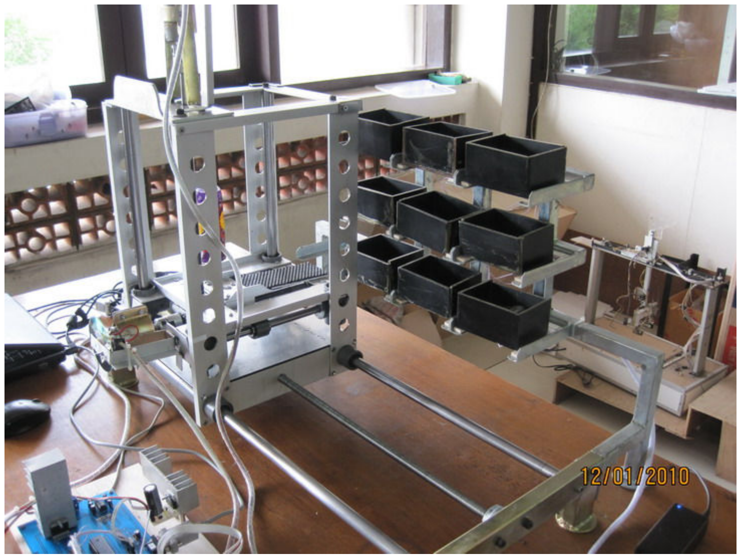
LAMPIRAN A

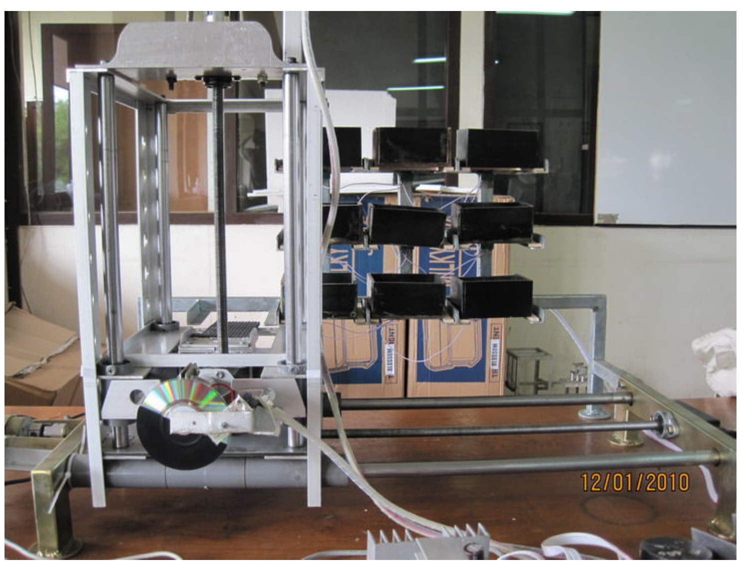
DAFTAR FOTO SISTEM

FOTO SISTEM

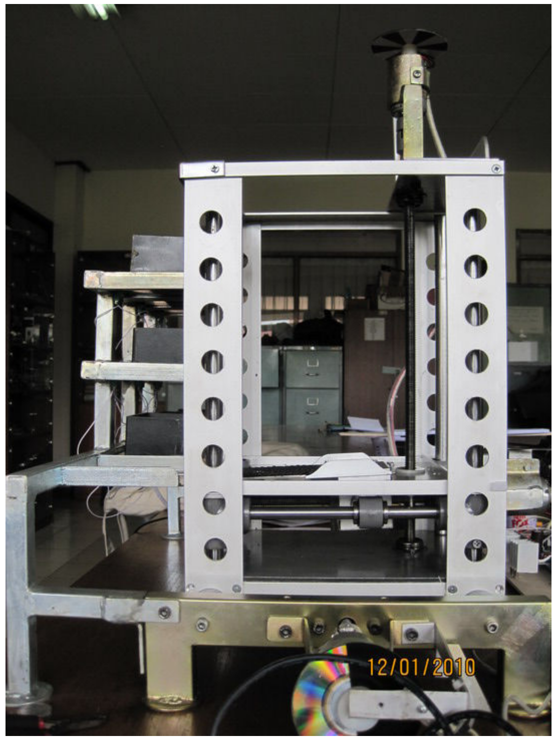
1. Tampak Keseluruhan ASRS (*Automatic Storage and Retrieval System*)



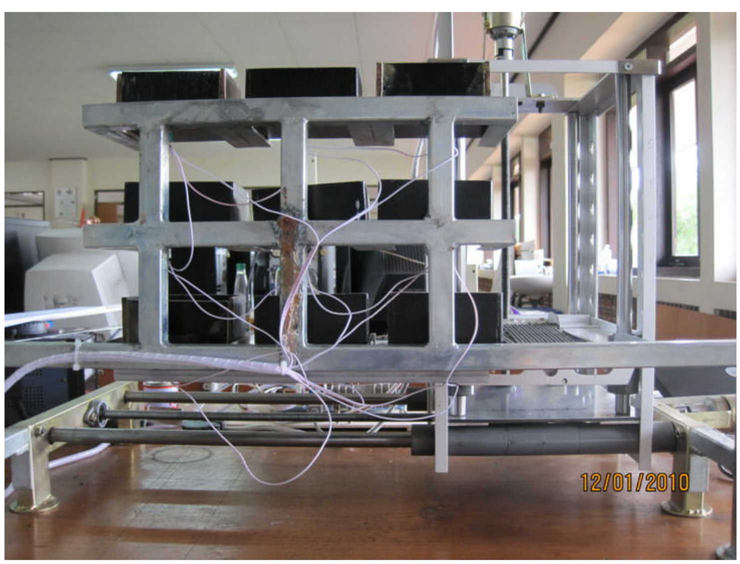
2. Tampak Depan ASRS (*Automatic Storage and Retrieval System*)



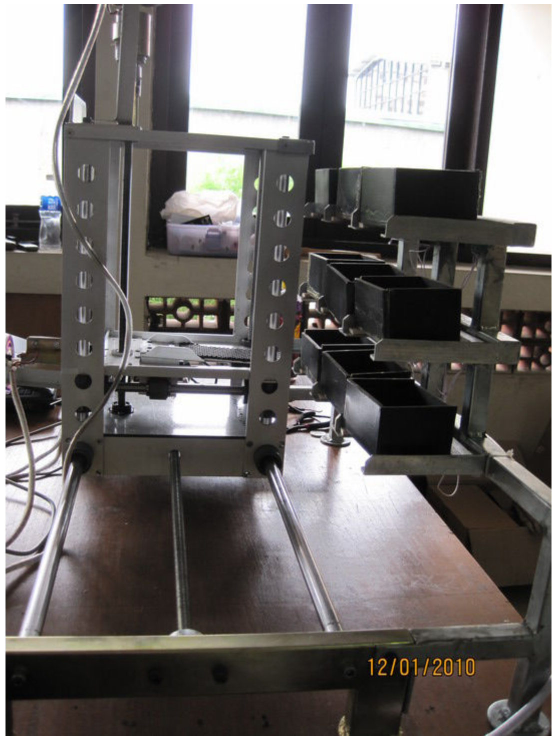
3. Tampak Samping Kiri ASRS (*Automatic Storage and Retrieval System*)



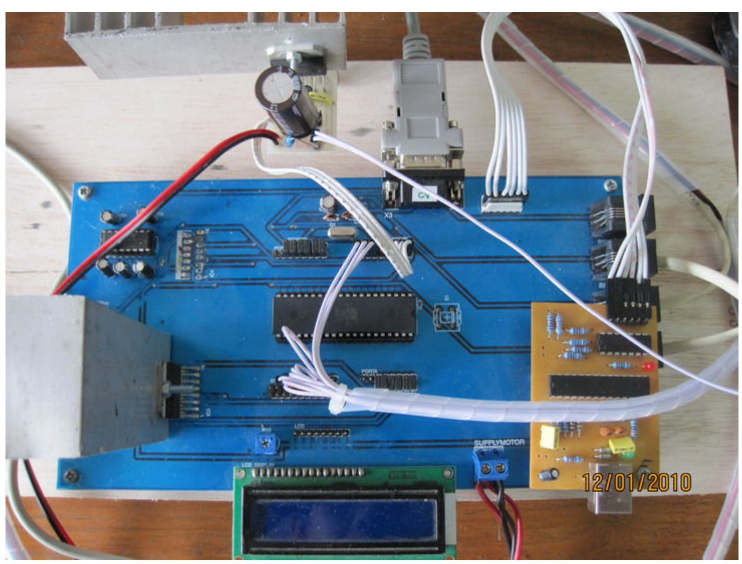
4. Tampak Belakang ASRS (*Automatic Storage and Retrieval System*)



5. Tampak Samping Kanan ASRS (*Automatic Storage and Retrieval System*)



6. Tampak Atas Rangkaian Mikrokontroler



LAMPIRAN B
PROGRAM PADA MIKROKONTROLER ATMEGA16

Daftar Program Mikrokontroler

```
/*****************************************************
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    : 11/12/2009
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>
#include <delay.h>
#include <stdio.h>
unsigned int a,b,c,posisi,kondisi,system;
unsigned char dat[1];

#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
unsigned char text[32];
unsigned int maju,mundur,naik,turun,kiri,kanan,info;
void main(void)
{
// Declare your local variables here

// Input/Output Ports initialization
// Port A initialization
// Func7=Out Func6=Out Func5=Out Func4=Out Func3=Out Func2=Out
Func1=Out Func0=Out
// State7=0 State6=0 State5=0 State4=0 State3=0 State2=0 State1=0 State0=0
PORTA=0x00;
DDRA=0xFF;

// Port B initialization
// Func7=In Func6=In Func5=In Func4=In Func3=In Func2=Out Func1=Out
Func0=Out
// State7=P State6=P State5=P State4=T State3=T State2=0 State1=0 State0=0
PORTB=0xE0;
DDRB=0x07;
```

```
// Port C initialization
// Func7=In Func6=In Func5=In Func4=In Func3=In Func2=In Func1=In
Func0=In
// State7=T State6=T State5=P State4=P State3=P State2=P State1=P State0=P
PORTC=0x3F;
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=P State4=P State3=P State2=P State1=T State0=T
PORTD=0x3C;
DDRD=0x00;

TCCR0=0x00;
TCNT0=0x00;
OCR0=0x00;

TCCR1A=0x00;
TCCR1B=0x00;
TCNT1H=0x00;
TCNT1L=0x00;
ICR1H=0x00;
ICR1L=0x00;
OCR1AH=0x00;
OCR1AL=0x00;
OCR1BH=0x00;
OCR1BL=0x00;

ASSR=0x00;
TCCR2=0x00;
TCNT2=0x00;
OCR2=0x00;

MCUCR=0x00;
MCUCSR=0x00;

TIMSK=0x00;

UCSRA=0x00;
```

```
UCSRB=0x98;
UCSRC=0x86;
UBRRH=0x00;
UBRRL=0x47;

ACSR=0x80;
SFIOR=0x00;

#asm("sei")

//*** PROGRAM MASTER ***

while(1)
{

printf("tes");
start:
system=getchar();

if(system=='1')//*** Keadaan Automatic ***
	{
	kondisi=getchar();
	if(kondisi=='1')	//*** Simpan ***
		{

		if(PINC.0==1) posisi='1';
		if(PINC.1==1) posisi='2';
		else if(PINC.2==1) posisi='3';
		else if(PINC.3==1) posisi='4';
		else if(PINC.4==1) posisi='5';
		else if(PINC.5==1) posisi='6';
		else if(PINB.7==1) posisi='7';
		else if(PINB.6==1) posisi='8';
		else if(PINB.5==1) posisi='9';
		}
	}
	else			//*** Manual ***
	{
	kondisi=getchar();
		if(kondisi=='1') //store
```

```
        }
        {
        if(PINC.0==1) printf("A"); delay_ms(20);
        if(PINC.1==1) printf("B"); delay_ms(20);
        if(PINC.2==1) printf("C"); delay_ms(20);
        if(PINC.3==1) printf("D"); delay_ms(20);
        if(PINC.4==1) printf("E"); delay_ms(20);
        if(PINC.5==1) printf("F"); delay_ms(20);
        if(PINB.7==1) printf("G"); delay_ms(20);
        if(PINB.5==1) printf("H"); delay_ms(20);
        if(PINB.6==1) printf("I");  delay_ms(20);
        }

        else

          {
          posisi=getchar();
                if(PINC.0==0 && posisi=='1') goto start;
                if(PINC.1==0 && posisi=='2') goto start;
                if(PINC.2==0 && posisi=='3') goto start;
                if(PINC.3==0 && posisi=='4') goto start;
                if(PINC.4==0 && posisi=='5') goto start;
                if(PINC.5==0 && posisi=='6') goto start;
                if(PINB.7==0 && posisi=='7') goto start;
                if(PINB.6==0 && posisi=='8') goto start;
                if(PINB.5==0 && posisi=='9') goto start;
          }
          else
          {
          posisi=getchar();
          }

      }

switch (posisi) {

  case '1':maju=99;
        naik=0;
        mundur=99;
        turun=0;
```

```
        kiri=137;
        kanan=137;
break;
case '2':maju=99;
        naik=0;
        mundur=99;
        turun=0;
        kiri=274;
        kanan=274;
break;
case '3':maju=99;
        naik=0;
        mundur=99;
        turun=0;
        kiri=411;
        kanan=411;
break;
 case '4':maju=99;
        naik=113;
        mundur=99;
        turun=113;
        kiri=137;
        kanan=137;
break;
 case '5':maju=99;
        naik=113;
        mundur=99;
        turun=113;
        kiri=274;
        kanan=274;
break;
 case '6':maju=99;
        naik=113;
        mundur=99;
        turun=113;
        kiri=411;
        kanan=411;
break;
 case '7':maju=99;
        naik=226;
```

```
          mundur=99;
          turun=226;
          kiri=137;
          kanan=137;
   break;
    case '8':maju=99;
          naik=226;
          mundur=99;
          turun=226;
          kiri=274;
          kanan=274;
   break;
    case '9':maju=99;
          naik=226;
          mundur=99;
          turun=226;
          kiri=411;
          kanan=411;
   break;
   };

        if(kondisi=='1')
        {

//*** PROGRAM PENYIMPANAN ***

while(a<=maju)
        {
        PORTA.5=1;
        PORTA.2=1;
        PORTA.3=0;
        if(PIND.3 != b){a++;b=PIND.3;}
        }
        a=0;
        PORTA.5=1;
        PORTA.2=0;
        PORTA.3=1;
        delay_ms(20);
        PORTA.5=0;
        delay_ms(1000);
```

```
 while(a<=15)
        {
        PORTB.0=0;
        PORTB.1=1;
        PORTB.2=1;
        if(PIND.4 != b) {a++;b=PIND.4;}
        }
        a=0;
        PORTB.0=1;
        PORTB.1=0;
        PORTB.2=1;
        delay_ms(20);
        PORTB.2=0;
        delay_ms(1000);

while(a<=mundur)
        {
        PORTA.5=1;
        PORTA.2=0;
        PORTA.3=1;
        if(PIND.3 != b){a++;b=PIND.3;}
        }
        a=0;
        PORTA.5=1;
        PORTA.2=1;
        PORTA.3=0;
        delay_ms(30);
        PORTA.5=0;
        delay_ms(1000);

while(a<=kanan)
        {
        PORTA.4=1;
        PORTA.0=1;
        PORTA.1=0;
        if(PIND.2 != b){a++;b=PIND.2;}
        }
        a=0;
        PORTA.4=1;
```

```
        PORTA.0=0;
        PORTA.1=1;
        delay_ms(20);
        PORTA.4=0;
        delay_ms(1000);

        if(naik>=1)
        {

while(a<=naik)
        {
        PORTB.0=0;
        PORTB.1=1;
        PORTB.2=1;
        if(PIND.4 != b) {a++;b=PIND.4;}
        }
        a=0;
        PORTB.0=1;
        PORTB.1=0;
        PORTB.2=1;
        delay_ms(20);
        PORTB.2=0;
        delay_ms(1000);

        }

while(a<=maju)
        {
        PORTA.5=1;
        PORTA.2=1;
        PORTA.3=0;
        if(PIND.3 != b){a++;b=PIND.3;}
        }
        a=0;
        PORTA.5=1;
        PORTA.2=0;
        PORTA.3=1;
        delay_ms(20);
        PORTA.5=0;
        delay_ms(1000);
```

```
while(a<=15)
        {
        PORTB.0=0;
        PORTB.1=0;
        PORTB.2=1;
        if(PIND.4 != b) {a++;b=PIND.4;}
        }
        a=0;
        PORTB.0=0;
        PORTB.1=1;
        PORTB.2=1;
        delay_ms(40);
        PORTB.2=0;
        delay_ms(1000);

while(a<=mundur)
        {
        PORTA.5=1;
        PORTA.2=0;
        PORTA.3=1;
        if(PIND.3 != b){a++;b=PIND.3;}
        }
        a=0;
        PORTA.5=1;
        PORTA.2=1;
        PORTA.3=0;
        delay_ms(30);
        PORTA.5=0;
        delay_ms(1000);

        if(naik>=1)
        {

while(a<=turun)
        {
        PORTB.0=0;
        PORTB.1=0;
        PORTB.2=1;
        if(PIND.4 != b) {a++;b=PIND.4;}
```

```
        }
        a=0;
        PORTB.0=0;
        PORTB.1=1;
        PORTB.2=1;
        delay_ms(40);
        PORTB.2=0;
        delay_ms(1000);
        }

 while(a<=kiri)
        {
        PORTA.4=1;
        PORTA.0=0;
        PORTA.1=1;
        if(PIND.2 != b){a++;b=PIND.2;}
        }
        a=0;
        PORTA.4=1;
        PORTA.0=1;
        PORTA.1=0;
        delay_ms(30);
        PORTA.4=0;
        delay_ms(1000);
        }
        else if(kondisi=='0')
        {

//*** PROGRAM PENGAMBILAN ***

while(a<=kanan)
        {
        PORTA.4=1;
        PORTA.0=1;
        PORTA.1=0;
        if(PIND.2 != b){a++;b=PIND.2;}
        }
        a=0;
        PORTA.4=1;
        PORTA.0=0;
```

```
        PORTA.1=1;
        delay_ms(20);
        PORTA.4=0;
        delay_ms(1000);

        if(naik>1)
        {

while(a<=naik)
        {
        PORTB.0=0;
        PORTB.1=1;
        PORTB.2=1;
        if(PIND.4 != b) {a++;b=PIND.4;}
        }
        a=0;
        PORTB.0=1;
        PORTB.1=0;
        PORTB.2=1;
        delay_ms(20);
        PORTB.2=0;
        delay_ms(1000);
        }

while(a<=maju)
        {
        PORTA.5=1;
        PORTA.2=1;
        PORTA.3=0;
        if(PIND.3 != b){a++;b=PIND.3;}
        }
        a=0;
        PORTA.5=1;
        PORTA.2=0;
        PORTA.3=1;
        delay_ms(20);
        PORTA.5=0;
        delay_ms(1000);

 while(a<=15)
```

```
	{
	PORTB.0=0;
	PORTB.1=1;
	PORTB.2=1;
	if(PIND.4 != b) {a++;b=PIND.4;}
	}
	a=0;
	PORTB.0=1;
	PORTB.1=0;
	PORTB.2=1;
	delay_ms(20);
	PORTB.2=0;
	delay_ms(1000);

while(a<=mundur)
	{
	PORTA.5=1;
	PORTA.2=0;
	PORTA.3=1;
	if(PIND.3 != b){a++;b=PIND.3;}
	}
	a=0;
	PORTA.5=1;
	PORTA.2=1;
	PORTA.3=0;
	delay_ms(30);
	PORTA.5=0;
	delay_ms(1000);

while(a<=kiri)
	{
	PORTA.4=1;
	PORTA.0=0;
	PORTA.1=1;
	if(PIND.2 != b){a++;b=PIND.2;}
	}
	a=0;
	PORTA.4=1;
	PORTA.0=1;
	PORTA.1=0;
```

```
        delay_ms(30);
        PORTA.4=0;
        delay_ms(1000);

        if(turun>=1)
        {

while(a<=turun)
        {
        PORTB.0=0;
        PORTB.1=0;
        PORTB.2=1;
        if(PIND.4 != b) {a++;b=PIND.4;}
        }
        a=0;
        PORTB.0=0;
        PORTB.1=1;
        PORTB.2=1;
        delay_ms(40);
        PORTB.2=0;
        delay_ms(1000);
        }

while(a<=maju)
        {
        PORTA.5=1;
        PORTA.2=1;
        PORTA.3=0;
        if(PIND.3 != b){a++;b=PIND.3;}
        }
        a=0;
        PORTA.5=1;
        PORTA.2=0;
        PORTA.3=1;
        delay_ms(20);
        PORTA.5=0;
        delay_ms(1000);

while(a<=15)
        {
```

```
        PORTB.0=0;
        PORTB.1=0;
        PORTB.2=1;
        if(PIND.4 != b) {a++;b=PIND.4;}
        }
        a=0;
        PORTB.0=0;
        PORTB.1=1;
        PORTB.2=1;
        delay_ms(40);
        PORTB.2=0;
        delay_ms(1000);

while(a<=mundur)
        {
        PORTA.5=1;
        PORTA.2=0;
        PORTA.3=1;
        if(PIND.3 != b){a++;b=PIND.3;}
        }
        a=0;
        PORTA.5=1;
        PORTA.2=1;
        PORTA.3=0;
        delay_ms(30);
        PORTA.5=0;
        delay_ms(1000);
        }
        }
        }
```

LAMPIRAN C

DAFTAR PROGRAM MICROSOFT VISUAL BASIC 6.0

Daftar Program Microsoft Visual Basic 6.0

```
Private Sub automatic_Click()

If automatic.Value = 1 Then
    tampilan_system.Text = 1
    manual.Visible = False
    kolom1.Visible = False
    kolom2.Visible = False
    kolom3.Visible = False
    kolom4.Visible = False
    kolom5.Visible = False
    kolom6.Visible = False
    kolom7.Visible = False
    kolom8.Visible = False
    kolom9.Visible = False
    Else
    tampilan_system.Text = " anda belum memilih "
    manual.Visible = True
    kolom1.Visible = True
    kolom2.Visible = True
    kolom3.Visible = True
    kolom4.Visible = True
    kolom5.Visible = True
    kolom6.Visible = True
    kolom7.Visible = True
    kolom8.Visible = True
    kolom9.Visible = True
End If

End Sub
```

```
Private Sub execute_Click()

Shape1.FillColor = &HFF00&
Shape2.FillColor = &HFF00&
Shape3.FillColor = &HFF00&
Shape4.FillColor = &HFF00&
Shape5.FillColor = &HFF00&
Shape6.FillColor = &HFF00&
Shape7.FillColor = &HFF00&
Shape8.FillColor = &HFF00&
Shape9.FillColor = &HFF00&

Dim system As Variant
Dim command As Variant
Dim kolom As Variant

If automatic.Value = 1 Then
   system = 1
   End If

If manual.Value = 1 Then
   system = 0
   End If

If store.Value = 1 Then
   command = 1
   End If

If retrive.Value = 1 Then
   command = 0
   End If
```

```
If kolom1.Value = 1 Then
    kolom = 1
    End If

If kolom2.Value = 1 Then
    kolom = 2
    End If

If kolom3.Value = 1 Then
    kolom = 3
    End If

If kolom4.Value = 1 Then
    kolom = 4
    End If

If kolom5.Value = 1 Then
    kolom = 5
    End If

If kolom6.Value = 1 Then
    kolom = 6
    End If

If kolom7.Value = 1 Then
    kolom = 7
    End If

If kolom8.Value = 1 Then
    kolom = 8
```

```
    End If

If kolom9.Value = 1 Then
    kolom = 9
    End If

tampilan_utama.Text = system & command & kolom
If automatic.Value = 1 Then
    MSComm1.Output = system & command
Else
    MSComm1.Output = system & command & kolom
End If

End Sub

Private Sub Form_Load()

    MSComm1.CommPort = 3
    MSComm1.Settings = "9600 , n , 8 , 1"
    MSComm1.PortOpen = True

End Sub

Private Sub kolom1_Click()

If kolom1.Value = 1 Then
    tampilan_kolom = " kolom 1 "
    kolom2.Visible = False
    kolom3.Visible = False
    kolom4.Visible = False
    kolom5.Visible = False
```

```
    kolom6.Visible = False
    kolom7.Visible = False
    kolom8.Visible = False
    kolom9.Visible = False
    Else
    kolom1.Value = 0
    tampilan_kolom = " anda belum memilih "
    kolom2.Visible = True
    kolom3.Visible = True
    kolom4.Visible = True
    kolom5.Visible = True
    kolom6.Visible = True
    kolom7.Visible = True
    kolom8.Visible = True
    kolom9.Visible = True
    End If

End Sub

Private Sub kolom2_Click()

If kolom2.Value = 1 Then
    tampilan_kolom = " kolom 2 "
    kolom1.Visible = False
    kolom3.Visible = False
    kolom4.Visible = False
    kolom5.Visible = False
    kolom6.Visible = False
    kolom7.Visible = False
    kolom8.Visible = False
    kolom9.Visible = False
```

```
    Else
    kolom2.Value = 0
    tampilan_kolom = " anda belum memilih "
    kolom1.Visible = True
    kolom3.Visible = True
    kolom4.Visible = True
    kolom5.Visible = True
    kolom6.Visible = True
    kolom7.Visible = True
    kolom8.Visible = True
    kolom9.Visible = True
    End If

End Sub

Private Sub kolom3_Click()

If kolom3.Value = 1 Then
    tampilan_kolom = " kolom 3 "
    kolom2.Visible = False
    kolom1.Visible = False
    kolom4.Visible = False
    kolom5.Visible = False
    kolom6.Visible = False
    kolom7.Visible = False
    kolom8.Visible = False
    kolom9.Visible = False
    Else
    kolom3.Value = 0
    tampilan_kolom = " anda belum memilih "
    kolom2.Visible = True
```

```
    kolom1.Visible = True
    kolom4.Visible = True
    kolom5.Visible = True
    kolom6.Visible = True
    kolom7.Visible = True
    kolom8.Visible = True
    kolom9.Visible = True

    End If

End Sub

Private Sub kolom4_Click()

If kolom4.Value = 1 Then
    tampilan_kolom = " kolom 4 "
    kolom2.Visible = False
    kolom3.Visible = False
    kolom1.Visible = False
    kolom5.Visible = False
    kolom6.Visible = False
    kolom7.Visible = False
    kolom8.Visible = False
    kolom9.Visible = False
    Else
    kolom4.Value = 0
    tampilan_kolom = " anda belum memilih "
    kolom2.Visible = True
    kolom3.Visible = True
    kolom1.Visible = True
    kolom5.Visible = True
```

```
    kolom6.Visible = True
    kolom7.Visible = True
    kolom8.Visible = True
    kolom9.Visible = True
    End If

End Sub

Private Sub kolom5_Click()

If kolom5.Value = 1 Then
    tampilan_kolom = " kolom 5 "
    kolom2.Visible = False
    kolom3.Visible = False
    kolom4.Visible = False
    kolom1.Visible = False
    kolom6.Visible = False
    kolom7.Visible = False
    kolom8.Visible = False
    kolom9.Visible = False
    Else
    kolom5.Value = 0
    tampilan_kolom = " anda belum memilih "
    kolom2.Visible = True
    kolom3.Visible = True
    kolom4.Visible = True
    kolom1.Visible = True
    kolom6.Visible = True
    kolom7.Visible = True
    kolom8.Visible = True
    kolom9.Visible = True
```

```
    End If

End Sub

Private Sub kolom6_Click()

If kolom6.Value = 1 Then
    tampilan_kolom = " kolom 6 "
    kolom2.Visible = False
    kolom3.Visible = False
    kolom4.Visible = False
    kolom5.Visible = False
    kolom1.Visible = False
    kolom7.Visible = False
    kolom8.Visible = False
    kolom9.Visible = False
    Else
    kolom6.Value = 0
    tampilan_kolom = " anda belum memilih "
    kolom2.Visible = True
    kolom3.Visible = True
    kolom4.Visible = True
    kolom5.Visible = True
    kolom1.Visible = True
    kolom7.Visible = True
    kolom8.Visible = True
    kolom9.Visible = True
    End If

End Sub
```

```
Private Sub kolom7_Click()

If kolom7.Value = 1 Then
    tampilan_kolom = " kolom 7 "
    kolom2.Visible = False
    kolom3.Visible = False
    kolom4.Visible = False
    kolom5.Visible = False
    kolom6.Visible = False
    kolom1.Visible = False
    kolom8.Visible = False
    kolom9.Visible = False
    Else
    kolom7.Value = 0
    tampilan_kolom = " anda belum memilih "
    kolom2.Visible = True
    kolom3.Visible = True
    kolom4.Visible = True
    kolom5.Visible = True
    kolom6.Visible = True
    kolom1.Visible = True
    kolom8.Visible = True
    kolom9.Visible = True
    End If

End Sub

Private Sub kolom8_Click()

If kolom8.Value = 1 Then
    tampilan_kolom = " kolom 8 "
```

```
    kolom2.Visible = False
    kolom3.Visible = False
    kolom4.Visible = False
    kolom5.Visible = False
    kolom6.Visible = False
    kolom7.Visible = False
    kolom1.Visible = False
    kolom9.Visible = False
    Else
    kolom8.Value = 0
    tampilan_kolom = " anda belum memilih "
    kolom2.Visible = True
    kolom3.Visible = True
    kolom4.Visible = True
    kolom5.Visible = True
    kolom6.Visible = True
    kolom7.Visible = True
    kolom1.Visible = True
    kolom9.Visible = True
    End If

End Sub

Private Sub kolom9_Click()

If kolom9.Value = 1 Then
    tampilan_kolom = " kolom 9 "
    kolom2.Visible = False
    kolom3.Visible = False
    kolom4.Visible = False
    kolom5.Visible = False
```

```
    kolom6.Visible = False
    kolom7.Visible = False
    kolom8.Visible = False
    kolom1.Visible = False
    Else
    kolom9.Value = 0
    tampilan_kolom = " anda belum memilih "
    kolom2.Visible = True
    kolom3.Visible = True
    kolom4.Visible = True
    kolom5.Visible = True
    kolom6.Visible = True
    kolom7.Visible = True
    kolom8.Visible = True
    kolom1.Visible = True
    End If

End Sub

Private Sub manual_Click()

If manual.Value = 1 Then
    tampilan_system.Text = 0
    automatic.Visible = False
    Else
    tampilan_system.Text = " anda belum memilih "
    automatic.Visible = True
    End If

End Sub
```

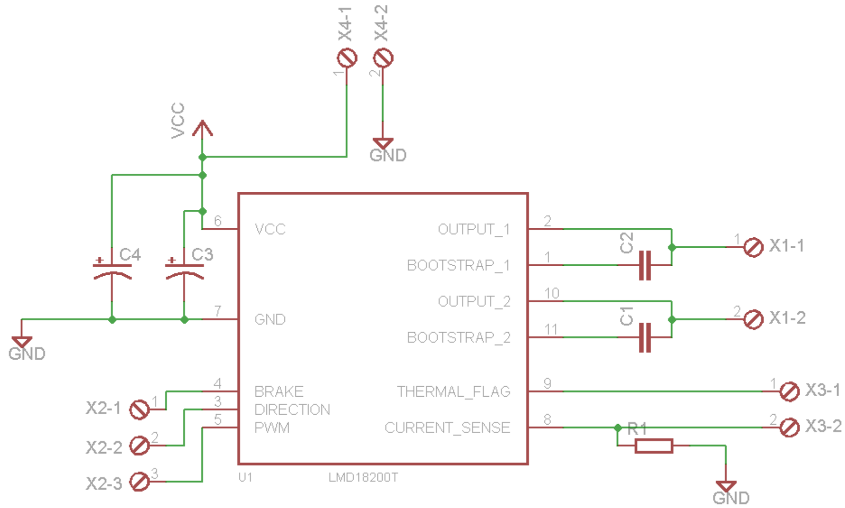
```
Private Sub retrive_Click()

If retrive.Value = 1 Then
    tampilan_command.Text = 0
    store.Visible = False
    kolom1.Visible = True
    kolom2.Visible = True
    kolom3.Visible = True
    kolom4.Visible = True
    kolom5.Visible = True
    kolom6.Visible = True
    kolom7.Visible = True
    kolom8.Visible = True
    kolom9.Visible = True
    Else
    tampilan_command.Text = " anda belum memilih "
    store.Visible = True
    End If

End Sub

Private Sub store_Click()

If store.Value = 1 Then
    tampilan_command.Text = 1
    retrive.Visible = False
    Else
    tampilan_command.Text = " anda belum memilih "
    retrive.Visible = True
    End If
```

```
End Sub

Private Sub Timer1_Timer()

hasil = MSComm1.Input
If Len(hasil) > 0 Then
Text1.Text = hasil
End If

If hasil = "A" Then
Shape1.FillColor = &HFF&
End If

If hasil = "B" Then
Shape2.FillColor = &HFF&
End If

If hasil = "C" Then
Shape3.FillColor = &HFF&
End If

If hasil = "D" Then
Shape4.FillColor = &HFF&
End If

If hasil = "E" Then
Shape5.FillColor = &HFF&
End If

If hasil = "F" Then
```

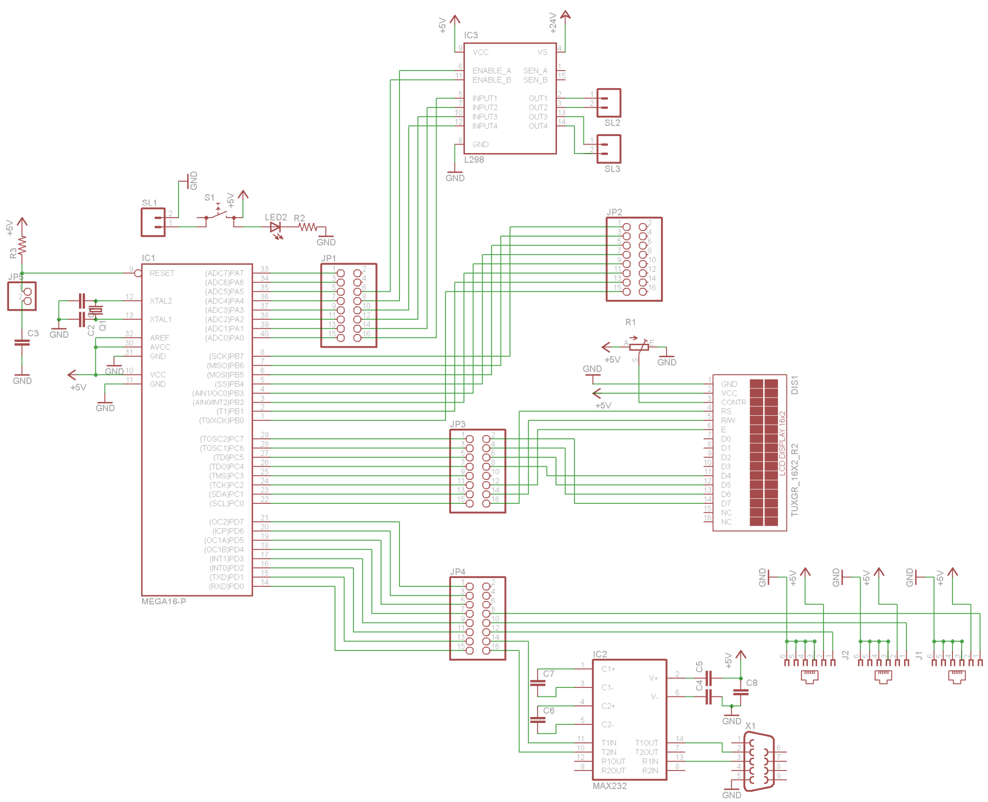
```
Shape6.FillColor = &HFF&
End If

If hasil = "G" Then
Shape7.FillColor = &HFF&
End If

If hasil = "H" Then
Shape8.FillColor = &HFF&
End If

If hasil = "I" Then
Shape9.FillColor = &HFF&
End If

End Sub
```

LAMPIRAN D
GAMBAR RANGKAIAN

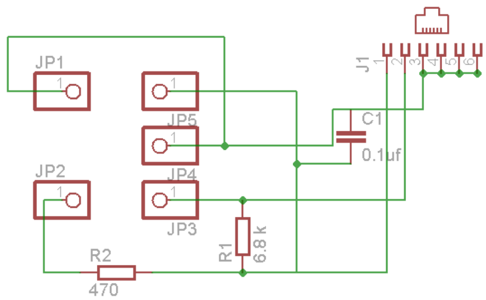
1. Rangkaian *Driver* Motor LMD18200



2. Rangkaian PCB Utama



3. Rangkaian Sensor *Rotary Encoder*



LAMPIRAN E

DAFTAR TABEL PENGAMATAN

Daftar Tabel Pengamatan

Tabel E.1. Waktu *Command Store* Tanpa Beban

No.	Koordinat / Kolom	Tanpa Beban										Rata - rata
		1	2	3	4	5	6	7	8	9	10	
1	Kolom 1	24,53	24,37	24,19	24,41	24,12	24,06	24,11	24,29	24,19	23,93	24,22
2	Kolom 2	31,28	30,87	30,65	30,61	30,72	30,85	30,88	30,54	30,66	30,25	30,73
3	Kolom 3	37,21	37,31	37,44	36,78	37,81	36,75	36,97	36,65	36,69	36,81	37,04
4	Kolom 4	30,62	30,72	30,59	30,88	30,69	30,53	30,62	30,53	31,44	30,68	30,73
5	Kolom 5	37,13	37,75	37,07	37,21	37,72	37,59	36,94	37,09	38,15	36,97	37,36
6	Kolom 6	43,11	43,41	44,16	43,44	43,12	43,44	43,84	44,11	43,72	43,87	43,62
7	Kolom 7	36,12	36,11	36,69	36,66	36,21	36,22	36,46	36,53	35,97	36,12	36,31
8	Kolom 8	42,41	41,47	42,19	42,13	43,96	41,97	42,06	43,12	42,56	42,91	42,48
9	Kolom 9	48,62	49,75	48,75	48,57	48,53	47,59	47,47	47,94	48,01	47,65	48,29

Tabel E.2. Waktu *Command Store* dengan Beban 500 gram

No.	Koordinat / Kolom	Dengan Beban 500 gram										Rata - rata
		1	2	3	4	5	6	7	8	9	10	
1	Kolom 1	23,06	23,06	22,78	22,97	22,91	23,31	22,89	23,14	23,67	23,98	23,18
2	Kolom 2	29,01	29,22	30,44	28,78	30,51	30,52	30,65	30,12	31,02	31,45	30,17
3	Kolom 3	35,31	35,51	34,97	34,72	34,92	34,55	34,18	34,33	34,78	35,04	34,83
4	Kolom 4	30,59	30,44	31,09	30,69	30,47	30,74	30,21	30,49	31,08	30,33	30,61
5	Kolom 5	36,91	37,97	37,34	37,47	36,44	36,22	36,69	36,41	36,55	36,78	36,88
6	Kolom 6	43,63	43,84	42,41	42,44	44,63	43,87	43,44	42,72	42,69	43,18	43,29
7	Kolom 7	37,83	37,09	37,28	37,23	37,82	37,85	37,12	38,03	36,98	37,28	37,45
8	Kolom 8	42,68	42,79	42,91	42,97	43,03	41,89	42,39	42,56	42,33	42,46	42,60
9	Kolom 9	48,85	49,06	49,97	48,78	48,59	47,32	48,34	48,29	48,66	49,39	48,73

Tabel E.3. Waktu *Command Retrieve* tanpa Beban

No.	Koordinat / Kolom	Tanpa Beban										Rata - rata
		1	2	3	4	5	6	7	8	9	10	
1	Kolom 1	22,15	22,79	23,14	23,22	22,59	22,41	22,65	22,45	22,33	22,87	22,66
2	Kolom 2	29,44	28,78	29,11	28,13	28,25	28,78	29,31	29,44	29,51	28,49	28,92
3	Kolom 3	34,03	34,31	34,32	35,47	34,35	34,67	34,15	35,12	35,61	34,26	34,63
4	Kolom 4	31,11	30,38	30,56	31,13	32,53	31,17	30,89	31,75	31,27	31,63	31,24
5	Kolom 5	35,91	36,01	37,03	37,38	36,24	37,25	37,43	37,52	37,03	36,77	36,86
6	Kolom 6	42,61	42,44	41,78	41,72	42,35	42,87	41,44	41,39	41,98	42,34	42,09
7	Kolom 7	34,16	35,81	36,07	34,22	35,94	34,77	34,62	34,84	34,94	34,87	35,02
8	Kolom 8	41,25	41,16	41,63	40,47	40,59	41,39	40,62	40,78	42,03	41,23	41,12
9	Kolom 9	47,29	47,19	48,25	49,88	47,75	48,98	47,49	48,38	48,32	48,78	48,23

Tabel E.4. Waktu *Command Retrieve* dengan Beban 500 gram

No.	Koordinat / Kolom	Dengan Beban 500 gram										Rata - rata
		1	2	3	4	5	6	7	8	9	10	
1	Kolom 1	22,35	22,25	22,47	22,59	22,38	23,03	22,65	22,73	22,95	22,49	22,59
2	Kolom 2	28,66	28,19	28,37	29,22	28,53	28,43	28,45	28,53	27,96	27,63	28,40
3	Kolom 3	34,97	33,44	34,13	34,87	34,51	34,77	34,42	34,96	35,03	34,25	34,54
4	Kolom 4	31,41	31,34	32,16	32,16	32,07	31,11	32,64	32,42	32,97	32,41	32,07
5	Kolom 5	37,69	35,94	37,01	37,41	37,03	36,05	36,71	36,86	36,94	36,79	36,84
6	Kolom 6	43,06	42,31	43,12	44,37	42,16	43,26	43,87	42,97	42,93	43,03	43,11
7	Kolom 7	35,67	34,44	35,23	35,34	34,87	35,95	35,33	35,76	34,65	34,78	35,20
8	Kolom 8	41,94	41,66	42,22	42,19	41,78	41,72	42,23	42,13	41,56	41,94	41,94
9	Kolom 9	47,12	48,44	47,56	48,03	48,01	48,32	47,89	47,76	47,84	47,79	47,88

Tabel E.5. Pergeseran Tanpa Beban

No.	Kolom	Koordinat	Ukuran Referensi (cm)	Pergeseran (cm) 1	2	3	4	5	6	7	8	9	10	Rata-rata
1	Kolom 1	Sumbu X	11,98	11,91	12,02	12,03	12,05	12,11	12,22	12,25	12,31	12,51	12,58	12,20
		Sumbu Y	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
		Sumbu Z	8,66	8,65	8,65	8,67	8,67	8,67	8,67	8,68	8,68	8,68	8,69	8,67
2	Kolom 2	Sumbu X	23,97	24,01	24,02	24,05	24,21	24,31	24,41	24,55	24,57	24,61	24,82	24,36
		Sumbu Y	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
		Sumbu Z	173,25	8,65	8,65	8,67	8,67	8,67	8,67	8,68	8,68	8,68	8,69	8,67
3	Kolom 3	Sumbu X	35,96	35,91	35,85	35,86	35,88	35,98	36,01	36,02	36,03	36,02	36,03	35,96
		Sumbu Y	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
		Sumbu Z	17,32	8,65	8,65	8,67	8,67	8,67	8,67	8,68	8,68	8,68	8,69	8,67
4	Kolom 4	Sumbu X	11,98	12,01	12,11	12,24	12,29	12,31	12,49	12,62	12,84	12,92	13,01	12,48
		Sumbu Y	11,63	9,91	9,85	9,81	9,81	9,85	9,85	9,81	9,85	9,85	9,91	9,85
		Sumbu Z	173,25	8,65	8,65	8,67	8,67	8,67	8,67	8,68	8,68	8,68	8,69	8,67
5	Kolom 5	Sumbu X	23,97	23,92	23,92	23,93	24,09	24,27	24,41	24,58	24,58	24,63	24,82	24,32
		Sumbu Y	11,63	9,91	9,91	10,01	10,11	10,11	10,21	10,21	10,25	10,41	10,41	10,15
		Sumbu Z	17,325	8,65	8,65	8,67	8,67	8,67	8,67	8,68	8,68	8,68	8,69	8,67
6	Kolom 6	Sumbu X	35,96	35,81	35,81	35,88	35,88	35,88	35,88	35,92	35,94	35,97	36,01	35,90
		Sumbu Y	11,63	9,81	9,71	9,71	9,81	9,76	9,72	9,82	9,81	9,65	9,65	9,75
		Sumbu Z	17,325	8,65	8,65	8,67	8,67	8,67	8,67	8,68	8,68	8,68	8,69	8,67
7	Kolom 7	Sumbu X	11,98	12,01	12,02	12,21	12,29	12,52	12,83	13,05	13,12	13,32	13,47	12,68
		Sumbu Y	19,77	19,65	19,91	20,03	20,04	20,01	20,12	20,48	21,03	21,04	21,15	20,35
		Sumbu Z	17,325	8,65	8,65	8,67	8,67	8,67	8,67	8,68	8,68	8,68	8,69	8,67
8	Kolom 8	Sumbu X	23,97	23,92	23,97	23,97	23,97	23,99	24,01	24,12	24,32	24,45	24,72	24,14
		Sumbu Y	19,77	18,61	18,91	19,07	19,23	19,39	19,61	19,83	19,93	20,04	20,27	19,49
		Sumbu Z	173,25	8,65	8,65	8,67	8,67	8,67	8,67	8,68	8,68	8,68	8,69	8,67
9	Kolom 9	Sumbu X	35,96	35,92	35,93	35,98	35,98	35,99	35,99	36,01	36,01	36,03	36,02	35,99
		Sumbu Y	19,77	19,69	19,78	20,09	20,25	20,22	20,46	20,69	20,63	21,13	21,48	20,44
		Sumbu Z	17,325	8,65	8,65	8,67	8,67	8,67	8,67	8,68	8,68	8,68	8,69	8,67

Tabel E.6. Pergeseran Dengan Beban 500 gram

No.	Kolom	Koordinat	Ukuran Referensi (cm)	Pergeseran (cm)										Rata-rata
				1	2	3	4	5	6	7	8	9	10	
1	Kolom 1	Sumbu X		11,91	12,02	12,03	12,05	12,11	12,22	12,25	12,31	12,51	12,58	12,20
		Sumbu Y		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
		Sumbu Z		8,65	8,65	8,67	8,67	8,67	8,67	8,68	8,68	8,68	8,69	8,67
2	Kolom 2	Sumbu X		24,01	24,02	24,05	24,21	24,31	24,41	24,55	24,57	24,61	24,82	24,36
		Sumbu Y		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
		Sumbu Z		8,65	8,65	8,67	8,67	8,67	8,67	8,68	8,68	8,68	8,69	8,67
3	Kolom 3	Sumbu X		35,91	35,85	35,86	35,88	35,98	36,01	36,02	36,03	36,02	36,03	35,96
		Sumbu Y		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
		Sumbu Z		8,65	8,65	8,67	8,67	8,67	8,67	8,68	8,68	8,68	8,69	8,67
4	Kolom 4	Sumbu X		12,01	12,11	12,24	12,29	12,31	12,49	12,62	12,84	12,92	13,01	12,48
		Sumbu Y		9,41	9,41	9,45	9,45	9,41	9,45	9,51	9,61	9,71	9,75	9,52
		Sumbu Z		8,65	8,65	8,67	8,67	8,67	8,67	8,68	8,68	8,68	8,69	8,67
5	Kolom 5	Sumbu X		23,92	23,92	23,93	24,09	24,27	24,41	24,58	24,58	24,63	24,82	24,32
		Sumbu Y		9,91	9,91	9,91	10,01	10,01	10,01	10,01	10,11	10,11	10,15	10,01
		Sumbu Z		8,65	8,65	8,67	8,67	8,67	8,67	8,68	8,68	8,68	8,69	8,67
6	Kolom 6	Sumbu X		35,81	35,81	35,88	35,88	35,88	35,88	35,92	35,94	35,97	36,01	35,90
		Sumbu Y		9,41	9,51	9,55	9,55	9,56	9,61	9,73	9,82	9,93	9,95	9,66
		Sumbu Z		8,65	8,65	8,67	8,67	8,67	8,67	8,68	8,68	8,68	8,69	8,67
7	Kolom 7	Sumbu X		12,01	12,02	12,21	12,29	12,52	12,83	13,05	13,12	13,32	13,47	12,68
		Sumbu Y		19,63	19,72	19,63	19,81	20,03	20,21	20,42	20,73	20,72	21,12	20,20
		Sumbu Z		8,65	8,65	8,67	8,67	8,67	8,67	8,68	8,68	8,68	8,69	8,67
8	Kolom 8	Sumbu X		23,92	23,97	23,97	23,97	23,99	24,01	24,12	24,32	24,45	24,72	24,14
		Sumbu Y		19,02	19,05	19,13	19,15	19,33	19,72	19,96	20,32	20,67	20,83	19,72
		Sumbu Z		8,65	8,65	8,67	8,67	8,67	8,67	8,68	8,68	8,68	8,69	8,67
9	Kolom 9	Sumbu X		35,92	35,93	35,98	35,98	35,99	35,99	36,01	36,01	36,03	36,02	35,99
		Sumbu Y		18,75	19,02	19,47	19,86	20,23	20,52	21,52	21,62	21,71	21,93	20,46
		Sumbu Z		8,65	8,65	8,67	8,67	8,67	8,67	8,68	8,68	8,68	8,69	8,67

LAMPIRAN F
DATA SHEET

National Semiconductor

April 2005

LMD18200
3A, 55V H-Bridge

General Description

The LMD18200 is a 3A H-Bridge designed for motion control applications. The device is built using a multi-technology process which combines bipolar and CMOS control circuitry with DMOS power devices on the same monolithic structure. Ideal for driving DC and stepper motors; the LMD18200 accommodates peak output currents up to 6A. An innovative circuit which facilitates low-loss sensing of the output current has been implemented.

Features

- Delivers up to 3A continuous output
- Operates at supply voltages up to 55V
- Low R_{DS}(ON) typically 0.3Ω per switch
- TTL and CMOS compatible inputs
- No “shoot-through” current
- Thermal warning flag output at 145˚C
- Thermal shutdown (outputs off) at 170˚C
- Internal clamp diodes
- Shorted load protection
- Internal charge pump with external bootstrap capability

Applications

- DC and stepper motor drives
- Position and velocity servomechanisms
- Factory automation robots
- Numerically controlled machinery
- Computer printers and plotters

Functional Diagram

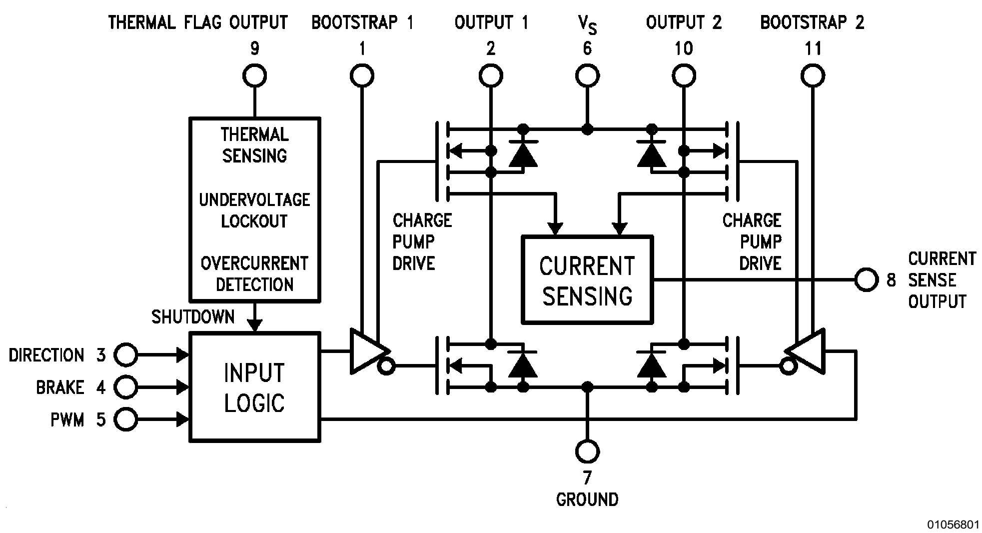
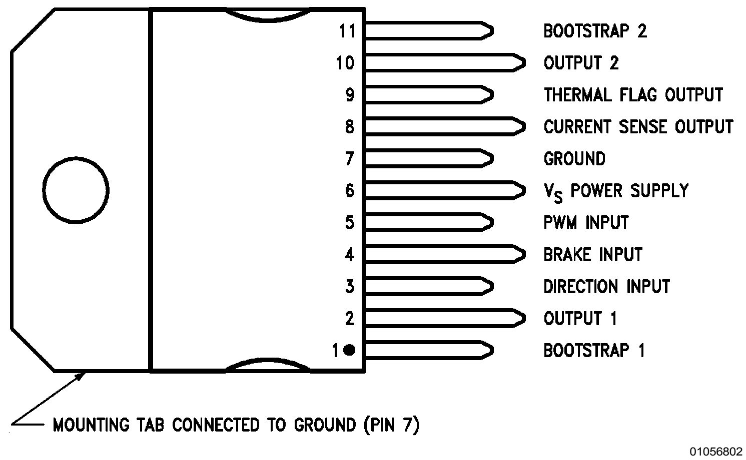
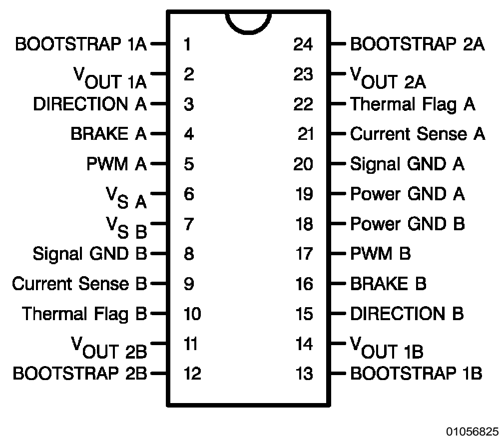


FIGURE 1. Functional Block Diagram of LMD18200

Connection Diagrams and Ordering Information



11-Lead TO-220 Package
Top View
Order Number LMD18200T
See NS Package TA11B



24-Lead Dual-in-Line Package
Top View
Order Number LMD18200-2D-QV
5962-9232501VXA
LMD18200-2D/883
5962-9232501MXA
See NS Package DA24B

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Total Supply Voltage (V_S, Pin 6)	60V
Voltage at Pins 3, 4, 5, 8 and 9	12V
Voltage at Bootstrap Pins	
(Pins 1 and 11)	V_{OUT} +16V
Peak Output Current (200 ms)	6A
Continuous Output Current (Note 2)	3A
Power Dissipation (Note 3)	25W
Power Dissipation (T_A = 25˚C, Free Air)	3W
Junction Temperature, $T_{J(max)}$	150˚C
ESD Susceptibility (Note 4)	1500V
Storage Temperature, T_{STG}	−40˚C to +150˚C
Lead Temperature (Soldering, 10 sec.)	300˚C

Operating Ratings (Note 1)

Junction Temperature, T_J	−40˚C to +125˚C
V_S Supply Voltage	+12V to +55V

Electrical Characteristics (Note 5)

The following specifications apply for V_S = 42V, unless otherwise specified. **Boldface** limits apply over the entire operating temperature range, −40˚C ≤ T_J ≤ +125˚C, all other limits are for T_A = T_J = 25˚C.

Symbol	Parameter	Conditions	Typ	Limit	Units
R_{DS}(ON)	Switch ON Resistance	Output Current = 3A (Note 6)	0.33	0.4/**0.6**	Ω (max)
R_{DS}(ON)	Switch ON Resistance	Output Current = 6A (Note 6)	0.33	0.4/**0.6**	Ω (max)
V_{CLAMP}	Clamp Diode Forward Drop	Clamp Current = 3A (Note 6)	1.2	1.5	V (max)
V_{IL}	Logic Low Input Voltage	Pins 3, 4, 5		**−0.1**	V (min)
				0.8	V (max)
I_{IL}	Logic Low Input Current	V_{IN} = −0.1V, Pins = 3, 4, 5		**−10**	µA (max)
V_{IH}	Logic High Input Voltage	Pins 3, 4, 5		**2**	V (min)
				12	V (max)
I_{IH}	Logic High Input Current	V_{IN} = 12V, Pins = 3, 4, 5		**10**	µA (max)
	Current Sense Output	I_{OUT} = 1A (Note 8)	377	325/**300**	µA (min)
				425/**450**	µA (max)
	Current Sense Linearity	1A ≤ I_{OUT} ≤ 3A (Note 7)	±6	±9	%
	Undervoltage Lockout	Outputs turn OFF		9	V (min)
				11	V (max)
T_{JW}	Warning Flag Temperature	Pin 9 ≤ 0.8V, I_L = 2 mA	145		˚C
V_F(ON)	Flag Output Saturation Voltage	T_J = T_{JW}, I_L = 2 mA	0.15		V
I_F(OFF)	Flag Output Leakage	V_F = 12V	0.2	10	µA (max)
T_{JSD}	Shutdown Temperature	Outputs Turn OFF	170		˚C
I_S	Quiescent Supply Current	All Logic Inputs Low	13	25	mA (max)
t_{Don}	Output Turn-On Delay Time	Sourcing Outputs, I_{OUT} = 3A	300		ns
		Sinking Outputs, I_{OUT} = 3A	300		ns
t_{on}	Output Turn-On Switching Time	Bootstrap Capacitor = 10 nF			
		Sourcing Outputs, I_{OUT} = 3A	100		ns
		Sinking Outputs, I_{OUT} = 3A	80		ns
t_{Doff}	Output Turn-Off Delay Times	Sourcing Outputs, I_{OUT} = 3A	200		ns
		Sinking Outputs, I_{OUT} = 3A	200		ns
t_{off}	Output Turn-Off Switching Times	Bootstrap Capacitor = 10 nF			
		Sourcing Outputs, I_{OUT} = 3A	75		ns
		Sinking Outputs, I_{OUT} = 3A	70		ns
t_{pw}	Minimum Input Pulse Width	Pins 3, 4 and 5	1		µs
t_{cpr}	Charge Pump Rise Time	No Bootstrap Capacitor	20		µs

Electrical Characteristics Notes

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications do not apply when operating the device beyond its rated operating conditions.

Note 2: See Application Information for details regarding current limiting.

Note 3: The maximum power dissipation must be derated at elevated temperatures and is a function of $T_{J(max)}$, θ_{JA}, and T_A. The maximum allowable power dissipation at any temperature is $P_{D(max)} = (T_{J(max)} - T_A)/\theta_{JA}$, or the number given in the Absolute Ratings, whichever is lower. The typical thermal resistance from junction to case (θ_{JC}) is 1.0˚C/W and from junction to ambient (θ_{JA}) is 30˚C/W. For guaranteed operation $T_{J(max)}$ = 125˚C.

Note 4: Human-body model, 100 pF discharged through a 1.5 kΩ resistor. Except Bootstrap pins (pins 1 and 11) which are protected to 1000V of ESD.

Note 5: All limits are 100% production tested at 25˚C. Temperature extreme limits are guaranteed via correlation using accepted SQC (Statistical Quality Control)
methods. All limits are used to calculate AOQL, (Average Outgoing Quality Level).

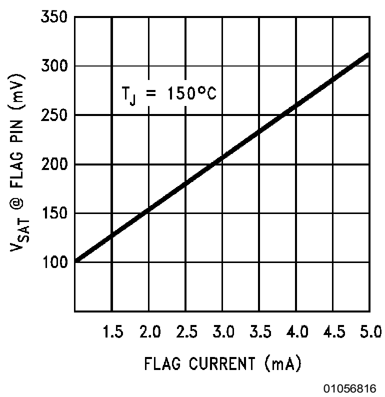
Note 6: Output currents are pulsed (t_W < 2 ms, Duty Cycle < 5%).

Note 7: Regulation is calculated relative to the current sense output value with a 1A load.

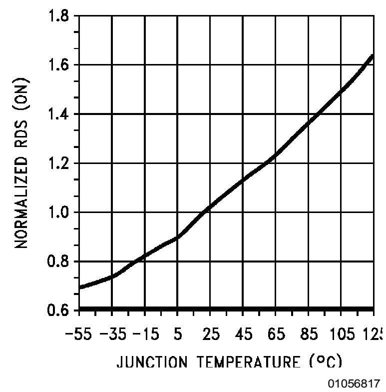
Note 8: Selections for tighter tolerance are available. Contact factory.

Typical Performance Characteristics

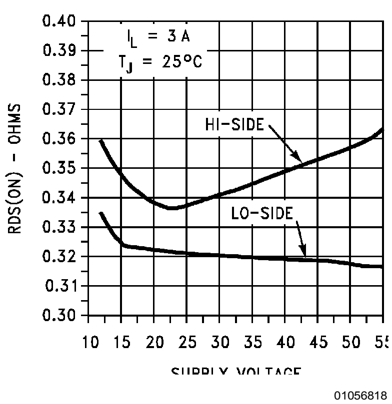
V_{SAT} vs Flag Current



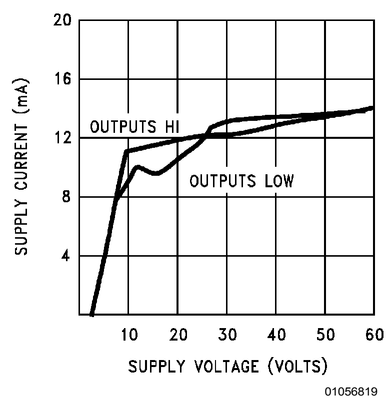
R_{DS}(ON) vs Temperature



R_{DS}(ON) vs Supply Voltage

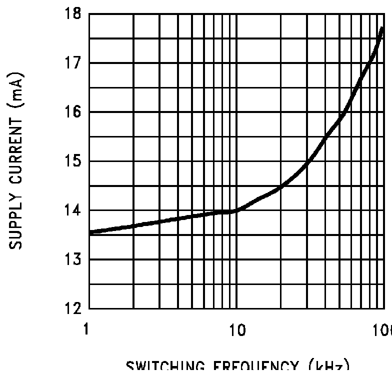


Supply Current vs Supply Voltage



Typical Performance Characteristics (Continued)

Supply Current vs Frequency (V_S = 42V)



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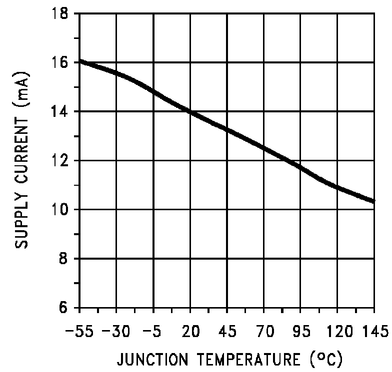
Supply Current vs Temperature (V_S = 42V)



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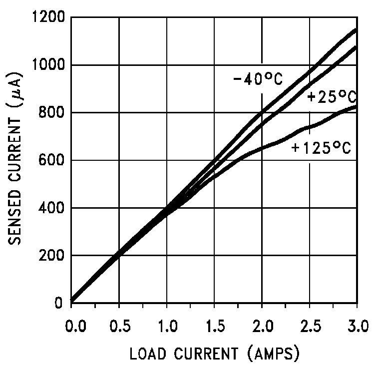
Current Sense Output vs Load Current



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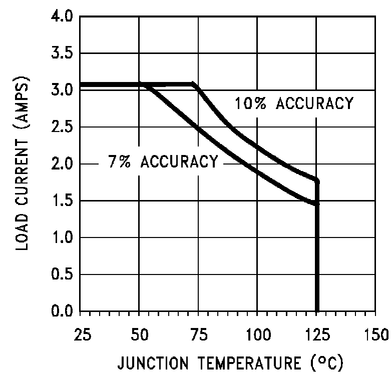
Current Sense Operating Region



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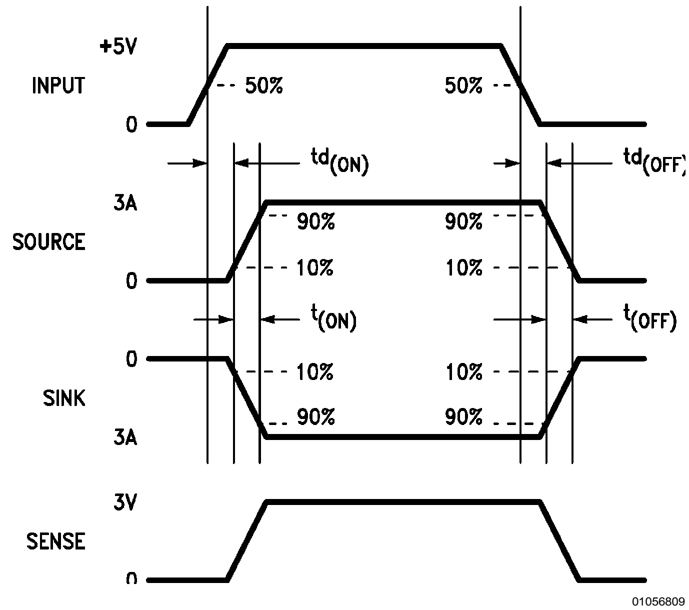
Test Circuit

Switching Time Definitions



Pinout Description

(See Connection Diagram)

Pin 1, BOOTSTRAP 1 Input: Bootstrap capacitor pin for half H-bridge number 1. The recommended capacitor (10 nF) is connected between pins 1 and 2.

Pin 2, OUTPUT 1: Half H-bridge number 1 output.

Pin 3, DIRECTION Input: See *Table 1*. This input controls the direction of current flow between OUTPUT 1 and OUT- PUT 2 (pins 2 and 10) and, therefore, the direction of rotation of a motor load.

Pin 4, BRAKE Input: See *Table 1*. This input is used to brake a motor by effectively shorting its terminals. When braking is desired, this input is taken to a logic high level and
it is also necessary to apply logic high to PWM input, pin 5. The drivers that short the motor are determined by the logic level at the DIRECTION input (Pin 3): with Pin 3 logic high, both current sourcing output transistors are ON; with Pin 3 logic low, both current sinking output transistors are ON. All output transistors can be turned OFF by applying a logic high to Pin 4 and a logic low to PWM input Pin 5; in this case only
a small bias current (approximately −1.5 mA) exists at each output pin.

Pin 5, PWM Input: See *Table 1*. How this input (and DIREC- TION input, Pin 3) is used is determined by the format of the PWM Signal.

Pin 6, V_S Power Supply

Pin 7, GROUND Connection: This pin is the ground return, and is internally connected to the mounting tab.

Pin 8, CURRENT SENSE Output: This pin provides the sourcing current sensing output signal, which is typically
377 µA/A.

Pin 9, THERMAL FLAG Output: This pin provides the thermal warning flag output signal. Pin 9 becomes active-low at 145˚C (junction temperature). However the chip will not shut itself down until 170˚C is reached at the junction.

Pin 10, OUTPUT 2: Half H-bridge number 2 output.

Pin 11, BOOTSTRAP 2 Input: Bootstrap capacitor pin for Half H-bridge number 2. The recommended capacitor (10 nF) is connected between pins 10 and 11.

TABLE 1. Logic Truth Table

PWM	Dir	Brake	Active Output Drivers
H	H	L	Source 1, Sink 2
H	L	L	Sink 1, Source 2
L	X	L	Source 1, Source 2
H	H	H	Source 1, Source 2
H	L	H	Sink 1, Sink 2
L	X	H	NONE

Application Information

TYPES OF PWM SIGNALS

The LMD18200 readily interfaces with different forms of PWM signals. Use of the part with two of the more popular forms of PWM is described in the following paragraphs.

Simple, locked anti-phase PWM consists of a single, vari- able duty-cycle signal in which is encoded both direction and amplitude information (see *Figure 2*). A 50% duty-cycle PWM signal represents zero drive, since the net value of voltage (integrated over one period) delivered to the load is zero. For the LMD18200, the PWM signal drives the direc- tion input (pin 3) and the PWM input (pin 5) is tied to logic

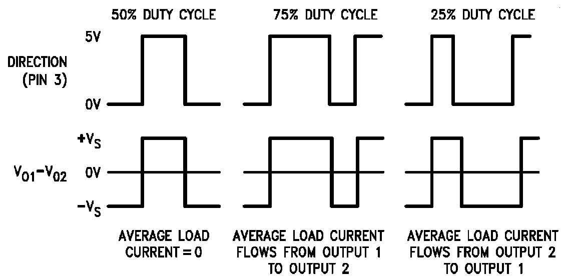


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FIGURE 2. Locked Anti-Phase PWM Control

SIGNAL TRANSITION REQUIREMENTS

To ensure proper internal logic performance, it is good prac- tice to avoid aligning the falling and rising edges of input signals. A delay of at least 1 μsec should be incorporated between transitions of the Direction, Brake, and/or PWM input signals. A conservative approach is be sure there is at least 500ns delay between the end of the first transition and the beginning of the second transition. See *Figure*

Sign/magnitude PWM consists of separate direction (sign) and amplitude (magnitude) signals (see *Figure 3*). The (ab- solute) magnitude signal is duty-cycle modulated, and the absence of a pulse signal (a continuous logic low level) represents zero drive. Current delivered to the load is pro- portional to pulse width. For the LMD18200, the DIRECTION input (pin 3) is driven by the sign signal and the PWM input
(pin 5) is driven by the magnitude signal.

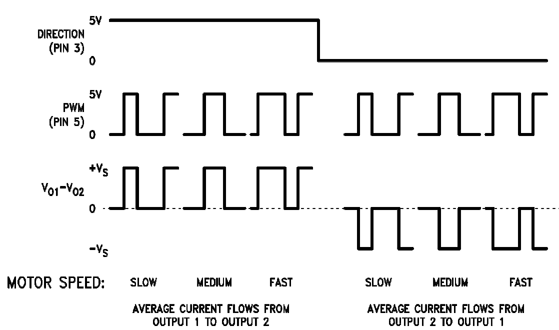

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FIGURE 3. Sign/Magnitude PWM Control

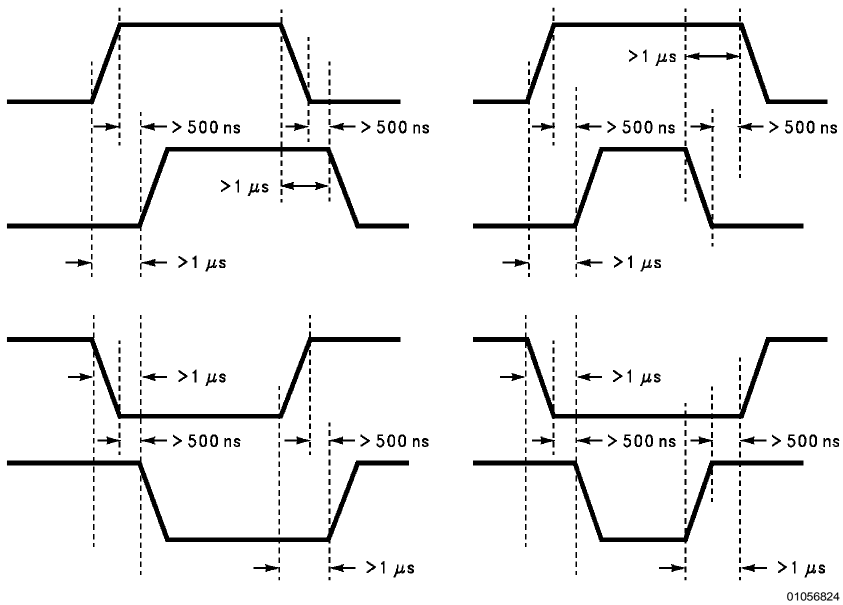

FIGURE 4. Transitions in Brake, Direction, or PWM Must Be Separated By At Least 1 μsec

USING THE CURRENT SENSE OUTPUT

The CURRENT SENSE output (pin 8) has a sensitivity of 377 μA per ampere of output current. For optimal accuracy and linearity of this signal, the value of voltage generating resistor between pin 8 and ground should be chosen to limit the maximum voltage developed at pin 8 to 5V, or less. The maximum voltage compliance is 12V.

It should be noted that the recirculating currents (free wheel- ing currents) are ignored by the current sense circuitry. Therefore, only the currents in the upper sourcing outputs are sensed.

USING THE THERMAL WARNING FLAG

The THERMAL FLAG output (pin 9) is an open collector transistor. This permits a wired OR connection of thermal warning flag outputs from multiple LMD18200's, and allows the user to set the logic high level of the output signal swing to match system requirements. This output typically drives the interrupt input of a system controller. The interrupt ser- vice routine would then be designed to take appropriate steps, such as reducing load currents or initiating an orderly system shutdown. The maximum voltage compliance on the flag pin is 12V.

SUPPLY BYPASSING

During switching transitions the levels of fast current changes experienced may cause troublesome voltage tran- sients across system stray inductance.

It is normally necessary to bypass the supply rail with a high quality capacitor(s) connected as close as possible to the V_S Power Supply (Pin 6) and GROUND (Pin 7). A 1 μF high- frequency ceramic capacitor is recommended. Care should be taken to limit the transients on the supply pin below the Absolute Maximum Rating of the device. When operating the chip at supply voltages above 40V a voltage suppressor (transorb) such as P6KE62A is recommended from supply to ground. Typically the ceramic capacitor can be eliminated in the presence of the voltage suppressor. Note that when driving high load currents a greater amount of supply bypass capacitance (in general at least 100 μF per Amp of load current) is required to absorb the recirculating currents of the inductive loads.

CURRENT LIMITING

Current limiting protection circuitry has been incorporated into the design of the LMD18200. With any power device it is important to consider the effects of the substantial surge currents through the device that may occur as a result of shorted loads. The protection circuitry monitors this increase in current (the threshold is set to approximately 10 Amps) and shuts off the power device as quickly as possible in the event of an overload condition. In a typical motor driving application the most common overload faults are caused by shorted motor windings and locked rotors. Under these con- ditions the inductance of the motor (as well as any series inductance in the V_{CC} supply line) serves to reduce the magnitude of a current surge to a safe level for the LMD18200. Once the device is shut down, the control cir- cuitry will periodically try to turn the power device back on. This feature allows the immediate return to normal operation in the event that the fault condition has been removed. While the fault remains however, the device will cycle in and out of thermal shutdown. This can create voltage transients on the V_{CC} supply line and therefore proper supply bypassing tech- niques are required.

The most severe condition for any power device is a direct, hard-wired ("screwdriver") long term short from an output to ground. This condition can generate a surge of current through the power device on the order of 15 Amps and require the die and package to dissipate up to 500 Watts of power for the short time required for the protection circuitry

to shut off the power device. This energy can be destructive, particularly at higher operating voltages (>30V) so some precautions are in order. Proper heat sink design is essential and it is normally necessary to heat sink the V_{CC} supply pin
(pin 6) with 1 square inch of copper on the PCB.

INTERNAL CHARGE PUMP AND USE OF BOOTSTRAP CAPACITORS

To turn on the high-side (sourcing) DMOS power devices, the gate of each device must be driven approximately 8V more positive than the supply voltage. To achieve this an internal charge pump is used to provide the gate drive voltage. As shown in *Figure 5*, an internal capacitor is alternately switched to ground and charged to about 14V, then switched to V supply thereby providing a gate drive voltage greater than V supply. This switching action is controlled by a continuously running internal 300 kHz oscillator. The rise time of this drive voltage is typically 20 µs which is suitable for operating frequencies up to 1 kHz.

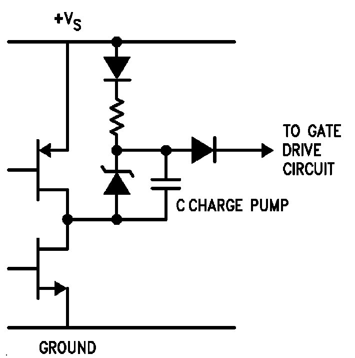

FIGURE 5. Internal Charge Pump Circuitry

For higher switching frequencies, the LMD18200 provides for the use of external bootstrap capacitors. The bootstrap principle is in essence a second charge pump whereby a large value capacitor is used which has enough energy to quickly charge the parasitic gate input capacitance of the power device resulting in much faster rise times. The switching action is accomplished by the power switches themselves *Figure 6*. External 10 nF capacitors, connected from the outputs to the bootstrap pins of each high-side switch provide typically less than 100 ns rise times allowing switching frequencies up to 500 kHz.

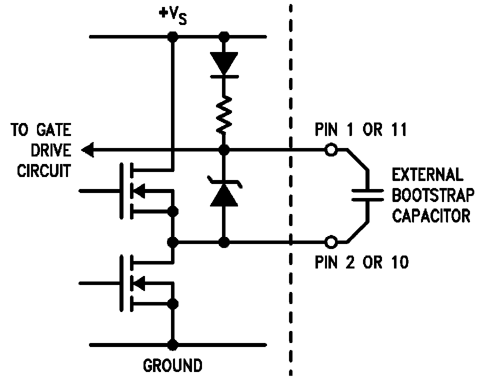

FIGURE 6. Bootstrap Circuitry

INTERNAL PROTECTION DIODES

A major consideration when switching current through inductive loads is protection of the switching power devices from the large voltage transients that occur. Each of the four switches in the LMD18200 have a built-in protection diode to clamp transient voltages exceeding the positive supply or ground to a safe diode voltage drop across the switch.

The reverse recovery characteristics of these diodes, once the transient has subsided, is important. These diodes must come out of conduction quickly and the power switches must be able to conduct the additional reverse recovery current of the diodes. The reverse recovery time of the diodes protecting the sourcing power devices is typically only 70 ns with a reverse recovery current of 1A when tested with a full 6A of forward current through the diode. For the sinking devices the recovery time is typically 100 ns with 4A of reverse current under the same conditions.

Typical Applications

FIXED OFF-TIME CONTROL

This circuit controls the current through the motor by applying an average voltage equal to zero to the motor terminals for a fixed period of time, whenever the current through the motor exceeds the commanded current. This action causes the motor current to vary slightly about an externally controlled average level. The duration of the Off-period is adjusted by the resistor and capacitor combination of the LM555. In this circuit the Sign/Magnitude mode of operation is implemented (see Types of PWM Signals).

Typical Applications (Continued)

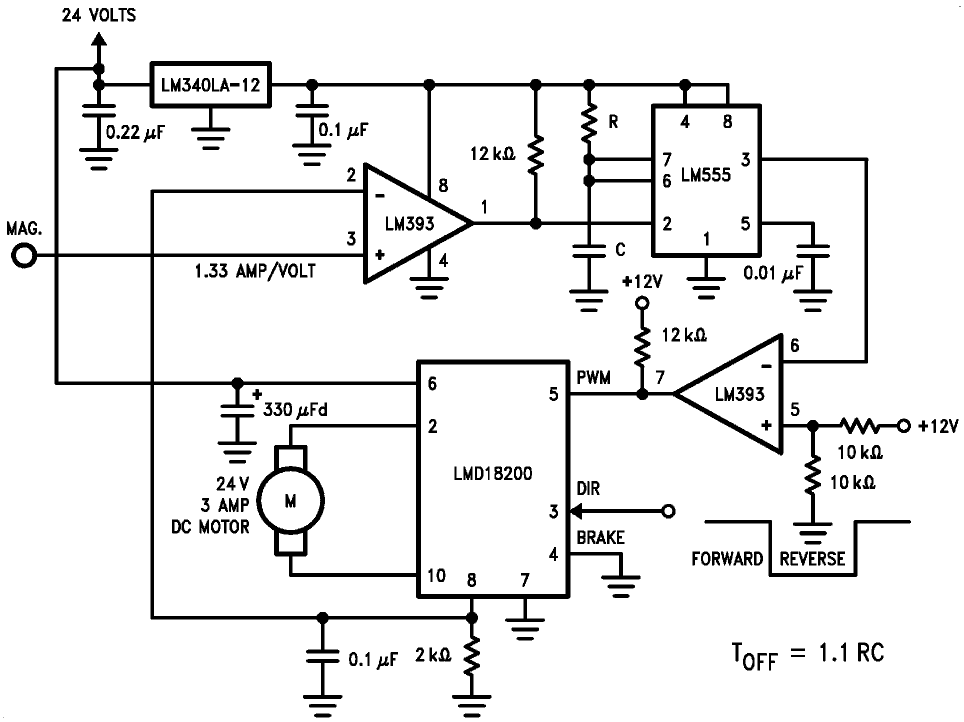

FIGURE 7. Fixed Off-Time Control

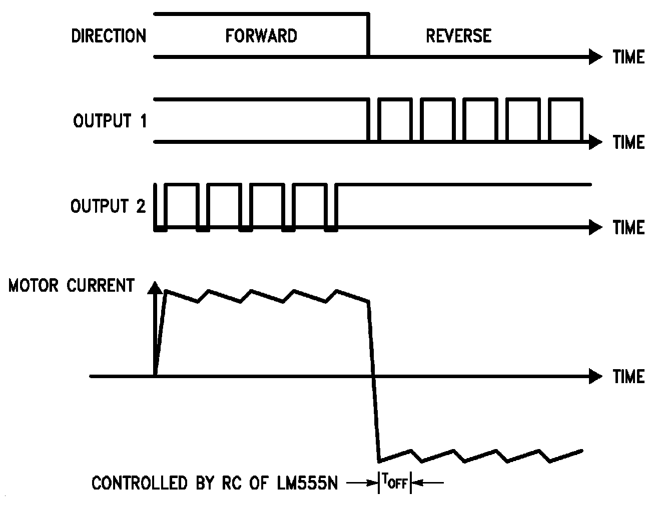

FIGURE 8. Switching Waveforms

TORQUE REGULATION

Locked Anti-Phase Control of a brushed DC motor. Current sense output of the LMD18200 provides load sensing. The LM3524D is a general purpose PWM controller. The relation- ship of peak motor current to adjustment voltage is shown in *Figure 10*.

Typical Applications (Continued)

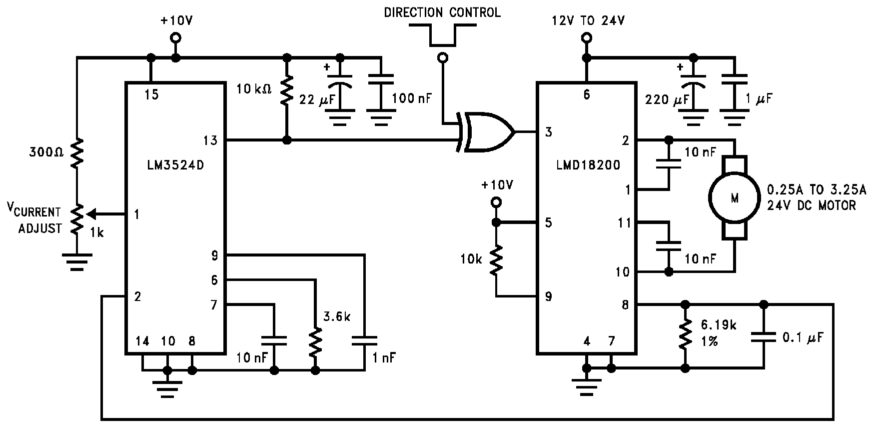

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FIGURE 9. Locked Anti-Phase Control Regulates Torque

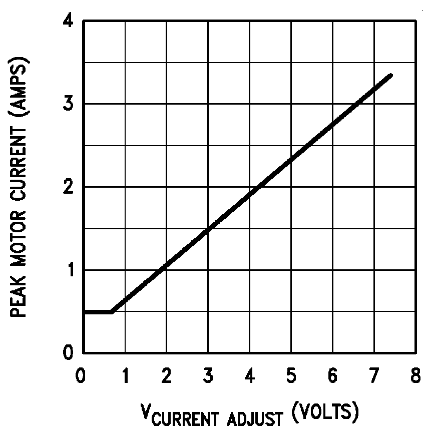

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FIGURE 10. Peak Motor Current vs Adjustment Voltage

VELOCITY REGULATION

Utilizes tachometer output from the motor to sense motor speed for a locked anti-phase control loop. The relationship of motor speed to the speed adjustment control voltage is shown in *Figure 12*.

Typical Applications (Continued)

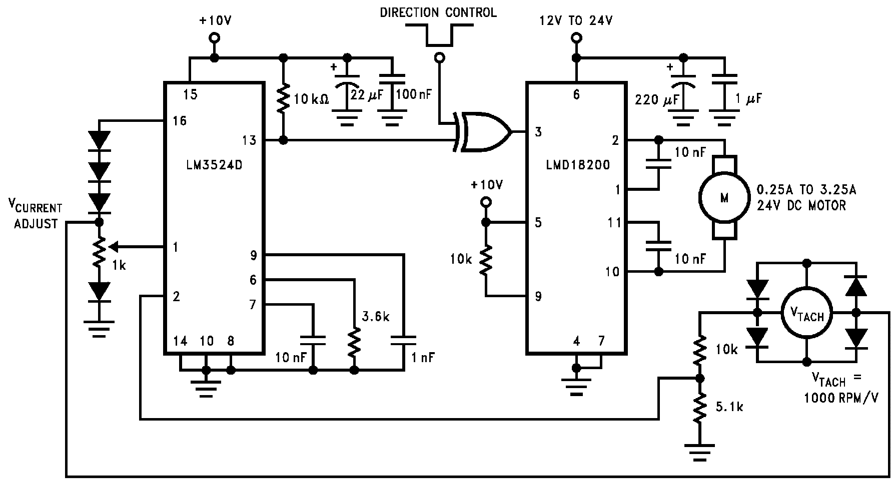

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FIGURE 11. Regulate Velocity with Tachometer Feedback

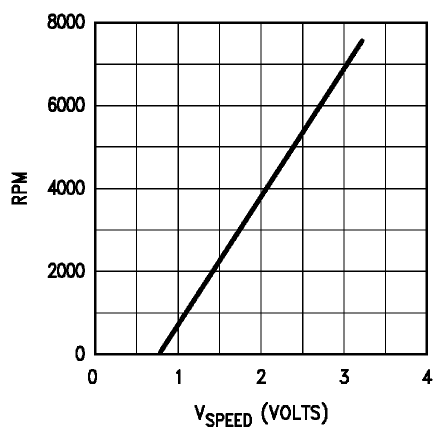

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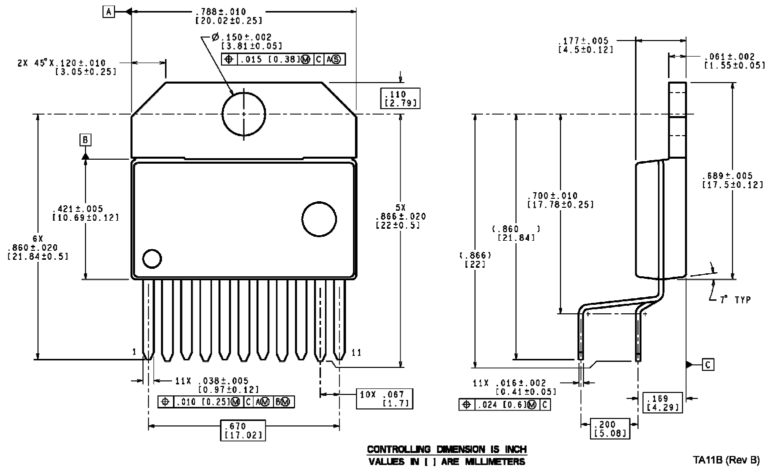
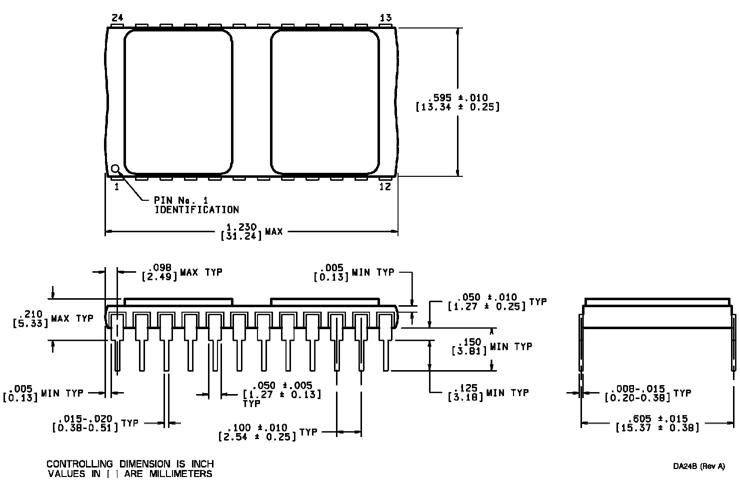
FIGURE 12. Motor Speed vs Control Voltage

Physical Dimensions inches (millimeters) unless otherwise noted



11-Lead TO-220 Power Package (T) Order Number LMD18200T NS Package Number TA11B

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



24-Lead Dual-in-Line Package Order Number LMD18200-2D-QV 5962-9232501VXA LMD18200-2D/883 5962-9232501MXA NS Package Number DA24B

LIFE SUPPORT POLICY

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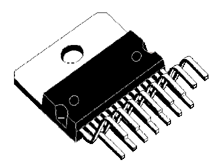
1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

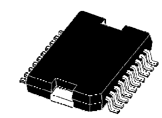
BANNED SUBSTANCE COMPLIANCE

DUAL FULL-BRIDGE DRIVER

- OPERATING SUPPLY VOLTAGE UP TO 46 V
- TOTAL DC CURRENT UP TO 4 A
- LOW SATURATION VOLTAGE
- OVERTEMPERATURE PROTECTION
- LOGICAL "0" INPUT VOLTAGE UP TO 1.5 V (HIGH NOISE IMMUNITY)



Multiwatt15



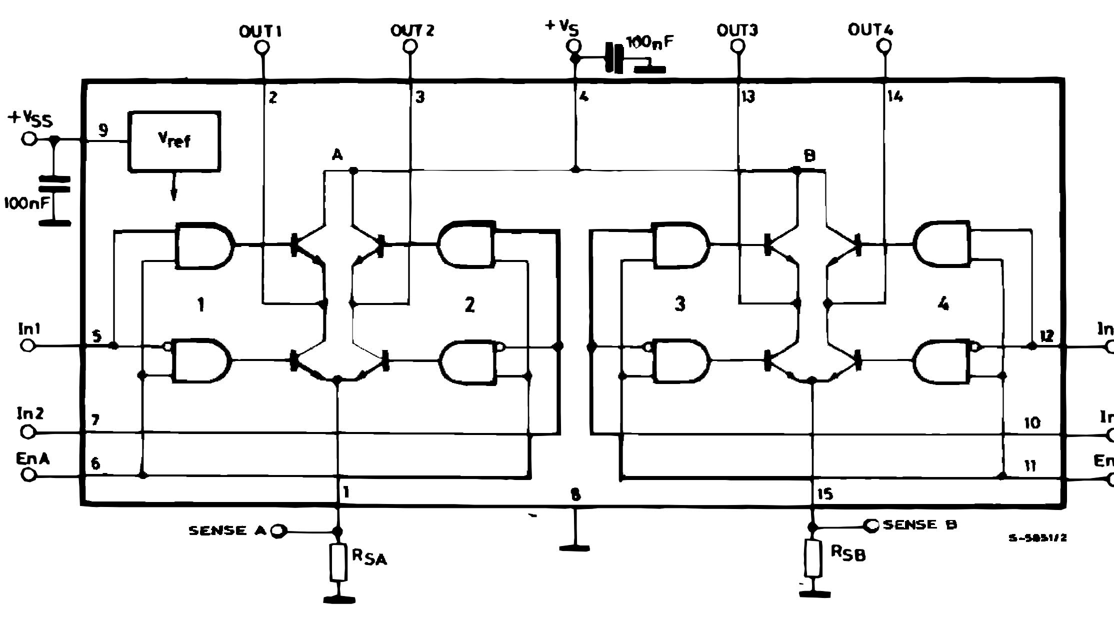
PowerSO20

ORDERING NUMBERS : L298N (Multiwatt Vert.)
L298HN (Multiwatt Horiz.)
L298P (PowerSO20)

DESCRIPTION

The L298 is an integrated monolithic circuit in a 15-lead Multiwatt and PowerSO20 packages. It is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive inductive loads such as relays, solenoids, DC and stepping motors. Two enable inputs are provided to enable or disable the device independently of the input signals. The emitters of the lower transistors of each bridge are connected together and the corresponding external terminal can be used for the connection of an external sensing resistor. An additional supply input is provided so that the logic works at a lower voltage.

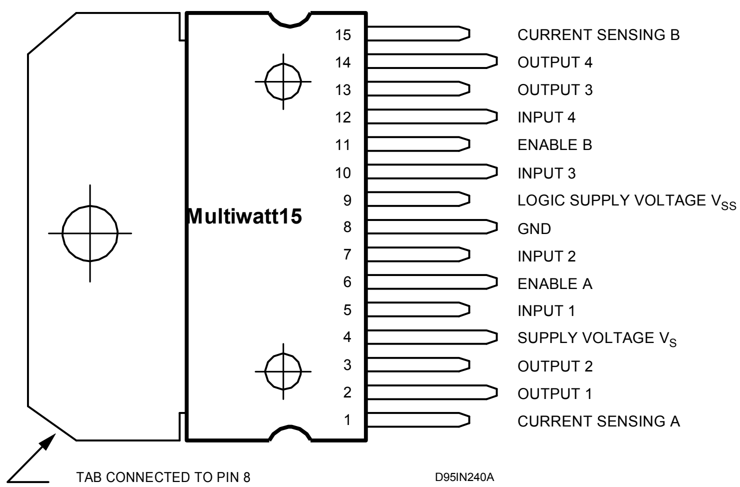
BLOCK DIAGRAM

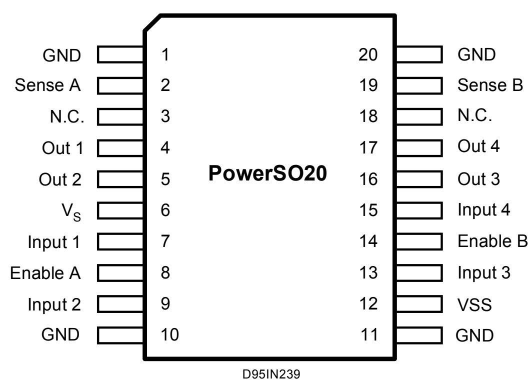


ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	Power Supply	50	V
V_{SS}	Logic Supply Voltage	7	V
V_I,V_{en}	Input and Enable Voltage	–0.3 to 7	V
I_O	Peak Output Current (each Channel) – Non Repetitive (t = 100µs) –Repetitive (80% on –20% off; t_{on} = 10ms) –DC Operation	 3 2.5 2	 A A A
V_{sens}	Sensing Voltage	–1 to 2.3	V
P_{tot}	Total Power Dissipation (T_{case} = 75°C)	25	W
T_{op}	Junction Operating Temperature	–25 to 130	°C
T_{stg}, T_j	Storage and Junction Temperature	–40 to 150	°C

PIN CONNECTIONS (top view)





THERMAL DATA

Symbol	Parameter		PowerSO20	Multiwatt15	Unit
$R_{th\ j\text{-}case}$	Thermal Resistance Junction-case	Max.	–	3	°C/W
$R_{th\ j\text{-}amb}$	Thermal Resistance Junction-ambient	Max.	13 (*)	35	°C/W

(*) Mounted on aluminum substrate

PIN FUNCTIONS (refer to the block diagram)

MW.15	PowerSO	Name	Function
1;15	2;19	Sense A; Sense B	Between this pin and ground is connected the sense resistor to control the current of the load.
2;3	4;5	Out 1; Out 2	Outputs of the Bridge A; the current that flows through the load connected between these two pins is monitored at pin 1.
4	6	V_S	Supply Voltage for the Power Output Stages. A non-inductive 100nF capacitor must be connected between this pin and ground.
5;7	7;9	Input 1; Input 2	TTL Compatible Inputs of the Bridge A.
6;11	8;14	Enable A; Enable B	TTL Compatible Enable Input: the L state disables the bridge A (enable A) and/or the bridge B (enable B).
8	1,10,11,20	GND	Ground.
9	12	VSS	Supply Voltage for the Logic Blocks. A100nF capacitor must be connected between this pin and ground.
10; 12	13;15	Input 3; Input 4	TTL Compatible Inputs of the Bridge B.
13; 14	16;17	Out 3; Out 4	Outputs of the Bridge B. The current that flows through the load connected between these two pins is monitored at pin 15.
–	3;18	N.C.	Not Connected

ELECTRICAL CHARACTERISTICS (V_S = 42V; V_{SS} = 5V, T_j = 25°C; unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_S	Supply Voltage (pin 4)	Operative Condition	V_{IH} +2.5		46	V
V_{SS}	Logic Supply Voltage (pin 9)		4.5	5	7	V
I_S	Quiescent Supply Current (pin 4)	V_{en} = H; I_L = 0 V_i = L V_i = H		13 50	22 70	mA mA
		V_{en} = L V_i = X			4	mA
I_{SS}	Quiescent Current from V_{SS} (pin 9)	V_{en} = H; I_L = 0 V_i = L V_i = H		24 7	36 12	mA mA
		V_{en} = L V_i = X			6	mA
V_{iL}	Input Low Voltage (pins 5, 7, 10, 12)		–0.3		1.5	V
V_{iH}	Input High Voltage (pins 5, 7, 10, 12)		2.3		VSS	V
I_{iL}	Low Voltage Input Current (pins 5, 7, 10, 12)	V_i = L			–10	μA
I_{iH}	High Voltage Input Current (pins 5, 7, 10, 12)	Vi = H ≤ V_{SS} –0.6V		30	100	μA
V_{en} = L	Enable Low Voltage (pins 6, 11)		–0.3		1.5	V
V_{en} = H	Enable High Voltage (pins 6, 11)		2.3		V_{SS}	V
I_{en} = L	Low Voltage Enable Current (pins 6, 11)	V_{en} = L			–10	μA
I_{en} = H	High Voltage Enable Current (pins 6, 11)	V_{en} = H ≤ V_{SS} –0.6V		30	100	μA
$V_{CEsat (H)}$	Source Saturation Voltage	I_L = 1A I_L = 2A	0.95	1.35 2	1.7 2.7	V V
$V_{CEsat (L)}$	Sink Saturation Voltage	I_L = 1A (5) I_L = 2A (5)	0.85	1.2 1.7	1.6 2.3	V V
V_{CEsat}	Total Drop	I_L = 1A (5) I_L = 2A (5)	1.80		3.2 4.9	V V
V_{sens}	Sensing Voltage (pins 1, 15)		–1 (1)		2	V

ELECTRICAL CHARACTERISTICS (continued)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
T_1 (V_i)	Source Current Turn-off Delay	0.5 V_i to 0.9 I_L (2); (4)		1.5		μs
T_2 (V_i)	Source Current Fall Time	0.9 I_L to 0.1 I_L (2); (4)		0.2		μs
T_3 (V_i)	Source Current Turn-on Delay	0.5 V_i to 0.1 I_L (2); (4)		2		μs
T_4 (V_i)	Source Current Rise Time	0.1 I_L to 0.9 I_L (2); (4)		0.7		μs
T_5 (V_i)	Sink Current Turn-off Delay	0.5 V_i to 0.9 I_L (3); (4)		0.7		μs
T_6 (V_i)	Sink Current Fall Time	0.9 I_L to 0.1 I_L (3); (4)		0.25		μs
T_7 (V_i)	Sink Current Turn-on Delay	0.5 V_i to 0.9 I_L (3); (4)		1.6		μs
T_8 (V_i)	Sink Current Rise Time	0.1 I_L to 0.9 I_L (3); (4)		0.2		μs
fc (V_i)	Commutation Frequency	I_L = 2A		25	40	KHz
T_1 (V_{en})	Source Current Turn-off Delay	0.5 V_{en} to 0.9 I_L (2); (4)		3		μs
T_2 (V_{en})	Source Current Fall Time	0.9 I_L to 0.1 I_L (2); (4)		1		μs
T_3 (V_{en})	Source Current Turn-on Delay	0.5 V_{en} to 0.1 I_L (2); (4)		0.3		μs
T_4 (V_{en})	Source Current Rise Time	0.1 I_L to 0.9 I_L (2); (4)		0.4		μs
T_5 (V_{en})	Sink Current Turn-off Delay	0.5 V_{en} to 0.9 I_L (3); (4)		2.2		μs
T_6 (V_{en})	Sink Current Fall Time	0.9 I_L to 0.1 I_L (3); (4)		0.35		μs
T_7 (V_{en})	Sink Current Turn-on Delay	0.5 V_{en} to 0.9 I_L (3); (4)		0.25		μs
T_8 (V_{en})	Sink Current Rise Time	0.1 I_L to 0.9 I_L (3); (4)		0.1		μs

1) 1)Sensing voltage can be –1 V for t ≤ 50 μsec; in steady state V_{sens} min ≥ – 0.5 V.
2) See fig. 2.
3) See fig. 4.
4) The load must be a pure resistor.

Figure 1 : Typical Saturation Voltage vs. Output Current.

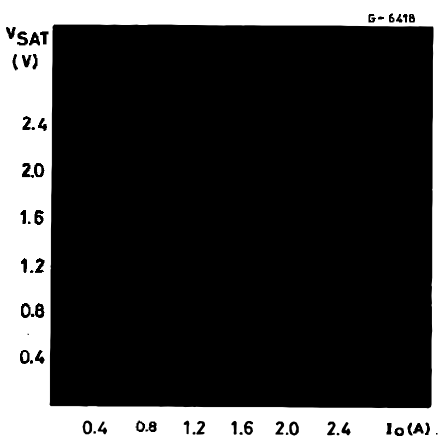
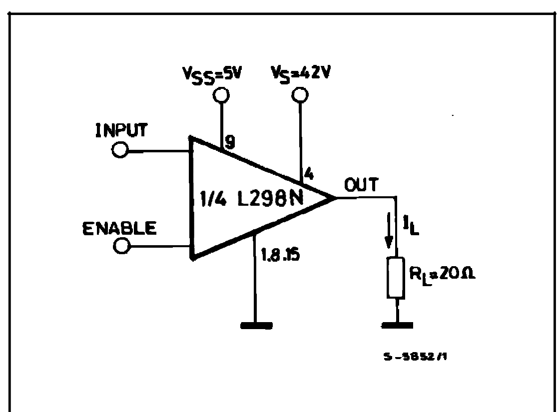


Figure 2 : Switching Times Test Circuits.



Note : For INPUT Switching, set EN = H
For ENABLE Switching, set IN = H

Figure 3 : Source Current Delay Times vs. Input or Enable Switching.

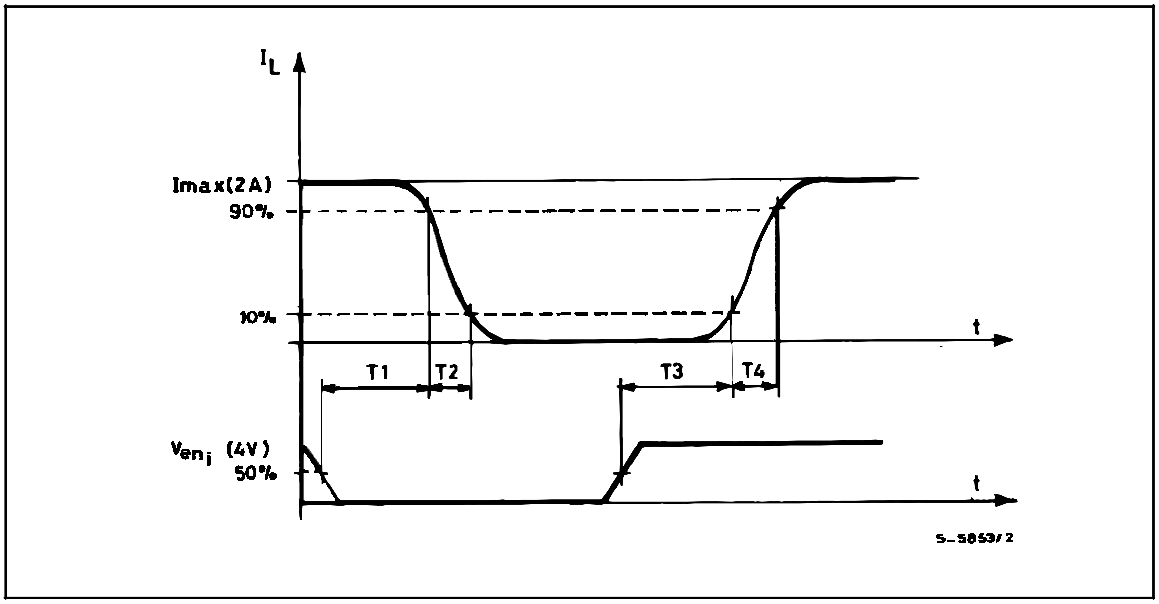
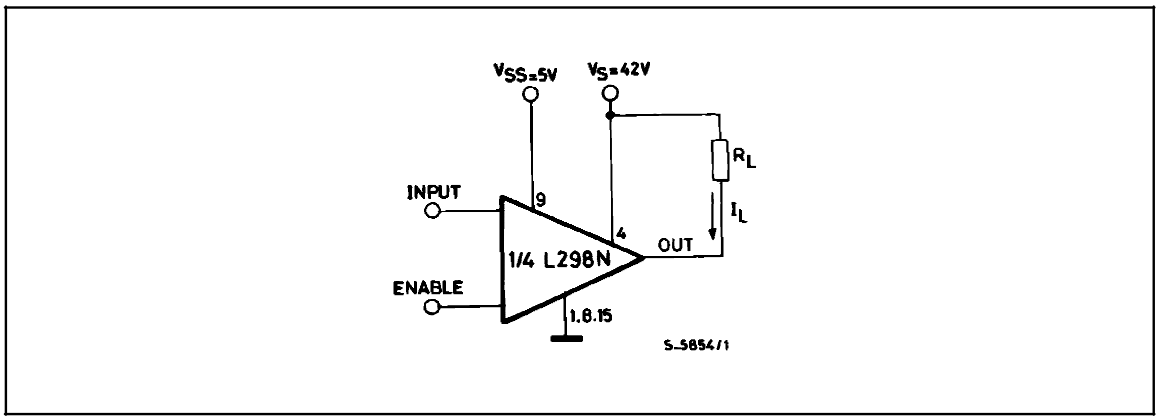


Figure 4 : Switching Times Test Circuits.



Note : For INPUT Switching, set EN = H
For ENABLE Switching, set IN = L

Figure 5 : Sink Current Delay Times vs. Input 0 V Enable Switching.

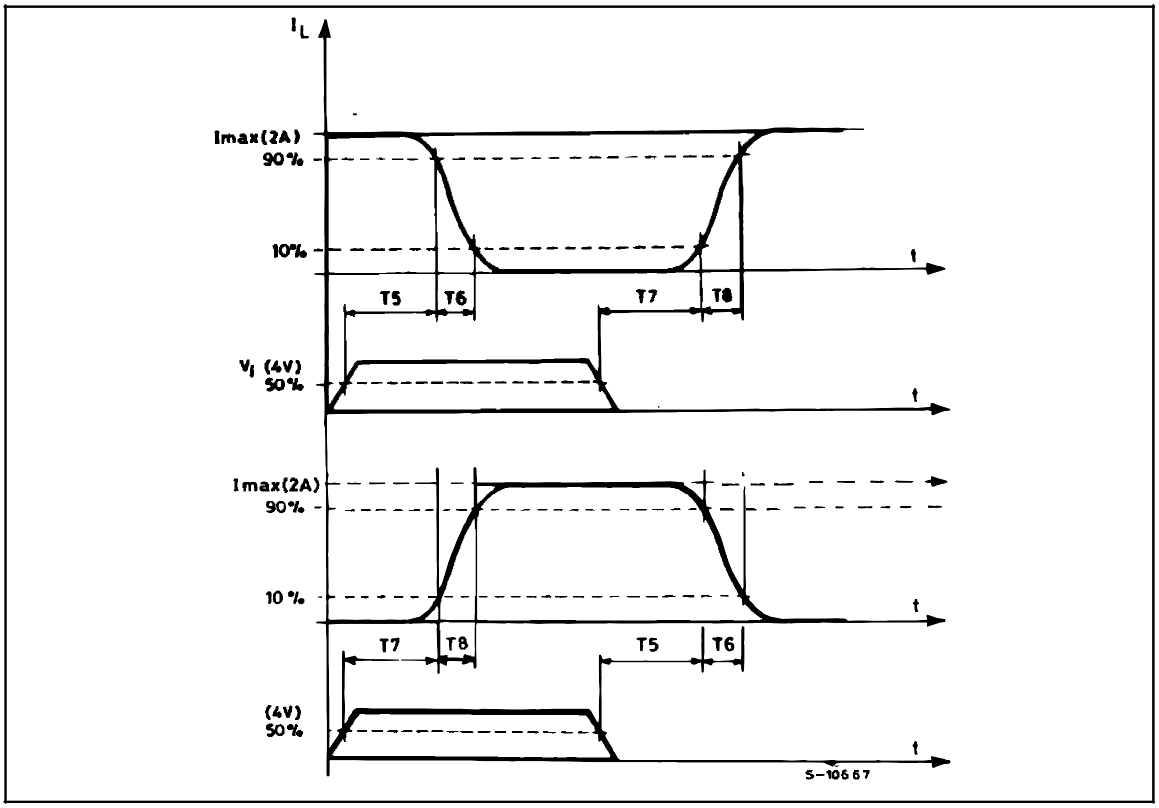
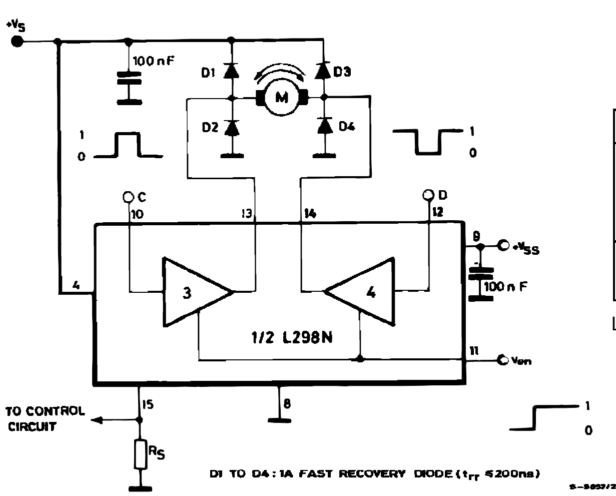


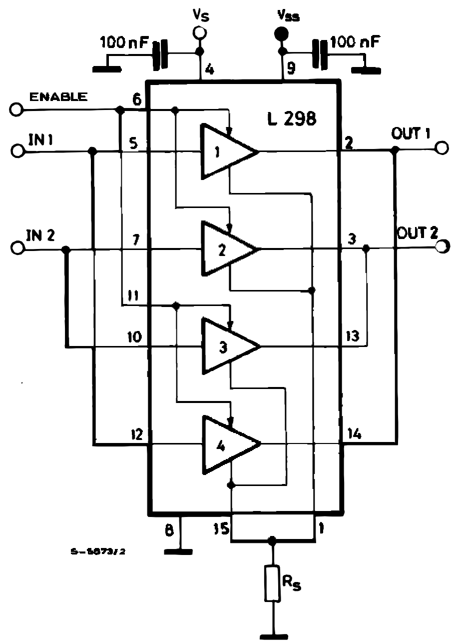
Figure 6 : Bidirectional DC Motor Control.



Inputs		Function
V_{en} = H	C = H ; D = L	Forward
	C = L ; D = H	Reverse
	C = D	Fast Motor Stop
V_{en} = L	C = X ; D = X	Free Running Motor Stop

L = Low H = High X = Don't care

Figure 7 : For higher currents, outputs can be paralleled. Take care to parallel channel 1 with channel 4 and channel 2 with channel 3.



APPLICATION INFORMATION (Refer to the block diagram)

1.1. POWER OUTPUT STAGE

The L298 integrates two power output stages (A ; B). The power output stage is a bridge configuration and its outputs can drive an inductive load in common or differenzial mode, depending on the state of the inputs. The current that flows through the load comes out from the bridge at the sense output : an external resistor (R_{SA} ; R_{SB}.) allows to detect the intensity of this current.

1.2. INPUT STAGE

Each bridge is driven by means of four gates the input of which are In1 ; In2 ; EnA and In3 ; In4 ; EnB. The In inputs set the bridge state when The En input is high ; a low state of the En input inhibits the bridge. All the inputs are TTL compatible.

2. SUGGESTIONS

A non inductive capacitor, usually of 100 nF, must be foreseen between both Vs and Vss, to ground, as near as possible to GND pin. When the large capacitor of the power supply is too far from the IC, a second smaller one must be foreseen near the L298.

The sense resistor, not of a wire wound type, must be grounded near the negative pole of Vs that must be near the GND pin of the I.C.

Each input must be connected to the source of the driving signals by means of a very short path.

Turn-On and Turn-Off : Before to Turn-ON the Supply Voltage and before to Turn it OFF, the Enable input must be driven to the Low state.

3. APPLICATIONS

Fig 6 shows a bidirectional DC motor control Schematic Diagram for which only one bridge is needed. The external bridge of diodes D1 to D4 is made by four fast recovery elements ($t_{rr} \leq$ 200 nsec) that must be chosen of a VF as low as possible at the worst case of the load current.

The sense output voltage can be used to control the current amplitude by chopping the inputs, or to provide overcurrent protection by switching low the enable input.

The brake function (Fast motor stop) requires that the Absolute Maximum Rating of 2 Amps must never be overcome.

When the repetitive peak current needed from the load is higher than 2 Amps, a paralleled configuration can be chosen (See Fig.7).

An external bridge of diodes are required when inductive loads are driven and when the inputs of the IC are chopped ; Shottky diodes would be preferred.

This solution can drive until 3 Amps In DC operation and until 3.5 Amps of a repetitive peak current.

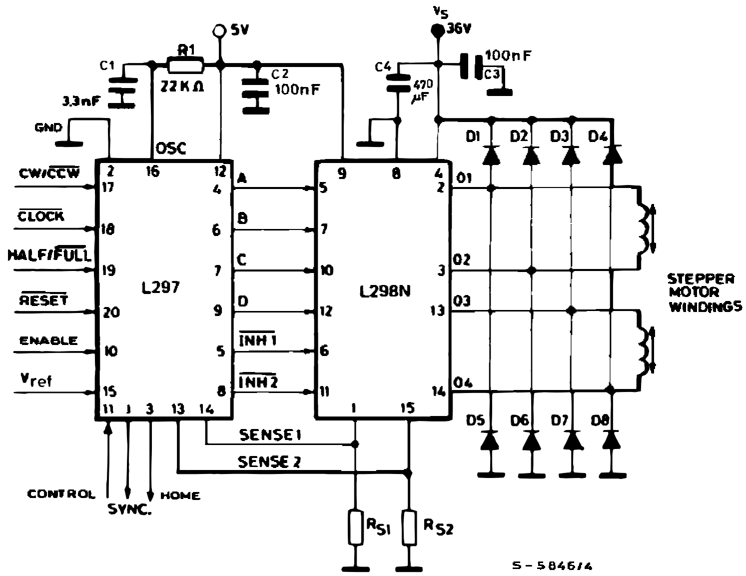
On Fig 8 it is shown the driving of a two phase bipolar stepper motor ; the needed signals to drive the inputs of the L298 are generated, in this example, from the IC L297.

Fig 9 shows an example of P.C.B. designed for the application of Fig 8.

Figure 8 : Two Phase Bipolar Stepper Motor Circuit.

Fig 10 shows a second two phase bipolar stepper motor control circuit where the current is controlled by the I.C. L

This circuit drives bipolar stepper motors with winding currents up to 2 A. The diodes are fast 2 A types.



$R_{S1} = R_{S2} = 0.5\ \Omega$

D1 to D8 = 2 A Fast diodes { $V_F \leq 1.2$ V @ I = 2 A; trr ≤ 200 ns }

Figure 9 : Suggested Printed Circuit Board Layout for the Circuit of fig. 8 (1:1 scale).

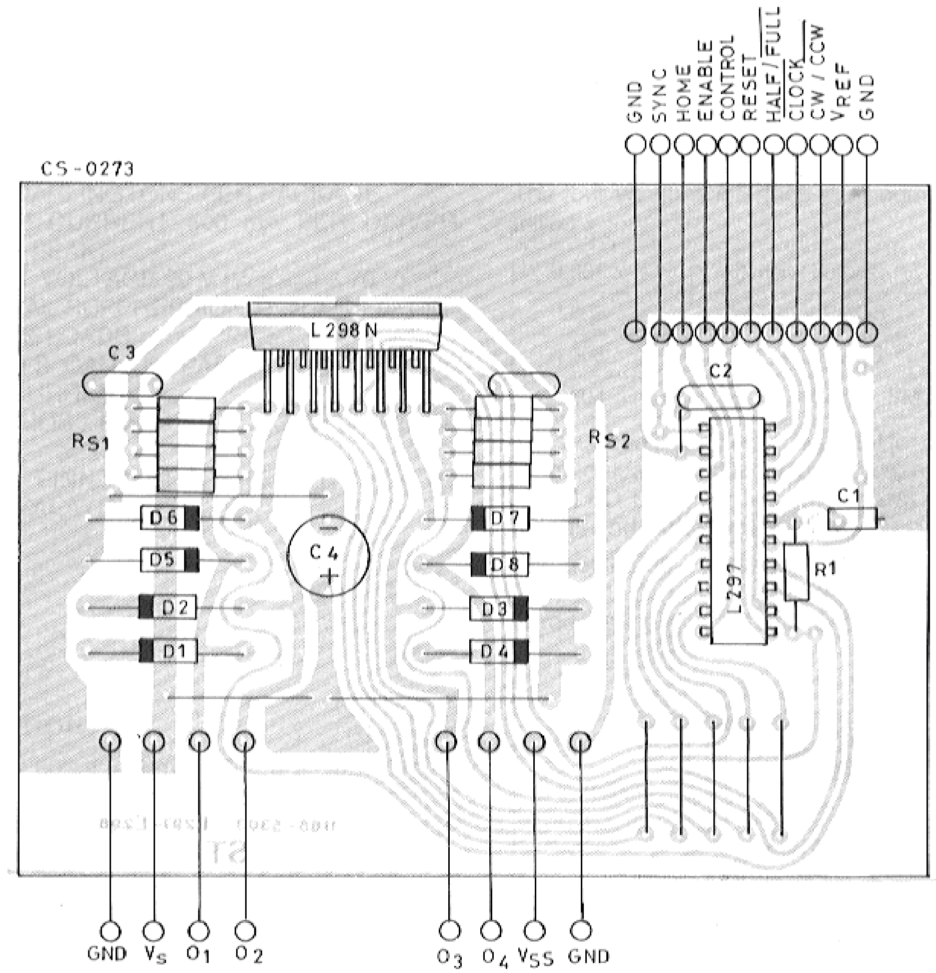
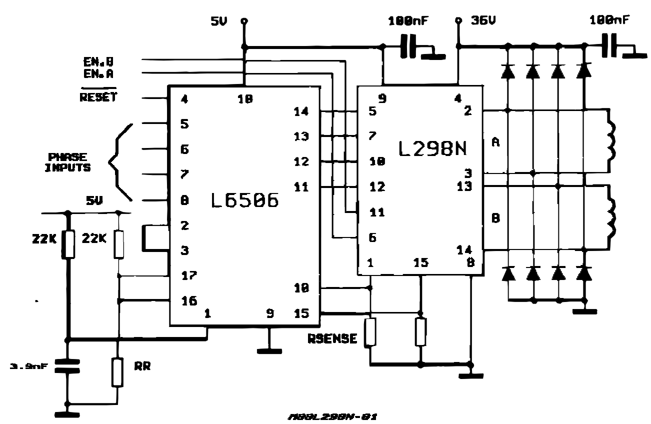


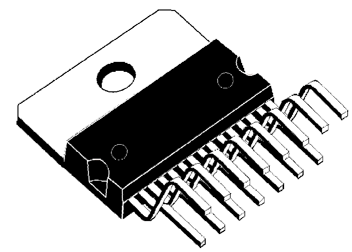
Figure 10 : Two Phase Bipolar Stepper Motor Control Circuit by Using the Current Controller L6506.



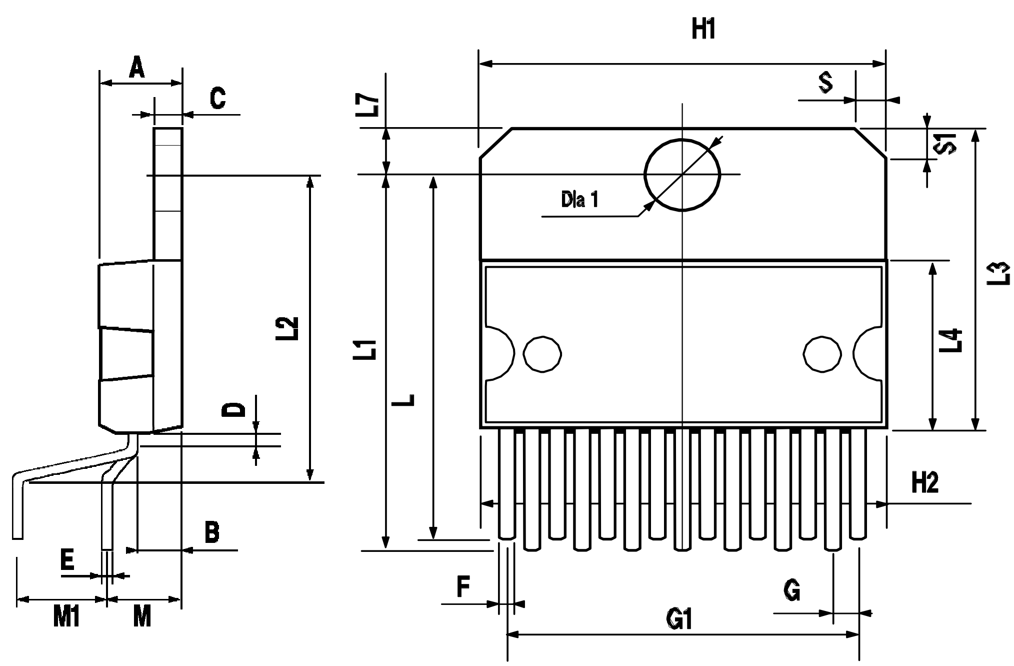
RR and Rsense depend from the load current

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			5			0.197
B			2.65			0.104
C			1.6			0.063
D		1			0.039	
E	0.49		0.55	0.019		0.022
F	0.66		0.75	0.026		0.030
G	1.02	1.27	1.52	0.040	0.050	0.060
G1	17.53	17.78	18.03	0.690	0.700	0.710
H1	19.6			0.772		
H2			20.2			0.795
L	21.9	22.2	22.5	0.862	0.874	0.886
L1	21.7	22.1	22.5	0.854	0.870	0.886
L2	17.65		18.1	0.695		0.713
L3	17.25	17.5	17.75	0.679	0.689	0.699
L4	10.3	10.7	10.9	0.406	0.421	0.429
L7	2.65		2.9	0.104		0.114
M	4.25	4.55	4.85	0.167	0.179	0.191
M1	4.63	5.08	5.53	0.182	0.200	0.218
S	1.9		2.6	0.075		0.102
S1	1.9		2.6	0.075		0.102
Dia1	3.65		3.85	0.144		0.152

OUTLINE AND MECHANICAL DATA

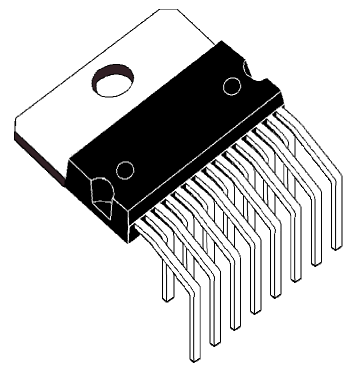


Multiwatt15 V

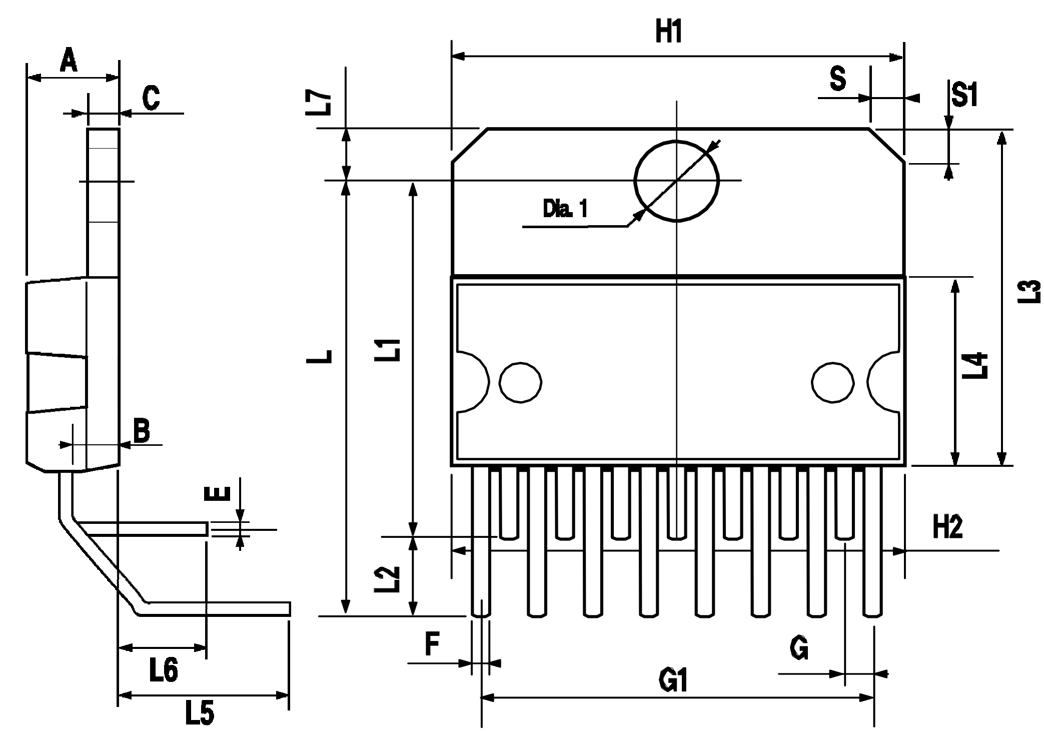


DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			5			0.197
B			2.65			0.104
C			1.6			0.063
E	0.49		0.55	0.019		0.022
F	0.66		0.75	0.026		0.030
G	1.14	1.27	1.4	0.045	0.050	0.055
G1	17.57	17.78	17.91	0.692	0.700	0.705
H1	19.6			0.772		
H2			20.2			0.795
L		20.57			0.810	
L1		18.03			0.710	
L2		2.54			0.100	
L3	17.25	17.5	17.75	0.679	0.689	0.699
L4	10.3	10.7	10.9	0.406	0.421	0.429
L5		5.28			0.208	
L6		2.38			0.094	
L7	2.65		2.9	0.104		0.114
S	1.9		2.6	0.075		0.102
S1	1.9		2.6	0.075		0.102
Dia1	3.65		3.85	0.144		0.152

OUTLINE AND MECHANICAL DATA



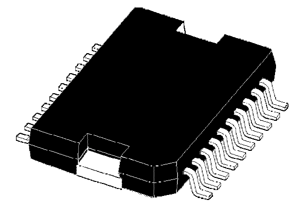
Multiwatt15 H



DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			3.6			0.142
a1	0.1		0.3	0.004		0.012
a2			3.3			0.130
a3	0		0.1	0.000		0.004
b	0.4		0.53	0.016		0.021
c	0.23		0.32	0.009		0.013
D (1)	15.8		16	0.622		0.630
D1	9.4		9.8	0.370		0.386
E	13.9		14.5	0.547		0.570
e		1.27			0.050	
e3		11.43			0.450	
E1 (1)	10.9		11.1	0.429		0.437
E2			2.9			0.114
E3	5.8		6.2	0.228		0.244
G	0		0.1	0.000		0.004
H	15.5		15.9	0.610		0.626
h			1.1			0.043
L	0.8		1.1	0.031		0.043
N	10˚ (max.)					
S	8˚ (max.)					
T		10			0.394	

(1) "D and F" do not include mold flash or protrusions.
- Mold flash or protrusions shall not exceed 0.15 mm (0.006").
- Critical dimensions: "E", "G" and "a3"

OUTLINE AND MECHANICAL DATA



JEDEC MO-166

PowerSO20