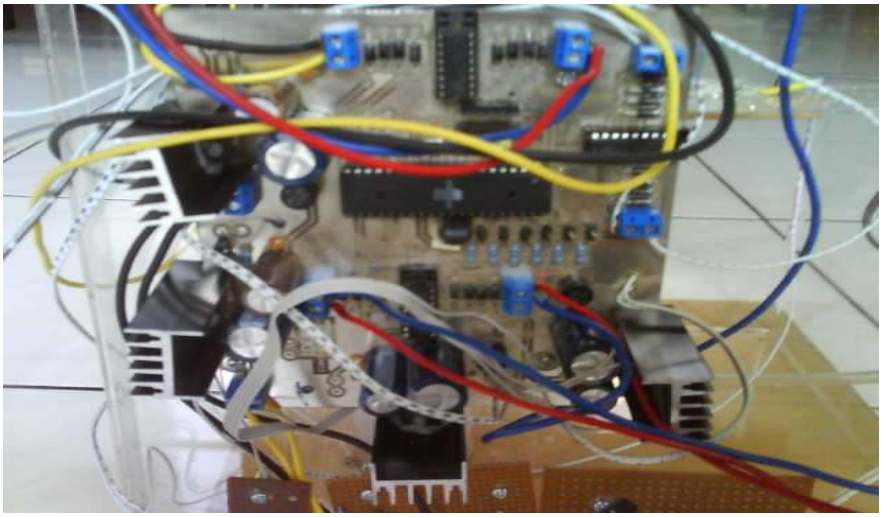
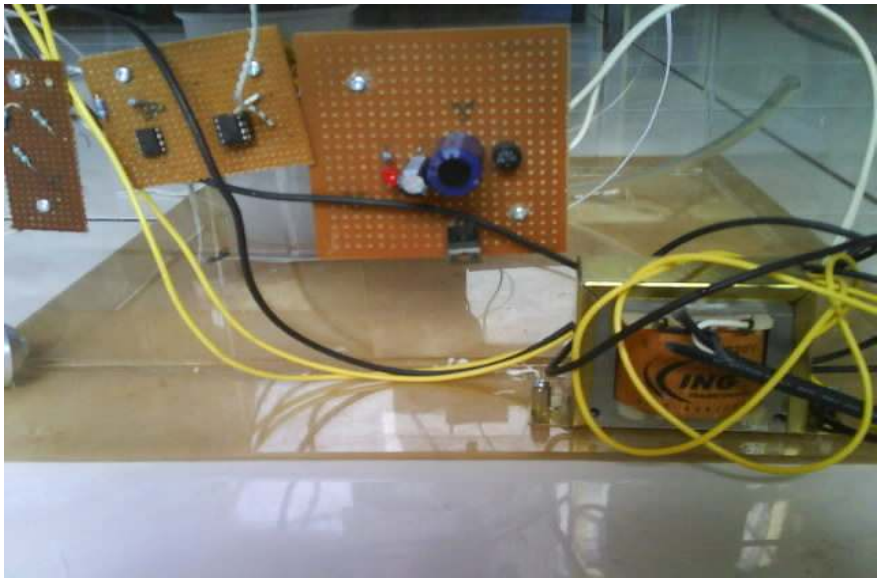


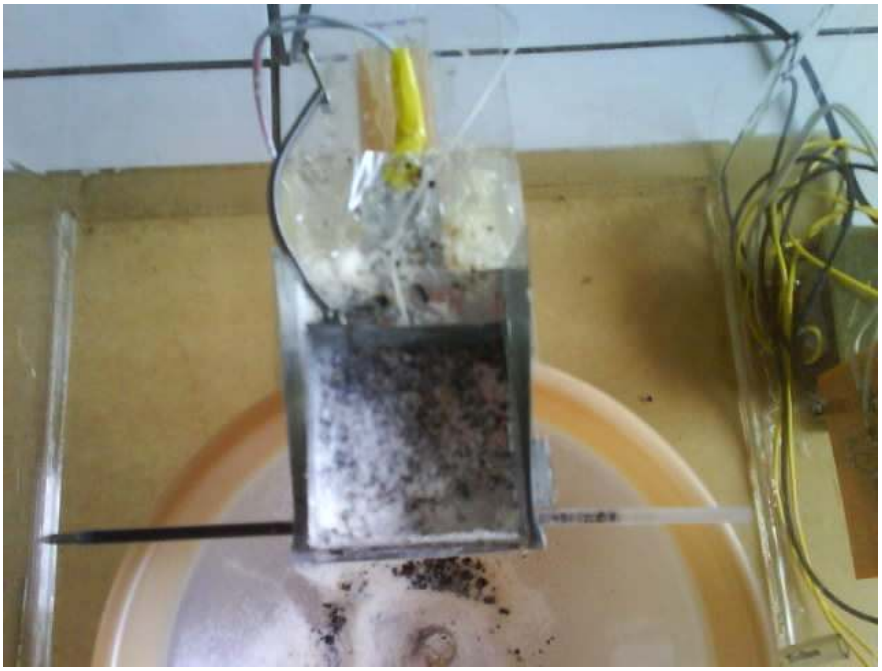
Rangkaian *controller driver* motor

Mesin pencampur minuman berbasis Mikrokontroler



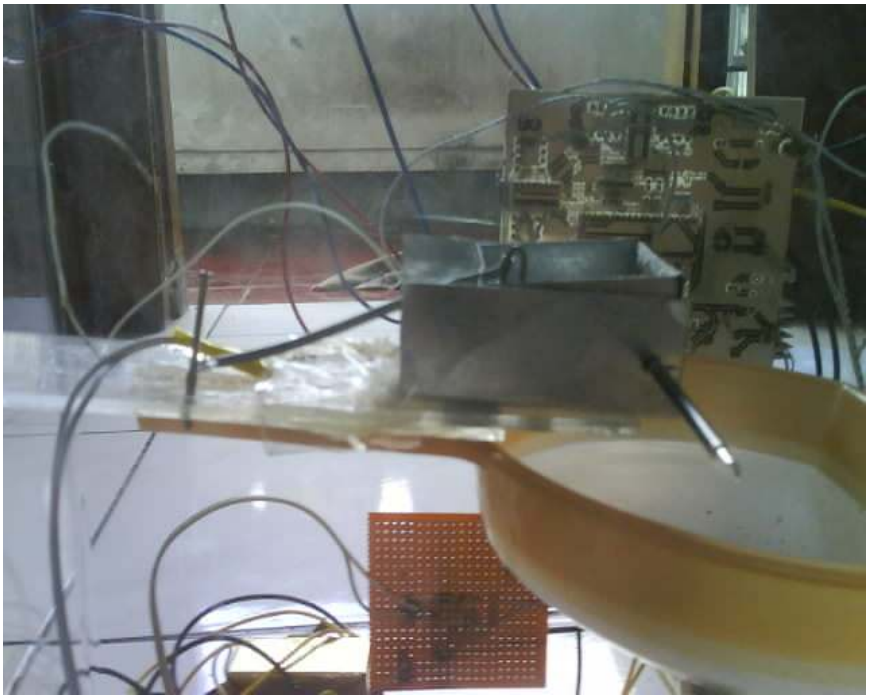
Rangkaian jembatan, rangkaian Op-Amp, dan rangkaian *power supplay*

Gelas pengaduk (*Mixer*)



Bak penimbangan tampak dari atas

Bak penimbangan dan lubang tempat pemasangan strain gauge



Bak Penimbangan tampak dari samping

Motor penggerak katup

Teko air panas tempat sumber air yang dicampur

Program:

```
#include <mega8535.h>
#include <delay.h>

//OUTPUT (MOTOR DC/KATUP)
#define KATUP_KOPI_1            PORTC.0
#define KATUP_KOPI_2            PORTC.1
#define KATUP_GULA_1            PORTC.2
#define KATUP_GULA_2            PORTC.3
#define KATUP_CRIMER_1          PORTC.4
#define KATUP_CRIMER_2          PORTC.5
#define KATUP_TABUNG_1          PORTC.6
#define KATUP_TABUNG_2          PORTC.7
#define EN_KOPI                 PORTD.0
#define EN_GULA                 PORTD.1
#define EN_CRIMER               PORTD.2
#define EN_TABUNG               PORTD.3

#define MIXER                   PORTB.0
#define POMPA_AIR               PORTB.1
#define POMPA_AKHIR             PORTB.2

//INPUT DIGITAL (MENU)
#define KOPI_PAHIT              PINB.3
#define KOPI_MANIS              PINB.4
#define KOPI_MANIS_CRIMER       PINB.5


unsigned int adc_data;
#define ADC_VREF_TYPE 0x00

// ADC interrupt service routine
interrupt [ADC_INT] void adc_isr(void)
{
// Read the AD conversion result
adc_data=ADCW;
}

// Read the AD conversion result
// with noise canceling
unsigned int read_adc(unsigned char adc_input)
```

```
{
ADMUX=adc_input | (ADC_VREF_TYPE & 0xff);
#asm
   in   r30,mcucr
   cbr  r30,__sm_mask
   sbr  r30,__se_bit | __sm_adc_noise_red
   out  mcucr,r30
   sleep
   cbr  r30,__se_bit
   out  mcucr,r30
#endasm
return adc_data;
}

// Declare your global variables here

void main(void)
{
// Declare your local variables here
float kopi;
float gula;
float crimer;

PORTA=0x00;
DDRA=0x00;

PORTB=0b11111000;
DDRB=0b00000111;

PORTC=0x00;
DDRC=0xFF;

PORTD=0x00;
DDRD=0xFF;

MCUCR=0x00;
MCUCSR=0x00;

TIMSK=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=0x8C;

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

while (1)
    {

//=====================================================================
=============
//MENU KOPI PAHIT
//=====================================================================
=============
    if(KOPI_PAHIT== 0) //pushbutton di-short ke ground
    {
    //pompa air mengisi tabung pencampuran selama 10s=300ml

    POMPA_AIR=1;
    delay_ms(10000);
    POMPA_AIR=0;

    //MASUKAN KOPI
    //jika baca sensor berat sudah mencapai 5gr, misal data digitalnya
n=(0.6/5)*1024=122.88
    EN_KOPI=1;      //KATUP KOPI BUKA
    KATUP_KOPI_1=1;
    KATUP_KOPI_2=0;

    while(!(kopi>=122.88)){
    kopi=read_adc(0); //BACA SENSOR
    }
    EN_KOPI=0;      //KATUP KOPI TUTUP
    KATUP_KOPI_1=1;
    KATUP_KOPI_2=1;
```

```
    //MASUKAN KE TABUNG PENCAMPUR
    EN_TABUNG=1;     //KATUP TABUNG BUKA
    KATUP_TABUNG_1=1;
    KATUP_TABUNG_2=0;
    delay_ms(2000);
    EN_TABUNG=0;     //KATUP TABUNG TUTUP
    KATUP_TABUNG_1=1;
    KATUP_TABUNG_2=1;

    //aduk selama 20 s
    MIXER=1;
    delay_ms(20000);
    MIXER=0;

    //buka kran tabung untuk dimasukan ke tempat selanjutnya
    POMPA_AKHIR=1;
    delay_ms(11000);
    POMPA_AKHIR=0;
    }//akhir pembuatan kopi pahit


//================================================================================ //MENU KOPI MANIS
//================================================================================
    if(KOPI_MANIS == 0) //pushbutton di-short ke ground
    {
    //pompa air mengisi tabung pencampuran selama 10s=300ml

    POMPA_AIR=1;
    delay_ms(10000);
    POMPA_AIR=0;


    //MASUKAN KOPI
    //jika baca sensor berat sudah mencapai 5gr, misal data digitalnya
n=(0.6/5)*1024=122.88
    EN_KOPI=1;      //KATUP KOPI BUKA
    KATUP_KOPI_1=1;
    KATUP_KOPI_2=0;

    while(!(kopi>=122.88)){
```

```
kopi=read_adc(0); //BACA SENSOR
}
EN_KOPI=0;       //KATUP KOPI TUTUP
KATUP_KOPI_1=1;
KATUP_KOPI_2=1;

//MASUKAN KE TABUNG PENCAMPUR
EN_TABUNG=1;     //KATUP TABUNG BUKA
KATUP_TABUNG_1=1;
KATUP_TABUNG_2=0;
delay_ms(2000);
EN_TABUNG=0;     //KATUP TABUNG TUTUP
KATUP_TABUNG_1=1;
KATUP_TABUNG_2=1;

//MASUKAN GULA
//komposisinya 30gr(1.3v), jadi data digitalnya n=(1.3/5)*1024=266.24
EN_GULA=1;       //KATUP GULA BUKA
KATUP_GULA_1=1;
KATUP_GULA_2=0;
while(!(gula>=266.24)){
gula=read_adc(0); //BACA SENSOR
}
EN_GULA=0;       //KATUP GULA TUTUP
KATUP_GULA_1=1;
KATUP_GULA_2=1;

 //MASUKAN KE TABUNG PENCAMPUR
EN_TABUNG=1;     //KATUP TABUNG BUKA
KATUP_TABUNG_1=1;
KATUP_TABUNG_2=0;
delay_ms(2000);
EN_TABUNG=0;     //KATUP TABUNG TUTUP
KATUP_TABUNG_1=1;
KATUP_TABUNG_2=1;

//aduk selama 20 s
MIXER=1;
delay_ms(20000);
MIXER=0;

//buka kran tabung untuk dimasukan ke tempat selanjutnya
```

```
    POMPA_AKHIR=1;
    delay_ms(11000);
    POMPA_AKHIR=0;
    }//akhir pembuatan kopi manis


//=====================================================================
============
//MENU KOPI MANIS CRIMER
//=====================================================================
=============
    if(KOPI_MANIS_CRIMER == 0) //pushbutton di-short ke ground
    {
    //pompa air mengisi tabung pencampuran selama 10s=300ml
        POMPA_AIR=1;
    delay_ms(10000);
    POMPA_AIR=0;


    //MASUKAN KOPI
    //jika baca sensor berat sudah mencapai 5gr, misal data digitalnya
n=(0.6/5)*1024=122.88
    EN_KOPI=1;      //KATUP KOPI BUKA
    KATUP_KOPI_1=1;
    KATUP_KOPI_2=0;

    while(!(kopi>=122.88)){
    kopi=read_adc(0); //BACA SENSOR
    }
    EN_KOPI=0;      //KATUP KOPI TUTUP
    KATUP_KOPI_1=1;
    KATUP_KOPI_2=1;

    //MASUKAN KE TABUNG PENCAMPUR
    EN_TABUNG=1;     //KATUP TABUNG BUKA
    KATUP_TABUNG_1=1;
    KATUP_TABUNG_2=0;
    delay_ms(2000);
    EN_TABUNG=0;     //KATUP TABUNG TUTUP
    KATUP_TABUNG_1=1;
    KATUP_TABUNG_2=1;
```

```
//MASUKAN GULA
//komposisinya 30gr(1.3v), jadi data digitalnya n=(1.3/5)*1024=266.24
EN_GULA=1;       //KATUP GULA BUKA
KATUP_GULA_1=1;
KATUP_GULA_2=0;
while(!(gula>=266.24)){
gula=read_adc(0); //BACA SENSOR
}
EN_GULA=0;       //KATUP GULA TUTUP
KATUP_GULA_1=1;
KATUP_GULA_2=1;

 //MASUKAN KE TABUNG PENCAMPUR
EN_TABUNG=1;     //KATUP TABUNG BUKA
KATUP_TABUNG_1=1;
KATUP_TABUNG_2=0;
delay_ms(2000);
EN_TABUNG=0;     //KATUP TABUNG TUTUP
KATUP_TABUNG_1=1;
KATUP_TABUNG_2=1;


//MASUKAN CRIMER
//komposisinya 10gr(0.8v), jadi data digitalnya n=(0.8/5)*1024=163.84
EN_CRIMER=1;     //KATUP CRIMER BUKA
KATUP_CRIMER_1=1;
KATUP_CRIMER_2=0;
while(!(crimer>=163.84)){
crimer=read_adc(0);
}
EN_CRIMER=0;     //KATUP CRIMER TUTUP
KATUP_CRIMER_1=1;
KATUP_CRIMER_2=1;

 //MASUKAN KE TABUNG PENCAMPUR
EN_TABUNG=1;     //KATUP TABUNG BUKA
KATUP_TABUNG_1=1;
KATUP_TABUNG_2=0;
delay_ms(2000);
EN_TABUNG=0;     //KATUP TABUNG TUTUP
KATUP_TABUNG_1=1;
KATUP_TABUNG_2=1;
```

```
    //aduk selama 20 s
    MIXER=1;
    delay_ms(20000);
    MIXER=0;

    //buka kran tabung untuk dimasukan ke tempat selanjutnya
    POMPA_AKHIR=1;
    delay_ms(11000);
    POMPA_AKHIR=0;
    }//Akhir pembuatan kopi manis crimer

    };
}
```

LM258, LM358, LM358A, LM2904, LM2904A, LM2904V, NCV2904

Single Supply Dual Operational Amplifiers

Utilizing the circuit designs perfected for Quad Operational Amplifiers, these dual operational amplifiers feature low power drain, a common mode input voltage range extending to ground/V_{EE}, and single supply or split supply operation. The LM358 series is equivalent to one−half of an LM324.

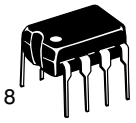
These amplifiers have several distinct advantages over standard operational amplifier types in single supply applications. They can operate at supply voltages as low as 3.0 V or as high as 32 V, with quiescent currents about one−fifth of those associated with the MC1741 (on a per amplifier basis). The common mode input range includes the negative supply, thereby eliminating the necessity for external biasing components in many applications. The output voltage range also includes the negative power supply voltage.

Features

- Short Circuit Protected Outputs
- True Differential Input Stage
- Single Supply Operation: 3.0 V to 32 V
- Low Input Bias Currents
- Internally Compensated
- Common Mode Range Extends to Negative Supply
- Single and Split Supply Operation
- ESD Clamps on the Inputs Increase Ruggedness of the Device without Affecting Operation
- Pb−Free Packages are Available
- NCV Prefix for Automotive and Other Applications Requiring Site and Control Changes

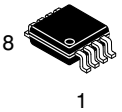
ON Semiconductor®

http://onsemi.com



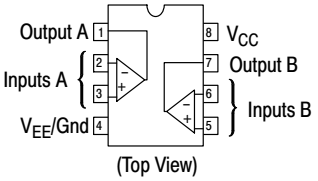
PDIP−8
N, AN, VN SUFFIX
CASE 626

SOIC−8
D, VD SUFFIX
CASE 751



Micro8™
DMR2 SUFFIX
CASE 846A

PIN CONNECTIONS



ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 10 of this data sheet.

DEVICE MARKING INFORMATION

See general marking information in the device marking section on page 11 of this data sheet.

© Semiconductor Components Industries, LLC, 2008

Single Supply **Split Supplies**

Figure 1.

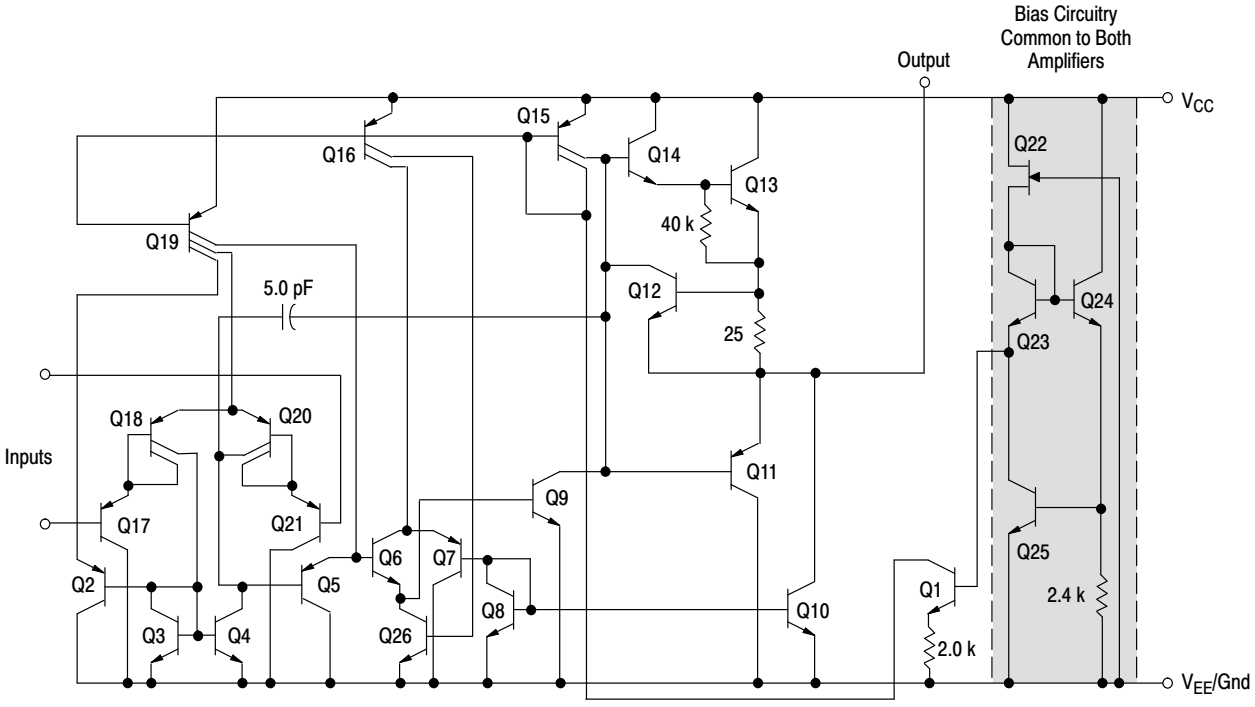


Figure 2. Representative Schematic Diagram
(One−Half of Circuit Shown)

MAXIMUM RATINGS (T_A = +25°C, unless otherwise noted.)

Rating		Symbol	Value	Unit
Power Supply Voltages Single Supply Split Supplies		 V_{CC} V_{CC}, V_{EE}	 32 ±16	Vdc
Input Differential Voltage Range (Note 1)		V_{IDR}	±32	Vdc
Input Common Mode Voltage Range (Note 2)		V_{ICR}	−0.3 to 32	Vdc
Output Short Circuit Duration		t_{SC}	Continuous	
Junction Temperature		T_J	150	°C
Thermal Resistance, Junction−to−Air (Note 3)	Case 846A Case 751 Case 626	$R_{\theta JA}$	238 212 161	°C/W
Storage Temperature Range		T_{stg}	−65 to +150	°C
ESD Protection at any Pin Human Body Model Machine Model		V_{esd}	 2000 200	V
Operating Ambient Temperature Range	 LM258 LM358, LM358A LM2904/LM2904A LM2904V, NCV2904 (Note 4)	T_A	 −25 to +85 0 to +70 −40 to +105 −40 to +125	°C

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

1. Split Power Supplies.
2. For supply voltages less than 32 V the absolute maximum input voltage is equal to the supply voltage.
3. All $R_{\theta JA}$ measurements made on evaluation board with 1 oz. copper traces of minimum pad size. All device outputs were active.
4. *NCV2904 is qualified for automotive use.*

ELECTRICAL CHARACTERISTICS (V_{CC} = 5.0 V, V_{EE} = GND, T_A = 25°C, unless otherwise noted.)

Characteristic	Symbol	LM258			LM358			LM358A			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage V_{CC} = 5.0 V to 30 V, V_{IC} = 0 V to V_{CC} −1.7 V, $V_O \simeq$ 1.4 V, R_S = 0 Ω	V_{IO}										mV
T_A = 25°C		–	2.0	5.0	–	2.0	7.0	–	2.0	3.0	
T_A = T_{high} (Note 5)		–	–	7.0	–	–	9.0	–	–	5.0	
T_A = T_{low} (Note 5)		–	–	7.0	–	–	9.0	–	–	5.0	
Average Temperature Coefficient of Input Offset Voltage T_A = T_{high} to T_{low} (Note 5)	$\Delta V_{IO}/\Delta T$	–	7.0	–	–	7.0	–	–	7.0	–	μV/°C
Input Offset Current	I_{IO}	–	3.0	30	–	5.0	50	–	5.0	30	nA
T_A = T_{high} to T_{low} (Note 5)		–	–	100	–	–	150	–	–	75	
Input Bias Current	I_{IB}	–	−45	−150	–	−45	−250	–	−45	−100	
T_A = T_{high} to T_{low} (Note 5)		–	−50	−300	–	−50	−500	–	−50	−200	
Average Temperature Coefficient of Input Offset Current T_A = T_{high} to T_{low} (Note 5)	$\Delta I_{IO}/\Delta T$	–	10	–	–	10	–	–	10	–	pA/°C
Input Common Mode Voltage Range (Note 6), V_{CC} = 30 V	V_{ICR}	0	–	28.3	0	–	28.3	0	–	28.5	V
V_{CC} = 30 V, T_A = T_{high} to T_{low}		0	–	28	0	–	28	0	–	28	
Differential Input Voltage Range	V_{IDR}	–	–	V_{CC}	–	–	V_{CC}	–	–	V_{CC}	V
Large Signal Open Loop Voltage Gain	A_{VOL}										V/mV
R_L = 2.0 kΩ, V_{CC} = 15 V, For Large V_O Swing,		50	100	–	25	100	–	25	100	–	
T_A = T_{high} to T_{low} (Note 5)		25	–	–	15	–	–	15	–	–	
Channel Separation 1.0 kHz ≤ f ≤ 20 kHz, Input Referenced	CS	–	−120	–	–	−120	–	–	−120	–	dB
Common Mode Rejection R_S ≤ 10 kΩ	CMR	70	85	–	65	70	–	65	70	–	dB
Power Supply Rejection	PSR	65	100	–	65	100	–	65	100	–	dB
Output Voltage−High Limit T_A = T_{high} to T_{low} (Note 5)	V_{OH}										V
V_{CC} = 5.0 V, R_L = 2.0 kΩ, T_A = 25°C		3.3	3.5	–	3.3	3.5	–	3.3	3.5	–	
V_{CC} = 30 V, R_L = 2.0 kΩ		26	–	–	26	–	–	26	–	–	
V_{CC} = 30 V, R_L = 10 kΩ		27	28	–	27	28	–	27	28	–	
Output Voltage−Low Limit V_{CC} = 5.0 V, R_L = 10 kΩ, T_A = T_{high} to T_{low} (Note 5)	V_{OL}	–	5.0	20	–	5.0	20	–	5.0	20	mV
Output Source Current	I_{O+}										mA
V_{ID} = +1.0 V, V_{CC} = 15 V		20	40	–	20	40	–	20	40	–	
T_A = T_{high} to T_{low} (LM358A Only)								10	–	–	
Output Sink Current	I_{O-}										
V_{ID} = −1.0 V, V_{CC} = 15 V		10	20	–	10	20	–	10	20	–	mA
T_A = T_{high} to T_{low} (LM358A Only)								5.0	–	–	mA
V_{ID} = −1.0 V, V_O = 200 mV		12	50	–	12	50	–	12	50	–	μA
Output Short Circuit to Ground (Note 7)	I_{SC}	–	40	60	–	40	60	–	40	60	mA
Power Supply Current (Total Device) T_A = T_{high} to T_{low} (Note 5)	I_{CC}										mA
V_{CC} = 30 V, V_O = 0 V, R_L = ∞		–	1.5	3.0	–	1.5	3.0	–	1.5	2.0	
V_{CC} = 5 V, V_O = 0 V, R_L = ∞		–	0.7	1.2	–	0.7	1.2	–	0.7	1.2	

5. LM258: T_{low} = −25°C, T_{high} = +85°C
   LM358, LM358A: T_{low} = 0°C, T_{high} = +70°C
   LM2904/LM2904A: T_{low} = −40°C, T_{high} = +105°C
   LM2904V & NCV2904: T_{low} = −40°C, T_{high} = +125°C
   NCV2904 is qualified for automotive use.
6. The input common mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common mode voltage range is V_{CC} − 1.7 V.
7. Short circuits from the output to V_{CC} can cause excessive heating and eventual destruction. Destructive dissipation can result from simultaneous shorts on all amplifiers.

ELECTRICAL CHARACTERISTICS (V_{CC} = 5.0 V, V_{EE} = Gnd, T_A = 25°C, unless otherwise noted.)

Characteristic	Symbol	LM2904			LM2904A			LM2904V, NCV2904			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage V_{CC} = 5.0 V to 30 V, V_{IC} = 0 V to V_{CC} −1.7 V, $V_O \simeq$ 1.4 V, R_S = 0 Ω	V_{IO}										mV
T_A = 25°C		–	2.0	7.0	–	2.0	7.0	–	–	7.0	
$T_A = T_{high}$ (Note 8)		–	–	10	–	–	10	–	–	13	
$T_A = T_{low}$ (Note 8)		–	–	10	–	–	10	–	–	10	
Average Temperature Coefficient of Input Offset Voltage $T_A = T_{high}$ to T_{low} (Note 8)	$\Delta V_{IO}/\Delta T$	–	7.0	–	–	7.0	–	–	7.0	–	μV/°C
Input Offset Current	I_{IO}	–	5.0	50	–	5.0	50	–	5.0	50	nA
$T_A = T_{high}$ to T_{low} (Note 8)		–	45	200	–	45	200	–	45	200	
Input Bias Current	I_{IB}	–	−45	−250	–	−45	−100	–	−45	−250	
$T_A = T_{high}$ to T_{low} (Note 8)		–	−50	−500	–	−50	−250	–	−50	−500	
Average Temperature Coefficient of Input Offset Current $T_A = T_{high}$ to T_{low} (Note 8)	$\Delta I_{IO}/\Delta T$	–	10	–	–	10	–	–	10	–	pA/°C
Input Common Mode Voltage Range (Note 9), V_{CC} = 30 V	V_{ICR}	0	–	24.3	0	–	24.3	0	–	24.3	V
V_{CC} = 30 V, $T_A = T_{high}$ to T_{low}		0	–	24	0	–	24	0	–	24	
Differential Input Voltage Range	V_{IDR}	–	–	V_{CC}	–	–	V_{CC}	–	–	V_{CC}	V
Large Signal Open Loop Voltage Gain	A_{VOL}										V/mV
R_L = 2.0 kΩ, V_{CC} = 15 V, For Large V_O Swing,		25	100	–	25	100	–	25	100	–	
$T_A = T_{high}$ to T_{low} (Note 8)		15	–	–	15	–	–	15	–	–	
Channel Separation 1.0 kHz ≤ f ≤ 20 kHz, Input Referenced	CS	–	−120	–	–	−120	–	–	−120	–	dB
Common Mode Rejection R_S ≤ 10 kΩ	CMR	50	70	–	50	70	–	50	70	–	dB
Power Supply Rejection	PSR	50	100	–	50	100	–	50	100	–	dB
Output Voltage−High Limit $T_A = T_{high}$ to T_{low} (Note 8)	V_{OH}										V
V_{CC} = 5.0 V, R_L = 2.0 kΩ, T_A = 25°C		3.3	3.5	–	3.3	3.5	–	3.3	3.5	–	
V_{CC} = 30 V, R_L = 2.0 kΩ		22	–	–	22	–	–	22	–	–	
V_{CC} = 30 V, R_L = 10 kΩ		23	24	–	23	24	–	23	24	–	
Output Voltage−Low Limit V_{CC} = 5.0 V, R_L = 10 kΩ, $T_A = T_{high}$ to T_{low} (Note 8)	V_{OL}	–	5.0	20	–	5.0	20	–	5.0	20	mV
Output Source Current V_{ID} = +1.0 V, V_{CC} = 15 V	I_{O+}	20	40	–	20	40	–	20	40	–	mA
Output Sink Current	I_{O-}										
V_{ID} = −1.0 V, V_{CC} = 15 V		10	20	–	10	20	–	10	20	–	mA
V_{ID} = −1.0 V, V_O = 200 mV		–	–	–	–	–	–	–	–	–	μA
Output Short Circuit to Ground (Note 10)	I_{SC}	–	40	60	–	40	60	–	40	60	mA
Power Supply Current (Total Device) $T_A = T_{high}$ to T_{low} (Note 8)	I_{CC}										mA
V_{CC} = 30 V, V_O = 0 V, R_L = ∞		–	1.5	3.0	–	1.5	3.0	–	1.5	3.0	
V_{CC} = 5 V, V_O = 0 V, R_L = ∞		–	0.7	1.2	–	0.7	1.2	–	0.7	1.2	

8. LM258: T_{low} = −25°C, T_{high} = +85°C; LM358, LM358A: T_{low} = 0°C, T_{high} = +70°C
   LM2904/LM2904A: T_{low} = −40°C, T_{high} = +105°C; LM2904V & NCV2904: T_{low} = −40°C, T_{high} = +125°C
   NCV2904 is qualified for automotive use.
9. The input common mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common mode voltage range is V_{CC} − 1.7 V.
10. Short circuits from the output to V_{CC} can cause excessive heating and eventual destruction. Destructive dissipation can result from simultaneous shorts on all amplifiers.

CIRCUIT DESCRIPTION

The LM358 series is made using two internally compensated, two−stage operational amplifiers. The first stage of each consists of differential input devices Q20 and Q18 with input buffer transistors Q21 and Q17 and the differential to single ended converter Q3 and Q4. The first stage performs not only the first stage gain function but also performs the level shifting and transconductance reduction functions. By reducing the transconductance, a smaller compensation capacitor (only 5.0 pF) can be employed, thus saving chip area. The transconductance reduction is accomplished by splitting the collectors of Q20 and Q18. Another feature of this input stage is that the input common mode range can include the negative supply or ground, in single supply operation, without saturating either the input devices or the differential to single−ended converter. The second stage consists of a standard current source load amplifier stage.

Each amplifier is biased from an internal−voltage regulator which has a low temperature coefficient thus giving each amplifier good temperature characteristics as well as excellent power supply rejection.

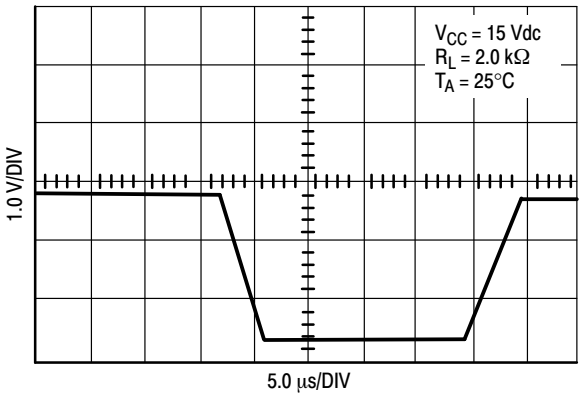


Figure 3. Large Signal Voltage Follower Response

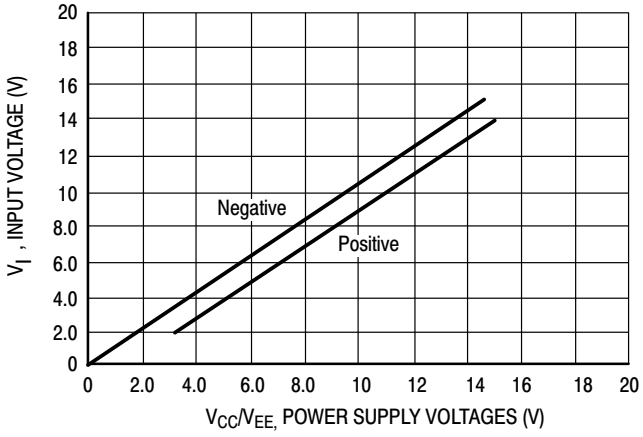


Figure 4. Input Voltage Range

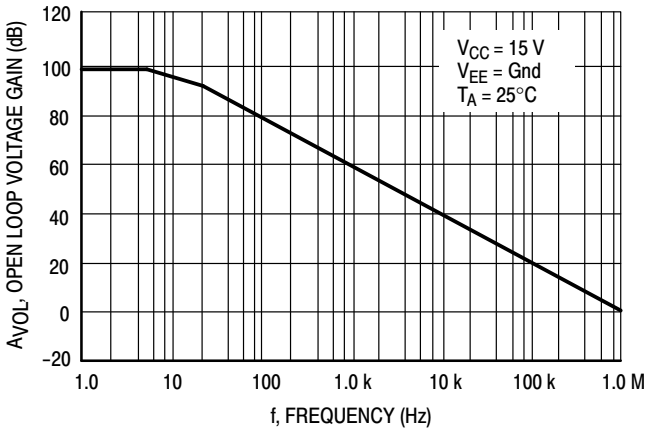


Figure 5. Large−Signal Open Loop Voltage Gain

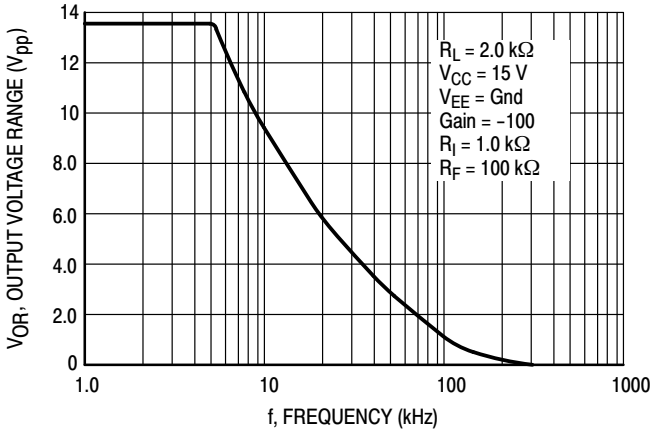


Figure 6. Large−Signal Frequency Response

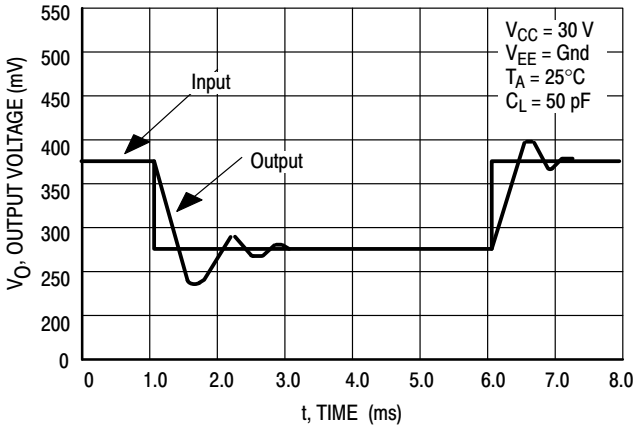


Figure 7. Small Signal Voltage Follower Pulse Response (Noninverting)

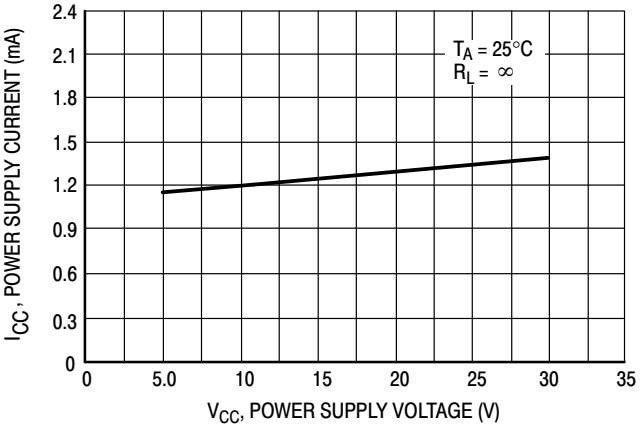


Figure 8. Power Supply Current versus Power Supply Voltage

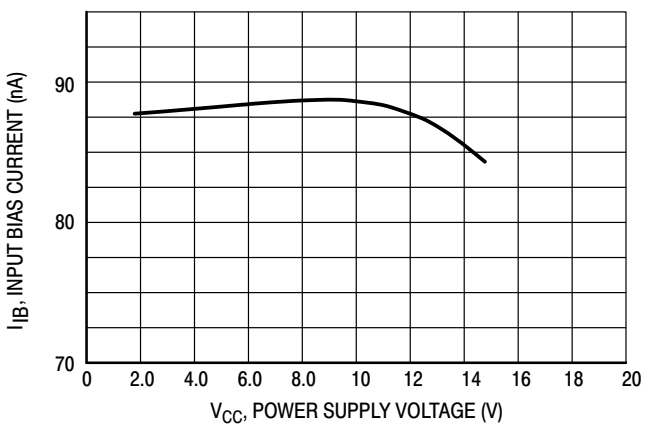


Figure 9. Input Bias Current versus Supply Voltage

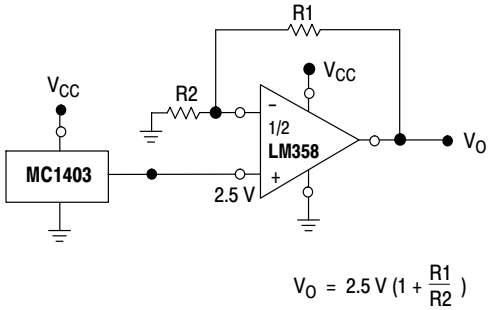


Figure 10. Voltage Reference

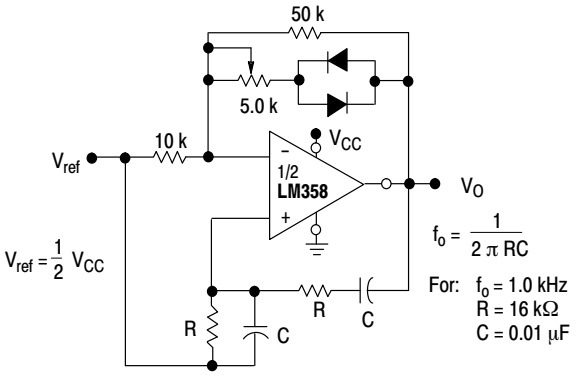


Figure 11. Wien Bridge Oscillator

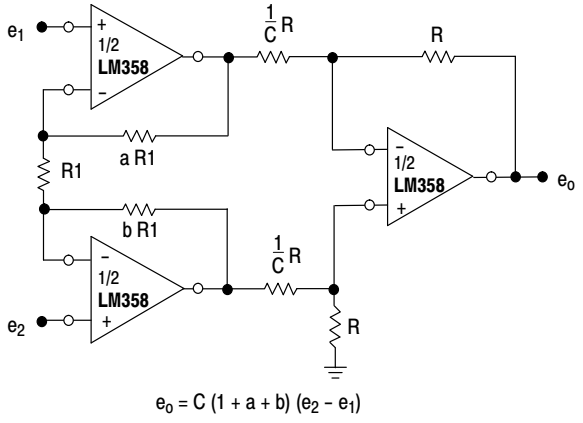


Figure 12. High Impedance Differential Amplifier

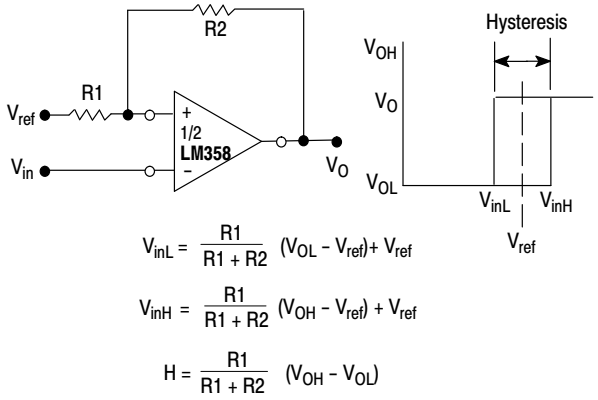


Figure 13. Comparator with Hysteresis

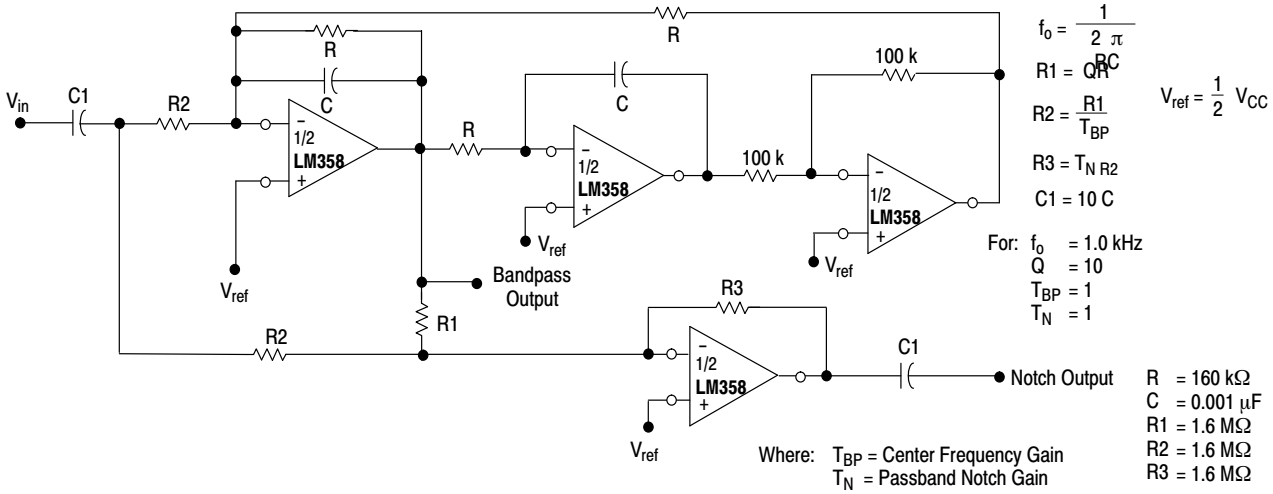
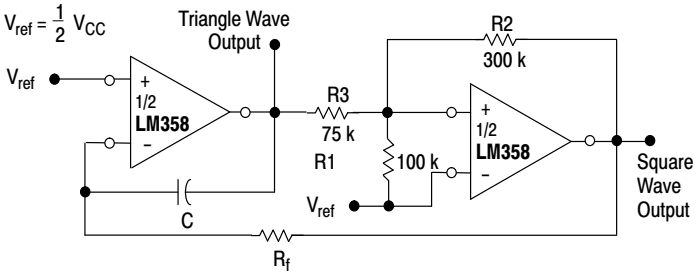
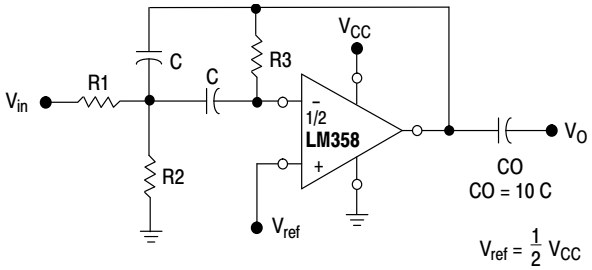


Figure 14. Bi–Quad Filter



$$f = \frac{R1 + R_C}{4 CR_f R1} \quad \text{if, } R3 = \frac{R2\ R1}{R2 + R1}$$

Figure 15. Function Generator



Given: f_o = center frequency

$A(f_o)$ = gain at center frequency

Choose value f_o, C

Then: $R3 = \frac{Q}{\pi f_o C}$

$$R1 = \frac{R3}{2 A(f_o)}$$

$$R2 = \frac{R1\ R3}{4Q^2 R1 - R3}$$

For less than 10% error from operational amplifier. $\frac{Q_o f_o}{BW} < 0.1$

Where f_o and BW are expressed in Hz.

If source impedance varies, filter may be preceded with voltage follower buffer to stabilize filter parameters.

Figure 16. Multiple Feedback Bandpass Filter

ORDERING INFORMATION

Device	Operating Temperature Range	Package	Shipping†
LM358ADR2G	0°C to +70°C	SOIC−8 (Pb−Free)	2500 Tape & Reel
LM358D		SOIC−8	98 Units/Rail
LM358DG		SOIC−8 (Pb−Free)	98 Units/Rail
LM358DR2		SOIC−8	2500 Tape & Reel
LM358DR2G		SOIC−8 (Pb−Free)	2500 Tape & Reel
LM358DMR2		Micro8	4000 Tape & Reel
LM358DMR2G		Micro8 (Pb−Free)	4000 Tape & Reel
LM358N		PDIP−8	50 Units/Rail
LM358NG		PDIP−8 (Pb−Free)	50 Units/Rail
LM258D	−25°C to +85°C	SOIC−8	98 Units/Rail
LM258DG		SOIC−8 (Pb−Free)	98 Units/Rail
LM258DR2		SOIC−8	2500 Tape & Reel
LM258DR2G		SOIC−8 (Pb−Free)	2500 Tape & Reel
LM258DMR2		Micro8	4000 Tape & Reel
LM258DMR2G		Micro8 (Pb−Free)	4000 Tape & Reel
LM258N		PDIP−8	50 Units/Rail
LM258NG		PDIP−8 (Pb−Free)	50 Units/Rail
LM2904D	−40°C to +105°C	SOIC−8	98 Units/Rail
LM2904DG		SOIC−8 (Pb−Free)	98 Units/Rail
LM2904DR2		SOIC−8	2500 Tape & Reel
LM2904DR2G		SOIC−8 (Pb−Free)	2500 Tape & Reel
LM2904DMR2		Micro8	2500 Tape & Reel
LM2904DMR2G		Micro8 (Pb−Free)	2500 Tape & Reel
LM2904N		PDIP−8	50 Units/Rail
LM2904NG		PDIP−8 (Pb−Free)	50 Units/Rail
LM2904ADMG		Micro8 (Pb−Free)	4000 Tape & Reel
LM2904ADMR2		Micro8	4000 Tape & Reel
LM2904ADMR2G		Micro8 (Pb−Free)	4000 Tape & Reel
LM2904AN		PDIP−8	50 Units/Rail
LM2904ANG		PDIP−8 (Pb−Free)	50 Units/Rail

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

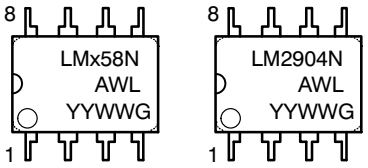
ORDERING INFORMATION

Device	Operating Temperature Range	Package	Shipping†
LM2904VD	−40°C to +125°C	SOIC−8	98 Units/Rail
LM2904VDG		SOIC−8 (Pb−Free)	98 Units/Rail
LM2904VDR2		SOIC−8	2500 Tape & Reel
LM2904VDR2G		SOIC−8 (Pb−Free)	2500 Tape & Reel
LM2904VDMR2		Micro8	4000 Tape & Reel
LM2904VDMR2G		Micro8 (Pb−Free)	4000 Tape & Reel
LM2904VN		PDIP−8	50 Units/Rail
LM2904VNG		PDIP−8 (Pb−Free)	50 Units/Rail
NCV2904DR2*		SOIC−8	2500 Tape & Reel
NCV2904DR2G*		SOIC−8 (Pb−Free)	2500 Tape & Reel
NCV2904DMR2*		Micro8	4000 Tape & Reel
NCV2904DMR2G*		Micro8 (Pb−Free)	4000 Tape & Reel

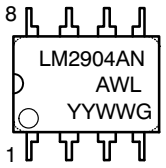
†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.
*NCV2904 is qualified for automotive use.

MARKING DIAGRAMS

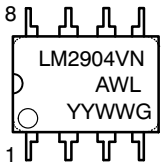
PDIP−8
N SUFFIX
CASE 626



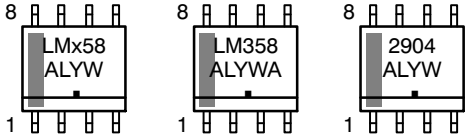
PDIP−8
AN SUFFIX
CASE 626



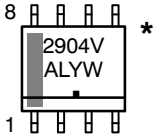
PDIP−8
VN SUFFIX
CASE 626



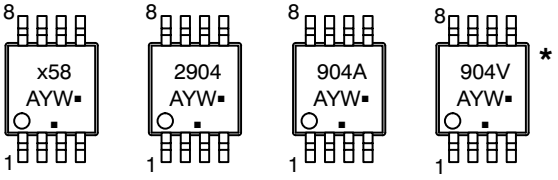
SOIC−8
D SUFFIX
CASE 751



SOIC−8
VD SUFFIX
CASE 751



Micro8
DMR2 SUFFIX
CASE 846A

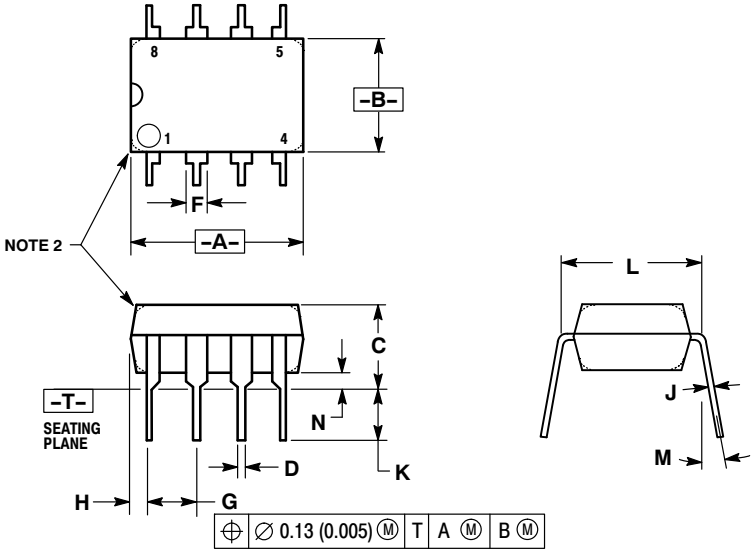


x = 2 or 3
A = Assembly Location
WL, L = Wafer Lot
YY, Y = Year
WW, W = Work Week
G = Pb−Free Package
▪ = Pb−Free Package − (Note: Microdot may be in either location)

*This diagram also applies to NCV2904

PACKAGE DIMENSIONS

PDIP−8
N, AN, VN SUFFIX
CASE 626−05
ISSUE L

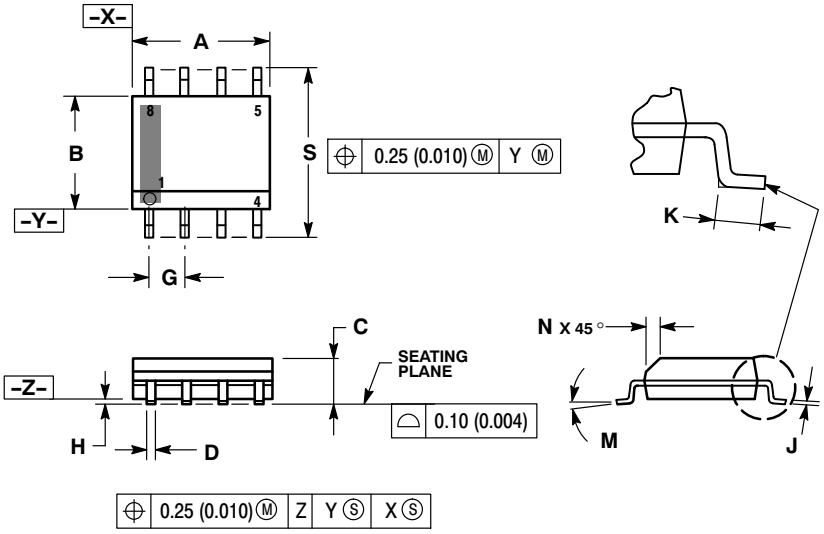


NOTES:
1. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
2. PACKAGE CONTOUR OPTIONAL (ROUND OR SQUARE CORNERS).
3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	9.40	10.16	0.370	0.400
B	6.10	6.60	0.240	0.260
C	3.94	4.45	0.155	0.175
D	0.38	0.51	0.015	0.020
F	1.02	1.78	0.040	0.070
G	2.54 BSC		0.100 BSC	
H	0.76	1.27	0.030	0.050
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300 BSC	
M	---	10°	---	10°
N	0.76	1.01	0.030	0.040

PACKAGE DIMENSIONS

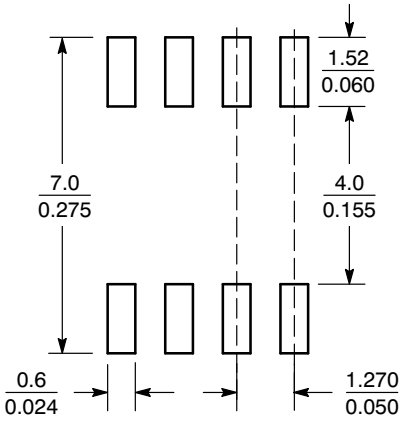
SOIC−8 NB
CASE 751−07
ISSUE AJ



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. 751−01 THRU 751−06 ARE OBSOLETE. NEW STANDARD IS 751−07.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.197
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.053	0.069
D	0.33	0.51	0.013	0.020
G	1.27 BSC		0.050 BSC	
H	0.10	0.25	0.004	0.010
J	0.19	0.25	0.007	0.010
K	0.40	1.27	0.016	0.050
M	0 °	8 °	0 °	8 °
N	0.25	0.50	0.010	0.020
S	5.80	6.20	0.228	0.244

SOLDERING FOOTPRINT*

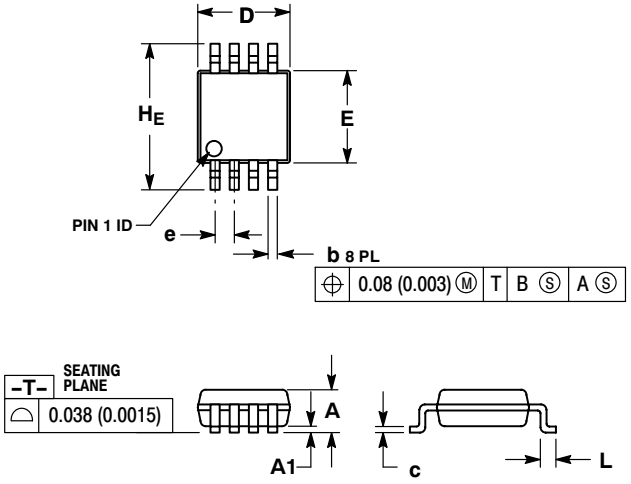


SCALE 6:1 (mm / inches)

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

PACKAGE DIMENSIONS

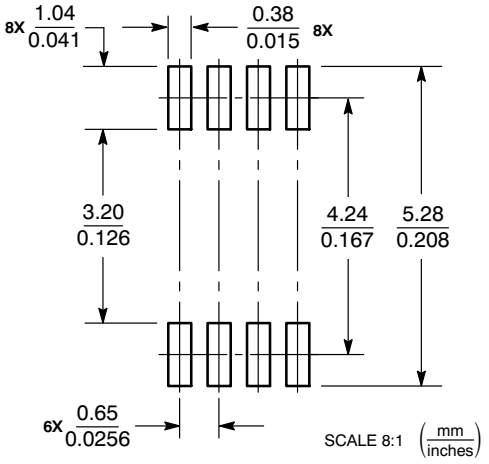
Micro8™
CASE 846A−02
ISSUE G



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
5. 846A−01 OBSOLETE, NEW STANDARD 846A−02.

	MILLIMETERS			INCHES		
DIM	MIN	NOM	MAX	MIN	NOM	MAX
A	−−	−−	1.10	−−	−−	0.043
A1	0.05	0.08	0.15	0.002	0.003	0.006
b	0.25	0.33	0.40	0.010	0.013	0.016
c	0.13	0.18	0.23	0.005	0.007	0.009
D	2.90	3.00	3.10	0.114	0.118	0.122
E	2.90	3.00	3.10	0.114	0.118	0.122
e	0.65 BSC			0.026 BSC		
L	0.40	0.55	0.70	0.016	0.021	0.028
H_E	4.75	4.90	5.05	0.187	0.193	0.199

SOLDERING FOOTPRINT*



*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

Micro8 is a trademark of International Rectifier.

ON Semiconductor and ON are registered trademarks of Semiconductor Components Industries, LLC (SCILLC). SCILLC reserves the right to make changes without further notice to any products herein. SCILLC makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does SCILLC assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. "Typical" parameters which may be provided in SCILLC data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. SCILLC does not convey any license under its patent rights nor the rights of others. SCILLC products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the SCILLC product could create a situation where personal injury or death may occur. Should Buyer purchase or use SCILLC products for any such unintended or unauthorized application, Buyer shall indemnify and hold SCILLC and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that SCILLC was negligent regarding the design or manufacture of the part. SCILLC is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:
Literature Distribution Center for ON Semiconductor
P.O. Box 5163, Denver, Colorado 80217 USA
Phone: 303−675−2175 or 800−344−3860 Toll Free USA/Canada
Fax: 303−675−2176 or 800−344−3867 Toll Free USA/Canada
Email: orderlit@onsemi.com

N. American Technical Support: 800−282−9855 Toll Free USA/Canada
Europe, Middle East and Africa Technical Support:
Phone: 421 33 790 2910
Japan Customer Focus Center
Phone: 81−3−5773−3850

ON Semiconductor Website: **www.onsemi.com**

Order Literature: http://www.onsemi.com/orderlit

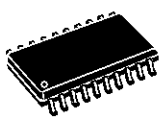
For additional information, please contact your local Sales Representative

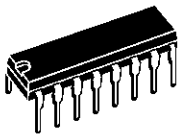
SGS-THOMSON MICROELECTRONICS

L293D
L293DD

PUSH-PULL FOUR CHANNEL DRIVER WITH DIODES

- 600mA OUTPUT CURRENT CAPABILITY PER CHANNEL
- 1.2A PEAK OUTPUT CURRENT (non repetitive) PER CHANNEL
- ENABLE FACILITY
- OVERTEMPERATURE PROTECTION
- LOGICAL "0" INPUT VOLTAGE UP TO 1.5 V (HIGH NOISE IMMUNITY)
- INTERNAL CLAMP DIODES





SO(12+4+4) **Powerdip (12+2+2)**

ORDERING NUMBERS:

L293DD L293D

DESCRIPTION

The Device is a monolithic integrated high voltage, high current four channel driver designed to accept standard DTL or TTL logic levels and drive inductive loads (such as relays solenoides, DC and stepping motors) and switching power transistors.

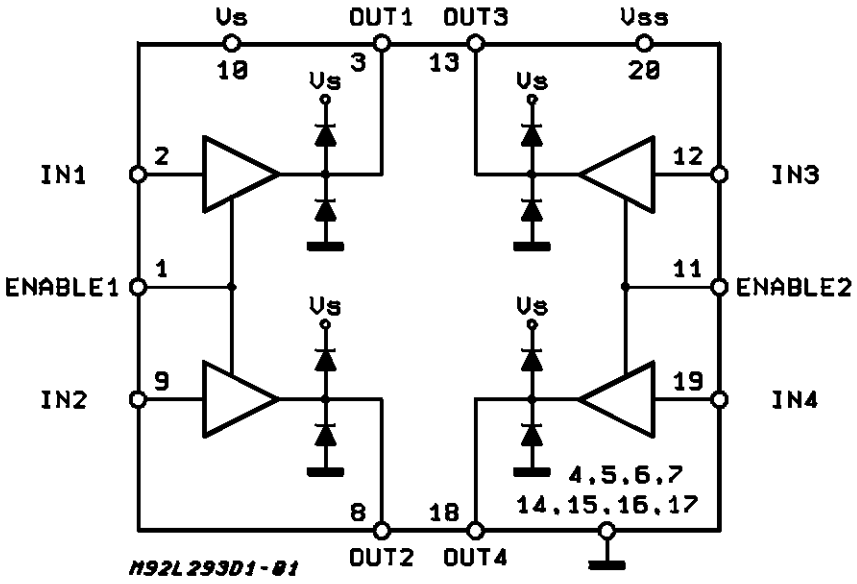
To simplify use as two bridges each pair of channels is equipped with an enable input. A separate supply input is provided for the logic, allowing operation at a lower voltage and internal clamp diodes are included.

This device is suitable for use in switching applications at frequencies up to 5 kHz.

The L293D is assembled in a 16 lead plastic packaage which has 4 center pins connected together and used for heatsinking

The L293DD is assembled in a 20 lead surface mount which has 8 center pins connected together and used for heatsinking.

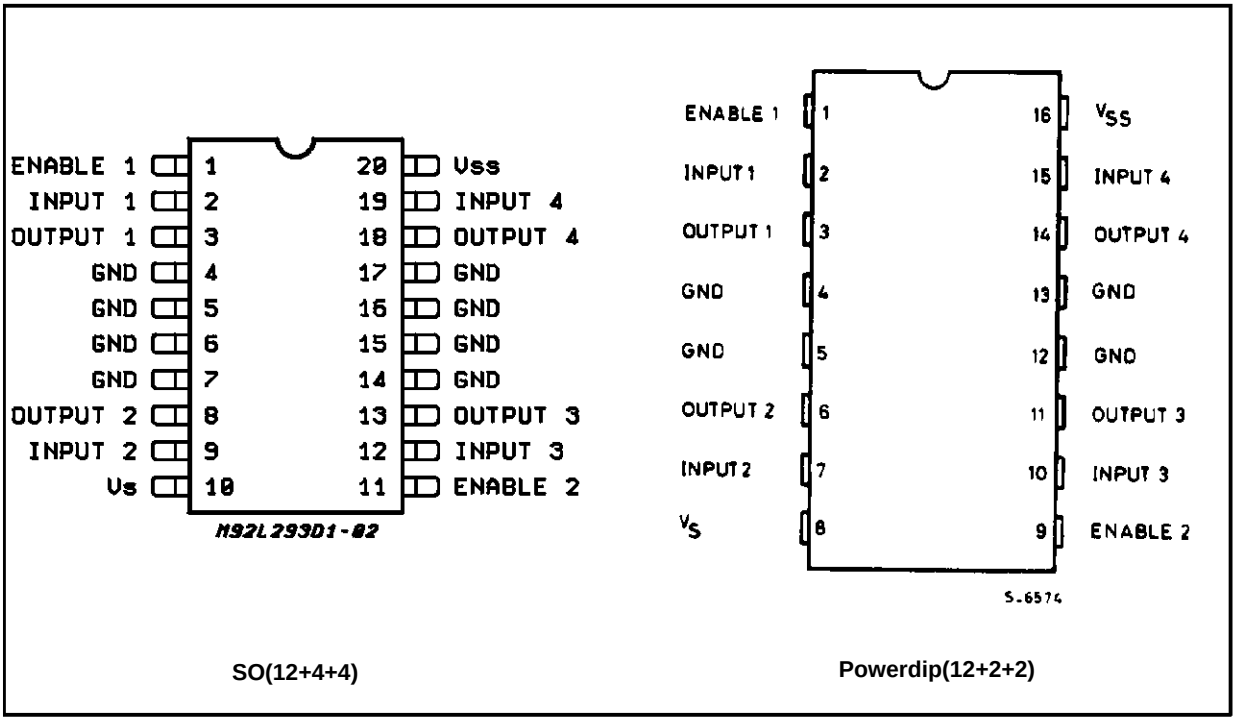
BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	Supply Voltage	36	V
V_{SS}	Logic Supply Voltage	36	V
V_i	Input Voltage	7	V
V_{en}	Enable Voltage	7	V
I_o	Peak Output Current (100 µs non repetitive)	1.2	A
P_{tot}	Total Power Dissipation at T_{pins} = 90 °C	4	W
T_{stg}, T_j	Storage and Junction Temperature	– 40 to 150	°C

PIN CONNECTIONS (Top view)



SO(12+4+4) **Powerdip(12+2+2)**

THERMAL DATA

Symbol	Decription		DIP	SO	Unit
$R_{th\ j\text{-}pins}$	Thermal Resistance Junction-pins	max.	–	14	°C/W
$R_{th\ j\text{-}amb}$	Thermal Resistance junction-ambient	max.	80	50 (*)	°C/W
$R_{th\ j\text{-}case}$	Thermal Resistance Junction-case	max.	14	–	

(*) With 6sq. cm on board heatsink.

ELECTRICAL CHARACTERISTICS (for each channel, V_S = 24 V, V_{SS} = 5 V, T_{amb} = 25 °C, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_S	Supply Voltage (pin 10)		V_{SS}		36	V
V_{SS}	Logic Supply Voltage (pin 20)		4.5		36	V
I_S	Total Quiescent Supply Current (pin 10)	V_i = L ; I_O = 0 ; V_{en} = H		2	6	mA
		V_i = H ; I_O = 0 ; V_{en} = H		16	24	mA
		V_{en} = L			4	mA
I_{SS}	Total Quiescent Logic Supply Current (pin 20)	V_i = L ; I_O = 0 ; V_{en} = H		44	60	mA
		V_i = H ; I_O = 0 ; V_{en} = H		16	22	mA
		V_{en} = L		16	24	mA
V_{IL}	Input Low Voltage (pin 2, 9, 12, 19)		– 0.3		1.5	V
V_{IH}	Input High Voltage (pin 2, 9, 12, 19)	$V_{SS} \leq 7$ V	2.3		V_{SS}	V
		$V_{SS} > 7$ V	2.3		7	V
I_{IL}	Low Voltage Input Current (pin 2, 9, 12, 19)	V_{IL} = 1.5 V			– 10	µA
I_{IH}	High Voltage Input Current (pin 2, 9, 12, 19)	$2.3\ V \leq V_{IH} \leq V_{SS} - 0.6\ V$		30	100	µA
$V_{en\,L}$	Enable Low Voltage (pin 1, 11)		– 0.3		1.5	V
$V_{en\,H}$	Enable High Voltage (pin 1, 11)	$V_{SS} \leq 7$ V	2.3		V_{SS}	V
		$V_{SS} > 7$ V	2.3		7	V
$I_{en\,L}$	Low Voltage Enable Current (pin 1, 11)	$V_{en\,L}$ = 1.5 V		– 30	– 100	µA
$I_{en\,H}$	High Voltage Enable Current (pin 1, 11)	$2.3\ V \leq V_{en\,H} \leq V_{SS} - 0.6\ V$			± 10	µA
$V_{CE(sat)H}$	Source Output Saturation Voltage (pins 3, 8, 13, 18)	I_O = – 0.6 A		1.4	1.8	V
$V_{CE(sat)L}$	Sink Output Saturation Voltage (pins 3, 8, 13, 18)	I_O = + 0.6 A		1.2	1.8	V
V_F	Clamp Diode Forward Voltage	I_O = 600nA		1.3		V
t_r	Rise Time (*)	0.1 to 0.9 V_O		250		ns
t_f	Fall Time (*)	0.9 to 0.1 V_O		250		ns
t_{on}	Turn-on Delay (*)	0.5 V_i to 0.5 V_O		750		ns
t_{off}	Turn-off Delay (*)	0.5 V_i to 0.5 V_O		200		ns

(*) See fig. 1.

TRUTH TABLE (one channel)

Input	Enable (*)	Output
H	H	H
L	H	L
H	L	Z
L	L	Z

Z = High output impedance
(*) Relative to the considered channel

Figure 1: Switching Times

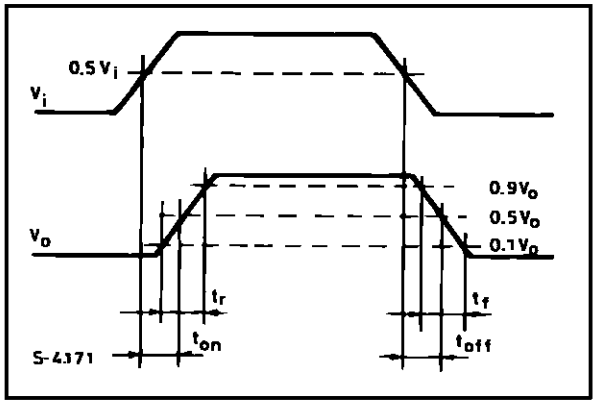
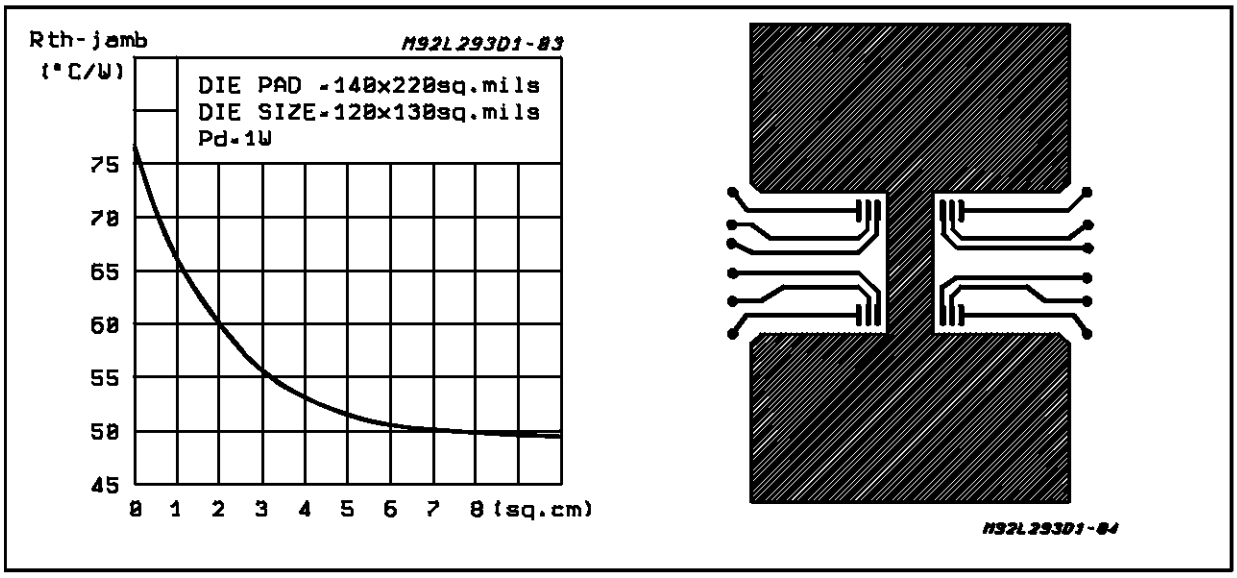
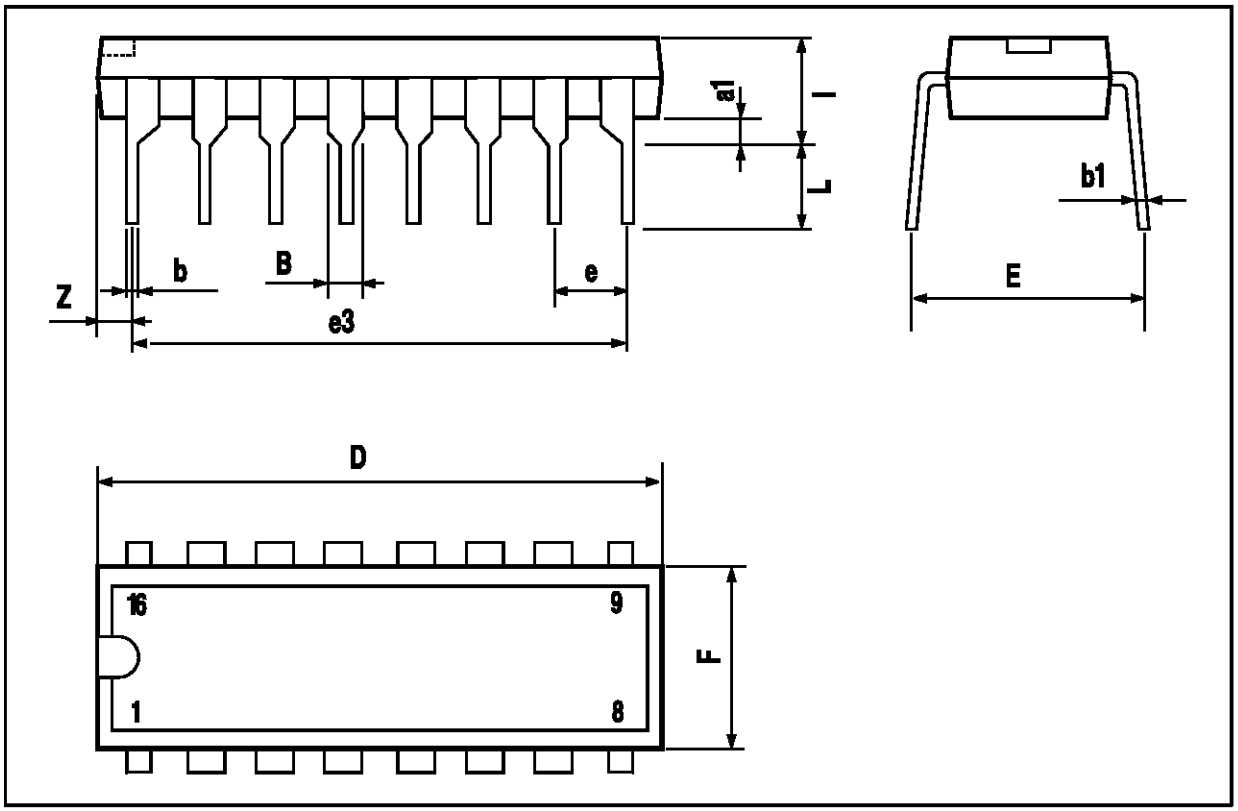


Figure 2: Junction to ambient thermal resistance vs. area on board heatsink (SO12+4+4 package)



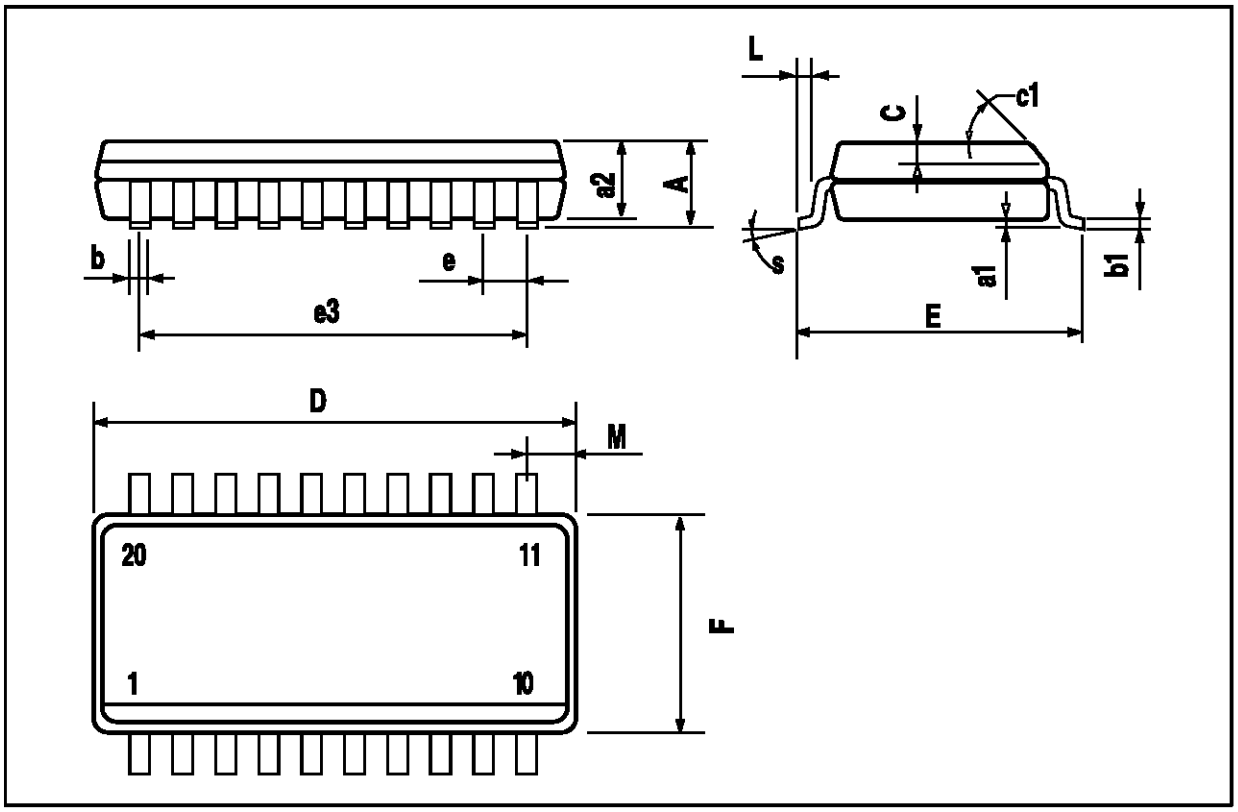
POWERDIP16 PACKAGE MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
a1	0.51			0.020		
B	0.85		1.40	0.033		0.055
b		0.50			0.020	
b1	0.38		0.50	0.015		0.020
D			20.0			0.787
E		8.80			0.346	
e		2.54			0.100	
e3		17.78			0.700	
F			7.10			0.280
I			5.10			0.201
L		3.30			0.130	
Z			1.27			0.050



SO20 PACKAGE MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			2.65			0.104
a1	0.1		0.2	0.004		0.008
a2			2.45			0.096
b	0.35		0.49	0.014		0.019
b1	0.23		0.32	0.009		0.013
C		0.5			0.020	
c1		45			1.772	
D		1	12.6		0.039	0.496
E	10		10.65	0.394		0.419
e		1.27			0.050	
e3		11.43			0.450	
F		1	7.4		0.039	0.291
G	8.8		9.15	0.346		0.360
L	0.5		1.27	0.020		0.050
M			0.75			0.030
S	8° (max.)					



Information furnished is believed to be accurate and reliable. However, SGS-THOMSON Microelectronics assumes no responsibility for the consequences of use of such information nor for any infringement of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of SGS-THOMSON Microelectronics. Specification mentioned in this publication are subject to change without notice. This publication supersedes and replaces all information previously supplied. SGS-THOMSON Microelectronics products are not authorized for use as critical components in life support devices or systems without express written approval of SGS-THOMSON Microelectronics.

© 1996 SGS-THOMSON Microelectronics – Printed in Italy – All Rights Reserved

SGS-THOMSON Microelectronics GROUP OF COMPANIES

Australia - Brazil - Canada - China - France - Germany - Hong Kong - Italy - Japan - Korea - Malaysia - Malta - Morocco - The Netherlands - Singapore - Spain - Sweden - Switzerland - Taiwan - Thailand - United Kingdom - U.S.A.

This datasheet has been download from:

www.datasheetcatalog.com

Datasheets for electronics components.