied by 5 is 625. If the decimal point is moved to ten's position it read 62.5F on the screen.

pH Probe

To monitor the pH of the aquarium I use a PHE-1304-NB (J3). This pH probe requires a split supply. This is done using an extra op-amp on the MAX 494 (U2) chip. With a reversed biased 2.7V Zenner diode I make a floating Gnd from this probe. That is then used as a reference voltage on the AD-623. With the instrumentational amplifier, AD623, I amplify the difference by 10 because the output of the probe is +-20mV/pH with 0V at 7pH. By doing this I can subtract a constant from the A/D quantized value to get the pH. Now if a decimal point is inserted in the ten's place and correct pH is achieved.

User Interface

Keypad

The Keypad used is a (8x2) matrix keypad KP-24 (KP1). The keypad is connected to Port B of the microcontroller. It will allow the user to input settings into the control system. The KP-24 is splash-proof, and is ideal for a possibly moist environment. This keypad will offer a fast way to set this controller. The buttons will be labeled as in Figure 2 (ten digits plus menu buttons for each menu option, Time, Temp, pH, Feeding, Lamp, H2O Change).

LCD

The LCD is a 2x16 liquid crystal display. This display is connected to (PDLC4-6) and (PA7-0). Under normal operation it will display the date, time, temperature, and pH. Also, the LCD will allow the user to set all settings on this control system.

LEDs

The LED's of this project are used to convey additional information to the user (not shown on LCD.) The LEDs are connected to PT0, PT1, and PS0. They will be illuminated to show Heater On, Change Water, and Power Lost. When the heater relay is active meaning the control bit is low the heater LED (PT0) will illuminate. When it is time to change the water in the aquarium (the pH is out of range or time for regular schedule) the LED (PT1) will illuminate. When the input from the power supply is active the Power Lost LED will illuminate letting the user know that the power is out and the controller is operating on battery backed-up power.

Parts List

Item	Quantity	Part Description	Designators
1	2	Capacitor - 10% 22pF	C8,C9
3	1	Capacitor - 10% 330pF	C5
5	6	Capacitor - 10% 0.1uF	C1,C3,C4,C7,C10,C12
7	2	Capacitor - 10% 10uF	C2,C11
9	1	Capacitor - 10% 3nF	C6
11	1	Header - 2x6 pin BDM	J1
13	1	Temperature probe - Vernier DCT-DIN	J2
15	1	pH Probe - Omega - PHE-1304-NB	J3
17	1	Microcontroller - Motorola - MC9S12DP256B	U1
19	1	Quad Relay - Tyco - SSRQ-240-D20	K1
21	3	LED 67-1096-NB	LED1,LED2,LED3
23	1	Stepper Motor - K82701-P2	M1
25	1	Resistor - 22k 1%	R1
27	1	Resistor - 680 1%	R2
29	5	Resistor - 1k 1%	R3,R10,R15,R16,R17
31	1	Resistor - 4k 1%	R4
33	1	Resistor - 3k 1%	R5
35	3	Resistor - 220 1%	R6,R13R14
37	1	Resistor - 10k 1%	R7
39	1	Resistor - 7.5k 1%	R8
41	1	Resistor - 30k 1%	R9
43	1	Resistor - 18k 1%	R11
45	1	Resistor - 11.1k 1%	R12
47	1	Quad op-amp MAX494	U2
49	1	Low Voltage Reset - MAX6314	U3
51	1	Darlington Pair Driver - ULN2003AN	U4
53	1	Stepper Motor Controller - L297	U5
55	1	Instrumentational Amplifier - AD623	U6
57	1	Crystal - 16Mhz 30PPM CA-301 16.000M-C	X1
59	1	Zenner Diode - 1N5223B 2.7V	Z1
61	1	Power Supply 6V 1.2A Uninterruptible AL6246C	PS
63	4	3 prong outlet 5-15-R female	P2,P3,P4,P5
65	1	3 prong outlet 5-15-R male	P1
67	1	AD780 2.5VDC precision	U8