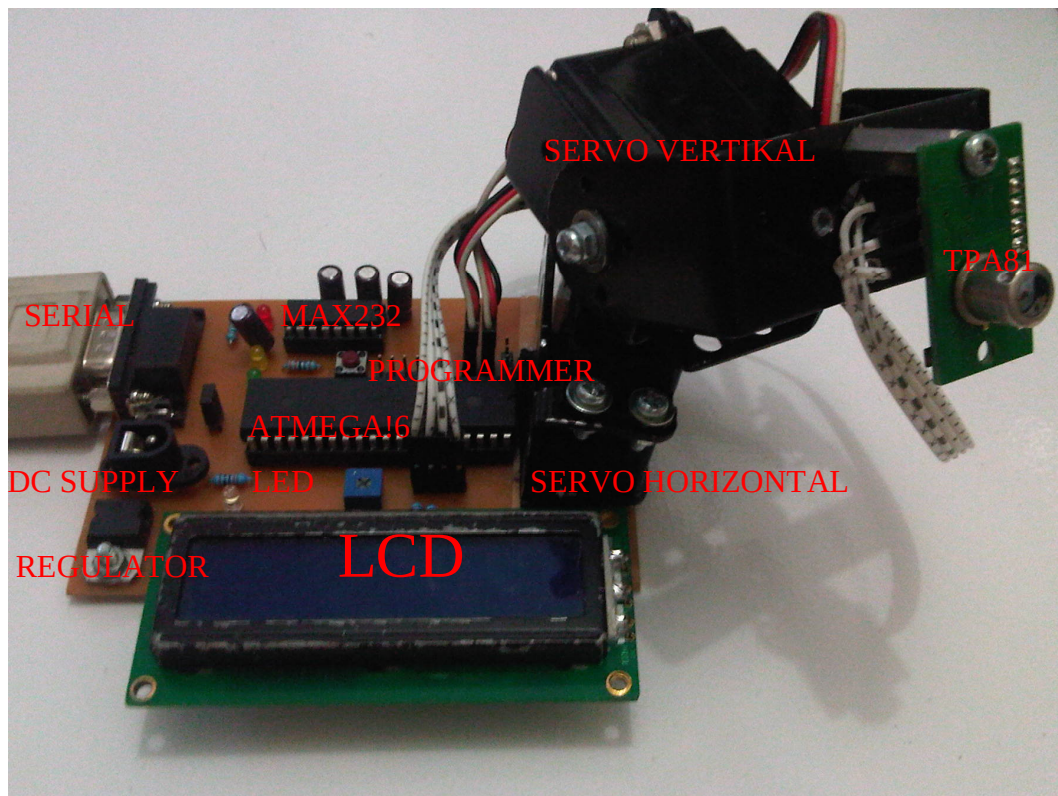


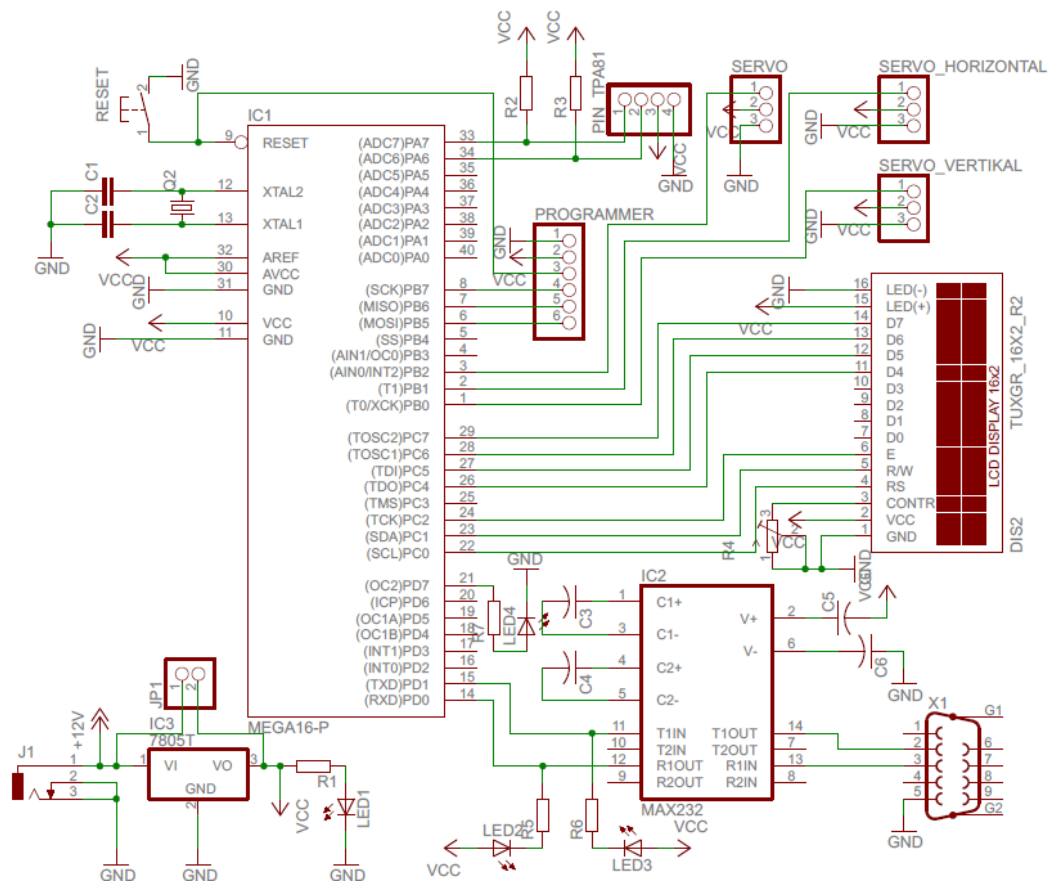
LAMPIRAN A
FOTO ALAT



LAMPIRAN B

SKEMATIK PERANCANGAN TPA81 UNTUK

THERMOSCANNER BERBASIS ATMEGA16



Berikut ini adalah daftar komponen dari skematik perancangan TPA81 untuk *thermoscanner* berbasis mikrokontroler ATmega16 yang dapat dilihat pada tabel berikut :

Nama Komponen	Label	Nilai
Kapasitor	C1	22 pF
Kapasitor	C2	22 pF
Kapasitor	C3	1 μ F/100V
Kapasitor	C4	1 μ F/100V
Kapasitor	C5	1 μ F/100V
Kapasitor	C6	1 μ F/100V
Kristal	Q2	11.0592 MHz
Resistor	R1	330 ohm
Resistor	R2	1k8 ohm
Resistor	R3	1k8 ohm
Potensiometer	R4	10 kohm
Resistor	R5	330 ohm
Resistor	R6	330 ohm
Resistor	R7	330 ohm

LAMPIRAN C
PROGRAM PADA ATMEGA16
DAN PROGRAM APLIKASI PADA MICROSOFT
VISUAL BASIC

ATMEGA16	C-1
PROGRAM APLIKASI PADA VISUAL BASIC	C-9

PROGRAM ATMEGA16

/******

This program was produced by the
CodeWizardAVR V1.25.3 Standard
Automatic Program Generator
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<http://www.hpinfotech.com>

Project :
Version :
Date : 10/28/2011
Author : Wilbert Tannady
Company :
Comments:

Chip type : ATmega16
Program type : Application
Clock frequency : 11.059200 MHz
Memory model : Small
External SRAM size : 0
Data Stack size : 256

*****/

```
#include <mega16.h>
#include <stdio.h>
#include <delay.h>
unsigned char reg,data,i,pixel[8],revision,ambient;
unsigned int w =1,j,k,x;
unsigned int a,q,r;
```

```
// I2C Bus functions
#asm
.equ __i2c_port=0x1B ;PORTA
.equ __sda_bit=6
.equ __scl_bit=7
#endasm
#include <i2c.h>
```

```
// Alphanumeric LCD Module functions
#asm
.equ __lcd_port=0x15 ;PORTC
#endasm
#include <lcd.h>
```

```

#define RXB8 1
#define TXB8 0
#define UPE 2
#define OVR 3
#define FE 4
#define UDRE 5
#define RXC 7

#define FRAMING_ERROR (1<<FE)
#define PARITY_ERROR (1<<UPE)
#define DATA_OVERRUN (1<<OVR)
#define DATA_REGISTER_EMPTY (1<<UDRE)
#define RX_COMPLETE (1<<RXC)

// USART Receiver buffer
#define RX_BUFFER_SIZE 8
char rx_buffer[RX_BUFFER_SIZE];

#if RX_BUFFER_SIZE<256
unsigned char rx_wr_index,rx_rd_index,rx_counter;
#else
unsigned int rx_wr_index,rx_rd_index,rx_counter;
#endif

// This flag is set on USART Receiver buffer overflow
bit rx_buffer_overflow;

// USART Receiver interrupt service routine
interrupt [USART_RXC] void usart_rx_isr(void)
{
char status,data;
status=UCSRA;
data=UDR;
if ((status & (FRAMING_ERROR | PARITY_ERROR |
DATA_OVERRUN))==0)
{
rx_buffer[rx_wr_index]=data;
if (++rx_wr_index == RX_BUFFER_SIZE) rx_wr_index=0;
if (++rx_counter == RX_BUFFER_SIZE)
{
rx_counter=0;
rx_buffer_overflow=1;
};
};
}

```

```

#ifndef _DEBUG_TERMINAL_IO_
// Get a character from the USART Receiver buffer
#define _ALTERNATE_GETCHAR_
#pragma used+
char getchar(void)
{
    char data;
    while (rx_counter==0);
    data=rx_buffer[rx_rd_index];
    if (++rx_rd_index == RX_BUFFER_SIZE) rx_rd_index=0;
    #asm("cli")
    --rx_counter;
    #asm("sei")
    return data;
}
#pragma used-
#endif

// Standard Input/Output functions
#include <stdio.h>

// Declare your global variables here

void TPA_read(){
    delay_ms(40); //menunggu 40 ms untuk pembacaan yang akurat
    i2c_start();
    i2c_write(0xD0);
    i2c_write(reg);
    i2c_start();
    i2c_write(0xD1);
    data=i2c_read(0);
    i2c_stop();
}

void suhu(){
    reg=0x00;
    TPA_read();
    revision=data;
    reg=0x01;
    TPA_read();
    ambient=data;
    for (i=0;i<8;i++) {
        reg=reg+1; // reg=0x02,0x03,...,0x09
        TPA_read();
        pixel[i]=data;
    }
}

```

```
}
```

```
void servo_posisi_awal(){  
    for (i = 0; i < 18; i++) {  
        PORTB.0 = 1;  
        delay_us(500);  
        PORTB.0 = 0;  
        delay_us(19500);  
    }  
    for (i = 0; i < 15; i++) {  
        PORTB.1 = 1;  
        delay_us(1722);  
        PORTB.1 = 0;  
        delay_us(18278);  
    }  
}
```

```
void servo_posisi_awal2(){  
    for (i = 0; i < 18; i++) {  
        PORTB.0 = 1;  
        delay_us(500);  
        PORTB.0 = 0;  
        delay_us(19500);  
    }  
    for (i = 0; i < 15; i++) {  
        PORTB.1 = 1;  
        delay_us(1500);  
        PORTB.1 = 0;  
        delay_us(18444);  
    }  
}
```

```
void main(void)  
{  
    // Declare your local variables here  
  
    // Input/Output Ports initialization  
    // Port A initialization  
    // Func7=In Func6=In Func5=In Func4=In Func3=In Func2=In Func1=In  
    Func0=In  
    // State7=T State6=T State5=T State4=T State3=T State2=T State1=T State0=T  
    PORTA=0x00;
```



```
DDRA=0x00;
```

```
// Port B initialization
```

```
// Func7=In Func6=In Func5=In Func4=In Func3=In Func2=In Func1=Out  
Func0=Out
```

```
// State7=T State6=T State5=T State4=T State3=T State2=T State1=0 State0=0
```

```
PORTB=0x00;
```

```
DDRB=0x03;
```

```
// Port C initialization
```

```
// Func7=In Func6=In Func5=In Func4=In Func3=In Func2=In Func1=In  
Func0=In
```

```
// State7=T State6=T State5=T State4=T State3=T State2=T State1=T State0=T
```

```
PORTC=0x00;
```

```
DDRC=0x00;
```

```
// Port D initialization
```

```
// Func7=In Func6=In Func5=In Func4=In Func3=In Func2=In Func1=In  
Func0=In
```

```
// State7=T State6=T State5=T State4=T State3=T State2=T State1=T State0=T
```

```
PORTD=0x00;
```

```
DDRD=0x00;
```

```
// Timer/Counter 0 initialization
```

```
// Clock source: System Clock
```

```
// Clock value: Timer 0 Stopped
```

```
// Mode: Normal top=FFh
```

```
// OC0 output: Disconnected
```

```
TCCR0=0x00;
```

```
TCNT0=0x00;
```

```
OCR0=0x00;
```

```
// Timer/Counter 1 initialization
```

```
// Clock source: System Clock
```

```
// Clock value: Timer 1 Stopped
```

```
// Mode: Normal top=FFFFh
```

```
// OC1A output: Discon.
```

```
// OC1B output: Discon.
```

```
// Noise Canceler: Off
```

```
// Input Capture on Falling Edge
```

```
// Timer 1 Overflow Interrupt: Off
```

```
// Input Capture Interrupt: Off
```

```
// Compare A Match Interrupt: Off
```

```
// Compare B Match Interrupt: Off
```

```
TCCR1A=0x00;
```

```
TCCR1B=0x00;
```

```

TCNT1H=0x00;
TCNT1L=0x00;
ICR1H=0x00;
ICR1L=0x00;
OCR1AH=0x00;
OCR1AL=0x00;
OCR1BH=0x00;
OCR1BL=0x00;

// Timer/Counter 2 initialization
// Clock source: System Clock
// Clock value: Timer 2 Stopped
// Mode: Normal top=FFh
// OC2 output: Disconnected
ASSR=0x00;
TCCR2=0x00;
TCNT2=0x00;
OCR2=0x00;

// External Interrupt(s) initialization
// INT0: Off
// INT1: Off
// INT2: Off
MCUCR=0x00;
MCUCSR=0x00;

// Timer(s)/Counter(s) Interrupt(s) initialization
TIMSK=0x00;

// USART initialization
// Communication Parameters: 8 Data, 1 Stop, No Parity
// USART Receiver: On
// USART Transmitter: On
// USART Mode: Asynchronous
// USART Baud rate: 9600
UCSRA=0x00;
UCSRB=0x98;
UCSRC=0x86;
UBRRH=0x00;
UBRRL=0x47;

// Analog Comparator initialization
// Analog Comparator: Off
// Analog Comparator Input Capture by Timer/Counter 1: Off
ACSR=0x80;
SFIOR=0x00;

```

```

// I2C Bus initialization
i2c_init();

// LCD module initialization
lcd_init(16);

// Global enable interrupts
#asm("sei")

x=1;
q=1;
r=1;
while (1){

    while(q==1){
        while(r==1){
            servo_posisi_awal();
            r=0;
        }
        //step 3 derajat
        x=x+3;
        suhu();

printf("%03d#%03d#%03d#%03d#%03d#%03d#%03d#%03d\r",w++,pixel[0],pixel[1],pixel[2],pixel[3],pixel[4],pixel[5],pixel[6],pixel[7]);
        delay_ms(400);
        if ( w >= 45){
            w=1;
            r=2;
            q=2;
        }
        if(x>=135){
            x=0;
        }
        //scanning
        for(a=0;a<1;a++){
            DDRB.0 = 1;
            PORTB.0 = 1;
            delay_us(500);
            for(j=0;j<x;j++){
                delay_us(11);
            }
            PORTB.0= 0;
            for(k=0;k<(1755-x);k++){

```


PROGRAM APLIKASI PADA VISUAL BASIC

```
Dim c(1000, 1000) As Integer
```

```
Dim y(1000, 1000) As Integer
```

```
Private Sub Form_Load()
```

```
MSComm1.CommPort = 1
```

```
MSComm1.RThreshold = 20
```

```
MSComm1.SThreshold = 1
```

```
MSComm1.Settings = "9600,n,8,1"
```

```
MSComm1.PortOpen = True
```

```
MSComm1.DTREnable = True
```

```
Timer1.Enabled = True
```

```
RichTextBox1.Text = ""
```

```
Dim i As Integer
```

```
For i = 1 To 32
```

```
    Load Label80(i)
```

```
    Load Label81(i)
```

```
    Load Label82(i)
```

```
    Load Label90(i)
```

```
    Load Label91(i)
```

```
    Load Label92(i)
```

```
    Label80(i).Top = Label80(i - 1).Top + Label80(i).Height
```

```
    Label81(i).Top = Label81(i - 1).Top + Label81(i).Height
```

```
    Label82(i).Top = Label82(i - 1).Top + Label82(i).Height
```

```
    Label90(i).Top = Label90(i - 1).Top + Label90(i).Height
```

```
    Label91(i).Top = Label91(i - 1).Top + Label91(i).Height
```

```
    Label92(i).Top = Label91(i - 1).Top + Label91(i).Height
```

```
    Label80(i).Visible = True
```

```
    Label81(i).Visible = True
```

```
    Label82(i).Visible = True
```

```
    Label90(i).Visible = True
```

```
    Label91(i).Visible = True
```

```
    Label92(i).Visible = True
```

```
Next i
```

```
For i = 1 To 16
```

```
    Load Label1(i)
```

```
    Load Label2(i)
```

```
    Load Label3(i)
```

```
    Load Label4(i)
```

```
    Load Label5(i)
```

Load Label6(i)
 Load Label7(i)
 Load Label8(i)
 Load Label9(i)
 Load Label10(i)
 Load Label11(i)
 Load Label12(i)
 Load Label13(i)
 Load Label14(i)
 Load Label15(i)
 Load Label16(i)
 Load Label17(i)
 Load Label18(i)
 Load Label19(i)
 Load Label20(i)
 Load Label21(i)
 Load Label22(i)
 Load Label23(i)
 Load Label24(i)
 Load Label25(i)
 Load Label26(i)
 Load Label27(i)
 Load Label28(i)
 Load Label29(i)
 Load Label30(i)
 Load Label31(i)
 Load Label32(i)
 Load Label33(i)
 Load Label34(i)
 Load Label35(i)
 Load Label36(i)
 Load Label37(i)
 Load Label38(i)
 Load Label39(i)
 Load Label40(i)
 Load Label41(i)
 Load Label42(i)
 Load Label43(i)
 Load Label44(i)
 Load Label45(i)
 Label1(i).Top = Label1(i - 1).Top + Label1(i).Height
 Label2(i).Top = Label2(i - 1).Top + Label2(i).Height
 Label3(i).Top = Label3(i - 1).Top + Label3(i).Height
 Label4(i).Top = Label4(i - 1).Top + Label4(i).Height
 Label5(i).Top = Label5(i - 1).Top + Label5(i).Height
 Label6(i).Top = Label6(i - 1).Top + Label6(i).Height

Label7(i).Top = Label7(i - 1).Top + Label7(i).Height
 Label8(i).Top = Label8(i - 1).Top + Label8(i).Height
 Label9(i).Top = Label9(i - 1).Top + Label9(i).Height
 Label10(i).Top = Label10(i - 1).Top + Label10(i).Height
 Label11(i).Top = Label11(i - 1).Top + Label11(i).Height
 Label12(i).Top = Label12(i - 1).Top + Label12(i).Height
 Label13(i).Top = Label13(i - 1).Top + Label13(i).Height
 Label14(i).Top = Label14(i - 1).Top + Label14(i).Height
 Label15(i).Top = Label15(i - 1).Top + Label15(i).Height
 Label16(i).Top = Label16(i - 1).Top + Label16(i).Height
 Label17(i).Top = Label17(i - 1).Top + Label17(i).Height
 Label18(i).Top = Label18(i - 1).Top + Label18(i).Height
 Label19(i).Top = Label19(i - 1).Top + Label19(i).Height
 Label20(i).Top = Label20(i - 1).Top + Label20(i).Height
 Label21(i).Top = Label21(i - 1).Top + Label21(i).Height
 Label22(i).Top = Label22(i - 1).Top + Label22(i).Height
 Label23(i).Top = Label23(i - 1).Top + Label23(i).Height
 Label24(i).Top = Label24(i - 1).Top + Label24(i).Height
 Label25(i).Top = Label25(i - 1).Top + Label25(i).Height
 Label26(i).Top = Label26(i - 1).Top + Label26(i).Height
 Label27(i).Top = Label27(i - 1).Top + Label27(i).Height
 Label28(i).Top = Label28(i - 1).Top + Label28(i).Height
 Label29(i).Top = Label29(i - 1).Top + Label29(i).Height
 Label30(i).Top = Label30(i - 1).Top + Label30(i).Height
 Label31(i).Top = Label31(i - 1).Top + Label31(i).Height
 Label32(i).Top = Label32(i - 1).Top + Label32(i).Height
 Label33(i).Top = Label33(i - 1).Top + Label33(i).Height
 Label34(i).Top = Label34(i - 1).Top + Label34(i).Height
 Label35(i).Top = Label35(i - 1).Top + Label35(i).Height
 Label36(i).Top = Label36(i - 1).Top + Label36(i).Height
 Label37(i).Top = Label37(i - 1).Top + Label37(i).Height
 Label38(i).Top = Label38(i - 1).Top + Label38(i).Height
 Label39(i).Top = Label39(i - 1).Top + Label39(i).Height
 Label40(i).Top = Label40(i - 1).Top + Label40(i).Height
 Label41(i).Top = Label41(i - 1).Top + Label41(i).Height
 Label42(i).Top = Label42(i - 1).Top + Label42(i).Height
 Label43(i).Top = Label43(i - 1).Top + Label43(i).Height
 Label44(i).Top = Label44(i - 1).Top + Label44(i).Height
 Label45(i).Top = Label45(i - 1).Top + Label45(i).Height
 Label1(i).Visible = True
 Label2(i).Visible = True
 Label3(i).Visible = True
 Label4(i).Visible = True
 Label5(i).Visible = True
 Label6(i).Visible = True
 Label7(i).Visible = True

```

Label8(i).Visible = True
Label9(i).Visible = True
Label10(i).Visible = True
Label11(i).Visible = True
Label12(i).Visible = True
Label13(i).Visible = True
Label14(i).Visible = True
Label15(i).Visible = True
Label16(i).Visible = True
Label17(i).Visible = True
Label18(i).Visible = True
Label19(i).Visible = True
Label20(i).Visible = True
Label21(i).Visible = True
Label22(i).Visible = True
Label23(i).Visible = True
Label24(i).Visible = True
Label25(i).Visible = True
Label26(i).Visible = True
Label27(i).Visible = True
Label28(i).Visible = True
Label29(i).Visible = True
Label30(i).Visible = True
Label31(i).Visible = True
Label32(i).Visible = True
Label33(i).Visible = True
Label34(i).Visible = True
Label35(i).Visible = True
Label36(i).Visible = True
Label37(i).Visible = True
Label38(i).Visible = True
Label39(i).Visible = True
Label40(i).Visible = True
Label41(i).Visible = True
Label42(i).Visible = True
Label43(i).Visible = True
Label44(i).Visible = True
Label45(i).Visible = True
Next i
Open "Hasil.txt" For Output As #1
Write #1, Now
End Sub
Private Function bawah(a)
For k = 1 To 29 Step 4
    y(k + 1, a) = y(k, a) + (y((k - 1) + 5, a) - y(k, a)) * 0.25
    y(k + 2, a) = y(k, a) + (y((k - 1) + 5, a) - y(k, a)) * 0.5

```



```

    y(k + 3, a) = y(k, a) + (y((k - 1) + 5, a) - y(k, a)) * 0.75
Next k
End Function
Private Function kanan(a)
    For k = 1 To 29 Step 4
        y(k, a - 3) = c(k, a - 4) + (y(k, a) - c(k, a - 4)) * 0.25
        y(k + 1, a - 3) = c(k + 1, a - 4) + (y(k + 1, a) - c(k + 1, a - 4)) * 0.25
        y(k + 2, a - 3) = c(k + 2, a - 4) + (y(k + 2, a) - c(k + 2, a - 4)) * 0.25
        y(k + 3, a - 3) = c(k + 3, a - 4) + (y(k + 3, a) - c(k + 3, a - 4)) * 0.25

        y(k, a - 2) = c(k, a - 4) + (y(k, a) - c(k, a - 4)) * 0.5
        y(k + 1, a - 2) = c(k + 1, a - 4) + (y(k + 1, a) - c(k + 1, a - 4)) * 0.5
        y(k + 2, a - 2) = c(k + 2, a - 4) + (y(k + 2, a) - c(k + 2, a - 4)) * 0.5
        y(k + 3, a - 2) = c(k + 3, a - 4) + (y(k + 3, a) - c(k + 3, a - 4)) * 0.5

        y(k, a - 1) = c(k, a - 4) + (y(k, a) - c(k, a - 4)) * 0.75
        y(k + 1, a - 1) = c(k + 1, a - 4) + (y(k + 1, a) - c(k + 1, a - 4)) * 0.75
        y(k + 2, a - 1) = c(k + 2, a - 4) + (y(k + 2, a) - c(k + 2, a - 4)) * 0.75
        y(k + 3, a - 1) = c(k + 3, a - 4) + (y(k + 3, a) - c(k + 3, a - 4)) * 0.75
    Next k
End Function
Private Function interpolasi_linear(a)
    For z = 1 To 29
        If y(z, a) <= 45 Then
            Line (20 + a, 20 + (z - 1))-(20 + a, 20 + z), RGB(0, 0, 2.5 * y(z, a) + 50),
BF
        ElseIf y(z, a) >= 65 Then
            Line (20 + a, 20 + (z - 1))-(20 + a, 20 + z), RGB(0.69 * y(z, a) + 151.875,
0, 0), BF
        Else
            Line (20 + a, 20 + (z - 1))-(20 + a, 20 + z), RGB(2.63 * y(z, a) - 7.89, 0,
2.63 * y(z, a) - 7.89), BF
        End If
    Next z

    For z = 1 To 29
        If y(z, a - 3) <= 45 Then
            Line (20 + a - 3, 20 + (z - 1))-(20 + a - 3, 20 + z), RGB(0, 0, 2.5 * y(z, a -
3) + 50), BF
        ElseIf y(z, a - 3) >= 65 Then
            Line (20 + a - 3, 20 + (z - 1))-(20 + a - 3, 20 + z), RGB(0.69 * y(z, a) +
151.875, 0, 0), BF
        Else
            Line (20 + a - 3, 20 + (z - 1))-(20 + a - 3, 20 + z), RGB(2.63 * y(z, a - 3) -
7.89, 0, 2.63 * y(z, a - 3) - 7.89), BF
    Next z

```

```

    End If
Next z

For z = 1 To 29
    If y(z, a - 2) <= 45 Then
        Line (20 + a - 2, 20 + (z - 1))-(20 + a - 2, 20 + z), RGB(0, 0, 2.5 * y(z, a - 2) + 50), BF
    ElseIf y(z, a - 2) >= 65 Then
        Line (20 + a - 2, 20 + (z - 1))-(20 + a - 2, 20 + z), RGB(0.69 * y(z, a) + 151.875, 0, 0), BF
    Else
        Line (20 + a - 2, 20 + (z - 1))-(20 + a - 2, 20 + z), RGB(2.63 * y(z, a - 2) - 7.89, 0, 2.63 * y(z, a - 2) - 7.89), BF
    End If
Next z

For z = 1 To 29
    If y(z, a - 1) <= 45 Then
        Line (20 + a - 1, 20 + (z - 1))-(20 + a - 1, 20 + z), RGB(0, 0, 2.5 * y(z, a - 1) + 50), BF
    ElseIf y(z, a - 1) >= 65 Then
        Line (20 + a - 1, 20 + (z - 1))-(20 + a - 1, 20 + z), RGB(0.69 * y(z, a) + 151.875, 0, 0), BF
    Else
        Line (20 + a - 1, 20 + (z - 1))-(20 + a - 1, 20 + z), RGB(2.63 * y(z, a - 1) - 7.89, 0, 2.63 * y(z, a - 1) - 7.89), BF
    End If
Next z
End Function
Private Function interpolasi_linear_1(a)
    For z = 1 To 29
        If y(z, a) <= 29 Then
            Line (20 + a, 20 + (z - 1))-(20 + a, 20 + z), RGB(0, 0, 2.5 * y(z, a) + 50), BF
        ElseIf y(z, a) >= 31 Then
            Line (20 + a, 20 + (z - 1))-(20 + a, 20 + z), RGB(6.88 * y(z, a) - 20, 0, 0), BF
        Else
            Line (20 + a, 20 + (z - 1))-(20 + a, 20 + z), RGB(2.63 * y(z, a) - 7.89, 0, 2.63 * y(z, a) - 7.89), BF
        End If
    Next z

    For z = 1 To 29
        If y(z, a - 3) <= 29 Then

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        Line (20 + a - 3, 20 + (z - 1))-(20 + a - 3, 20 + z), RGB(0, 0, 2.5 * y(z, a -
3) + 50), BF
        ElseIf y(z, a - 3) >= 31 Then
            Line (20 + a - 3, 20 + (z - 1))-(20 + a - 3, 20 + z), RGB(6.88 * y(z, a - 3) -
20, 0, 0), BF
        Else
            Line (20 + a - 3, 20 + (z - 1))-(20 + a - 3, 20 + z), RGB(2.63 * y(z, a - 3) -
7.89, 0, 2.63 * y(z, a - 3) - 7.89), BF
        End If
    Next z

    For z = 1 To 29
        If y(z, a - 2) <= 29 Then
            Line (20 + a - 2, 20 + (z - 1))-(20 + a - 2, 20 + z), RGB(0, 0, 2.5 * y(z, a -
2) + 50), BF
        ElseIf y(z, a - 2) >= 31 Then
            Line (20 + a - 2, 20 + (z - 1))-(20 + a - 2, 20 + z), RGB(6.88 * y(z, a - 2) -
20, 0, 0), BF
        Else
            Line (20 + a - 2, 20 + (z - 1))-(20 + a - 2, 20 + z), RGB(2.63 * y(z, a - 2) -
7.89, 0, 2.63 * y(z, a - 2) - 7.89), BF
        End If
    Next z

    For z = 1 To 29
        If y(z, a - 1) <= 29 Then
            Line (20 + a - 1, 20 + (z - 1))-(20 + a - 1, 20 + z), RGB(0, 0, 2.5 * y(z, a -
1) + 50), BF
        ElseIf y(z, a - 1) >= 31 Then
            Line (20 + a - 1, 20 + (z - 1))-(20 + a - 1, 20 + z), RGB(6.88 * y(z, a - 1) -
20, 0, 0), BF
        Else
            Line (20 + a - 1, 20 + (z - 1))-(20 + a - 1, 20 + z), RGB(2.63 * y(z, a - 1) -
7.89, 0, 2.63 * y(z, a - 1) - 7.89), BF
        End If
    Next z
End Function
Private Function tampil_kanan_80(a)
    For i = 1 To 32
        c(i, a - 4) = Val(Label80(i).Caption)
        Label81(i).Caption = Val(c(i, a - 4))
    Next i
End Function
Private Function tampil_kanan_81(a)
    For i = 1 To 32
        c(i, a - 4) = Val(Label81(i).Caption)

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    Label82(i).Caption = Val(c(i, a - 4))
Next i
End Function
Private Function tampil_kanan_82(a)
    For i = 1 To 32
        c(i, a - 4) = Val(Label82(i).Caption)
        Label80(i).Caption = Val(c(i, a - 4))
    Next i
End Function
Private Function tampil_bawah_82(a)
    For i = 1 To 32
        Label82(i).Caption = Val(y(i, a))
    Next i
End Function
Private Function tampil_bawah_81(a)
    For i = 1 To 32
        Label81(i).Caption = Val(y(i, a))
    Next i
End Function
Private Function tampil_bawah_80(a)
    For i = 1 To 32
        Label80(i).Caption = Val(y(i, a))
    Next i
End Function
Private Function Qbawah(a)
    For k = 33 To 61 Step 4
        y(k + 1, a) = y(k, a) + (y((k - 1) + 5, a) - y(k, a)) * 0.25
        y(k + 2, a) = y(k, a) + (y((k - 1) + 5, a) - y(k, a)) * 0.5
        y(k + 3, a) = y(k, a) + (y((k - 1) + 5, a) - y(k, a)) * 0.75
    Next k
End Function
Private Function Qkanan(a)
    For k = 33 To 61 Step 4
        y(k, a - 3) = c(k, a - 4) + (y(k, a) - c(k, a - 4)) * 0.25
        y(k + 1, a - 3) = c(k + 1, a - 4) + (y(k + 1, a) - c(k + 1, a - 4)) * 0.25
        y(k + 2, a - 3) = c(k + 2, a - 4) + (y(k + 2, a) - c(k + 2, a - 4)) * 0.25
        y(k + 3, a - 3) = c(k + 3, a - 4) + (y(k + 3, a) - c(k + 3, a - 4)) * 0.25

        y(k, a - 2) = c(k, a - 4) + (y(k, a) - c(k, a - 4)) * 0.5
        y(k + 1, a - 2) = c(k + 1, a - 4) + (y(k + 1, a) - c(k + 1, a - 4)) * 0.5
        y(k + 2, a - 2) = c(k + 2, a - 4) + (y(k + 2, a) - c(k + 2, a - 4)) * 0.5
        y(k + 3, a - 2) = c(k + 3, a - 4) + (y(k + 3, a) - c(k + 3, a - 4)) * 0.5

        y(k, a - 1) = c(k, a - 4) + (y(k, a) - c(k, a - 4)) * 0.75
        y(k + 1, a - 1) = c(k + 1, a - 4) + (y(k + 1, a) - c(k + 1, a - 4)) * 0.75
        y(k + 2, a - 1) = c(k + 2, a - 4) + (y(k + 2, a) - c(k + 2, a - 4)) * 0.75
    Next k
End Function

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        y(k + 3, a - 1) = c(k + 3, a - 4) + (y(k + 3, a) - c(k + 3, a - 4)) * 0.75
    Next k
End Function
Private Function Qinterpolasi_linear(a)
    For z = 33 To 61
        If y(z, a) <= 45 Then
            Line (20 + a, 18 + (z - 1))-(20 + a, 18 + z), RGB(0, 0, 2.5 * y(z, a) + 50),
BF
        ElseIf y(z, a) >= 65 Then
            Line (20 + a, 18 + (z - 1))-(20 + a, 18 + z), RGB(0.69 * y(z, a) + 151.875,
0, 0), BF
        Else
            Line (20 + a, 18 + (z - 1))-(20 + a, 18 + z), RGB(2.63 * y(z, a) - 7.89, 0,
2.63 * y(z, a) - 7.89), BF
        End If
    Next z

    For z = 33 To 61
        If y(z, a - 3) <= 45 Then
            Line (20 + a - 3, 18 + (z - 1))-(20 + a - 3, 18 + z), RGB(0, 0, 2.5 * y(z, a -
3) + 50), BF
        ElseIf y(z, a - 3) >= 65 Then
            Line (20 + a - 3, 18 + (z - 1))-(20 + a - 3, 18 + z), RGB(0.69 * y(z, a) +
151.875, 0, 0), BF
        Else
            Line (20 + a - 3, 18 + (z - 1))-(20 + a - 3, 18 + z), RGB(2.63 * y(z, a - 3) -
7.89, 0, 2.63 * y(z, a - 3) - 7.89), BF
        End If
    Next z

    For z = 33 To 61
        If y(z, a - 2) <= 45 Then
            Line (20 + a - 2, 18 + (z - 1))-(20 + a - 2, 18 + z), RGB(0, 0, 2.5 * y(z, a -
2) + 50), BF
        ElseIf y(z, a - 2) >= 65 Then
            Line (20 + a - 2, 18 + (z - 1))-(20 + a - 2, 18 + z), RGB(0.69 * y(z, a) +
151.875, 0, 0), BF
        Else
            Line (20 + a - 2, 18 + (z - 1))-(20 + a - 2, 18 + z), RGB(2.63 * y(z, a - 2) -
7.89, 0, 2.63 * y(z, a - 2) - 7.89), BF
        End If
    Next z

    For z = 33 To 61
        If y(z, a - 1) <= 45 Then

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        Line (20 + a - 1, 18 + (z - 1))-(20 + a - 1, 18 + z), RGB(0, 0, 2.5 * y(z, a -
1) + 50), BF
        ElseIf y(z, a - 1) >= 65 Then
            Line (20 + a - 1, 18 + (z - 1))-(20 + a - 1, 18 + z), RGB(0.69 * y(z, a) +
151.875, 0, 0), BF
        Else
            Line (20 + a - 1, 18 + (z - 1))-(20 + a - 1, 18 + z), RGB(2.63 * y(z, a - 1) -
7.89, 0, 2.63 * y(z, a - 1) - 7.89), BF
        End If
    Next z
End Function
Private Function Qinterpolasi_linear_1(a)
    For z = 33 To 61
        If y(z, a) <= 29 Then
            Line (20 + a, 18 + (z - 1))-(20 + a, 18 + z), RGB(0, 0, 2.5 * y(z, a) + 50),
BF
        ElseIf y(z, a) >= 31 Then
            Line (20 + a, 18 + (z - 1))-(20 + a, 18 + z), RGB(6.88 * y(z, a) - 20, 0, 0),
BF
        Else
            Line (20 + a, 18 + (z - 1))-(20 + a, 18 + z), RGB(2.63 * y(z, a) - 7.89, 0,
2.63 * y(z, a) - 7.89), BF
        End If
    Next z

    For z = 33 To 61
        If y(z, a - 3) <= 29 Then
            Line (20 + a - 3, 18 + (z - 1))-(20 + a - 3, 18 + z), RGB(0, 0, 2.5 * y(z, a -
3) + 50), BF
        ElseIf y(z, a - 3) >= 31 Then
            Line (20 + a - 3, 18 + (z - 1))-(20 + a - 3, 18 + z), RGB(6.88 * y(z, a - 3) -
20, 0, 0), BF
        Else
            Line (20 + a - 3, 18 + (z - 1))-(20 + a - 3, 18 + z), RGB(2.63 * y(z, a - 3) -
7.89, 0, 2.63 * y(z, a - 3) - 7.89), BF
        End If
    Next z

    For z = 33 To 61
        If y(z, a - 2) <= 29 Then
            Line (20 + a - 2, 18 + (z - 1))-(20 + a - 2, 18 + z), RGB(0, 0, 2.5 * y(z, a -
2) + 50), BF
        ElseIf y(z, a - 2) >= 31 Then
            Line (20 + a - 2, 18 + (z - 1))-(20 + a - 2, 18 + z), RGB(6.88 * y(z, a - 2) -
20, 0, 0), BF
        Else

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```

        Line (20 + a - 2, 18 + (z - 1))-(20 + a - 2, 18 + z), RGB(2.63 * y(z, a - 2) -
7.89, 0, 2.63 * y(z, a - 2) - 7.89), BF
    End If
Next z

For z = 33 To 61
    If y(z, a - 1) <= 29 Then
        Line (20 + a - 1, 18 + (z - 1))-(20 + a - 1, 18 + z), RGB(0, 0, 2.5 * y(z, a -
1) + 50), BF
    ElseIf y(z, a - 1) >= 31 Then
        Line (20 + a - 1, 18 + (z - 1))-(20 + a - 1, 18 + z), RGB(6.88 * y(z, a - 1) -
20, 0, 0), BF
    Else
        Line (20 + a - 1, 18 + (z - 1))-(20 + a - 1, 18 + z), RGB(2.63 * y(z, a - 1) -
7.89, 0, 2.63 * y(z, a - 1) - 7.89), BF
    End If
Next z
End Function
Private Function Qtampil_bawah_90(a)
    For i = 1 To 32
        Label90(i).Caption = Val(y(i + 32, a))
    Next i
End Function
Private Function Qtampil_bawah_92(a)
    For i = 1 To 32
        Label92(i).Caption = Val(y(i + 32, a))
    Next i
End Function
Private Function Qtampil_bawah_91(a)
    For i = 1 To 32
        Label91(i).Caption = Val(y(i + 32, a))
    Next i
End Function
Private Function Qtampil_kanan_90(a)
    For i = 1 To 32
        c(i + 32, a - 4) = Val(Label90(i).Caption)
        Label91(i).Caption = Val(c(i + 32, a - 4))
    Next i
End Function
Private Function Qtampil_kanan_91(a)
    For i = 1 To 32
        c(i + 32, a - 4) = Val(Label91(i).Caption)
        Label92(i).Caption = Val(c(i + 32, a - 4))
    Next i
End Function
Private Function Qtampil_kanan_92(a)

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    For i = 1 To 32
        c(i + 32, a - 4) = Val(Label92(i).Caption)
        Label90(i).Caption = Val(c(i + 32, a - 4))
    Next i
End Function
Private Sub Form_Unload(Cancel As Integer)
    Close #1
End Sub
Private Sub Timer1_Timer()
    'tampil_kanan_80 (a),tampil_kanan_82 (a),tampil_kanan_81 (a)
    'tampil_bawah_82 (a),tampil_bawah_81 (a),tampil_bawah_80 (a)
    Dim SEMENTARA As Variant
    SEMENTARA = MSComm1.Input
    RichTextBox1.Text = SEMENTARA
    Write #1, SEMENTARA

    If Mid(SEMENTARA, 1, 3) = 1 Then
        a = 0
        For i = 1 To 8
            Label1(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
            y((i - 1) * 4 + 1, a) = Val(Label1(i).Caption)
        Next i

        bawah (0)
        tampil_bawah_80 (0)

        If Option1.Value = True Then
            For z = 1 To 29
                If y(z, a) <= 45 Then
                    Line (20 + a, 20 + (z - 1))-(20 + a, 20 + z), RGB(0, 0, 2.5 * y(z, a) +
50), BF
                ElseIf y(z, a) >= 65 Then
                    Line (20 + a, 20 + (z - 1))-(20 + a, 20 + z), RGB(0.69 * y(z, a) +
151.875, 0, 0), BF
                Else
                    Line (20 + a, 20 + (z - 1))-(20 + a, 20 + z), RGB(2.63 * y(z, a) - 7.89, 0,
2.63 * y(z, a) - 7.89), BF
                End If
            Next z
        End If
        If Option2.Value = True Then
            For z = 1 To 29
                If y(z, a) <= 29 Then
                    Line (20 + a, 20 + (z - 1))-(20 + a, 20 + z), RGB(0, 0, 13.1 * y(z, a) -
112.5), BF
                End If
            Next z
        End If
    End If

```



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        ElseIf y(z, a) >= 31 Then
            Line (20 + a, 20 + (z - 1))-(20 + a, 20 + z), RGB(3.67 * y(z, a) + 71.7, 0,
0), BF
        Else
            Line (20 + a, 20 + (z - 1))-(20 + a, 20 + z), RGB(6 * y(z, a) - 74, 0, 6 *
y(z, a) - 74), BF
        End If
    Next z
End If

```

```

ElseIf Mid(SEMENTARA, 1, 3) = 2 Then
    a = 4
    For i = 1 To 8
        Label2(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label2(i).Caption)
    Next i
    tampil_kanan_80 (4)
    bawah (4)
    tampil_bawah_82 (4)
    kanan (4)
    If Option1.Value = True Then
        interpolasi_linear (4)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (4)
    End If

```

```

ElseIf Mid(SEMENTARA, 1, 3) = 3 Then
    a = 8
    For i = 1 To 8
        Label3(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label3(i).Caption)
    Next i
    tampil_kanan_82 (8)
    bawah (8)
    tampil_bawah_81 (8)
    kanan (8)
    If Option1.Value = True Then
        interpolasi_linear (8)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (8)
    End If

```

```

ElseIf Mid(SEMENTARA, 1, 3) = 4 Then
    a = 12
    For i = 1 To 8
        Label4(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label4(i).Caption)
    Next i
    tampil_kanan_81 (12)
    bawah (12)
    tampil_bawah_80 (12)
    kanan (12)
    If Option1.Value = True Then
        interpolasi_linear (12)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (12)
    End If

```

```

ElseIf Mid(SEMENTARA, 1, 3) = 5 Then
    a = 16
    For i = 1 To 8
        Label5(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label5(i).Caption)
    Next i
    tampil_kanan_80 (16)
    bawah (16)
    tampil_bawah_82 (16)
    kanan (16)
    If Option1.Value = True Then
        interpolasi_linear (16)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (16)
    End If

```

```

ElseIf Mid(SEMENTARA, 1, 3) = 6 Then
    a = 20
    For i = 1 To 8
        Label6(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label6(i).Caption)
    Next i
    tampil_kanan_82 (20)
    bawah (20)
    tampil_bawah_81 (20)
    kanan (20)
    If Option1.Value = True Then
        interpolasi_linear (20)
    End If

```

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End If
If Option2.Value = True Then
    interpolasi_linear_1 (20)
End If

ElseIf Mid(SEMENTARA, 1, 3) = 7 Then
    a = 24
    For i = 1 To 8
        Label7(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label7(i).Caption)
    Next i
    tampil_kanan_81 (24)
    bawah (24)
    tampil_bawah_80 (24)
    kanan (24)
    If Option1.Value = True Then
        interpolasi_linear (24)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (24)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 8 Then
    a = 28
    For i = 1 To 8
        Label8(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label8(i).Caption)
    Next i
    tampil_kanan_80 (28)
    bawah (28)
    tampil_bawah_82 (28)
    kanan (28)
    If Option1.Value = True Then
        interpolasi_linear (28)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (28)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 9 Then
    a = 32
    For i = 1 To 8
        Label9(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label9(i).Caption)
    Next i
    tampil_kanan_82 (32)

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    bawah (32)
    tampil_bawah_81 (32)
    kanan (32)
    If Option1.Value = True Then
        interpolasi_linear (32)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (32)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 10 Then
    a = 36
    For i = 1 To 8
        Label10(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label10(i).Caption)
    Next i
    tampil_kanan_81 (36)
    bawah (36)
    tampil_bawah_80 (36)
    kanan (36)
    If Option1.Value = True Then
        interpolasi_linear (36)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (36)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 11 Then
    a = 40
    For i = 1 To 8
        Label11(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label11(i).Caption)
    Next i
    tampil_kanan_80 (40)
    bawah (40)
    tampil_bawah_82 (40)
    kanan (40)
    If Option1.Value = True Then
        interpolasi_linear (40)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (40)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 12 Then
    a = 44

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For i = 1 To 8
    Label12(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
    y((i - 1) * 4 + 1, a) = Val(Label12(i).Caption)
Next i
tampil_kanan_82 (44)
bawah (44)
tampil_bawah_81 (44)
kanan (44)
If Option1.Value = True Then
    interpolasi_linear (44)
End If
If Option2.Value = True Then
    interpolasi_linear_1 (44)
End If

ElseIf Mid(SEMENTARA, 1, 3) = 13 Then
    a = 48
    For i = 1 To 8
        Label13(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label13(i).Caption)
    Next i
    tampil_kanan_81 (48)
    bawah (48)
    tampil_bawah_80 (48)
    kanan (48)
    If Option1.Value = True Then
        interpolasi_linear (48)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (48)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 14 Then
    a = 52
    For i = 1 To 8
        Label14(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label14(i).Caption)
    Next i
    tampil_kanan_80 (52)
    bawah (52)
    tampil_bawah_82 (52)
    kanan (52)
    If Option1.Value = True Then
        interpolasi_linear (52)
    End If
    If Option2.Value = True Then

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        interpolasi_linear_1 (52)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 15 Then
    a = 56
    For i = 1 To 8
        Label15(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label15(i).Caption)
    Next i
    tampil_kanan_82 (56)
    bawah (56)
    tampil_bawah_81 (56)
    kanan (56)
    If Option1.Value = True Then
        interpolasi_linear (56)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (56)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 16 Then
    a = 60
    For i = 1 To 8
        Label16(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label16(i).Caption)
    Next i
    tampil_kanan_81 (60)
    bawah (60)
    tampil_bawah_80 (60)
    kanan (60)
    If Option1.Value = True Then
        interpolasi_linear (60)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (60)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 17 Then
    a = 64
    For i = 1 To 8
        Label17(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label17(i).Caption)
    Next i
    tampil_kanan_80 (64)
    bawah (64)
    tampil_bawah_82 (64)

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kanan (64)
If Option1.Value = True Then
    interpolasi_linear (64)
End If
If Option2.Value = True Then
    interpolasi_linear_1 (64)
End If

ElseIf Mid(SEMENTARA, 1, 3) = 18 Then
    a = 68
    For i = 1 To 8
        Label18(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label18(i).Caption)
    Next i
    tampil_kanan_82 (68)
    bawah (68)
    tampil_bawah_81 (68)
    kanan (68)
    If Option1.Value = True Then
        interpolasi_linear (68)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (68)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 19 Then
    a = 72
    For i = 1 To 8
        Label19(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label19(i).Caption)
    Next i
    tampil_kanan_81 (72)
    bawah (72)
    tampil_bawah_80 (72)
    kanan (72)
    If Option1.Value = True Then
        interpolasi_linear (72)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (72)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 20 Then
    a = 76
    For i = 1 To 8
        Label20(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)

```

```

        y((i - 1) * 4 + 1, a) = Val(Label20(i).Caption)
    Next i
    tampil_kanan_80 (76)
    bawah (76)
    tampil_bawah_82 (76)
    kanan (76)
    If Option1.Value = True Then
        interpolasi_linear (76)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (76)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 21 Then
    a = 80
    For i = 1 To 8
        Label21(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label21(i).Caption)
    Next i
    tampil_kanan_82 (80)
    bawah (80)
    tampil_bawah_81 (80)
    kanan (80)
    If Option1.Value = True Then
        interpolasi_linear (80)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (80)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 22 Then
    a = 84
    For i = 1 To 8
        Label22(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label22(i).Caption)
    Next i
    tampil_kanan_81 (84)
    bawah (84)
    tampil_bawah_80 (84)
    kanan (84)
    If Option1.Value = True Then
        interpolasi_linear (84)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (84)
    End If

```



```

ElseIf Mid(SEMENTARA, 1, 3) = 23 Then
    a = 88
    For i = 1 To 8
        Label23(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label23(i).Caption)
    Next i
    tampil_kanan_80 (88)
    bawah (88)
    tampil_bawah_82 (88)
    kanan (88)
    If Option1.Value = True Then
        interpolasi_linear (88)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (88)
    End If

```

```

ElseIf Mid(SEMENTARA, 1, 3) = 24 Then
    a = 92
    For i = 1 To 8
        Label24(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label24(i).Caption)
    Next i
    tampil_kanan_82 (92)
    bawah (92)
    tampil_bawah_81 (92)
    kanan (92)
    If Option1.Value = True Then
        interpolasi_linear (92)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (92)
    End If

```

```

ElseIf Mid(SEMENTARA, 1, 3) = 25 Then
    a = 96
    For i = 1 To 8
        Label25(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label25(i).Caption)
    Next i
    tampil_kanan_81 (96)
    bawah (96)
    tampil_bawah_80 (96)
    kanan (96)
    If Option1.Value = True Then

```

```

        interpolasi_linear (96)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (96)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 26 Then
    a = 100
    For i = 1 To 8
        Label26(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label26(i).Caption)
    Next i
    tampil_kanan_80 (100)
    bawah (100)
    tampil_bawah_82 (100)
    kanan (100)
    If Option1.Value = True Then
        interpolasi_linear (100)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (100)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 27 Then
    a = 104
    For i = 1 To 8
        Label27(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label27(i).Caption)
    Next i
    tampil_kanan_82 (104)
    bawah (104)
    tampil_bawah_81 (104)
    kanan (104)
    If Option1.Value = True Then
        interpolasi_linear (104)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (104)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 28 Then
    a = 108
    For i = 1 To 8
        Label28(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label28(i).Caption)
    Next i

```

```

tampil_kanan_81 (108)
bawah (108)
tampil_bawah_80 (108)
kanan (108)
If Option1.Value = True Then
    interpolasi_linear (108)
End If
If Option2.Value = True Then
    interpolasi_linear_1 (108)
End If

ElseIf Mid(SEMENTARA, 1, 3) = 29 Then
    a = 112
    For i = 1 To 8
        Label29(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label29(i).Caption)
    Next i
    tampil_kanan_80 (112)
    bawah (112)
    tampil_bawah_82 (112)
    kanan (112)
    If Option1.Value = True Then
        interpolasi_linear (112)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (112)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 30 Then
    a = 116
    For i = 1 To 8
        Label30(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label30(i).Caption)
    Next i
    tampil_kanan_82 (116)
    bawah (116)
    tampil_bawah_81 (116)
    kanan (116)
    If Option1.Value = True Then
        interpolasi_linear (116)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (116)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 31 Then

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```

a = 120
For i = 1 To 8
    Label31(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
    y((i - 1) * 4 + 1, a) = Val(Label31(i).Caption)
Next i
tampil_kanan_81 (120)
bawah (120)
tampil_bawah_80 (120)
kanan (120)
If Option1.Value = True Then
    interpolasi_linear (120)
End If
If Option2.Value = True Then
    interpolasi_linear_1 (120)
End If

ElseIf Mid(SEMENTARA, 1, 3) = 32 Then
a = 124
For i = 1 To 8
    Label32(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
    y((i - 1) * 4 + 1, a) = Val(Label32(i).Caption)
Next i
tampil_kanan_80 (124)
bawah (124)
tampil_bawah_82 (124)
kanan (124)
If Option1.Value = True Then
    interpolasi_linear (124)
End If
If Option2.Value = True Then
    interpolasi_linear_1 (124)
End If

ElseIf Mid(SEMENTARA, 1, 3) = 33 Then
a = 128
For i = 1 To 8
    Label33(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
    y((i - 1) * 4 + 1, a) = Val(Label33(i).Caption)
Next i
tampil_kanan_82 (128)
bawah (128)
tampil_bawah_81 (128)
kanan (128)
If Option1.Value = True Then
    interpolasi_linear (128)
End If

```

```

If Option2.Value = True Then
    interpolasi_linear_1 (128)
End If

ElseIf Mid(SEMENTARA, 1, 3) = 34 Then
    a = 132
    For i = 1 To 8
        Label34(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label34(i).Caption)
    Next i
    tampil_kanan_81 (132)
    bawah (132)
    tampil_bawah_80 (132)
    kanan (132)
    If Option1.Value = True Then
        interpolasi_linear (132)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (132)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 35 Then
    a = 136
    For i = 1 To 8
        Label35(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label35(i).Caption)
    Next i
    tampil_kanan_80 (136)
    bawah (136)
    tampil_bawah_82 (136)
    kanan (136)
    If Option1.Value = True Then
        interpolasi_linear (136)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (136)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 36 Then
    a = 140
    For i = 1 To 8
        Label36(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label36(i).Caption)
    Next i
    tampil_kanan_82 (140)
    bawah (140)

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tampil_bawah_81 (140)
kanan (140)
If Option1.Value = True Then
    interpolasi_linear (140)
End If
If Option2.Value = True Then
    interpolasi_linear_1 (140)
End If

ElseIf Mid(SEMENTARA, 1, 3) = 37 Then
    a = 144
    For i = 1 To 8
        Label37(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label37(i).Caption)
    Next i
    tampil_kanan_81 (144)
    bawah (144)
    tampil_bawah_80 (144)
    kanan (144)
    If Option1.Value = True Then
        interpolasi_linear (144)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (144)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 38 Then
    a = 148
    For i = 1 To 8
        Label38(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label38(i).Caption)
    Next i
    tampil_kanan_80 (148)
    bawah (148)
    tampil_bawah_82 (148)
    kanan (148)
    If Option1.Value = True Then
        interpolasi_linear (148)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (148)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 39 Then
    a = 152
    For i = 1 To 8

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        Label39(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label39(i).Caption)
    Next i
    tampil_kanan_82 (152)
    bawah (152)
    tampil_bawah_81 (152)
    kanan (152)
    If Option1.Value = True Then
        interpolasi_linear (152)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (152)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 40 Then
    a = 156
    For i = 1 To 8
        Label40(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label40(i).Caption)
    Next i
    tampil_kanan_81 (156)
    bawah (156)
    tampil_bawah_80 (156)
    kanan (156)
    If Option1.Value = True Then
        interpolasi_linear (156)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (156)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 41 Then
    a = 160
    For i = 1 To 8
        Label41(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label41(i).Caption)
    Next i
    tampil_kanan_80 (160)
    bawah (160)
    tampil_bawah_82 (160)
    kanan (160)
    If Option1.Value = True Then
        interpolasi_linear (160)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (160)
    End If

```

```

End If

ElseIf Mid(SEMENTARA, 1, 3) = 42 Then
    a = 164
    For i = 1 To 8
        Label42(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label42(i).Caption)
    Next i
    tampil_kanan_82 (164)
    bawah (164)
    tampil_bawah_81 (164)
    kanan (164)
    If Option1.Value = True Then
        interpolasi_linear (164)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (164)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 43 Then
    a = 168
    For i = 1 To 8
        Label43(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label43(i).Caption)
    Next i
    tampil_kanan_81 (168)
    bawah (168)
    tampil_bawah_80 (168)
    kanan (168)
    If Option1.Value = True Then
        interpolasi_linear (168)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (168)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 44 Then
    a = 172
    For i = 1 To 8
        Label44(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label44(i).Caption)
    Next i
    tampil_kanan_80 (172)
    bawah (172)
    tampil_bawah_82 (172)
    kanan (172)

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If Option1.Value = True Then
    interpolasi_linear (172)
End If
If Option2.Value = True Then
    interpolasi_linear_1 (172)
End If

ElseIf Mid(SEMENTARA, 1, 3) = 45 Then
    a = 176
    For i = 1 To 8
        Label45(i).Caption = Mid(SEMENTARA, i * 4 + 1, 3)
        y((i - 1) * 4 + 1, a) = Val(Label45(i).Caption)
    Next i
    tampil_kanan_82 (176)
    bawah (176)
    tampil_bawah_81 (176)
    kanan (176)
    If Option1.Value = True Then
        interpolasi_linear (176)
    End If
    If Option2.Value = True Then
        interpolasi_linear_1 (176)
    End If

'//////////////////////////////////////////////////////////////////BAWAH//////////////////////////////////////////////////////////////////
ElseIf Mid(SEMENTARA, 1, 3) = 46 Then
    a = 0
    For i = 9 To 16
        Label1(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label1(i).Caption)
    Next i
    Qbawah (0)
    Qtampil_bawah_90 (0)

    If Option1.Value = True Then
        For z = 33 To 61
            If y(z, a) <= 45 Then
                Line (20 + a, 18 + (z - 1))-(20 + a, 18 + z), RGB(0, 0, 2.5 * y(z, a) +
50), BF
            ElseIf y(z, a) >= 65 Then
                Line (20 + a, 18 + (z - 1))-(20 + a, 18 + z), RGB(0.69 * y(z, a) +
151.875, 0, 0), BF
            Else
                Line (20 + a, 18 + (z - 1))-(20 + a, 18 + z), RGB(2.63 * y(z, a) - 7.89, 0,
2.63 * y(z, a) - 7.89), BF
            End If
        Next z
    End If

```

```

    Next z
End If
If Option2.Value = True Then
    For z = 33 To 61
        If y(z, a) <= 29 Then
            Line (20 + a, 18 + (z - 1))-(20 + a, 18 + z), RGB(0, 0, 2.5 * y(z, a) +
50), BF
        ElseIf y(z, a) >= 31 Then
            Line (20 + a, 18 + (z - 1))-(20 + a, 18 + z), RGB(1.12 * y(z, a) + 31.97,
0, 0), BF
        Else
            Line (20 + a, 18 + (z - 1))-(20 + a, 18 + z), RGB(2.63 * y(z, a) - 7.89, 0,
2.63 * y(z, a) - 7.89), BF
        End If
    Next z
End If

```

```

ElseIf Mid(SEMENTARA, 1, 3) = 47 Then
    a = 4
    For i = 9 To 16
        Label2(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label2(i).Caption)
    Next i
    Qtampil_kanan_90 (4)
    Qbawah (4)
    Qtampil_bawah_92 (4)
    Qkanan (4)
    If Option1.Value = True Then
        Qinterpolasi_linear (4)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (4)
    End If

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```

ElseIf Mid(SEMENTARA, 1, 3) = 48 Then
    a = 8
    For i = 9 To 16
        Label3(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label3(i).Caption)
    Next i
    Qtampil_kanan_92 (8)
    Qbawah (8)
    Qtampil_bawah_91 (8)

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```

Qkanan (8)
If Option1.Value = True Then
    Qinterpolasi_linear (8)
End If
If Option2.Value = True Then
    Qinterpolasi_linear_1 (8)
End If

ElseIf Mid(SEMENTARA, 1, 3) = 49 Then
    a = 12
    For i = 9 To 16
        Label4(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label4(i).Caption)
    Next i
    Qtampil_kanan_91 (12)
    Qbawah (12)
    Qtampil_bawah_90 (12)
    Qkanan (12)
    If Option1.Value = True Then
        Qinterpolasi_linear (12)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (12)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 50 Then
    a = 16
    For i = 9 To 16
        Label5(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label5(i).Caption)
    Next i
    Qtampil_kanan_90 (16)
    Qbawah (16)
    Qtampil_bawah_92 (16)
    Qkanan (16)
    If Option1.Value = True Then
        Qinterpolasi_linear (16)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (16)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 51 Then
    a = 20
    For i = 9 To 16
        Label6(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)

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        y((i - 1) * 4 + 1, a) = Val(Label6(i).Caption)
    Next i
    Qtampil_kanan_92 (20)
    Qbawah (20)
    Qtampil_bawah_91 (20)
    Qkanan (20)
    If Option1.Value = True Then
        Qinterpolasi_linear (20)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (20)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 52 Then
    a = 24
    For i = 9 To 16
        Label7(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label7(i).Caption)
    Next i
    Qtampil_kanan_91 (24)
    Qbawah (24)
    Qtampil_bawah_90 (24)
    Qkanan (24)
    If Option1.Value = True Then
        Qinterpolasi_linear (24)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (24)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 53 Then
    a = 28
    For i = 9 To 16
        Label8(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label8(i).Caption)
    Next i
    Qtampil_kanan_90 (28)
    Qbawah (28)
    Qtampil_bawah_92 (28)
    Qkanan (28)
    If Option1.Value = True Then
        Qinterpolasi_linear (28)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (28)
    End If

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```

ElseIf Mid(SEMENTARA, 1, 3) = 54 Then
    a = 32
    For i = 9 To 16
        Label9(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label9(i).Caption)
    Next i
    Qtampil_kanan_92 (32)
    Qbawah (32)
    Qtampil_bawah_91 (32)
    Qkanan (32)
    If Option1.Value = True Then
        Qinterpolasi_linear (32)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (32)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 55 Then
    a = 36
    For i = 9 To 16
        Label10(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label10(i).Caption)
    Next i
    Qtampil_kanan_91 (36)
    Qbawah (36)
    Qtampil_bawah_90 (36)
    Qkanan (36)
    If Option1.Value = True Then
        Qinterpolasi_linear (36)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (36)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 56 Then
    a = 40
    For i = 9 To 16
        Label11(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label11(i).Caption)
    Next i
    Qtampil_kanan_90 (40)
    Qbawah (40)
    Qtampil_bawah_92 (40)
    Qkanan (40)
    If Option1.Value = True Then

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        Qinterpolasi_linear (40)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (40)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 57 Then
    a = 44
    For i = 9 To 16
        Label12(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label12(i).Caption)
    Next i
    Qtampil_kanan_92 (44)
    Qbawah (44)
    Qtampil_bawah_91 (44)
    Qkanan (44)
    If Option1.Value = True Then
        Qinterpolasi_linear (44)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (44)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 58 Then
    a = 48
    For i = 9 To 16
        Label13(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label13(i).Caption)
    Next i
    Qtampil_kanan_91 (48)
    Qbawah (48)
    Qtampil_bawah_90 (48)
    Qkanan (48)
    If Option1.Value = True Then
        Qinterpolasi_linear (48)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (48)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 59 Then
    a = 52
    For i = 9 To 16
        Label14(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label14(i).Caption)
    Next i

```

```

Qtampil_kanan_90 (52)
Qbawah (52)
Qtampil_bawah_92 (52)
Qkanan (52)
If Option1.Value = True Then
    Qinterpolasi_linear (52)
End If
If Option2.Value = True Then
    Qinterpolasi_linear_1 (52)
End If

ElseIf Mid(SEMENTARA, 1, 3) = 60 Then
    a = 56
    For i = 9 To 16
        Label15(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label15(i).Caption)
    Next i
    Qtampil_kanan_92 (56)
    Qbawah (56)
    Qtampil_bawah_91 (56)
    Qkanan (56)
    If Option1.Value = True Then
        Qinterpolasi_linear (56)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (56)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 61 Then
    a = 60
    For i = 9 To 16
        Label16(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label16(i).Caption)
    Next i
    Qtampil_kanan_91 (60)
    Qbawah (60)
    Qtampil_bawah_90 (60)
    Qkanan (60)
    If Option1.Value = True Then
        Qinterpolasi_linear (60)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (60)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 62 Then

```

```

a = 64
For i = 9 To 16
    Label17(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
    y((i - 1) * 4 + 1, a) = Val(Label17(i).Caption)
Next i
Qtampil_kanan_90 (64)
Qbawah (64)
Qtampil_bawah_92 (64)
Qkanan (64)
If Option1.Value = True Then
    Qinterpolasi_linear (64)
End If
If Option2.Value = True Then
    Qinterpolasi_linear_1 (64)
End If

ElseIf Mid(SEMENTARA, 1, 3) = 63 Then
a = 68
For i = 9 To 16
    Label18(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
    y((i - 1) * 4 + 1, a) = Val(Label18(i).Caption)
Next i
Qtampil_kanan_92 (68)
Qbawah (68)
Qtampil_bawah_91 (68)
Qkanan (68)
If Option1.Value = True Then
    Qinterpolasi_linear (68)
End If
If Option2.Value = True Then
    Qinterpolasi_linear_1 (68)
End If

ElseIf Mid(SEMENTARA, 1, 3) = 64 Then
a = 72
For i = 9 To 16
    Label19(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
    y((i - 1) * 4 + 1, a) = Val(Label19(i).Caption)
Next i
Qtampil_kanan_91 (72)
Qbawah (72)
Qtampil_bawah_90 (72)
Qkanan (72)
If Option1.Value = True Then
    Qinterpolasi_linear (72)
End If

```



```

If Option2.Value = True Then
    Qinterpolasi_linear_1 (72)
End If

ElseIf Mid(SEMENTARA, 1, 3) = 65 Then
    a = 76
    For i = 9 To 16
        Label20(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label20(i).Caption)
    Next i
    Qtampil_kanan_90 (76)
    Qbawah (76)
    Qtampil_bawah_92 (76)
    Qkanan (76)
    If Option1.Value = True Then
        Qinterpolasi_linear (76)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (76)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 66 Then
    a = 80
    For i = 9 To 16
        Label21(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label21(i).Caption)
    Next i
    Qtampil_kanan_92 (80)
    Qbawah (80)
    Qtampil_bawah_91 (80)
    Qkanan (80)
    If Option1.Value = True Then
        Qinterpolasi_linear (80)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (80)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 67 Then
    a = 84
    For i = 9 To 16
        Label22(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label22(i).Caption)
    Next i
    Qtampil_kanan_91 (84)
    Qbawah (84)

```

```

Qtampil_bawah_90 (84)
Qkanan (84)
If Option1.Value = True Then
    Qinterpolasi_linear (84)
End If
If Option2.Value = True Then
    Qinterpolasi_linear_1 (84)
End If

ElseIf Mid(SEMENTARA, 1, 3) = 68 Then
    a = 88
    For i = 9 To 16
        Label23(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label23(i).Caption)
    Next i
    Qtampil_kanan_90 (88)
    Qbawah (88)
    Qtampil_bawah_92 (88)
    Qkanan (88)
    If Option1.Value = True Then
        Qinterpolasi_linear (88)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (88)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 69 Then
    a = 92
    For i = 9 To 16
        Label24(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label24(i).Caption)
    Next i
    Qtampil_kanan_92 (92)
    Qbawah (92)
    Qtampil_bawah_91 (92)
    Qkanan (92)
    If Option1.Value = True Then
        Qinterpolasi_linear (92)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (92)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 70 Then
    a = 96
    For i = 9 To 16

```

```

        Label25(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label25(i).Caption)
    Next i
    Qtampil_kanan_91 (96)
    Qbawah (96)
    Qtampil_bawah_90 (96)
    Qkanan (96)
    If Option1.Value = True Then
        Qinterpolasi_linear (96)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (96)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 71 Then
    a = 100
    For i = 9 To 16
        Label26(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label26(i).Caption)
    Next i
    Qtampil_kanan_90 (100)
    Qbawah (100)
    Qtampil_bawah_92 (100)
    Qkanan (100)
    If Option1.Value = True Then
        Qinterpolasi_linear (100)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (100)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 72 Then
    a = 104
    For i = 9 To 16
        Label27(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label27(i).Caption)
    Next i
    Qtampil_kanan_92 (104)
    Qbawah (104)
    Qtampil_bawah_91 (104)
    Qkanan (104)
    If Option1.Value = True Then
        Qinterpolasi_linear (104)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (104)
    End If

```

```

End If

ElseIf Mid(SEMENTARA, 1, 3) = 73 Then
    a = 108
    For i = 9 To 16
        Label28(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label28(i).Caption)
    Next i
    Qtampil_kanan_91 (108)
    Qbawah (108)
    Qtampil_bawah_90 (108)
    Qkanan (108)
    If Option1.Value = True Then
        Qinterpolasi_linear (108)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (108)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 74 Then
    a = 112
    For i = 9 To 16
        Label29(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label29(i).Caption)
    Next i
    Qtampil_kanan_90 (112)
    Qbawah (112)
    Qtampil_bawah_92 (112)
    Qkanan (112)
    If Option1.Value = True Then
        Qinterpolasi_linear (112)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (112)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 75 Then
    a = 116
    For i = 9 To 16
        Label30(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label30(i).Caption)
    Next i
    Qtampil_kanan_92 (116)
    Qbawah (116)
    Qtampil_bawah_91 (116)
    Qkanan (116)

```

```

If Option1.Value = True Then
    Qinterpolasi_linear (116)
End If
If Option2.Value = True Then
    Qinterpolasi_linear_1 (116)
End If

ElseIf Mid(SEMENTARA, 1, 3) = 76 Then
    a = 120
    For i = 9 To 16
        Label31(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label31(i).Caption)
    Next i
    Qtampil_kanan_91 (120)
    Qbawah (120)
    Qtampil_bawah_90 (120)
    Qkanan (120)
    If Option1.Value = True Then
        Qinterpolasi_linear (120)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (120)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 77 Then
    a = 124
    For i = 9 To 16
        Label32(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label32(i).Caption)
    Next i
    Qtampil_kanan_90 (124)
    Qbawah (124)
    Qtampil_bawah_92 (124)
    Qkanan (124)
    If Option1.Value = True Then
        Qinterpolasi_linear (124)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (124)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 78 Then
    a = 128
    For i = 9 To 16
        Label33(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label33(i).Caption)
    
```

```

Next i
Qtampil_kanan_92 (128)
Qbawah (128)
Qtampil_bawah_91 (128)
Qkanan (128)
If Option1.Value = True Then
    Qinterpolasi_linear (128)
End If
If Option2.Value = True Then
    Qinterpolasi_linear_1 (128)
End If

ElseIf Mid(SEMENTARA, 1, 3) = 79 Then
    a = 132
    For i = 9 To 16
        Label34(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label34(i).Caption)
    Next i
    Qtampil_kanan_91 (132)
    Qbawah (132)
    Qtampil_bawah_90 (132)
    Qkanan (132)
    If Option1.Value = True Then
        Qinterpolasi_linear (132)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (132)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 80 Then
    a = 136
    For i = 9 To 16
        Label35(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label35(i).Caption)
    Next i
    Qtampil_kanan_90 (136)
    Qbawah (136)
    Qtampil_bawah_92 (136)
    Qkanan (136)
    If Option1.Value = True Then
        Qinterpolasi_linear (136)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (136)
    End If

```

```

ElseIf Mid(SEMENTARA, 1, 3) = 81 Then
    a = 140
    For i = 9 To 16
        Label36(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label36(i).Caption)
    Next i
    Qtampil_kanan_92 (140)
    Qbawah (140)
    Qtampil_bawah_91 (140)
    Qkanan (140)
    If Option1.Value = True Then
        Qinterpolasi_linear (140)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (140)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 82 Then
    a = 144
    For i = 9 To 16
        Label37(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label37(i).Caption)
    Next i
    Qtampil_kanan_91 (144)
    Qbawah (144)
    Qtampil_bawah_90 (144)
    Qkanan (144)
    If Option1.Value = True Then
        Qinterpolasi_linear (144)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (144)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 83 Then
    a = 148
    For i = 9 To 16
        Label38(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label38(i).Caption)
    Next i
    Qtampil_kanan_90 (148)
    Qbawah (148)
    Qtampil_bawah_92 (148)
    Qkanan (148)
    If Option1.Value = True Then
        Qinterpolasi_linear (148)
    End If

```

```

End If
If Option2.Value = True Then
    Qinterpolasi_linear_1 (148)
End If

ElseIf Mid(SEMENTARA, 1, 3) = 84 Then
    a = 152
    For i = 9 To 16
        Label39(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label39(i).Caption)
    Next i
    Qtampil_kanan_92 (152)
    Qbawah (152)
    Qtampil_bawah_91 (152)
    Qkanan (152)
    If Option1.Value = True Then
        Qinterpolasi_linear (152)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (152)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 85 Then
    a = 156
    For i = 9 To 16
        Label40(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label40(i).Caption)
    Next i
    Qtampil_kanan_91 (156)
    Qbawah (156)
    Qtampil_bawah_90 (156)
    Qkanan (156)
    If Option1.Value = True Then
        Qinterpolasi_linear (156)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (156)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 86 Then
    a = 160
    For i = 9 To 16
        Label41(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label41(i).Caption)
    Next i
    Qtampil_kanan_90 (160)

```



```

Qbawah (160)
Qtampil_bawah_92 (160)
Qkanan (160)
If Option1.Value = True Then
    Qinterpolasi_linear (160)
End If
If Option2.Value = True Then
    Qinterpolasi_linear_1 (160)
End If

ElseIf Mid(SEMENTARA, 1, 3) = 87 Then
    a = 164
    For i = 9 To 16
        Label42(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label42(i).Caption)
    Next i
    Qtampil_kanan_92 (164)
    Qbawah (164)
    Qtampil_bawah_91 (164)
    Qkanan (164)
    If Option1.Value = True Then
        Qinterpolasi_linear (164)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (164)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 88 Then
    a = 168
    For i = 9 To 16
        Label43(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label43(i).Caption)
    Next i
    Qtampil_kanan_91 (168)
    Qbawah (168)
    Qtampil_bawah_90 (168)
    Qkanan (168)
    If Option1.Value = True Then
        Qinterpolasi_linear (168)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (168)
    End If

ElseIf Mid(SEMENTARA, 1, 3) = 89 Then
    a = 172

```

```

For i = 9 To 16
    Label44(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
    y((i - 1) * 4 + 1, a) = Val(Label44(i).Caption)
Next i
Qtampil_kanan_90 (172)
Qbawah (172)
Qtampil_bawah_92 (172)
Qkanan (172)
If Option1.Value = True Then
    Qinterpolasi_linear (172)
End If
If Option2.Value = True Then
    Qinterpolasi_linear_1 (172)
End If

ElseIf Mid(SEMENTARA, 1, 3) = 90 Then
    a = 176
    For i = 9 To 16
        Label45(i).Caption = Mid(SEMENTARA, i * 4 - 31, 3)
        y((i - 1) * 4 + 1, a) = Val(Label45(i).Caption)
    Next i
    Qtampil_kanan_92 (176)
    Qbawah (176)
    Qtampil_bawah_91 (176)
    Qkanan (176)
    If Option1.Value = True Then
        Qinterpolasi_linear (176)
    End If
    If Option2.Value = True Then
        Qinterpolasi_linear_1 (176)
    End If

End If
End Sub

```

LAMPIRAN D
DATA SHEET

ATMEGA16	D-1
THERMOPILE ARRAY TPA81.....	D-7
MAX232	D-12

Features

- High-performance, Low-power Atmel® AVR® 8-bit Microcontroller
- Advanced RISC Architecture
 - 131 Powerful Instructions – Most Single-clock Cycle Execution
 - 32 x 8 General Purpose Working Registers
 - Fully Static Operation
 - Up to 16 MIPS Throughput at 16 MHz
 - On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory segments
 - 16 Kbytes of In-System Self-programmable Flash program memory
 - 512 Bytes EEPROM
 - 1 Kbyte Internal SRAM
 - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
 - Data retention: 20 years at 85°C/100 years at 25°C⁽¹⁾
 - Optional Boot Code Section with Independent Lock Bits
 - In-System Programming by On-chip Boot Program
 - True Read-While-Write Operation
 - Programming Lock for Software Security
- JTAG (IEEE std. 1149.1 Compliant) Interface
 - Boundary-scan Capabilities According to the JTAG Standard
 - Extensive On-chip Debug Support
 - Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface
- Peripheral Features
 - Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes
 - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
 - Real Time Counter with Separate Oscillator
 - Four PWM Channels
 - 8-channel, 10-bit ADC
 - 8 Single-ended Channels
 - 7 Differential Channels in TQFP Package Only
 - 2 Differential Channels with Programmable Gain at 1x, 10x, or 200x
 - Byte-oriented Two-wire Serial Interface
 - Programmable Serial USART
 - Master/Slave SPI Serial Interface
 - Programmable Watchdog Timer with Separate On-chip Oscillator
 - On-chip Analog Comparator
- Special Microcontroller Features
 - Power-on Reset and Programmable Brown-out Detection
 - Internal Calibrated RC Oscillator
 - External and Internal Interrupt Sources
 - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby and Extended Standby
- I/O and Packages
 - 32 Programmable I/O Lines
 - 40-pin PDIP, 44-lead TQFP, and 44-pad QFN/MLF
- Operating Voltages
 - 2.7V - 5.5V for ATmega16L
 - 4.5V - 5.5V for ATmega16
- Speed Grades
 - 0 - 8 MHz for ATmega16L
 - 0 - 16 MHz for ATmega16
- Power Consumption @ 1 MHz, 3V, and 25°C for ATmega16L
 - Active: 1.1 mA
 - Idle Mode: 0.35 mA
 - Power-down Mode: < 1 µA



**8-bit AVR®
Microcontroller
with 16K Bytes
In-System
Programmable
Flash**

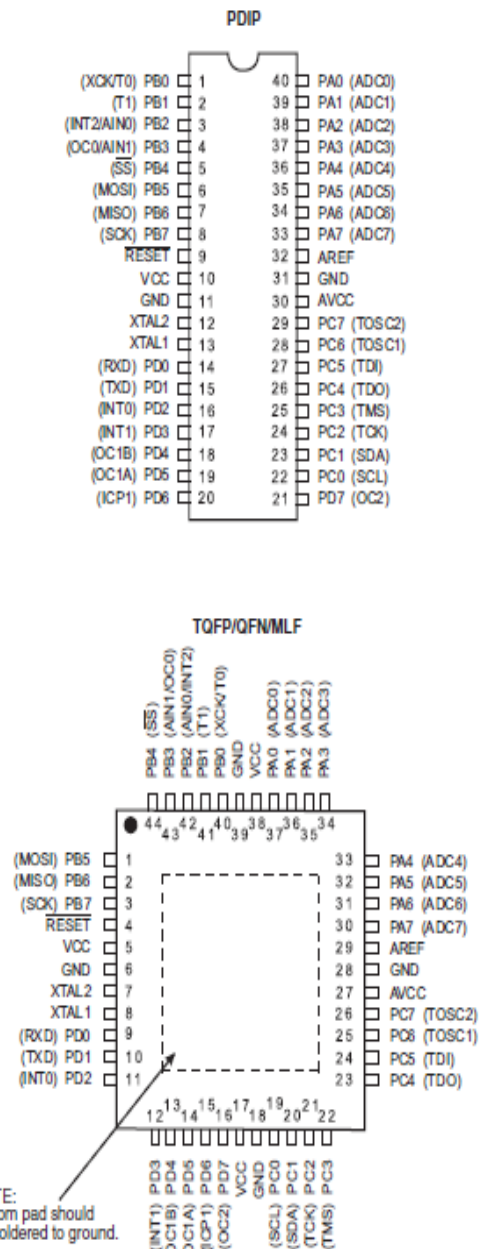
**ATmega16
ATmega16L**

Rev. 2466T-AVR-07/10



Pin Configurations

Figure 1. Pinout ATmega16



Disclaimer

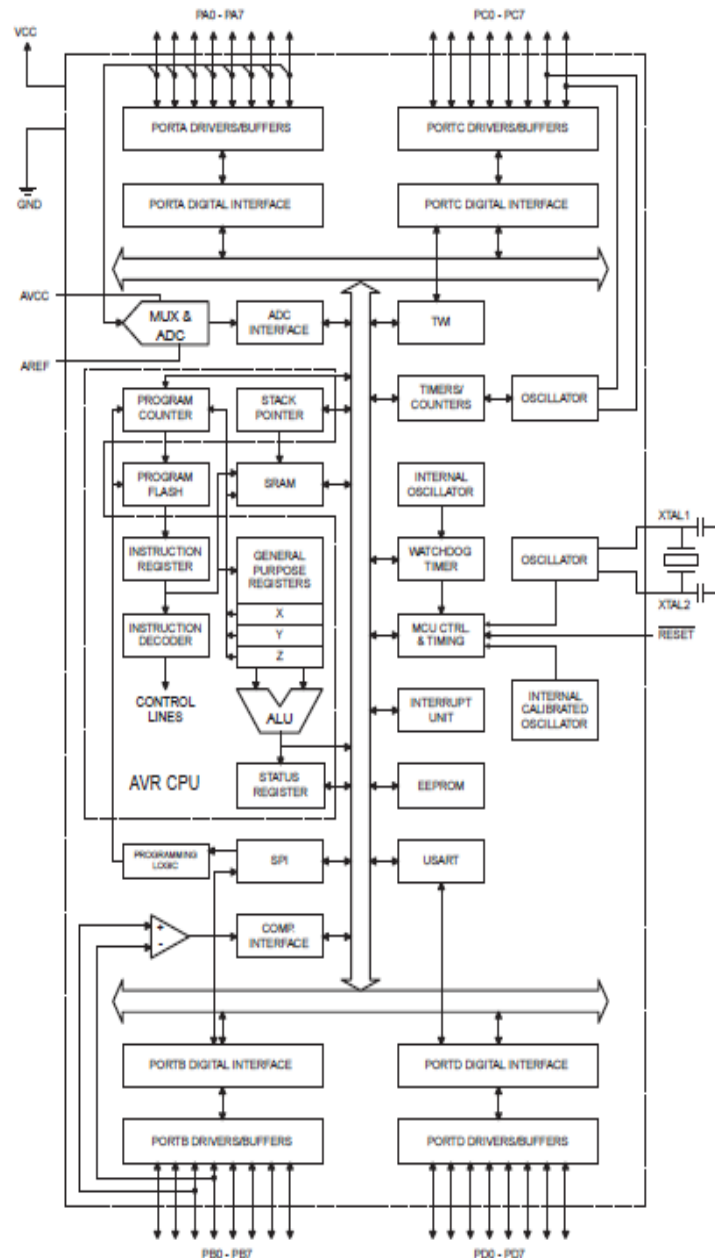
Typical values contained in this datasheet are based on simulations and characterization of other AVR microcontrollers manufactured on the same process technology. Min and Max values will be available after the device is characterized.

Overview

The ATmega16 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega16 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

Block Diagram

Figure 2. Block Diagram



The AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers.

The ATmega16 provides the following features: 16 Kbytes of In-System Programmable Flash Program memory with Read-While-Write capabilities, 512 bytes EEPROM, 1 Kbyte SRAM, 32 general purpose I/O lines, 32 general purpose working registers, a JTAG interface for Boundary-scan, On-chip Debugging support and programming, three flexible Timer/Counters with compare modes, Internal and External Interrupts, a serial programmable USART, a byte oriented Two-wire Serial Interface, an 8-channel, 10-bit ADC with optional differential input stage with programmable gain (TQFP package only), a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and six software selectable power saving modes. The Idle mode stops the CPU while allowing the USART, Two-wire interface, A/D Converter, SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next External Interrupt or Hardware Reset. In Power-save mode, the Asynchronous Timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except Asynchronous Timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low-power consumption. In Extended Standby mode, both the main Oscillator and the Asynchronous Timer continue to run.

The device is manufactured using Atmel's high density nonvolatile memory technology. The On-chip ISP Flash allows the program memory to be reprogrammed in-system through an SPI serial interface, by a conventional nonvolatile memory programmer, or by an On-chip Boot program running on the AVR core. The boot program can use any interface to download the application program in the Application Flash memory. Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega16 is a powerful microcontroller that provides a highly-flexible and cost-effective solution to many embedded control applications.

The ATmega16 AVR is supported with a full suite of program and system development tools including: C compilers, macro assemblers, program debugger/simulators, in-circuit emulators, and evaluation kits.

Pin Descriptions

VCC Digital supply voltage.

GND Ground.

Port A (PA7..PA0) Port A serves as the analog inputs to the A/D Converter.

Port A also serves as an 8-bit bi-directional I/O port, if the A/D Converter is not used. Port pins can provide internal pull-up resistors (selected for each bit). The Port A output buffers have symmetrical drive characteristics with both high sink and source capability. When pins PA0 to PA7 are used as inputs and are externally pulled low, they will source current if the internal pull-up resistors are activated. The Port A pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port B (PB7..PB0)	Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running. Port B also serves the functions of various special features of the ATmega16 as listed on page 58.
Port C (PC7..PC0)	Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running. If the JTAG interface is enabled, the pull-up resistors on pins PC5(TDI), PC3(TMS) and PC2(TCK) will be activated even if a reset occurs. Port C also serves the functions of the JTAG interface and other special features of the ATmega16 as listed on page 61.
Port D (PD7..PD0)	Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running. Port D also serves the functions of various special features of the ATmega16 as listed on page 63.
$\overline{\text{RESET}}$	Reset Input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running. The minimum pulse length is given in Table 15 on page 38. Shorter pulses are not guaranteed to generate a reset.
XTAL1	Input to the inverting Oscillator amplifier and input to the internal clock operating circuit.
XTAL2	Output from the inverting Oscillator amplifier.
AVCC	AVCC is the supply voltage pin for Port A and the A/D Converter. It should be externally connected to V_{CC}, even if the ADC is not used. If the ADC is used, it should be connected to V_{CC} through a low-pass filter.
AREF	AREF is the analog reference pin for the A/D Converter.

Figure 15. Reset Logic

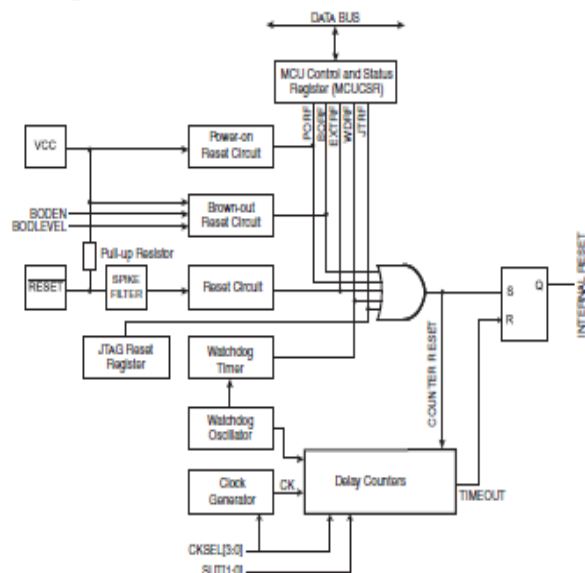


Table 15. Reset Characteristics

Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{POT}	Power-on Reset Threshold Voltage (rising)			1.4	2.3	V
	Power-on Reset Threshold Voltage (falling) ⁽¹⁾			1.3	2.3	
V_{RST}	RESET Pin Threshold Voltage		$0.1V_{CC}$		$0.9V_{CC}$	
t_{RST}	Minimum pulse width on RESET Pin				1.5	μs
V_{BOT}	Brown-out Reset Threshold Voltage ⁽²⁾	BODLEVEL = 1	2.5	2.7	3.2	V
		BODLEVEL = 0	3.6	4.0	4.5	
t_{BOD}	Minimum low voltage period for Brown-out Detection	BODLEVEL = 1		2		μs
		BODLEVEL = 0		2		
V_{HYS}	Brown-out Detector hysteresis			50		mV

- Notes:
1. The Power-on Reset will not work unless the supply voltage has been below V_{POT} (falling).
 2. V_{BOT} may be below nominal minimum operating voltage for some devices. For devices where this is the case, the device is tested down to $V_{CC} = V_{BOT}$ during the production test. This guarantees that a Brown-out Reset will occur before V_{CC} drops to a voltage where correct operation of the microcontroller is no longer guaranteed. The test is performed using BODLEVEL = 1 for ATmega16L and BODLEVEL = 0 for ATmega16. BODLEVEL = 1 is not applicable for ATmega16.

TPA81 Thermopile Array

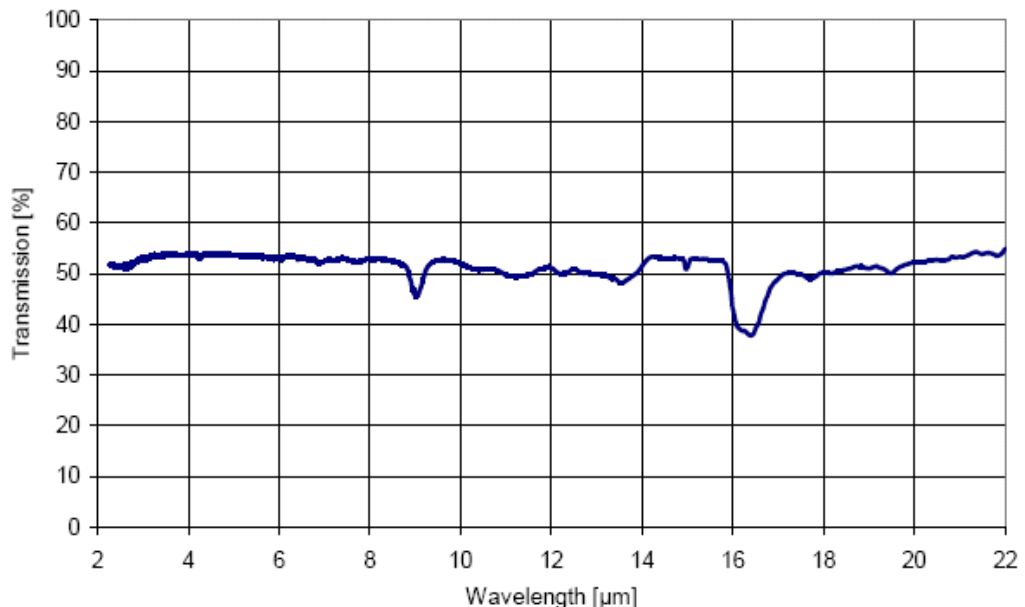
Technical Specification

Introduction

The TPA81 is a thermopile array detecting infra-red in the 2 μ m-22 μ m range. This is the wavelength of radiant heat. The Pyro-electric sensors that are used commonly in burglar alarms and to switch on outside lights, detect infra-red in the same waveband. These Pyro-electric sensors can only detect a change in heat levels though - hence they are movement detectors. Although useful in robotics, their applications are limited as they are unable to detect and measure the temperature of a static heat source. Another type of sensor is the thermopile array. These are used in non-contact infra-red thermometers. They have a very wide detection angle or field of view (FOV) of around 100° and need either shrouding or a lens or commonly both to get a more useful FOV of around 12°. Some have a built in lens. More recently sensors with an array of thermopiles, built in electronics and a silicon lens have become available. This is the type used in the TPA81. It has a array of eight thermopiles arranged in a row. The TPA81 can measure the temperature of 8 adjacent points simultaneously. The TPA81 can also control a servo to pan the module and build up a thermal image. The TPA81 can detect a candle flame at a range 2 metres (6ft) and is unaffected by ambient light!

Spectral Response

The response of the TPA81 is typically 2 μ m to 22 μ m and is shown below:



Field of View (FOV)

The typical field of view of the TPA81 is 41° by 6° making each of the eight pixels 5.12° by 6°. The array of eight pixels is orientated along the length of the PCB - that's from top to bottom in the diagram below. Pixel number one is nearest the tab on the sensor - or at the bottom in the diagram below.

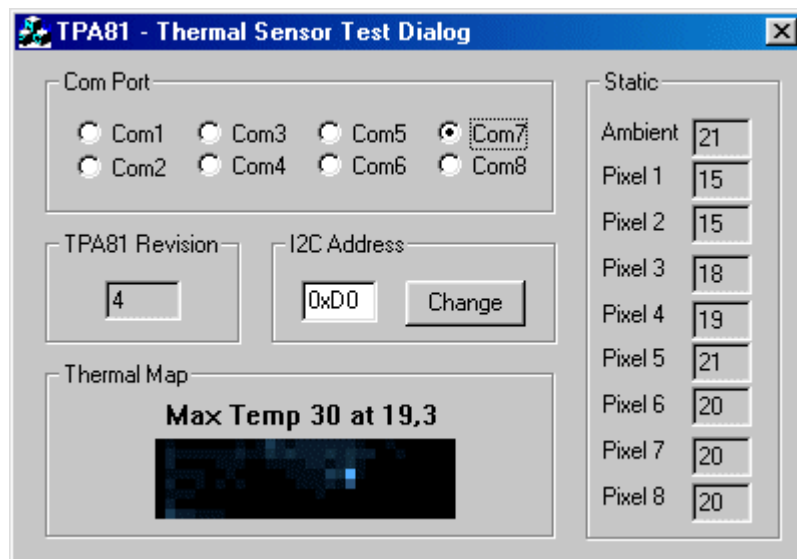
Sensitivity

Here's some numbers from one of our test modules:

For a candle, the numbers for each of the eight pixels at a range of 1 meter in a cool room at 12°C are: 11 10 11 12 12 29 15 13 (All °C). You can see the candle showing up as the 29°C reading. At a range of 2 meters this reduces to 20°C - still around 8°C above ambient and easily detectable. At 0.6 meter (2ft) its around 64°C. At 0.3 meter (1ft) its 100°C+.

In a warmer room at 18°C, the candle measures 27°C at 2 meters. This is because the candle only occupies a small part of the sensors field of view and the candles point heat source is added to the back ground ambient - not swamped by it. A human at 2 meters will show up as around 29°C with a background 20°C ambient.

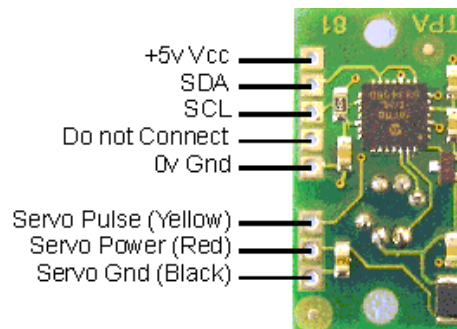
The following is a snapshot of our test program. It displays a 32x8 bitmap produced by using a servo to pan the sensor. If you want a copy of this windows based program, [its here](#), but you will need an RF04/CM02 to connect the TPA81 to your PC. Here you can see a candle flame about a meter away showing up as the bright spot.



Connections

All communication with the TPA81 is via the I2C bus. If you are unfamiliar with the I2C bus, there is a [tutorial](#) which will help. The TPA81 uses our standard I2C 5 pin connection layout. The "Do Not Connect" pin should be left unconnected. It is actually the CPU MCLR line and is used once only in our workshop to program the PIC16F88 on-board after assembly, and has an internal pull-up resistor. The

SCL and SDA lines should each have a pull-up resistor to +5v somewhere on the I2C bus. You only need one pair of resistors, not a pair for every module. They are normally located with the bus master rather than the slaves. The TPA81 is always a slave - never a bus master. If you need them, I recommend 1.8k resistors. Some modules such as the OOPic already have pull-up resistors and you do not need to add any more. A servo port will connect directly to a standard RC servo and is powered from the modules 5v supply. We use an HS311. Commands can be sent to the TPA81 to position the servo, the servo pulses are generated by the TPA81 module.



Registers

The TPA81 appears as a set of 10 registers.

Register	Read	Write
0	Software Revision	Command Register
1	Ambient Temperature °C	Servo Range (V6 or higher only)
2	Pixel 1 Temperature °C	N/A
3	Pixel 2	N/A
4	Pixel 3	N/A
5	Pixel 4	N/A
6	Pixel 5	N/A
7	Pixel 6	N/A
8	Pixel 7	N/A
9	Pixel 8	N/A

Only registers 0, and 1 can be written to. Register 0 is the command register and is used to set the servo position and also when changing the TPA81's I2C address. It cannot be read. Reading from register 0 returns the TPA81 software revision. Writing to register 1 sets the servo range - see below. It cannot be read back, reading register 1 reads the ambient temperature.

There are 9 temperature readings available, all in degrees centigrade (°C). Register 1 is the ambient temperature as measured within the sensor. Registers 2-9 are the 8 pixel temperatures. Temperature acquisition is continuously performed and the readings will be correct approx 40mS after the sensor points to a new position.

Servo Position

Commands 0 to 30 set the servo position. There are 31 steps (0-30) which typically represent 180° rotation on a Hitec HS311 servo. The calculation is $SERVO_POS * 60 + 540\mu S$. So the range of the servo pulse is 0.54mS to 2.34mS in 60uS steps. Writing any other value to the command register will stop the servo pulses.

Command		Action
Decimal	Hex	
0	0x00	Set servo position to minimum
nn	nn	Set servo position
31	0x1F	Set servo position to maximum
160	0xA0	1st in sequence to change I2C address
165	0xA5	3rd in sequence to change I2C address
170	0xAA	2nd in sequence to change I2C address

Firmware Version 6 or higher.

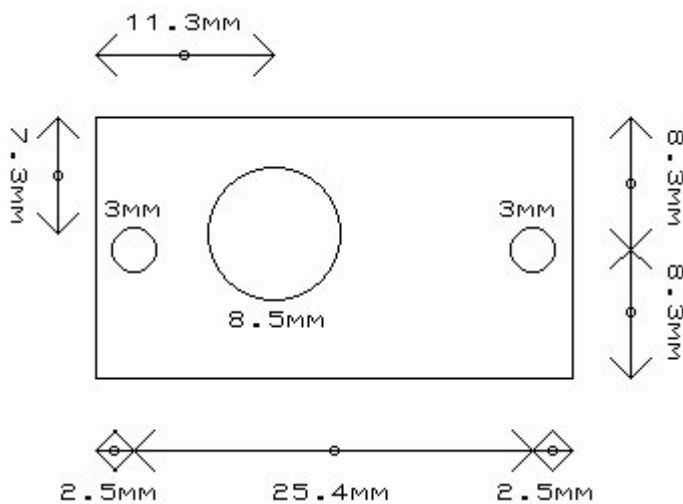
As from Version 6 (March 2005) we have added a new write only register (register 1) to allow you to vary the range of the servo stepping. It defaults to the same 180 degree range on a Hitec HS311 servo as earlier versions. You can write values from 20 to 120 to the range register. If you attempt to write a value less than 20, it will be set to 20. If you attempt to write a value greater than 120, it will be set to 120. The calculation for the range in uS is $((31 * ServoRange) / 2)$. Setting a range of 20 will give a range of $(31 * 20) / 2$ or 310uS. Setting a range of 120 will give a range of $(31 * 120) / 2$ or 1860uS. In all cases the available range is centered on the servo's mid position of 1500uS. So in the first example, the 310uS range will be from 1345uS to 1655uS (Or 1.345 to 1.655mS if you prefer). The second example of 1860uS range centered on 1500uS gives a range of 570uS to 2430uS. On power up the range register is set to 120, which give the same range as earlier versions.

Changing the I2C Bus Address

To change the I2C address of the TPA81 you must have only one module on the bus. Write the 3 sequence commands in the correct order followed by the address. Example; to change the address of a TPA81 currently at 0xD0 (the default shipped address) to 0xD2, write the following to address 0xD0; (0xA0, 0xAA, 0xA5, 0xD2). These commands must be sent in the correct sequence to change the I2C address, additionally, No other command may be issued in the

middle of the sequence. The sequence must be sent to the command register at location 0, which means 4 separate write transactions on the I2C bus. Additionally, there MUST be a delay of at least 50uS between the writing of each byte of the address change sequence. When done, you should label the sensor with its address, if you lose track of the module addresses, the only way to find out what it is to search all the addresses one at a time and see which one responds. The TPA81 can be set to any of eight I2C addresses - 0xD0, 0xD2, 0xD4, 0xD6, 0xD8, 0xDA, 0xDC, 0xDE. The factory default shipped address is 0xD0.

Mechanical Layout

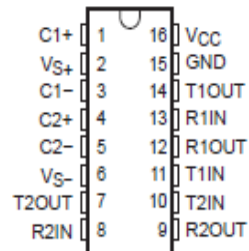


MAX232, MAX232I DUAL EIA-232 DRIVERS/RECEIVERS

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- Meets or Exceeds TIA/EIA-232-F and ITU Recommendation V.28
- Operates From a Single 5-V Power Supply With 1.0- μ F Charge-Pump Capacitors
- Operates Up To 120 kbit/s
- Two Drivers and Two Receivers
- ± 30 -V Input Levels
- Low Supply Current . . . 8 mA Typical
- ESD Protection Exceeds JESD 22 – 2000-V Human-Body Model (A114-A)
- Upgrade With Improved ESD (15-kV HBM) and 0.1- μ F Charge-Pump Capacitors is Available With the MAX202
- Applications
 - TIA/EIA-232-F, Battery-Powered Systems, Terminals, Modems, and Computers

MAX232 . . . D, DW, N, OR NS PACKAGE
MAX232I . . . D, DW, OR N PACKAGE
(TOP VIEW)



description/ordering information

The MAX232 is a dual driver/receiver that includes a capacitive voltage generator to supply TIA/EIA-232-F voltage levels from a single 5-V supply. Each receiver converts TIA/EIA-232-F inputs to 5-V TTL/CMOS levels. These receivers have a typical threshold of 1.3 V, a typical hysteresis of 0.5 V, and can accept ± 30 -V inputs. Each driver converts TTL/CMOS input levels into TIA/EIA-232-F levels. The driver, receiver, and voltage-generator functions are available as cells in the Texas Instruments LinASIC™ library.

ORDERING INFORMATION

T _A	PACKAGE†	ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	PDIP (N)	Tube of 25	MAX232N
	SOIC (D)	Tube of 40	MAX232D
		Reel of 2500	MAX232DR
	SOIC (DW)	Tube of 40	MAX232DW
		Reel of 2000	MAX232DWR
	SOP (NS)	Reel of 2000	MAX232NSR
-40°C to 85°C	PDIP (N)	Tube of 25	MAX232IN
	SOIC (D)	Tube of 40	MAX232ID
		Reel of 2500	MAX232IDR
	SOIC (DW)	Tube of 40	MAX232IDW
		Reel of 2000	MAX232IDWR

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.



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PRODUCTION DATA Information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

**TEXAS
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1

MAX232, MAX232I **DUAL EIA-232 DRIVERS/RECEIVERS**

SLLS047L – FEBRUARY 1989 – REVISED MARCH 2004

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Input supply voltage range, V_{CC} (see Note 1)	–0.3 V to 6 V
Positive output supply voltage range, V_{S+}	$V_{CC} - 0.3$ V to 15 V
Negative output supply voltage range, V_{S-}	–0.3 V to –15 V
Input voltage range, V_I : Driver	–0.3 V to $V_{CC} + 0.3$ V
Receiver	±30 V
Output voltage range, V_O : T1OUT, T2OUT	$V_{S-} - 0.3$ V to $V_{S+} + 0.3$ V
R1OUT, R2OUT	–0.3 V to $V_{CC} + 0.3$ V
Short-circuit duration: T1OUT, T2OUT	Unlimited
Package thermal impedance, θ_{JA} (see Notes 2 and 3): D package	73°C/W
DW package	57°C/W
N package	67°C/W
NS package	64°C/W
Operating virtual junction temperature, T_J	150°C
Storage temperature range, T_{stg}	–65°C to 150°C

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES: 1. All voltages are with respect to network GND.

2. Maximum power dissipation is a function of $T_J(\text{max})$, θ_{JA} , and T_A . The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(\text{max}) - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.

3. The package thermal impedance is calculated in accordance with JEDEC 51-7.

recommended operating conditions

		MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage	4.5	5	5.5	V
V_{IH}	High-level input voltage (T1IN, T2IN)	2			V
V_{IL}	Low-level input voltage (T1IN, T2IN)			0.8	V
R1IN, R2IN	Receiver input voltage			±30	V
T_A	Operating free-air temperature			0	°C
				70	
				–40	85

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 4 and Figure 4)

PARAMETER	TEST CONDITIONS	MIN	TYP†	MAX	UNIT
I_{CC} Supply current	$V_{CC} = 5.5$ V, All outputs open, $T_A = 25^\circ\text{C}$		8	10	mA

† All typical values are at $V_{CC} = 5$ V and $T_A = 25^\circ\text{C}$.

NOTE 4: Test conditions are C1–C4 = 1 μF at $V_{CC} = 5 \text{ V} \pm 0.5 \text{ V}$.

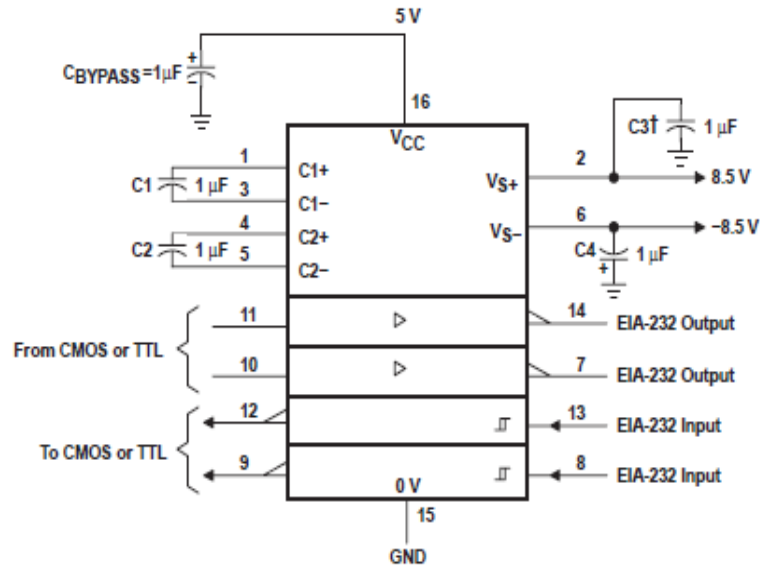


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APPLICATION INFORMATION



† C3 can be connected to V_{CC} or GND.

NOTES: A. Resistor values shown are nominal.

B. Nonpolarized ceramic capacitors are acceptable. If polarized tantalum or electrolytic capacitors are used, they should be connected as shown. In addition to the 1- μ F capacitors shown, the MAX202 can operate with 0.1- μ F capacitors.

Figure 4. Typical Operating Circuit



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