Lab 2: Interfacing with a Sensor Device on an Embedded Computer System

16.480/552 Microprocessor Design II and Embedded Systems

Instructor: *Prof. Yan Luo*

Group-12

Due:11/01/17

Submitted: 11/01/17

By,

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Contributions:

Group Member I: Aravind Dhulipalla – Deigned the code for PIC side also helped for coding the Galileo part.

Group Member 2: Zubair Sikandar Nadaph – Assisted with the connections of GPIO ports and also with the strobe signal also assisted in developing the pic side of the code.

Group Member 3: Dhushyanth -

Purpose:

The main purpose of this project is to design bus protocol between intel Galileo (master) and PIC (slave). And transmit the ADC value read by PIC to the Galileo board over bus protocol using strobe mechanism. And display those value on the computer screen using putty software.

Introduction:

The main objective of this lab is to read the data from a photo resistor through ADC module of the microcontroller PIC16F18857. Send those 10-bit data, over the 4-bit bus using a strobe mechanism, by breaking the value to 4 bits. The Galileo sends one of these commands MSG_PING, MSG_RESET, MSG_GET and MSG_TURNxxx to the PIC microcontroller and PIC responds to these commands respectively. When the Galileo sends the MSG_Get command the PIC reads the ADC value and sends it to the Galileo and it prints the value.

Materials, devices and Instruments:

1. Bread board
2. Wires to connect
3. PIC16F18857 microcontroller
4. Pickit3
5. LED
6. Photo resistor
7. one 10k resistor
8. Servo Motor
9. Serial to USB connector
10. Multi-meter
11. Voltage supply (3.3V)
12. Intel Galileo Gen 2 Board
13. Yocto Linux
14. MPLAB IDE
15. Putty Software

Schematic:

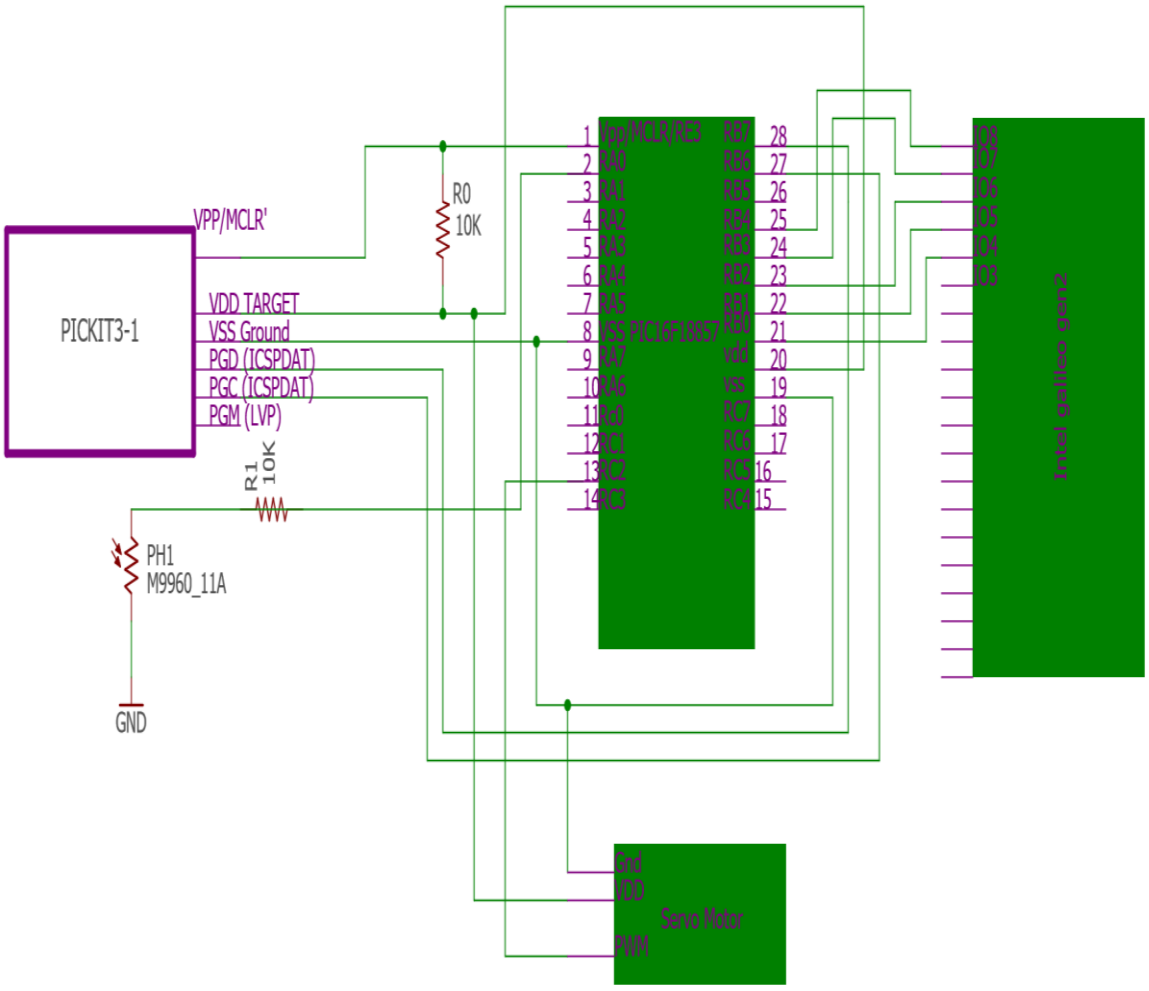
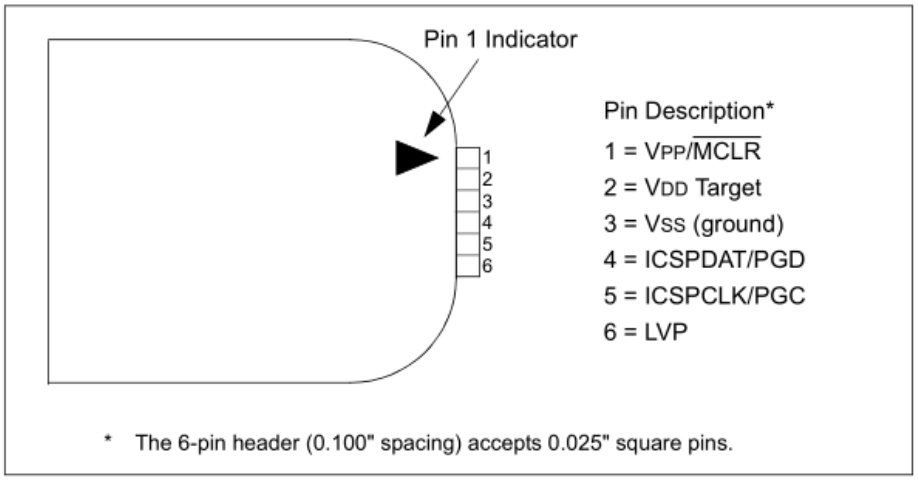
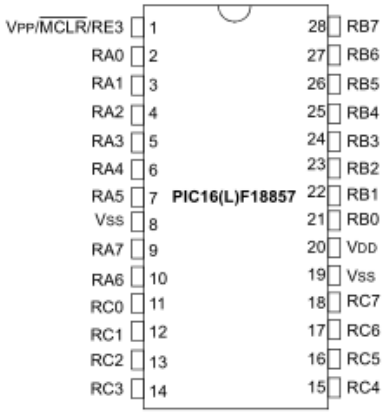

PICKIT3-1
VPP/MCLR'
VDD TARGET
VSS Ground
PGD (ICSPDAT)
PGC (ICSPDAT)
PGM (LVP)
R0
10K
R1
10K
PH1
M9960_11A
GND
PIC16F18857
Intel galileo gen2
Servo Motor
Gnd
VDD
PWM

FIGURE 1-2: PICKIT™ 3 PROGRAMMER CONNECTOR PINOUT



PIN DIAGRAMS

28-pin SPDIP, SOIC, SSOP



Note 1: See Table 2 for location of all peripheral functions.

2: All VDD and all VSS pins must be connected at the circuit board level. Allowing one or more VSS or VDD pins to float may result in degraded electrical performance or non-functionality.

Hardware Design: Initially Pickit3 is connected to the microcontroller. The Galileo GPIO ports are used to used to connect to the PIC microcontroller. The Galileo's D4,D5,D6,D7 are connected to the PIC's Port B RB0.RB1,RB2,RB3 repectively and Galileo's D8 is used as a stobe and it is connected to the PIC's PORTB pin RB4. The galileo sets the strobe as low saying that there is some data that need to be sent or to be received. Then it sets the stobe to high and puts the command on the data bus and makes the strobe go low saying that data has been sent. PIC will receive the data from the data bus when the strobe signal is high and when it is low it knows that the data sending is completed. Then PIC sees that the strobe is low that means it can send the data and when the stobe goes high it keeps the data on the data bus the galileo reads the data and sets the strobe to low.

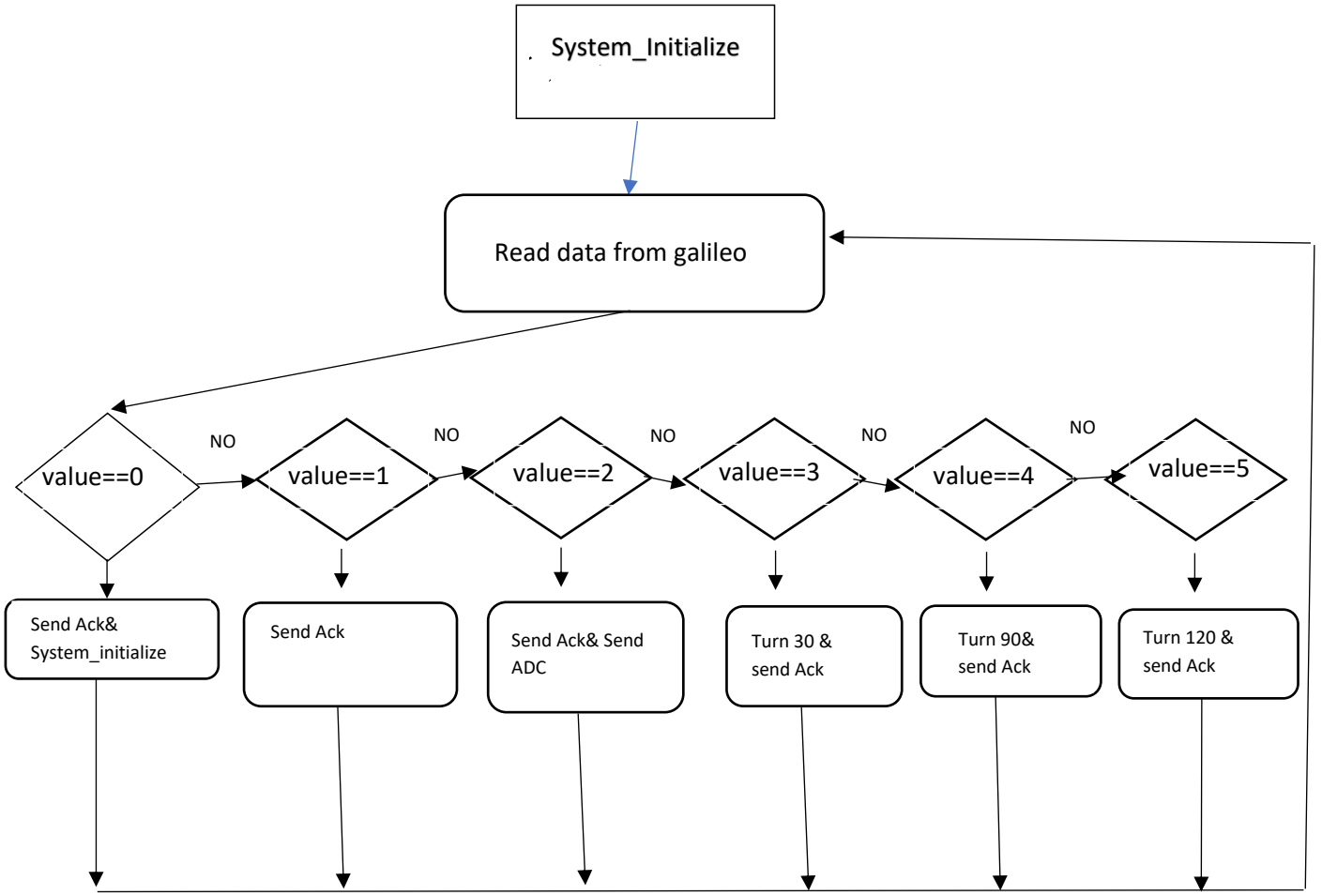
The LDR is connected to pin RA0 and ADC is configured to use the PORTA Pin RA0 so that it can read the value from LDR and convert it to digital value using the internal ADC module in the PIC.

Linux commands used for GPIO's

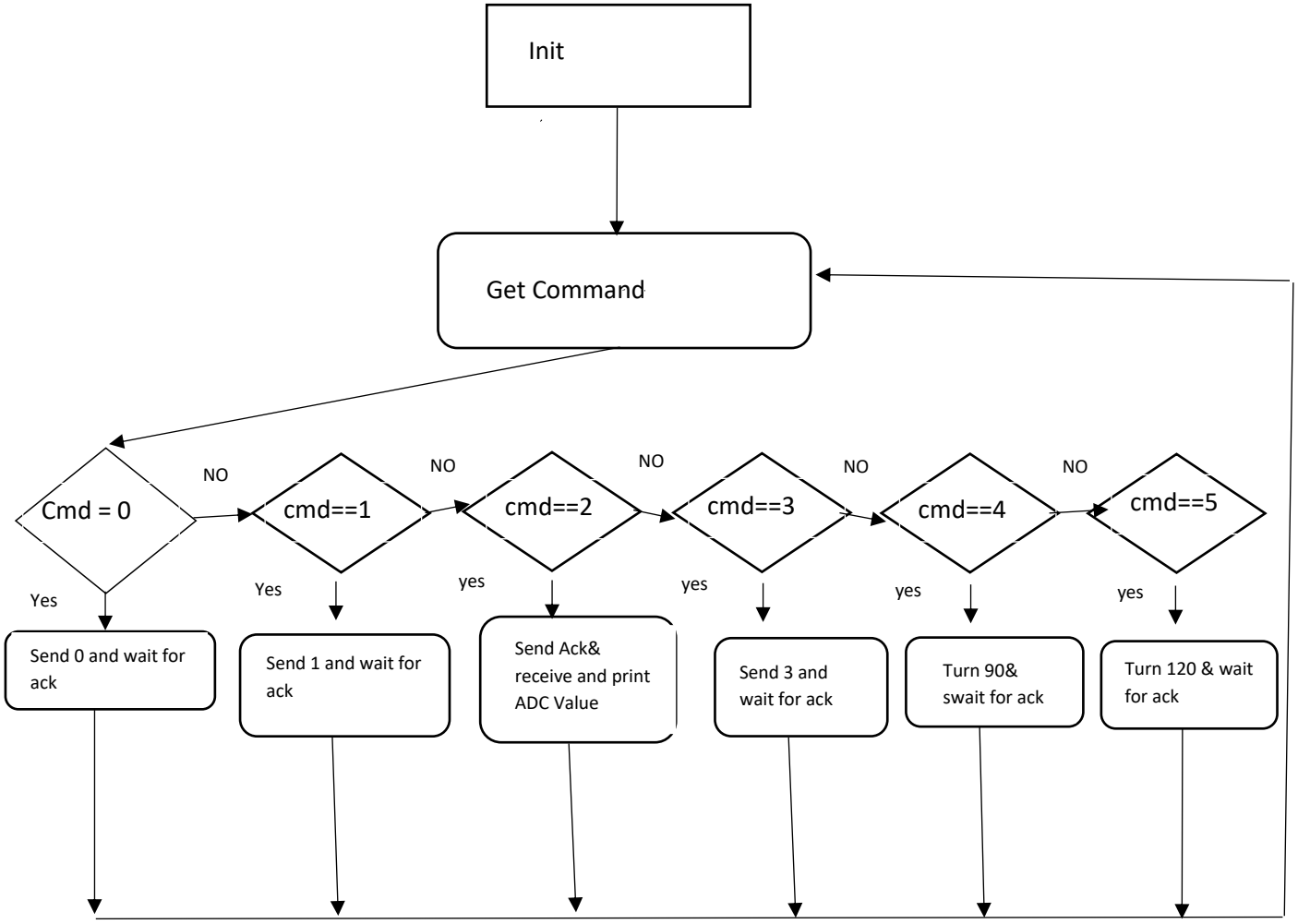
- echo -n "x" > /sys/class/gpio/export – exports the respective GPIO pinx
- echo in > /sys/class/gpio/gpio$x/direction – sets the direction as input for gpio pin x
- echo out > /sys/class/gpio/gpio$x/direction – sets the direction as output for gpio pinx
- echo -n "x" > /sys/class/gpio/unexport – unexports the respective GPIO pin
- echo -n "0 or 1"> /sys/class/gpio/gpio$x/value – writes 0 or 1 if the direction is out
- cat /sys/class/gpio/gpio38/value – gives the value if the pin is set as an input
-

To configure a gpio pin on galileo first we need to export the pin package and we should set the direction as input or output and we can read or write to the pin using value. Aslo we need to configure the shifter gpio pins to make the GPIO's to work.

Software Design:



Galileo Flowchart:



PIC code:

```
/*
 * File:   PIC and Galileo communication
 *
 *
 * simple PIC program example
 * for UMass Lowell 16.480/552
 *
 * Author: Aravind, Zubair, Dushyanth
 *
 */

#include <pic16f18857.h>
#include "mcc_generated_files/mcc.h"
//default library
#define value 0x0
#define MSG_ACK 0xE
#define MSG_NOTHING 0xF
#define ADC_Temp 0b0000000000

/* Circuit Connections
  Signal STROBE   RC6
  Signal D0       RC2
  Signal D1       RC3
  Signal D2       RC4
  Signal D3       RC5
 */
void Timer2_Init(void)
{
// CCPTMRS0 = 0x01; //SELECTED TIMER 2 FOR
PWM
T2CON = 0x80; //CONFIGURED TIMER 2
T2CLKCONbits.CS = 0x01; //clk in relation with
osc frequency
T2HLT = 0x00; //TIMER MODE
T2RST = 0x00; //Reset Source
PR2 = 0xFF; //lOAD THE PR2 VALUE
TMR2 = 0x00; //PRESCALE VALUE IS 0
PIR4bits.TMR2IF = 0; // CLEAR THE INTERRUPT
FLAG
//T2CONbits.ON = 1; // START THE TIMER
}

void PWM_Init(void)
{
CCP1CONbits.EN = 1; // ENABLING THE
CCP1CONbits.FMT = 0; //RIGHT ALLIGNED
FORMAT
CCP1CONbits.MODE = 0xF; // SETTING THE
MODE TO PWM
CCPR1H = 0x00; // RH TO 0
CCPR1L = 0X00; //RL TO 0
CCPTMRS0 = 0X01; // SELECTS TIMER2
}
void PWM_signal_out(unsigned int duty)
{
   T2CONbits.ON = 1; // START THE TIMER
PMD3bits.PWM6MD = 0; //PWM 6 is enabled
CCPR1H = duty >>2; // 2 MSB'S IN CCPR1H
CCPR1L = (duty & 0x0003)<<6; //8 LSB'S IN
CCPR1L
}
 int ADC_conversion_results()
{
   TRISAbits.TRISA0 = 1; // SETTING PORTA PIN0
TRISTATE REGISTER TO INPUT
   ANSELAbits.ANSA0 = 1; // SETTING PORTA
PIN0 AS A ANALOG INPUT
   ADCON0bits.ADON = 1;  // ACTIVATING THE
ADC MODULE
   ADCON0bits.GO = 1;    // START CONVERTING
   while(ADCON0bits.ADGO)// WAIT UNTIL THE
CONVERSION
   {
   }
   int b = (ADRESH<<8)+(ADRESL); // MAKE THE
ADC RESULT IN 10BITS
     ADCON0bits.GO = 0; // STOP CONVERTING
   return(b); // RETURN THE RESULT VALUE
}

void ADC_Init(void)
{
```

```
   ADCON1 = 0x00; // setting control register 1
to 0
   ADCON2 = 0x00; // setting control register 2
to 0
   ADCON3 = 0x00; // setting control register 3
to 0
   ADSTAT = 0x00; // setting threshold register
and not overflowed  to 0
   ADCAP  = 0x00; // disabling ADC capacitors
   ADACT  = 0x00; // disabling Auto conversion
trigger control register
   ADPRE  = 0x00; // setting precharge time
control to 0
   ADCLK  = 0x00; // setting ADC clk
   ADREF  = 0x00; // setting ADC positive and
negative reference voltages
   ANSELAbits.ANSA0 = 1; // setting ADC analog
channel input to 1
   ADCON0 = 0x84; // setting ADCON0 to the
required mode.

}

void set_receive()
{
  //1.set RC6 as digital input
  //2.set RC2, RC3, RC4 and RC5 as digital inputs
  //TRISC = 0xFF;
   ANSELB = 0x00;
  TRISBbits.TRISB0=1;
  TRISBbits.TRISB1=1;
  TRISBbits.TRISB2=1;
  TRISBbits.TRISB3=1;
  TRISBbits.TRISB4=1;
}

void set_send()
{
   ANSELB = 0x00;
   TRISBbits.TRISB0= 0;
   TRISBbits.TRISB1= 0;
   TRISBbits.TRISB2= 0;
   TRISBbits.TRISB3= 0;
}

unsigned char receive_msg()
{
   /* 1.wait strobe high
   2.wait strobe low
   3.read the data
   4.wait strobe high
   5.return the data*/
   set_receive();
   while(PORTBbits.RB4 == 0);
   unsigned char message = 0x00;
    message = ((PORTBbits.RB0)|
(PORTBbits.RB1<<1) | (PORTBbits.RB2<<2) |
(PORTBbits.RB3<<3));
   while(PORTBbits.RB4 == 1);
   return message;
}


void Strobe(char message)
{
     ANSELB = 0x00;
   TRISBbits.TRISB0=0;
   TRISBbits.TRISB1=0;
   TRISBbits.TRISB2=0;
   TRISBbits.TRISB3=0;
   TRISBbits.TRISB4 = 1;
   /*PORTBbits.RB0 = 1;
   PORTBbits.RB1 = 1;
   PORTBbits.RB2 = 1;
   PORTBbits.RB3 = 1;
    */
   while(PORTBbits.RB4==1);
   LATBbits.LATB0 = message & 0x01;
   LATBbits.LATB1 = (message>>1)&0x01;
   LATBbits.LATB2 = (message>>2)&0x01;
   LATBbits.LATB3 = (message>>3)&0x01;
   while(PORTBbits.RB4==0);
}
```

```
void SendADC(int ADCValue)
{

   set_send();
   char a = (ADCValue & 0x0F);
   char b = (ADCValue & 0xF0)>>4;
   char c = (ADCValue & 0x300)>>8;
   Strobe(a);
   Strobe(b);
   Strobe(c);
  }
// Main program
void main (void)
{

   int ADC;
   SYSTEM_Initialize();
   ADC_Init();
   Timer2_Init();
   PWM_Init();
   TRISCbits.TRISC2=0;
   unsigned char msg;
//    ANSELC =0;
   while(1)
   {
   msg=receive_msg();
   switch(msg)
   {
      //Reset
      case 0x00:
       Strobe(MSG_ACK);
       __delay_ms(1000);
       SYSTEM_Initialize();
       break;
       //PING
      case 0x01:
         Strobe(MSG_ACK);
         break;
       //Get
      case 0x02:
         Strobe(MSG_ACK);
         ADC = ADC_conversion_results();
         SendADC(ADC);
         break;
      //TURN 30
      case 0x03:
         PWM_signal_out(100);
         for(int i=0;i<=35;i++)
         {
            PORTCbits.RC2 = 1;
            __delay_ms(3.500);
            PORTCbits.RC2 = 0;
            __delay_ms(16.500);
         }
         break;
      //TURN 90
      case 0x04:
         for(int i=0;i<=35;i++)
         {
            PORTCbits.RC2 = 1;
            __delay_ms(3.500);
            PORTCbits.RC2 = 0;
            __delay_ms(16.500);
         }
         break;
      //TURN 120
      case 0x05:
         for(int i=0;i<=35;i++)
         {
            PORTCbits.RC2 = 1;
            __delay_ms(3.500);
            PORTCbits.RC2 = 0;
            __delay_ms(16.500);
         }
         break;
   }
   }
}
```

Galileo Code:

```
#include <stdlib.h>
#include <stdio.h>
#include <fcntl.h>
#include <unistd.h>
#include <string.h>
#define MSG_RESET 0x0
#define MSG_PING 0x1
#define MSG_GET 0x2
#define MSG_TURN30 0x3
#define MSG_TURN90 0x04
#define MSG_TURN120 0x5

void Export()
{
                        //export the pin 8 GPIO 40
                                system("echo 40 >
/sys/class/gpio/export");
                                //export the pin 7 GPIO
38
      system("echo 38 > /sys/class/gpio/export");
                                //export pin 6 GPIO 1
and SHIFTER GPIO 20
                                system("echo 1 >
/sys/class/gpio/export");
                                system("echo 20 >
/sys/class/gpio/export");
                                //export pin 5 GPIO 0
and SHIFTER GPIO 18
                                system("echo 0 >
/sys/class/gpio/export");
                                system("echo 18 >
/sys/class/gpio/export");
                                //export pin 4 GPIO 6
and SHIFTER GPIO 36
                                system("echo 6 >
/sys/class/gpio/export");
                                system("echo 36 >
/sys/class/gpio/export");
}
void UnExport()
{
                        //export the pin 8 GPIO 40
                                system("echo 40 >
/sys/class/gpio/unexport");
                                //export the pin 7 GPIO
38
      system("echo 38 >
/sys/class/gpio/unexport");
                                //export pin 6 GPIO 1
and SHIFTER GPIO 20
                                system("echo 1 >
/sys/class/gpio/unexport");
                                system("echo 20 >
/sys/class/gpio/unexport");
                                //export pin 5 GPIO 0
and SHIFTER GPIO 18
                                system("echo 0 >
/sys/class/gpio/unexport");
                                system("echo 18 >
/sys/class/gpio/unexport");
                                //export pin 4 GPIO 6
and SHIFTER GPIO 36
                                system("echo 6 >
/sys/class/gpio/unexport");
                                system("echo 36 >
/sys/class/gpio/unexport");
}
void SetGPIO_output()
{
   //setting pin8 as an output
                        system("echo out >
/sys/class/gpio/gpio40/direction");
                        //Setting pin7 as an output
                        system("echo out >
/sys/class/gpio/gpio38/direction");
                        //setting pin6 as an output
                        system("echo out >
/sys/class/gpio/gpio1/direction");
                        system("echo out >
/sys/class/gpio/gpio20/direction");
                        //setting pin5 as an output
```

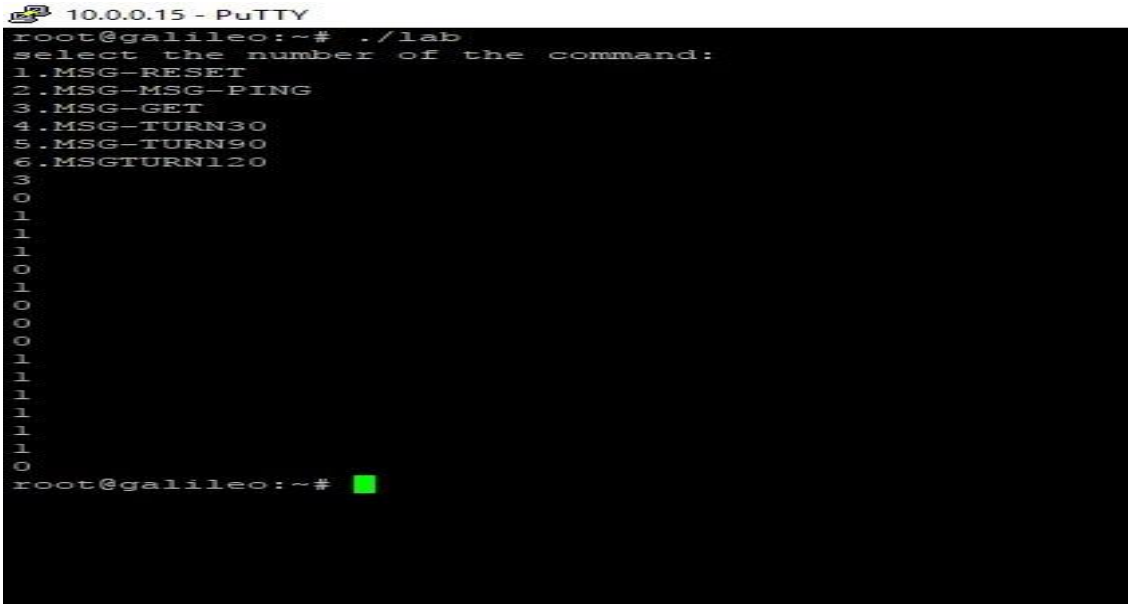
```
                system("echo out > /sys/class/gpio/gpio0/direction");
                system("echo out > /sys/class/gpio/gpio18/direction");
                //setting pin4 as output
                system("echo out > /sys/class/gpio/gpio6/direction");
                system("echo out > /sys/class/gpio/gpio36/direction");
}

void SetGPIO_Input()
{
                //Setting pin7 as an input
                system("echo in > /sys/class/gpio/gpio38/direction");
                //setting pin6 as an input
                system("echo in > /sys/class/gpio/gpio1/direction");
                system("echo in > /sys/class/gpio/gpio20/direction");
                //setting pin5 as an input
                system("echo in > /sys/class/gpio/gpio0/direction");
                system("echo in > /sys/class/gpio/gpio18/direction");
                //setting pin4 as input
                system("echo in > /sys/class/gpio/gpio6/direction");
                system("echo in > /sys/class/gpio/gpio36/direction");
}

int main()
{
                int msg;
                printf("select the number of the command: \n1.MSG-RESET \n2.MSG-MSG-PING \n3.MSG-GET \n4.MSG-TURN30 \n5.MSG-TURN90 \n6.MSGTURN120\n");
   scanf("%d",&msg);
  switch(msg)
  {
                case 1:
                Export();
                SetGPIO_output();
                 system("echo 0 > /sys/class/gpio/gpio40/value");
                        system("echo 0 > /sys/class/gpio/gpio6/value");
                        system("echo 0 > /sys/class/gpio/gpio0/value");
                        system("echo 0 > /sys/class/gpio/gpio1/value");
                        system("echo 0 > /sys/class/gpio/gpio38/value");
                        system("echo 1 > /sys/class/gpio/gpio40/value");
      usleep(10000);
                        system("echo 0 > /sys/class/gpio/gpio40/value");
                UnExport();
                        Export();
                SetGPIO_Input();
                        system("echo 0 > /sys/class/gpio/gpio40/value");
                        system("echo 1 > /sys/class/gpio/gpio40/value");
                        system("cat /sys/class/gpio/gpio6/value");
                        system("cat /sys/class/gpio/gpio0/value");
                        system("cat /sys/class/gpio/gpio1/value");
                        system("cat /sys/class/gpio/gpio38/value");
                        usleep(10000);
                        system("echo 0 > /sys/class/gpio/gpio40/value");
                UnExport();
                        break;
                        case 2:
                        Export();
                SetGPIO_output();
```

```
                    system("echo 0 >
/sys/class/gpio/gpio40/value");
                    system("echo 1 >
/sys/class/gpio/gpio6/value");
                    system("echo 0 >
/sys/class/gpio/gpio0/value");
                    system("echo 0 >
/sys/class/gpio/gpio1/value");
                    system("echo 0 >
/sys/class/gpio/gpio38/value");
                system("echo 1 >
/sys/class/gpio/gpio40/value");
                    usleep(10000);
                    system("echo 0 >
/sys/class/gpio/gpio40/value");
                    UnExport();
                    Export();
                SetGPIO_Input();
                    system("echo 0 >
/sys/class/gpio/gpio40/value");
                    //usleep(10000);
                    system("echo 1 >
/sys/class/gpio/gpio40/value");
                    system("cat
/sys/class/gpio/gpio6/value");
                    system("cat
/sys/class/gpio/gpio0/value");
                    system("cat
/sys/class/gpio/gpio1/value");
                    system("cat
/sys/class/gpio/gpio38/value");
                    usleep(10000);
                    system("echo 0 >
/sys/class/gpio/gpio40/value");
                UnExport();
                    break;
                    case 3:
                    Export();
                SetGPIO_output();
                    system("echo 0 >
/sys/class/gpio/gpio40/value");
                    system("echo 0 >
/sys/class/gpio/gpio6/value");
                    system("echo 1 >
/sys/class/gpio/gpio0/value");
                    system("echo 0 >
/sys/class/gpio/gpio1/value");
                    system("echo 0 >
/sys/class/gpio/gpio38/value");
                    system("echo 1 >
/sys/class/gpio/gpio40/value");
                    usleep(10000);
                    system("echo 0 >
/sys/class/gpio/gpio40/value");
                    UnExport();
                    Export();
                SetGPIO_Input();
                    system("echo 0 >
/sys/class/gpio/gpio40/value");
                    system("echo 1 >
/sys/class/gpio/gpio40/value");
                    system("cat
/sys/class/gpio/gpio6/value");
                    system("cat
/sys/class/gpio/gpio0/value");
                    system("cat
/sys/class/gpio/gpio1/value");
                    system("cat
/sys/class/gpio/gpio38/value");
                    usleep(10000);
                    system("echo 0 >
/sys/class/gpio/gpio40/value");
                    system("echo 1 >
/sys/class/gpio/gpio40/value");
                    system("cat
/sys/class/gpio/gpio6/value");
                    system("cat
/sys/class/gpio/gpio0/value");
                    system("cat
/sys/class/gpio/gpio1/value");
                    system("cat
/sys/class/gpio/gpio38/value");
                    usleep(10000);
```

```
                    system("echo 0 > /sys/class/gpio/gpio40/value");
                    system("echo 1 > /sys/class/gpio/gpio40/value");
                    system("cat /sys/class/gpio/gpio6/value");
                    system("cat /sys/class/gpio/gpio0/value");
                    system("cat /sys/class/gpio/gpio1/value");
                    system("cat /sys/class/gpio/gpio38/value");
                    usleep(10000);
                    system("echo 0 > /sys/class/gpio/gpio40/value");
                    system("echo 1 > /sys/class/gpio/gpio40/value");
                    system("cat /sys/class/gpio/gpio6/value");
                    system("cat /sys/class/gpio/gpio0/value");
                    system("cat /sys/class/gpio/gpio1/value");
                    system("cat /sys/class/gpio/gpio38/value");
                    usleep(10000);
                    system("echo 0 > /sys/class/gpio/gpio40/value");
                    UnExport();
                    break;
                    case 4:

                Export();
                  SetGPIO_output();
                    system("echo 0 > /sys/class/gpio/gpio40/value");
                    system("echo 1 > /sys/class/gpio/gpio6/value");
                    system("echo 1 > /sys/class/gpio/gpio0/value");
                    system("echo 0 > /sys/class/gpio/gpio1/value");
                    system("echo 0 > /sys/class/gpio/gpio38/value");
                    system("echo 1 > /sys/class/gpio/gpio40/value");
                    usleep(10000);
                    system("echo 0 > /sys/class/gpio/gpio40/value");
                    UnExport();
                    Export();
                  SetGPIO_Input();
                 system("echo 0 > /sys/class/gpio/gpio40/value");
                    usleep(10000);
                    system("echo 1 > /sys/class/gpio/gpio40/value");
                    system("cat /sys/class/gpio/gpio6/value");
                    system("cat /sys/class/gpio/gpio0/value");
                    system("cat /sys/class/gpio/gpio1/value");
                    system("cat /sys/class/gpio/gpio38/value");
                    system("echo 0 > /sys/class/gpio/gpio40/value");
                  UnExport();
                  UnExport();
                    break;
                    case 5:

                Export();
                  SetGPIO_output();
                    system("echo 0 > /sys/class/gpio/gpio40/value");
                    system("echo 0 > /sys/class/gpio/gpio6/value");
                    system("echo 0 > /sys/class/gpio/gpio0/value");
                    system("echo 1 > /sys/class/gpio/gpio1/value");
                    system("echo 0 > /sys/class/gpio/gpio38/value");
```

```
                    system("echo 1 >
/sys/class/gpio/gpio40/value");
                    usleep(10000);
                    system("echo 0 >
/sys/class/gpio/gpio40/value");
                    UnExport();
                    Export();
                SetGPIO_Input();
               system("echo 0 >
/sys/class/gpio/gpio40/value");
                    usleep(10000);
                    system("echo 1 >
/sys/class/gpio/gpio40/value");
                    system("cat
/sys/class/gpio/gpio6/value");
                    system("cat
/sys/class/gpio/gpio0/value");
                    system("cat
/sys/class/gpio/gpio1/value");
                    system("cat
/sys/class/gpio/gpio38/value");
                    system("echo 0 >
/sys/class/gpio/gpio40/value");
                UnExport();
                UnExport();
                    break;
                    case 6:

              Export();
                SetGPIO_output();
                    system("echo 0 >
/sys/class/gpio/gpio40/value");
                    system("echo 1 >
/sys/class/gpio/gpio6/value");
                    system("echo 0 >
/sys/class/gpio/gpio0/value");
                    system("echo 1 >
/sys/class/gpio/gpio1/value");
                    system("echo 0 >
/sys/class/gpio/gpio38/value");
                system("echo 1 >
/sys/class/gpio/gpio40/value");
                    usleep(10000);
                    system("echo 0 >
/sys/class/gpio/gpio40/value");
                    UnExport();
                    Export();
                SetGPIO_Input();
               system("echo 0 >
/sys/class/gpio/gpio40/value");
                    usleep(10000);
                    system("echo 1 >
/sys/class/gpio/gpio40/value");
                    system("cat
/sys/class/gpio/gpio6/value");
                    system("cat
/sys/class/gpio/gpio0/value");
                    system("cat
/sys/class/gpio/gpio1/value");
                    system("cat
/sys/class/gpio/gpio38/value");
                    system("echo 0 >
/sys/class/gpio/gpio40/value");
                UnExport();
                    break;
  }
}
```

Results:



As you can see in the putty when we gave a command 3 which is MSG_Get the Pic send an Ack and an 12 bit ADC value the first 4 bits which are 0 1 1 1 is an ACK message and the next 10 bits is our ADC value.

I. Trouble Shooting

The first is to assure the correctness of the circuit by blinking the LED for few minutes without the sensor data. Then relate the sensor data to ON the led. To check the sensor, you need to measure the voltage across it during blocked and unblocked situations. The measured values are 2.8v during unblocked and 1v during the blocked. To estimate ADC output using the formula. Signal = (sample/1024) * Reference voltage. For 2.8v, sample = 868. For 1v, sample = 310 with reference voltage = 3.3 v and (2^10- 10bits of ADC value) 1024 base value.

The second is to troubleshoot the PORTB- data pins configurations by blinking the LED at every pin used.

Third is to configure GPIO ports 4,5,6,7,8 of Intel Galileo by blinking LED at each port used.