a. Hardware Configurations

This section covers the hardware configurations for the MCU and peripheral boards. It also describes why certain design decisions were made throughout the project development process.

i. MCU Board

The MCU Board consists of:

- MC9S12XEP100 144 pin LQFP
- Decoupling Capacitors
- Crystal
- Header Pins

The MCU Board is essentially just a breakout board for the MC9S12XEP100 controller. This board contains the microcontroller, crystal, and capacitors necessary for decoupling of the power supply pins and for the operation of the crystal. This board also contains the header pins necessary to connect directly to the peripheral board.

ii. Peripheral Board

The Peripheral board consists of the following circuits:

- LEDs
- DIP Switches
- Push button input
- Grayhill Series 96 4x4 Keypad
- New Haven 2x16 LCD with RGB Backlight
- Missing Pulse Detector
- Analog Temperature sensor
- Analog Pressure sensor
- Analog Potentiometer input
- Tone generating circuit
- Stepper motor
- DC motor
- Sonar Range finder Socket
- Bluetooth Module Socket
- Buffered LEDs

Port	Peripheral	# of Pins	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
A	Keypad1	8	Col 4	Col 3	Col 2	Col 1	Row 4	Row 3	Row 2	Row 1
B	Dip Switches	8	7	6	5	4	3	2	1	0
C	LEDs	8	7	6	5	4	3	2	1	0
D	Misc	8	LCD Enable	LCD R/W	LCD Reg Sel	Miss Pulse	Stepper	Stepper	Stepper	Stepper
E		8	Pinout	Pinout	Pinout	ECLOCK	LCD B/L Sel MSB	LCD B/L Sel LSB	IRQ PB	
H		8	Pinout	Pinout	Pinout	Pinout	Pinout	Pinout	Pinout	Pinout
J		7	Pinout	Pinout	Pinout	Pinout		Pinout	BT RX Pinout	BT TX Pinout
K	LCD Module Data bus line	8	DB7 (MSB)	DB6	DB5	DB4	DB3	DB2	DB1	DB0 (LSB)
M		8	Pinout	Pinout	Pinout	Pinout	Pinout	Pinout	Pinout	Pinout
P		8	Pinout	Pinout	Pinout	Pinout	Pinout	Pinout	DC encoder	DC Motor
S		8	SPI CS	SPI SCLK	SPI DIN	Push Button	Pinout	Pinout	Pinout	Pinout
T		8	Sonar Echo	Sonar Init	Speaker Pot	Pinout	Pinout	Pinout	Pinout	Pinout
AD0	Temp	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AD1	Pressure	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AD2	POT	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 1 – Port connections

LEDs

There is a row of eight LEDs at the bottom left hand side of the board which are connected to the individual bits 0-7 of Port C. The LEDs are driven by a Darlington Transistor Array which supplies the necessary power.

DIP Switches

There are eight DIP switches on the left side of the board which are connected to the individual bits 0-7 of Port B.

Push Button Input

There is a push button next to the DIP switch array at the bottom of the board. This push button is connected to Bit 4 of Port S. The button is tied high and when pressed it will ground the connected pin.

Grayhill Series 96 4x4 Keypad

The keypad used in this design is a standard *matrix* interface keypad. This keypad is connected to bits 0-7 of Port A. Bits 0-3 represent key rows 1-4 respectively; and bits 4-7 represent key columns 1-4 respectively.

Keypad Key	Value
1	EE
2	DE
3	BE
4	ED
5	DD
6	BD
7	EB
8	DB
9	BB
0	D7
*	E7
#	B7
A	7E
B	7D
C	7B
D	77

Table 2 – Value of Port A that corresponds to each key

New Haven 2x16 LCD with RGB Backlight

The LCD module chosen for this board is a standard parallel interface screen with a backlight. The LCD utilizes part of Port D, part of Port E and Port K of the microcontroller. Port K is connected to the data lines 0-7 of the LCD. Bits 5, 6, and 7 of Port D are connected to the *register select, R/W select, and enable* lines respectively. Bits 2 and 3 of Port E are used to select the backlight color of the screen. Port D Bit 5 is the *register select* line which is used to tell the screen whether you are sending data or a command. Bit 6 is connected to the *R/W* select line which allows the user to either write to the screen or read from it (i.e. read the busy bit). Bit 7 is connected to the screen *enable* line which is falling edge triggered.

Bits 2 and 3 of Port E are the backlight color select lines. The backlight may be Red (0b01), Green (0b10), or Blue (0b11). Bit 2 is the LSB and Bit 3 is the MSB; these pins are connected to a decoder and inverter in order to select and drive the color of the backlight.

Missing Pulse Detector

The missing pulse detector input is connected to Bit 4 of Port D. This circuit was not changed from the previous design and therefore functions as it did before. Jumper J3 selects the timeout period of either 5ms or 50ms.

Analog Temperature Sensor

The Temperature sensor circuit is connected to Port AD 0 and has not been changed from the previous design. The temperature is measured in 10mV/°F.

Analog Pressure Sensor

The pressure sensor is connected to Port AD 1. The sensor used is a MPX5050GP sensor from Freescale Semiconductor. The sensor can measure up to 7.25 PSI and its outputs from 0~4.7V.

Analog Potentiometer

There is a potentiometer connected to Port AD 2. This simple analog input allows the user to vary the input voltage to the A/D converter between 0~2.5V.

Tone Generating Circuit

The audio circuit on this board consists of a 555 timer, an audio amplifier, and a speaker. The 555 timer is set up as a voltage controlled oscillator (VCO) which outputs a waveform with a frequency which is inversely proportional to the input voltage (as the voltage increases the frequency decreases). This audio

circuit contains two possible inputs. The first being a timer signal from the Enhanced Capture Timer module (ECT) of the MCU which bypasses the 555 timer and is connected to a volume control potentiometer; this input is connected to Bit 5 of Port T. The other input is through a Maxim 522 Digital to Analog converter which feeds the 555 timer circuit. The Max522 D/A converter is controlled via the SPI connection of Bits 5-7 of Port S. The inputs are selected via jumper J2. *Note: The 555 VCO circuit produces unpredictable tones around the 0V input area. The VCO produces a tone constantly when connected; only the pitch may be changed.*

Stepper Motor

The stepper motor on the board is connected to Bits 0-3 of Port D. Jumper J1 must be in the left most position in order to supply power to this motor. The Stepper motor is operated by placing a sequence of numbers on its control lines. The repeating sequence is 0x6, 0x5, 0x9, 0xa, 0x6, etc.; in this order the motor will step one tick at a time in the clockwise direction. If these numbers are mixed up the stepper motor will jump around instead of stepping one tick at a time. When not in use, this motor should either be disconnected or sent a 0x0 to avoid constant power to any of the coils in the motor which could damage the motor.

DC Motor

There is a DC motor on the board also, and it is connected to Bit 0 of Port P. Port P can be programmed to provide a Pulse Width Modulation (PWM) signal to control this motor. Port P is also associated with the standard timer (TIM) module of the MCU and may be used to manually create a PWM wave signal for the motor. Jumper J1 must be in the left most position in order to supply power to this motor.

The DC motor also has an RPM sensor which utilizes an IR emitter and receiver. The motor must have a disk on the end of the shaft with alternating black and clear stripes in order to use the RPM sensor. This RPM sensing circuit is connected to Bit 1 of Port P. This bit must be configured as an input compare pin for the TIM module in order to detect the speed of the motor.

Sonar Range Finder Socket

There is an RJ11 socket in the upper left hand corner of the board which allows the department's sonar range finder devices to interact with the MCU. The INIT pin is connected to Port T Bit 6 and the ECHO pin is connected to Port T Bit 7.

This configuration is the same as the old board's configuration. The only difference would be the address of Port T on the MCU.

Bluetooth Module Socket

There is a 10 pin SIP socket at the top of the board labeled "Parallax Bl-th Module". This socket is provided for the Parallax Easy Bluetooth module. This module is configurable through the serial link which is connected to Bits 0-1 of Port J. The complete datasheet for this module is included in the appendices of this report.

Buffered LEDs

The three LEDs on the board labeled *Buffered LEDs* are not connected to any port on the MCU. They are connected to a Darlington Transistor Array for power requirements, and their inputs are located just below them labeled *1, 2, 3*. These LEDs may be utilized via jumper wires from one of the additional Port headers or from additional hardware built for the board, such as a student's design project.