Weiner Meister Final Report

ME218c – June 6th, 2008

DESIGN OVERVIEW

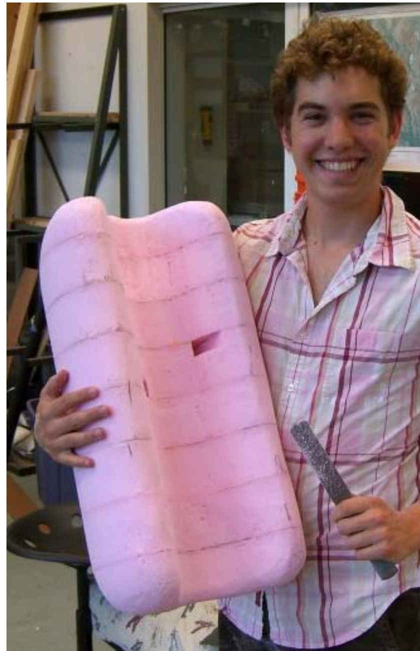
Game Strategy:
Our strategy for the game was to have a fast and maneuverable boat with immense long-range water dispensing capabilities. For water dispensing we chose to use a long distance squirting apparatus versus a short-range dumping apparatus. This combination of long range water dispensing with our agile boat allows us to be a strong offensive and defensive force during game play.

MECHANICAL DESIGN

Boat

Our two-independent-propeller drive train worked in tandem with our "bun-shaped" hull allowing us to achieve this goal of combined speed and maneuverability. For water dispensing, the boat featured two bilge pumps which directed the water through two nozzles mounted to the front of our craft. The boat also featured a sealed midsection to house all of the electronics.

Hull



The hull is constructed of closed-cell foam which was carved into its delicious bun shape. The underside of the hull is shaped so that there are two pontoons on either side to help stabilize the boat. The hull also features cutouts on the underside to house the drive train components as wells as the bilge pumps for water dispensing.

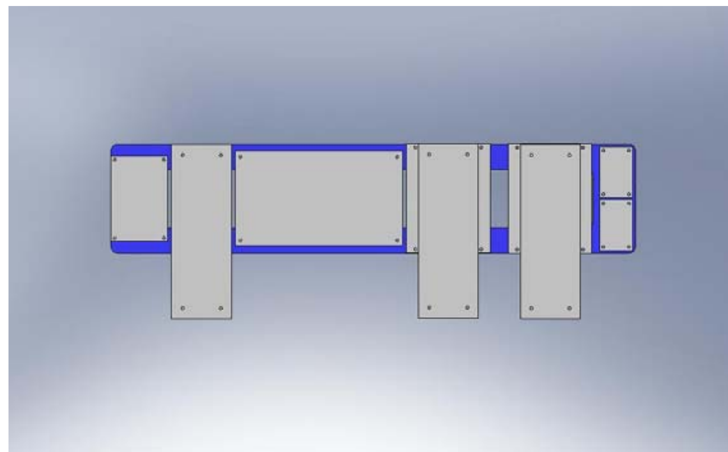
Drive train

Our drive consists of two independent dc motors each driving their own propellers. The motors are housed inside sealed PVC pipe and have drive shafts exiting through grease-sealed bushings. These drive shafts are connected to RC boat propellers. The use of the two independent motors allows the boat to go backwards, forwards and rotate in place.

Water dispensing

The boat features two 500 gallon per hour bilge pumps that provide some serious water dispensing capabilities. The pumped water runs up to the top of our boat through vinyl tubing and is then forced through a brass nozzle. The nozzle was sized such that it gives us a fairly long range (~12 feet) without compromising our sizable volumetric flow.

Board mounting/Water proofing



All of our circuitry is mounted on a masonite board which easily slips in and out of a piece of PVC pipe. The masonite board allows the electronics to sit in the middle of the

pipe so that if water were to enter the pipe it would sit in a pool below the electronics. The PVC pipe has a sealed cap on one end and a removable one on the other. The PVC pipe features a small slit on the side which allows us to route the wiring into the pipe. The slit is located such that when the cap is pressed on, the wiring is compressed to eliminate any air gaps for water to get in.

Helm

The helm is designed to simulate the classic barbeque experience. There is an actual barbeque incorporated into the helm as a well barbeque utensil and condiments. The user manipulates the barbeque utensil and condiments to maneuver the boat and to squirt water. The helm also communicates information to the captain through the use of dynamic graphical indicators which are controlled by servos. There is also a siren to indicate when the boat is “stood down”.

Indicators

The helm uses servo controlled indicators to communicate the current active base as well as the number of the boat the helm is currently controlling. The servos are mounted underneath the main table surface and have arrows mounted to them. The servos rotate the arrows to various positions to point at the necessary graphic to convey the appropriate information.

Board mounting

The boards are mounted to a laser-cut piece of masonite which fits inside of the barbeque. The masonite board features openings to allow wiring to be easily mounted down and out of the barbeque.

Sensors/Inputs

The speed and direction of the boat are controlled using a barbeque utensil derived joystick. A barbeque spatula was cut and then brazed to a threaded piece of brass. This allows the spatula handle to be threaded onto the joystick. The joystick is a store bought item which essentially consists of two potentiometers mounted to a threaded piece of rod. Mounting the spatula handle to the joystick allows the captain to use the spatula handle to maneuver the boat in an intuitive way (pushing the spatula forward makes the boat go forward, etc.).

The water dispensing is activated by shaking a container of mustard. The mustard bottle contains a weighted bare wire inside which makes contact with an aluminum tube when the mustard container is shaken. When contact is made the microprocessor sends a signal to the boat telling it to squirt water.

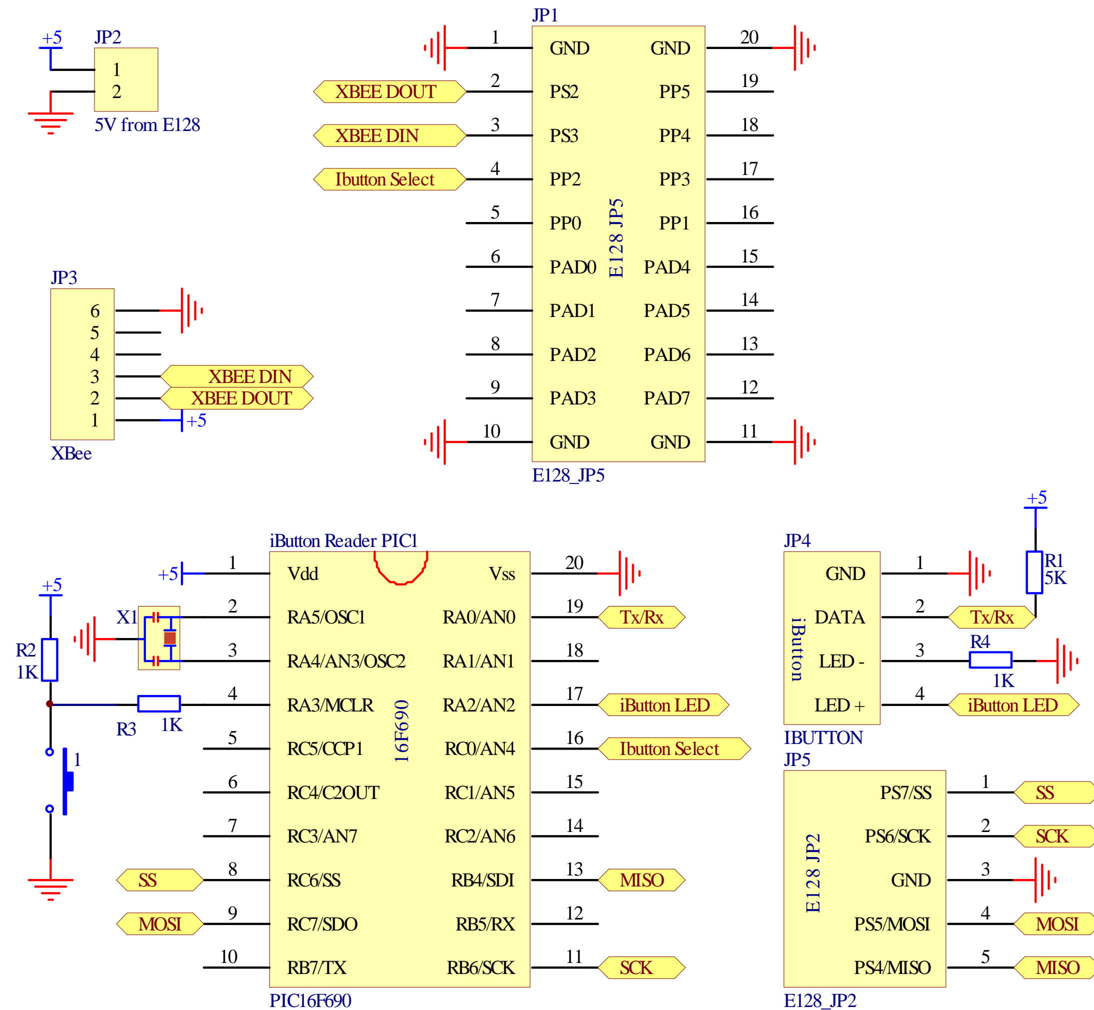
The helm also features two “special” buttons. They are simply two push buttons which can be used to control “special” features the boats may contain. For example, our boat had a siren which could be activated using these special buttons.

ELECTRICAL DESIGN

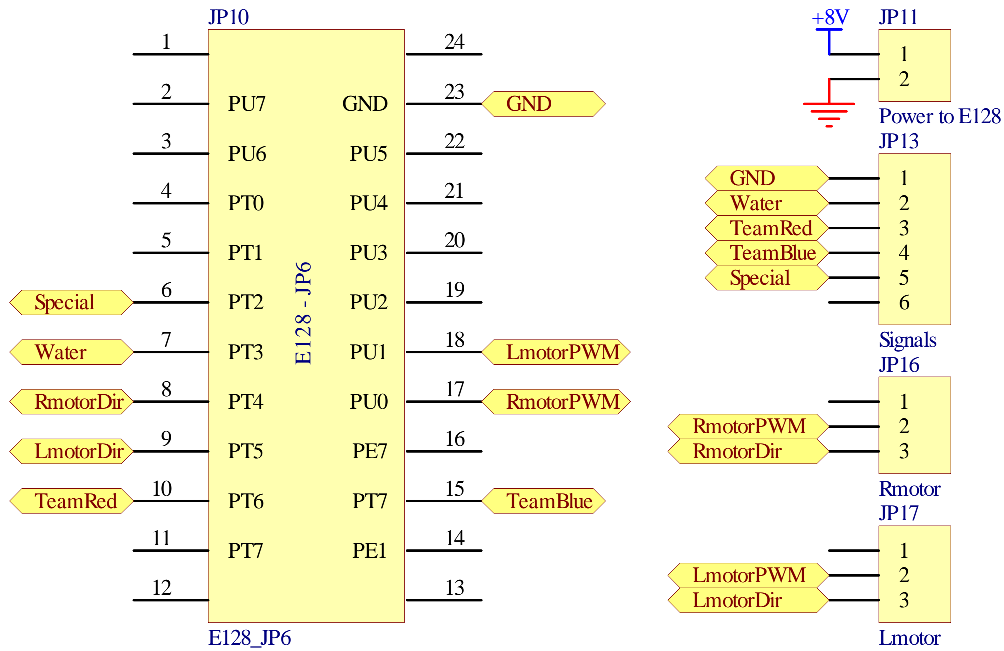
Boat JP5 Board - iButton and XBee

This board has connections for the E128 to communicate with the Xbee board provided to us, and has a PIC circuit for iButton reading. Note that we had to jumper two connections on the Xbee board to allow the header input to communicate with the Xbee module without a PIC on the Xbee board.

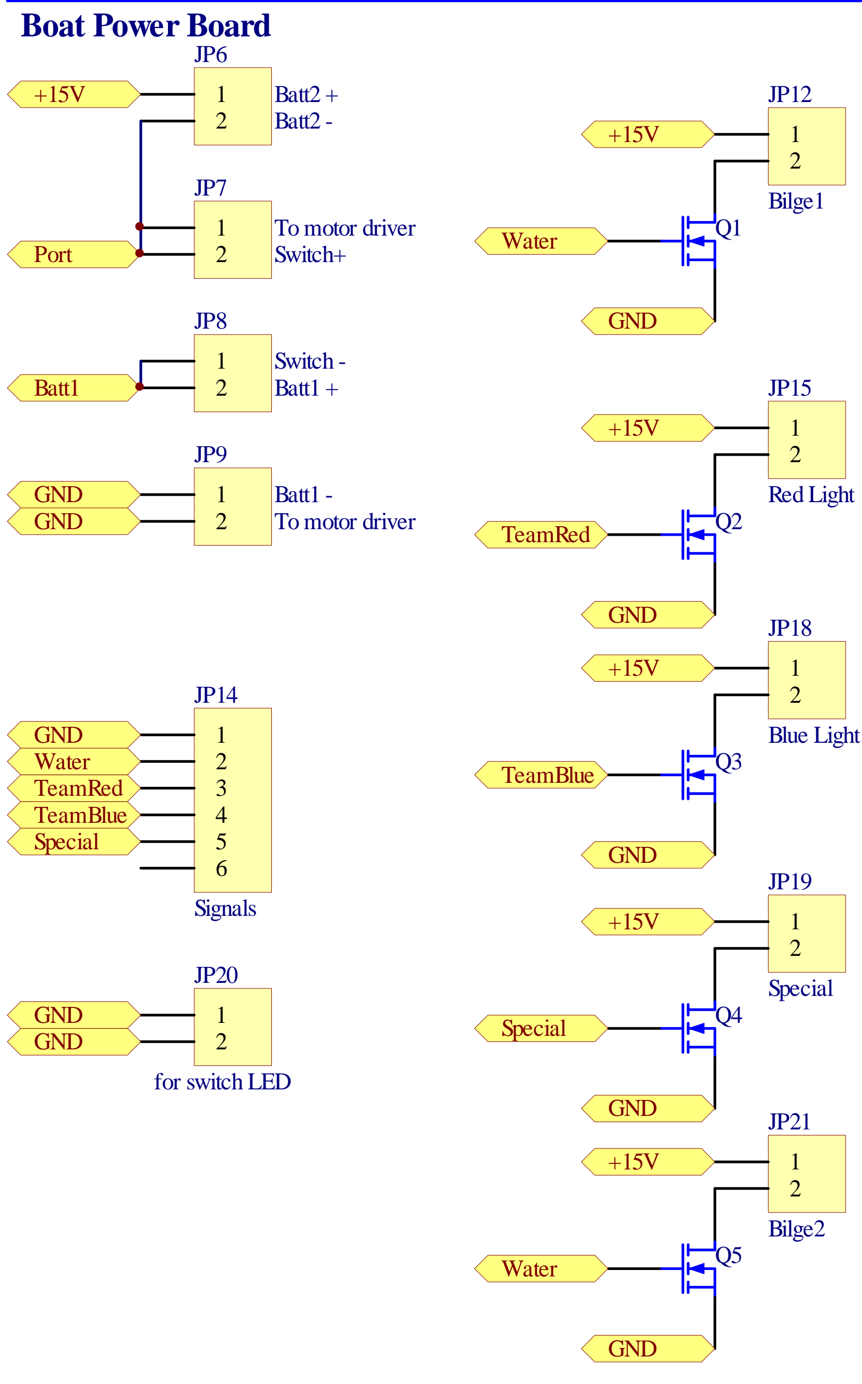
We opted to use a PIC for reading the iButton since it is easier to control the timing when the device is dedicated to just this function. The iButton uses a 1-wire communication scheme that requires controlling and then reading the same line. The E128 indicated to the PIC that it wanted an iButton number by lowering a single enable line. The PIC indicates to the user that it wants to read an iButton by flashing the LED in the center of the reader. When it successfully reads the serial number, it then uses SPI to transfer the required bytes to the E128. Once the E128 has verified that there is a matched serial number, it raises the enable line to end this stage. This satisfies the project requirement that either the boat or helm must have two actively communicating processors.



Boat JP6 Board - Outputs:
This board has connections for the PWM signal to the motor drivers and the digital outputs for water and special functions. Very simple, indeed.



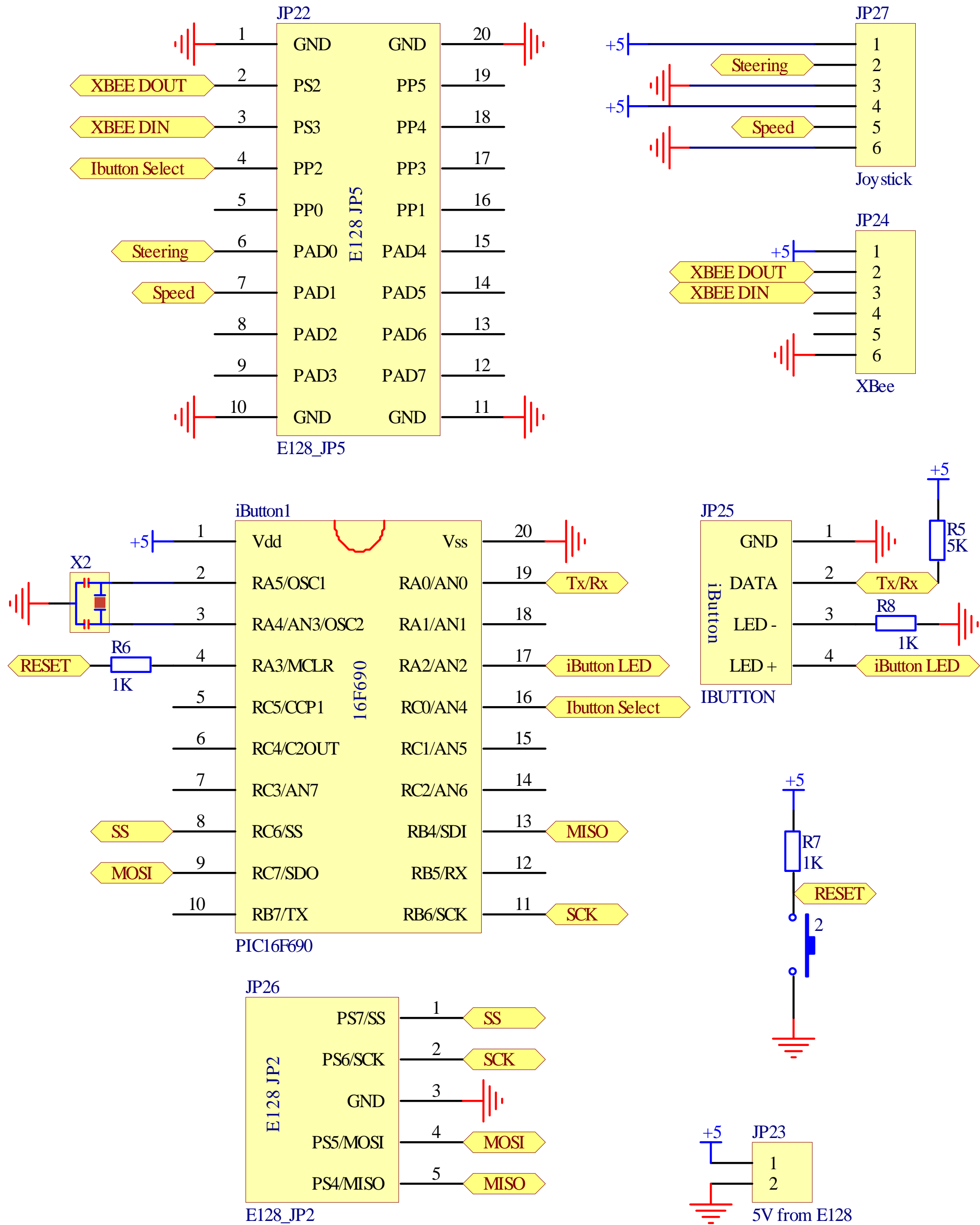
Boat Power Board:
This board has a block of screw terminals for connecting the batteries, power switch, and power to the motor drivers. It also has a block of power MOSFETs that each control a bilge pump or light, according to the signals received from the JP6 board.



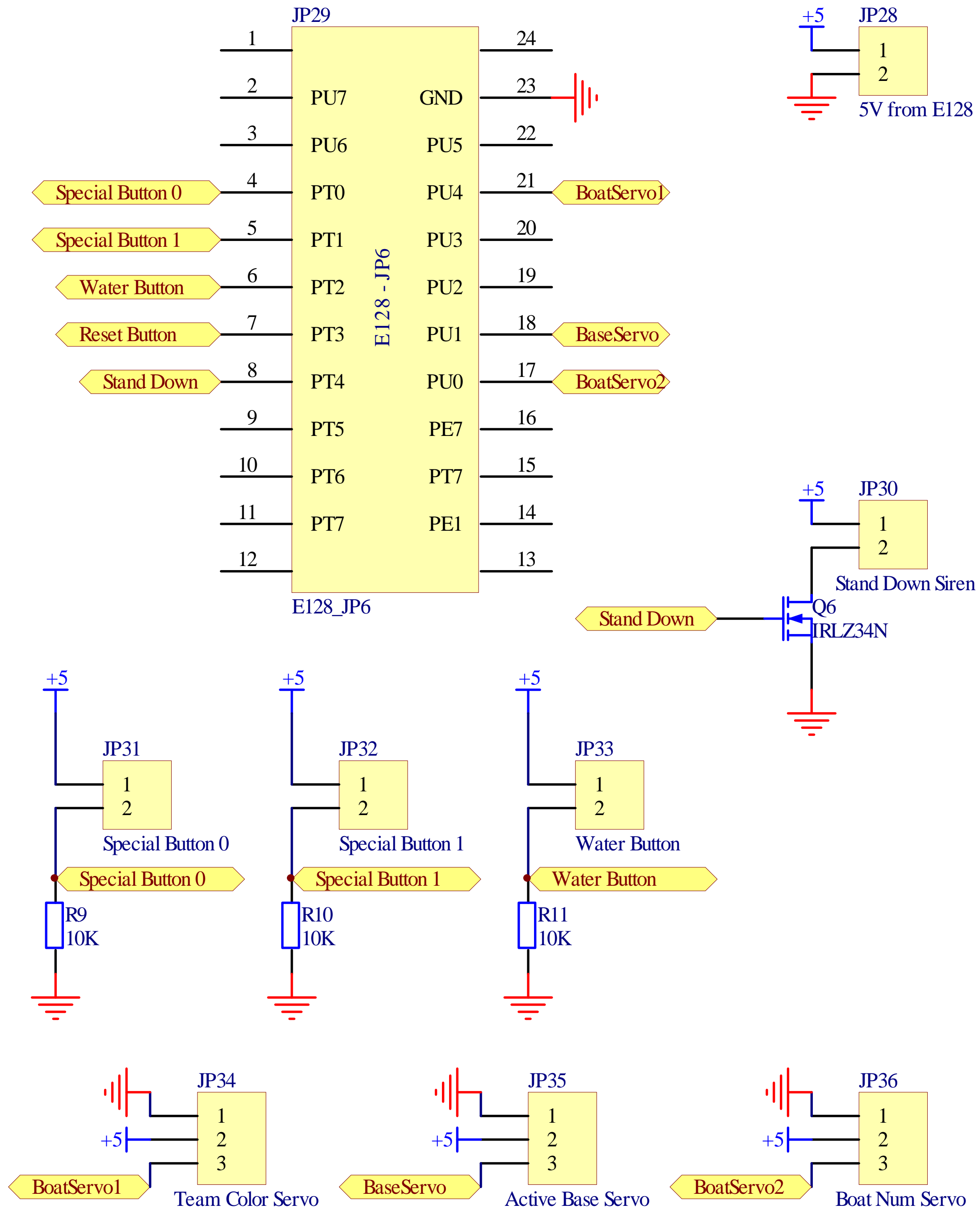
Boat E128 Pin Table:

Vessel - E128					
		JP6 24 Pin		RIBBON CABLE -->	
Use	Name	Pin Number	Pin Number	Name	Use
	NC	1	24	NC	
	PU7	2	23	GND	
	PU6	3	22	PU5	
RESET BUTTON (IN)	PT0	4	21	PU4	
	PT1	5	20	PU3	
SIREN (OUT)	PT2	6	19	PU2	
WATER (OUT)	PT3	7	18	PU1	LMOTOR_PWM (OUT)
RMOTOR_DIR (OUT)	PT4	8	17	PU0	RMOTOR_PWM (OUT)
LMOTOR_DIR (OUT)	PT5	9	16	PE7	
TEAM_COLOR_RED (OUT)	PT6	10	15	PT7	TEAM_COLOR_BLUE (OUT)
	PE0	11	14	PE1	
	NC	12	13	NC	
<-- RIBBON CABLE		JP5 20 Pin			
Use	Name	Pin Number	Pin Number	Name	Use
	GND	1	20	GND	
XBEE DOUT (IN)	PS2	2	19	PP5	
XBEE DIN (OUT)	PS3	3	18	PP4	
Ibutton Select	PP2	4	17	PP3	
	PP0	5	16	PP1	
	PAD0	6	15	PAD4	
	PAD1	7	14	PAD5	
	PAD2	8	13	PAD6	
	PAD3	9	12	PAD7	
	GND	10	11	GND	
<-- KEY		JP2 5 Pin			
Use	Name	Pin Number			
	PS7/SS	1			
	PS6/SCK	2			
	GND	3			
	PS5/MOSI	4			
	PS4/MISO	5			

Helm JP5 Board – iButton, Xbee, Joystick:
This board is virtually a copy of the boat iButton and Xbee board. Since the JP5 connector on the E128 also has the analog input port, this includes a connection for the joystick.

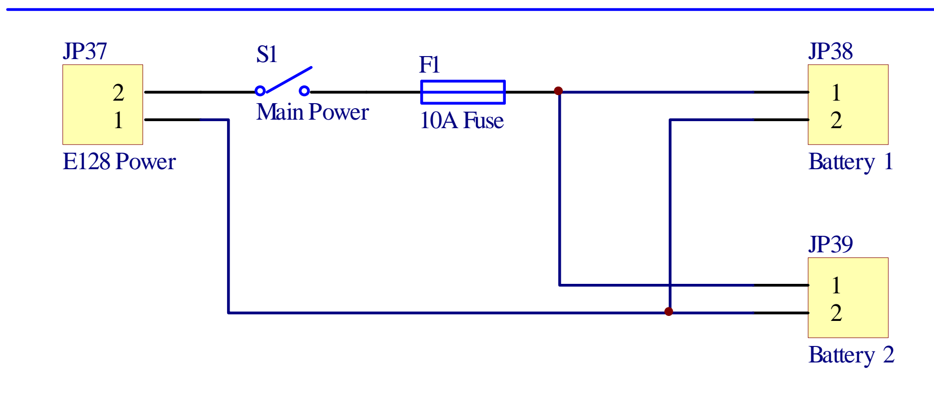


Helm JP6 Board – Inputs and Servos:
This board has inputs for the various buttons on the helm, and outputs to control the servos that indicate team number and active base. A MOSFET is used to power the siren.



Helm Power Management:
The helm is powered by two 7.2 V NiCad batteries which are wired in parallel. The output of the batteries runs through a 10 Amp fuse to protect our microprocessor and circuits in case something goes awry. There is also a switch which is used to power on and off the entire electrical system. Voltage regulation is handled by the voltage regulator on the E128 protection board.

Our calculations show that our helm is capable of running for **15 hours** off of these two batteries. Each of the batteries provides 1500 mAh and the average current draw of our entire electrical system is 200 mA. Thus our runtime is 15 hours (3000 mAh / 200 mA).



Helm E128 Pin Table

Helm - E128

JP6 24 Pin — **RIBBON CABLE -->**

Use	Name	Pin Number	Pin Number	Name	Use
	NC	1	24	NC	
	PU7	2	23	GND	
	PU6	3	22	PU5	
Special Button 0 (IN)	PT0	4	21	PU4	ACTIVE BASE SERVO (OUT)
Special Button 1 (IN)	PT1	5	20	PU3	
WATER BUTTON (IN)	PT2	6	19	PU2	
RESET BUTTON (IN)	PT3	7	18	PU1	RED BOAT NUM (OUT)
STAND DOWN (OUT)	PT4	8	17	PU0	BLUE BOAT NUM (OUT)
	PT5	9	16	PE7	
	PT6	10	15	PT7	
	PE0	11	14	PE1	
	NC	12	13	NC	

<-- RIBBON CABLE — **JP5 20 Pin**

Use	Name	Pin Number	Pin Number	Name	Use
	GND	1	20	GND	
XBEE DOUT (IN)	PS2	2	19	PP5	
XBEE DIN (OUT)	PS3	3	18	PP4	
Ibutton Select	PP2	4	17	PP3	
	PP0	5	16	PP1	
STEERING (IN)	PAD0	6	15	PAD4	
SPEED (IN)	PAD1	7	14	PAD5	
	PAD2	8	13	PAD6	
.	PAD3	9	12	PAD7	
	GND	10	11	GND	

<-- KEY — **JP2 5 Pin**

Use	Name	Pin Number
	PS7/SS	1
	PS6/SCK	2
	GND	3
	PS5/MOSI	4
	PS4/MISO	5

Selected component values and calculations:

Power MOSFETs (IRLZ34N)

Max voltage:	55V
Max current:	30A
Bilge pump draw:	2.5A
Indicator light draw:	100mA
Siren draw:	100mA

→ All devices are well under the max capacity, even without heat sinks.

Motor Drivers (TLE5206-2):

Rated continuous current:		5	A
Rated peak current:	6	A	
Max Stall Current:			
Motor coil resistance:	1.8	ohms	
Max supply voltage:		~7	V
Max stall current (V/R):	~4	A	

→ Under limit. In practice, current draw was about 2A.

Regulator on E128 Board:

Max current:		1	A
Average current draw for Helm:	200	mA	
E128-powered devices on boat:	250	mA	

→ All is good.

Bill of Materials*				
Boat:				
Description	Quantity	Unit Cost	Total	
1/2 sheet Pink Foam	1	$10.00	$10.00	
2 ft section 4" ABS pipe	1	$4.95	$4.95	
4" ABS end cap	2	$6.58	$13.16	
4mm Motor shaft	2	$10.55	$21.10	
4mm Universal Joint	2	$7.65	$15.30	
35mm, 2 blade propeller	2	$3.60	$7.20	
Shaft grease (waterproofing)	1	$3.29	$3.29	
500 GPH Bilge Pump	2	$15.00	$30.00	
1-1/4" PVC pipe	1	$5.00	$5.00	
Maxon A-max 6V motor	2	$0.00	$0.00	
Perf Board	3	$2.95	$8.85	
Helm:				
Weber Grill	1	$0.00	$0.00	
Spatula	1	$0.00	$0.00	
Mustard Bottle	1	$2.49	$2.49	
Servos	3	$0.00	$0.00	
Perf Board	2	$2.95	$5.90	
Odds and Ends:				
Wire of various gages	1	$0.00	$0.00	
Paint and stuff	1	$0.00	$0.00	
Lots of molex	1	$5.00	$5.00	
Switches and Lights	1	$10.00	$10.00	
	Grand Total		$142.24	
* cost = $0 denotes part was donated, found, stolen, or otherwise acquired				

SOFTWARE DESIGN

Software Overview

We thanked ourselves everyday for our decision to use an E128 as the primary processor on both the boat and the helm. This allowed us to do the vast majority of our programming in C (versus the assembly language used on the PICs). Programming in C made it much easier to create and debug robust state machines for both the helm and boat. We were also able to share a lot of the code between the boat and the helm which made it much easier to make system wide changes.

Our boat and helm implemented the state machines that were created by the communication committee. The committee essentially laid out exactly how our software needed to behave so all we had to do was implement it. Below is a description of how the helm and boat behave during game play. This is lifted from the document the communications committee created and is what we used as a reference when coding.

Pairing

When powered up, the helms and craft enter a ‘waiting for iButton’ state. Once a helm detects an iButton, the serial number is read and the helm enters the ‘waiting for sync’ state. Once in this state, the helm attempts to sync with a craft by repeatedly broadcasting an **IBUTTON** message containing the identity of the read iButton. Similarly, crafts also power up into a ‘waiting for iButton’ state. Once a craft reads an iButton, it transitions to a ‘waiting for sync’ state in which it monitors all broadcast messages sent by the helms.

When a craft receives an **IBUTTON** broadcast message, it checks the iButton identification data. If this data matches the iButton read by the craft, it transitions into the ‘game’ state. During this transition, the craft stores the address of the helm that sent the message and sends a **MATCHED** message in response to the helm. This message informs the helm which craft it is controlling for the remainder of the round. In the future, the helm may only send commands to that particular craft and the craft must only respond to commands from that helm and the admirals.

Pre-Game Operation

After successfully pairing, both the helm and craft should check the serial number from the iButton and display their team affiliation (odd serial numbers are for red team and even serial numbers are for blue teams). While this display could be performed immediately upon receiving an iButton serial number, it should be activated only when the craft has successfully paired with its helm. This display will indicate not only affiliation, but also, a successful pairing. Furthermore, after pairing, the helm must indicate to the helmsperson the number of the craft it is controlling.

The helm should at this point transition to a ‘wait for game’ state. While in this state the helm should send **NO_ACTION** commands at a rate of 5Hz in order to maintain the RF link with the craft and prevent it from moving. Meanwhile, the craft will transition to a ‘game’ state.

Helms remain in the ‘waiting for game’ state until the admirals broadcast the **START_OF_GAME** command. Once this command is issued, the game begins and helms may commence sending **COMMAND** signals to craft. Each **COMMAND** signal indicates the desired speed, direction, water delivery status (on/off), and all other special commands (see table of commands for more details). Admirals must then transmit a **RED/BLUE_GOAL** command to specify which goal is active.

Admiral Commands

During the game, admirals may send **STAND_DOWN** or **HARD / SOFT_RESET** commands directly to any craft. When a **STAND_DOWN** command is received, the craft must cease all activity and pass this command along to the helm. It is encouraged, but not required, that the craft also visibly communicate that it is disabled to observers of the match. The craft must take no action other than retransmitting **STAND_DOWN_RECEIVED** to the helm until the helm acknowledges the transmission. Once the helm receives and acknowledges the **STAND_DOWN_RECEIVED** command, it should send **NO_ACTION** commands until the stand down period expires (10 seconds) and display that the craft has been stood down to the helmsperson.

When a craft receives a **HARD_RESET** command from the Admiral, it must stop what it is doing, reset its team association, disassociate from its helm, and return to the initial ‘waiting for iButton’ state. A **SOFT_RESET** command is similar to a **HARD_RESET** command except that the craft remains in the ‘game’ state and does not disassociate from its paired helm. In other words, after receiving a **SOFT_RESET** command, the craft shut off all actuators, water, and special abilities then listens for new commands from its previously paired helm.

Admirals may also broadcast a **RED/BLUE_GOAL** broadcast command to all helms/craft. Upon, receiving this command, all helms must indicate the active base and players must move their craft to the proper side of the playfield, or be subject to a **STAND_DOWN** command.

Admirals may also **PING** craft or helms in order to determine the state and pairing of each craft/helm. Upon receiving a **PING** command, crafts and helms must respond with their state and pairing.

At the end of the game, the admirals will issue an **END_GAME** command. Upon receiving this command, helms will cease all water delivery and may only send motion commands directing craft back to the starting area. After all craft have returned, the admiralty will broadcast a **HARD_RESET** command

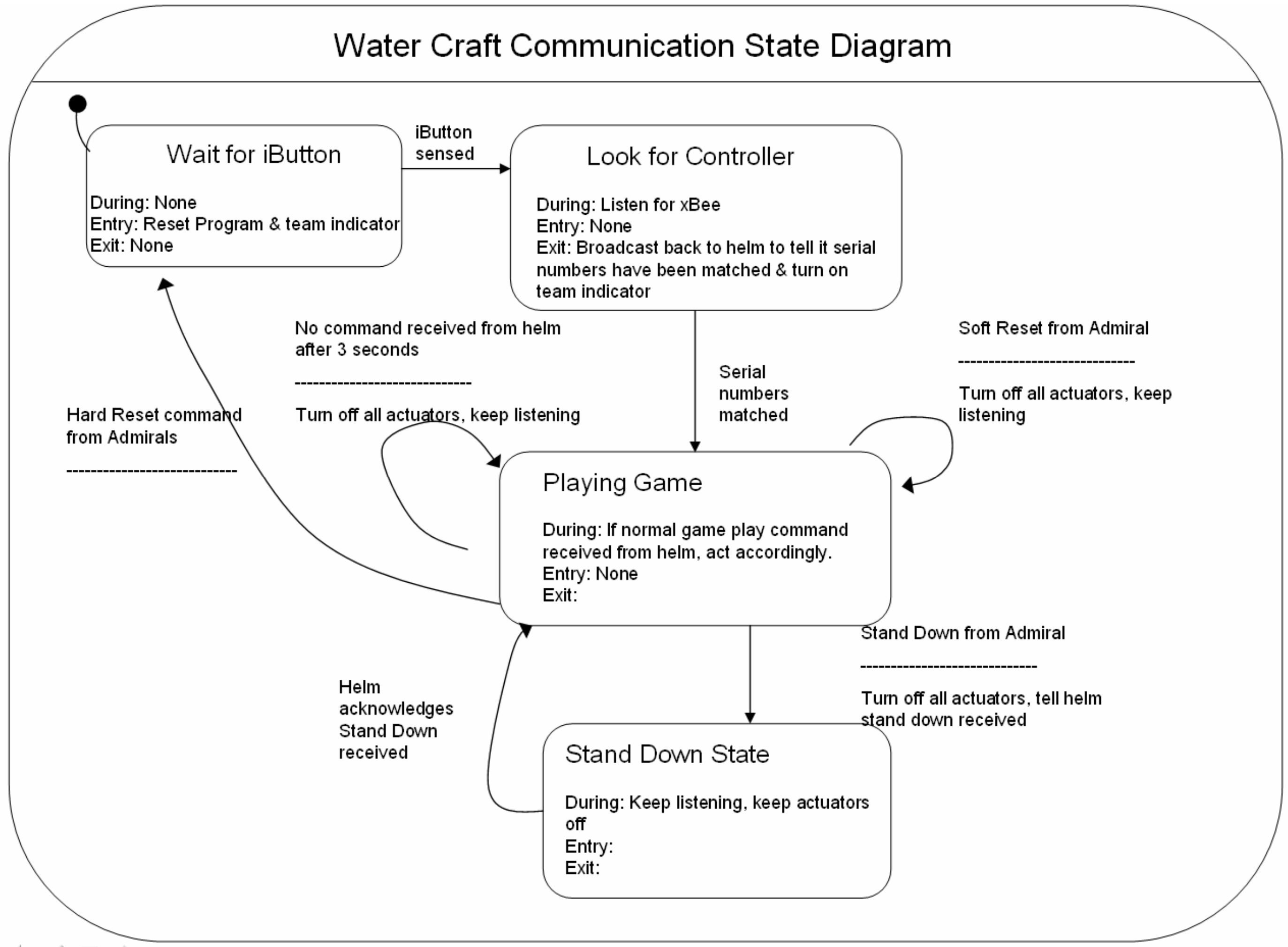
to all craft and helms in order to break all helm/craft pairings. Helms and craft should both respond to this command by disassociating from their paired craft/helm, resetting all visible team/craft affiliations, and returning to the 'waiting for iButton' state.

Communications Failure

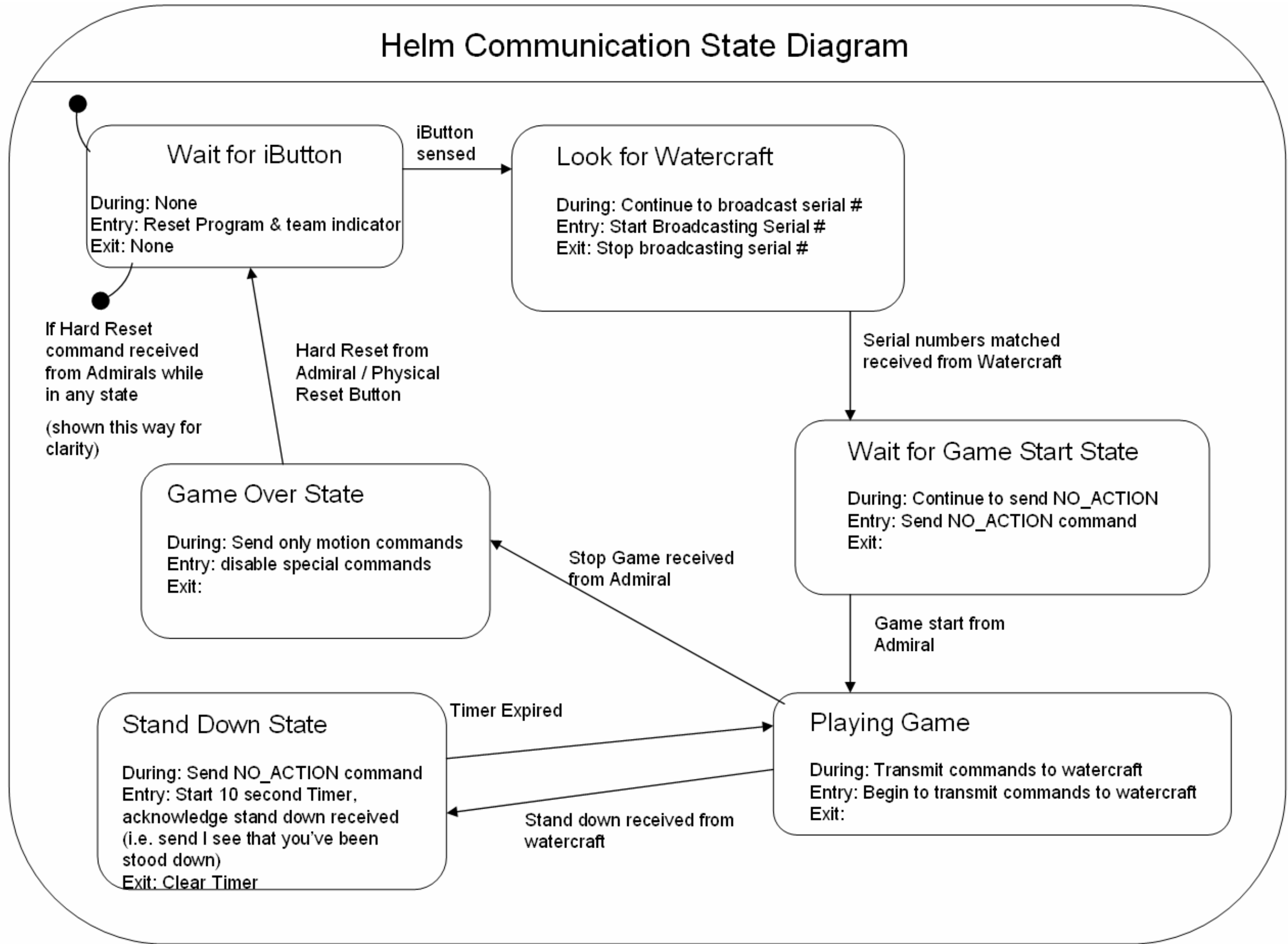
If, at any time, the helm and craft fall out of communication (no packets are received by the craft) for a period of greater than three seconds, the craft must turn off all actuators, water, and special functions. This is to prevent damage from and to the uncontrolled craft. Unless a **HARD_RESET** command is issued, the craft should continue to listen for commands from the helm. Control of the craft should resume as normal once communications are reestablished (possibly by bringing the helm into the receiving range of the craft).

State Diagrams

Craft



Helm



E128 Code Listing

boat.h

```
#ifndef BOAT
#define BOAT

//FUNCTION PROTOTYPES
// Public Function Prototypes
int RunBoatSM(int CurrentEvent);
void StartBoatSM (void);
int QueryBoatSM (void);
int CheckBoatEvents (void);

//Private function prototypes
static int During_BST_WAITING_FOR_IBUTTON(int Event);
static int During_BST_LOOKING_FOR_HELM(int Event);
static int During_BST_PLAYING_GAME(int Event);
static int During_BST_STANDING_DOWN(int Event);
static void ParseNavByte(unsigned char NAV);
static void ParseSpecialByte(unsigned char SPEC);

#endif
```

boat.c

```
//----------- boat.c ---------------//
//-- code courtesy of WeinerMeister-//
//----------------------------------//

//boat.c contains any code that is specific to the boat, including propeller control

#include "headers.h"

//global variables
extern unsigned char GMyTeam;

/*---------------------------- Module Variables ---------------------------*/
// everybody needs a state variable, you may need others as well
static int CurrentState = 0;

/*---------------------------- Boat Event Checkers ------------------------*/


//main event checker for the boat state machine
//most events occur as a result of a new xbee communication packet, which we parse here
int CheckBoatEvents(void)
{
        int CurrentEvent = EV_NO_EVENT;
        int KeyStroke;

        //Check for events
        //These events should be arranged in order of priority, since
        //if two events are encountered at once, only process the first one so the second
is processed the next time around

        if(CheckXbeeRX()){
          CurrentEvent = EV_NEW_XBEE;
        }
        else if(CheckSendTimer()){
          CurrentEvent = EV_TMR_SEND;
        }

        #ifdef SIMULATE_EVENTS //this allows us to simulate our state machine using
keyboard presses
        if (kbhit() != 0){ //there was a key pressed
                KeyStroke = getchar();
                switch(toupper(KeyStroke)){
```

```
                        case 'N' : CurrentEvent = EV_NEXT; break;
                }
                //check for signals that we want to send an admiral command
                SimulateAdmiral(KeyStroke);
        }
        #endif

        return(CurrentEvent);
}

/*---------------------------- Boat State Machine ---------------------------*/
int RunBoatSM( int CurrentEvent )
{
   unsigned char MakeTransition = FALSE;/* are we making a state transition? */
   int NextState = CurrentState;

   //print out our current state machine status
   if(CurrentEvent != EV_NO_EVENT)
        PrintState(CurrentState, CurrentEvent);

   switch ( CurrentState )
   {
       case BST_WAITING_FOR_IBUTTON :
         // Execute During function for state one. EV_ENTRY & EV_EXIT are processed here
         CurrentEvent = During_BST_WAITING_FOR_IBUTTON(CurrentEvent);
         //process any events
         if ( CurrentEvent != EV_NO_EVENT )
         {
            switch (CurrentEvent)
            {
               case EV_NEXT: //if a next command is pressed, skip ahead
                        NextState = BST_LOOKING_FOR_HELM;
                        MakeTransition = TRUE;
               break;
               case EV_IBUTTON: //If an ibutton tapped us, move on
                        NextState = BST_LOOKING_FOR_HELM;
                        MakeTransition = TRUE;
               break;
                       }
         }
       break;

       case BST_LOOKING_FOR_HELM :
            // Execute During function for state one. EV_ENTRY & EV_EXIT are processed
here
            CurrentEvent = During_BST_LOOKING_FOR_HELM(CurrentEvent);
            //process any events
            if ( CurrentEvent != EV_NO_EVENT )
            {
                switch (CurrentEvent)
                {
                    case EV_NEXT: //if a next command is pressed, skip ahead
                        SimulateIbutton(IAMBOAT); //hard code the other zigbee address
into our communications
                        NextState = BST_PLAYING_GAME;
                        MakeTransition = TRUE;
                    break;

                    case EV_MATCHED: //We are matched with the helm, so move on
                        NextState = BST_PLAYING_GAME;
                        MakeTransition = TRUE;
                    break;

                    case EV_HARD_RESET: //We are being reset to read another ibutton
                        NextState = BST_WAITING_FOR_IBUTTON;
                        MakeTransition = TRUE;
                    break;
                }
            }
       break;
```

```
        case BST_PLAYING_GAME :
          // Execute During function for state one. EV_ENTRY & EV_EXIT are processed here
          CurrentEvent = During_BST_PLAYING_GAME(CurrentEvent);
          //process any events
          if ( CurrentEvent != EV_NO_EVENT )
          {
             switch (CurrentEvent)
             {
                 case EV_STAND_DOWN: //We have been asked to stand down, so stop all
actuation
                          NextState = BST_STANDING_DOWN;
                          MakeTransition = TRUE;
                 break;
                 case EV_NEXT: //if a next command is pressed, skip ahead
                          NextState = BST_WAITING_FOR_IBUTTON;
                          MakeTransition = TRUE;
                 break;
                 case EV_HARD_RESET: //We are being broken up from our helm
                          NextState = BST_WAITING_FOR_IBUTTON;
                          MakeTransition = TRUE;
                 break;
             }
          }
        break;

        case BST_STANDING_DOWN :
          // Execute During function for state one. EV_ENTRY & EV_EXIT are processed here
          CurrentEvent = During_BST_STANDING_DOWN(CurrentEvent);
          //process any events
          if ( CurrentEvent != EV_NO_EVENT )
          {
             switch (CurrentEvent)
             {
                 case EV_NEXT: //if a next command is pressed, skip ahead
                          NextState = BST_PLAYING_GAME;
                          MakeTransition = TRUE;
                 break;
                 case EV_PLAY_ON: //Continue playing the game, now that stand down is
acknowledged by helm
                          NextState = BST_PLAYING_GAME;
                          MakeTransition = TRUE;
                 break;
                 }
                        }
         break;
         }


         // Check for error events, and printout
         if(CurrentEvent == EV_ERROR)
                printf("EV_ERROR FOUND!\r\n");

         //   If we are making a state transition
         if (MakeTransition == TRUE)
         {
            //   Execute exit function for current state
            RunBoatSM(EV_EXIT);
            CurrentState = NextState; //Modify state variable
            //   Execute entry function for new state
            RunBoatSM(EV_ENTRY);
         }

         return(CurrentEvent);
}

/****************************************************************************
Function
StartGameSM
****************************************************************************/
void StartBoatSM ( void )
{
```

```
   CurrentState = BST_WAITING_FOR_IBUTTON;
   // call the entry function (if any) for the ENTRY_STATE
   RunBoatSM(EV_ENTRY);
}

int QueryBoatSM ( void )
{
   return(CurrentState);
}

/*****************************************************************************
 private functions
 *****************************************************************************/

static int During_BST_WAITING_FOR_IBUTTON(int Event){
    // process EV_ENTRY & EV_EXIT events
    if ( Event == EV_ENTRY)
    {
        //reset all module variables and stop all actuators
        GMyTeam = NOTEAM;
        Stop(); //stop both propellers
        EraseStoredSerial(); //erase previously stored ibutton serial
        PTT &= BIT6LO;  //reset team lights
        PTT &= BIT7LO;
    }else if ( Event == EV_EXIT)
    {
    }else
    // do the 'during' function for this state
    {
      //check for ibutton touch and update team affiliation accordingly
      if(RequestIbutton()) //if there is an ibutton present with a valid serial number,
move on
        return EV_IBUTTON;
    }
    return Event;
}

static int During_BST_LOOKING_FOR_HELM(int Event){
    // process EV_ENTRY & EV_EXIT events
    if ( Event == EV_ENTRY)
    {
    }else if ( Event == EV_EXIT)
    {
    }else
    // do the 'during' function for this state
    {
      //listen for xbee communications
      if(Event == EV_NEW_XBEE){
        if(GetXbeeByte0() == IBUTTON){ //is the communication telling us about an
ibutton?
          if(CheckSerialMatch()){
            printf("We have a matched serial number! AKA we got that bitch\r\n");
            //we're a match, so do what we need to
            //get to know each others' zigbee addresses
            ImprintPartner();

            //set our team affiliation based on ibutton serial number
            // (moved light illumination into here)
            SetTeam(GetStoredSerialLSB());

            //send message to the helm telling it that we have a match
            Send218Data(TO_PARTNER, WATERCRAFT, MATCHED_1, MATCHED_2);

            //and move to the game
            return EV_MATCHED;
          }
        }
      }
    }
    return Event;
}
```

```
static int During_BST_PLAYING_GAME(int Event){
    // process EV_ENTRY & EV_EXIT events
    if ( Event == EV_ENTRY)
    {
        //initialize and reset the timer the check for lost communication
        SetTimer(TMR_LOST_COMM, LOST_COMM_TIME);
    }else if ( Event == EV_EXIT){
        //turn off all actuators
        Stop(); //stop both propellers
    }else
    // do the 'during' function for this state
    {
      //check xbee for admiral commands and nav commands
      if(Event == EV_NEW_XBEE){
        if(GetXbeeByte0() == ADMIRAL){ //admiral commands
                   switch(GetXbeeByte2()){
                //if there is a stand down command, turn off all actuators and report
stand down to helm
                       case STAND_DOWN: //0x01
                           Send218Data(TO_ADMIRAL, ACK, 0, STAND_DOWN); //acknowledge
stand down command
                           return EV_STAND_DOWN;
                       break;
                       //if there is a soft reset, turn off all actuators and stay in
this state
                case SOFT_RESET: //0x20
                    Send218Data(TO_ADMIRAL, ACK, 0, SOFT_RESET); //acknowledge soft reset
                           Stop(); //turn off all actuators
                           ParseSpecialByte(0x00);//turn off water and all special
functions
                       break;
                //hard reset command: go back to beginning of state machine
               case HARD_RESET: //0x40
                           return EV_HARD_RESET;
                       break;
                   }

        }
        else if(GetXbeeByte0() == NAVIGATION){ //nav commands
            //kick the lost com timer
            SetTimer(TMR_LOST_COMM, LOST_COMM_TIME);
            ParseNavByte(GetXbeeByte1());
            ParseSpecialByte(GetXbeeByte2());
        }
      }
      //if there is no communication for three seconds, turn off all actuators and listen
      else if(CheckTimerExpired(TMR_LOST_COMM) == TRUE) {
            printf("We lost communication with helm. Turning off all actuators. \r\n");
            Stop(); //turn off all actuators
            ParseSpecialByte(0x00);//turn off water and all special functions
      }
    }
    return Event;
}

static int During_BST_STANDING_DOWN(int Event){
    // process EV_ENTRY & EV_EXIT events
    if ( Event == EV_ENTRY)
    {
        Stop(); //turn off all actuators
        ParseSpecialByte(0x00);//turn off water and all special functions
    }else if ( Event == EV_EXIT)
    {
    }else
    // do the 'during' function for this state
    {
        //check to see if the helm has acknowledged that we are standing down
        if(Event == EV_NEW_XBEE){
            if(GetXbeeByte0() == ACK){ //helm acknowledgement that craft is standing down
                          printf("Helm acknowledged our stand down\r\n");
```

```
                            return EV_PLAY_ON;
                }
            }
        else {  //if we have not been acknowledged, try again
                //tell the helm that we are standing down
                Send218Data(TO_PARTNER, WATERCRAFT, STAND_DOWN_RECEIVED_1,
STAND_DOWN_RECEIVED_2);
        }
    }
    return Event;
}

/*---------------------------- End state machine ---------------------------*/

//Parses an 8-bit nav byte containing speed and direction information
//translates speed and direction into L and R prop power
//R = speed + direction
//L = speed - direction
static void ParseNavByte(unsigned char NAV) {
    unsigned char spdNIB; //speed (from lower nibble; 0=reverse, F=forward, 8=stopped)
    unsigned char dirNIB; //direction (from upper nibble; 0=fullL, F=fullR, 8=straight)
    char Lpower, Rpower;
    char Ldirection = FORWARD; //actual calculated L motor direction
    char Rdirection = FORWARD; //actual calculated R motor direction
    char dutyValues[8] = {0,28,40,52,64,76,88,100};

    printf("NAV BYTE = %x\r\n", NAV);
    //separate out speed and direction nibbles
    spdNIB=NAV&(0x0F); //mask out the upper nibble
    dirNIB=(NAV&(0xF0))>>4; //mask out the lower nibble, then shift data into the lower
nibble

    //calculate relative left and right power based on speed and direction
    //FIX THIS HACKY CONVERSION CODE
    Lpower=(spdNIB-8)-(dirNIB-8); //now centered around 0 (positive=FWD, negative=BACK)
    Rpower=(spdNIB-8)+(dirNIB-8); //now centered around 0

    //convert to duty and direction
    if(Lpower < 0){
    Ldirection = BACKWARD;
    Lpower *= -1;
    }
    if(Rpower < 0){
    Rdirection = BACKWARD;
    Rpower *= -1;
    }

    //make sure power values are in range
    if(Lpower > 7)
    Lpower = 7;
    if(Rpower > 7)
    Rpower = 7;

    //look up duty cycles in a table, and set the motors
    SetMotor(L_MOTOR, Ldirection, dutyValues[Lpower]);
    SetMotor(R_MOTOR, Rdirection, dutyValues[Rpower]);

    //print debugging functions
    printf("SpeedNIB = %d | DirectionNIB = %d \r\n",spdNIB,dirNIB);
    printf("Lpower = %d | Rpower = %d \r\n",Lpower,Rpower);
    printf("Lmotor = %d (dir=%d) | Rmotor = %d (dir=%d)
\r\n\r\n",dutyValues[Lpower],Ldirection,dutyValues[Rpower],Rdirection);
}

//Parses an 8-bit special byte, following a navigation header
static void ParseSpecialByte(unsigned char SPEC){
        printf("SPEC BYTE = %x\r\n", SPEC);
        //special button 0 or special button 1 is active
        if((SPEC & (0x30)) != 0){
            printf("Special active. Siren on!\r\n");
            PTT |= BIT2HI; //turn on siren output
```

```
        }else{
            printf("Specials off.\r\n");
            PTT &= BIT2LO; //turn off siren output
        }

    //parse water shooting
    if((SPEC & (0x0F)) != 0){ //if water is shooting
            printf("Water shooter on!\r\n");
            PTT |= BIT3HI; //turn on water output
        }else{
            printf("Water off.\r\n");
            PTT &= BIT3LO; //turn off water output
        }
}

//------------ TEST FUNCTION -----------------//

#ifdef BOAT_TEST  //send a string of commands to the boat and see how L and R motors
respond

void main(void){
  InitAll();

  while(TRUE){
    PrintDecAsBin(0x8F);
    printf(" - Full straight Forward! \r\n");
    ParseNavByte(0x8F);
    Wait(1500);

    PrintDecAsBin(0x83);
    printf(" - Partial straight backward \r\n");
    ParseNavByte(0x83);
    Wait(1500);

    PrintDecAsBin(0xFF);
    printf(" - Full right forward \r\n");
    ParseNavByte(0xFF);
    Wait(1500);

    PrintDecAsBin(0x25);
    printf(" - Partial left backward \r\n");
    ParseNavByte(0x25);
    Wait(1500);

    PrintDecAsBin(0x88);
    printf(" - Stopped \r\n");
    ParseNavByte(0x88);
    Wait(1500);
  }
}

#endif
```

defines.h

```
#ifndef DEFINES
#define DEFINES

//Test defines
#define HELM_MAIN
//#define BOAT_MAIN
//#define PWM_TEST
//#define BOAT_TEST
//#define IBUTTON_SPI_TEST
//#define XBEE_TEST
//#define SERVO_TEST
//#define HELM_TEST
//#define HELM_SERVO_TEST
#define SIMULATE_EVENTS        //don't really need it but for simulating events

//who am I (depends on program target)
```

```
#define IAMBOAT 0
#define IAMHELM 1

//team affiliation
#define NOTEAM 0
#define RED    1
#define BLUE   2
#define BASEA  3
#define BASEB  4

//send-to definitions
#define TO_BROADCAST    0
#define TO_PARTNER            1
#define TO_ADMIRAL            2

//Convenience
#define TRUE    1
#define FALSE   0
#define SUCCESS 0
#define FAILURE 1

//assign timer numbers
#define TMR_WAIT               0
#define TMR_SEND            1 //keeps track of period between sends during game at rate
of 5Hz
#define TMR_LOST_COMM       2 //if comm with partner is lost for three seconds
#define TMR_STAND_DOWN      3 //for letting us know when we can start playing again
#define TMR_MUSTARD_SHAKE   4
#define SEND_RATE          200 //send new data every 200ms (CHANGE BACK!!)
#define STAND_DOWN_TIME       10000 //stand down lasts for 10 seconds
#define LOST_COMM_TIME  3000 //how much time we will tolerate no comm from helm
#define MUSTARD_SHAKE_TIME 1000 //number of milliseconds that the mustard should come out
after you shake

//STATES
//boat state machine
#define BST_WAITING_FOR_IBUTTON       1
#define BST_LOOKING_FOR_HELM          2
#define BST_PLAYING_GAME              3
#define BST_STANDING_DOWN             4
//helm state machine
#define HST_WAITING_FOR_IBUTTON       1
#define HST_LOOKING_FOR_BOAT          2
#define HST_WAITING_FOR_GAME_START    3
#define HST_PLAYING_GAME              4
#define HST_CRUISING_POST_GAME        5
#define HST_STANDING_DOWN             6

//EVENTS
//general
#define EV_NO_EVENT                 1
#define EV_ENTRY                    2
#define EV_EXIT                            3
#define EV_ERROR                    4
//helm commands to craft
#define EV_NO_ACTION            5 //signal
#define EV_IBUTTON                    6 //event if a valid ibutton is received
//admiral commands to craft
#define EV_STAND_DOWN         7
#define EV_GAME_START         8
#define EV_GAME_STOP          9
#define EV_HARD_RESET         10
//timer events
#define EV_TMR_SEND                   11
#define EV_TMR_LOST_COMM      12 //if no communication for 3 seconds
//other
#define EV_MATCHED                    13
#define EV_PLAY_ON            14
#define EV_NEXT               15
#define EV_NEW_XBEE           16
```

```
//boating
#define R_MOTOR        1 //use to ID the right motor
#define L_MOTOR        0 //use to ID the left motor
#define BOTH_MOTORS 2 //makes both motors do their thing
#define FORWARD        1 //motor pushes the robot forward
#define BACKWARD       0 //motor pushes the robot backward
#define RIGHT          1
#define LEFT           0

//propellor motor PWM
#define PRESCALER 2            //24Mhz clock / 2 = 12 MHz
#define POSTSCALER 3    //12 MHz / (3*2) = 2000 kHz
#define MS (24000/(PRESCALER*POSTSCALER*2)) // =1000 defines the number of ticks in a
microsecond
#define MOTOR_PWM_PERIOD 100 //(MS/10) //MS/10 = 20kHz
#define DEFAULT_MOTOR_DUTY (MOTOR_PWM_PERIOD) //default duty cycle = 100%

//Ibutton
#define IBUTTON_RESET_BYTE  0xFF //arbitrary reset pattern

// SCI
#define BAUD_BITS           156          // (24000000/(16*156) = 9615 Baud)        (very
wrong?)
#define XBEE_MESSAGE_SIZE   12
#define SET_TO_MASTER       1
#define SET_TO_SLAVE        0

//SERVO PWM HELPERS
#define PRESCALER_A 16        //24Mhz clock / 16 = 1500 Khz
#define POSTSCALER_A 36               //24Mhz / 16 / (2*36) = 20.83 kilohertz
#define MS_B (24000/(PRESCALER_A*POSTSCALER_A*2)) // =  20.83 defines the number of ticks
in a ms
#define SERVO_PWM_PERIOD 209 //(MS_B/200) = 50ish Hz
#define SERVO_MAX_DUTY 26
#define SERVO_MIN_DUTY 6       //used to be 2
#define SERVO_INIT_DUTY 6

#define ACTIVE_BASE_SERVO 4
#define RED_BOAT_NUM_SERVO 1
#define BLUE_BOAT_NUM_SERVO 0

//BOAT HELPERS
#define BOAT_PTT_INIT (BIT0LO) //0 is an input and the rest are outputs
#define BOAT_PTU_INIT (BIT0HI | BIT1HI); //Port U pins 0 and 1 are outputs
#define BOAT_PTAD_INIT ("AAAAAAAA") //0,1 are analog inputs the rest are inputs (but not
currently used)

//HELM HELPERS
#define HELM_PTT_INIT ((BIT0LO & BIT1LO & BIT2LO & BIT3LO)|(BIT4HI)) //0,1,2,3 are
inputs, 4 is an output
#define HELM_PTU_INIT (BIT0HI | BIT1HI | BIT4HI) //Port U pins 0, 1, and 4 are outputs
#define HELM_PTAD_INIT ("AAAAAAAA") //0,1 are analog inputs the rest are inputs (but not
currently used)

#define SPEED_PIN 1
#define DIRECTION_PIN 0
#define SPEED_CONVERSION 64
#define DIRECTION_CONVERSION 64

//------------- 218C Comm Definitions --------------------/
//Framing
#define START_BYTE            0x7E
#define LENGTH_MSB            0x00
#define LENGTH_LSB            0x08

//API identifier
#define API_RX                      0x81
#define API_TX                      0x01

//Frame ID:  change this to non-zero if you wish
//your xBee to respond with a Tx Status message
```

```
#define FRAME_ID                        0x00

//Addresses
#define ADMIRAL_ADDRESS_MSB    0xBC    // This was AF before, but the
#define ADMIRAL_ADDRESS_LSB    0xFF    // comm spec had a typo in it
#define HELM_MSB                        0xBC
#define CRAFT_MSB                       0xAF

//for ME218C Data Byte 0 Header
#define IBUTTON                    0x01
#define NAVIGATION                      0x02
#define ADMIRAL                    0x04
#define WATERCRAFT                      0x08
#define PING_RESPONSE          0x10
#define ACK                                 0x80

//Admiral Messages
#define STAND_DOWN                      0x01
#define START_GAME                      0x02
#define END_GAME                        0x04
#define BLUE_GOAL                       0x08
#define RED_GOAL                        0x10
#define SOFT_RESET                      0x20
#define HARD_RESET                      0x40
#define ADMIRAL_PING           0x80

//Commands from Helm to Watercraft
#define NO_ACTION_1                     0x88
#define NO_ACTION_2                     0x00

//Commands from Watercraft to Helm
#define STAND_DOWN_RECEIVED_1  0x00
#define STAND_DOWN_RECEIVED_2  0x02

#define MATCHED_1                       0x00
#define MATCHED_2                       0x01

//Ping Responses
#define WAITING_IBUTTON                 0x01
#define WAITING_PAIR           0x02
#define PAIRED                          0x04


#endif
```

headers.h

```
#ifndef HEADERS
#define HEADERS

//Standard Libraries
#include "ME218_E128.h"
#include <hidef.h>
#include <mc9s12e128.h>
#include <bitdefs.h>

#include "S12eVec.h"          /* vector addresses for interrupts */
#include <S12e128bits.h>    /* bit definitions  */

#include <timerS12.h>
#include <stdio.h>
#include <math.h>
#include <string.h>
#include "ADS12e.h"

//Our libraries
#include "boat.h"
#include "helm.h"
#include "defines.h"
#include "helpers.h"
#include "ibutton.h"
```

```
#include "main.h"
#include "motor.h"
#include "servo.h"
#include "xbee.h"

#endif
```

helm.h

```
#ifndef HELM
#define HELM

//FUNCTION PROTOTYPES
// Public Function Prototypes
int RunHelmSM(int CurrentEvent);
void StartHelmSM (void);
int QueryHelmSM (void);
int CheckHelmEvents(void);

//Private function prototypes
static int During_HST_CRUISING_POST_GAME(int Event);
static int During_HST_STANDING_DOWN(int Event);
static int During_HST_PLAYING_GAME(int Event);
static int During_HST_WAITING_FOR_GAME_START(int Event);
static int During_HST_LOOKING_FOR_BOAT(int Event);
static int During_HST_WAITING_FOR_IBUTTON(int Event);

static unsigned char GetSpeedLevel(void);
static unsigned char GetDirectionLevel(void);
static unsigned char CreateNavByte(void);
static unsigned char CreateSpecialByte(void);

//indicator control functions
static void SetBaseIndicator(unsigned char goal);
static void SetTeamIndicator(unsigned char team);

//switch checker functions
static unsigned char CheckResetState(void);
static unsigned char CheckSpec0State(void);
static unsigned char CheckSpec1State(void);
static unsigned char CheckWaterState(void);

#endif
```

helm.c

```
//----------- helm.c ---------------//
//-- code courtesy of WeinerMeister-//
//----------------------------------//

//helm.c contains any code that is specific to the helm, including reading all of the
inputs
//and sending zigbee packets to the boat

#include "headers.h"

//global variables
extern unsigned char GMyTeam;

//module variables
static unsigned char resetState, waterState;

/*---------------------------- Module Variables ---------------------------*/
// everybody needs a state variable, you may need others as well
static int CurrentState = 0;

/*---------------------------- Helm Event Checkers ------------------------*/

//main event checker for the helm state machine
```

```
//most events occur as a result of a new xbee communication packet, which we parse here
int CheckHelmEvents(void)
{
	int CurrentEvent = EV_NO_EVENT;
	int KeyStroke;

	//Check for events
	//These events should be arranged in order of priority, since
	//if two events are encountered at once, only process the first one so the second
is processed the next time around

	if(resetState != CheckResetState()){
		if(resetState == 0){
			resetState = 1; //toggle the state variable
			CurrentEvent = EV_HARD_RESET;
		} else
			resetState = 0;
	}

	if(CheckXbeeRX()){
	  CurrentEvent = EV_NEW_XBEE;
	}
	else if(CheckSendTimer()){
	  CurrentEvent = EV_TMR_SEND;
	}

	#ifdef SIMULATE_EVENTS //this allows us to simulate our state machine using
keyboard presses
	else if (kbhit() != 0){ //there was a key pressed
		KeyStroke = getchar();
		switch(toupper(KeyStroke)){
			case 'N' : CurrentEvent = EV_NEXT; break;
		}
		//check for signals that we want to send an admiral command
		SimulateAdmiral(KeyStroke);
	}
	#endif

	return(CurrentEvent);
}

/*---------------------------- Helm State Machine ---------------------------*/
int RunHelmSM( int CurrentEvent )
{
   unsigned char MakeTransition = FALSE;/* are we making a state transition? */
   int NextState = CurrentState;

   //print out our current state machine status
   if((CurrentEvent != EV_NO_EVENT) && (CurrentEvent != EV_NEW_XBEE))
        PrintState(CurrentState, CurrentEvent);

   switch ( CurrentState )
   {
       case HST_WAITING_FOR_IBUTTON :
            // Execute During function for state one. EV_ENTRY & EV_EXIT are processed
here
            CurrentEvent = During_HST_WAITING_FOR_IBUTTON(CurrentEvent);
            //process any events
            if ( CurrentEvent != EV_NO_EVENT )
            {
                switch (CurrentEvent)
                {
                case EV_NEXT: //if a next command is pressed, skip ahead
                                NextState = HST_LOOKING_FOR_BOAT;
                                MakeTransition = TRUE;
                break;
                case EV_IBUTTON: //If an ibutton tapped us, move on
                                NextState = HST_LOOKING_FOR_BOAT;
                                MakeTransition = TRUE;
                break;
                }
```

```
            }
            break;

        case HST_LOOKING_FOR_BOAT :
            // Execute During function for state one. EV_ENTRY & EV_EXIT are processed
here
            CurrentEvent = During_HST_LOOKING_FOR_BOAT(CurrentEvent);
            //process any events
            if ( CurrentEvent != EV_NO_EVENT )
            {
                switch (CurrentEvent)
                {
                case EV_NEXT: //if a next command is pressed, skip ahead
                    SimulateIbutton(IAMHELM); //hard code the other zigbee address into
our communications
                    NextState = BST_PLAYING_GAME;
                    MakeTransition = TRUE;
                break;
                case EV_MATCHED: //We are matched with the boat, so move on
                    NextState = BST_PLAYING_GAME;
                    MakeTransition = TRUE;
                break;
                case EV_HARD_RESET: //Go to initial state because we have been reset
                        NextState = HST_WAITING_FOR_IBUTTON;
                        MakeTransition = TRUE;
                break;
                }
            }
        break;

        case HST_WAITING_FOR_GAME_START :
          // Execute During function for state one. EV_ENTRY & EV_EXIT are processed here
          CurrentEvent = During_HST_WAITING_FOR_GAME_START(CurrentEvent);

          // HARD CODED TO START GAME RIGHT AWAY!!
          // REMOVE BEFORE FINAL CHECKOFF!
          //NextState = HST_PLAYING_GAME;
          //MakeTransition = TRUE;

          //process any events
          if ( CurrentEvent != EV_NO_EVENT )
          {
             switch (CurrentEvent)
             {
                case EV_NEXT: //if a next command is pressed, skip ahead
                        NextState = HST_PLAYING_GAME;
                        MakeTransition = TRUE;
                break;
                case EV_GAME_START: //we got an admiral command saying to start to the
game
                        NextState = HST_PLAYING_GAME;
                        MakeTransition = TRUE;
                break;
                case EV_HARD_RESET: //Go to initial state because we have been reset
                        NextState = HST_WAITING_FOR_IBUTTON;
                        MakeTransition = TRUE;
                break;
             }
          }
        break;

        case HST_PLAYING_GAME :
          // Execute During function for state one. EV_ENTRY & EV_EXIT are processed here
          CurrentEvent = During_HST_PLAYING_GAME(CurrentEvent);
          //process any events
          if ( CurrentEvent != EV_NO_EVENT )
          {
             switch (CurrentEvent)
             {
                case EV_STAND_DOWN: //if we get a stand down command, go into the stand
down state
```

```
                    NextState = HST_STANDING_DOWN;
                    MakeTransition = TRUE;
                break;
                case EV_NEXT: //if a next command is pressed, skip ahead
                        NextState = HST_CRUISING_POST_GAME;
                        MakeTransition = TRUE;
                break;
                case EV_GAME_STOP: //If we get a game over command from the admiral then
go to game over state
                        NextState = HST_CRUISING_POST_GAME;
                        MakeTransition = TRUE;
                break;
                case EV_HARD_RESET: //Go to initial state because we have been reset
                        NextState = HST_WAITING_FOR_IBUTTON;
                        MakeTransition = TRUE;
                break;
                }
         }
        break;

        case HST_STANDING_DOWN :
         // Execute During function for state one. EV_ENTRY & EV_EXIT are processed here
         CurrentEvent = During_HST_STANDING_DOWN(CurrentEvent);
         //process any events
         if ( CurrentEvent != EV_NO_EVENT )
         {
            switch (CurrentEvent)
            {
                case EV_NEXT: //if a next command is pressed, skip ahead
                        NextState = HST_PLAYING_GAME;
                        MakeTransition = TRUE;
                break;
                case EV_PLAY_ON: //Continue playing the game, now that stand down is
acknowledged by helm
                        NextState = HST_PLAYING_GAME;
                        MakeTransition = TRUE;
                break;
                case EV_HARD_RESET: //Go to initial state because we have been reset
                        NextState = HST_WAITING_FOR_IBUTTON;
                        MakeTransition = TRUE;
                break;
                }
         }
        break;

        case HST_CRUISING_POST_GAME :
         // Execute During function for state one. EV_ENTRY & EV_EXIT are processed here
         CurrentEvent = During_HST_CRUISING_POST_GAME(CurrentEvent);
         //process any events
         if ( CurrentEvent != EV_NO_EVENT )
         {
            switch (CurrentEvent)
            {
                case EV_NEXT: //if a next command is pressed, skip ahead
                        NextState = HST_WAITING_FOR_IBUTTON;
                        MakeTransition = TRUE;
                break;
                case EV_HARD_RESET: //Go to initial state because we have been reset
                        NextState = HST_WAITING_FOR_IBUTTON;
                        MakeTransition = TRUE;
                break;
                }
                            }
        break;
        }


        // Check for error events, and printout
        if(CurrentEvent == EV_ERROR)
               printf("EV_ERROR FOUND!\r\n");
```

```
        //   If we are making a state transition
        if (MakeTransition == TRUE)
        {
           //   Execute exit function for current state
           RunHelmSM(EV_EXIT);
           CurrentState = NextState; //Modify state variable
           //   Execute entry function for new state
           RunHelmSM(EV_ENTRY);
         }

        return(CurrentEvent);
}

/****************************************************************************
Function
StartGameSM
****************************************************************************/
void StartHelmSM ( void )
{
    //do initialization of helm module variables here
    //Initialize initial state of actuators
    resetState = CheckResetState();
    waterState = CheckWaterState();

   CurrentState = HST_WAITING_FOR_IBUTTON;
   // call the entry function (if any) for the ENTRY_STATE
   RunHelmSM(EV_ENTRY);
}

int QueryHelmSM ( void )
{
   return(CurrentState);
}

/***************************************************************************
 private functions
 ***************************************************************************/

static int During_HST_WAITING_FOR_IBUTTON(int Event){
    // process EV_ENTRY & EV_EXIT events
    if ( Event == EV_ENTRY)
    {
        //reset all module variables and stop all actuators
        GMyTeam = NOTEAM;
        EraseStoredSerial(); //erase previously stored ibutton serial

        //reset all servos to initial position
        printf("Initializing servos to home position\r\n");
        SetBaseIndicator(NOTEAM);
        SetTeamIndicator(NOTEAM);

        //turn off siren to indicate we are no longer being stood down
       printf("Initializing siren to OFF\r\n");
       PTT &= BIT4LO;

    }else if ( Event == EV_EXIT)
    {
    }else
    // do the 'during' function for this state
    {
      //check for ibutton touch and update team affiliation accordingly
      if(RequestIbutton()) //if there is an ibutton present with a valid serial number,
move on
        return EV_IBUTTON;
    }
    return Event;
}

static int During_HST_LOOKING_FOR_BOAT(int Event){
    // process EV_ENTRY & EV_EXIT events
    if ( Event == EV_ENTRY)
```

```
    {
    }else if ( Event == EV_EXIT)
    {
    }else
    // do the 'during' function for this state
    {
      //do we need to send zigbee communications
      if(Event == EV_TMR_SEND){
       //send serial number
       Send218Data(TO_BROADCAST, IBUTTON, GetStoredSerialMSB(), GetStoredSerialLSB());
      }

      //listen for xbee communications
      if(Event == EV_NEW_XBEE){
        if(GetXbeeByte0() == WATERCRAFT){ //is the communication telling us about an
ibutton?
          if((GetXbeeByte1() == MATCHED_1) && (GetXbeeByte2() == MATCHED_2)){
            //we're a match, so do what we need to
            //get to know each others' zigbee addresses
            ImprintPartner();

            //set our team affiliation (this feels weird for Mr. Helm)
            SetTeam(GetStoredSerialLSB());
            //turn on our team servo
            SetTeamIndicator(GetTeamNumber()); //use the team # to set our team
affiliation
            //and move to the waiting for game start stage

            return EV_MATCHED;
          }
        }
      }
    }
    return Event;
}

static int During_HST_WAITING_FOR_GAME_START(int Event){
    // process EV_ENTRY & EV_EXIT events
    if ( Event == EV_ENTRY)
    {
    }else if ( Event == EV_EXIT){
    //do nothing
    }else
    // do the 'during' function for this state
    {

      //do we need to send zigbee communications
      if(Event == EV_TMR_SEND){
       //send no action
       Send218Data(TO_PARTNER, NAVIGATION, NO_ACTION_1,NO_ACTION_2);
      }

      //check xbee for admiral command to start game
      if(Event == EV_NEW_XBEE){
        if(GetXbeeByte0() == ADMIRAL){ //admiral commands
                      if(GetXbeeByte2() == START_GAME){
                           Send218Data(TO_ADMIRAL, ACK, 0, START_GAME); //acknowledge game
has started
                               return EV_GAME_START;
                      }
        }
      }
    }
    return Event;
}

static int During_HST_PLAYING_GAME(int Event){
    // process EV_ENTRY & EV_EXIT events
    if ( Event == EV_ENTRY)
    {
    }else if ( Event == EV_EXIT)
```

```
    {
    }else
    // do the 'during' function for this state
    {
      //check xbee for admiral commands and nav commands
      if(Event == EV_NEW_XBEE){
        if(GetXbeeByte0() == WATERCRAFT){ //watercraft commands
                       if(GetXbeeByte2() == STAND_DOWN_RECEIVED_2)
                               //Acknowledge the boat is standing down
                               Send218Data(TO_PARTNER, ACK, STAND_DOWN_RECEIVED_1,
STAND_DOWN_RECEIVED_2);
                               return EV_STAND_DOWN;
        }
        // Check for admiral commands
        else if(GetXbeeByte0() == ADMIRAL){ //admiral commands
                        switch (GetXbeeByte2())
                        {
                               case END_GAME :
                                   Send218Data(TO_ADMIRAL, ACK, 0, END_GAME);
//acknowledge game has ended
                                       return EV_GAME_STOP;
                                       break;
                               case HARD_RESET :
                                       return EV_HARD_RESET;
                                       break;
                               case BLUE_GOAL :
                                       SetBaseIndicator(BASEA); //Turn on blue goal servo
                                       break;
                               case RED_GOAL :
                                       SetBaseIndicator(BASEB); //Turn on blue goal servo
                                       break;
                        }
        }
      }
      // if it is time to send, then we send nav and special data to our boat
      if(Event ==  EV_TMR_SEND)
      {
               Send218Data(TO_PARTNER, NAVIGATION, CreateNavByte(), CreateSpecialByte());
      }
    }
    return Event;
}

static int During_HST_STANDING_DOWN(int Event){
    // process EV_ENTRY & EV_EXIT events
    if ( Event == EV_ENTRY)
    {
        SetTimer(TMR_STAND_DOWN, STAND_DOWN_TIME);

        //turn on siren to indicate we are being stood down
        printf("Turning on siren as we stand down\r\n");
        PTT |= BIT4HI;

    }else if ( Event == EV_EXIT)
    {
        //turn off siren to indicate we are no longer being stood down
        printf("Turning off siren as we exit stand down\r\n");
        PTT &= BIT4LO;

    }else
    // do the 'during' function for this state
    {
      //check xbee for admiral commands and nav commands
      if(Event == EV_NEW_XBEE){

        // Check for admiral commands
        if(GetXbeeByte0() == ADMIRAL){ //admiral commands
                        switch (GetXbeeByte2())
                        {
                               case END_GAME :
                                       return EV_GAME_STOP;
```

```
                                    break;
                            case HARD_RESET :
                                    return EV_HARD_RESET;
                                    break;
                            case BLUE_GOAL :
                                    SetBaseIndicator(BLUE); //Turn on blue goal servo
                                    break;
                            case RED_GOAL :
                                    SetBaseIndicator(RED); //Turn on blue goal servo
                                    break;
                      }
        }

      }
      //Check if stand down timer is expired
      if(CheckTimerExpired(TMR_STAND_DOWN))
       return EV_PLAY_ON;

      //do we need to send zigbee communications
      if(Event == EV_TMR_SEND)
       //Send218Data(TO_PARTNER, NAVIGATION, NO_ACTION_1,NO_ACTION_2);
       Send218Data(TO_PARTNER, ACK, STAND_DOWN_RECEIVED_1, STAND_DOWN_RECEIVED_2); //keep
acknowledging to make sure our boat knows that we know that it's standing down
    }
    return Event;
}

static int During_HST_CRUISING_POST_GAME(int Event){
    // process EV_ENTRY & EV_EXIT events
    if ( Event == EV_ENTRY)
    {
        SetBaseIndicator(NOTEAM);
        SetTeamIndicator(NOTEAM);
    }else if ( Event == EV_EXIT)
    {
    }else
    // do the 'during' function for this state
    {
      //check xbee for admiral commands and nav commands
      if(Event == EV_NEW_XBEE){
        // Check for admiral commands
        if(GetXbeeByte0() == ADMIRAL){ //admiral commands
                      if (GetXbeeByte2() == HARD_RESET)
                            return EV_HARD_RESET;
        }
      }
      // if it is time to send, then we send nav and special data to our boat
      if(Event ==  EV_TMR_SEND)
      {
              Send218Data(TO_PARTNER, NAVIGATION, CreateNavByte(), 0x00);
      }
    }
    return Event;
}

//-------------------------- END OF DURING FUNCTIONS -----------------------------------/

// Creates the special byte, which will be sent to the boat
static unsigned char CreateSpecialByte (void)
{
       unsigned char special_byte = 0;

       //special button 0
       if(CheckSpec0State()) special_byte |= BIT5HI;
       //special button 1
       if(CheckSpec1State()) special_byte |= BIT4HI;
       //water dispensor
       if(CheckWaterState()) special_byte |= 0x0F;

       return special_byte;
}
```

```
//Gets the readings from the speed and direction inputs and assembles
//byte1 to send the appropriate data to the boat
static unsigned char CreateNavByte(void)
{
        unsigned char speed_level;
        unsigned char direction_level;
        unsigned char byte1;

        //Read the sensors and store the values
        speed_level = GetSpeedLevel();
        direction_level = GetDirectionLevel();
        //Shift a nibble and put it in the byte
        byte1 = (direction_level << 4);
        //Add the lower nibble
        byte1 += speed_level;

    printf("    byte1: %h \r\n", byte1);
        return byte1;
}

//Returns a number between 0 and 15 (one nibble)
static unsigned char GetSpeedLevel(void)
{
        int temp;
        unsigned char level;

        temp = ADS12_ReadADPin(SPEED_PIN);

        //this should get us a number between 0 and 15
        level = temp/SPEED_CONVERSION + 1; //add one to correct for voltage levels

        //some test to make sure we are in the range
        if(level > 15)
                level = 15;
        if(level < 0)
                level = 0;

    printf("    speed level: %d \r\n", level);
        return level;
}

//Returns a number between 0 and 15 (one nibble)
static unsigned char GetDirectionLevel(void)
{
        int temp;
        unsigned char level;

        temp = ADS12_ReadADPin(DIRECTION_PIN);

        //this should get us a number between 0 and 15
        level = temp/DIRECTION_CONVERSION + 1; //add one to correct for voltage levels

        //some test to make sure we are in the range
        if(level > 15)
                level = 15;
        if(level < 0)
                level = 0;

    printf("    direction level: %d \r\n", level);
        return level;
}

//sets the goal servo to red, blue, or no team
static void SetBaseIndicator(unsigned char goal){
    if(goal == BASEA){
        SetServoPosition(8, ACTIVE_BASE_SERVO);
        printf("Setting base indicator servo to BASEA\r\n");
    }
    else if (goal == BASEB) {
        SetServoPosition(26, ACTIVE_BASE_SERVO);
```

```
        printf("Setting base indicator servo to BASEB\r\n");
    }
    else{ //no team
        SetServoPosition(17, ACTIVE_BASE_SERVO);
        printf("Setting base indicator servo to NONE\r\n");
    }
}

//sets the team indicator servo to the correct position, and zeros the other team's servo
static void SetTeamIndicator(unsigned char team){
    printf("Setting team indicator servo to team number: %d\r\n", team);
    if((team % 2) == 0){ //we are on the red team
        SetServoPosition(team, RED_BOAT_NUM_SERVO);
        SetServoPosition(0, BLUE_BOAT_NUM_SERVO);
    }
    else {  //we are on the blue team
        SetServoPosition(team, BLUE_BOAT_NUM_SERVO);
        SetServoPosition(0, RED_BOAT_NUM_SERVO);
    }
}

static unsigned char CheckResetState(void){
        if(PTT & BIT3HI) return TRUE;
        else return FALSE;
}

static unsigned char CheckSpec0State(void){
        if(PTT & BIT0HI) return TRUE;
        else return FALSE;
}

static unsigned char CheckSpec1State(void){
        if(PTT & BIT1HI) return TRUE;
        else return FALSE;
}

static unsigned char CheckWaterState(void){
        //check for a change in tilt switch position from disengaged to engaged
        unsigned char switchState;
        if((PTT & BIT2HI) == 0)
            switchState = 0; //the current state of the mustard switch
        else
            switchState = 1;

        if(waterState != switchState){
                //reset the timer for continuing spray
                TMRS12_InitTimer(TMR_MUSTARD_SHAKE, MUSTARD_SHAKE_TIME);
        waterState = switchState;
        }

        if(TMRS12_IsTimerExpired(TMR_MUSTARD_SHAKE) == TMRS12_EXPIRED)
            return FALSE; //do not spray
        return TRUE; //spray away
}


//-------------------TEST FUNCTIONS---------------//

//Tests the basic helm xbee transmitting functionality
#ifdef HELM_TEST
void main(void)
{
        unsigned char byte0;
        unsigned char byte1;
        unsigned char byte2;

        printf("Being Helm Test! \r\n");
        while(TRUE)
        {
                //This is blocking code so we only transmit at 5Hz
                Wait(SEND_RATE);
```

```
                printf("Time to transmit! \r\n");
                //Get all the data we need to send a packet
                byte0 = NAVIGATION; //for testing we are sending navigation commands
                byte1 = CreateNavByte();
                byte2 = CreateSpecialByte(); //for testing we don't need the special
actions byte

                //Send218Data(TO_PARTNER, byte0, byte1, byte2);
                Send218Data(TO_BROADCAST, byte0, byte1, byte2);
                printf("Transmission complete! \r\n");

        }
}

#endif

//tests to make sure the servos on the helm are pointing to the correct places
#ifdef HELM_SERVO_TEST
void main(void)
{
        char i;
        InitAll();
        //Cycle through variable pulse lengths
        while(TRUE)
        {
                printf("Testing base indicator servo\r\n");
                SetBaseIndicator(NOTEAM);
                Wait(1500);
                SetBaseIndicator(BASEA);
                Wait(1500);
                SetBaseIndicator(BASEB);
                Wait(1500);

                for(i=0; i<=12; i++)
                {
                    SetTeamIndicator(i);
                    Wait(2000);
                }
        }
}

#endif
```

helpers.h

```
#ifndef HELPERS
#define HELPERS

//Function Prototypes
//timer functions
void Wait(int ticks);
void SetTimer(unsigned char timer, int ticks);
unsigned char CheckTimerExpired(unsigned char timer);
unsigned char CheckSendTimer(void);

//other helper functions
void PrintDecAsBin(unsigned char decimal);
void TestDecToBin(void);
void dec2bin(unsigned char decimal, unsigned char *binary);

#endif
```

helpers.c

```
//------------ helpers.c -----------//
//-- code courtesey of BurgerStache -//
//----------------------------------//
```

```
#include "headers.h"

//Waits for a number of milliseconds given by ticks (blocking)
void Wait(int ticks){
        //uses timer 0 for blocking WAIT, which is one of 8 possible timers
        TMRS12_InitTimer(TMR_WAIT,ticks);
        while(TMRS12_IsTimerExpired(0) != TMRS12_EXPIRED);
}

//sets a timer to count down
//input the length of the timer in MS and the ID of the timer
void SetTimer(unsigned char timer, int ticks){
        printf("  Timer %d set with ticks = %d\r\n", timer, ticks);
        TMRS12_InitTimer(timer,ticks);
}

//returns true if 200ms have passed, so it is time to send
unsigned char CheckSendTimer(void){
        //Initialize if this is the first time calling this function
        if((TMRS12_IsTimerActive(TMR_SEND) == FALSE) || (TMRS12_IsTimerExpired(TMR_SEND)
== TMRS12_EXPIRED))
        {
                TMRS12_InitTimer(TMR_SEND,SEND_RATE);  //reset the timer if we are
returning true
                return TRUE;    //return true if 200ms has elapsed since last call
        }
        return FALSE;
}

//returns true if the given timer is expired
unsigned char CheckTimerExpired(unsigned char timer){
        unsigned char timex = (TMRS12_IsTimerExpired(timer) == TMRS12_EXPIRED);
        if(timex == TRUE){
                printf("  Timer %d expired\r\n", timer);
                TMRS12_ClearTimerExpired(timer); //clear the timer so we don't keep
creating events
        }
        return timex;
}

//prints a decimal number as a binary string
void PrintDecAsBin(unsigned char decimal){
        char binary[80];
        dec2bin(decimal,binary);
        printf("%s", binary);
}

//Test function for our decimal to binary printing function
void TestDecToBin(void)
{
        long decimal;
        char binary[80];
        printf("\r\n Enter an integer value : ");
        scanf("%ld",&decimal);
        dec2bin(decimal,binary);
        printf("\r\n The binary value of %ld is %s \r\n",decimal,binary);
        getchar(); // trap enter
        getchar(); // wait
}

// accepts a positive decimal integer and returns a binary coded string
void dec2bin(unsigned char decimal, char *binary)
{
        int k = 0, n = 0;
        int neg_flag = 0;
        int remain;
        char temp[80];

        do //parse the number, starting with the LSB
        {
                remain = decimal % 2;
```

```
                // whittle down the decimal number
                decimal = decimal / 2;
                // converts digit 0 or 1 to character '0' or '1'
                temp[k++] = remain + '0';
        } while (decimal > 0);

        //fill the remaining bits with zeros
        while(k<8)
        {
                temp[k++] = '0';
        }

        // reverse the spelling
        while (k > 0)
                binary[n++] = temp[--k];

        binary[n] = 0; // end with NULL
}
```

ibutton.h

```
//----------- ibutton.c ------------//
//-- code courtesy of WeinerMeister-//
//----------------------------------//

//ibutton.c asks for byte #2 from the ibutton to get the serial number

#include "headers.h"

//Function prototyes

//public
void InitSPI(int isMaster);
unsigned char ReadIbutton(void);
unsigned char GetStoredSerialLSB(void);
unsigned char GetStoredSerialMSB(void);
void EraseStoredSerial(void);


//private
unsigned char RequestIbutton(void);
static unsigned char SPITx(unsigned char Tx);
static unsigned char SPIRx(void);
static unsigned int ReceiveIbuttonByte(void);
```

ibutton.c

```
//----------- ibutton.c ------------//
//-- code courtesy of WeinerMeister-//
//----------------------------------//

//ibutton.c is responsible for interfacing with the ibutton and mangaging the team
affiliation data structure
//asks for byte #2 from the ibutton to get the serial number
//loooks up a table of serial numbers and corresponding team colors

#include "headers.h"

//global variables
extern unsigned char GMyTeam;

//module variables
unsigned char MySerialLSB = 0;
unsigned char MySerialMSB = 0;

unsigned char SerialDataLow = 0;
unsigned char SerialDataHigh = 0;
unsigned char NewSerialFlag = 0;

/////////////////////////////////////////
```

```
//           SPI FUNCTIONS                        //
////////////////////////////////////////

//Initialize SPI
void InitSPI(int isMaster)
{
        //Initialize the SPI system
        SPICR1 |= _S12_SPE;     //Enable SPI
        SPICR1 |= _S12_SPIE;    //Enable SPI Interrupt


        switch (isMaster)
        {
                case SET_TO_MASTER:
                        SPICR1 |= _S12_MSTR; //Make master
                        printf("SPI mode changed to MASTER \n\r");
                        break;
                case SET_TO_SLAVE:
                        SPICR1 &= ~_S12_MSTR; //Make slave
                        printf("SPI mode changed to SLAVE \n\r");
                        break;
                default:
                        printf("Error setting SPI mode! \n\r");
                        break;
        }

        //Setup commands for the SPI control register
        SPICR1 |= _S12_CPOL; //Clock polarity: active LOW
        SPICR1 |= _S12_CPHA; //Clock phase: sample EVEN edges
        SPICR1 |= _S12_SSOE; //Slave select output enable
        SPICR2 |= _S12_MODFEN; //Mode Fault Enable
        //SPICR1 |= _S12_SPIE; //slave: receive reg has new data
        //SPICR1 |= _S12_SPTIE; //master: Tx buffer is empty

        //Set the baud rate to 11kHz
        /****** Baud rate = 24MHz / ((SPPR+1)*2^(SPR+1))*****/
        SPIBR |= _S12_SPPR2 | _S12_SPPR1 | _S12_SPPR0; //7
        SPIBR |= _S12_SPR2 | _S12_SPR1 | _S12_SPR0;    //7

        EnableInterrupts;
}

//reads the serial number on the ibutton, which is the second byte
//if the serial number does exist in our table, set the team!
unsigned char ReadIbutton(void){

    //ignore first byte from the ibutton
    //receive the second byte and verify that it is a proper serial number
    //return the serial number if it is valid
    //also save this serial number as a module variable
    //MySerial = serial #
    //do a table lookup and set our team number accordingly
    GMyTeam = BLUE; //ex
    //return 0 if a bad serial number or no ibutton
    return 0;
}

//simply returns our stored serial number, returning zero if not affiliated with an
ibutton
unsigned char GetStoredSerialLSB(void){
  return MySerialLSB;
}

unsigned char GetStoredSerialMSB(void){
  return MySerialMSB;
}

//simply erases our stored serial number, replacing it with zero
void EraseStoredSerial(void){
  MySerialLSB = 0;
  MySerialMSB = 0;
```

```
}

//send character IBUTTON_RESET_BYTE to the ibutton, which signals the PIC to clear its
memory of which ibutton it met
static void ResetIbutton(void){
  //send a special code to the pic that signals it to clear its memory of past ibuttons
  SPITx(IBUTTON_RESET_BYTE);
}


//Transmits a character to the SPI data register, then procedes to transmit it
automatically
//Returns SUCCESS if transmitted successfully
//Returns FAILURE if another transfer is in progress
static unsigned char SPITx(unsigned char Tx){
        unsigned char dummy = 0; //dummy variable for reading SPISR. Simply by reading a
variable in, it is cleared.

        //printf("Ready, writing data...\n\r");
        //Transmit
        if((SPISR & _S12_SPTEF) == 0) //This line will fail if the slave is not
                return FAILURE;
        //clear the SPIF flag, which is the received data flag. May not be necessary
        dummy = SPISR;
    dummy = SPIDR;
        //clear the SPTEF flag and writes data to SPIDR
        dummy = SPISR;
        SPIDR = Tx;
        //printf("Done transmitting...\n\r");

        return SUCCESS;
}

//Returns a character that is received from the E128 SPI data register
static unsigned char SPIRx(void){
        unsigned char dummy = 0;
        unsigned char Rx; //data that is to be received

        //Receive
        //printf("Want to read from slave...\n\r");
        while( (SPISR & _S12_SPTEF) == 0); //BLOCKING CODE: will wait to receive data
        //while( (SPISR & _S12_SPIF) == 0); slave uses SPIF usually, master usues SPTEF
usually. But both are reset.

        //Clears the SPIF flag
        dummy = SPISR;
  dummy = SPIDR;

  //Clears SPTEF flag and transmits dummy data
  dummy = SPISR;
        SPIDR = 0; //transmits a zero
        while(!(SPISR & _S12_SPTEF)); //also blocking code. Necessary, but may split into
two functions for project.
        //while( (SPISR & _S12_SPIF) == 0);

        //Read what is received and return it in Rx
        dummy = SPISR;
  Rx = SPIDR;

  //printf("SPIRx sees: %d\n\r", Rx);
  return Rx;
}


unsigned char RequestIbutton(void)
{   // This sets PTP2 high to signal the PIC to read an iButton.
    // An ISR reads the data in when it is received.
    // When both bytes have been received and the NewSerialFlag is set
    // this function sets the received data into the MySerial variables
    // and returns TRUE.
```

```
  DDRP |= BIT2HI;
  PTP |= BIT2HI;

  if(NewSerialFlag) {
    PTP &= BIT2LO;
    MySerialLSB = SerialDataLow;
    MySerialMSB = SerialDataHigh;
    NewSerialFlag = 0;          //clear flag
    printf("Ibutton requested = %x %x \r\n", SerialDataHigh, SerialDataLow);

    return TRUE;
  }

  return FALSE;

}

/*// OLD, BLOCKING WAY TO receive IButton byte
static unsigned int ReceiveIbuttonByte(void)
{
  char dummy;

  PTP |= BIT2HI;

  while(!(SPISR & _S12_SPIF));           // BLOCKING CODE!!! ************
  dummy = SPISR;
  SerialDataLow = SPIDR;

  while(!(SPISR & _S12_SPIF));    // BLOCKING CODE!!! ************
  dummy = SPISR;
  SerialDataHigh = SPIDR;

  SerialDataHigh = ( SerialDataHigh << 8 ) + SerialDataLow;

  PTP &= BIT2LO;

  return SerialDataHigh;

}*/

void interrupt _Vec_spi ReadSPI (void)
{
    static unsigned char byte_number = 1;
    unsigned char status;
        unsigned char new_data;

        //THOU SHALT NOT USE PRINTF IN AN SPI INTERRUPT ROUTINE!!
        //printf("\n\rR");

        status = SPISR;
        new_data = SPIDR;             //Read data (this also clears the flag)

        if((byte_number == 1) && (NewSerialFlag != 1))              //
          {
              //printf("1\n\r"); //"D" = we have data
                  SerialDataLow = new_data;
                  byte_number = 2;
          }
         else if((byte_number == 2) && (NewSerialFlag != 1))        //
            {
              //printf("2\n\r"); //"D" = we have data
                  SerialDataHigh = new_data;
                  byte_number = 1;
                  NewSerialFlag = 1;
                 }
}  // End of SPI ISR


/*------------- TESTING FUNCTIONS -------------------*/
```

```
//the main function is used for testing only
#ifdef IBUTTON_SPI_TEST
void main(void)
{
	unsigned int iButton = 0;
	unsigned char dummy;

	printf("Beginning SPI test for E128!\n\r");

	//Initialize various functionalities
	InitSPI(SET_TO_SLAVE);

	//Init PP2 to output (to tell pic to send the serial number)
	DDRP |= BIT2HI;
	PTP &= BIT2LO;

	while(TRUE)
	{



		if(kbhit() != 0)
		{
			dummy = getchar(); //this makes it not go into a weird loop

			printf("Beginning to get iButton");
			while( !( RequestIbutton() ) );

			printf("Byte 1 is: %X \n\r", MySerialLSB);
			printf("Byte 2 is: %X \n\r", MySerialMSB);

		}
	}

	return;
}
#endif
```

main.h

```
#ifndef MAIN
#define MAIN

//Function prototypes
void InitAll(void);
void InitBoat(void);
void InitHelm(void);
unsigned char CheckSerialMatch(void);
void SimulateAdmiral(unsigned char KeyStroke);
void PrintState(int state, int event);
void SetTeam(unsigned char teamNum);

#endif
```

main.c

```
//----------- main.c ---------------//
//-- code courtesy of WeinerMeister-//
//----------------------------------//

#include "headers.h"

//global variables
unsigned char GMyTeam;

#ifdef HELM_MAIN
    unsigned char GWhoAmI = IAMHELM; //IAMHELM or IAMBOAT
#else
    unsigned char GWhoAmI = IAMBOAT; //IAMHELM or IAMBOAT
```

```
#endif


//module variables

#ifdef BOAT_MAIN
void main(void){
        //Initialize all variables
        InitAll();
        //start the master state machine initialization
        printf("Starting boat state machine\r\n");
        StartBoatSM();
        //check for and handle events
        while(TRUE){
                RunBoatSM(CheckBoatEvents());
        }
}
#endif

#ifdef HELM_MAIN
void main(void){
        //Initialize all variables
        InitAll();
        //start the master state machine initialization
        printf("Starting helm state machine\r\n");
        StartHelmSM();
        //check for and handle events
        while(TRUE){
                RunHelmSM(CheckHelmEvents());
        }
}
#endif

//InitAll does any initialization that is identical for the boat and the helm
//then it calls the specific boat and helm init procedures
void InitAll(void) {
        printf("\r\nWelcome to me.\r\n");
    printf("Initializing all.\r\n");

        //Initialize timer
        TMRS12_Init(TMRS12_RATE_1MS);

        //call inferior initialization functions
        InitSPI(SET_TO_SLAVE);
        InitSCI();//for xbee

        //Init PP2 to output (to tell pic to send the serial number)
        DDRP |= BIT2HI;
        PTP &= BIT2LO;

        //team affiliation
        GMyTeam = NOTEAM;

    //Check and print battery voltages
    //CheckBattVoltages();

    //Do specialized init procedures for boat and helm
    if(GWhoAmI == IAMBOAT){ //check the boat SM if we're a boat
      printf("I am the boat.\r\n");
      InitBoat();
    }else{      //I am a helm
      printf("I am the helm.\r\n");
      InitHelm();
    }
}

//Init boat ports, etc.
void InitBoat(void){
  printf("Initializing boat.\r\n");
  InitPWM();          //Initialize PWM for boat propellors
```

```
  //Set port directions
  DDRT = BOAT_PTT_INIT;
  DDRU = BOAT_PTU_INIT;

  //Set inital pin values
  PTT = 0;
  PTU = 0;

  //Set motors to begin at a stop
        Stop();
}

//Init helm ports, etc.
void InitHelm(void){
  printf("Initializing helm.\r\n");

  InitServoPWM(); //for silly helm dials

  //Set port directions
  DDRT = HELM_PTT_INIT;
  DDRU = HELM_PTU_INIT;

  //Set inital pin values
  PTT = 0;
  PTU = 0;

  //AD
  ADS12_Init(HELM_PTAD_INIT);

  //Initializes AD ports
    if(ADS12_Init(BOAT_PTAD_INIT) != ADS12_OK)
        printf("ERR: AD Initialization unsuccessful\r\n");

}

//compares the serial number incoming from the xbee and the ibutton serial
//if they are the same (and non-zero), then return TRUE
//call this only when you know that an ibutton has been read with RequestIbutton
unsigned char CheckSerialMatch(void){
      //return true if both bytes are matched and non-zero
      return ((GetXbeeByte1() == GetStoredSerialMSB())                              //MSB
it matched
              && (GetXbeeByte2() == GetStoredSerialLSB())                            //LSB
is matched
              && ((GetXbeeByte1() != 0) || (GetXbeeByte2() != 0))); //at least one byte
is non-zero
}

//sets our team affiliation and appropriate lights
void SetTeam(unsigned char teamNum){

    printf("Team number = %d\r\n",teamNum);
    //if we have a matched ibutton, then set our team affiliation
    if((teamNum %2) == 0){//even teams are BLUE
      printf("We're on the BLUE team\r\n");
      PTT |= BIT7HI;  //blue team on and red team off
      PTT &= BIT6LO;
      GMyTeam = BLUE;
    }
    else //odd teams are RED
    {
      printf("We're on the RED team\r\n");
      PTT |= BIT6HI;  //red team on and blue team off
      PTT &= BIT7LO;
      GMyTeam = RED;
    }
}

//takes a keystroke (numbers 1 through 8) and sends the corresponding admiral command to
our partner
void SimulateAdmiral(unsigned char KeyStroke){
```

```
        unsigned char sendByte = 0;
        switch(toupper(KeyStroke)){
                case '1' :
                    sendByte = STAND_DOWN;
                    printf("Admiral says to STAND_DOWN\r\n");
                    break;
                case '2' :
                    sendByte = START_GAME;
                    printf("Admiral says to START_GAME\r\n");
                    break;
                case '3' :
                    sendByte = END_GAME;
                    printf("Admiral says to END_GAME\r\n");
                    break;
                case '4' :
                    sendByte = BLUE_GOAL;
                    printf("Admiral says to BLUE_GOAL\r\n");
                    break;
                case '5' :
                    sendByte = RED_GOAL;
                    printf("Admiral says to RED_GOAL\r\n");
                    break;
                case '6' :
                    sendByte = SOFT_RESET;
                    printf("Admiral says to SOFT_RESET\r\n");
                    break;
                case '7' :
                    sendByte = HARD_RESET;
                    printf("Admiral says to HARD_RESET\r\n");
                    break;
                case '8' :
                    sendByte = ADMIRAL_PING;
                    printf("Admiral says to ADMIRAL_PING\r\n");
                    break;
    }
    //send an admiral command to our partner
    if(sendByte != 0)
        Send218Data(TO_PARTNER, ADMIRAL, 0x00, sendByte);
}

//------------ DEBUGGING FUNCTIONS -----------------//

void PrintState(int state, int event){

   printf("\r\n-----State Machine-----\r\n");
   printf("CurrentState = ");
   if(GWhoAmI == IAMBOAT){
       //boat
       switch(state) {
            case BST_WAITING_FOR_IBUTTON    : printf("BST_WAITING_FOR_IBUTTON"); break;
            case BST_LOOKING_FOR_HELM       : printf("BST_LOOKING_FOR_HELM"); break;
            case BST_PLAYING_GAME           : printf("BST_PLAYING_GAME"); break;
            case BST_STANDING_DOWN          : printf("BST_STANDING_DOWN"); break;
        }
   }
   else{
        //helm
        switch(state) {
            case HST_WAITING_FOR_IBUTTON    : printf("HST_WAITING_FOR_IBUTTON"); break;
            case HST_LOOKING_FOR_BOAT       : printf("HST_LOOKING_FOR_BOAT"); break;
            case HST_WAITING_FOR_GAME_START : printf("HST_WAITING_FOR_GAME_START");
break;
            case HST_PLAYING_GAME           : printf("HST_PLAYING_GAME"); break;
            case HST_CRUISING_POST_GAME     : printf("HST_CRUISING_POST_GAME"); break;
            case HST_STANDING_DOWN          : printf("HST_STANDING_DOWN"); break;
        }
   }
   printf("\r\nCurrentEvent = ");
    switch(event) {
        case EV_NO_EVENT    : printf("EV_NO_EVENT"); break;
        case EV_ENTRY       : printf("EV_ENTRY"); break;
```

```
        case EV_EXIT        : printf("EV_EXIT"); break;
        case EV_ERROR       : printf("EV_ERROR"); break;
        case EV_NO_ACTION   : printf("EV_NO_ACTION"); break;
        case EV_IBUTTON     : printf("EV_IBUTTON"); break;
        case EV_STAND_DOWN  : printf("EV_STAND_DOWN"); break;
        case EV_GAME_START  : printf("EV_GAME_START"); break;
        case EV_GAME_STOP   : printf("EV_GAME_STOP"); break;
        case EV_HARD_RESET  : printf("EV_HARD_RESET"); break;
        case EV_TMR_SEND    : printf("EV_TMR_SEND"); break;
        case EV_TMR_LOST_COMM: printf("EV_TMR_LOST_COMM"); break;
        case EV_MATCHED     : printf("EV_MATCHED"); break;
        case EV_PLAY_ON     : printf("EV_PLAY_ON"); break;
        case EV_NEXT        : printf("EV_NEXT"); break;
        case EV_NEW_XBEE    : printf("EV_NEW_XBEE"); break;

    }
    printf("\r\n");
}
```

motor.h

```
#ifndef MOTOR
#define MOTOR

//FUNCTION PROTOTYPES
// Public Function Prototypes
void InitPWM(void);
void SetMotor(char motorID, char direction, char duty);
void Stop(void); //stops both motors


#endif
```

motor.c

```
//----------- motor.c ---------------//
//-- code courtesy of WeinerMeister-//
//----------------------------------//

//motor.c contains any code that is specific to the boat, including propeller control

#include "headers.h"

//Initializes the PWM subystem on the E128
void InitPWM(void){
        //Initialize the clock
        PWMSCLA = POSTSCALER; //scale the A clock by / (3*2)
        PWMPRCLK |= 1; //use clock A with M/4 scalar (write to bit 1)

        //Initialize PWM for motor 1 (T0)
        PWME |= BIT0HI; //enable PWM on bit 0
        MODRR |= BIT0HI; //map T0 to PWM
        PWMCLK |= BIT0HI; //use SA (scaled clock)
        PWMPOL |= BIT0HI; //select the PWM polarity. 1 = output initially high
        PWMPER0 = MOTOR_PWM_PERIOD; //contains the count of the total number of cycles on
clock A or SA that will constitute the total period for PWM channel 0
        PWMDTY0 = DEFAULT_MOTOR_DUTY; //contains the count of the total number of cycles
on either clock A or SA that will constitute the active period for PWM channel 0

        //Initialize PWM for motor 2 (T1)
        PWME |= BIT1HI; //enable PWM on bit 1
        MODRR |= BIT1HI; //map T1 to PWM
        PWMCLK |= BIT1HI; //use SA (scaled clock)
        PWMPOL |= BIT1HI; //select the PWM polarity. 1 = output initially high
        PWMPER1 = MOTOR_PWM_PERIOD; //contains the count of the total number of cycles on
clock A or SA that will constitute the total period for PWM channel 0
        PWMDTY1 = DEFAULT_MOTOR_DUTY; //contains the count of the total number of cycles
on either clock A or SA that will constitute the active period for PWM channel 0
}
```

```
//Sets the duty cycle of the given motor and sets the direction output
//motorID = LEFT or RIGHT
//direction = FORWARD or BACKWARD
//duty = 0 to 100
void SetMotor(char motorID, char direction, char duty){
	//calculate the number of clock ticks to give powers to the motor
	unsigned int dutyTicks;
	dutyTicks = (MOTOR_PWM_PERIOD * duty)/100;

	//check to make sure the parameters are in bounds
	if(duty < 0 || duty > 100){
		printf("ERR: duty out of bounds in SetMotor \r\n");
		return; //failure
	}
	if(!((direction == FORWARD) || (direction == BACKWARD))){
		printf("ERR: direction must be forward or backward \r\n");
		return; //failure
	}
	if(!((motorID == R_MOTOR) || (motorID == L_MOTOR) || (motorID == BOTH_MOTORS))){
		printf("ERR: unknown motorID given \r\n");
		return; //failure
	}

	//Set the direction and PWM based on which motor and which direction are selcted
	if((motorID == L_MOTOR)||(motorID == BOTH_MOTORS)){
		if(direction == FORWARD){
			PTT |= BIT5HI; //set direction pin output
		    PWMDTY1 = (char)(MOTOR_PWM_PERIOD-dutyTicks); //set motor PWM
registers as prescribed by the PWM subsystem. Invert duty when direction pin is high.
			//printf("I'm setting left motor duty to: %d  (INVERSE)
\n\r",dutyTicks);
		}else{
			PTT &= BIT5LO;
			PWMDTY1 = (char)dutyTicks;
			//printf("I'm setting left motor duty to: %d \n\r",dutyTicks);
		}
	}
	if((motorID == R_MOTOR) || (motorID == BOTH_MOTORS)){
		//set direction pin output
		if(direction == FORWARD){
			PTT |= BIT4HI;
		    PWMDTY0 = (char)(MOTOR_PWM_PERIOD-dutyTicks); //set motor PWM
registers as prescribed by the PWM subsystem. Invert duty when direction pin is high.
			//printf("I'm setting right motor duty to: %d  (INVERSE)
\n\r",dutyTicks);
		}else{
			PTT &= BIT4LO;
			PWMDTY0 = (char)dutyTicks;
			//printf("I'm setting right motor duty to: %d \n\r",dutyTicks);
		}
	}
}

//stop the boat in its tracks
void Stop(void){
	//printf("   Now stopping\r\n");
	SetMotor(BOTH_MOTORS, FORWARD, 0);
}
```

servo.h

```
#ifndef SERVO
#define SERVO

//FUNCTION PROTOTYPES
void InitServoPWM(void);
void SetServoPosition(char position, char servo_id);

#endif SERVO
```

servo.c

```
//----------- servo.c -------------//
//-- code courtesy of BurgerStache --//
//-------------------////-----------//

//Standard Libraries
#include "headers.h"

//Initializes the PWM subystem for servos on the HELM
void InitServoPWM(void)
{
        //Initialize the clock
        PWMSCLA = POSTSCALER_A; //scale the A clock by / (2*75)
        PWMPRCLK |= 0x04;             //use clock A with M/16 scalar

        //Initialize PWM for servo
        PWME |= (BIT0HI | BIT1HI | BIT4HI);  //enable PWM on bits 0, 1, 4
        MODRR |= (BIT0HI | BIT1HI | BIT4HI); //map PWM to port U on 0, 1, 4
        PWMCLK |= (BIT0HI | BIT1HI | BIT4HI);        //use SA (scaled clock)
        PWMPOL |= (BIT0HI | BIT1HI | BIT4HI);        //select the PWM polarity. 1 = output
initially high
        PWMCAE |= (BIT0HI | BIT1HI | BIT4HI);        //center align the PWM signal
        //Set the period for all three PWM channels
        PWMPER0 = SERVO_PWM_PERIOD;
        PWMPER1 = SERVO_PWM_PERIOD;
        PWMPER4 = SERVO_PWM_PERIOD;
        //Set the initial duty cycle for all three PWM channels
        PWMDTY0 = SERVO_INIT_DUTY;
        PWMDTY1 = SERVO_INIT_DUTY;
        PWMDTY4 = SERVO_INIT_DUTY;    //contains the count of the total number of cycles
on either clock A or SA that will constitute the active period for PWM channel 0
}

//Public function to allow servos to be positioned to a positions 0 through 19
void SetServoPosition(char team, char servo_id)
{
  char position;

  //Scale the position input to a duty cycle and check to make sure it is not too high
  if(servo_id == ACTIVE_BASE_SERVO)
        position = team;
  else if(servo_id == RED_BOAT_NUM_SERVO)
    switch(team) {
        case 0:
              position =  5;
        break;

        case 12:
                 position =  9;
        break;

        case 10:
                 position =  13;
        break;

        case 8:
                 position =  17;
        break;

        case 6:
                 position =  21;
        break;

        case 4:
                 position =  24;
        break;

        case 2:
                 position =  27;
        break;
```

```
    }
    else if(servo_id == BLUE_BOAT_NUM_SERVO)
    switch(team) {
        case 11:
              position =  6;
        break;

        case 9:
                 position =  9;
        break;

        case 7:
                 position =  12;
        break;

        case 5:
                 position =  15;
        break;

        case 3:
                 position =  19;
        break;

        case 1:
                 position =  22;
        break;

        case 0:
                 position =  26;
        break;
    }

  if(position > SERVO_MAX_DUTY)
    position = SERVO_MAX_DUTY;

  printf("Setting servo id %d to position %d, team %d\r\n", servo_id, position, team);

  //Update the appropriate PWM duty
  if(servo_id == BLUE_BOAT_NUM_SERVO)
    PWMDTY0 = position;
  if(servo_id == RED_BOAT_NUM_SERVO)
    PWMDTY1 = position;
  if(servo_id == ACTIVE_BASE_SERVO)
    PWMDTY4 = position;
}

//------------------Test Routine----------------------//
#ifdef SERVO_TEST

void main(void)
{
        char i;
        InitAll();

        //Cycle through variable pulse lengths
        while(TRUE)
        {

                for(i=0; i<30; i++)
                {
                        //SetServoPosition(i, ACTIVE_BASE_SERVO);
                        //SetServoPosition(i, RED_BOAT_NUM_SERVO);
                        SetServoPosition(i, BLUE_BOAT_NUM_SERVO);
                        printf("Position: %d \r\n", i);
                        Wait(1000);
                }
        }
}

#endif
```

xbee.h

```
#ifndef xbee
#define xbee

// Function Prototypes
//public functions
void InitSCI (void);
void Send218Data(unsigned char destination, unsigned char byte0, unsigned char byte1,
unsigned char byte2);
unsigned char CheckXbeeRX(void);
unsigned char GetXbeeByte0(void);
unsigned char GetXbeeByte1(void);
unsigned char GetXbeeByte2(void);
unsigned char GetTeamNumber(void);
void ImprintPartner(void);
void SimulateIbutton(unsigned char us);

//private functions
static void CheckPingBack(void);
static void ResetChecksum(void);
static unsigned char GetChecksum(void);
static void SendData(unsigned char data);
static void ProcessNewData(void);

#endif
```

xbee.c

```
// xBee preliminary testing
//
// Team Burgerstache
// Created May 7, 2008
//

#include "headers.h"

//global variables
extern unsigned char GWhoAmI;

//module variables
static unsigned char CheckSum;
static unsigned char RXDataBuffer[XBEE_MESSAGE_SIZE]; //12 bytes to match 218 comm
standard, plus one extra for good luck
static unsigned char RXDataBufferIndex = 0;
static unsigned char RXFlag = FALSE;

static unsigned char RXSourceMSB = 0;  //Byte 5
static unsigned char RXSourceLSB = 0;  //Byte 6

static unsigned char RXbyte0 = 0;  //Byte 9
static unsigned char RXbyte1 = 0;  //Byte 10
static unsigned char RXbyte2 = 0;  //Byte 11

static unsigned char MyPartnerDestMSB = 0x00;
static unsigned char MyPartnerDestLSB = 0x00;

/*
//Q: what if packets are dropped? Are we getting them in order? WTF?
*/

// Initialization
void InitSCI (void)
{
        printf("Initializing SCI.\r\n");
        // CONFIGURE SCI
        SCI1BDH = 0x00;                // write SCI1BDH - want it to be 0
        SCI1BDL = BAUD_BITS;   // write SCI1BDL - this is 156
        SCI1CR1 = 0x00;                // write SCI1CR1 - clear register (all zeros) for
proper config
```

```
        SCI1CR2 |= BIT5HI;              // bit 5 for receive interrupt
        SCI1CR2 |= BIT3HI | BIT2HI;          // bit 2 and 3 for tx/rx enable
        SCI1CR2 |= BIT4HI;                    // bit 4 for idle line interrupt

   //Port S
        DDRS &= BIT2LO;  //Input
    DDRS |= BIT3HI;    // Output... not sure if we need this and should do a master
initialize elsewhere

        // INTERRUPTS
        EnableInterrupts;
}

//Polling function that checks the xbee for new data
//if there is new data, it is processed and put into module variables
//returns true if new data was intercepted, false otherwise
unsigned char CheckXbeeRX(void) {
   //printf("Checking for xbee data...\r\n");
   if(RXFlag == TRUE)
   {
      RXFlag = FALSE;
      ProcessNewData(); //put data into module variables and print them out
      CheckPingBack(); //ping the admiral back if we need to do so

      //printf("Data arrival on xbee complete.\r\n");
      return TRUE;
   }
   else
              //printf("        No new data received! \n\r");

         return FALSE;
}

//if the admiral pings us, ping it back
static void CheckPingBack(void){
  unsigned char byte0, byte1, byte2;
  //CHECK FOR SIGNEDNESS!!!!!!!
  /*
  printf("Checking to see if we should ping back to admiral... \r\n");
  printf("RXbyte0 = %d \r\n",RXbyte0);
  printf("ADMIRAL = %d \r\n",ADMIRAL);
  printf("RXbyte2 = %d \r\n",RXbyte2);
  printf("ADMIRAL_PING = %d \r\n",ADMIRAL_PING);
  */
  if((RXbyte0 == ADMIRAL) && (RXbyte2 == ADMIRAL_PING)){

    byte0 = PING_RESPONSE;
    if(GWhoAmI == IAMBOAT){ //check the boat SM if we're a boat
      if(QueryBoatSM() == BST_WAITING_FOR_IBUTTON)
        byte1 = 0x01; //if waiting for iButton
      else if(QueryBoatSM() == BST_LOOKING_FOR_HELM)
        byte1 =       0x02; // if iButton read and waiting for pairing
      else
        byte1 = 0x04; //if paired
    }else{      //I am a helm
      if(QueryHelmSM() == HST_WAITING_FOR_IBUTTON)
        byte1 = 0x01; //if waiting for iButton
      else if(QueryHelmSM() == HST_LOOKING_FOR_BOAT)
        byte1 =       0x02; // if iButton read and waiting for pairing
      else
        byte1 = 0x04; //if paired
    }
    byte2 = MyPartnerDestLSB; //default is 0x00

    printf("Sending admiral response to ping \r\n");
    Send218Data(TO_ADMIRAL,byte0, byte1, byte2); //do the pingback!
  }
}

//update partner because we did the ibutton dance
//the source of the last message we processed is now our partner
```

```
void ImprintPartner(void){
  printf("Imprint Partner \r\n");
  MyPartnerDestMSB = RXSourceMSB;
  MyPartnerDestLSB = RXSourceLSB;
}

//returns the team number, which is based on the lower nibble of the boat's address
//returns 0 if the team is not yet chosen (partner not yet imprinted)
unsigned char GetTeamNumber(void){
    return MyPartnerDestLSB;
}

//simulates an ibutton read, pairing us with our own helm (or boat)
void SimulateIbutton(unsigned char us) {
    printf("Simulate Ibutton \r\n");
    if(us == IAMBOAT) {
          MyPartnerDestMSB = 0xBC;
          MyPartnerDestLSB = 0x04;
    }else{  //we are helm
          MyPartnerDestMSB = 0xAF;
          MyPartnerDestLSB = 0x04;
    }
}

//header
unsigned char GetXbeeByte0(void){
  return RXbyte0;
}

//nav
unsigned char GetXbeeByte1(void){
  return RXbyte1;
}

//parameters
unsigned char GetXbeeByte2(void){
  return RXbyte2;
}

//Transmit command
//header, navigation, special
//If broadcast is true send a broadcast, otherwise send it to our partner
void Send218Data(unsigned char destination, unsigned char byte0, unsigned char byte1,
unsigned char byte2){
    unsigned char destMSB, destLSB;
    unsigned char checksum;
    unsigned char options = 0x00;

    printf("Sending data...\r\n");
    //send the damn data
    SendData(START_BYTE); //start delimiter
    SendData(LENGTH_MSB); //length MSB
    SendData(LENGTH_LSB); //length LSB
    ResetChecksum();
    SendData(API_TX); //API identifier (TX request 16-bit)
    SendData(FRAME_ID); //Frame ID
    //send destination bytes according to desired dest type
    if(destination == TO_BROADCAST){
      destMSB=0xFF; //Destination address
      destLSB=0xFF;
    }
    else if (destination == TO_ADMIRAL){
      destMSB=ADMIRAL_ADDRESS_MSB;
      destLSB=ADMIRAL_ADDRESS_LSB;
    }
    else {
      destMSB=MyPartnerDestMSB;
      destLSB=MyPartnerDestLSB;
    }
    //send destination data
    SendData(destMSB);
```

```
    SendData(destLSB);

    SendData(options);     //options (was 0x01 for testing), it is now initialized as a
variable above
    SendData(byte0);    //output data 1
    SendData(byte1);    //output data 2
    SendData(byte2);    //output data 3

    checksum = GetChecksum();
    SendData(checksum);  //checksum

    //print the data
    printf("Sending byte 1: %x   Start Byte \r\n", START_BYTE);
    printf("Sending byte 2: %x   Length MSB \r\n", LENGTH_MSB);
    printf("Sending byte 3: %x   Length LSB \r\n", LENGTH_LSB);
    printf("Sending byte 4: %x   API_TX \r\n", API_TX);
    printf("Sending byte 5: %x   FRAME_ID \r\n", FRAME_ID);
    printf("Sending byte 6: %x   Dest MSB \r\n", destMSB);
    printf("Sending byte 7: %x   Dest LSB \r\n", destLSB);
    printf("Sending byte 8: %x   Options \r\n", options);
    printf("Sending byte 9: %x   Data Byte 0 \r\n", byte0);
    printf("Sending byte 10: %x   Data Byte 1 \r\n", byte1);
    printf("Sending byte 11: %x   Data Byte 2 \r\n", byte2);
    printf("Sending byte 12: %x   Checksum \r\n", checksum);

    printf("Sending complete.\r\n");
}

// Interrupt routine for when we get new data
//   take packets from the xbee and save them into an array
//   then sets a flag high that tells us there is new xbee data available for processing
void interrupt _Vec_sci1 ReadData (void)
{
      unsigned char status;
          unsigned char new_data;

          //printf("R");

          status = SCI1SR1;
          new_data = SCI1DRL;         //Read data (this also clears the flag)

          if(status & BIT5HI)         //Check RDRF to see if we have good data
          {
              //printf("D"); //"D" = we have data
                   // Process new data by putting it into the buffer array
                   RXDataBuffer[RXDataBufferIndex] = new_data;
                   RXDataBufferIndex++;

                   if(RXDataBufferIndex >= (XBEE_MESSAGE_SIZE))
                   {
                     RXDataBufferIndex = 0; //reset index
                     RXFlag = TRUE; //we have new data!
                     //printf("F\n\r"); //"F" = buffer is full
                   }

                }


        if(status & BIT4HI)      //reset the index if there is an idle
          {
               //printf("I"); //"I" = line is idle
                  RXDataBufferIndex = 0; //reset index
          }
}

// process new data
static void ProcessNewData(void)
{
       unsigned char index = 0;
       unsigned char binary[9];
```

```
        //printf("Processing message now... \r\n");

        //Store the values of the important bytes in module variables
        RXSourceMSB = RXDataBuffer[4];
        RXSourceLSB = RXDataBuffer[5];

        RXbyte0 = RXDataBuffer[8];
        RXbyte1 = RXDataBuffer[9];
        RXbyte2 = RXDataBuffer[10];

/*
        //Prints out any data that arrives
        while(index < XBEE_MESSAGE_SIZE)
        {
          //dec2bin(RXDataBuffer[index],binary); //convert the data to binary for
debugging
          printf("Processing byte %d: %x    ", (index + 1), (RXDataBuffer[index]));
          switch(index+1){ //switch based on what byte we read
            case 1: printf("Start Delimiter"); break;
            case 2: printf("Length MSB"); break;
            case 3: printf("Length LSB"); break;
            case 4: printf("API Identifier"); break;
            case 5: printf("Source Addr MSB"); break;
            case 6: printf("Source Addr LSB"); break;
            case 7: printf("Signal strength"); break;
            case 8: printf("Options"); break;
            case 9: printf("Data Byte 0 - Header"); break;
            case 10: printf("Data Byte 1"); break;
            case 11: printf("Data Byte 2"); break;
            case 12: printf("Checksum"); break;
          }

          printf("\r\n");

          index++;
        }

        printf("Processing complete! \r\n");
*/
}

// Sends a byte of data over SCI
static void SendData(unsigned char data)
{
        //char binary[80];
        unsigned char dummy = 0;
        //dec2bin(data,binary); //convert the data to binary for debugging

        while((SCI1SR1 &= BIT6HI) == 0); //TC = transmit complete (stall until this is 1)
          //do nada

        dummy = SCI1SR1; //clears TDRE by reading sci
        SCI1DRL = data;         //actually sends

        //add data to our checksum
        CheckSum += data;

        //print out the data we're sending (in binary)
        //printf("Sending data: %s \r\n", binary);

}

//this function resets our checksum
static void ResetChecksum(void){
    CheckSum = 0;
}

//get the current checksum value, and print it
static unsigned char GetChecksum(void){
    unsigned char FinalCheckSum;
    FinalCheckSum = (0xFF - CheckSum);
```

```
    //printf("FinalCheckSum = %x\r\n", FinalCheckSum);
    return FinalCheckSum;
}

//--------- TEST CODE -------------

//checks for key presses, then broadcasts a message (different depending on key= s or b)
//uses interrupt-driven read, which is processed when 'r' is pressed
#ifdef XBEE_TEST
void main (void)
{
        unsigned char keyInput;

        printf("XBee Test Code! (press any key to cont) \r\n");
        printf("press 's' to send, 'r' to receive \r\n");

   //Initialize all of our ports and SCI registers
   InitAll();

   while(TRUE){
       if(kbhit() != 0){
               keyInput = getchar(); //this makes it not go into a weird loop

               //send test
               if(keyInput == 's')
                       Send218Data(TO_BROADCAST, 0xAA, 0xAA, 0xAA);
               if(keyInput == 'b')
                       Send218Data(TO_BROADCAST, 0xBB, 0xBB, 0xBB);
               //receive test
               if(keyInput == 'r')
                       CheckXbeeRX();
       }

                  //printf("still looping\r\n");
   }
}
#endif
```

helpers.h

```
#ifndef HELPERS
#define HELPERS

//Function Prototypes
//timer functions
void Wait(int ticks);
void SetTimer(unsigned char timer, int ticks);
unsigned char CheckTimerExpired(unsigned char timer);
unsigned char CheckSendTimer(void);

//other helper functions
void PrintDecAsBin(unsigned char decimal);
void TestDecToBin(void);
void dec2bin(unsigned char decimal, unsigned char *binary);

#endif
```

PIC Code

ibutton.asm

```
; ME218C Project - iButton Code

; Adam Leeper

; 5/08/08

; GENERAL DESCRIPTION:

; this code reads the iButton, communicates its value
```

```
; to the HC12, and also controls the iButton reader's

; LED light and a buzzer which sounds to indicate a successful

; read.  Error checking takes place in the HC12.


; admininstrative stuff:

       list P=PIC16F690
        #include "p16F690.inc"
        __config (_CP_OFF & _WDT_OFF & _PWRTE_ON & _HS_OSC)


; variable definitions:

DCount          EQU    0x2D
ACount          EQU    0x2F
TCount          EQU    0x2C
BitVal          EQU    0x2E
TempByte        EQU    0x20
Byte1           EQU    0x21
Byte2           EQU    0x22
Byte3           EQU    0x23
Byte4           EQU    0x24
Byte5           EQU    0x25
Byte6           EQU    0x26
Byte7           EQU    0x27
Byte8           EQU    0x28


; port definitions:
EnablePort      EQU     PORTC
EnablePin       EQU     0 ; signal from the Master that an iButton should be read

ButtonPort      EQU     PORTA
ButtonPin       EQU     0 ; the open-drain port used for the iButton reader
Carry           EQU     0

ClockPort       EQU     PORTC ; the clock pin for the synchronous communiction
ClockPin        EQU     1 ; of iButton data to the HC12

InfoPort        EQU     PORTC ; the info pin for the same...
InfoPin         EQU     2

LEDPort         EQU     PORTA ; controls the reader's LED
LEDPin          EQU     2
LEDSink          EQU     1

BuzzPort        EQU     PORTC ; controls a buzzer
BuzzPin         EQU     4

ConfigA                 equ            b'11111000'    ; Config RA0 as output
ConfigB                 equ            b'11111111'    ; Config placeholder
ConfigC                 equ            b'11111001'    ; Config RC1-RC4 as outputs

SDI              equ     4         ; SDI
SCK              equ     6         ; SCK
SS               equ     6         ; SS
SDO              equ     7         ; SDO

#define     iButton     ButtonPort,ButtonPin
#define     iLED        LEDPort,LEDPin
#define     LED_ON      BSF iLED
#define     LED_OFF     BCF iLED
#define     SS_LOW      BCF PORTC,SS
#define     SS_HIGH     BSF PORTC,SS


       ORG             0
```

```
       GOTO    Main
       ORG     5

Main:
                              CLRF    PORTA
                              CLRF    PORTB
                              CLRF    PORTC

                       ; Set up pins for Tx/Rx...
                CALL    Bank2           ; move to Bank2, for ANSEL
                CLRF    ANSEL           ; set all pins to digital
                CLRF    ANSELH          ; set all pins to digital

                ; Set up pins for Input/ Output
                BANKSEL TRISA           ; move to Bank1, for TRIS
                MOVLW   ConfigA         ; load ConfigA
                MOVWF   TRISA           ; Write PortA I/O
                              MOVLW   ConfigB                 ; load ConfigB
                              MOVWF   TRISB                   ; Write PortB I/O
                MOVLW   ConfigC         ; load ConfigC
                MOVWF   TRISC           ; Write PortC I/O

                ; Initialize timer
                CALL    Bank0           ; move to Bank 0 for Timer1 stuff
                CLRF    T1CON           ; Clear all timer 1 settings
                CLRF    TMR1H           ;       Clear timer1 high byte
                CLRF    TMR1L           ;       Clear timer1 low byte
                BCF     T1CON,T1CKPS1   ; set prescaler to 1:8
                BCF     T1CON,T1CKPS0   ; ''
                BSF     T1CON,TMR1ON    ; turn on timer 1, starts to increment
                              MOVLW   b'00001000'             ; Set output compare to
software interrupt
                              MOVWF   CCP1CON

                ; Initialize SSP
                BANKSEL SSPSTAT         ; Bank 1
                CLRF    SSPSTAT         ; SMP = 0, CKE = 0, and clear status bits
                BANKSEL SSPCON
                MOVLW   b'00110010'     ; Set up SPI port, Master mode, Fosc/64,
                MOVWF   SSPCON          ; Write it to register
                BSF     PORTC,SDO
                NOP
                BSF     PORTB,SCK
                NOP
                BSF     PORTC,SS
                BANKSEL TRISC
                BSF     TRISB,4         ; SDI
                BCF     TRISB,6         ; SCK
                BCF     TRISC,6         ; SS
                BCF     TRISC,7         ; SDO

                CALL    Bank0           ; move to Bank0, ready to go
                CLRF    Byte2
                CLRF    Byte3

Start:
               BTFSS   EnablePort,EnablePin   ; we wait until the HC12 says it
        GOTO    Start                              ; wants to read an iButton...

Reset_State:
        ;MOVF    SSPBUF,W    ; Read SSPBUF to avoid setting overflow flag
        ;MOVF    Byte2,W     ; For ME218, we care about Byte 2 and Byte 3
        ;MOVWF   SSPBUF

        LED_ON
        CALL    Wait750ms   ;
        LED_OFF
        CALL    Wait750ms   ;

        CALL    Wait490
        CALL    SetOUT
```

```
        BCF     iButton                 ; pulse line low
        CALL   Wait490                 ; wait for 500us
        CALL    SetIN                   ; float line
        BSF     iButton
        CALL            Wait50                  ; wait for iButton to respond with presence
        BTFSC           iButton                   ; the line is pulled low here if
        CLRF            ACount                              ; an iButton is present.
However, since the mechanical
        INCF            ACount,F                            ; bounce of the contact lasts
for a while, I make sure
        CALL            Wait490                             ; that 20 consecutive
presence pulses have been seen
        MOVLW           0xFD                                ; before moving on!
        ADDWF           ACount,W
        BTFSS           STATUS,Carry
        GOTO            Start

Send_Reset:
        BSF     iButton
        CALL    SetOUT
        CALL    Wait490
        CALL    Wait490
        BCF     iButton
        CALL    Wait490
        BSF     iButton
        CALL    Wait490

Send0x33:
        CALL    SetOUT
        CALL   Write1      ; this is the command to ask for the iButton's
        CALL            Write1      ; unique ID number
        CALL            Write0
        CALL            Write0
        CALL            Write1
        CALL            Write1
        CALL            Write0
        CALL            Write0
        CALL            Wait490

Get8Bytes: ;getting the 8 bytes...
        CALL            GetByte ;
        MOVWF           Byte1       ; Family Code Byte
        CALL            GetByte
        MOVWF           Byte2       ; SS Byte 1
        CALL            GetByte
        MOVWF           Byte3       ; SS Byte 2
        CALL            GetByte
        MOVWF           Byte4       ; SS Byte 3
        CALL            GetByte
        MOVWF           Byte5       ; SS Byte 4
        CALL            GetByte
        MOVWF           Byte6       ; SS Byte 5
        CALL            GetByte
        MOVWF           Byte7       ; SS Byte 6
        CALL            GetByte
        MOVWF           Byte8       ; CRC Byte

Send8Bytes:
        BANKSEL SSPSTAT
        BCF     SSPSTAT,BF
        BANKSEL PORTA

        SS_LOW
        MOVF    SSPBUF,W    ; Read SSPBUF to avoid setting overflow flag
        MOVF    Byte2,W     ; For ME218, we care about Byte 2
        MOVWF   SSPBUF
        BANKSEL SSPSTAT
Xmit_Loop2:
        BTFSS   SSPSTAT,BF
        GOTO    Xmit_Loop2
        BANKSEL PORTA
```

```
        SS_HIGH

        CALL    Wait70
        SS_LOW
        MOVF    SSPBUF,W    ; Read SSPBUF to avoid setting overflow flag
        MOVF    Byte3,W     ; For ME218, we care about Byte 3 also
        MOVWF   SSPBUF
        BANKSEL SSPSTAT
Xmit_Loop3:
        BTFSS   SSPSTAT,BF
        GOTO    Xmit_Loop3
        BANKSEL PORTA
        SS_HIGH

        ; The old janky way to do it
        MOVF          Byte1,W        ; sending the 8 bytes to the HC12...
        CALL          SendByte
        MOVF          Byte2,W
        CALL          SendByte
        MOVF          Byte3,W
        CALL          SendByte
        MOVF          Byte4,W
        CALL          SendByte
        MOVF          Byte5,W
        CALL          SendByte
        MOVF          Byte6,W
        CALL          SendByte
        MOVF          Byte7,W
        CALL          SendByte
        MOVF          Byte8,W
        CALL          SendByte

Finish:
        CALL          Wait750ms ; at the end, we give the HC12 some time to think
        CALL          Wait750ms ; and then see if it still needs an ibutton read
        CALL          Wait750ms
        CALL          Wait750ms
        ;CALL         Wait490
        GOTO          Start


; ************************************************************

SendByte: ; starting with a byte in the W register
       MOVWF   TempByte       ; we store that value in "TempByte"
       MOVLW   0x08
       MOVWF   ACount
SendLoop: ; we loop the following 8 times:
       BTFSS   TempByte,0                          ; we set the info line to follow the
       BCF     InfoPort,InfoPin             ; value of the LSB of TempByte
       BTFSC   TempByte,0
       BSF     InfoPort,InfoPin
       CALL    Wait5                               ; we wait a little
       BSF     ClockPort,ClockPin           ; and pulse the clock, signalling the
       Call    Wait50                              ; HC12 to read
       BCF     ClockPort,ClockPin
       Call    Wait5
       RRF     TempByte,1                          ; we then rotate the file to the
right,
       DECFSZ  ACount,1                            ; placing the next bit in the LSB
spot
       GOTO    SendLoop                            ; and repeat!
       RETURN

; ************************************************************
GetByte:
        LED_ON
        MOVLW             0x08
        MOVWF             ACount
        CLRF              TempByte
ByteLoop:          ; we loop the following 8 times:
```

```
        RRF                 TempByte,F      ; we rotate our result regester to the left
        CALL                RW1             ; call the read function, which sets "BitVal"
        BTFSC               BitVal,0        ; then read BitVal and change the MSB
        BSF         TempByte,7      ; of TempByte accordingly.
        DECFSZ              ACount,F
        GOTO                ByteLoop        ; and do it again!
        MOVF                TempByte,W
        LED_OFF
        RETURN
; ***********************************************************

Write0: ; writing zero is just a long low followed by a short hi:
        BCF     iButton
        CALL    SetOUT
        CALL            Wait50
        CALL            SetIN
        CALL            Wait25
        RETURN

Write1: ; writing one is a short low followed by a long hi:
        BCF             iButton
        CALL    SetOUT
        CALL            Wait5
        CALL    SetIN
        CALL            Wait70
        RETURN

RW1: ; reading a bit looks like writing a 1, but checking
        CLRF            BitVal
        BCF             iButton
        CALL    SetOUT
        ;LED_ON
        CALL    Wait5
        CALL    SetIN
        CALL    Wait5
        BTFSC   iButton
        BSF             BitVal,0
        ;LED_OFF
        CALL    Wait50
        CALL    Wait5
       RETURN

; ******************************************
; Bank*
; These routines set the STATUS register with the
; correct bits to move to the desired bank.
;******************************************
Bank0:          ; Sets RP1,RP0 = 0,0 so we move to Bank0
                BCF     STATUS,RP1
                BCF     STATUS,RP0
                RETURN

Bank1:          ; Sets RP1,RP0 = 0,1 so we move to Bank1
                BCF     STATUS,RP1
                BSF     STATUS,RP0
                RETURN

Bank2:          ; Sets RP1,RP0 = 1,0 so we move to Bank2
                BSF     STATUS,RP1
                BCF     STATUS,RP0
                RETURN

Bank3:          ; Sets RP1,RP0 = 1,1 so we move to Bank3
                BSF     STATUS,RP1
                BSF     STATUS,RP0
                RETURN
                ; End of Bank setting functions
;*********************************************

SetIN:
                              BANKSEL TRISA
```

```
                BSF         TRISA,ButtonPin
        BANKSEL PORTA
                RETURN

SetOUT:
                BANKSEL TRISA
                BCF         TRISA,ButtonPin
        BANKSEL PORTA
                RETURN

; *************************************

Wait750ms:
                BANKSEL T1CON           ; move to Bank 0 for Timer1 stuff
        MOVLW   0x10
        MOVWF   TCount
        MOVLW   0xFF
                MOVWF   CCPR1H
                MOVLW   0xFF
                MOVWF   CCPR1L

        CLRF    T1CON           ; Clear all timer 1 settings
        CLRF    TMR1H           ;       Clear timer1 high byte
        CLRF    TMR1L           ;       Clear timer1 low byte
        BSF     T1CON,TMR1ON    ; turn on timer 1, starts to increment

Timer_Loop      ;BTFSS   PIR1,TMR1IF       ; Check timer overflow flag
                BTFSS   PIR1,CCP1IF           ; Check for output compare
flag
        GOTO    Timer_Loop       ; Loops until the timer compares
        BCF     PIR1,CCP1IF     ; Reset timer1 CCP flag
        DECFSZ  TCount,F        ;
        GOTO    Timer_Loop      ; Loops until the timer compares 50 times
                CLRF    T1CON                 ; Turn off timer1
                RETURN

; ***************************************
Wait490:
                BANKSEL T1CON           ; move to Bank 0 for Timer1 stuff
                MOVLW   0x09
                MOVWF   CCPR1H
                MOVLW   0xC4
                MOVWF   CCPR1L

        CLRF    T1CON           ; Clear all timer 1 settings
        CLRF    TMR1H           ;       Clear timer1 high byte
        CLRF    TMR1L           ;       Clear timer1 low byte
        BSF     T1CON,TMR1ON    ; turn on timer 1, starts to increment

Loop490        ;BTFSS   PIR1,TMR1IF       ; Check timer overflow flag
                BTFSS   PIR1,CCP1IF           ; Check for output compare
flag
        GOTO    Loop490              ; Loops until the timer compares
        BCF     PIR1,CCP1IF     ; Reset timer1 CCP flag
                CLRF    T1CON                 ; Turn off timer1
                RETURN

; **************************************
Wait50:
                BANKSEL T1CON           ; move to Bank 0 for Timer1 stuff
                MOVLW   0x00
                MOVWF   CCPR1H
                MOVLW   0xE1                  ; 45 * 5 = 225 = 0xE1
                MOVWF   CCPR1L

        CLRF    T1CON           ; Clear all timer 1 settings
        CLRF    TMR1H           ;       Clear timer1 high byte
        CLRF    TMR1L           ;       Clear timer1 low byte
        BSF     T1CON,TMR1ON    ; turn on timer 1, starts to increment

Loop50:        ;BTFSS   PIR1,TMR1IF       ; Check timer overflow flag
```

```
                        BTFSS   PIR1,CCP1IF           ; Check for output compare
flag
                GOTO    Loop50        ; Loops until the timer compares
                BCF     PIR1,CCP1IF     ; Reset timer1 CCP flag
                        CLRF    T1CON                 ; Turn off timer1
                        RETURN

; ***********************************
Wait5:
                        BANKSEL T1CON           ; move to Bank 0 for Timer1 stuff
                        MOVLW   0x00
                        MOVWF   CCPR1H
                        MOVLW   0x05                  ; 1 * 5 = 5 = 0x05
                        MOVWF   CCPR1L

                CLRF    T1CON           ; Clear all timer 1 settings
                CLRF    TMR1H           ;       Clear timer1 high byte
                CLRF    TMR1L           ;       Clear timer1 low byte
                BSF     T1CON,TMR1ON    ; turn on timer 1, starts to increment

Loop5          ;BTFSS   PIR1,TMR1IF       ; Check timer overflow flag
                        BTFSS   PIR1,CCP1IF           ; Check for output compare
flag
                GOTO    Loop5         ; Loops until the timer compares
                BCF     PIR1,CCP1IF     ; Reset timer1 CCP flag
                        CLRF    T1CON                 ; Turn off timer1
                        RETURN

; **************************************
Wait70:
                        BANKSEL T1CON           ; move to Bank 0 for Timer1 stuff
                        MOVLW   0x01
                        MOVWF   CCPR1H
                        MOVLW   0x45                  ; 65 * 5 = 325 = 0x145
                        MOVWF   CCPR1L

                CLRF    T1CON           ; Clear all timer 1 settings
                CLRF    TMR1H           ;       Clear timer1 high byte
                CLRF    TMR1L           ;       Clear timer1 low byte
                BSF     T1CON,TMR1ON    ; turn on timer 1, starts to increment

Loop70         ;BTFSS   PIR1,TMR1IF       ; Check timer overflow flag
                        BTFSS   PIR1,CCP1IF           ; Check for output compare
flag
                GOTO    Loop70        ; Loops until the timer compares
                BCF     PIR1,CCP1IF     ; Reset timer1 CCP flag
                        CLRF    T1CON                 ; Turn off timer1
                        RETURN

; ****************************************
Wait25:
                        BANKSEL T1CON           ; move to Bank 0 for Timer1 stuff
                        MOVLW   0x00
                        MOVWF   CCPR1H
                        MOVLW   0x7D                  ; 25 * 5 = 125 = 0x7D
                        MOVWF   CCPR1L

                CLRF    T1CON           ; Clear all timer 1 settings
                CLRF    TMR1H           ;       Clear timer1 high byte
                CLRF    TMR1L           ;       Clear timer1 low byte
                BSF     T1CON,TMR1ON    ; turn on timer 1, starts to increment

Loop25         ;BTFSS   PIR1,TMR1IF       ; Check timer overflow flag
                        BTFSS   PIR1,CCP1IF           ; Check for output compare
flag
                GOTO    Loop25        ; Loops until the timer compares
                BCF     PIR1,CCP1IF     ; Reset timer1 CCP flag
                        CLRF    T1CON                 ; Turn off timer1
                        RETURN
```

```
; ******************************


; *************************************************************
      end
; *************************************************************
```