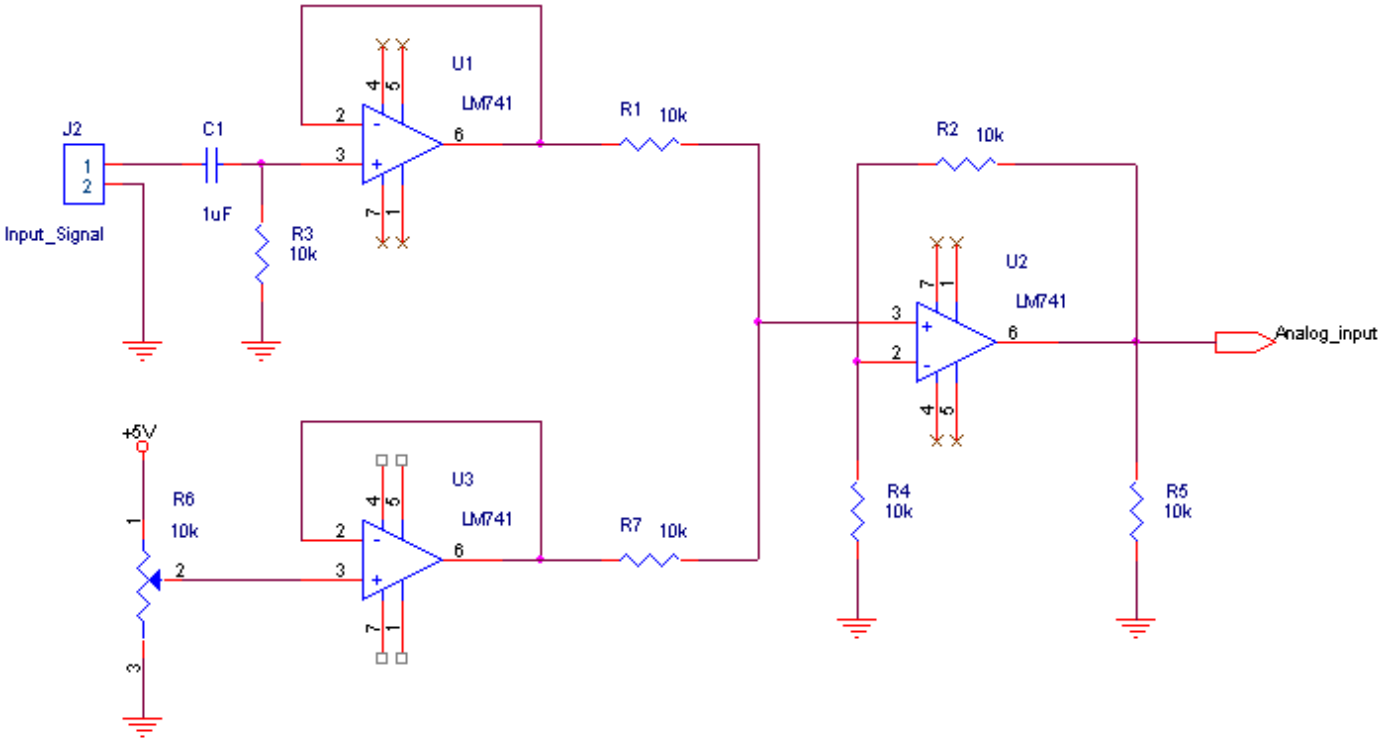
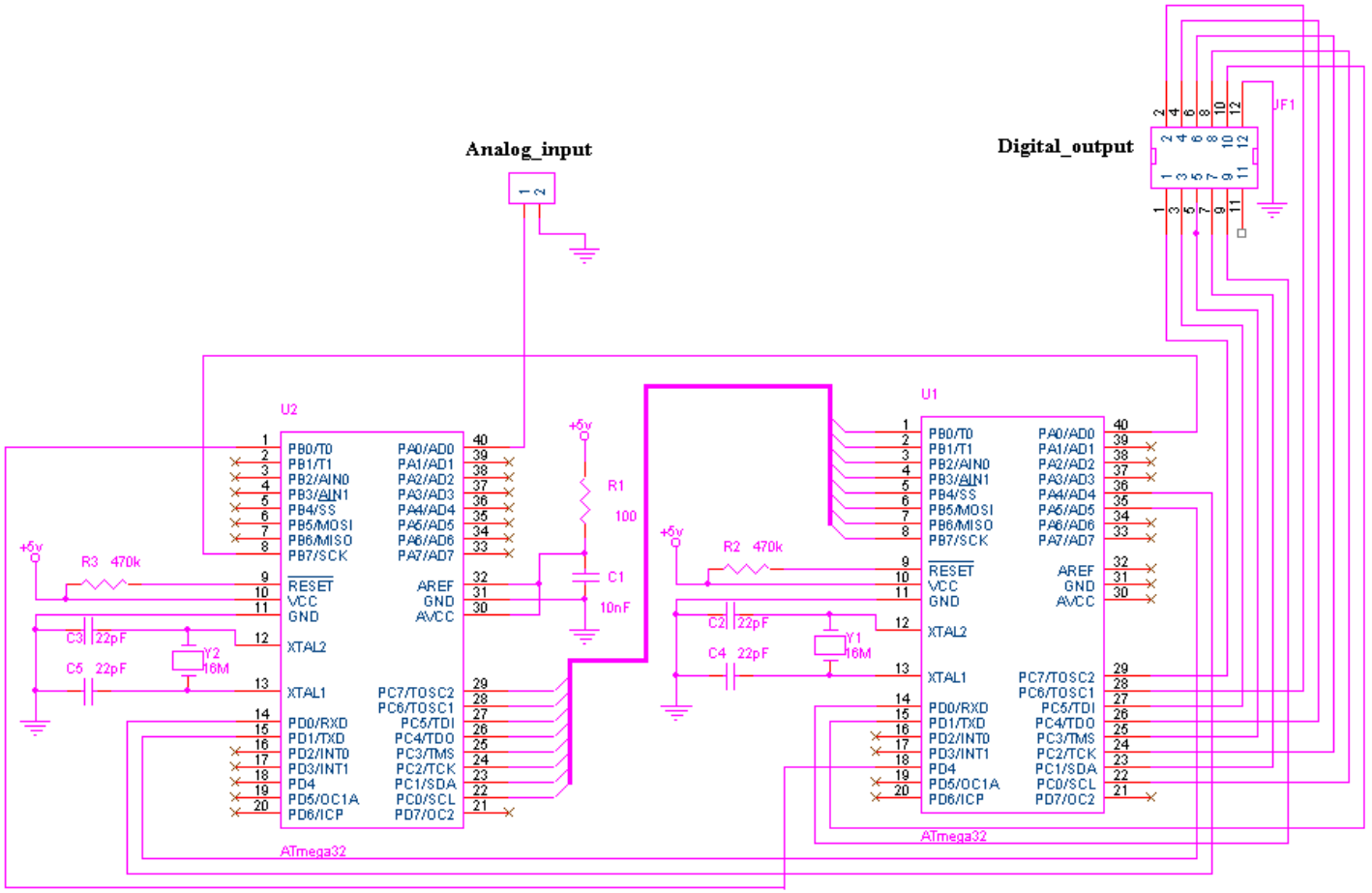
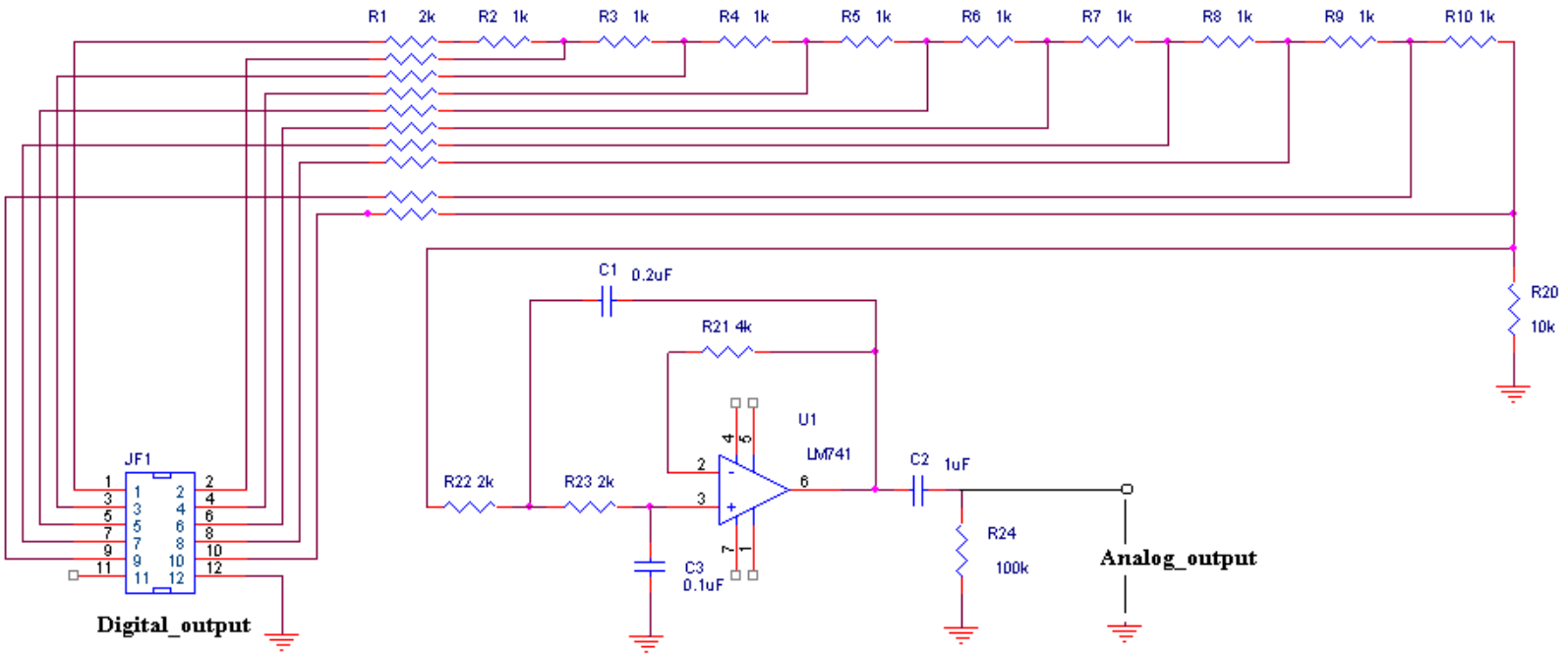
ภาคผนวก ก วงจรที่ใช้ในงานวิจัย



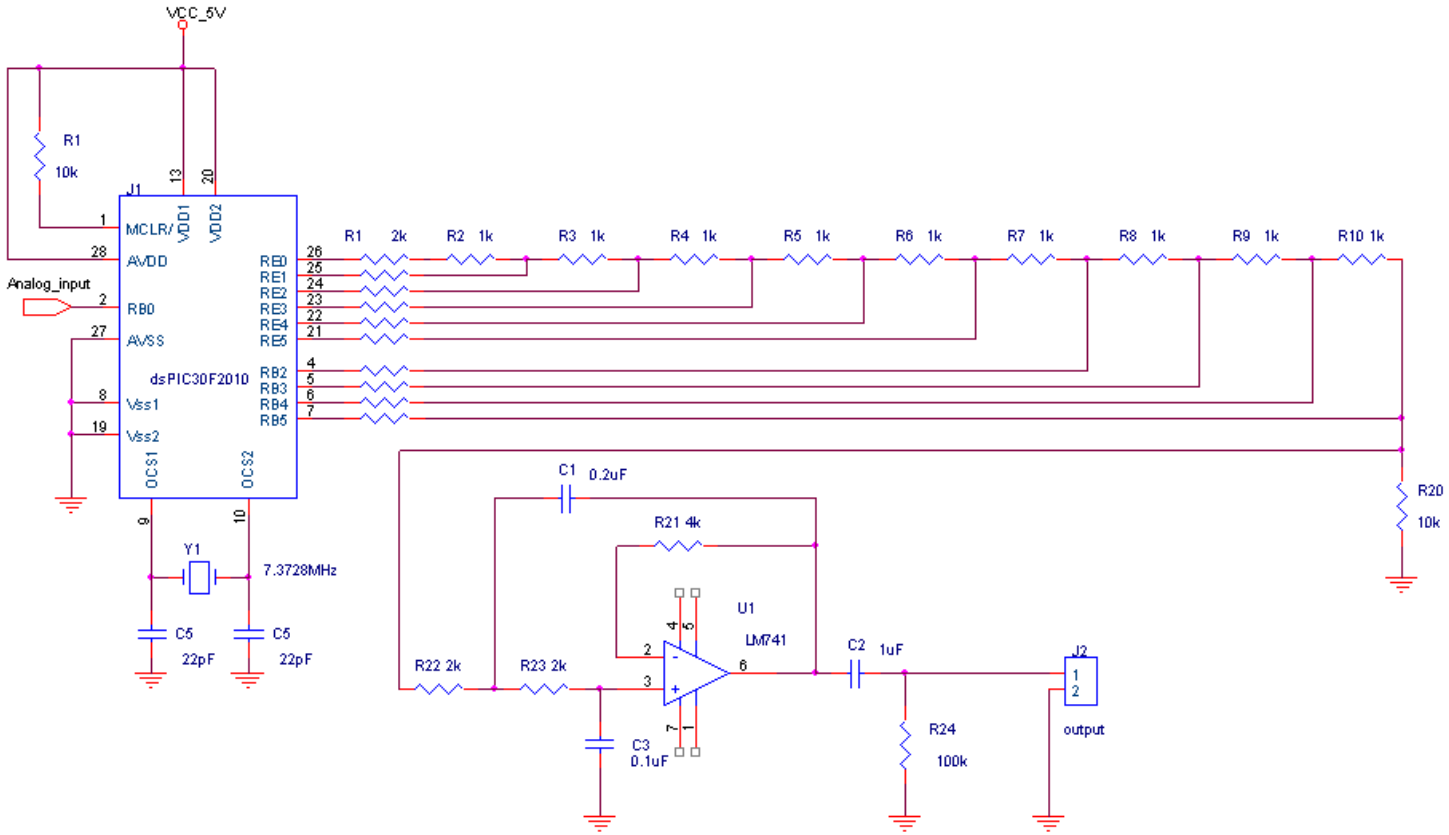
ผก.1 วงจรยกระดับสัญญาณอะนาลอกเพื่อป้อนเป็นอินพุตให้กับไมโครคอนโทรลเลอร์



ผก.2 วงจรการประยุกต์ใช้ไมโครคอนโทรลเลอร์ AVR ATmega32 จำนวน 2 ตัวเป็นโครงข่าย ADLINE



ผก.3 วงจรแปลงสัญญาณดิจิตอลจากเอาท์พุตไมโครคอนโทรลเลอร์ AVR ATmega32 เป็นสัญญาณอะนาลอกและวงจรกรองสัญญาณความถี่ต่ำ



ผก.4 วงจรการประยุกต์ใช้ไมโครคอนโทรลเลอร์ dsPIC30F2010 เป็นโครงข่ายประสาท ADALINE วงจรแปลงสัญญาณดิจิตอลเป็นอะนาลอกและวงจรกรองสัญญาณความถี่ต่ำ

ภาคผนวก ข โปรแกรมที่ใช้ในงานวิจัย

```
#include <mega32.h>
#include <stdio.h>
unsigned char buffer,chip2_ok,buf_portd;
int data_in;
int buff[91];
void handcheck(void)
{
 buffer = PINB;                          //PINB0 is input for check chip2 ready
 chip2_ok = buffer&0x01;
 while(chip2_ok ==0x01)
     {
  buffer = PINB;                        //PINB0 is input for check chip2 ready
  chip2_ok = buffer&0x01;
      }//end while
}

void senddata(int data)
{
unsigned char low_byte,high_byte;
 low_byte = data &0xff;
 high_byte = (data>>8)&0x03;
 PORTC = low_byte;
 PORTD = high_byte & 0xef;      // send data high byte and set bit 4 for
handcheck
 buf_portd = high_byte & 0xef;
}

void next_data(void)
{
 PORTD =buf_portd|0x10;
}
```

ผข.1 โปรแกรมโครงข่าย ADALINE สำหรับ AVR ATmega32 ตัวที่ 1

```
void shif_data(void)
{
unsigned char x,y;
 y=0;
 for(x=0;x<90;x++)  //90
   {
      y=x+1;
     buff[x] =buff[y];
   }
buff[90] =data_in;
}//end func

void main(void)
{
 unsigned char i,n,data_L,chek_convs;
 int data_H;                          // Declare your local variables here
  // input
PORTB=0x00;                         // defind portB NO pull up
DDRB =0x00;                          //defind portB is input
 // output
PORTC=0xff;                         // defind PORTC initial output is 0xff
DDRC=0xff;                          // defind PORTC is output
PORTD=0xff;                         // defind PORTD is initial output is 0xff
DDRD=0xff;                          // defind PORTD is output
ADMUX=0x40;
ADCSR=0x82;
ADCSR|=0x40;
for(;;)
     {
        chek_convs = ADCSR & 0x40;
       if(chek_convs ==0)
          {
```

ผข.1 โปรแกรมโครงข่าย ADALINE สำหรับ AVR ATmega32 ตัวที่ 1 (ต่อ)

```
                data_L = ADCL & 0xfe;
                data_H= ADCH & 0x0003;
                data_in = (data_H<<8)|data_L;
                data_in = data_in-512;
                if((data_in<3)&&(data_in>-3))data_in=0;
                if((data_in&0x8000)!=0) // if data_in is minus (-)
                  {
                     data_in = (data_in*(-1))|0x0200; // data_in is minus
                  }
              shif_data();
              for(i=0;i<10;i++)
                  {
                     n =i*10;
                    senddata(buff[n]);
                     handcheck();       // check chip to already recieve all data
                                        // if already recieve to get next data
                    next_data();
                  }//end for
             ADCSR|=0x40;  // convert ADC Next data
           } //end if
       }//end for
} //end main
```

ผข.1 โปรแกรมโครงข่าย ADALINE สำหรับ AVR ATmega32 ตัวที่ 1 (ต่อ)

```
#include <mega32.h>
#include <stdio.h>
unsigned char buffer,chip1_ok;
unsigned char buf_portd;
int temp;
int tab[10];
float  w1,w2,w3,w4,w5,w6,w7,w8,w9,b;
float p0, p1,p2,p3,p4,p5,p6,p7,p8;
float s1,s2,s3,s4,s5,s6,s7,s8,s9;
float a_output,e_error,lr,data,sum1,sum2;
unsigned char low_byte_R,buf_high_R;
unsigned char low_byte_da,high_byte_da;
int high_byte_R;

void initial_data(void)
 {
  w1=0;
  w2=0;
  w3=0;
  w4=0;
  w5=0;
  w6=0;
  w7=0;
  w8=0;
  w9=0;
  b=0;
  lr=0.005;    // 0.005
 }
```

ผข.2 โปรแกรมโครงข่าย ADALINE สำหรับ AVR ATmega32 ตัวที่ 2

```
void main(void)
{
unsigned char i;
// input
PORTA= 0x00;                          // defind portA no pull up
DDRA = 0x00;                          //defind portA is input
PORTB=0x00;                           // defind portB no pull up
DDRB =0x00;                           //defind portB is input
//  output
PORTC=0xff;                           // defind PORTC initial output is
0xff
DDRC=0xff;                            // defind PORTC is output
PORTD=0xff;                           // defind PORTD is initial output
is 0xff
DDRD=0xff;                            // defind PORTD is output
buf_portd =0x00;
initial_data();
//next_data();
PORTD =buf_portd |0x10;      //00010000 for tell chip1 already
recieve data
buf_portd = buf_portd |0x10;
for(;;)
    {
        for(i=0;i<10;i++)                  //handcheck();
          {
              buffer = PINA;       //PINA0 is input for check chip1
ready send data
              chip1_ok = buffer&0x01;
              while(chip1_ok ==0x01)
                {
```

ผข.2 โปรแกรมโครงข่าย ADALINE สำหรับ AVR ATmega32 ตัวที่ 2 (ต่อ)

```
                buffer = PINA;//PINB0 is input for check chip2 ready
                 chip1_ok = buffer&0x01;
              }//end while

 low_byte_R = PINB;
 buf_high_R = PINA;
 PORTD   = buf_portd & 0xef;    // tell chip1 already reieve data
 buf_portd = buf_portd & 0xef;
 high_byte_R= (buf_high_R>>4)&0x03; // recieve data high byte
 tab[i]  = (high_byte_R<<8)|low_byte_R;
 //next_data();
PORTD =buf_portd |0x10; //00010000 for tell chip1 already
buf_portd = buf_portd |0x10;
}
// adaline();
 if((tab[0]&0x200)!=0)
   {
       p8= (float)(tab[0]&0x1ff)*0.004;
       p8 =0-p8;
   }
 else p8= (float)(tab[0]&0x1ff)*0.004;
 if((tab[1]&0x200)!=0)
 {
       p7= (float)(tab[1]&0x1ff)*0.004;
       p7 =0-p7;
  }
  else p7= (float)(tab[1]&0x1ff)*0.004;
  if((tab[2]&0x200)!=0)
   {
        p6= (float)(tab[2]&0x1ff)*0.004;
        p6 =0-p6;
    }
```

ผข.2 โปรแกรมโครงข่าย ADALINE สำหรับ AVR ATmega32 ตัวที่ 2 (ต่อ)

```
else  p6= (float)(tab[2]&0x1ff)*0.004;
if((tab[3]&0x200)!=0)
  {
      p5= (float)(tab[3]&0x1ff)*0.004;
      p5 =0-p5;
   }
  else p5= (float)(tab[3]&0x1ff)*0.004;
  if((tab[4]&0x200)!=0)
   {
      p4= (float)(tab[4]&0x1ff)*0.004;
      p4 =0-p4;
    }
   else p4= (float)(tab[4]&0x1ff)*0.004;
    if((tab[5]&0x200)!=0)
    {
       p3= (float)(tab[5]&0x1ff)*0.004;
       p3 =0-p3;
     }
    else p3= (float)(tab[5]&0x1ff)*0.004;
     if((tab[6]&0x200)!=0)
     {
        p2= (float)(tab[6]&0x1ff)*0.004;
        p2 =0-p2;
      }
     else p2= (float)(tab[6]&0x1ff)*0.004;
     if((tab[7]&0x200)!=0)
     {
         p1= (float)(tab[7]&0x1ff)*0.004;
          p1 =0-p1;
      }
```

ผข.2 โปรแกรมโครงข่าย ADALINE สำหรับ AVR ATmega32 ตัวที่ 2 (ต่อ)

```
            else p1= (float)(tab[7]&0x1ff)*0.004;
                 if((tab[8]&0x200)!=0)
                {
                   p0= (float)(tab[8]&0x1ff)*0.004;
                   p0 =0-p0;
                  }
                 else p0= (float)(tab[8]&0x1ff)*0.004;
                 if((tab[9]&0x200)!=0)
                  {
                     data = (float)(tab[9]&0x1ff)*0.004;
                     data =0-data;
                  }
           else data= (float)(tab[9]&0x1ff)*0.004;
//a_output=(p0*w1+p1*w2+p2*w3+p3*w4+p4*w5+p5*w6+p6*w7+p
7*w8+p8*w9)+b;
            s1 = p0*w1;
            s2 = p1*w2;
            s3 = p2*w3;
            s4 = p3*w4;
            s5 = p4*w5;
            s6 = p5*w6;
            s7 = p6*w7;
            s8 = p7*w8;
            s9 = p8*w9;
             a_output = s1+s2+s3+s4+s5+s6+s7+s8+s9+b;
             e_error=data-a_output;        /* input(t)-output(t-9) */
             sum1 = 2.0*lr;
             sum2 = sum1*e_error;
             w1 = w1+sum2*p0;
             w2 = w2+sum2*p1;
             w3 = w3+sum2*p2;
```

ผข.2 โปรแกรมโครงข่าย ADALINE สำหรับ AVR ATmega32 ตัวที่ 2 (ต่อ)

```
                w4 = w4+sum2*p3;
                w5 = w5+sum2*p4;
                w6 = w6+sum2*p5;
                w7 = w7+sum2*p6;
                w8 = w8+sum2*p7;
                w9 = w9+sum2*p8;
                 b  = b+sum2;
                 temp=(int)(a_output*250);
                // temp=(int)((data*250)-(a_output*250));
                 temp = temp+512;
                 low_byte_da = temp &0xff;
                 high_byte_da = (temp>>8)&0x03;
                 PORTD =  high_byte_da|0x10;     // send data high byte
                 buf_portd =  high_byte_da|0x10;
                 PORTC = low_byte_da;
    }//end for
} //end main
```

ผข.2 โปรแกรมโครงข่าย ADALINE สำหรับ AVR ATmega32 ตัวที่ 2 (ต่อ)

```
#include<p30f2010.h>            // Header file for dsPIC30F2010
#include<adc10.h>               // Module function for 10 bit ADC
#include<timer.h>
int buff[91];
float  w1,w2,w3,w4,w5,w6,w7,w8,w9,b,lr;
float p0, p1,p2,p3,p4,p5,p6,p7,p8,common,data_first; /* tap input */
int temp;
float a_output,e_error;
char flag_interrupt;
int datain;
//-------------------------------------------------//
//------------ Function initialize ACD module ---------------//
//-------------------------------------------------//
void adc_init()
{
unsigned int Channel, PinConfig, Scanselect, Adcon3_reg,
Adcon2_reg,Adcon1_reg;
ADCON1bits.ADON = 0;                // Turn off ADC
Channel  =  ADC_CH0_POS_SAMPLEA_AN0;
SetChanADC10(Channel);              // Set channel configuration
ConfigIntADC10(ADC_INT_DISABLE); // Disable  interrupt for
ADC
PinConfig  =  ENABLE_AN0_ANA;
Scanselect      =  SKIP_SCAN_AN1 &      SKIP_SCAN_AN2 &
                   SKIP_SCAN_AN3 &      SKIP_SCAN_AN4 &
                         // Scan for AN0-AN3
                   SKIP_SCAN_AN5 & SKIP_SCAN_AN6 &
                   SKIP_SCAN_AN7;
Adcon3_reg    =       ADC_SAMPLE_TIME_1 &
```

ผข.3 โปรแกรมโครงข่าย ADALINE สำหรับ dsPIC30F2010

```
ADC_CONV_CLK_SYSTEM &          ADC_CONV_CLK_10Tcy;
Adcon2_reg  = ADC_VREF_AVDD_AVSS &// Vref at Vdd and Vss
              ADC_SCAN_OFF & // Enable scan for ADC
              ADC_ALT_BUF_OFF & // Disable alternate buffer
              ADC_ALT_INPUT_OFF &// Disable alternate input
              ADC_CONVERT_CH0&// Select CH0 convert
              ADC_SAMPLES_PER_INT_1; // 16 sample between
                                     //interrupt
Adcon1_reg  =  ADC_MODULE_ON &         // Enable module ADC
               ADC_IDLE_CONTINUE &// ADC run on idle mode
               ADC_FORMAT_INTG &// Output value integer format
               ADC_CLK_MANUAL &// ADC manual clock
               ADC_SAMPLE_SIMULTANEOUS &
                                  // ADC     sampling simultaneous
ADC_AUTO_SAMPLING_ON;          // ADC auto sampling
OpenADC10(Adcon1_reg, Adcon2_reg,        Adcon3_reg,PinConfig,
Scanselect);     // Turn on ADC module
}
//-------------------------------------------------//
//------------ Interrupt service routine for timer1------------//
//-------------------------------------------------//
void _ISR _T1Interrupt(void)
{
   IFS0bits.T1IF = 0;            // Clear Timer interrupt flag
   flag_interrupt =0;
}
```

ผข.3 โปรแกรมโครงข่าย ADALINE สำหรับ dsPIC30F2010 (ต่อ)

```
//-------------------------------------------------//
//------------ Initial interrupt timer  1  --------------------//
//-------------------------------------------------//
void initial_timer1(void)
{
 unsigned int match_value;
ConfigIntTimer1(T1_INT_PRIOR_1 & // Timer1 interrupt priority 1
                T1_INT_ON);          // Enable interrupt for timer1
WriteTimer1(0)                  // Clear count value at TMR1 register
//match_value = 7373;                   // Load value Interval 1 ms
match_value = 14756;          // Load value Interval 1 ms because use
                                        // PLL 8x
OpenTimer1(T1_ON &                      // Start timer1
T1_GATE_OFF &       // Disable gate pin for timer1
T1_IDLE_STOP &      // Stop timer in idle mode
T1_PS_1_1 &           // Presceler 1:1
T1_SYNC_EXT_OFF &                       // Disable sync external source
T1_SOURCE_INT, match_value);       // Wait till the timer matches
                                        //with the period value
}
 int get_adc(void)
{
 int data_adc;
ADCON1bits.SAMP = 1;        // Start Sampling
while(!ADCON1bits.SAMP);  // Wait for End Sampling process
ConvertADC10();               // Convert ADC
while(ADCON1bits.SAMP);   // Ensure for Sampling success
while(BusyADC10());           // Ensure for Sampling success
data_adc = ReadADC10(0);    // Keep value for ADC value
return (data_adc-512);
//return (data_adc);
}
```

ผข.3 โปรแกรมโครงข่าย ADALINE สำหรับ dsPIC30F2010 (ต่อ)

```
//-------------------------------------------------//
//---------------  out put port  t0  DAC  ---------------//
//-------------------------------------------------//
void out_dac(int data_out)
{
 int data,data_B;
 data_out = (data_out+512) & 0x3ff;
// data_out = (data_out) & 0x3ff;
 data = data_out;                          // use RE0 - RE5, RE8 is output
 PORTE = (PORTE&0x100)|(data & 0x003f);
 data_B = (data>>4)&0x003f;
 PORTB = data_B;
}

void initial_data(void)
 {
   char index;
   for(index=0;index<91;index++)    // clear buffer
    buff[index] = 0;
    w1=0;
    w2=0;
    w3=0;
    w4=0;
    w5=0;
    w6=0;
    w7=0;
    w8=0;
    w9=0;
    b=0;
    lr=0.005;
 }
```

ผข.3 โปรแกรมโครงข่าย ADALINE สำหรับ dsPIC30F2010 (ต่อ)

```
void adaline(int data2adaline)
{
unsigned char x,y;
//float p0, p1,p2,p3,p4,p5,p6,p7,p8,common,data_first; /* tap input
*/
//int temp;
 p8= (float)(buff[0]*0.004);
 p7= (float)(buff[10]*0.004);
p6= (float)(buff[20]*0.004);
 p5= (float)(buff[30]*0.004);
 p4= (float)(buff[40]*0.004);
 p3= (float)(buff[50]*0.004);
 p2= (float)(buff[60]*0.004);
p1= (float)(buff[70]*0.004);
p0= (float)(buff[80]*0.004);
 data_first=(float)(buff[90]*0.004);
 y=0;
 for(x=0;x<90;x++)
{
     y=x+1;
    buff[x] =buff[y];                    // shift data
}
  buff[90] =data2adaline;
a_output=(p0*w1+p1*w2+p2*w3+p3*w4+p4*w5+p5*w6+p6*w7+p7*
             w8+p8*w9)+b;
 e_error=data_first - a_output;   /* input(t)-output(t-9) */
 common = 2*lr*e_error;  // for reduce time
 w1= w1+common*p0;   // w1+2*lr*p0*e_error;
 w2= w2+common*p1;   // w2+2*lr*p1*e_error;
 w3= w3+common*p2;   // w3+2*lr*p2*e_error;
```

ผข.3 โปรแกรมโครงข่าย ADALINE สำหรับ dsPIC30F2010 (ต่อ)

```
 w4= w4+common*p3;   // w4+2*lr*p3*e_error;
 w5= w5+common*p4;   // w5+2*lr*p4*e_error;
 w6= w6+common*p5;   // w6+2*lr*p5*e_error;
 w7= w7+common*p6;   // w7+2*lr*p6*e_error;
 w8= w8+common*p7;   // w8+2*lr*p7*e_error;
 w9= w9+common*p8;   // w9+2*lr*p8*e_error;
 b = b+2*lr*e_error;
 temp=(int)(e_error*250);
 out_dac(temp);
}
//-------------------------------------------------//
//----------------- Main Program ------------------//
//-------------------------------------------------//
int main(void)
{
unsigned int i,old_data; // Keep data
adc_init();                // Initial ADC
initial_timer1();
initial_data();            // initial data of adaline
flag_interrupt = 1;
TRISE = 0x000;
TRISB = 0x03;
 TRISEbits.TRISE8 =0;
datain = 0;
while(1)                          // Infinite loop
{
while(flag_interrupt!=0);    // loop if flag is 0  until flag =1
flag_interrupt=1;
datain = get_adc();
 adaline(datain);         // process of adaline and send data to output dac
  }  //End while
} end Main
```

ผข.3 โปรแกรมโครงข่าย ADALINE สำหรับ dsPIC30F2010 (ต่อ)

โปรมแกรมบันทึกสัญญาณไฟฟ้าขณะยกน้ำหนัก

โปรแกรมเปรียบสัญญาณ