LAMPIRAN A

GAMBAR SISTEM PENJEJAKAN LETAK KENDARAAN BERMOTOR DENGAN MENGGUNAKAN MMS

LAMPIRAN B
PROGRAM MICROCONTROLLER ATMEGA 16

```
/*****************************************************
This program was produced by the
CodeWizardAVR V1.25.3 Standard
Automatic Program Generator
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Project :
Version :
Date    : 1/29/2010
Author  : F4CG
Company : F4CG
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>
unsigned int a,b,c,d,e;

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

// Timer 1 overflow interrupt service routine
interrupt [TIM1_OVF] void timer1_ovf_isr(void)
{
// Place your code here
if(c<1) b=-3;
else if(c<42,5) b=-2;
else if(c<85) b=-1;
else if(c<127,5) b=0;
else if(c<170) b=1;
else if(c<212,5) b=2;
else b=3;
if(d<1) a=0;
```

```
else if(d<14) a=1;
else if(d<28) a=2;
else if(d<42) a=3;
else a=4;
printf("%d#%d",a,b);
d=0;
}

#define ADC_VREF_TYPE 0x20

// Read the 8 most significant bits
// of the AD conversion result
unsigned char read_adc(unsigned char adc_input)
{
ADMUX=adc_input | (ADC_VREF_TYPE & 0xff);
// Start the AD conversion
ADCSRA|=0x40;
// Wait for the AD conversion to complete
while ((ADCSRA & 0x10)==0);
ADCSRA|=0x10;
return ADCH;
}

// Declare your global variables here

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=In Func0=In
// State7=T State6=T State5=T State4=T State3=T State2=T State1=T State0=P
PORTB=0x01;
DDRB=0x00;

// 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: 43.200 kHz
// Mode: Normal top=FFFFh
// OC1A output: Discon.
// OC1B output: Discon.
// Noise Canceler: Off
// Input Capture on Falling Edge
// Timer 1 Overflow Interrupt: On
// Input Capture Interrupt: Off
// Compare A Match Interrupt: Off
// Compare B Match Interrupt: Off
TCCR1A=0x00;
TCCR1B=0x04;
TCNT1H=0x00;
TCNT1L=0x00;
ICR1H=0xA8;
ICR1L=0xC0;
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=0x04;

// 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=0x18;
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;

// ADC initialization
// ADC Clock frequency: 691.200 kHz
// ADC Voltage Reference: AREF pin
// ADC Auto Trigger Source: None
ADMUX=ADC_VREF_TYPE & 0xff;
ADCSRA=0x84;

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

while (1)
      {
      // Place your code here
      PINB.0=e;
```

```
    if(PINB.0!=e) d++;
    while(PINB.0!=e)
    {
    }
    c=read_adc(0);




    };
}
```

LAMPIRAN C
CODE VISUAL BASIC

Form 1

```
‘ mengatur pergerakan mobil
Private Sub Form_Load()
   MSComm1.CommPort = 1
   MSComm1.RThreshold = 20
   MSComm1.SThreshold = 1
   MSComm1.Settings = "115200,n,8,1"
   MSComm1.PortOpen = True
   MSComm1.DTREnable = True

   rtb.Text = ""
End Sub

Private Sub MSComm1_OnComm()
   Dim SEMENTARA As Variant

SEMENTARA = MSComm1.Input
   rtb.Text = SEMENTARA

   Data = Split(SEMENTARA, "#")

Private Sub Text1_Change()
Text1.SelStart = 0
Text1.SelLength = Len(Text1.Text)
Text1.SetFocus

End Sub

Private Sub Text2_Change()
Dim a, b, c As String

Text2.SelStart = 0
Text2.SelLength = Len(Text1.Text)
Text2.SetFocus

If Text1.Text = 0 Then
Form1.Shape1.Left = Form1.Shape1.Left
Form1.Shape1.Top = Form1.Shape1.Top

ElseIf Text1.Text = 1 Then
```

```
    If Text2.Text = -3 Then
       Form1.Shape1.Left = Form1.Shape1.Left - 50
    ElseIf Text2.Text = -2 Then
       Form1.Shape1.Top = Form1.Shape1.Top - 25
       Form1.Shape1.Left = Form1.Shape1.Left - 50
    ElseIf Text2.Text = -1 Then
       Form1.Shape1.Top = Form1.Shape1.Top - 75
       Form1.Shape1.Left = Form1.Shape1.Left - 50
    ElseIf Text2.Text = 0 Then
       Form1.Shape1.Top = Form1.Shape1.Top - 50
    ElseIf Text2.Text = 1 Then
       Form1.Shape1.Top = Form1.Shape1.Top - 50
       Form1.Shape1.Left = Form1.Shape1.Left + 25
    ElseIf Text2.Text = 2 Then
       Form1.Shape1.Top = Form1.Shape1.Top - 50
       Form1.Shape1.Left = Form1.Shape1.Left + 75
    ElseIf Text2.Text = 3 Then
       Form1.Shape1.Left = Form1.Shape1.Left + 50
    End If
ElseIf Text1.Text = 2 Then
    If Text2.Text = -3 Then
       Form1.Shape1.Left = Form1.Shape1.Left - 50
       Form1.Shape1.Left = Form1.Shape1.Left - 50
    ElseIf Text2.Text = -2 Then
       Form1.Shape1.Top = Form1.Shape1.Top - 25
       Form1.Shape1.Left = Form1.Shape1.Left - 50
       Form1.Shape1.Top = Form1.Shape1.Top - 25
       Form1.Shape1.Left = Form1.Shape1.Left - 50
    ElseIf Text2.Text = -1 Then
       Form1.Shape1.Top = Form1.Shape1.Top - 75
       Form1.Shape1.Left = Form1.Shape1.Left - 50
       Form1.Shape1.Top = Form1.Shape1.Top - 75
       Form1.Shape1.Left = Form1.Shape1.Left - 50
    ElseIf Text2.Text = 0 Then
       Form1.Shape1.Top = Form1.Shape1.Top - 50
       Form1.Shape1.Top = Form1.Shape1.Top - 50
    ElseIf Text2.Text = 1 Then
       Form1.Shape1.Top = Form1.Shape1.Top - 50
       Form1.Shape1.Left = Form1.Shape1.Left + 25
       Form1.Shape1.Top = Form1.Shape1.Top - 50
       Form1.Shape1.Left = Form1.Shape1.Left + 25
    ElseIf Text2.Text = 2 Then
       Form1.Shape1.Top = Form1.Shape1.Top - 50
       Form1.Shape1.Left = Form1.Shape1.Left + 75
       Form1.Shape1.Top = Form1.Shape1.Top - 50
       Form1.Shape1.Left = Form1.Shape1.Left + 75
```

```
    ElseIf Text2.Text = 3 Then
        Form1.Shape1.Left = Form1.Shape1.Left + 50
        Form1.Shape1.Left = Form1.Shape1.Left + 50
    End If
ElseIf Text1.Text = 3 Then
    If Text2.Text = -3 Then
        Form1.Shape1.Left = Form1.Shape1.Left - 50
        Form1.Shape1.Left = Form1.Shape1.Left - 50
        Form1.Shape1.Left = Form1.Shape1.Left - 50
    ElseIf Text2.Text = -2 Then
        Form1.Shape1.Top = Form1.Shape1.Top - 25
        Form1.Shape1.Left = Form1.Shape1.Left - 50
        Form1.Shape1.Top = Form1.Shape1.Top - 25
        Form1.Shape1.Left = Form1.Shape1.Left - 50
        Form1.Shape1.Top = Form1.Shape1.Top - 25
        Form1.Shape1.Left = Form1.Shape1.Left - 50
    ElseIf Text2.Text = -1 Then
        Form1.Shape1.Top = Form1.Shape1.Top - 75
        Form1.Shape1.Left = Form1.Shape1.Left - 50
        Form1.Shape1.Top = Form1.Shape1.Top - 75
        Form1.Shape1.Left = Form1.Shape1.Left - 50
        Form1.Shape1.Top = Form1.Shape1.Top - 75
        Form1.Shape1.Left = Form1.Shape1.Left - 50
    ElseIf Text2.Text = 0 Then
        Form1.Shape1.Top = Form1.Shape1.Top - 50
        Form1.Shape1.Top = Form1.Shape1.Top - 50
        Form1.Shape1.Top = Form1.Shape1.Top - 50
    ElseIf Text2.Text = 1 Then
        Form1.Shape1.Top = Form1.Shape1.Top - 50
        Form1.Shape1.Left = Form1.Shape1.Left + 25
        Form1.Shape1.Top = Form1.Shape1.Top - 50
        Form1.Shape1.Left = Form1.Shape1.Left + 25
        Form1.Shape1.Top = Form1.Shape1.Top - 50
        Form1.Shape1.Left = Form1.Shape1.Left + 25
    ElseIf Text2.Text = 2 Then
        Form1.Shape1.Top = Form1.Shape1.Top - 50
        Form1.Shape1.Left = Form1.Shape1.Left + 75
        Form1.Shape1.Top = Form1.Shape1.Top - 50
        Form1.Shape1.Left = Form1.Shape1.Left + 75
        Form1.Shape1.Top = Form1.Shape1.Top - 50
        Form1.Shape1.Left = Form1.Shape1.Left + 75
    ElseIf Text2.Text = 3 Then
        Form1.Shape1.Left = Form1.Shape1.Left + 50
        Form1.Shape1.Left = Form1.Shape1.Left + 50
        Form1.Shape1.Left = Form1.Shape1.Left + 50
    End If
```

```
ElseIf Text1.Text = 4 Then
   If Text2.Text = -3 Then
      Form1.Shape1.Left = Form1.Shape1.Left - 50
      Form1.Shape1.Left = Form1.Shape1.Left - 50
      Form1.Shape1.Left = Form1.Shape1.Left - 50
      Form1.Shape1.Left = Form1.Shape1.Left - 50
   ElseIf Text2.Text = -2 Then
      Form1.Shape1.Top = Form1.Shape1.Top - 25
      Form1.Shape1.Left = Form1.Shape1.Left - 50
      Form1.Shape1.Top = Form1.Shape1.Top - 25
      Form1.Shape1.Left = Form1.Shape1.Left - 50
      Form1.Shape1.Top = Form1.Shape1.Top - 25
      Form1.Shape1.Left = Form1.Shape1.Left - 50
      Form1.Shape1.Top = Form1.Shape1.Top - 25
      Form1.Shape1.Left = Form1.Shape1.Left - 50
   ElseIf Text2.Text = -1 Then
      Form1.Shape1.Top = Form1.Shape1.Top - 75
      Form1.Shape1.Left = Form1.Shape1.Left - 50
      Form1.Shape1.Top = Form1.Shape1.Top - 75
      Form1.Shape1.Left = Form1.Shape1.Left - 50
      Form1.Shape1.Top = Form1.Shape1.Top - 75
      Form1.Shape1.Left = Form1.Shape1.Left - 50
      Form1.Shape1.Top = Form1.Shape1.Top - 75
      Form1.Shape1.Left = Form1.Shape1.Left - 50
   ElseIf Text2.Text = 0 Then
      Form1.Shape1.Top = Form1.Shape1.Top - 50
      Form1.Shape1.Top = Form1.Shape1.Top - 50
      Form1.Shape1.Top = Form1.Shape1.Top - 50
      Form1.Shape1.Top = Form1.Shape1.Top - 50
   ElseIf Text2.Text = 1 Then
      Form1.Shape1.Top = Form1.Shape1.Top - 50
      Form1.Shape1.Left = Form1.Shape1.Left + 25
      Form1.Shape1.Top = Form1.Shape1.Top - 50
      Form1.Shape1.Left = Form1.Shape1.Left + 25
      Form1.Shape1.Top = Form1.Shape1.Top - 50
      Form1.Shape1.Left = Form1.Shape1.Left + 25
      Form1.Shape1.Top = Form1.Shape1.Top - 50
      Form1.Shape1.Left = Form1.Shape1.Left + 25
   ElseIf Text2.Text = 2 Then
      Form1.Shape1.Top = Form1.Shape1.Top - 50
      Form1.Shape1.Left = Form1.Shape1.Left + 75
      Form1.Shape1.Top = Form1.Shape1.Top - 50
      Form1.Shape1.Left = Form1.Shape1.Left + 75
      Form1.Shape1.Top = Form1.Shape1.Top - 50
      Form1.Shape1.Left = Form1.Shape1.Left + 75
      Form1.Shape1.Top = Form1.Shape1.Top - 50
```

```
        Form1.Shape1.Left = Form1.Shape1.Left + 75
    ElseIf Text2.Text = 3 Then
        Form1.Shape1.Left = Form1.Shape1.Left + 50
        Form1.Shape1.Left = Form1.Shape1.Left + 50
        Form1.Shape1.Left = Form1.Shape1.Left + 50
        Form1.Shape1.Left = Form1.Shape1.Left + 50
    End If

End If
End Sub
```

Form 2

```
‘printscreen gambar

Private Function PrintScreen(PictureBox As PictureBox) As Boolean
  On Error GoTo ErrorTrap
  Clipboard.Clear
  DoEvents

  '0 = layar, 1 = form
  keybd_event vbKeySnapshot, 0, 0&, 0&

  DoEvents
  Set PictureBox.Picture = Clipboard.GetData(0)
  DoEvents
  'Clipboard.Clear
  PrintScreen = True

ErrorTrap:
End Function

Private Sub ArrangeScrollBars()
  Dim have_wid As Single, have_hgt As Single
  Dim need_wid As Single, need_hgt As Single
  Dim need_hbar As Boolean, need_vbar As Boolean

  On Error Resume Next
  If WindowState = vbMinimized Then Exit Sub

  need_wid = picInner.Width + (picOuter.Width - picOuter.ScaleWidth)
  need_hgt = picInner.Height + (picOuter.Height - picOuter.ScaleHeight)
  have_wid = picOuter.Width
  have_hgt = picOuter.Height
  need_hbar = (need_wid > have_wid)
  If need_hbar Then have_hgt = have_hgt - HBar.Height
```

```
  need_vbar = (need_hgt > have_hgt)
  If need_vbar Then
    have_wid = have_wid - VBar.Width
    If Not need_hbar Then
      need_hbar = (need_wid > have_wid)
      If need_hbar Then have_hgt = have_hgt - HBar.Height
    End If
  End If

  picOuter.Move picOuter.Left, picOuter.Top, have_wid, have_hgt

  If need_hbar Then
    HBar.Move picOuter.Left, have_hgt, have_wid
    HBar.Min = 0
    HBar.Max = picOuter.ScaleWidth - picInner.Width
    HBar.LargeChange = picOuter.ScaleWidth
    HBar.SmallChange = picOuter.ScaleWidth / 5
    HBar.Visible = True
  Else
    HBar.Visible = False
  End If

  If need_vbar Then
    VBar.Move picOuter.Left + picOuter.Width, picOuter.Top, VBar.Width, have_hgt
    VBar.Min = 0
    VBar.Max = picOuter.ScaleHeight - picInner.Height
    VBar.LargeChange = picOuter.ScaleHeight
    VBar.SmallChange = picOuter.ScaleHeight / 5
    VBar.Visible = True
  Else
    VBar.Visible = False
  End If


End Sub


Private Sub Timer1_Timer()
Dim tekan As Integer


'1. capture gambar
SaveFormImageToFile Form1, Picture1, "C:\MMS.bmp"
'ubah format bmp ke jpeg
PicFormat321.SaveBmpToJpeg "C:\MMS.bmp", "C:\MMS.jpg", "65"
```

```
' kirim MMS:
 MousePointer = vbHourglass
   TextResult.Text = ""

   ' Device Properties
   objMm1Protocol.Device = ComboDevice.Text

   ' Server Properties
   objMm1Protocol.ProviderMMSC = "http://mmsc.indosat.com"
   objMm1Protocol.ProviderAPN = "indosatmms"
   objMm1Protocol.ProviderWAPGateway = "010.019.019.019"
   objMm1Protocol.ProviderAPNAccount = "indosat"
   objMm1Protocol.ProviderAPNPassword = "indosat"

   'LogFile
   objMm1Protocol.LogFile = TextLogfile.Text

   'Message Properties

   objMmsMessage.Clear
   objMmsMessage.AddRecipient Text3.Text        'kirim ke nomor tujuan
   objMmsMessage.Subject = "MMS"

   objMmsSlide.Duration = 5
   objMmsSlide.AddAttachment "c:\MMS.jpg"
   objMmsSlide.AddText
   objMmsMessage.AddSlide objMmsSlide

   objMm1Protocol.Connect

   TextResult.Text = "ERROR #" & objMm1Protocol.LastError & " : " &
objMm1Protocol.GetErrorDescription(objMm1Protocol.LastError)
   TextResponse.Text = objMm1Protocol.ProviderResponse

   If (objMm1Protocol.LastError = 0) Then

      objMm1Protocol.Send objMmsMessage

      TextResult.Text = "ERROR #" & objMm1Protocol.LastError & " : " &
objMm1Protocol.GetErrorDescription(objMm1Protocol.LastError)
      TextResponse.Text = objMm1Protocol.ProviderResponse

      objMm1Protocol.Disconnect
   End If
```

```
    MousePointer = vbDefault

End Select

End Sub
```

LAMPIRAN D
DATA SHEET

FAIRCHILD
SEMICONDUCTOR®

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MC78XX/LM78XX/MC78XXA

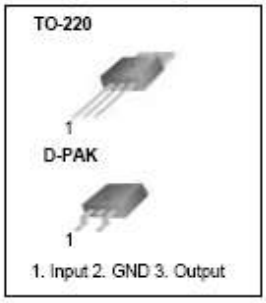
3-Terminal 1A Positive Voltage Regulator

Features

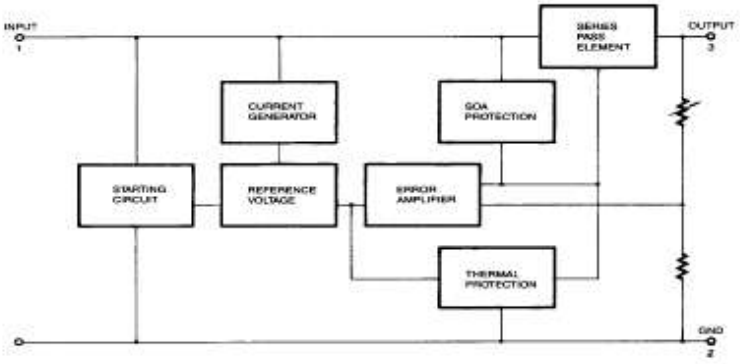
- Output Current up to 1A
- Output Voltages of 5, 6, 8, 9, 10, 12, 15, 18, 24V
- Thermal Overload Protection
- Short Circuit Protection
- Output Transistor Safe Operating Area Protection

Description

The MC78XX/LM78XX/MC78XXA series of three terminal positive regulators are available in the TO-220/D-PAK package and with several fixed output voltages, making them useful in a wide range of applications. Each type employs internal current limiting, thermal shut down and safe operating area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.



Internal Block Digram



Rev. 1.0.1

Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Input Voltage (for V_O = 5V to 18V) (for V_O = 24V)	V_I V_I	35 40	V V
Thermal Resistance Junction-Cases (TO-220)	$R_{\theta JC}$	5	°C/W
Thermal Resistance Junction-Air (TO-220)	$R_{\theta JA}$	65	°C/W
Operating Temperature Range	TOPR	0 ~ +125	°C
Storage Temperature Range	TSTG	-65 ~ +150	°C

Electrical Characteristics (MC7805/LM7805)

(Refer to test circuit ,0°C < T_J < 125°C, I_O = 500mA, V_I = 10V, C_I= 0.33µF, C_O= 0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7805/LM7805 Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25 °C		4.8	5.0	5.2	V
		5.0mA ≤ Io ≤ 1.0A, P_O ≤ 15W V_I = 7V to 20V		4.75	5.0	5.25	
Line Regulation (Note1)	Regline	T_J=+25 °C	V_O = 7V to 25V	-	4.0	100	mV
			V_I = 8V to 12V	-	1.6	50	
Load Regulation (Note1)	Regload	T_J=+25 °C	IO = 5.0mA to1.5A	-	9	100	mV
			I_O =250mA to 750mA	-	4	50	
Quiescent Current	IQ	T_J =+25 °C		-	5.0	8.0	mA
Quiescent Current Change	ΔIQ	I_O = 5mA to 1.0A		-	0.03	0.5	mA
		V_I= 7V to 25V		-	0.3	1.3	
Output Voltage Drift	ΔVO/ΔT	I_O= 5mA		-	-0.8	-	mV/ °C
Output Noise Voltage	VN	f = 10Hz to 100KHz, T_A=+25 °C		-	42	-	µV/Vo
Ripple Rejection	RR	f = 120Hz V_O = 8V to 18V		62	73	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J =+25 °C		-	2	-	V
Output Resistance	rO	f = 1KHz		-	15	-	mΩ
Short Circuit Current	ISC	V_I = 35V, T_A =+25 °C		-	230	-	mA
Peak Current	IPK	T_J =+25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Changes in V_o due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7805A)

(Refer to the test circuits. 0°C < T_J < 125°C, I_O =1A, V_I = 10V, C_I=0.33µF, C_O=0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit
Output Voltage	VO	T_J =+25 °C		4.9	5	5.1	V
		I_O = 5mA to 1A, P_O ≤ 15W V_I = 7.5V to 20V		4.8	5	5.2	
Line Regulation (Note1)	Regline	V_I = 7.5V to 25V I_O = 500mA		-	5	50	mV
		V_I = 8V to 12V		-	3	50	
		T_J =+25 °C	V_I= 7.3V to 20V	-	5	50	
			V_I= 8V to 12V	-	1.5	25	
Load Regulation (Note1)	Regload	T_J =+25 °C I_O = 5mA to 1.5A		-	9	100	mV
		I_O = 5mA to 1A		-	9	100	
		I_O = 250mA to 750mA		-	4	50	
Quiescent Current	IQ	T_J =+25 °C		-	5.0	8	mA
Quiescent Current Change	ΔIQ	I_O = 5mA to 1A		-	-	0.5	mA
		V_I = 8 V to 25V, I_O = 500mA		-	-	0.8	
		V_I = 7.5V to 20V, T_J =+25 °C		-	-	0.8	
Output Voltage Drift	ΔV/ΔT	Io = 5mA		-	-0.8	-	mV/ °C
Output Noise Voltage	VN	f = 10Hz to 100KHz T_A =+25 °C		-	10	-	µV/Vo
Ripple Rejection	RR	f = 120Hz, I_O = 500mA V_I = 8V to 18V		-	68	-	dB
Dropout Voltage	VDrop	I_O = 1A, T_J =+25 °C		-	2	-	V
Output Resistance	rO	f = 1KHz		-	17	-	mΩ
Short Circuit Current	ISC	V_I= 35V, T_A =+25 °C		-	250	-	mA
Peak Current	IPK	T_J= +25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Change in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Typical Perfomance Characteristics

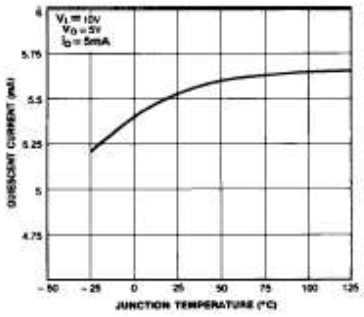


Figure 1. Quiescent Current

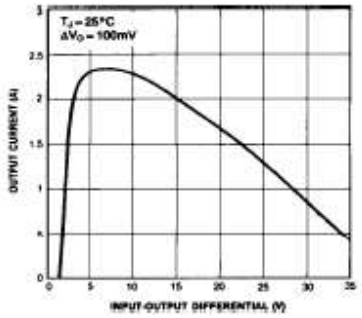


Figure 2. Peak Output Current

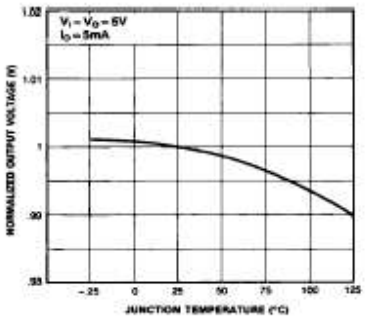


Figure 3. Output Voltage

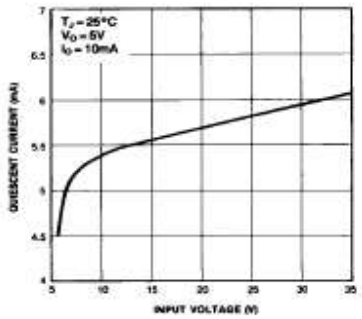


Figure 4. Quiescent Current

Typical Applications

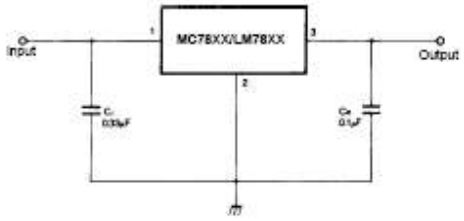


Figure 5. DC Parameters

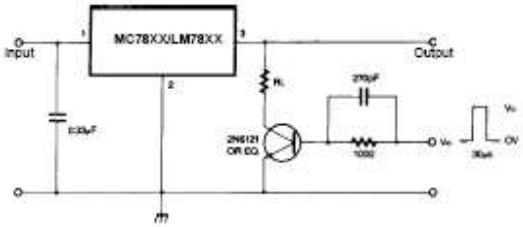


Figure 6. Load Regulation

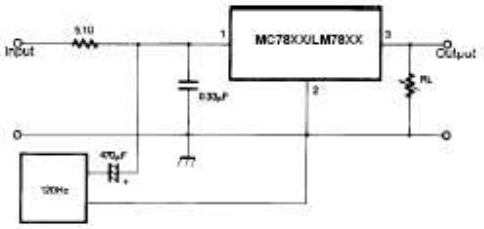


Figure 7. Ripple Rejection

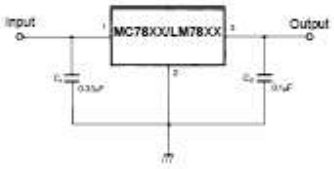
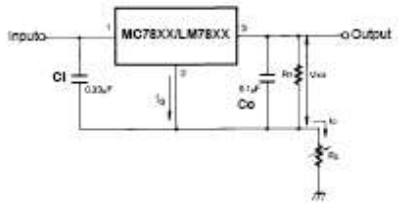


Figure 8. Fixed Output Regulator



$$I_o = \frac{V_{xx}}{R1} + I_Q$$

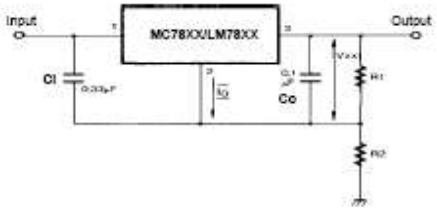
Figure 9. Constant Current Regulator

Notes:

(1) To specify an output voltage. substitute voltage value for "XX." A common ground is required between the input and the Output voltage. The input voltage must remain typically 2.0V above the output voltage even during the low point on the input ripple voltage.

(2) C_I is required if regulator is located an appreciable distance from power Supply filter.

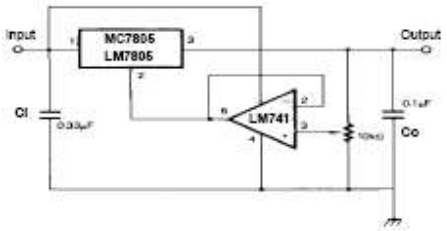
(3) C_O improves stability and transient response.



$$I_{R1} \geq 5IQ$$

$$V_O = V_{XX}(1+R_2/R_1)+I_QR_2$$

Figure 10. Circuit for Increasing Output Voltage



$$I_{R1} \geq 5\ I_Q$$

$$V_O = V_{XX}(1+R_2/R_1)+I_QR_2$$

Figure 11. Adjustable Output Regulator (7 to 30V)

Ordering Information

Product Number	Output Voltage Tolerance	Package	Operating Temperature
LM7805CT	±4%	TO-220	0 ~ + 125°C

Product Number	Output Voltage Tolerance	Package	Operating Temperature
MC7805CT	±4%	TO-220	0 ~ + 125°C
MC7806CT			
MC7808CT			
MC7809CT			
MC7810CT			
MC7812CT			
MC7815CT			
MC7818CT			
MC7824CT			
MC7805CDT		D-PAK	
MC7806CDT			
MC7808CDT			
MC7809CDT			
MC7810CDT			
MC7812CDT			
MC7805ACT	±2%	TO-220	
MC7806ACT			
MC7808ACT			
MC7809ACT			
MC7810ACT			
MC7812ACT			
MC7815ACT			
MC7818ACT			
MC7824ACT			

19-4323; Rev 15; 1/06

MAXIM

+5V-Powered, Multichannel RS-232 Drivers/Receivers

General Description

The MAX220–MAX249 family of line drivers/receivers is intended for all EIA/TIA-232E and V.28/V.24 communications interfaces, particularly applications where ±12V is not available.

These parts are especially useful in battery-powered systems, since their low-power shutdown mode reduces power dissipation to less than 5µW. The MAX225, MAX233, MAX235, and MAX245/MAX246/MAX247 use no external components and are recommended for applications where printed circuit board space is critical.

Applications

Portable Computers

Low-Power Modems

Interface Translation

Battery-Powered RS-232 Systems

Multidrop RS-232 Networks

AutoShutdown and UCSP are trademarks of Maxim Integrated Products, Inc.

Next-Generation Device Features

- **For Low-Voltage, Integrated ESD Applications MAX3222E/MAX3232E/MAX3237E/MAX3241E/ MAX3246E: +3.0V to +5.5V, Low-Power, Up to 1Mbps, True RS-232 Transceivers Using Four 0.1µF External Capacitors (MAX3246E Available in a UCSP™ Package)**
- **For Low-Cost Applications MAX221E: ±15kV ESD-Protected, +5V, 1µA, Single RS-232 Transceiver with AutoShutdown™**

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX220CPE	0°C to +70°C	16 Plastic DIP
MAX220CSE	0°C to +70°C	16 Narrow SO
MAX220CWE	0°C to +70°C	16 Wide SO
MAX220C/D	0°C to +70°C	Dice*
MAX220EPE	-40°C to +85°C	16 Plastic DIP
MAX220ESE	-40°C to +85°C	16 Narrow SO
MAX220EWE	-40°C to +85°C	16 Wide SO
MAX220EJE	-40°C to +85°C	16 CERDIP
MAX220MJE	-55°C to +125°C	16 CERDIP

Ordering Information continued at end of data sheet.

**Contact factory for dice specifications.*

Selection Table

Part Number	Power Supply (V)	No. of RS-232 Drivers/Rx	No. of Ext. Caps	Nominal Cap. Value (µF)	SHDN & Three-State	Rx Active in SHDN	Data Rate (kbps)	Features
MAX220	+5	2/2	4	0.047/0.33	No	—	120	Ultra-low-power, industry-standard pinout
MAX222	+5	2/2	4	0.1	Yes	—	200	Low-power shutdown
MAX223 (MAX213)	+5	4/5	4	1.0 (0.1)	Yes	✔	120	MAX241 and receivers active in shutdown
MAX225	+5	5/5	0	—	Yes	✔	120	Available in SO
MAX230 (MAX200)	+5	5/0	4	1.0 (0.1)	Yes	—	120	5 drivers with shutdown
MAX231 (MAX201)	+5 and +7.5 to +13.2	2/2	2	1.0 (0.1)	No	—	120	Standard +5/+12V or battery supplies; same functions as MAX232
MAX232 (MAX202)	+5	2/2	4	1.0 (0.1)	No	—	120 (64)	Industry standard
MAX232A	+5	2/2	4	0.1	No	—	200	Higher slew rate, small caps
MAX233 (MAX203)	+5	2/2	0	—	No	—	120	No external caps
MAX233A	+5	2/2	0	—	No	—	200	No external caps, high slew rate
MAX234 (MAX204)	+5	4/0	4	1.0 (0.1)	No	—	120	Replaces 1488
MAX235 (MAX205)	+5	5/5	0	—	Yes	—	120	No external caps
MAX236 (MAX206)	+5	4/3	4	1.0 (0.1)	Yes	—	120	Shutdown, three state
MAX237 (MAX207)	+5	5/3	4	1.0 (0.1)	No	—	120	Complements IBM PC serial port
MAX238 (MAX208)	+5	4/4	4	1.0 (0.1)	No	—	120	Replaces 1488 and 1489
MAX239 (MAX209)	+5 and +7.5 to +13.2	3/5	2	1.0 (0.1)	No	—	120	Standard +5/+12V or battery supplies; single-package solution for IBM PC serial port
MAX240	+5	5/5	4	1.0	Yes	—	120	DIP or flatpack package
MAX241 (MAX211)	+5	4/5	4	1.0 (0.1)	Yes	—	120	Complete IBM PC serial port
MAX242	+5	2/2	4	0.1	Yes	✔	200	Separate shutdown and enable
MAX243	+5	2/2	4	0.1	No	—	200	Open-line detection simplifies cabling
MAX244	+5	8/10	4	1.0	No	—	120	High slew rate
MAX245	+5	8/10	0	—	Yes	✔	120	High slew rate, int. caps, two shutdown modes
MAX246	+5	8/10	0	—	Yes	✔	120	High slew rate, int. caps, three shutdown modes
MAX247	+5	8/9	0	—	Yes	✔	120	High slew rate, int. caps, nine operating modes
MAX248	+5	8/8	4	1.0	Yes	✔	120	High slew rate, selective half-chip enables
MAX249	+5	6/10	4	1.0	Yes	✔	120	Available in quad flatpack package

+5V-Powered, Multichannel RS-232 Drivers/Receivers

ABSOLUTE MAXIMUM RATINGS—MAX220/222/232A/233A/242/243

Supply Voltage (V_{CC}) ..... -0.3V to +6V
V+ (Note 1) ..... (V_{CC} - 0.3V) to +14V
V- (Note 1) ..... +0.3V to +14V
Input Voltages
T_{IN} ..... -0.3V to (V_{CC} - 0.3V)
R_{IN} (Except MAX220) ..... ±30V
R_{IN} (MAX220) ..... ±25V
T_{OUT} (Except MAX220) (Note 2) ..... ±15V
T_{OUT} (MAX220) ..... ±13.2V
Output Voltages
T_{OUT} ..... ±15V
R_{OUT} ..... -0.3V to (V_{CC} + 0.3V)
Driver/Receiver Output Short Circuited to GND ..... Continuous
Continuous Power Dissipation (T_A = +70°C)
16-Pin Plastic DIP (derate 10.53mW/°C above +70°C) ..842mW
18-Pin Plastic DIP (derate 11.11mW/°C above +70°C) ..889mW
20-Pin Plastic DIP (derate 8.00mW/°C above +70°C) ..440mW
16-Pin Narrow SO (derate 8.70mW/°C above +70°C) ...696mW
16-Pin Wide SO (derate 9.52mW/°C above +70°C) 762mW
18-Pin Wide SO (derate 9.52mW/°C above +70°C) 762mW
20-Pin Wide SO (derate 10.00mW/°C above +70°C) 800mW
20-Pin SSOP (derate 8.00mW/°C above +70°C) 640mW
16-Pin CERDIP (derate 10.00mW/°C above +70°C) 800mW
18-Pin CERDIP (derate 10.53mW/°C above +70°C) 842mW
Operating Temperature Ranges
MAX2__AC_ _, MAX2__C_ _ ..... 0°C to +70°C
MAX2__AE_ _, MAX2__E_ _ ..... -40°C to +85°C
MAX2__AM_ _, MAX2__M_ _ ..... -55°C to +125°C
Storage Temperature Range ..... -65°C to +160°C
Lead Temperature (soldering, 10s) (Note 3) ..... +300°C

Note 1: For the MAX220, V+ and V- can have a maximum magnitude of 7V, but their absolute difference cannot exceed 13V.
Note 2: Input voltage measured with T_{OUT} in high-impedance state, $\overline{SHDN}$ or V_{CC} = 0V.
Note 3: Maximum reflow temperature for the MAX233A is +225°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 in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS—MAX220/222/232A/233A/242/243

(V_{CC} = +5V ±10%, C1–C4 = 0.1µF, MAX220, C1 = 0.047µF, C2–C4 = 0.33µF, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
RS-232 TRANSMITTERS						
Output Voltage Swing	All transmitter outputs loaded with 3kΩ to GND		±5	±8		V
Input Logic Threshold Low				1.4	0.8	V
Input Logic Threshold High	All devices except MAX220		2	1.4		V
	MAX220: V_{CC} = 5.0V		2.4			
Logic Pullup/Input Current	All except MAX220, normal operation			5	40	µA
	$\overline{SHDN}$ = 0V, MAX222/MAX242, shutdown, MAX220			±0.01	±1	
Output Leakage Current	V_{CC} = 5.5V, $\overline{SHDN}$ = 0V, V_{OUT} = ±15V, MAX222/MAX242			±0.01	±10	µA
	V_{CC} = $\overline{SHDN}$ = 0V	V_{OUT} = ±15V		±0.01	±10	
		MAX220, V_{OUT} = ±12V			±25	
Data Rate				200	116	kbps
Transmitter Output Resistance	V_{CC} = V+ = V- = 0V, V_{OUT} = ±2V		300	10M		Ω
Output Short-Circuit Current	V_{OUT} = 0V	V_{OUT} = 0V	±7	±22		mA
		MAX220			±60	
RS-232 RECEIVERS						
RS-232 Input Voltage Operating Range					±30	V
		MAX220			±25	
RS-232 Input Threshold Low	V_{CC} = 5V	All except MAX243 $R2_{IN}$	0.8	1.3		V
		MAX243 $R2_{IN}$ (Note 4)	-3			
RS-232 Input Threshold High	V_{CC} = 5V	All except MAX243 $R2_{IN}$		1.8	2.4	V
		MAX243 $R2_{IN}$ (Note 4)		-0.5	-0.1	

ELECTRICAL CHARACTERISTICS—MAX220/222/232A/233A/242/243 (continued)

(V_{CC} = +5V ±10%, C1–C4 = 0.1µF, MAX220, C1 = 0.047µF, C2–C4 = 0.33µF, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
RS-232 Input Hysteresis	All except MAX220/MAX243, V_{CC} = 5V, no hysteresis in SHDN		0.2	0.5	1.0	V
	MAX220			0.3		
	MAX243			1		
RS-232 Input Resistance	T_A = +25°C (MAX220)		3	5	7	KΩ
			3	5	7	
TTL/CMOS Output Voltage Low	I_{OUT} = 3.2mA			0.2	0.4	V
	I_{OUT} = 1.6mA (MAX220)				0.4	
TTL/CMOS Output Voltage High	I_{OUT} = -1.0mA		3.5	V_{CC} - 0.2		V
TTL/CMOS Output Short-Circuit Current	Sourcing V_{OUT} = GND		-2	-10		mA
	Shrinking V_{OUT} = V_{CC}		10	30		
TTL/CMOS Output Leakage Current	$\overline{SHDN}$ = V_{CC} or $\overline{EN}$ = V_{CC} ($\overline{SHDN}$ = 0V for MAX222), 0V ≤ V_{OUT} ≤ V_{CC}			±0.05	±10	µA
EN Input Threshold Low	MAX242			1.4	0.8	V
EN Input Threshold High	MAX242		2.0	1.4		V
Operating Supply Voltage			4.5		5.5	V
V_{CC} Supply Current ($\overline{SHDN}$ = V_{CC}), figures 5, 6, 11, 19	No load	MAX220		0.5	2	µA
		MAX222/MAX232A/MAX233A/ MAX242/MAX243		4	10	
	3kΩ load both inputs	MAX220		12		
		MAX222/MAX232A/MAX233A/ MAX242/MAX243		15		
Shutdown Supply Current	MAX222/ MAX242	T_A = +25°C		0.1	10	µA
		T_A = 0°C to +70°C		2	50	
		T_A = -40°C to +85°C		2	50	
		T_A = -55°C to +125°C		35	100	
$\overline{SHDN}$ Input Leakage Current	MAX222/MAX242				±1	µA
$\overline{SHDN}$ Threshold Low	MAX222/MAX242			1.4	0.8	V
$\overline{SHDN}$ Threshold High	MAX222/MAX242		2.0	1.4		V
Transition Slew Rate	C_L = 50pF to 2500pF, R_L = 3kΩ to 7kΩ, V_{CC} = 5V, T_A = +25°C, measured from +3V to -3V or -3V	MAX222/MAX232A/MAX233/ MAX242/MAX243	6	12	30	V/µs
		MAX220	1.5	3	30.0	
Transmitter Propagation Delay TLL to RS-232 (Normal Operation), Figure 1	t_{PHLT}	MAX222/MAX232A/MAX233/ MAX242/MAX243		1.3	3.5	µs
		MAX220		4	10	
	t_{PLHT}	MAX222/MAX232A/MAX233/ MAX242/MAX243		1.5	3.5	
		MAX220		5	10	

Note 4: MAX243 $R2_{OUT}$ is guaranteed to be low when $R2_{IN}$ is ≥ 0V or is floating.

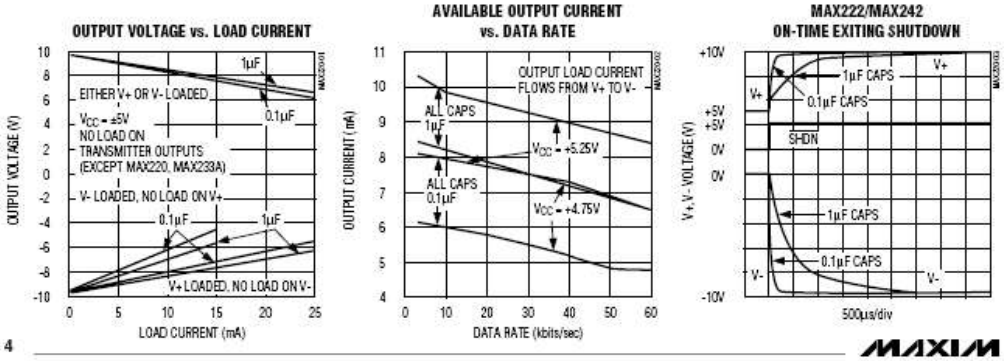
ELECTRICAL CHARACTERISTICS—MAX220/222/232A/233A/242/243 (continued)

(V_{CC} = +5V ±10%, C1–C4 = 0.1µF, MAX220, C1 = 0.047µF, C2–C4 = 0.33µF, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Receiver Propagation Delay RS-232 to TLL (Normal Operation), Figure 2	t_{PHLR}	MAX222/MAX232A/MAX233/ MAX242/MAX243		0.5	1	µs
		MAX220		0.6	3	
	t_{PLHR}	MAX222/MAX232A/MAX233/ MAX242/MAX243		0.6	1	
		MAX220		0.8	3	
Receiver Propagation Delay RS-232 to TLL (Shutdown), Figure 2	t_{PHLS}	MAX242		0.5	10	µs
	t_{PHLS}	MAX242		2.5	10	
Receiver-Output Enable Time, Figure 3	t_{ER}	MAX242		125	500	ns
Receiver-Output Disable Time, Figure 3	t_{DR}	MAX242		160	500	ns
Transmitter-Output Enable Time ($\overline{SHDN}$ Goes High), Figure 4	t_{ET}	MAX222/MAX242, 0.1µF caps (includes charge-pump start-up)		250		µs
Transmitter-Output Disable Time ($\overline{SHDN}$ Goes Low), Figure 4	t_{DT}	MAX222/MAX242, 0.1µF caps		600		ns
Transmitter + to - Propagation Delay Difference (Normal Operation)	t_{PHLT} - t_{PLHT}	MAX222/MAX232A/MAX233/ MAX242/MAX243		300		ns
		MAX220		2000		
Receiver + to - Propagation Delay Difference (Normal Operation)	t_{PHLR} - t_{PLHR}	MAX222/MAX232A/MAX233/ MAX242/MAX243		100		ns
		MAX220		225		

Typical Operating Characteristics

MAX220/MAX222/MAX232A/MAX233A/MAX242/MAX243



Features

- High-performance, Low-power 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
  - 16K Bytes of In-System Self-programmable Flash program memory
  - 512 Bytes EEPROM
  - 1K Byte Internal SRAM
  - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
  - Data retention: 20 years at 85°C/100 years at 25°C
  - 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
  - 2.7 - 5.5V for ATmega16L
  - 4.5 - 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

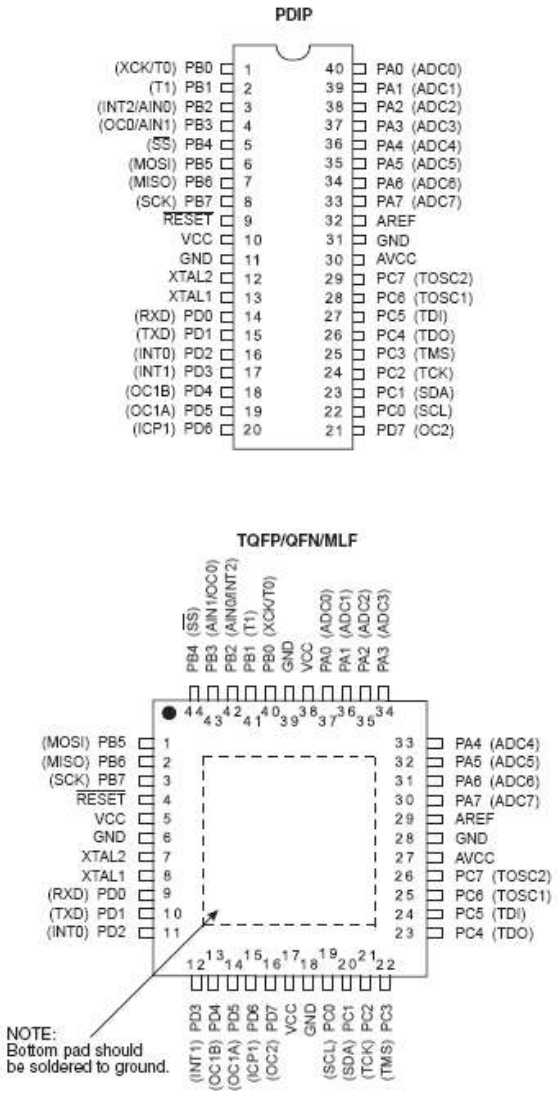
8-bit AVR® Microcontroller with 16K Bytes In-System Programmable Flash

ATmega16
ATmega16L

Summary

Pin Configurations

Figure 1. Pinout ATmega16



Disclaimer

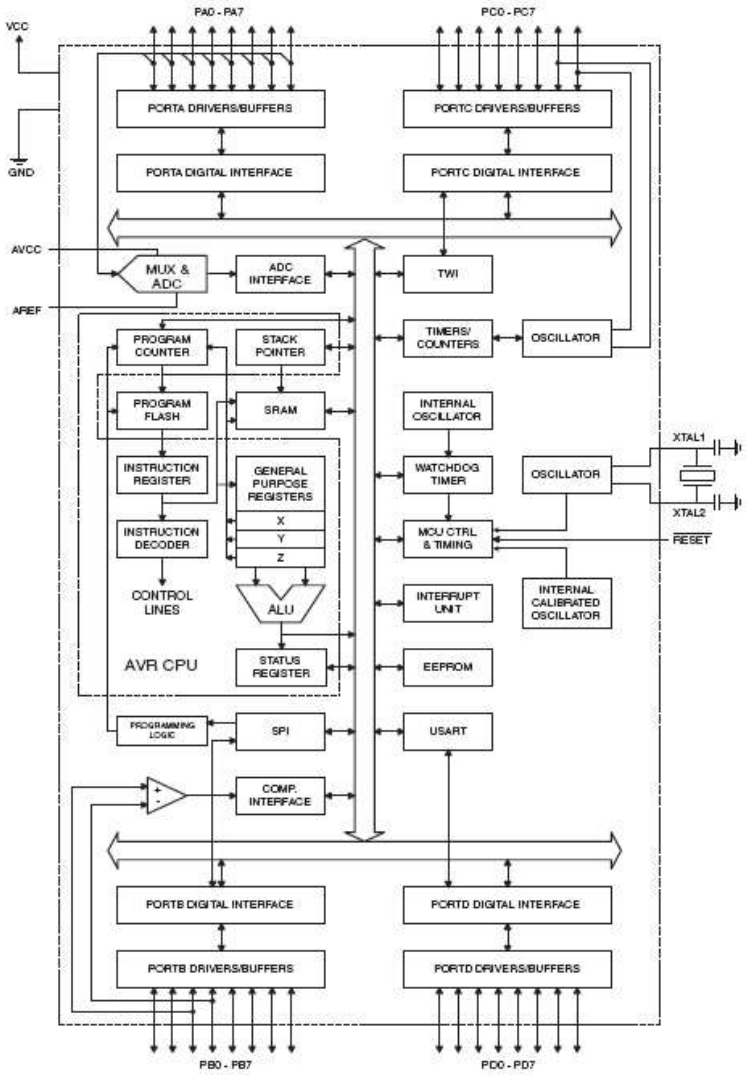
Typical values contained in this datasheet are based on simulations and characterization of other AVR microcontrollers manufactured on the same process technology. Min and Max values will be available after the device is characterized.

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



Register Summary

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
$3F ($5F)	SREG	I	T	H	S	V	N	Z	C	9
$3E ($5E)	SPH	–	–	–	–	–	SP10	SP9	SP8	12
$3D ($5D)	SPL	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0	12
$3C ($5C)	OCR0	Timer/Counter0 Output Compare Register								85
$3B ($5B)	GICR	INT1	INT0	INT2	–	–	–	IVSEL	IVCE	48, 69
$3A ($5A)	GIFR	INTF1	INTF0	INTF2	–	–	–	–	–	70
$39 ($59)	TIMSK	OCIE2	TOIE2	TICIE1	OCIE1A	OCIE1B	TOIE1	OCIE0	TOIE0	85, 115, 133
$38 ($58)	TIFR	OCF2	TOV2	ICF1	OCF1A	OCF1B	TOV1	OCF0	TOV0	86, 115, 133
$37 ($57)	SPMCR	SPMIE	RWWSB	–	RWWSRE	BLBSET	PGWRT	PGERS	SPMEN	250
$36 ($56)	TWCR	TWINT	TWEA	TWSTA	TWSTO	TWWC	TWEN	–	TWIE	180
$35 ($55)	MCUCR	SM2	SE	SM1	SM0	ISC11	ISC10	ISC01	ISC00	32, 68
$34 ($54)	MCUCSR	JTD	ISC2	–	JTRF	WDRF	BORF	EXTRF	PORF	41, 69, 231
$33 ($53)	TCCR0	FOC0	WGM00	COM01	COM00	WGM01	CS02	CS01	CS00	83
$32 ($52)	TCNT0	Timer/Counter0 (8 Bits)								85
$31[1] ($51)[1]	OSCCAL	Oscillator Calibration Register								30
	OCDR	On-Chip Debug Register								227
$30 ($50)	SFIOR	ADTS2	ADTS1	ADTS0	–	ACME	PUD	PSR2	PSR10	57,88,134,201,221
$2F ($4F)	TCCR1A	COM1A1	COM1A0	COM1B1	COM1B0	FOC1A	FOC1B	WGM11	WGM10	110
$2E ($4E)	TCCR1B	ICNC1	ICES1	–	WGM13	WGM12	CS12	CS11	CS10	113
$2D ($4D)	TCNT1H	Timer/Counter1 – Counter Register High Byte								114
$2C ($4C)	TCNT1L	Timer/Counter1 – Counter Register Low Byte								114
$2B ($4B)	OCR1AH	Timer/Counter1 – Output Compare Register A High Byte								114
$2A ($4A)	OCR1AL	Timer/Counter1 – Output Compare Register A Low Byte								114
$29 ($49)	OCR1BH	Timer/Counter1 – Output Compare Register B High Byte								114
$28 ($48)	OCR1BL	Timer/Counter1 – Output Compare Register B Low Byte								114
$27 ($47)	ICR1H	Timer/Counter1 – Input Capture Register High Byte								114
$26 ($46)	ICR1L	Timer/Counter1 – Input Capture Register Low Byte								114
$25 ($45)	TCCR2	FOC2	WGM20	COM21	COM20	WGM21	CS22	CS21	CS20	128
$24 ($44)	TCNT2	Timer/Counter2 (8 Bits)								130
$23 ($43)	OCR2	Timer/Counter2 Output Compare Register								130
$22 ($42)	ASSR	–	–	–	–	AS2	TCN2UB	OCR2UB	TCR2UB	131
$21 ($41)	WDTCR	–	–	–	WDTOE	WDE	WDP2	WDP1	WDP0	43
$20[2] ($40)[2]	UBRRH	URSEL	–	–	–	UBRR[11:8]				167
	UCSRC	URSEL	UMSEL	UPM1	UPM0	USBS	UCSZ1	UCSZ0	UCPOL	165
$1F ($3F)	EEARH	–	–	–	–	–	–	–	EEAR8	19
$1E ($3E)	EEARL	EEPROM Address Register Low Byte								19
$1D ($3D)	EEDR	EEPROM Data Register								19
$1C ($3C)	EECR	–	–	–	–	EERIE	EEMWE	EEWE	EERE	19
$1B ($3B)	PORTA	PORTA7	PORTA6	PORTA5	PORTA4	PORTA3	PORTA2	PORTA1	PORTA0	66
$1A ($3A)	DDRA	DDA7	DDA6	DDA5	DDA4	DDA3	DDA2	DDA1	DDA0	66
$19 ($39)	PINA	PINA7	PINA6	PINA5	PINA4	PINA3	PINA2	PINA1	PINA0	66
$18 ($38)	PORTB	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0	66
$17 ($37)	DDRB	DDB7	DDB6	DDB5	DDB4	DDB3	DDB2	DDB1	DDB0	66
$16 ($36)	PINB	PINB7	PINB6	PINB5	PINB4	PINB3	PINB2	PINB1	PINB0	66
$15 ($35)	PORTC	PORTC7	PORTC6	PORTC5	PORTC4	PORTC3	PORTC2	PORTC1	PORTC0	67
$14 ($34)	DDRC	DDC7	DDC6	DDC5	DDC4	DDC3	DDC2	DDC1	DDC0	67
$13 ($33)	PINC	PINC7	PINC6	PINC5	PINC4	PINC3	PINC2	PINC1	PINC0	67
$12 ($32)	PORTD	PORTD7	PORTD6	PORTD5	PORTD4	PORTD3	PORTD2	PORTD1	PORTD0	67
$11 ($31)	DDRD	DDD7	DDD6	DDD5	DDD4	DDD3	DDD2	DDD1	DDD0	67
$10 ($30)	PIND	PIND7	PIND6	PIND5	PIND4	PIND3	PIND2	PIND1	PIND0	67
$0F ($2F)	SPDR	SPI Data Register								142
$0E ($2E)	SPSR	SPIF	WCOL	–	–	–	–	–	SPI2X	142
$0D ($2D)	SPCR	SPIE	SPE	DORD	MSTR	CPOL	CPHA	SPR1	SPR0	140
$0C ($2C)	UDR	USART I/O Data Register								163
$0B ($2B)	UCSRA	RXC	TXC	UDRE	FE	DOR	PE	U2X	MPCM	164
$0A ($2A)	UCSRB	RXCIE	TXCIE	UDRIE	RXEN	TXEN	UCSZ2	RXB8	TXB8	165
$09 ($29)	UBRRL	USART Baud Rate Register Low Byte								167
$08 ($28)	ACSR	ACD	ACBG	ACO	ACI	ACIE	ACIC	ACIS1	ACIS0	202
$07 ($27)	ADMUX	REFS1	REFS0	ADLAR	MUX4	MUX3	MUX2	MUX1	MUX0	217
$06 ($26)	ADCSRA	ADEN	ADSC	ADATE	ADIF	ADIE	ADPS2	ADPS1	ADPS0	219
$05 ($25)	ADCH	ADC Data Register High Byte								220
$04 ($24)	ADCL	ADC Data Register Low Byte								220
$03 ($23)	TWDR	Two-wire Serial Interface Data Register								182
$02 ($22)	TWAR	TWA6	TWA5	TWA4	TWA3	TWA2	TWA1	TWA0	TWGCE	182

Instruction Set Summary

Mnemonics	Operands	Description	Operation	Flags	#Clocks
ARITHMETIC AND LOGIC INSTRUCTIONS					
ADD	Rd, Rr	Add two Registers	Rd ← Rd + Rr	Z,C,N,V,H	1
ADC	Rd, Rr	Add with Carry two Registers	Rd ← Rd + Rr + C	Z,C,N,V,H	1
ADIW	Rdl,K	Add Immediate to Word	Rdh:Rdl ← Rdh:Rdl + K	Z,C,N,V,S	2
SUB	Rd, Rr	Subtract two Registers	Rd ← Rd - Rr	Z,C,N,V,H	1
SUBI	Rd, K	Subtract Constant from Register	Rd ← Rd - K	Z,C,N,V,H	1
SBC	Rd, Rr	Subtract with Carry two Registers	Rd ← Rd - Rr - C	Z,C,N,V,H	1
SBCI	Rd, K	Subtract with Carry Constant from Reg.	Rd ← Rd - K - C	Z,C,N,V,H	1
SBIW	Rdl,K	Subtract Immediate from Word	Rdh:Rdl ← Rdh:Rdl - K	Z,C,N,V,S	2
AND	Rd, Rr	Logical AND Registers	Rd ← Rd • Rr	Z,N,V	1
ANDI	Rd, K	Logical AND Register and Constant	Rd ← Rd • K	Z,N,V	1
OR	Rd, Rr	Logical OR Registers	Rd ← Rd v Rr	Z,N,V	1
ORI	Rd, K	Logical OR Register and Constant	Rd ← Rd v K	Z,N,V	1
EOR	Rd, Rr	Exclusive OR Registers	Rd ← Rd ⊕ Rr	Z,N,V	1
COM	Rd	One's Complement	Rd ← $FF − Rd	Z,C,N,V	1
NEG	Rd	Two's Complement	Rd ← $00 − Rd	Z,C,N,V,H	1
SBR	Rd,K	Set Bit(s) in Register	Rd ← Rd v K	Z,N,V	1
CBR	Rd,K	Clear Bit(s) in Register	Rd ← Rd • ($FF - K)	Z,N,V	1
INC	Rd	Increment	Rd ← Rd + 1	Z,N,V	1
DEC	Rd	Decrement	Rd ← Rd − 1	Z,N,V	1
TST	Rd	Test for Zero or Minus	Rd ← Rd • Rd	Z,N,V	1
CLR	Rd	Clear Register	Rd ← Rd ⊕ Rd	Z,N,V	1
SER	Rd	Set Register	Rd ← $FF	None	1
MUL	Rd, Rr	Multiply Unsigned	R1:R0 ← Rd x Rr	Z,C	2
MULS	Rd, Rr	Multiply Signed	R1:R0 ← Rd x Rr	Z,C	2
MULSU	Rd, Rr	Multiply Signed with Unsigned	R1:R0 ← Rd x Rr	Z,C	2
FMUL	Rd, Rr	Fractional Multiply Unsigned	R1:R0 ← (Rd x Rr) << 1	Z,C	2
FMULS	Rd, Rr	Fractional Multiply Signed	R1:R0 ← (Rd x Rr) << 1	Z,C	2
FMULSU	Rd, Rr	Fractional Multiply Signed with Unsigned	R1:R0 ← (Rd x Rr) << 1	Z,C	2
BRANCH INSTRUCTIONS					
RJMP	k	Relative Jump	PC ← PC + k + 1	None	2
IJMP		Indirect Jump to (Z)	PC ← Z	None	2
JMP	k	Direct Jump	PC ← k	None	3
RCALL	k	Relative Subroutine Call	PC ← PC + k + 1	None	3
ICALL		Indirect Call to (Z)	PC ← Z	None	3
CALL	k	Direct Subroutine Call	PC ← k	None	4
RET		Subroutine Return	PC ← STACK	None	4
RETI		Interrupt Return	PC ← STACK	I	4
CPSE	Rd,Rr	Compare, Skip if Equal	if (Rd = Rr) PC ← PC + 2 or 3	None	1 / 2 / 3
CP	Rd,Rr	Compare	Rd − Rr	Z, N,V,C,H	1
CPC	Rd,Rr	Compare with Carry	Rd − Rr − C	Z, N,V,C,H	1
CPI	Rd,K	Compare Register with Immediate	Rd − K	Z, N,V,C,H	1
SBRC	Rr, b	Skip if Bit in Register Cleared	if (Rr(b)=0) PC ← PC + 2 or 3	None	1 / 2 / 3
SBRS	Rr, b	Skip if Bit in Register is Set	if (Rr(b)=1) PC ← PC + 2 or 3	None	1 / 2 / 3
SBIC	P, b	Skip if Bit in I/O Register Cleared	if (P(b)=0) PC ← PC + 2 or 3	None	1 / 2 / 3
SBIS	P, b	Skip if Bit in I/O Register is Set	if (P(b)=1) PC ← PC + 2 or 3	None	1 / 2 / 3
BRBS	s, k	Branch If Status Flag Set	if (SREG(s) = 1) then PC←PC+k + 1	None	1 / 2
BRBC	s, k	Branch If Status Flag Cleared	if (SREG(s) = 0) then PC←PC+k + 1	None	1 / 2
BREQ	k	Branch If Equal	if (Z = 1) then PC ← PC + k + 1	None	1 / 2
BRNE	k	Branch If Not Equal	if (Z = 0) then PC ← PC + k + 1	None	1 / 2
BRCS	k	Branch If Carry Set	if (C = 1) then PC ← PC + k + 1	None	1 / 2
BRCC	k	Branch If Carry Cleared	if (C = 0) then PC ← PC + k + 1	None	1 / 2
BRSH	k	Branch If Same or Higher	if (C = 0) then PC ← PC + k + 1	None	1 / 2
BRLO	k	Branch If Lower	if (C = 1) then PC ← PC + k + 1	None	1 / 2
BRMI	k	Branch If Minus	if (N = 1) then PC ← PC + k + 1	None	1 / 2
BRPL	k	Branch If Plus	if (N = 0) then PC ← PC + k + 1	None	1 / 2
BRGE	k	Branch If Greater or Equal, Signed	if (N ⊕ V= 0) then PC ← PC + k + 1	None	1 / 2
BRLT	k	Branch If Less Than Zero, Signed	if (N ⊕ V= 1) then PC ← PC + k + 1	None	1 / 2
BRHS	k	Branch If Half Carry Flag Set	if (H = 1) then PC ← PC + k + 1	None	1 / 2
BRHC	k	Branch If Half Carry Flag Cleared	if (H = 0) then PC ← PC + k + 1	None	1 / 2
BRTS	k	Branch If T Flag Set	if (T = 1) then PC ← PC + k + 1	None	1 / 2
BRTC	k	Branch If T Flag Cleared	if (T = 0) then PC ← PC + k + 1	None	1 / 2
BRVS	k	Branch If Overflow Flag is Set	if (V = 1) then PC ← PC + k + 1	None	1 / 2
BRVC	k	Branch If Overflow Flag is Cleared	if (V = 0) then PC ← PC + k + 1	None	1 / 2

Mnemonics	Operands	Description	Operation	Flags	#Clocks
BRIE	k	Branch if Interrupt Enabled	if (I = 1) then PC ← PC + k + 1	None	1 / 2
BRID	k	Branch if Interrupt Disabled	if (I = 0) then PC ← PC + k + 1	None	1 / 2
DATA TRANSFER INSTRUCTIONS					
MOV	Rd, Rr	Move Between Registers	Rd ← Rr	None	1
MOVW	Rd, Rr	Copy Register Word	Rd+1:Rd ← Rr+1:Rr	None	1
LDI	Rd, K	Load Immediate	Rd ← K	None	1
LD	Rd, X	Load Indirect	Rd ← (X)	None	2
LD	Rd, X+	Load Indirect and Post-Inc.	Rd ← (X), X ← X + 1	None	2
LD	Rd, - X	Load Indirect and Pre-Dec.	X ← X - 1, Rd ← (X)	None	2
LD	Rd, Y	Load Indirect	Rd ← (Y)	None	2
LD	Rd, Y+	Load Indirect and Post-Inc.	Rd ← (Y), Y ← Y + 1	None	2
LD	Rd, - Y	Load Indirect and Pre-Dec.	Y ← Y - 1, Rd ← (Y)	None	2
LDD	Rd,Y+q	Load Indirect with Displacement	Rd ← (Y + q)	None	2
LD	Rd, Z	Load Indirect	Rd ← (Z)	None	2
LD	Rd, Z+	Load Indirect and Post-Inc.	Rd ← (Z), Z ← Z+1	None	2
LD	Rd, -Z	Load Indirect and Pre-Dec.	Z ← Z - 1, Rd ← (Z)	None	2
LDD	Rd, Z+q	Load Indirect with Displacement	Rd ← (Z + q)	None	2
LDS	Rd, k	Load Direct from SRAM	Rd ← (k)	None	2
ST	X, Rr	Store Indirect	(X) ← Rr	None	2
ST	X+, Rr	Store Indirect and Post-Inc.	(X) ← Rr, X ← X + 1	None	2
ST	- X, Rr	Store Indirect and Pre-Dec.	X ← X - 1, (X) ← Rr	None	2
ST	Y, Rr	Store Indirect	(Y) ← Rr	None	2
ST	Y+, Rr	Store Indirect and Post-Inc.	(Y) ← Rr, Y ← Y + 1	None	2
ST	- Y, Rr	Store Indirect and Pre-Dec.	Y ← Y - 1, (Y) ← Rr	None	2
STD	Y+q,Rr	Store Indirect with Displacement	(Y + q) ← Rr	None	2
ST	Z, Rr	Store Indirect	(Z) ← Rr	None	2
ST	Z+, Rr	Store Indirect and Post-Inc.	(Z) ← Rr, Z ← Z + 1	None	2
ST	-Z, Rr	Store Indirect and Pre-Dec.	Z ← Z - 1, (Z) ← Rr	None	2
STD	Z+q,Rr	Store Indirect with Displacement	(Z + q) ← Rr	None	2
STS	k, Rr	Store Direct to SRAM	(k) ← Rr	None	2
LPM		Load Program Memory	R0 ← (Z)	None	3
LPM	Rd, Z	Load Program Memory	Rd ← (Z)	None	3
LPM	Rd, Z+	Load Program Memory and Post-Inc	Rd ← (Z), Z ← Z+1	None	3
SPM		Store Program Memory	(Z) ← R1:R0	None	-
IN	Rd, P	In Port	Rd ← P	None	1
OUT	P, Rr	Out Port	P ← Rr	None	1
PUSH	Rr	Push Register on Stack	STACK ← Rr	None	2
POP	Rd	Pop Register from Stack	Rd ← STACK	None	2
BIT AND BIT-TEST INSTRUCTIONS					
SBI	P,b	Set Bit in I/O Register	I/O(P,b) ← 1	None	2
CBI	P,b	Clear Bit in I/O Register	I/O(P,b) ← 0	None	2
LSL	Rd	Logical Shift Left	Rd(n+1) ← Rd(n), Rd(0) ← 0	Z,C,N,V	1
LSR	Rd	Logical Shift Right	Rd(n) ← Rd(n+1), Rd(7) ← 0	Z,C,N,V	1
ROL	Rd	Rotate Left Through Carry	Rd(0)←C,Rd(n+1)← Rd(n),C←Rd(7)	Z,C,N,V	1
ROR	Rd	Rotate Right Through Carry	Rd(7)←C,Rd(n)← Rd(n+1),C←Rd(0)	Z,C,N,V	1
ASR	Rd	Arithmetic Shift Right	Rd(n) ← Rd(n+1), n=0..6	Z,C,N,V	1
SWAP	Rd	Swap Nibbles	Rd(3..0)←Rd(7..4),Rd(7..4)←Rd(3..0)	None	1
BSET	s	Flag Set	SREG(s) ← 1	SREG(s)	1
BCLR	s	Flag Clear	SREG(s) ← 0	SREG(s)	1
BST	Rr, b	Bit Store from Register to T	T ← Rr(b)	T	1
BLD	Rd, b	Bit load from T to Register	Rd(b) ← T	None	1
SEC		Set Carry	C ← 1	C	1
CLC		Clear Carry	C ← 0	C	1
SEN		Set Negative Flag	N ← 1	N	1
CLN		Clear Negative Flag	N ← 0	N	1
SEZ		Set Zero Flag	Z ← 1	Z	1
CLZ		Clear Zero Flag	Z ← 0	Z	1
SEI		Global Interrupt Enable	I ← 1	I	1
CLI		Global Interrupt Disable	I ← 0	I	1
SES		Set Signed Test Flag	S ← 1	S	1
CLS		Clear Signed Test Flag	S ← 0	S	1
SEV		Set Twos Complement Overflow.	V ← 1	V	1
CLV		Clear Twos Complement Overflow	V ← 0	V	1
SET		Set T in SREG	T ← 1	T	1
CLT		Clear T in SREG	T ← 0	T	1
SEH		Set Half Carry Flag in SREG	H ← 1	H	1

Mnemonics	Operands	Description	Operation	Flags	#Clocks
CLH		Clear Half Carry Flag in SREG	H ← 0	H	1
MCU CONTROL INSTRUCTIONS					
NOP		No Operation		None	1
SLEEP		Sleep	(see specific descr. for Sleep function)	None	1
WDR		Watchdog Reset	(see specific descr. for WDR/timer)	None	1
BREAK		Break	For On-Chip Debug Only	None	N/A