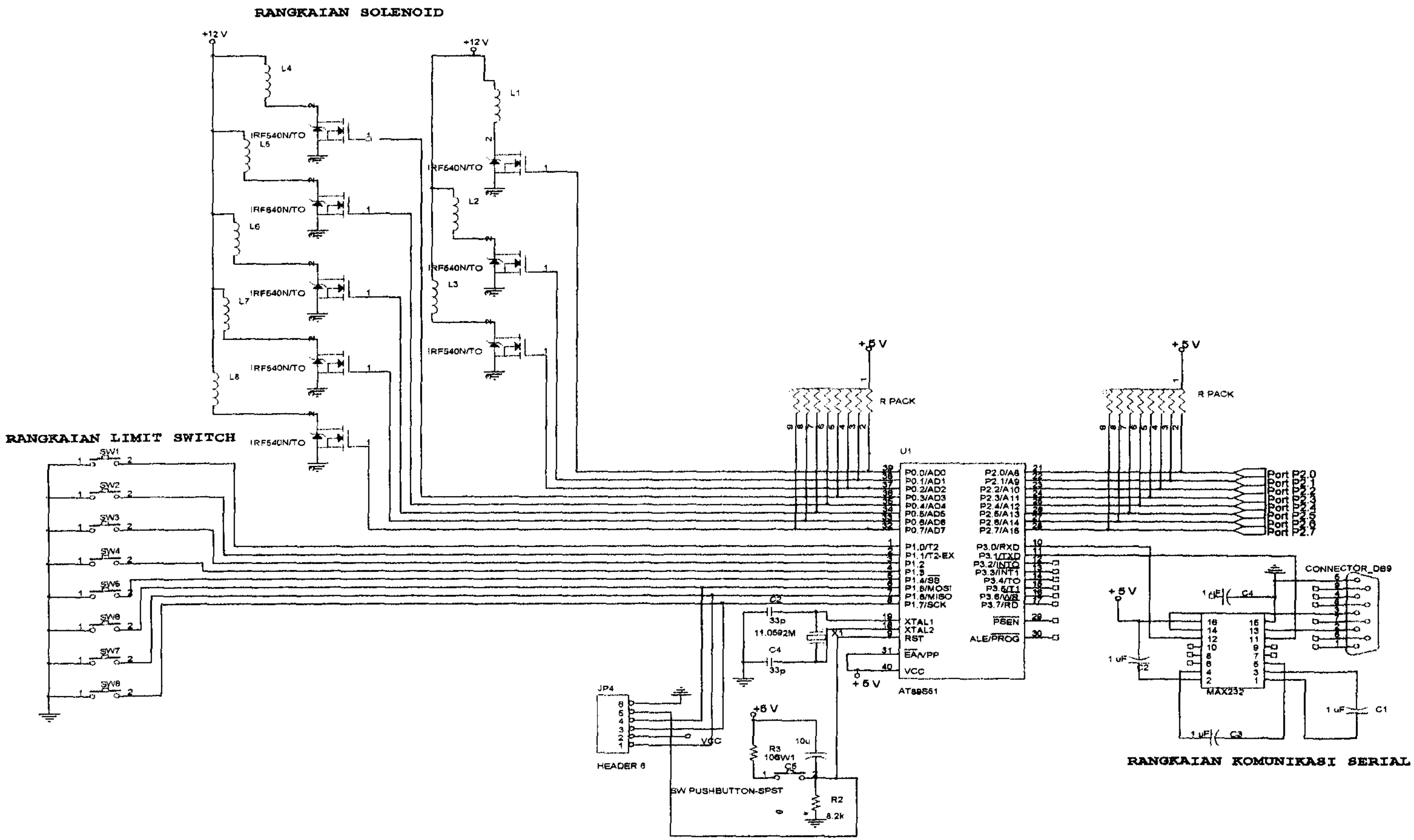
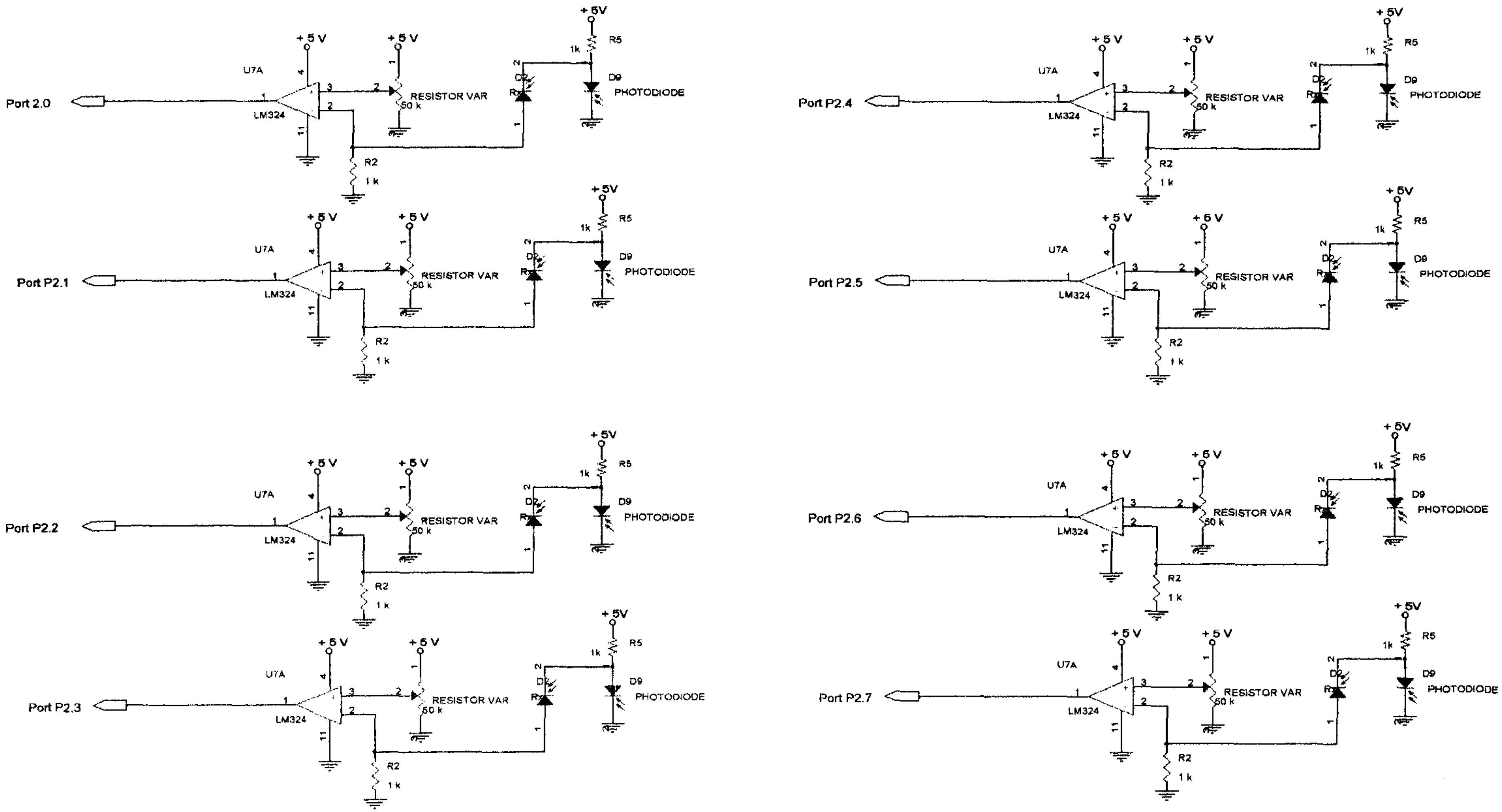
LAMPIRAN


RANGKAIAN SOLENOID
+12 V
L1
L2
L3
L4
L5
L6
L7
L8
IRF540N/TO
RANGKAIAN LIMIT SWITCH
SW1
SW2
SW3
SW4
SW5
SW6
SW7
SW8
+5 V
R PACK
U1
P0.0/AD0
P0.1/AD1
P0.2/AD2
P0.3/AD3
P0.4/AD4
P0.5/AD5
P0.6/AD6
P0.7/AD7
P1.0/T2
P1.1/T2-EX
P1.2
P1.3
P1.4/SS
P1.5/MOSI
P1.6/MISO
P1.7/SCK
XTAL1
XTAL2
RST
EA/VPP
VCC
P2.0/A8
P2.1/A9
P2.2/A10
P2.3/A11
P2.4/A12
P2.5/A13
P2.6/A14
P2.7/A15
P3.0/RXD
P3.1/TXD
P3.2/INT0
P3.3/INT1
P3.4/T0
P3.5/T1
P3.6/WR
P3.7/RD
PSEN
ALE/PROG
AT89S51
Port P2.0
Port P2.1
Port P2.2
Port P2.3
Port P2.4
Port P2.5
Port P2.6
Port P2.7
C2
33p
11.0592M
X1
C4
33p
JP4
HEADER 6
VCC
R3
10u
C5
SW PUSHBUTTON-SPST
R2
8.2k
CONNECTOR_DB9
C4
1 uF
C2
C1
C3
MAX232
RANGKAIAN KOMUNIKASI SERIAL

RANGKAIAN SENSOR



Program Form Menu

```
procedure TForm2.BitBtn1Click(Sender: TObject);
begin
form1.show;
with form1 do
edit2.clear;
end;

procedure TForm2.BitBtn2Click(Sender: TObject);
begin
form3.show;
with form3 do
edit2.Clear;
end;

procedure TForm2.BitBtn3Click(Sender: TObject);
begin
form4.show;
with form4 do
edit2.Clear;
end;

procedure TForm2.FormCreate(Sender: TObject);
begin

n:=0;
x:=64;
end;

procedure TForm2.SpeedButton1Click(Sender: TObject);
begin
application.Terminate;
end;

procedure TForm2.SpeedButton2Click(Sender: TObject);
begin
form5.QuickRep1.Preview;
end;

procedure TForm2.SpeedButton3Click(Sender: TObject);
begin
form5.QuickRep1.print;
end;
```

```
procedure TForm2.FormShow(Sender: TObject);
begin
form1.Hide;
end;

end.
```

Listing Program Form Masuk

```
procedure TForm1.BitBtn1Click(Sender: TObject);
begin
application.Terminate;
end;

procedure TForm1.Timer2Timer(Sender: TObject);
begin
label5.Caption:=datetostr(date);
end;

procedure TForm1.Timer3Timer(Sender: TObject);
begin
label6.Caption:=timetostr(time);
end;

procedure TForm1.ComPort1RxChar(Sender: TObject; Count: Integer);
var s:string;
begin
  comport1.ReadStr(s,1);
  edit1.Text:=s;
 if edit1.Text='9' then
 begin
  MessageDlg('LOCKER PENUH!!!', mtInformation,
   [mbOk], 0);
 end
  else
 begin
 table1.First;
 table1.Edit;
 table1.Insert;
 table1.Fields[0].AsString:=edit2.Text;
 table1.Fields[1].AsString:=table2.Fields[1].AsString;
 table1.Fields[2].AsString:=timetostr(time);
 table1.Fields[3].AsString:=datetostr(date);
 table1.Fields[4].AsString:='Masuk';
 table1.fields[5].asstring:=s;
 table1.Post;
 table1.Refresh;
 MessageDlg('Pintu Locker Ke '+ s + ' Telah TERBUKA !!!', mtInformation,
 [mbOk], 0);
```

```
edit2.Clear;
  begin
     with form4 do
     table1.Refresh;
     with form3 do
     table1.Refresh;
     with form5 do
     table1.Refresh;
   end;
end;
   end;

procedure TForm1.FormClose(Sender: TObject; var Action: TCloseAction);
begin
comport1.Connected:=false;
end;

procedure TForm1.FormShow(Sender: TObject);
begin
table1.Refresh;
end;

procedure TForm1.Edit2KeyPress(Sender: TObject; var Key: Char);
var ada,ketemu:boolean;
label lompat,lompat2;

begin
 ada:=false;

   table2.First;
   while not (table2.Eof) and not (ada) do
      begin
      if table2.Fields[0].AsString=edit2.Text then
            begin
            ada:=true;
            MessageDlg(' Anda sudah terdaftar!!', mtInformation,
            [mbOk], 0);
             end
            else
                  begin
                  table2.next;
                  end;

      end; //while
 // end; //if key
     //  goto lompat2;

  if ada then
  begin
  ada:=false;
  ketemu:=false;
```

```
 table1.First;
  while not (table1.Eof) and not(ada) do
     begin
   if ((table1.Fields[0].AsString=edit2.Text)) then
   begin
       ada:=true;
       if (table1.Fields[4].AsString='Masuk') then
          begin
           MessageDlg('Anda sudah punya loker!!', mtInformation,
           [mbOk], 0);
           ketemu:= true;
          end
       else
          begin
           MessageDlg('Anda mau keluar!!', mtInformation,
           [mbOk], 0);
           ketemu:=false;
          end
   end
   else
   begin
     table1.next;
   end;
 end; //while
if not(ketemu) then
          begin
             messageDlg('Anda Belum AKSES!!', mtInformation,
                [mbOk], 0);
                 comport1.WriteStr(#65);
end;
     end;
          end;
 end.
```

Listing Program Form Perpanjangan

```
procedure TForm3.Timer1Timer(Sender: TObject);
begin
label1.Caption:=datetostr(date);
end;

procedure TForm3.Timer2Timer(Sender: TObject);
begin
label2.Caption:=timetostr(time);
end;

procedure TForm3.Edit1KeyPress(Sender: TObject; var Key: Char);
begin
edit2.Text:=copy(edit1.Text,1,10);
end;
```

```
procedure TForm3.Edit2Change(Sender: TObject);
 begin
 table1.First;
 while not (table1.Eof) do
   begin
    if table1.Fields[0].AsString=edit2.Text
     then
      begin
      l5.Caption:=table1.Fields[5].AsString;
      label5.Caption:=table1.Fields[1].AsString;
      comport2.WriteStr(chr(strtoint(l5.Caption)+48));
      table1.First;
      table1.Edit;
      table1.Insert;
      table1.Fields[0].AsString:=edit2.Text;
      table1.Fields[1].AsString:=label5.Caption;
      table1.Fields[2].AsString:=timetostr(time);
      table1.Fields[3].AsString:=datetostr(date);
      table1.Fields[4].AsString:='Perpanjangan';
      table1.Fields[5].AsString:=l5.Caption;
      table1.Post;
      table1.Refresh;
      MessageDlg('Locker Ke '+ l5.caption +' Telah TERBUKA!!!.', mtInformation,
      [mbOk], 0);
      edit2.Clear;
         break;
        end
     else
     begin

     table1.Next;
      end;

end;

begin
with form1 do
 table1.Refresh;
with form4 do
  table1.Refresh;
 with form5 do
  table1.Refresh;
 end;
 end;


procedure TForm3.FormClose(Sender: TObject; var Action: TCloseAction);
begin
comport2.Connected:=false;
end;
```

```
procedure TForm3.FormShow(Sender: TObject);
begin
table1.Refresh;
end;

end.
```

Listing program Form Keluar

```
procedure TForm4.Timer1Timer(Sender: TObject);
begin
label3.Caption:=datetostr(date);
end;

procedure TForm4.Timer2Timer(Sender: TObject);
begin
label4.Caption:=timetostr(time);
end;

procedure TForm4.Edit2Change(Sender: TObject);
begin
  table1.First;
  while not (table1.Eof) do
    begin
    if table1.Fields[0].AsString=edit2.Text then
       begin

       label5.Caption:=table1.Fields[5].AsString;
       label6.Caption:=table1.Fields[1].AsString;
       comport3.WriteStr(chr(strtoint(label5.Caption)+48));
       table1.first;
       table1.Insert;
       table1.Fields[0].AsString:=edit2.Text;
       table1.Fields[1].AsString:=label6.Caption;
       table1.Fields[2].AsString:=timetostr(time);
       table1.Fields[3].AsString:=datetostr(date);
       table1.Fields[4].AsString:='Keluar';
       table1.Fields[5].AsString:=label5.Caption;
       table1.Post;
       table1.Refresh;
       MessageDlg('Pintu Locker Ke '+ label5.Caption + ' Telah TERBUKA !!!',
       mtInformation,[mbOk], 0);
       edit2.Clear;
       {close;}
       break;
       end
       else
       begin
```

```
        table1.Next;
        end;
        end;
        begin
         with form1 do
         table1.Refresh;
         with form3 do
         table1.Refresh;
         with form5 do
         table1.Refresh;
         end;

  end;

procedure TForm4.FormClose(Sender: TObject; var Action: TCloseAction);
begin
comport3.Connected:=false;
end;

procedure TForm4.FormShow(Sender: TObject);
begin
table1.Refresh;
end;
```

```
$include(reg51.inc)
;**********************************************************************
;PROGRAM ASSEMBLY PERANCANGAN DAN PEMBUATAN LOKER OTOMATIS
;**********************************************************************
        org   00h          ;Program dimulai pada alamat 00h
        ajmp mulai
        org   60h


mulai:
       mov p0,#00000000b
       mov p1,#0ffh
       acall  inisial


ulang:  mov     a,#00h
        jnb     ri,cek1    ;cek ke limit switch
        clr     ri
        mov     a,sbuf      ;
        cjne    a,#41h,lop1
        ajmp    pintu1
;----------------------------------------------------------------------
;ini untuk mengecek limit switch
;----------------------------------------------------------------------
cek1:   jnb p1.0,cek2
         clr p0.0

cek2:   jnb p1.1,cek3
         clr p0.1

:ek3:   jnb p1.2,cek4
        clr p0.2

:k4:    jnb p1.3,cek5
        clr p0.3

 k5:    jnb p1.4,cek6
        clr p0.4
```

```
cek6:   jnb p1.5,cek7
        clr p0.5

cek7:   jnb p1.6,cek8
        clr p0.6

cek8:   jnb p1.7,balik
        clr p0.7

balik:  ajmp ulang


pintu1: jnb  p2.0,buka1    ;cek sensor apa p2.0 ada barang kalau tidak ada lompat ke buka1
        ajmp pintu2        ;tidak ada barang lompat ke pintu2

buka1:  setb p0.0          ;buka solenoid1
        mov  a,#31h        ; pindah isi 31h ke A
        acall kirim        ;panggil kirim
        ajmp  ulang        ;lompat keulang

pintu2: jnb  p2.1,buka2    ;cek sensor apa p2.1 ada barang kalau tidak ada lompat ke buka2
        ajmp pintu3        ;tidak ada barang lompat ke pintu3
buka2:  setb p0.1          ;aktifkan solenoid2
        mov a,#32h         ;pindahkan isi32h ke A
        acall kirim
        ajmp  ulang

pintu3: jnb  p2.2,buka3    ;cek sensor apa p2.2 ada barang kalau tidak ada lompat ke buka3
        ajmp pintu4
buka3:  setb p0.2
        mov a,#33h
        acall kirim
        ajmp  ulang

lop1:   ajmp door1

pintu4: jnb  p2.3,buka4    ;cek sensor apa p2.3 ada barang kalau tidak ada lompat ke buka4
        ajmp pintu5

buka4:  setb p0.3
        mov a,#34h
        acall kirim
        ajmp  ulang

pintu5: jnb  p2.4,buka5    ;cek sensor apa p2.4 ada barang kalau tidak ada lompat ke buka5
```

```
        ajmp pintu6

buka5:   setb p0.4
         mov a,#35h
         acall kirim
         ajmp  ulang

pintu6:  jnb  p2.5,buka6   ;cek sensor apa p2.5 ada barang kalau tidak ada lompat ke buka6
         ajmp pintu7
buka6:   setb p0.5
         mov a,#36h
         acall kirim
         ajmp  ulang

pintu7:  jnb  p2.6,buka7    ;cek sensor apa p2.6 ada barang kalau tidak ada lompat ke buka7
         ajmp pintu8
buka7:   setb p0.6
         mov a,#37h
         acall kirim
         ajmp  ulang

pintu8:  jnb  p2.7,buka8  ;cek sensor apa p2.7 ada barang kalau tidak ada lompat ke buka8
         ajmp kirim_berita  ;mengirim data ke delphi
buka8:   setb p0.7
         mov  a,#38h
         acall kirim
         ajmp  ulang
;--------------------------------------------------------------------------------------------
; Perintah untuk mengirim data ke Delphi
;--------------------------------------------------------------------------------------------

kirim_berita: mov   a,#39h
              acall kirim      ;mengirim data
              ajmp  ulang


jauh:    ajmp   ulang

;--------------------------------------------------------------------------------------------
;perintah untuk keluar atau memperpanjang loker
;--------------------------------------------------------------------------------------------
door1:   cjne    a,#31h,door2
         setb    p0.0
         ajmp    ulang

door2:   cjne    a,#32h,door3
```

```
        setb    p0.1
        ajmp    ulang

door3:  cjne    a,#33h,door4
        setb    p0.2
        ajmp    ulang

door4:  cjne    a,#34h,door5
        setb    p0.3
        ajmp    ulang

door5:  cjne    a,#35h,door6
        setb    p0.4
        ajmp    ulang

door6:  cjne    a,#36h,door7
        setb    p0.5
        ajmp    ulang

door7:  cjne    a,#37h,door8
        setb    p0.6
        ajmp    ulang


door8:  cjne    a,#38h,jauh
        setb    p0.7
        ajmp    ulang

;------------------------------------------------------------------------------------------
;Mengirim data ke delphi
;------------------------------------------------------------------------------------------
kirim:  mov   sbuf,a
        jnb     ti,$
        clr     ti
        ret
;------------------------------------------------------------------------------------------
;inisialisasi port serial
;------------------------------------------------------------------------------------------
inisial:  anl  tmod,#0fh
          orl  tmod,#20h
          mov  th1,#0fah
          mov  tl1,#0fah
          mov  scon,#50h
          mov  pcon,#80h
          setb tr1
          clr  ti
```

```
clr ri
 ret
 end
```

9-4323; Rev 11; 2/03

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

General Description

he MAX220–MAX249 family of line drivers/receivers is ntended for all EIA/TIA-232E and V.28/V.24 communicaons interfaces, particularly applications where ±12V is ot available.

hese parts are especially useful in battery-powered sysems, since their low-power shutdown mode reduces ower dissipation to less than 5μW. The MAX225, AX233, MAX235, and MAX245/MAX246/MAX247 use o external components and are recommended for appliations where printed circuit board space is critical.

Applications

Portable Computers

Low-Power Modems

Interface Translation

Battery-Powered RS-232 Systems

Multidrop RS-232 Networks

Features

Superior to Bipolar

- ♦ **Operate from Single +5V Power Supply (+5V and +12V—MAX231/MAX239)**
- ♦ **Low-Power Receive Mode in Shutdown (MAX223/MAX242)**
- ♦ **Meet All EIA/TIA-232E and V.28 Specifications**
- ♦ **Multiple Drivers and Receivers**
- ♦ **3-State Driver and Receiver Outputs**
- ♦ **Open-Line Detection (MAX243)**

Ordering Information

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

Ordering Information continued at end of data sheet.

**Contact factory for dice specifications.*

Selection Table

'art lumber	Power Supply (V)	No. of RS-232 Drivers/Rx	No. of Ext. Caps	Nominal Cap. Value (μF)	SHDN & Three-State	Rx Active in SHDN	Data Rate (kbps)	Features
AX220	+5	2/2	4	0.1	No	—	120	Ultra-low-power, industry-standard pinout
AX222	+5	2/2	4	0.1	Yes	—	200	Low-power shutdown
AX223 (MAX213)	+5	4/5	4	1.0 (0.1)	Yes	✔	120	MAX241 and receivers active in shutdown
AX225	+5	5/5	0	—	Yes	✔	120	Available in SO
AX230 (MAX200)	+5	5/0	4	1.0 (0.1)	Yes	—	120	5 drivers with shutdown
AX231 (MAX201)	+5 and +7.5 to +13.2	2/2	2	1.0 (0.1)	No	—	120	Standard +5/+12V or battery supplies; same functions as MAX232
AX232 (MAX202)	+5	2/2	4	1.0 (0.1)	No	—	120 (64)	Industry standard
AX232A	+5	2/2	4	0.1	No	—	200	Higher slew rate, small caps
AX233 (MAX203)	+5	2/2	0	—	No	—	120	No external caps
AX233A	+5	2/2	0	—	No	—	200	No external caps, high slew rate
AX234 (MAX204)	+5	4/0	4	1.0 (0.1)	No	—	120	Replaces 1488
AX235 (MAX205)	+5	5/5	0	—	Yes	—	120	No external caps
X236 (MAX206)	+5	4/3	4	1.0 (0.1)	Yes	—	120	Shutdown, three state
X237 (MAX207)	+5	5/3	4	1.0 (0.1)	No	—	120	Complements IBM PC serial port
X238 (MAX208)	+5	4/4	4	1.0 (0.1)	No	—	120	Replaces 1488 and 1489
X239 (MAX209)	+5 and +7.5 to +13.2	3/5	2	1.0 (0.1)	No	—	120	Standard +5/+12V or battery supplies; single-package solution for IBM PC serial port
X240	+5	5/5	4	1.0	Yes	—	120	DIP or flatpack package
X241 (MAX211)	+5	4/5	4	1.0 (0.1)	Yes	—	120	Complete IBM PC serial port
X242	+5	2/2	4	0.1	Yes	✔	200	Separate shutdown and enable
X243	+5	2/2	4	0.1	No	—	200	Open-line detection simplifies cabling
X244	+5	8/10	4	1.0	No	—	120	High slew rate
X245	+5	8/10	0	—	Yes	✔	120	High slew rate, int. caps, two shutdown modes
X246	+5	8/10	0	—	Yes	✔	120	High slew rate, int. caps, three shutdown modes
X247	+5	8/9	0	—	Yes	✔	120	High slew rate, int. caps, nine operating modes
X248	+5	8/8	4	1.0	Yes	✔	120	High slew rate, selective half-chip enables
X249	+5	6/10	4	1.0	Yes	✔	120	Available in quad flatpack package

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

\BSOLUTE MAXIMUM RATINGS—MAX220/222/232A/233A/242/243

upply Voltage (V_{CC})....................-0.3V to +6V
nput Voltages
T_{IN}....................-0.3V to (V_{CC} - 0.3V)
R_{IN} (Except MAX220)....................±30V
R_{IN} (MAX220)....................±25V
T_{OUT} (Except MAX220) (Note 1)....................±15V
T_{OUT} (MAX220)....................±13.2V
utput Voltages
T_{OUT}....................±15V
R_{OUT}....................-0.3V to (V_{CC} + 0.3V)
river/Receiver Output Short Circuited to GND.........Continuous
ontinuous Power Dissipation (T_A = +70°C)
16-Pin Plastic DIP (derate 10.53mW/°C above +70°C)....842mW
18-Pin Plastic DIP (derate 11.11mW/°C above +70°C)....889mW
20-Pin Plastic DIP (derate 8.00mW/°C above +70°C)..440mW
16-Pin Narrow SO (derate 8.70mW/°C above +70°C)...696mW
16-Pin Wide SO (derate 9.52mW/°C above +70°C)......762mW
18-Pin Wide SO (derate 9.52mW/°C above +70°C)......762mW
20-Pin Wide SO (derate 10.00mW/°C above +70°C)....800mW
20-Pin SSOP (derate 8.00mW/°C above +70°C)..........640mW
16-Pin CERDIP (derate 10.00mW/°C above +70°C).....800mW
18-Pin CERDIP (derate 10.53mW/°C above +70°C).....842mW
Operating Temperature Ranges
MAX2_ _AC_ _, MAX2_ _C_ _....................0°C to +70°C
MAX2_ _AE_ _, MAX2_ _E_ _....................-40°C to +85°C
MAX2_ _AM_ _, MAX2_ _M_ _....................-55°C to +125°C
Storage Temperature Range....................-65°C to +160°C
Lead Temperature (soldering, 10s)....................+300°C

lote 1: Input voltage measured with T_{OUT} in high-impedance state, $\overline{SHDN}$ or V_{CC} = 0V.
lote 2: For the MAX220, V+ and V- can have a maximum magnitude of 7V, but their absolute difference cannot exceed 13V.

tresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional peration of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to bsolute maximum rating conditions for extended periods may affect device reliability.

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

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

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
RS-232 TRANSMITTERS						
Output Voltage Swing	All transmitter outputs loaded with 3kΩ to GND		±5	±8		V
Input Logic Threshold Low				1.4	0.8	V
Input Logic Threshold High	All devices except MAX220		2	1.4		V
	MAX220: V_{CC} = 5.0V		2.4			
Logic Pull-Up/Input Current	All except MAX220, normal operation			5	40	µA
	$\overline{SHDN}$ = 0V, MAX222/242, shutdown, MAX220			±0.01	±1	
Output Leakage Current	V_{CC} = 5.5V, $\overline{SHDN}$ = 0V, V_{OUT} = ±15V, MAX222/242			±0.01	±10	µA
	V_{CC} = $\overline{SHDN}$ = 0V, V_{OUT} = ±15V			±0.01	±10	
Data Rate				200	116	kbps
Transmitter Output Resistance	V_{CC} = V+ = V- = 0V, V_{OUT} = ±2V		300	10M		Ω
Output Short-Circuit Current	V_{OUT} = 0V		±7	±22		mA
RS-232 RECEIVERS						
RS-232 Input Voltage Operating Range					±30	V
RS-232 Input Threshold Low	V_{CC} = 5V	All except MAX243 $R2_{IN}$	0.8	1.3		V
		MAX243 $R2_{IN}$ (Note 2)	-3			
RS-232 Input Threshold High	V_{CC} = 5V	All except MAX243 $R2_{IN}$		1.8	2.4	V
		MAX243 $R2_{IN}$ (Note 2)		-0.5	-0.1	
RS-232 Input Hysteresis	All except MAX243, V_{CC} = 5V, no hysteresis in shdn.		0.2	0.5	1	V
	MAX243			1		
RS-232 Input Resistance			3	5	7	kΩ
TTL/CMOS Output Voltage Low	I_{OUT} = 3.2mA			0.2	0.4	V
TTL/CMOS Output Voltage High	I_{OUT} = -1.0mA		3.5	V_{CC} - 0.2		V
TTL/CMOS Output Short-Circuit Current	Sourcing V_{OUT} = GND		-2	-10		mA
	Shrinking V_{OUT} = V_{CC}		10	30		

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

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

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
TTL/CMOS Output Leakage Current	$\overline{SHDN}$ = V_{CC} or $\overline{EN}$ = V_{CC} ($\overline{SHDN}$ = 0V for MAX222), 0V ≤ V_{OUT} ≤ V_{CC}			±0.05	±10	µA
$\overline{EN}$ Input Threshold Low	MAX242			1.4	0.8	V
$\overline{EN}$ Input Threshold High	MAX242		2.0	1.4		V
Operating Supply Voltage			4.5		5.5	V
V_{CC} Supply Current ($\overline{SHDN}$ = V_{CC}), Figures 5, 6, 11, 19	No load	MAX220		0.5	2	mA
		MAX222/232A/233A/242/243		4	10	
	3kΩ load both inputs	MAX220		12		
		MAX222/232A/233A/242/243		15		
Shutdown Supply Current	MAX222/242	T_A = +25°C		0.1	10	µA
		T_A = 0°C to +70°C		2	50	
		T_A = -40°C to +85°C		2	50	
		T_A = -55°C to +125°C		35	100	
$\overline{SHDN}$ Input Leakage Current	MAX222/242				±1	µA
$\overline{SHDN}$ Threshold Low	MAX222/242			1.4	0.8	V
$\overline{SHDN}$ Threshold High	MAX222/242		2.0	1.4		V
Transition Slew Rate	C_L = 50pF to 2500pF, R_L = 3kΩ to 7kΩ, V_{CC} = 5V, T_A = +25°C, measured from +3V to -3V or -3V to +3V	MAX222/232A/233A/242/243	6	12	30	V/µs
		MAX220	1.5	3	30	
Transmitter Propagation Delay TLL to RS-232 (Normal Operation), Figure 1	t_{PHLT}	MAX222/232A/233A/242/243		1.3	3.5	µs
		MAX220		4	10	
	t_{PLHT}	MAX222/232A/233A/242/243		1.5	3.5	
		MAX220		5	10	
Receiver Propagation Delay RS-232 to TLL (Normal Operation), Figure 2	t_{PHLR}	MAX222/232A/233A/242/243		0.5	1	µs
		MAX220		0.6	3	
	t_{PLHR}	MAX222/232A/233A/242/243		0.6	1	
		MAX220		0.8	3	
Receiver Propagation Delay RS-232 to TLL (Shutdown), Figure 2	t_{PHLS}	MAX242		0.5	10	µs
	t_{PLHS}	MAX242		2.5	10	
Receiver-Output Enable Time, Figure 3	t_{ER}	MAX242		125	500	ns
Receiver-Output Disable Time, Figure 3	t_{DR}	MAX242		160	500	ns
Transmitter-Output Enable Time ($\overline{SHDN}$ Goes High), Figure 4	t_{ET}	MAX222/242, 0.1µF caps (includes charge-pump start-up)		250		µs
Transmitter-Output Disable Time ($\overline{SHDN}$ Goes Low), Figure 4	t_{DT}	MAX222/242, 0.1µF caps		600		ns
Transmitter + to - Propagation Delay Difference (Normal Operation)	t_{PHLT} - t_{PLHT}	MAX222/232A/233A/242/243		300		ns
		MAX220		2000		
Receiver + to - Propagation Delay Difference (Normal Operation)	t_{PHLR} - t_{PLHR}	MAX222/232A/233A/242/243		100		ns
		MAX220		225		

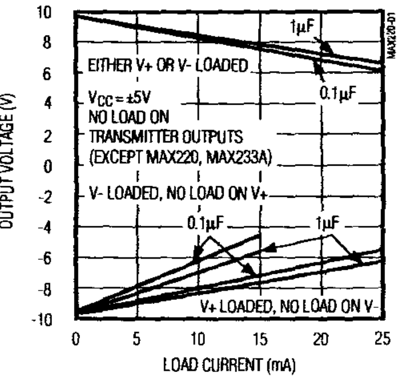
Note 3: MAX243 $R2_{OUT}$ is guaranteed to be low when $R2_{IN}$ is ≥ 0V or is floating.

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

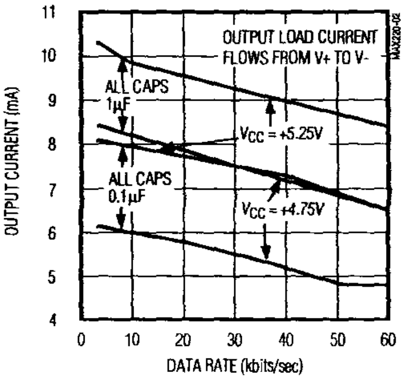
Typical Operating Characteristics

MAX220/MAX222/MAX232A/MAX233A/MAX242/MAX243

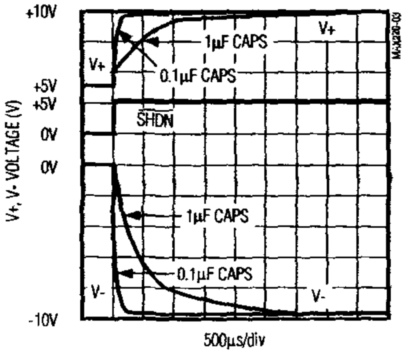
OUTPUT VOLTAGE vs. LOAD CURRENT



AVAILABLE OUTPUT CURRENT vs. DATA RATE



MAX222/MAX242 ON-TIME EXITING SHUTDOWN



ABSOLUTE MAXIMUM RATINGS—MAX223/MAX230–MAX241

V_{CC} .... -0.3V to +6V
V+ .... (V_{CC} - 0.3V) to +14V
V- .... +0.3V to -14V
Input Voltages
  T_{IN} .... -0.3V to (V_{CC} + 0.3V)
  R_{IN} .... ±30V
Output Voltages
  T_{OUT} .... (V+ + 0.3V) to (V- - 0.3V)
  R_{OUT} .... -0.3V to (V_{CC} + 0.3V)
Short-Circuit Duration, T_{OUT} .... Continuous
Continuous Power Dissipation (T_A = +70°C)
  14-Pin Plastic DIP (derate 10.00mW/°C above +70°C) 800mW
  16-Pin Plastic DIP (derate 10.53mW/°C above +70°C) 842mW
  20-Pin Plastic DIP (derate 11.11mW/°C above +70°C) 889mW
  24-Pin Narrow Plastic DIP
    (derate 13.33mW/°C above +70°C) 1.07W
  24-Pin Plastic DIP (derate 9.09mW/°C above +70°C) 500mW
  16-Pin Wide SO (derate 9.52mW/°C above +70°C) 762mW
  20-Pin Wide SO (derate 10.00mW/°C above +70°C) 800mW
  24-Pin Wide SO (derate 11.76mW/°C above +70°C) 941mW
  28-Pin Wide SO (derate 12.50mW/°C above +70°C) 1W
  44-Pin Plastic FP (derate 11.11mW/°C above +70°C) 889mW
  14-Pin CERDIP (derate 9.09mW/°C above +70°C) 727mW
  16-Pin CERDIP (derate 10.00mW/°C above +70°C) 800mW
  20-Pin CERDIP (derate 11.11mW/°C above +70°C) 889mW
  24-Pin Narrow CERDIP
    (derate 12.50mW/°C above +70°C) 1W
  24-Pin Sidebraze (derate 20.0mW/°C above +70°C) 1.6W
  28-Pin SSOP (derate 9.52mW/°C above +70°C) 762mW
Operating Temperature Ranges
  MAX2 _ _ C _ _ .... 0°C to +70°C
  MAX2 _ _ E _ _ .... -40°C to +85°C
  MAX2 _ _ M _ _ .... -55°C to +125°C
Storage Temperature Range .... -65°C to +160°C
Lead Temperature (soldering, 10s) .... +300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS—MAX223/MAX230–MAX241

(MAX223/230/232/234/236/237/238/240/241, V_{CC} = +5V ±10; MAX233/MAX235, V_{CC} = 5V ±5%, C1–C4 = 1.0µF; MAX231/MAX239, V_{CC} = 5V ±10%; V+ = 7.5V to 13.2V; T_A = T_{MIN} to T_{MAX}; unless otherwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Output Voltage Swing	All transmitter outputs loaded with 3kΩ to ground		±5.0	±7.3		V
V_{CC} Power-Supply Current	No load, T_A = +25°C	MAX232/233		5	10	mA
		MAX223/230/234–238/240/241		7	15	
		MAX231/239		0.4	1	
V+ Power-Supply Current		MAX231		1.8	5	mA
		MAX239		5	15	
Shutdown Supply Current	T_A = +25°C	MAX223		15	50	µA
		MAX230/235/236/240/241		1	10	
Input Logic Threshold Low	T_{IN}; EN, $\overline{SHDN}$ (MAX233); $\overline{EN}$, SHDN (MAX230/235–241)				0.8	V
Input Logic Threshold High	T_{IN}		2.0			V
	EN, $\overline{SHDN}$ (MAX223); $\overline{EN}$, SHDN (MAX230/235/236/240/241)		2.4			
Logic Pull-Up Current	T_{IN} = 0V			1.5	200	µA
Receiver Input Voltage Operating Range			-30		30	V

ELECTRICAL CHARACTERISTICS—MAX223/MAX230–MAX241 (continued)

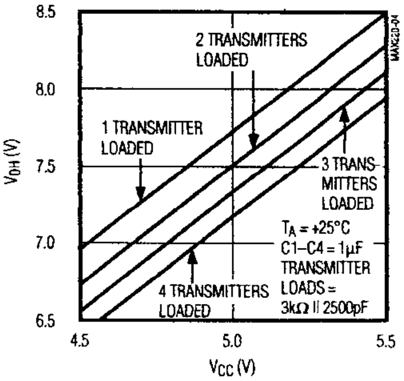
(MAX223/230/232/234/236/237/238/240/241, V_{CC} = +5V ±10; MAX233/MAX235, V_{CC} = 5V ±5%, C1–C4 = 1.0μF; MAX231/MAX239, V_{CC} = 5V ±10%; V+ = 7.5V to 13.2V; T_A = T_{MIN} to T_{MAX}; unless otherwise noted.)

PARAMETER	CONDITIONS			MIN	TYP	MAX	UNITS
RS-232 Input Threshold Low	T_A = +25°C, V_{CC} = 5V	Normal operation $\overline{SHDN}$ = 5V (MAX223) SHDN = 0V (MAX235/236/240/241)		0.8	1.2		V
		Shutdown (MAX223) $\overline{SHDN}$ = 0V, EN = 5V ($R4_{IN}$, $R5_{IN}$)		0.6	1.5		
RS-232 Input Threshold High	T_A = +25°C, V_{CC} = 5V	Normal operation $\overline{SHDN}$ = 5V (MAX223) SHDN = 0V (MAX235/236/240/241)			1.7	2.4	V
		Shutdown (MAX223) $\overline{SHDN}$ = 0V, EN = 5V ($R4_{IN}$, $R5_{IN}$)			1.5	2.4	
RS-232 Input Hysteresis	V_{CC} = 5V, no hysteresis in shutdown			0.2	0.5	1.0	V
RS-232 Input Resistance	T_A = +25°C, V_{CC} = 5V			3	5	7	kΩ
TTL/CMOS Output Voltage Low	I_{OUT} = 1.6mA (MAX231/232/233, I_{OUT} = 3.2mA)					0.4	V
TTL/CMOS Output Voltage High	I_{OUT} = -1mA			3.5	V_{CC} - 0.4		V
TTL/CMOS Output Leakage Current	0V ≤ R_{OUT} ≤ V_{CC}; EN = 0V (MAX223); $\overline{EN}$ = V_{CC} (MAX235–241)				0.05	±10	μA
Receiver Output Enable Time	Normal operation	MAX223			600		ns
		MAX235/236/239/240/241			400		
Receiver Output Disable Time	Normal operation	MAX223			900		ns
		MAX235/236/239/240/241			250		
Propagation Delay	RS-232 IN to TTL/CMOS OUT, C_L = 150pF	Normal operation			0.5	10	μs
		$\overline{SHDN}$ = 0V (MAX223)	t_{PHLS}		4	40	
			t_{PLHS}		6	40	
Transition Region Slew Rate	MAX223/MAX230/MAX234–241, T_A = +25°C, V_{CC} = 5V, R_L = 3kΩ to 7kΩ, C_L = 50pF to 2500pF, measured from +3V to -3V or -3V to +3V			3	5.1	30	V/μs
	MAX231/MAX232/MAX233, T_A = +25°C, V_{CC} = 5V, R_L = 3kΩ to 7kΩ, C_L = 50pF to 2500pF, measured from +3V to -3V or -3V to +3V				4	30	
Transmitter Output Resistance	V_{CC} = V+ = V- = 0V, V_{OUT} = ±2V			300			Ω
Transmitter Output Short-Circuit Current					±10		mA

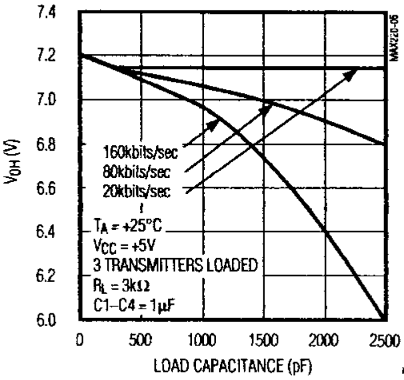
Typical Operating Characteristics

MAX223/MAX230–MAX241

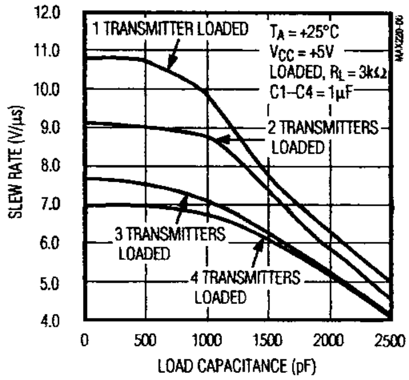
TRANSMITTER OUTPUT VOLTAGE (V_{OH}) vs. V_{CC}



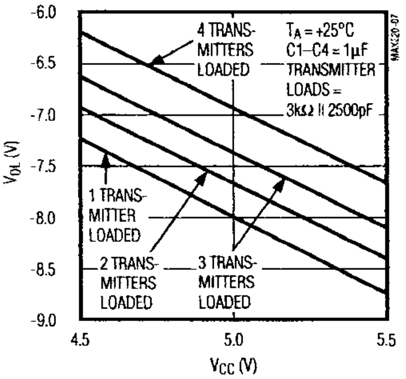
TRANSMITTER OUTPUT VOLTAGE (V_{OH}) vs. LOAD CAPACITANCE AT DIFFERENT DATA RATES



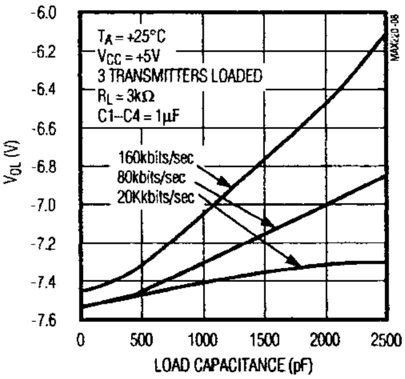
TRANSMITTER SLEW RATE vs. LOAD CAPACITANCE



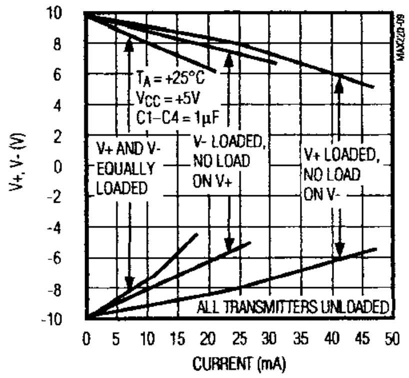
TRANSMITTER OUTPUT VOLTAGE (V_{OL}) vs. V_{CC}



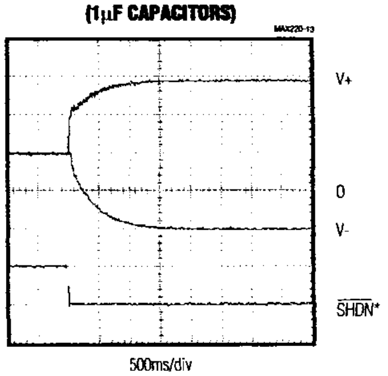
TRANSMITTER OUTPUT VOLTAGE (V_{OL}) vs. LOAD CAPACITANCE AT DIFFERENT DATA RATES



TRANSMITTER OUTPUT VOLTAGE (V+, V-) vs. LOAD CURRENT



V+, V- WHEN EXITING SHUTDOWN (1µF CAPACITORS)



*SHUTDOWN POLARITY IS REVERSED FOR NON MAX241 PARTS

\BSOLUTE MAXIMUM RATINGS—MAX225/MAX244–MAX249

upply Voltage (V_{CC}) ....-0.3V to +6V
ıput Voltages
T_{IN}, $\overline{ENA}$, $\overline{ENB}$, $\overline{ENR}$, $\overline{ENT}$, $\overline{ENRA}$,
$\overline{ENRB}$, $\overline{ENTA}$, $\overline{ENTB}$....................-0.3V to (V_{CC} + 0.3V)
R_{IN} ....±25V
T_{OUT} (Note 3)....................±15V
R_{OUT} ....-0.3V to (V_{CC} + 0.3V)
hort Circuit (one output at a time)
T_{OUT} to GND....................Continuous
R_{OUT} to GND....................Continuous

Continuous Power Dissipation (T_A = +70°C)
28-Pin Wide SO (derate 12.50mW/°C above +70°C) 1W
40-Pin Plastic DIP (derate 11.11mW/°C above +70°C) ...611mW
44-Pin PLCC (derate 13.33mW/°C above +70°C) 1.07W
Operating Temperature Ranges
MAX225C_ _, MAX24_C_ _ ....0°C to +70°C
MAX225E_ _, MAX24_E_ _ ....-40°C to +85°C
Storage Temperature Range....................-65°C to +160°C
Lead Temperature (soldering,10s)....................+300°C

lote 4: Input voltage measured with transmitter output in a high-impedance state, shutdown, or V_{CC} = 0V.

tresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional peration of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to bsolute maximum rating conditions for extended periods may affect device reliability.

ːLECTRICAL CHARACTERISTICS—MAX225/MAX244–MAX249

/AX225, V_{CC} = 5.0V ±5%; MAX244–MAX249, V_{CC} = +5.0V ±10%, external capacitors C1–C4 = 1µF; T_A = T_{MIN} to T_{MAX}; unless othrwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
RS-232 TRANSMITTERS						
Input Logic Threshold Low				1.4	0.8	V
Input Logic Threshold High			2	1.4		V
Logic Pull-Up/Input Current	Tables 1a–1d	Normal operation		10	50	µA
		Shutdown		±0.01	±1	
Data Rate	Tables 1a–1d, normal operation			120	64	kbps
Output Voltage Swing	All transmitter outputs loaded with 3kΩ to GND		±5	±7.5		V
Output Leakage Current (Shutdown)	Tables 1a–1d	$\overline{ENA}$, $\overline{ENB}$, $\overline{ENT}$, $\overline{ENTA}$, $\overline{ENTB}$ = V_{CC}, V_{OUT} = ±15V		±0.01	±25	µA
		V_{CC} = 0V, V_{OUT} = ±15V		±0.01	±25	
Transmitter Output Resistance	V_{CC} = V+ = V- = 0V, V_{OUT} = ±2V (Note 4)		300	10M		Ω
Output Short-Circuit Current	V_{OUT} = 0V		±7	±30		mA
RS-232 RECEIVERS						
RS-232 Input Voltage Operating Range					±25	V
RS-232 Input Threshold Low	V_{CC} = 5V		0.8	1.3		V
RS-232 Input Threshold High	V_{CC} = 5V			1.8	2.4	V
RS-232 Input Hysteresis	V_{CC} = 5V		0.2	0.5	1.0	V
RS-232 Input Resistance			3	5	7	kΩ
TTL/CMOS Output Voltage Low	I_{OUT} = 3.2mA			0.2	0.4	V
TTL/CMOS Output Voltage High	I_{OUT} = -1.0mA		3.5	V_{CC} - 0.2		V
TTL/CMOS Output Short-Circuit Current	Sourcing V_{OUT} = GND		-2	-10		mA
	Shrinking V_{OUT} = V_{CC}		10	30		
TTL/CMOS Output Leakage Current	Normal operation, outputs disabled, Tables 1a–1d, 0V ≤ V_{OUT} ≤ V_{CC}, $\overline{ENR\_}$ = V_{CC}			±0.05	±0.10	µA

ELECTRICAL CHARACTERISTICS—MAX225/MAX244–MAX249 (continued)

(MAX225, V_{CC} = 5.0V ±5%; MAX244–MAX249, V_{CC} = +5.0V ±10%, external capacitors C1–C4 = 1µF; T_A = T_{MIN} to T_{MAX}; unless otherwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
POWER SUPPLY AND CONTROL LOGIC						
Operating Supply Voltage		MAX225	4.75		5.25	V
		MAX244–MAX249	4.5		5.5	
V_{CC} Supply Current (Normal Operation)	No load	MAX225		10	20	mA
		MAX244–MAX249		11	30	
	3kΩ loads on all outputs	MAX225		40		
		MAX244–MAX249		57		
Shutdown Supply Current	T_A = +25°C			8	25	µA
	T_A = T_{MIN} to T_{MAX}				50	
Control Input	Leakage current				±1	µA
	Threshold low			1.4	0.8	V
	Threshold high		2.4	1.4		
AC CHARACTERISTICS						
Transition Slew Rate	C_L = 50pF to 2500pF, R_L = 3kΩ to 7kΩ, V_{CC} = 5V, T_A = +25°C, measured from +3V to -3V or -3V to +3V		5	10	30	V/µs
Transmitter Propagation Delay TLL to RS-232 (Normal Operation), Figure 1	t_{PHLT}			1.3	3.5	µs
	t_{PLHT}			1.5	3.5	
Receiver Propagation Delay TLL to RS-232 (Normal Operation), Figure 2	t_{PHLR}			0.6	1.5	µs
	t_{PLHR}			0.6	1.5	
Receiver Propagation Delay TLL to RS-232 (*Low-Power Mode*), Figure 2	t_{PHLS}			0.6	10	µs
	t_{PLHS}			3.0	10	
Transmitter + to - Propagation Delay Difference (Normal Operation)	t_{PHLT} - t_{PLHT}			350		ns
Receiver + to - Propagation Delay Difference (Normal Operation)	t_{PHLR} - t_{PLHR}			350		ns
Receiver-Output Enable Time, Figure 3	t_{ER}			100	500	ns
Receiver-Output Disable Time, Figure 3	t_{DR}			100	500	ns
Transmitter Enable Time	t_{ET}	MAX246–MAX249 (excludes charge-pump startup)		5		µs
		MAX225/MAX245–MAX249 (includes charge-pump startup)		10		ms
Transmitter Disable Time, Figure 4	t_{DT}			100		ns

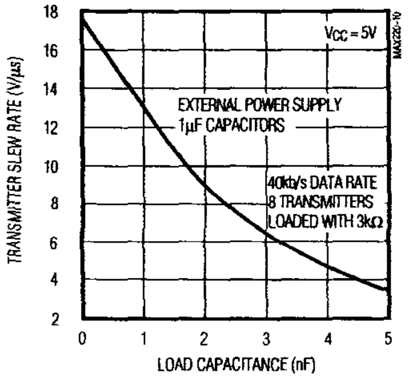
Note 5: The 300Ω minimum specification complies with EIA/TIA-232E, but the actual resistance when in shutdown mode or V_{CC} = 0V is 10MΩ as is implied by the leakage specification.

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

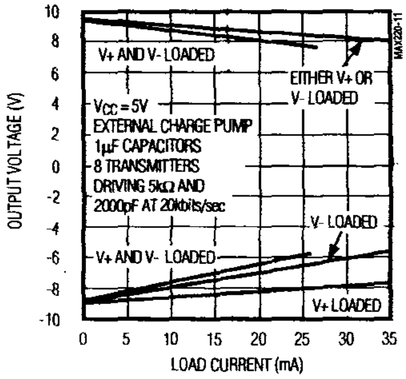
Typical Operating Characteristics

MAX225/MAX244–MAX249

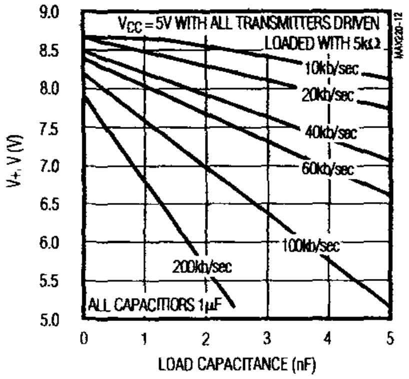
TRANSMITTER SLEW RATE vs. LOAD CAPACITANCE



OUTPUT VOLTAGE vs. LOAD CURRENT FOR V+ AND V-



TRANSMITTER OUTPUT VOLTAGE (V+, V-) vs. LOAD CAPACITANCE AT DIFFERENT DATA RATES



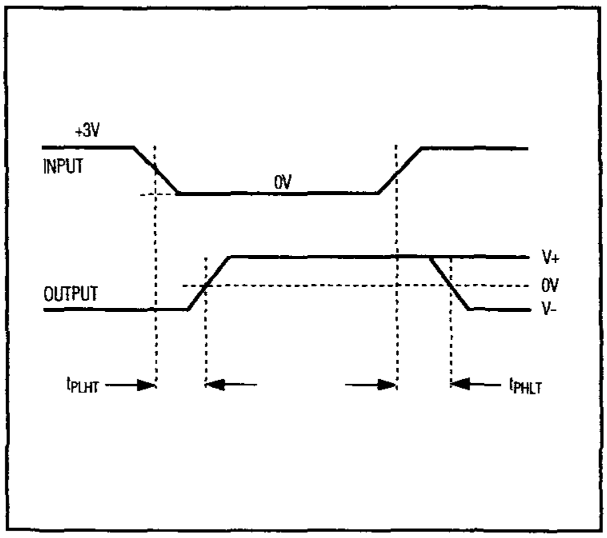


Figure 1. Transmitter Propagation-Delay Timing

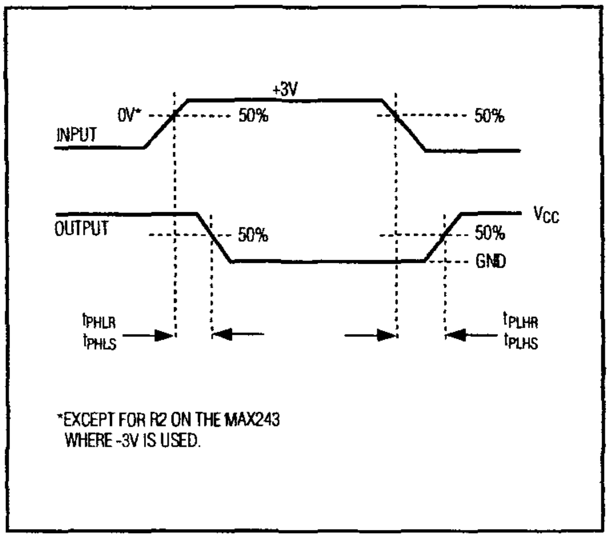


Figure 2. Receiver Propagation-Delay Timing

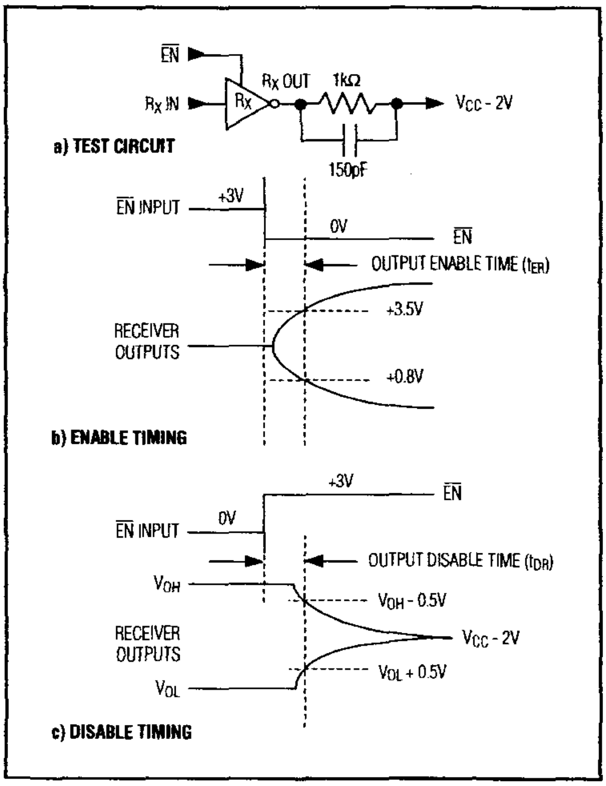


Figure 3. Receiver-Output Enable and Disable Timing

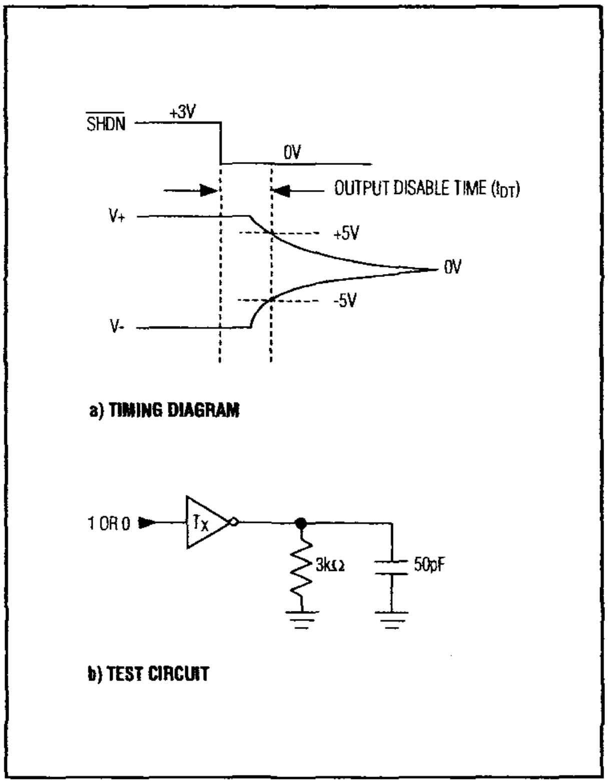


Figure 4. Transmitter-Output Disable Timing

Table 1a. MAX245 Control Pin Configurations

$\overline{ENT}$	$\overline{ENR}$	OPERATION STATUS	TRANSMITTERS	RECEIVERS
0	0	Normal Operation	All Active	All Active
0	1	Normal Operation	All Active	All 3-State
1	0	Shutdown	All 3-State	All Low-Power Receive Mode
1	1	Shutdown	All 3-State	All 3-State

Table 1b. MAX245 Control Pin Configurations

$\overline{ENT}$	$\overline{ENR}$	OPERATION STATUS	TRANSMITTERS		RECEIVERS	
			TA1–TA4	TB1–TB4	RA1–RA5	RB1–RB5
0	0	Normal Operation	All Active	All Active	All Active	All Active
0	1	Normal Operation	All Active	All Active	RA1–RA4 3-State, RA5 Active	RB1–RB4 3-State, RB5 Active
1	0	Shutdown	All 3-State	All 3-State	All Low-Power Receive Mode	All Low-Power Receive Mode
1	1	Shutdown	All 3-State	All 3-State	RA1–RA4 3-State, RA5 Low-Power Receive Mode	RB1–RB4 3-State, RB5 Low-Power Receive Mode

Table 1c. MAX246 Control Pin Configurations

$\overline{ENA}$	$\overline{ENB}$	OPERATION STATUS	TRANSMITTERS		RECEIVERS	
			TA1–TA4	TB1–TB4	RA1–RA5	RB1–RB5
0	0	Normal Operation	All Active	All Active	All Active	All Active
0	1	Normal Operation	All Active	All 3-State	All Active	RB1–RB4 3-State, RB5 Active
1	0	Shutdown	All 3-State	All Active	RA1–RA4 3-State, RA5 Active	All Active
1	1	Shutdown	All 3-State	All 3-State	RA1–RA4 3-State, RA5 Low-Power Receive Mode	RB1–RB4 3-State, RA5 Low-Power Receive Mode

Table 1d. MAX247/MAX248/MAX249 Control Pin Configurations

$\overline{ENTA}$	$\overline{ENTB}$	$\overline{ENRA}$	$\overline{ENRB}$	OPERATION STATUS		TRANSMITTERS		RECEIVERS	
					MAX247	TA1–TA4	TB1–TB4	RA1–RA4	RB1–RB5
					MAX248	TA1–TA4	TB1–TB4	RA1–RA4	RB1–RB4
					MAX249	TA1–TA3	TB1–TB3	RA1–RA5	RB1–RB5
0	0	0	0	Normal Operation		All Active	All Active	All Active	All Active
0	0	0	1	Normal Operation		All Active	All Active	All Active	All 3-State, except RB5 stays active on MAX247
0	0	1	0	Normal Operation		All Active	All Active	All 3-State	All Active
0	0	1	1	Normal Operation		All Active	All Active	All 3-State	All 3-State, except RB5 stays active on MAX247
0	1	0	0	Normal Operation		All Active	All 3-State	All Active	All Active
0	1	0	1	Normal Operation		All Active	All 3-State	All Active	All 3-State, except RB5 stays active on MAX247
0	1	1	0	Normal Operation		All Active	All 3-State	All 3-State	All Active
0	1	1	1	Normal Operation		All Active	All 3-State	All 3-State	All 3-State, except RB5 stays active on MAX247
1	0	0	0	Normal Operation		All 3-State	All Active	All Active	All Active
1	0	0	1	Normal Operation		All 3-State	All Active	All Active	All 3-State, except RB5 stays active on MAX247
1	0	1	0	Normal Operation		All 3-State	All Active	All 3-State	All Active
1	0	1	1	Normal Operation		All 3-State	All Active	All 3-State	All 3-State, except RB5 stays active on MAX247
1	1	0	0	Shutdown		All 3-State	All 3-State	Low-Power Receive Mode	Low-Power Receive Mode
1	1	0	1	Shutdown		All 3-State	All 3-State	Low-Power Receive Mode	All 3-State, except RB5 stays active on MAX247
1	1	1	0	Shutdown		All 3-State	All 3-State	All 3-State	Low-Power Receive Mode
1	1	1	1	Shutdown		All 3-State	All 3-State	All 3-State	All 3-State, except RB5 stays active on MAX247

Detailed Description

The MAX220–MAX249 contain four sections: dual charge-pump DC-DC voltage converters, RS-232 drivers, RS-232 receivers, and receiver and transmitter enable control inputs.

Dual Charge-Pump Voltage Converter

The MAX220–MAX249 have two internal charge-pumps that convert +5V to ±10V (unloaded) for RS-232 driver operation. The first converter uses capacitor C1 to double the +5V input to +10V on C3 at the V+ output. The second converter uses capacitor C2 to invert +10V to -10V on C4 at the V- output.

A small amount of power may be drawn from the +10V (V+) and -10V (V-) outputs to power external circuitry (see the *Typical Operating Characteristics* section), except on the MAX225 and MAX245–MAX247, where these pins are not available. V+ and V- are not regulated, so the output voltage drops with increasing load current. Do not load V+ and V- to a point that violates the minimum ±5V EIA/TIA-232E driver output voltage when sourcing current from V+ and V- to external circuitry.

When using the shutdown feature in the MAX222, MAX225, MAX230, MAX235, MAX236, MAX240, MAX241, and MAX245–MAX249, avoid using V+ and V- to power external circuitry. When these parts are shut down, V- falls to 0V, and V+ falls to +5V. For applications where a +10V external supply is applied to the V+ pin (instead of using the internal charge pump to generate +10V), the C1 capacitor must not be installed and the $\overline{SHDN}$ pin must be tied to V_{CC}. This is because V+ is internally connected to V_{CC} in shutdown mode.

RS-232 Drivers

The typical driver output voltage swing is ±8V when loaded with a nominal 5kΩ RS-232 receiver and V_{CC} = +5V. Output swing is guaranteed to meet the EIA/TIA-232E and V.28 specification, which calls for ±5V minimum driver output levels under worst-case conditions. These include a minimum 3kΩ load, V_{CC} = +4.5V, and maximum operating temperature. Unloaded driver output voltage ranges from (V+ -1.3V) to (V- +0.5V).

Input thresholds are both TTL and CMOS compatible. The inputs of unused drivers can be left unconnected since 400kΩ input pull-up resistors to V_{CC} are built in (except for the MAX220). The pull-up resistors force the outputs of unused drivers low because all drivers invert. The internal input pull-up resistors typically source 12µA, except in shutdown mode where the pull-ups are disabled. Driver outputs turn off and enter a high-impedance state—where leakage current is typically microamperes (maximum 25µA)—when in shutdown mode, in three-state mode, or when device power is removed. Outputs can be driven to ±15V. The power-supply current typically drops to 8µA in shutdown mode. The MAX220 does not have pull-up resistors to force the outputs of the unused drivers low. Connect unused inputs to GND or V_{CC}.

The MAX239 has a receiver three-state control line, and the MAX223, MAX225, MAX235, MAX236, MAX240, and MAX241 have both a receiver three-state control line and a low-power shutdown control. Table 2 shows the effects of the shutdown control and receiver three-state control on the receiver outputs.

The receiver TTL/CMOS outputs are in a high-impedance, three-state mode whenever the three-state enable line is high (for the MAX225/MAX235/MAX236/MAX239–MAX241), and are also high-impedance whenever the shutdown control line is high.

When in low-power shutdown mode, the driver outputs are turned off and their leakage current is less than 1µA with the driver output pulled to ground. The driver output leakage remains less than 1µA, even if the transmitter output is backdriven between 0V and (V_{CC} + 6V). Below -0.5V, the transmitter is diode clamped to ground with 1kΩ series impedance. The transmitter is also zener clamped to approximately V_{CC} + 6V, with a series impedance of 1kΩ.

The driver output slew rate is limited to less than 30V/µs as required by the EIA/TIA-232E and V.28 specifications. Typical slew rates are 24V/µs unloaded and 10V/µs loaded with 3Ω and 2500pF.

RS-232 Receivers

EIA/TIA-232E and V.28 specifications define a voltage level greater than 3V as a logic 0, so all receivers invert. Input thresholds are set at 0.8V and 2.4V, so receivers respond to TTL level inputs as well as EIA/TIA-232E and V.28 levels.

The receiver inputs withstand an input overvoltage up to ±25V and provide input terminating resistors with

Table 2. Three-State Control of Receivers

PART	SHDN	$\overline{SHDN}$	EN	$\overline{EN(R)}$	RECEIVERS
MAX223	—	Low High High	X Low High	—	High Impedance Active High Impedance
MAX225	—	—	—	Low High	High Impedance Active
MAX235 MAX236 MAX240	Low Low High	—	—	Low High X	High Impedance Active High Impedance

nominal 5kΩ values. The receivers implement Type 1 interpretation of the fault conditions of V.28 and EIA/TIA-232E.

The receiver input hysteresis is typically 0.5V with a guaranteed minimum of 0.2V. This produces clear output transitions with slow-moving input signals, even with moderate amounts of noise and ringing. The receiver propagation delay is typically 600ns and is independent of input swing direction.

Low-Power Receive Mode

The low-power receive-mode feature of the MAX223, MAX242, and MAX245–MAX249 puts the IC into shutdown mode but still allows it to receive information. This is important for applications where systems are periodically awakened to look for activity. Using low-power receive mode, the system can still receive a signal that will activate it on command and prepare it for communication at faster data rates. This operation conserves system power.

Negative Threshold—MAX243

The MAX243 is pin compatible with the MAX232A, differing only in that RS-232 cable fault protection is removed on one of the two receiver inputs. This means that control lines such as CTS and RTS can either be driven or left floating without interrupting communication. Different cables are not needed to interface with different pieces of equipment.

The input threshold of the receiver without cable fault protection is -0.8V rather than +1.4V. Its output goes positive only if the input is connected to a control line that is actively driven negative. If not driven, it defaults to the 0 or "OK to send" state. Normally, the MAX243's other receiver (+1.4V threshold) is used for the data line (TD or RD), while the negative threshold receiver is connected to the control line (DTR, DTS, CTS, RTS, etc.).

Other members of the RS-232 family implement the optional cable fault protection as specified by EIA/TIA-232E specifications. This means a receiver output goes high whenever its input is driven negative, left floating, or shorted to ground. The high output tells the serial communications IC to stop sending data. To avoid this, the control lines must either be driven or connected with jumpers to an appropriate positive voltage level.

Shutdown—MAX222–MAX242

On the MAX222, MAX235, MAX236, MAX240, and MAX241, all receivers are disabled during shutdown. On the MAX223 and MAX242, two receivers continue to operate in a reduced power mode when the chip is in shutdown. Under these conditions, the propagation delay increases to about 2.5µs for a high-to-low input transition. When in shutdown, the receiver acts as a CMOS inverter with no hysteresis. The MAX223 and MAX242 also have a receiver output enable input ($\overline{EN}$ for the MAX242 and EN for the MAX223) that allows receiver output control independent of $\overline{SHDN}$ (SHDN for MAX241). With all other devices, $\overline{SHDN}$ (SHDN for MAX241) also disables the receiver outputs.

The MAX225 provides five transmitters and five receivers, while the MAX245 provides ten receivers and eight transmitters. Both devices have separate receiver and transmitter-enable controls. The charge pumps turn off and the devices shut down when a logic high is applied to the ENT input. In this state, the supply current drops to less than 25µA and the receivers continue to operate in a low-power receive mode. Driver outputs enter a high-impedance state (three-state mode). On the MAX225, all five receivers are controlled by the $\overline{ENR}$ input. On the MAX245, eight of the receiver outputs are controlled by the $\overline{ENR}$ input, while the remaining two receivers (RA5 and RB5) are always active. RA1–RA4 and RB1–RB4 are put in a three-state mode when $\overline{ENR}$ is a logic high.

Receiver and Transmitter Enable Control Inputs

The MAX225 and MAX245–MAX249 feature transmitter and receiver enable controls.

The receivers have three modes of operation: full-speed receive (normal active), three-state (disabled), and low-power receive (enabled receivers continue to function at lower data rates). The receiver enable inputs control the full-speed receive and three-state modes. The transmitters have two modes of operation: full-speed transmit (normal active) and three-state (disabled). The transmitter enable inputs also control the shutdown mode. The device enters shutdown mode when all transmitters are disabled. Enabled receivers function in the low-power receive mode when in shutdown.

Tables 1a–1d define the control states. The MAX244 has no control pins and is not included in these tables.

The MAX246 has ten receivers and eight drivers with two control pins, each controlling one side of the device. A logic high at the A-side control input ($\overline{\text{ENA}}$) causes the four A-side receivers and drivers to go into a three-state mode. Similarly, the B-side control input ($\overline{\text{ENB}}$) causes the four B-side drivers and receivers to go into a three-state mode. As in the MAX245, one A-side and one B-side receiver (RA5 and RB5) remain active at all times. The entire device is put into shutdown mode when both the A and B sides are disabled ($\overline{\text{ENA}}$ = $\overline{\text{ENB}}$ = +5V).

The MAX247 provides nine receivers and eight drivers with four control pins. The $\overline{\text{ENRA}}$ and $\overline{\text{ENRB}}$ receiver enable inputs each control four receiver outputs. The $\overline{\text{ENTA}}$ and $\overline{\text{ENTB}}$ transmitter enable inputs each control four drivers. The ninth receiver (RB5) is always active. The device enters shutdown mode with a logic high on both $\overline{\text{ENTA}}$ and $\overline{\text{ENTB}}$.

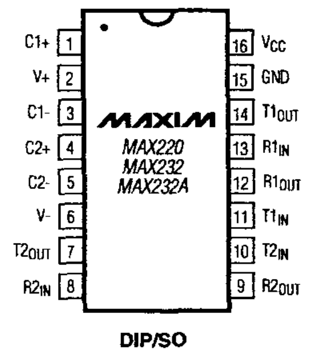
The MAX248 provides eight receivers and eight drivers with four control pins. The $\overline{\text{ENRA}}$ and $\overline{\text{ENRB}}$ receiver enable inputs each control four receiver outputs. The $\overline{\text{ENTA}}$ and $\overline{\text{ENTB}}$ transmitter enable inputs control four drivers each. This part does not have an always-active receiver. The device enters shutdown mode and transmitters go into a three-state mode with a logic high on both $\overline{\text{ENTA}}$ and $\overline{\text{ENTB}}$.

The MAX249 provides ten receivers and six drivers with four control pins. The $\overline{\text{ENRA}}$ and $\overline{\text{ENRB}}$ receiver enable inputs each control five receiver outputs. The $\overline{\text{ENTA}}$ and $\overline{\text{ENTB}}$ transmitter enable inputs control three drivers each. There is no always-active receiver. The device enters shutdown mode and transmitters go into a three-state mode with a logic high on both $\overline{\text{ENTA}}$ and $\overline{\text{ENTB}}$. In shutdown mode, active receivers operate in a low-power receive mode at data rates up to 20kbits/sec.

Applications Information

Figures 5 through 25 show pin configurations and typical operating circuits. In applications that are sensitive to power-supply noise, V_{CC} should be decoupled to ground with a capacitor of the same value as C1 and C2 connected as close as possible to the device.

TOP VIEW



CAPACITANCE (µF)					
DEVICE	C1	C2	C3	C4	C5
MAX220	4.7	4.7	10	10	4.7
MAX232	1.0	1.0	1.0	1.0	1.0
MAX232A	0.1	0.1	0.1	0.1	0.1

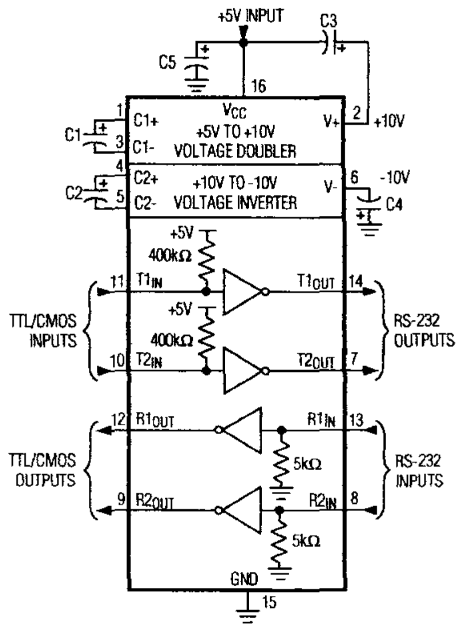
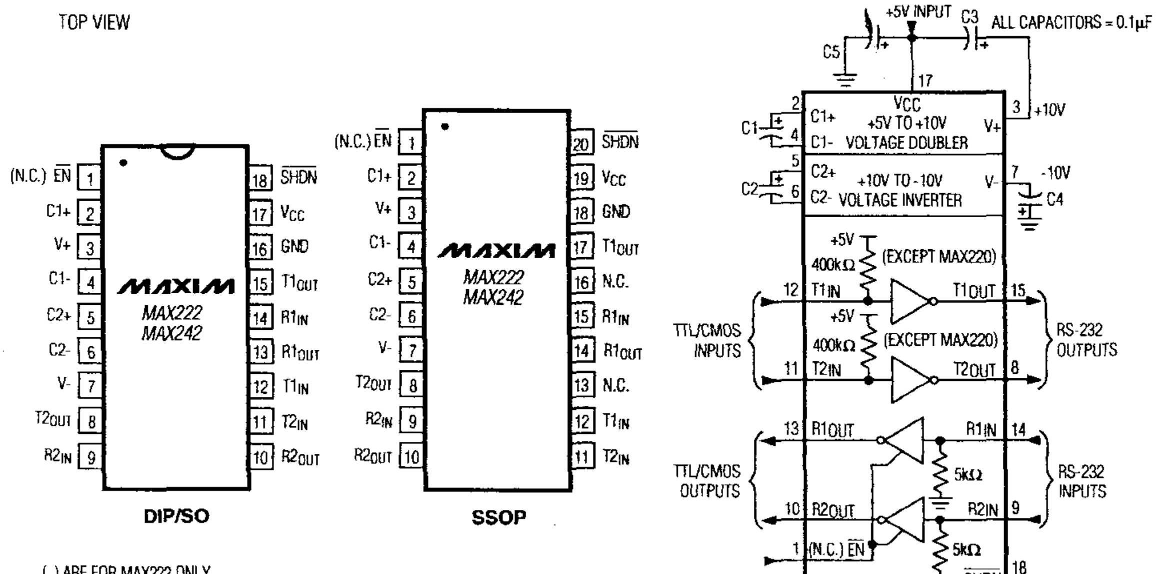
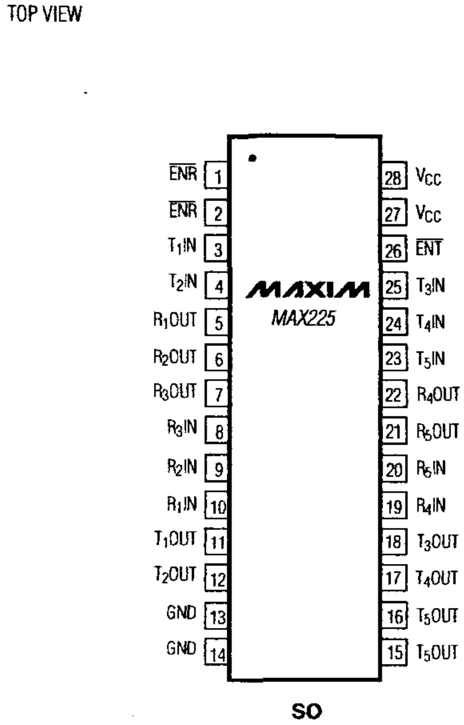


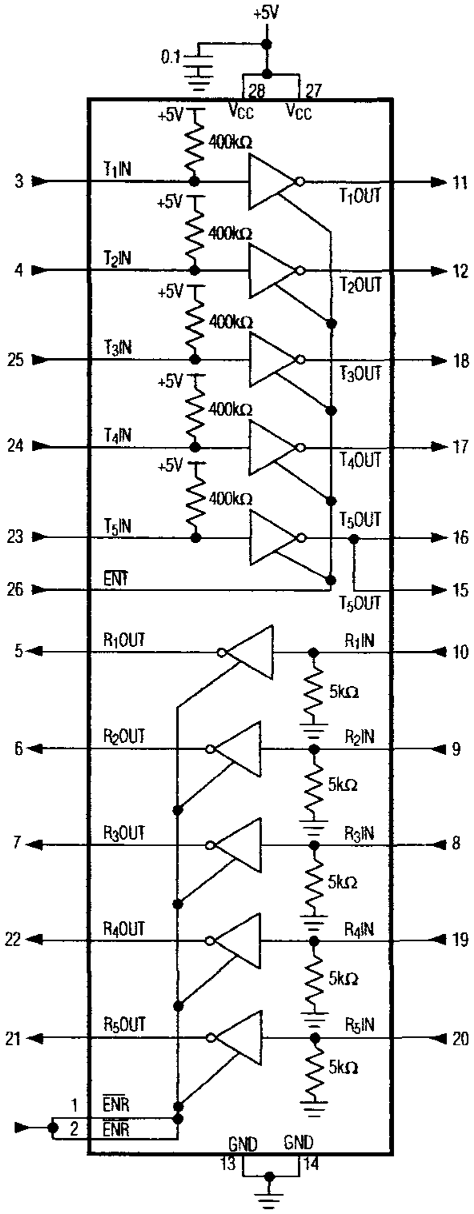
Figure 5. MAX220/MAX232/MAX232A Pin Configuration and Typical Operating Circuit



( ) ARE FOR MAX222 ONLY.
PIN NUMBERS IN TYPICAL OPERATING CIRCUIT ARE FOR DIP/SO PACKAGES ONLY.

Figure 6. MAX222/MAX242 Pin Configurations and Typical Operating Circuit





MAX225 FUNCTIONAL DESCRIPTION

5 RECEIVERS
5 TRANSMITTERS
2 CONTROL PINS
1 RECEIVER ENABLE ($\overline{ENR}$)
1 TRANSMITTER ENABLE ($\overline{ENT}$)

PINS ($\overline{ENR}$, GND, V_{CC}, T_5OUT) ARE INTERNALLY CONNECTED.
CONNECT EITHER OR BOTH EXTERNALLY. T_5OUT IS A SINGLE DRIVER.

Figure 7. MAX225 Pin Configuration and Typical Operating Circuit

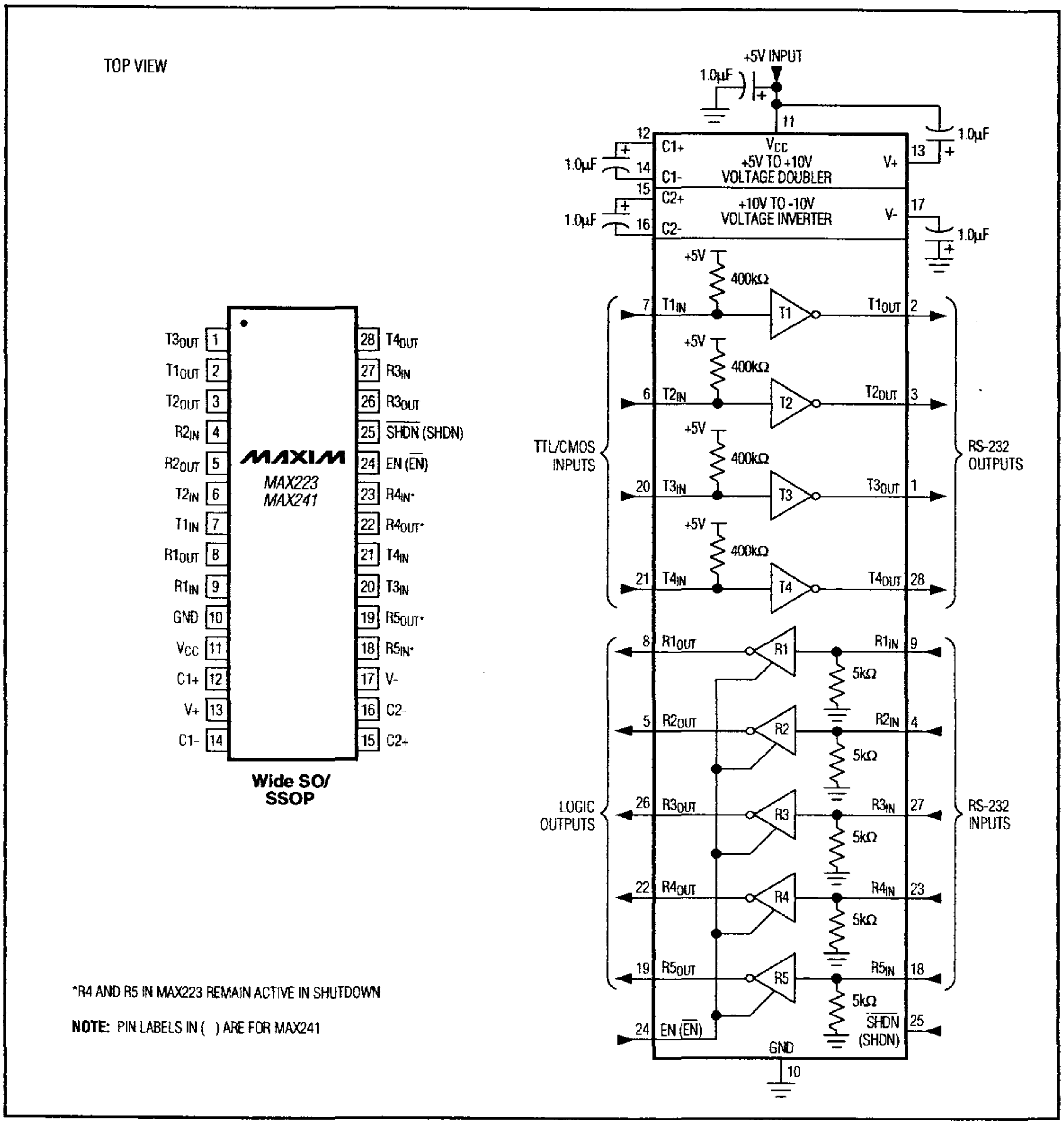
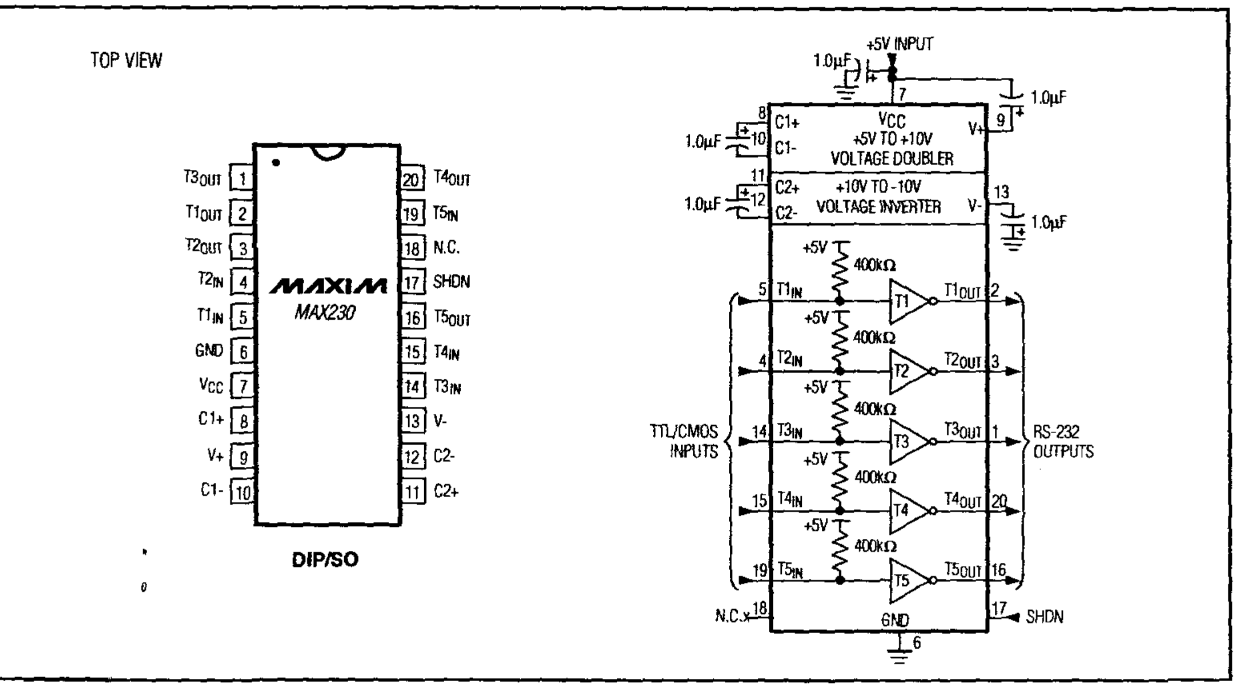
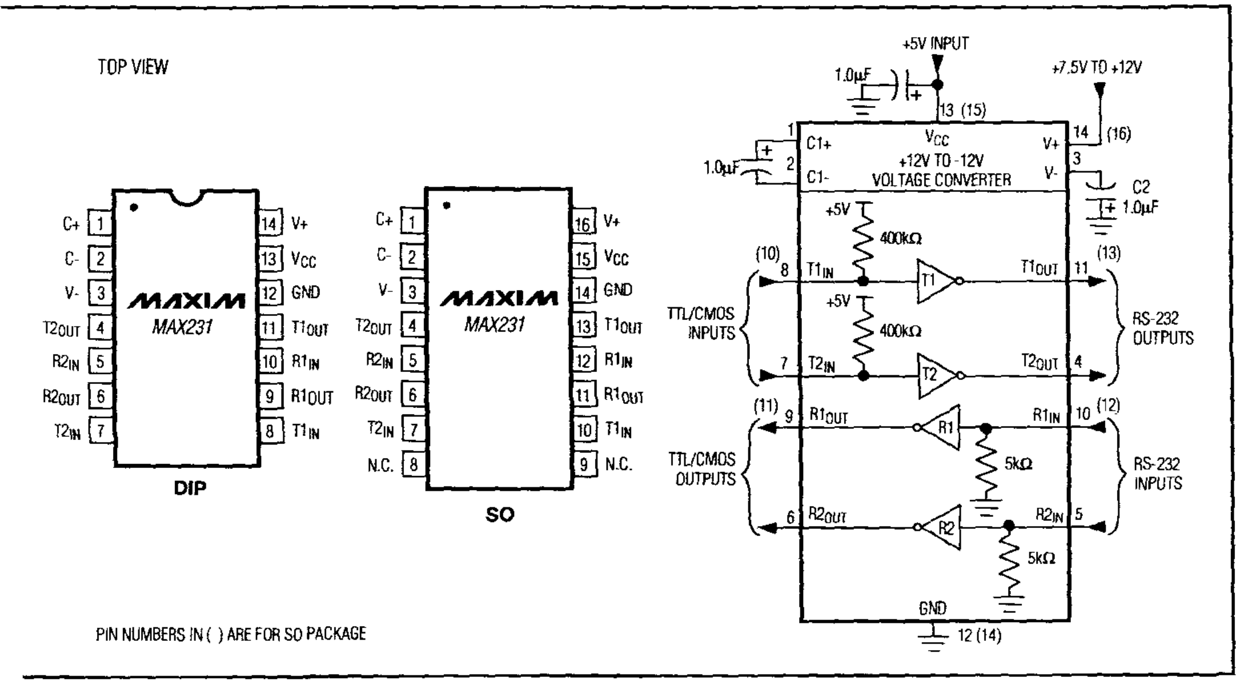


Figure 8. MAX223/MAX241 Pin Configuration and Typical Operating Circuit



igure 9. MAX230 Pin Configuration and Typical Operating Circuit



ure 10. MAX231 Pin Configurations and Typical Operating Circuit

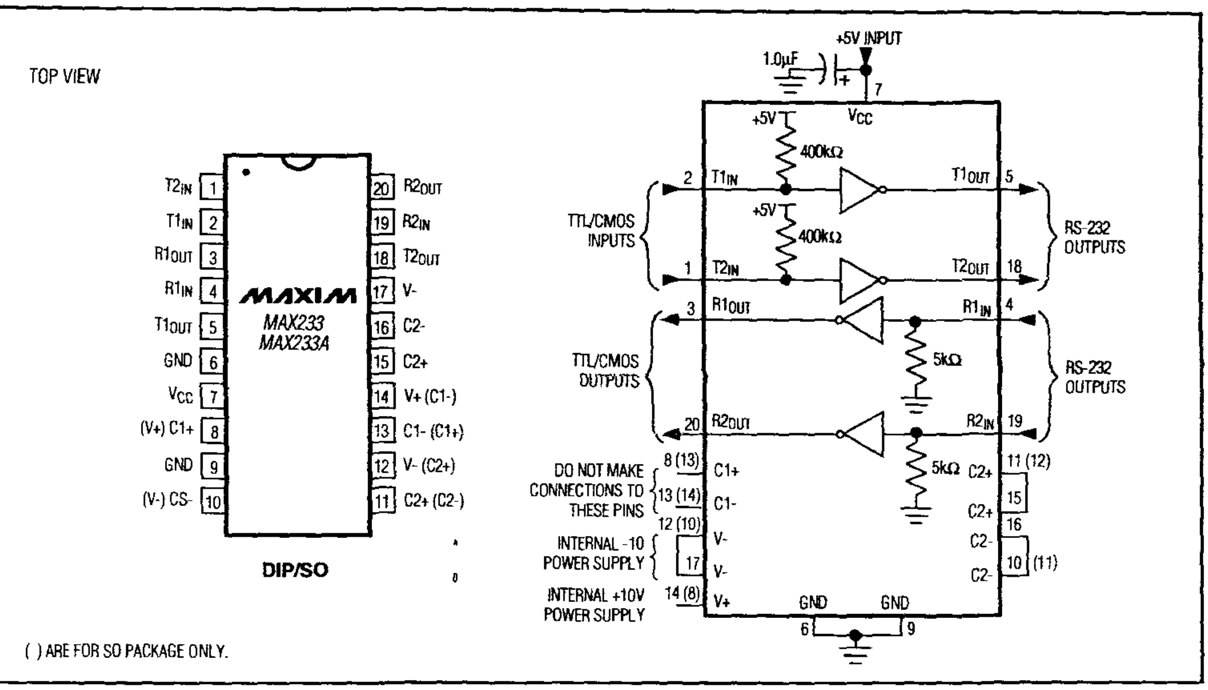


Figure 11. MAX233/MAX233A Pin Configuration and Typical Operating Circuit

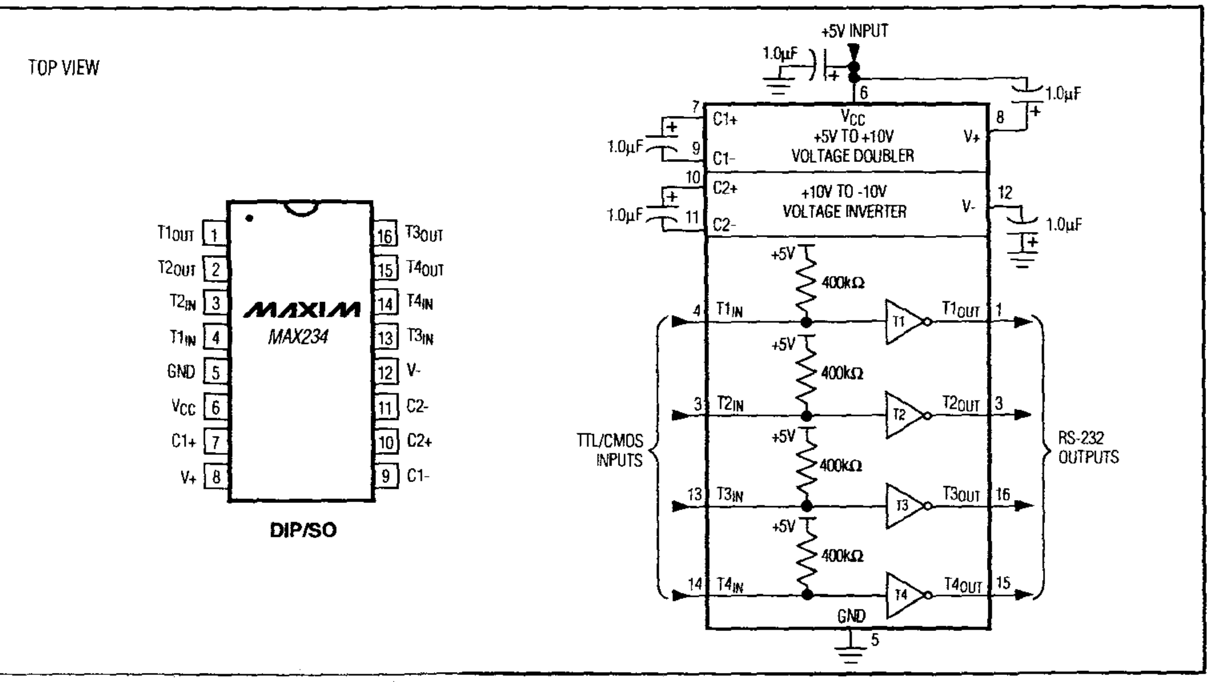


Figure 12. MAX234 Pin Configuration and Typical Operating Circuit

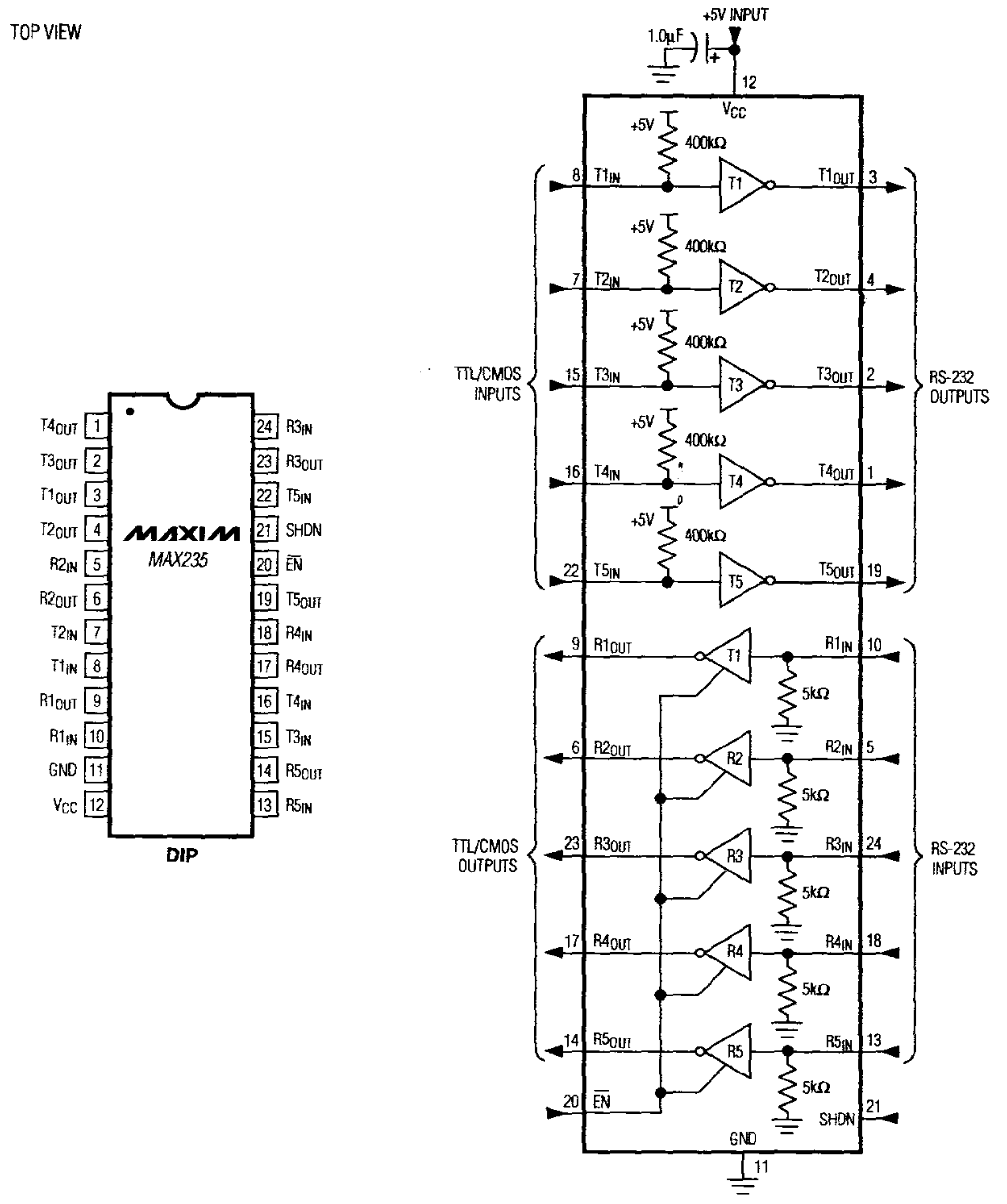
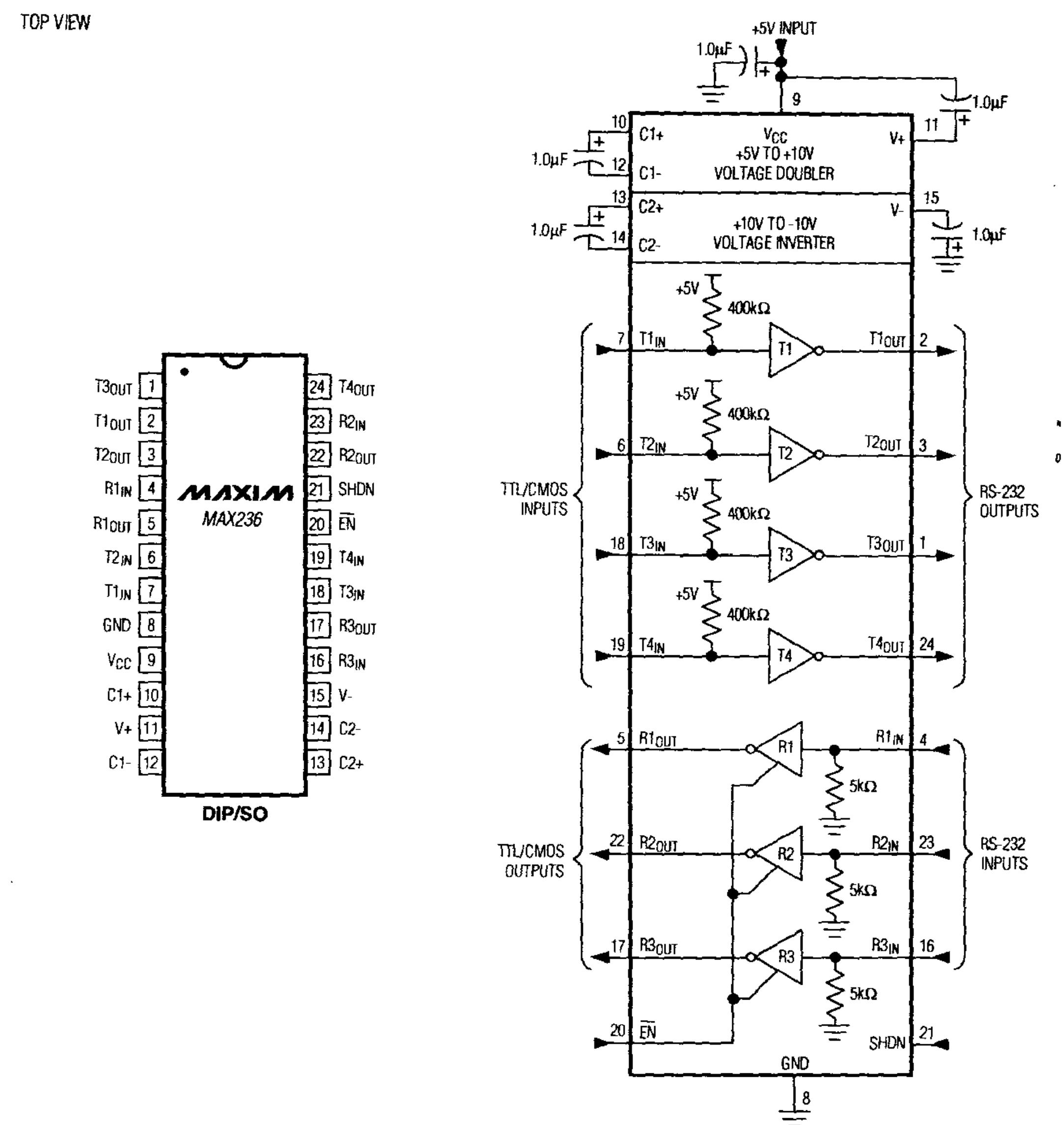
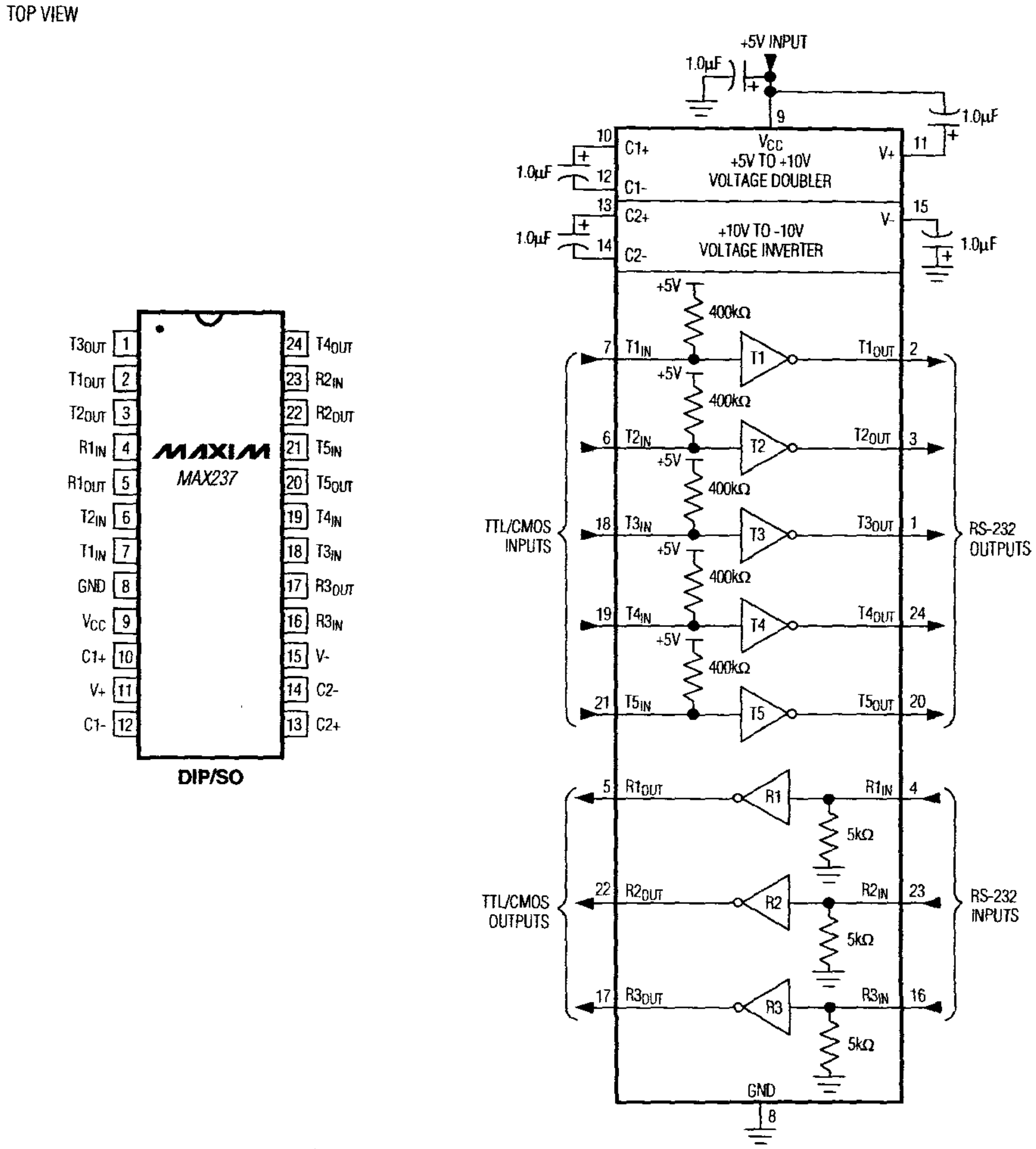


Figure 13. MAX235 Pin Configuration and Typical Operating Circuit



re 14. MAX236 Pin Configuration and Typical Operating Circuit



ure 15. MAX237 Pin Configuration and Typical Operating Circuit

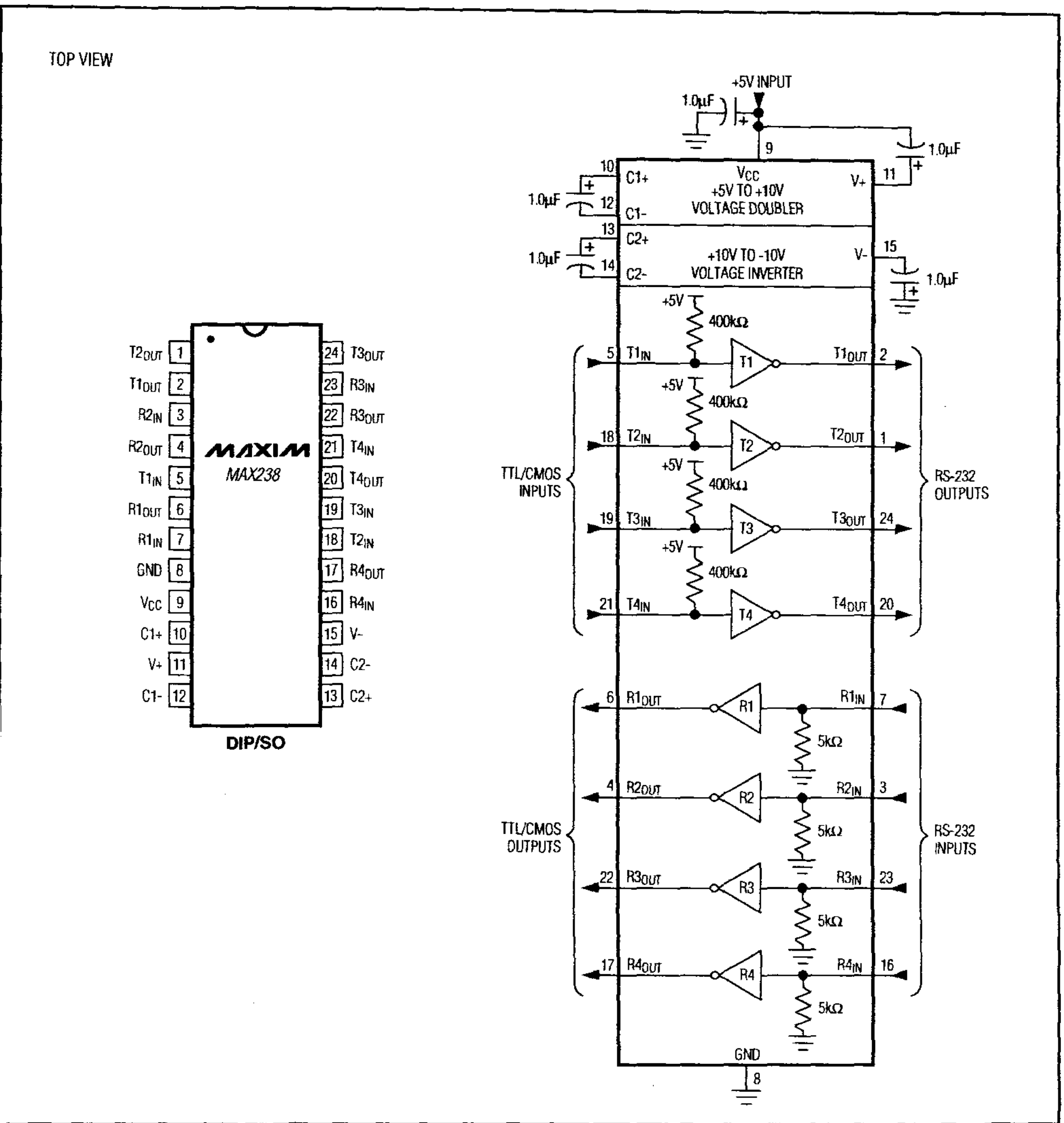


Figure 16. MAX238 Pin Configuration and Typical Operating Circuit

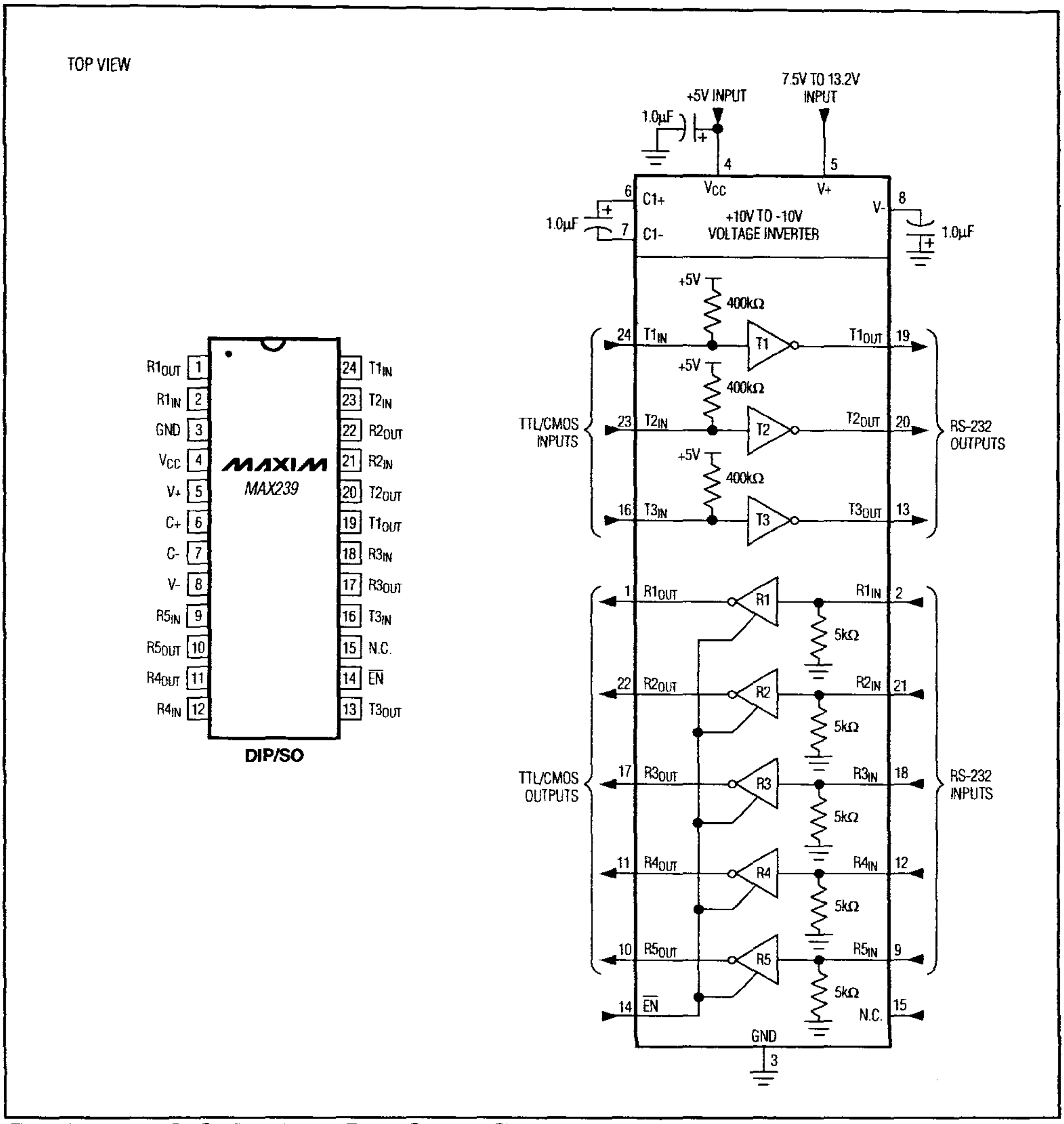


Figure 17. MAX239 Pin Configuration and Typical Operating Circuit

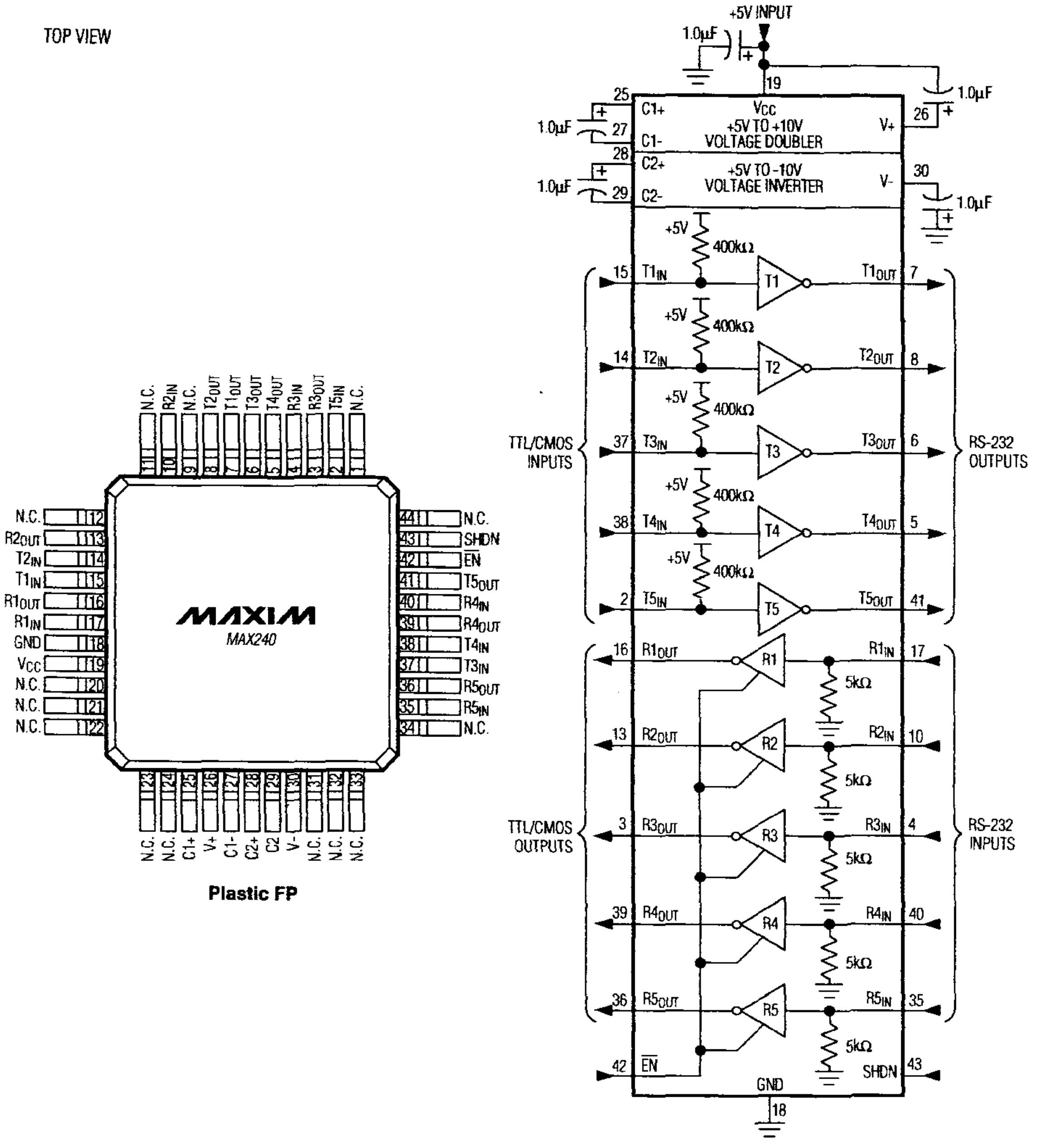
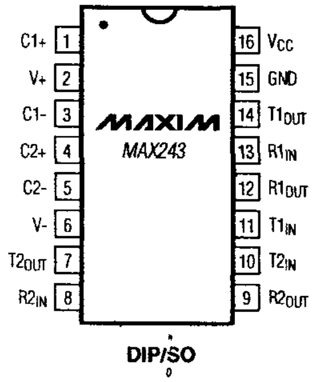
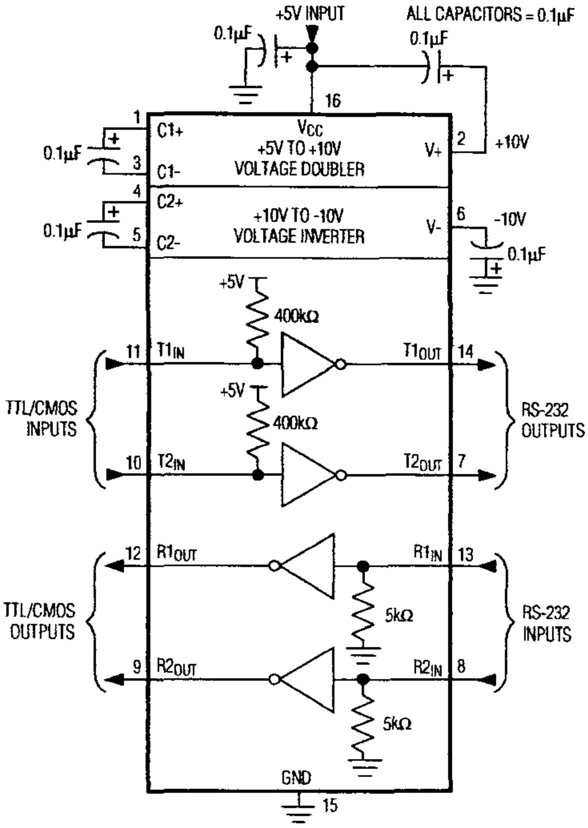


Figure 18. MAX240 Pin Configuration and Typical Operating Circuit

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

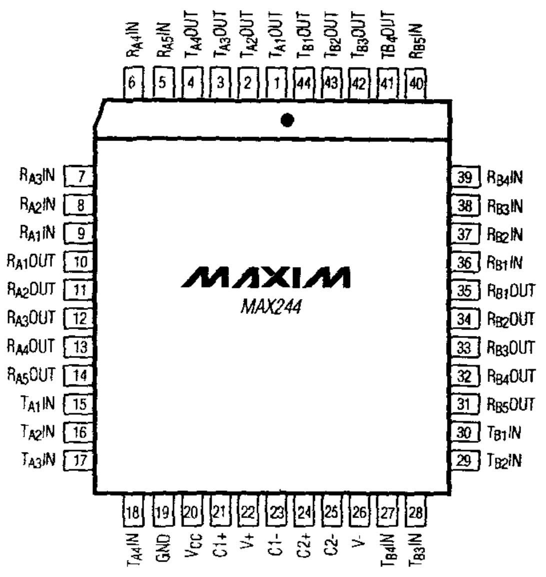
TOP VIEW





RECEIVER INPUT	R1 OUTPUT	R2 OUTPUT
≤ -3 V	HIGH	HIGH
OPEN	HIGH	LOW
≥ +3V	LOW	LOW

Figure 19. MAX243 Pin Configuration and Typical Operating Circuit

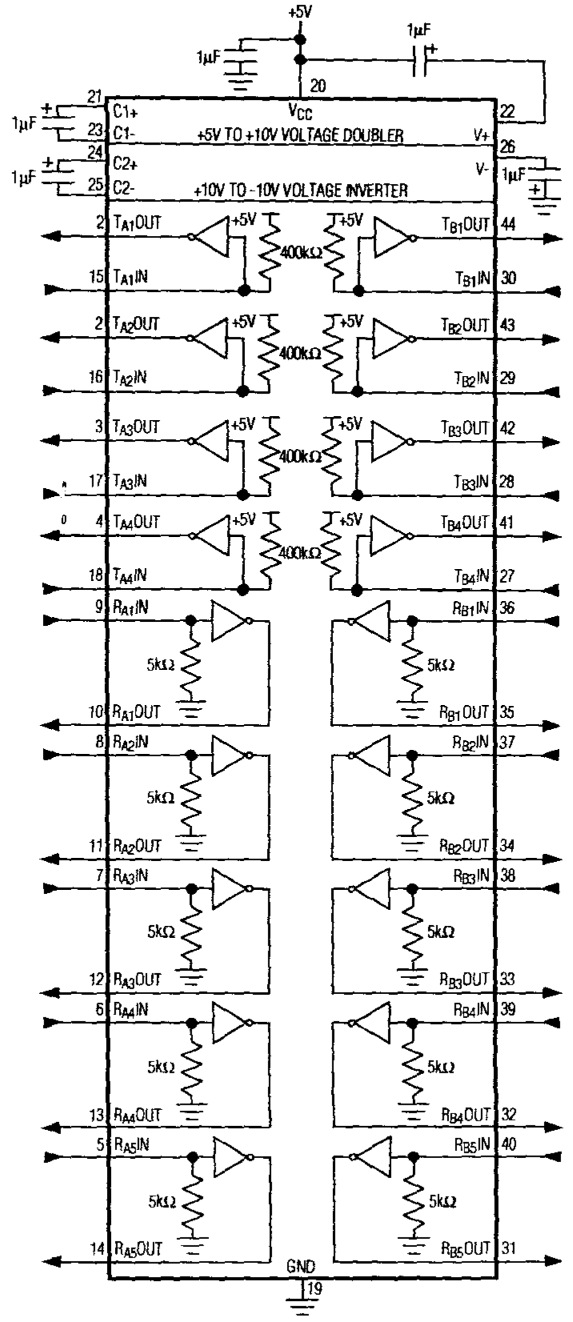


MAX249 FUNCTIONAL DESCRIPTION

10 RECEIVERS
- 5 A-SIDE RECEIVER
- 5 B-SIDE RECEIVER

8 TRANSMITTERS
- 4 A-SIDE TRANSMITTERS
- 4 B-SIDE TRANSMITTERS

NO CONTROL PINS



ıre 20. *MAX244 Pin Configuration and Typical Operating Circuit*

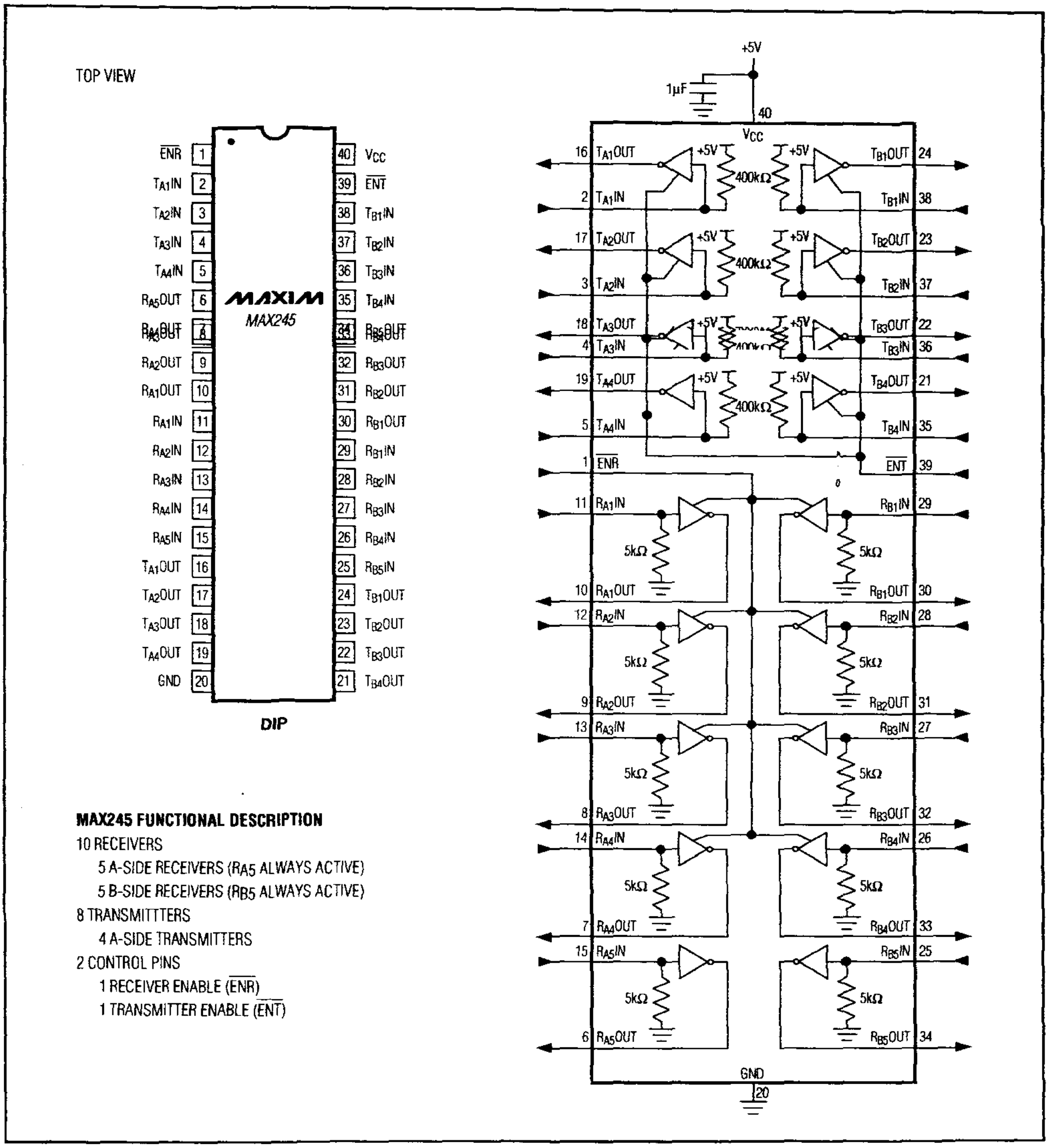
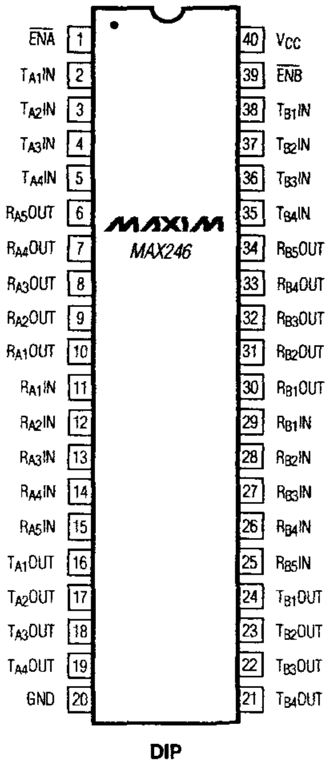
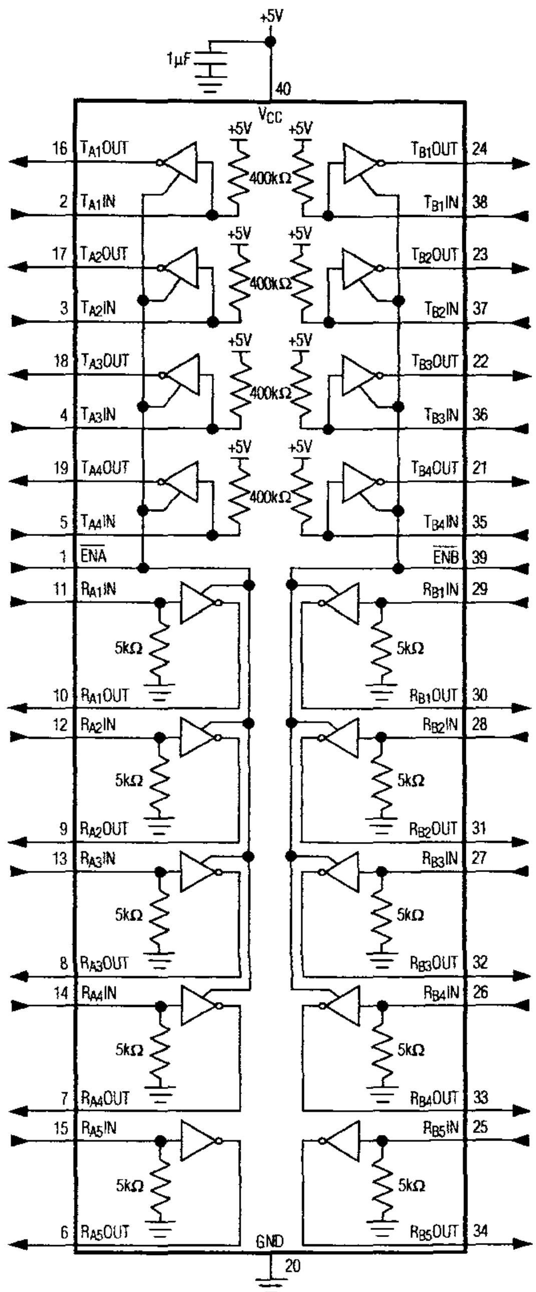


Figure 21. MAX245 Pin Configuration and Typical Operating Circuit

TOP VIEW





MAX246 FUNCTIONAL DESCRIPTION

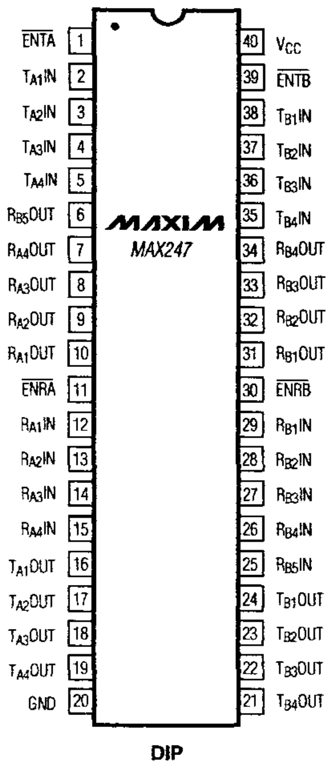
10 RECEIVERS
- 5 A-SIDE RECEIVERS (R_{A5} ALWAYS ACTIVE)
- 5 B-SIDE RECEIVERS (R_{B5} ALWAYS ACTIVE)

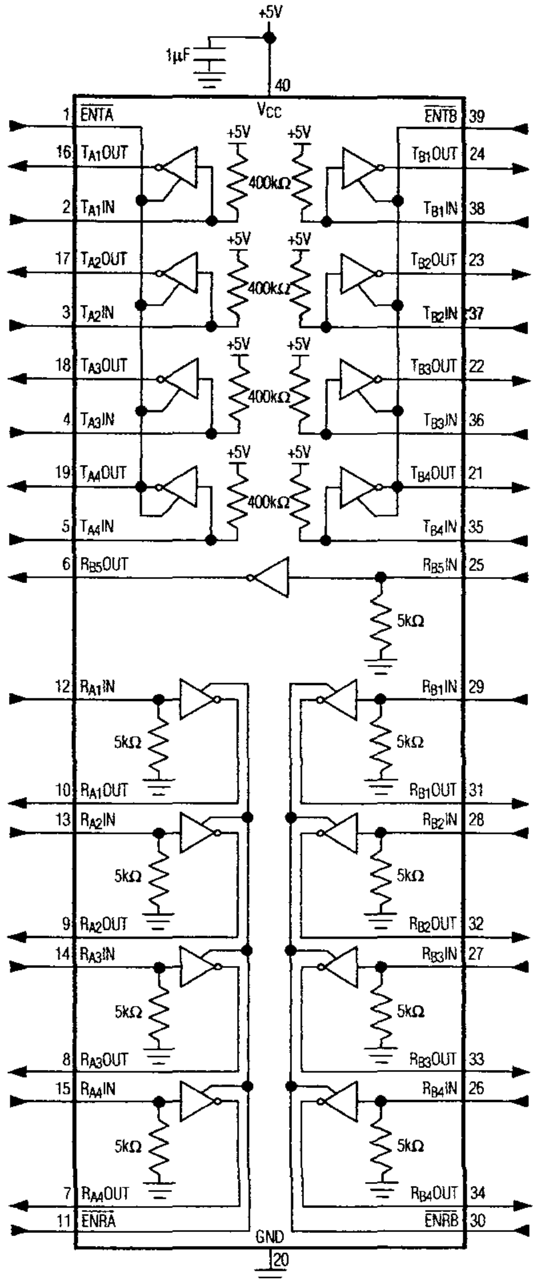
8 TRANSMITTERS
- 4 A-SIDE TRANSMITTERS
- 4 B-SIDE TRANSMITTERS

2 CONTROL PINS
- ENABLE A-SIDE ($\overline{ENA}$)
- ENABLE B-SIDE ($\overline{ENB}$)

Figure 22. MAX246 Pin Configuration and Typical Operating Circuit

TOP VIEW





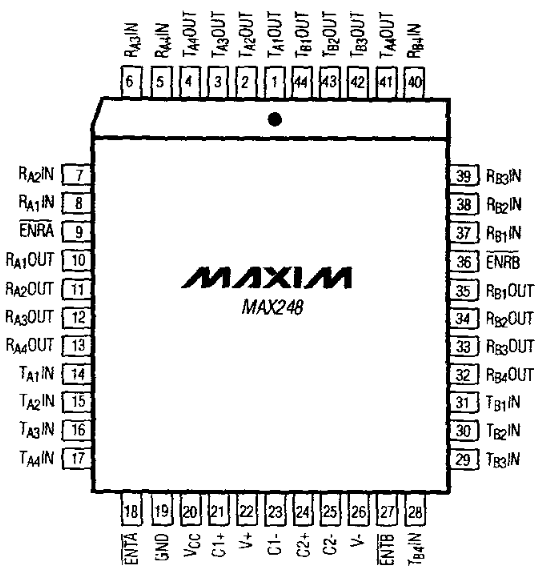
MAX247 FUNCTIONAL DESCRIPTION

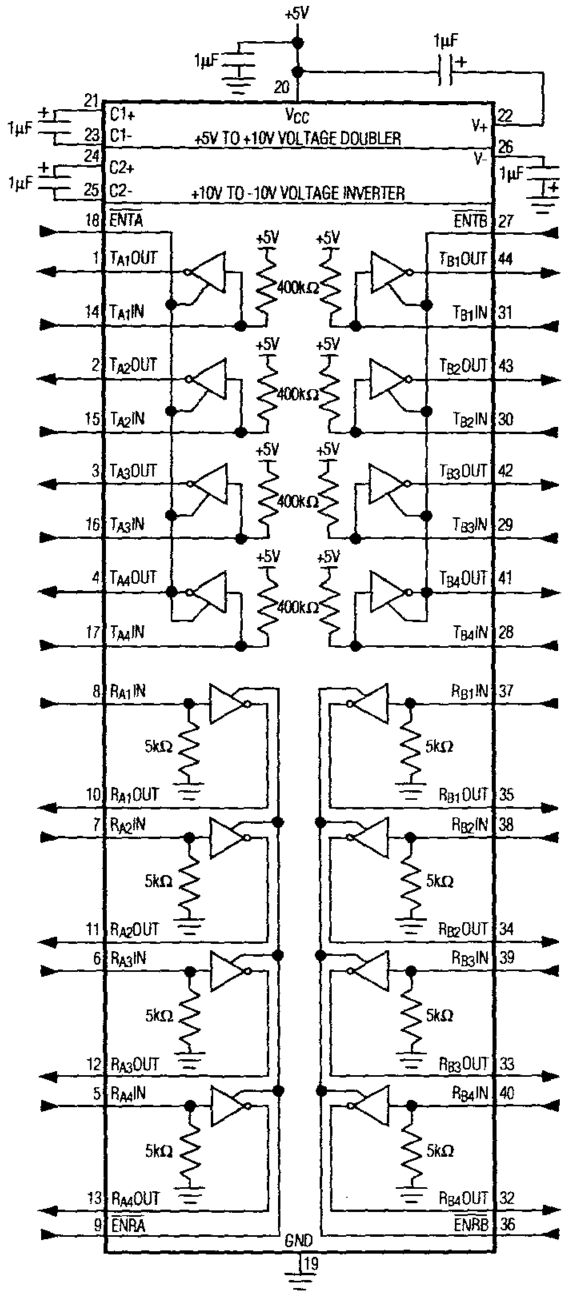
9 RECEIVERS
- 4 A-SIDE RECEIVERS
- 5 B-SIDE RECEIVERS (RB5 ALWAYS ACTIVE)

8 TRANSMITTERS
- 4 A-SIDE TRANSMITTERS
- 4 B-SIDE TRANSMITTERS

4 CONTROL PINS
- ENABLE RECEIVER A-SIDE (ENRA)
- ENABLE RECEIVER B-SIDE (ENRB)
- ENABLE RECEIVER A-SIDE (ENTA)
- ENABLE RECEIVERr B-SIDE (ENTB)

Figure 23. MAX247 Pin Configuration and Typical Operating Circuit





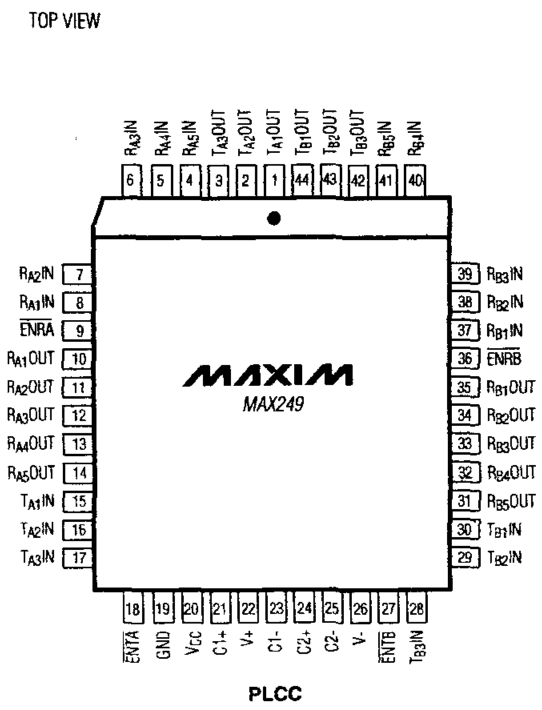
MAX248 FUNCTIONAL DESCRIPTION

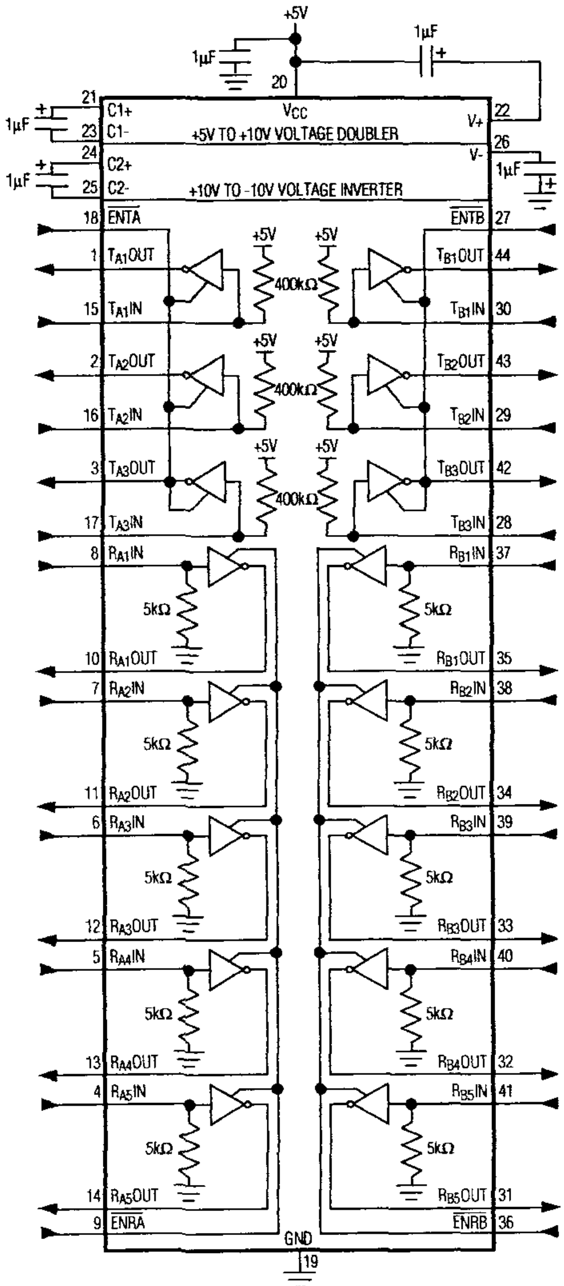
8 RECEIVERS
- 4 A-SIDE RECEIVERS
- 4 B-SIDE RECEIVERS

8 TRANSMITTERS
- 4 A-SIDE TRANSMITTERS
- 4 B-SIDE TRANSMITTERS

4 CONTROL PINS
- ENABLE RECEIVER A-SIDE ($\overline{ENRA}$)
- ENABLE RECEIVER B-SIDE ($\overline{ENRB}$)
- ENABLE RECEIVER A-SIDE ($\overline{ENTA}$)
- ENABLE RECEIVER B-SIDE ($\overline{ENTB}$)

'e 24. MAX248 Pin Configuration and Typical Operating Circuit





MAX249 FUNCTIONAL DESCRIPTION

10 RECEIVERS
- 5 A-SIDE RECEIVERS
- 5 B-SIDE RECEIVERS

6 TRANSMITTERS
- 3 A-SIDE TRANSMITTERS
- 3 B-SIDE TRANSMITTERS

4 CONTROL PINS
- ENABLE RECEIVER A-SIDE (ENRA)
- ENABLE RECEIVER B-SIDE (ENRB)
- ENABLE RECEIVER A-SIDE (ENTA)
- ENABLE RECEIVER B-SIDE (ENTB)

Figure 25. MAX249 Pin Configuration and Typical Operating Circuit

Ordering Information (continued)

PART	TEMP RANGE	PIN-PACKAGE
MAX222CPN	0°C to +70°C	18 Plastic DIP
MAX222CWN	0°C to +70°C	18 Wide SO
MAX222C/D	0°C to +70°C	Dice*
MAX222EPN	-40°C to +85°C	18 Plastic DIP
MAX222EWN	-40°C to +85°C	18 Wide SO
MAX222EJN	-40°C to +85°C	18 CERDIP
MAX222MJN	-55°C to +125°C	18 CERDIP
MAX223CAI	0°C to +70°C	28 SSOP
MAX223CWI	0°C to +70°C	28 Wide SO
MAX223C/D	0°C to +70°C	Dice*
MAX223EAI	-40°C to +85°C	28 SSOP
MAX223EWI	-40°C to +85°C	28 Wide SO
MAX225CWI	0°C to +70°C	28 Wide SO
MAX225EWI	-40°C to +85°C	28 Wide SO
MAX230CPP*	0°C to +70°C	20 Plastic DIP
MAX230CWP*	0°C to +70°C	20 Wide SO
MAX230C/D	0°C to +70°C	Dice*
MAX230EPP	-40°C to +85°C	20 Plastic DIP
MAX230EWP	-40°C to +85°C	20 Wide SO
MAX230EJP	-40°C to +85°C	20 CERDIP
MAX230MJP	-55°C to +125°C	20 CERDIP
MAX231CPD	0°C to +70°C	14 Plastic DIP
MAX231CWE	0°C to +70°C	16 Wide SO
MAX231CJD	0°C to +70°C	14 CERDIP
MAX231C/D	0°C to +70°C	Dice*
MAX231EPD	-40°C to +85°C	14 Plastic DIP
MAX231EWE	-40°C to +85°C	16 Wide SO
MAX231EJD	-40°C to +85°C	14 CERDIP
MAX231MJD	-55°C to +125°C	14 CERDIP
MAX232CPE	0°C to +70°C	16 Plastic DIP
MAX232CSE	0°C to +70°C	16 Narrow SO
MAX232CWE	0°C to +70°C	16 Wide SO
MAX232C/D	0°C to +70°C	Dice*
MAX232EPE	-40°C to +85°C	16 Plastic DIP
MAX232ESE	-40°C to +85°C	16 Narrow SO
MAX232EWE	-40°C to +85°C	16 Wide SO
MAX232EJE	-40°C to +85°C	16 CERDIP
MAX232MJE	-55°C to +125°C	16 CERDIP
MAX232MLP	-55°C to +125°C	20 LCC
MAX232ACPE	0°C to +70°C	16 Plastic DIP
MAX232ACSE	0°C to +70°C	16 Narrow SO
MAX232ACWE	0°C to +70°C	16 Wide SO
MAX232AC/D	0°C to +70°C	Dice*
MAX232AEPE	-40°C to +85°C	16 Plastic DIP
MAX232AESE	-40°C to +85°C	16 Narrow SO
MAX232AEWE	-40°C to +85°C	16 Wide SO
MAX232AEJE	-40°C to +85°C	16 CERDIP
MAX232AMJE	-55°C to +125°C	16 CERDIP
MAX232AMLP	-55°C to +125°C	20 LCC
MAX233CPP	0°C to +70°C	20 Plastic DIP
MAX233EPP	-40°C to +85°C	20 Plastic DIP
MAX233ACPP	0°C to +70°C	20 Plastic DIP
MAX233ACWP	0°C to +70°C	20 Wide SO
MAX233AEPP	-40°C to +85°C	20 Plastic DIP
MAX233AEWP	-40°C to +85°C	20 Wide SO
MAX234CPE	0°C to +70°C	16 Plastic DIP
MAX234CWE	0°C to +70°C	16 Wide SO
MAX234C/D	0°C to +70°C	Dice*
MAX234EPE	-40°C to +85°C	16 Plastic DIP
MAX234EWE	-40°C to +85°C	16 Wide SO
MAX234EJE	-40°C to +85°C	16 CERDIP
MAX234MJE	-55°C to +125°C	16 CERDIP
MAX235CPG	0°C to +70°C	24 Wide Plastic DIP
MAX235EPG	-40°C to +85°C	24 Wide Plastic DIP
MAX235EDG	-40°C to +85°C	24 Ceramic SB
MAX235MDG	-55°C to +125°C	24 Ceramic SB
MAX236CNG	0°C to +70°C	24 Narrow Plastic DIP
MAX236CWG	0°C to +70°C	24 Wide SO
MAX236C/D	0°C to +70°C	Dice*
MAX236ENG	-40°C to +85°C	24 Narrow Plastic DIP
MAX236EWG	-40°C to +85°C	24 Wide SO
MAX236ERG	-40°C to +85°C	24 Narrow CERDIP
MAX236MRG	-55°C to +125°C	24 Narrow CERDIP
MAX237CNG	0°C to +70°C	24 Narrow Plastic DIP
MAX237CWG	0°C to +70°C	24 Wide SO
MAX237C/D	0°C to +70°C	Dice*
MAX237ENG	-40°C to +85°C	24 Narrow Plastic DIP
MAX237EWG	-40°C to +85°C	24 Wide SO
MAX237ERG	-40°C to +85°C	24 Narrow CERDIP
MAX237MRG	-55°C to +125°C	24 Narrow CERDIP
MAX238CNG	0°C to +70°C	24 Narrow Plastic DIP
MAX238CWG	0°C to +70°C	24 Wide SO
MAX238C/D	0°C to +70°C	Dice*
MAX238ENG	-40°C to +85°C	24 Narrow Plastic DIP

** Contact factory for dice specifications.*

Ordering Information (continued)

PART	TEMP RANGE	PIN-PACKAGE
MAX238EWG	-40°C to +85°C	24 Wide SO
MAX238ERG	-40°C to +85°C	24 Narrow CERDIP
MAX238MRG	-55°C to +125°C	24 Narrow CERDIP
MAX239CNG	0°C to +70°C	24 Narrow Plastic DIP
MAX239CWG	0°C to +70°C	24 Wide SO
MAX239C/D	0°C to +70°C	Dice*
MAX239ENG	-40°C to +85°C	24 Narrow Plastic DIP
MAX239EWG	-40°C to +85°C	24 Wide SO
MAX239ERG	-40°C to +85°C	24 Narrow CERDIP
MAX239MRG	-55°C to +125°C	24 Narrow CERDIP
MAX240CMH	0°C to +70°C	44 Plastic FP
MAX240C/D	0°C to +70°C	Dice*
MAX241CAI	0°C to +70°C	28 SSOP
MAX241CWI	0°C to +70°C	28 Wide SO
MAX241C/D	0°C to +70°C	Dice*
MAX241EAI	-40°C to +85°C	28 SSOP
MAX241EWI	-40°C to +85°C	28 Wide SO
MAX242CAP	0°C to +70°C	20 SSOP
MAX242CPN	0°C to +70°C	18 Plastic DIP
MAX242CWN	0°C to +70°C	18 Wide SO
MAX242C/D	0°C to +70°C	Dice*
MAX242EPN	-40°C to +85°C	18 Plastic DIP
MAX242EWN	-40°C to +85°C	18 Wide SO
MAX242EJN	-40°C to +85°C	18 CERDIP
MAX242MJN	-55°C to +125°C	18 CERDIP

PART	TEMP RANGE	PIN-PACKAGE
MAX243CPE	0°C to +70°C	16 Plastic DIP
MAX243CSE	0°C to +70°C	16 Narrow SO
MAX243CWE	0°C to +70°C	16 Wide SO
MAX243C/D	0°C to +70°C	Dice*
MAX243EPE	-40°C to +85°C	16 Plastic DIP
MAX243ESE	-40°C to +85°C	16 Narrow SO
MAX243EWE	-40°C to +85°C	16 Wide SO
MAX243EJE	-40°C to +85°C	16 CERDIP
MAX243MJE	-55°C to +125°C	16 CERDIP
MAX244CQH	0°C to +70°C	44 PLCC
MAX244C/D	0°C to +70°C	Dice*
MAX244EQH	-40°C to +85°C	44 PLCC
MAX245CPL	0°C to +70°C	40 Plastic DIP
MAX245C/D	0°C to +70°C	Dice*
MAX245EPL	-40°C to +85°C	40 Plastic DIP
MAX246CPL	0°C to +70°C	40 Plastic DIP
MAX246C/D	0°C to +70°C	Dice*
MAX246EPL	-40°C to +85°C	40 Plastic DIP
MAX247CPL	0°C to +70°C	40 Plastic DIP
MAX247C/D	0°C to +70°C	Dice*
MAX247EPL	-40°C to +85°C	40 Plastic DIP
MAX248CQH	0°C to +70°C	44 PLCC
MAX248C/D	0°C to +70°C	Dice*
MAX248EQH	-40°C to +85°C	44 PLCC
MAX249CQH	0°C to +70°C	44 PLCC
MAX249EQH	-40°C to +85°C	44 PLCC

** Contact factory for dice specifications.*

Package Information

For the latest package outline information, go to **www.maxim-ic.com/packages**.

HARRIS Semiconductor

IRF540, IRF541, IRF542, IRF543, RF1S540, RF1S540SM

25A and 28A, 80V and 100V, 0.077 and 0.100 Ohm, N-Channel Power MOSFETs

ovember 1997

Features

- **25A and 28A, 80V and 100V**
- **$r_{DS(ON)}$ = 0.077Ω and 0.100Ω**
- **Single Pulse Avalanche Energy Rated**
- **Nanosecond Switching Speeds**
- **Linear Transfer Characteristics**
- **High Input Impedance**
- **Related Literature**
  - **TB334 "Guidelines for Soldering Surface Mount Components to PC Boards"**

Description

These are N-Channel enhancement mode silicon gate power field effect transistors. They are advanced power MOSFETs designed, tested, and guaranteed to withstand a specified level of energy in the breakdown avalanche mode of operation. All of these power MOSFETs are designed for applications such as switching regulators, switching convertors, motor drivers, relay drivers, and drivers for high power bipolar switching transistors requiring high speed and low gate drive power. These types can be operated directly from integrated circuits.

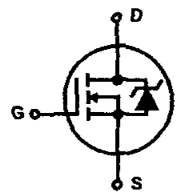
Formerly developmental type TA17421.

Ordering Information

PART NUMBER	PACKAGE	BRAND
IRF540	TO-220AB	IRF540
IRF541	TO-220AB	IRF541
IRF542	TO-220AB	IRF542
IRF543	TO-220AB	IRF543
RF1S540	TO-262AA	RF1S540
RF1S540SM	TO-263AB	RF1S540SM

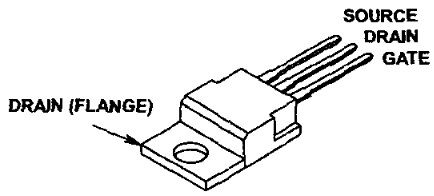
NOTE: When ordering, use the entire part number. Add the suffix 9A to obtain the TO-263AB variant in the tape and reel, i.e., RF1S540SM9A.

Symbol

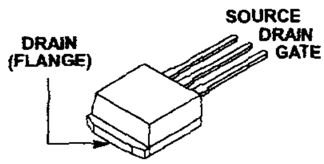


Packaging

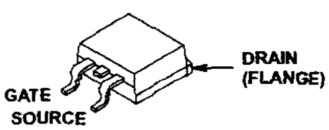
JEDEC TO-220AB



JEDEC TO-262AA



JEDEC TO-263AB



AUTION: These devices are sensitive to electrostatic discharge. Users should follow proper ESD Handling Procedures.

File Number **2309.3**

Absolute Maximum Ratings $T_C = 25^oC$, Unless Otherwise Specified

		IRF540, RF1S540, RF1S540SM	IRF541	IRF542	IRF543	UNITS
Drain to Source Breakdown Voltage (Note 1)	V_{DS}	100	80	100	80	V
Drain to Gate Voltage (R_{GS} = 20kΩ) (Note 1)	V_{DGR}	100	80	100	80	V
Continuous Drain Current	I_D	28	28	25	25	A
$T_C = 100^oC$	I_D	20	20	17	17	A
Pulsed Drain Current (Note 3)	I_{DM}	110	110	100	100	A
Gate to Source Voltage	V_{GS}	±20	±20	±20	±20	V
Maximum Power Dissipation	P_D	150	150	150	150	W
Dissipation Derating Factor		1	1	1	1	W/^{o}C
Single Pulse Avalanche Energy Rating (Note 4)	E_{AS}	230	230	230	230	mJ
Operating and Storage Temperature	T_J, T_{STG}	-55 to 175	-55 to 175	-55 to 175	-55 to 175	^{o}C
Maximum Temperature for Soldering						
Leads at 0.063in (1.6mm) from Case for 10s	T_L	300	300	300	300	^{o}C
Package Body for 10s, See Techbrief 334	T_{pkg}	260	260	260	260	^{o}C

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

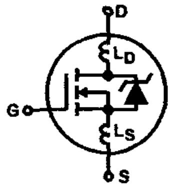
NOTE:

1. $T_J = 25^oC$ to $T_J = 150^oC$.

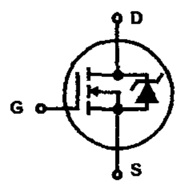
Electrical Specifications $T_C = 25^oC$, Unless Otherwise Specified

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Drain to Source Breakdown Voltage IRF540, IRF542, RF1S540, RF1S540SM	BV_{DSS}	I_D = 250μA, V_{GS} = 0V (Figure 10)	100	-	-	V
IRF541, IRF543			80	-	-	V
Gate to Threshold Voltage	$V_{GS(TH)}$	$V_{GS} = V_{DS}$, I_D = 250μA	2	-	4	V
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS} = Rated BV_{DSS}, V_{GS} = 0V	-	-	25	μA
		V_{DS} = 0.8 x Rated BV_{DSS}, V_{GS} = 0V $T_J = 150^oC$	-	-	250	μA
On-State Drain Current (Note 2) IRF540, IRF541, RF1S540, RF1S540SM	$I_{D(ON)}$	$V_{DS} > I_{D(ON)} \times r_{DS(ON)\,MAX}$, V_{GS} = 10V (Figure 7)	28	-	-	A
IRF542, IRF543			25	-	-	A
Gate to Source Leakage Current	I_{GSS}	V_{GS} = ±20V	-	-	±100	nA
Drain to Source On Resistance (Note 2) IRF540, IRF541, RF1S540, RF1S540SM	$r_{DS(ON)}$	I_D = 17A, V_{GS} = 10V (Figures 8, 9)	-	0.060	0.077	Ω
IRF542, IRF543			-	0.080	0.100	Ω
Forward Transconductance (Note 2)	g_{fs}	$V_{DS} \geq 50V$, I_D = 17A (Figure 12)	8.7	13	-	S
Turn-On Delay Time	$t_{d(ON)}$	V_{DD} = 50V, $I_D \approx 28A$, $R_G \approx 9.1\Omega$, $R_L = 1.7\Omega$ (Figures 17, 18) MOSFET Switching Times are Essentially Independent of Operating Temperature	-	15	23	ns
Rise Time	t_r		-	70	110	ns
Turn-Off Delay Time	$t_{d(OFF)}$		-	40	60	ns
Fall Time	t_f		-	50	75	ns
Total Gate Charge (Gate to Source + Gate to Drain)	$Q_{g(TOT)}$	V_{GS} = 10V, I_D = 28A, V_{DS} = 0.8 x Rated BV_{DSS}, $I_{g(REF)}$ = 1.5mA (Figures 14, 19, 20) Gate Charge is Essentially Independent of Operating Temperature	-	38	59	nC
Gate to Source Charge	Q_{gs}		-	8	-	nC
Gate to Drain "Miller" Charge	Q_{gd}		-	21	-	nC

Electrical Specifications T_C = 25°C, Unless Otherwise Specified **(Continued)**

PARAMETER	SYMBOL	TEST CONDITIONS		MIN	TYP	MAX	UNITS
Input Capacitance	C_{ISS}	V_{DS} = 25V, V_{GS} = 0V, f = 1MHz (Figure 11)		-	1450	-	pF
Output Capacitance	C_{OSS}			-	550	-	pF
Reverse Transfer Capacitance	C_{RSS}			-	100	-	pF
Internal Drain Inductance	L_D	Measured From the Contact Screw on Tab To Center of Die	Modified MOSFET Symbol Showing the Internal Devices Inductances 	-	3.5	-	nH
		Measured From the Drain Lead, 6mm (0.25in) from Package to Center of Die		-	4.5	-	nH
Internal Source Inductance	L_S	Measured From the Source Lead, 6mm (0.25in) From Header to Source Bonding Pad		-	7.5	-	nH
Thermal Resistance Junction to Case	$R_{\theta JC}$			-	-	1	°C/W
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	Free Air Operation		-	-	80	°C/W
	$R_{\theta JA}$	RF1S540SM Mounted on FR-4 Board with Minimum Mounting Pad		-	-	62	°C/W

Source to Drain Diode Specifications

PARAMETER	SYMBOL	TEST CONDITIONS		MIN	TYP	MAX	UNITS
Continuous Source to Drain Current	I_{SD}	Modified MOSFET Symbol Showing the Integral Reverse P-N Junction Diode		-	-	28	A
Pulse Source to Drain Current (Note 3)	I_{SDM}			-	-	110	A
Source to Drain Diode Voltage (Note 2)	V_{SD}	T_J = 25°C, I_{SD} = 27A, V_{GS} = 0V (Figure 13)		-	-	2.5	V
Reverse Recovery Time	t_{rr}	T_J = 25°C, I_{SD} = 28A, dI_{SD}/dt = 100A/μs		70	150	300	ns
Reverse Recovery Charge	Q_{RR}	T_J = 25°C, I_{SD} = 28A, dI_{SD}/dt = 100A/μs		0.44	1.0	1.9	μC

NOTES:

2. Pulse test: pulse width ≤ 300μs, duty cycle ≤ 2%.
3. Repetitive rating: pulse width limited by maximum junction temperature. See Transient Thermal Impedance curve (Figure 3).
4. V_{DD} = 25V, starting T_J = 25°C, L = 440μH, R_G = 25Ω, peak I_{AS} = 28A. (Figures 15, 16).

Typical Performance Curves Unless Otherwise Specified

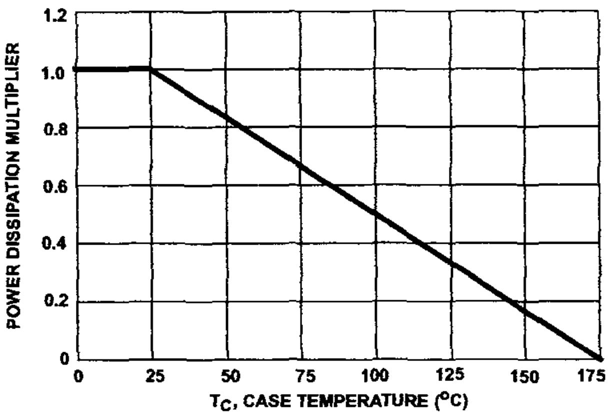


FIGURE 1. NORMALIZED POWER DISSIPATION vs CASE TEMPERATURE

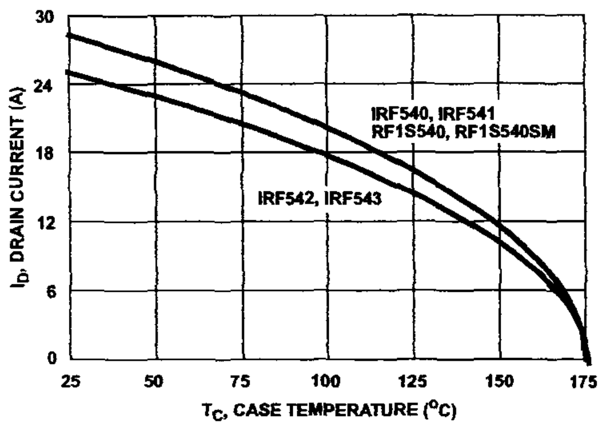


FIGURE 2. MAXIMUM CONTINUOUS DRAIN CURRENT vs CASE TEMPERATURE

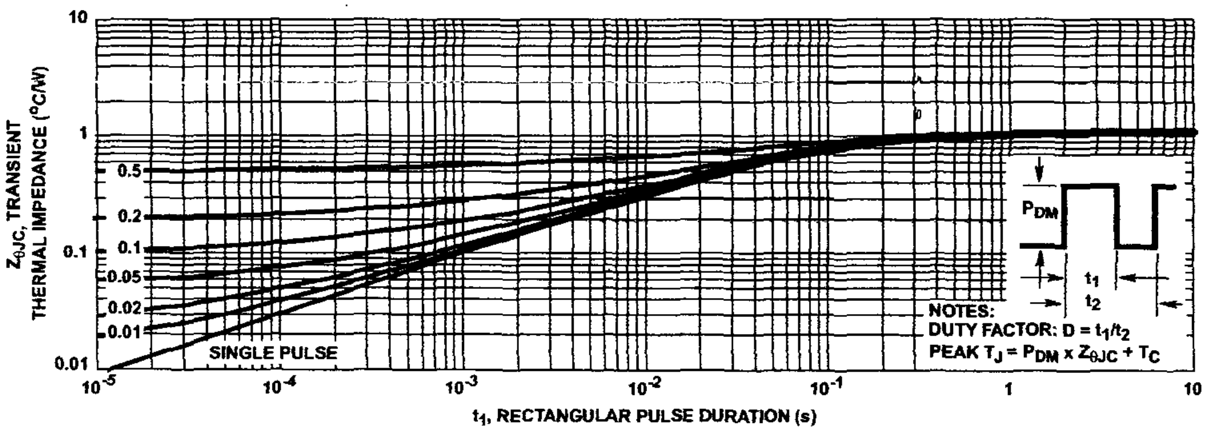


FIGURE 3. MAXIMUM TRANSIENT THERMAL IMPEDANCE

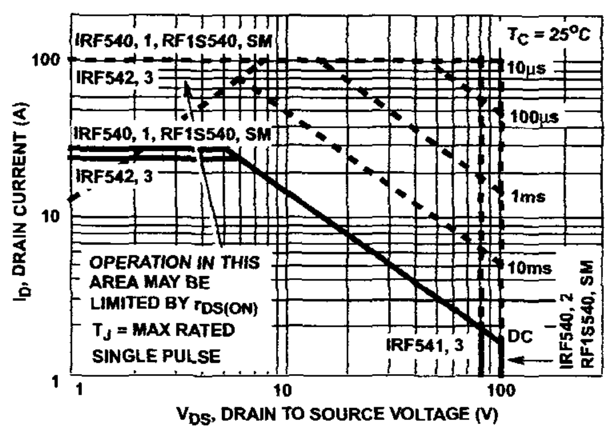


FIGURE 4. FORWARD BIAS SAFE OPERATING AREA

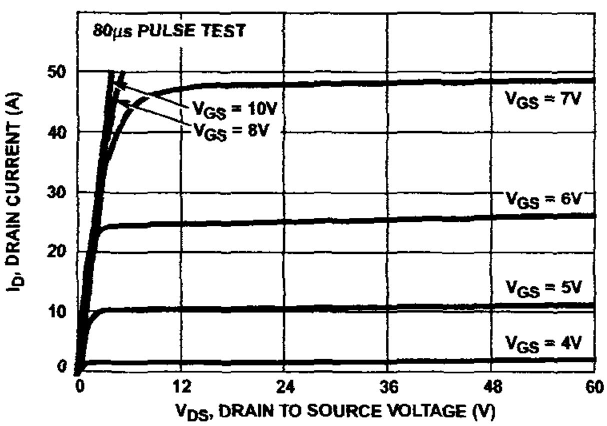


FIGURE 5. OUTPUT CHARACTERISTICS

Typical Performance Curves Unless Otherwise Specified (Continued)

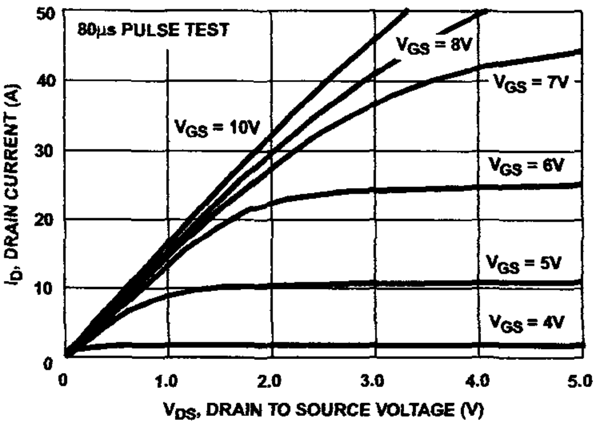


FIGURE 6. SATURATION CHARACTERISTICS

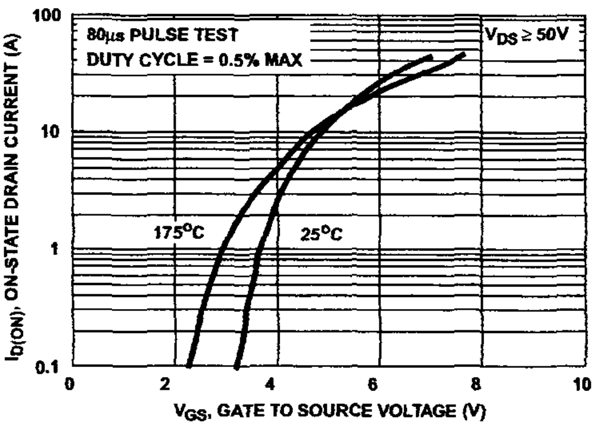


FIGURE 7. TRANSFER CHARACTERISTICS

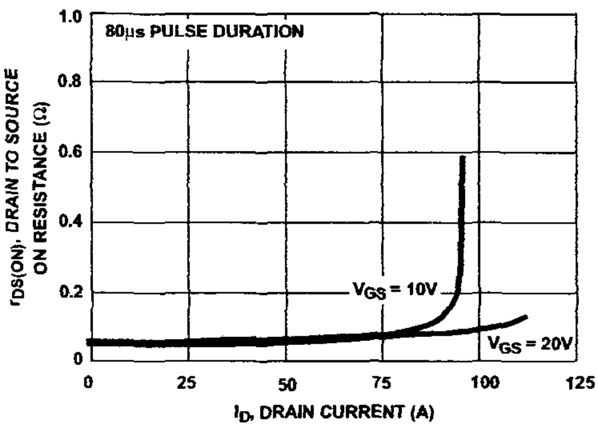


FIGURE 8. DRAIN TO SOURCE ON RESISTANCE vs GATE VOLTAGE AND DRAIN CURRENT

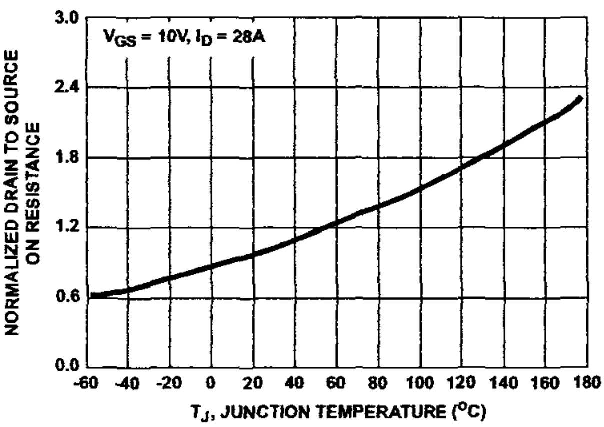


FIGURE 9. NORMALIZED DRAIN TO SOURCE ON RESISTANCE vs JUNCTION TEMPERATURE

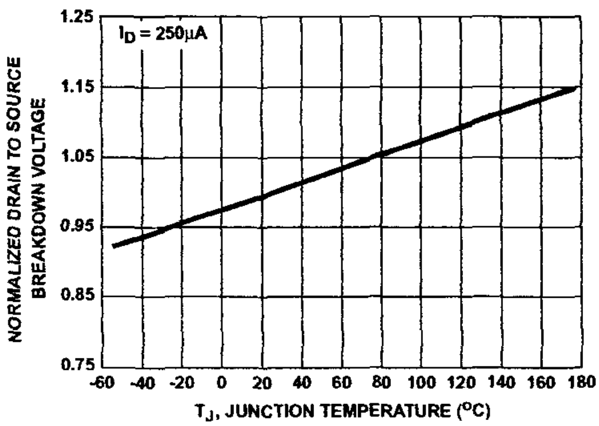


FIGURE 10. NORMALIZED DRAIN TO SOURCE BREAKDOWN VOLTAGE vs JUNCTION TEMPERATURE

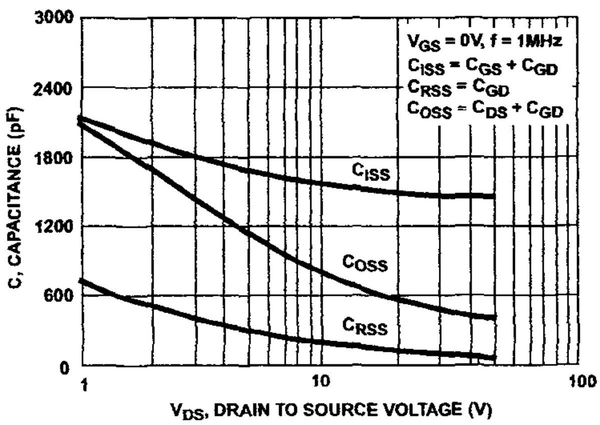


FIGURE 11. CAPACITANCE vs DRAIN TO SOURCE VOLTAGE

Typical Performance Curves Unless Otherwise Specified **(Continued)**

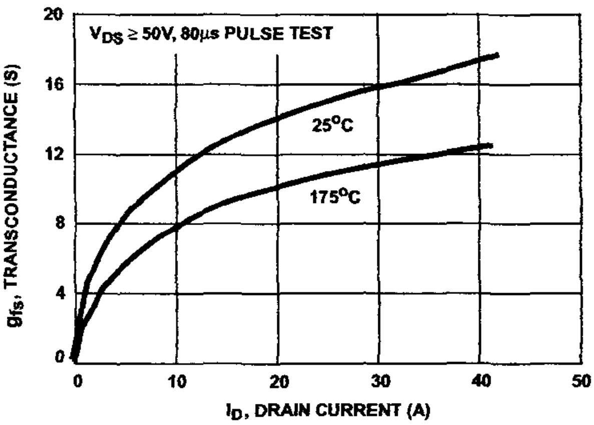


FIGURE 12. TRANSCONDUCTANCE vs DRAIN CURRENT

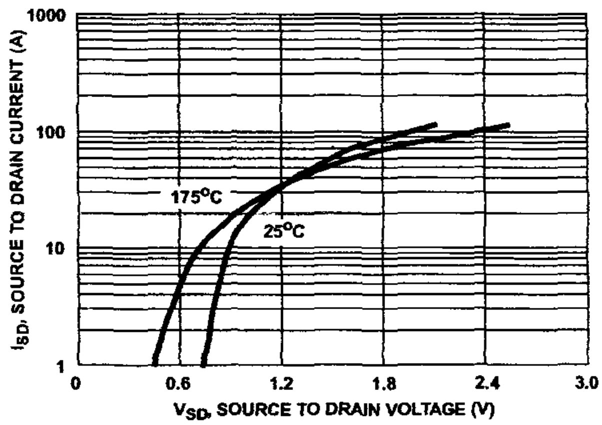


FIGURE 13. SOURCE TO DRAIN DIODE VOLTAGE

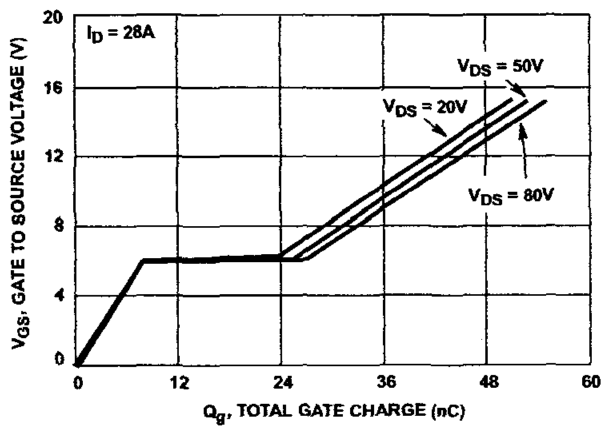


FIGURE 14. GATE TO SOURCE VOLTAGE vs GATE CHARGE

Test Circuits and Waveforms

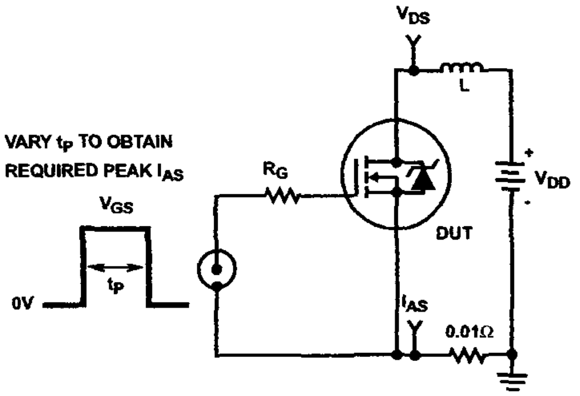


FIGURE 15. UNCLAMPED ENERGY TEST CIRCUIT

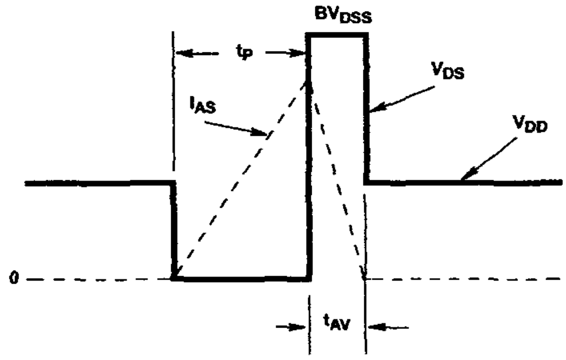


FIGURE 16. UNCLAMPED ENERGY WAVEFORMS

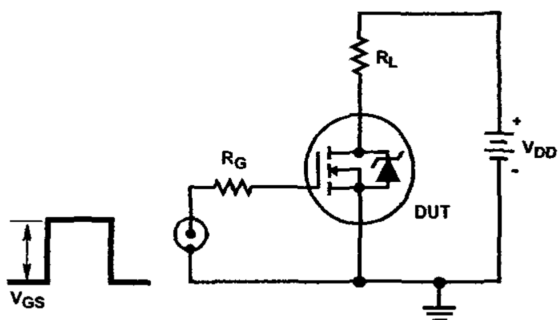


FIGURE 17. SWITCHING TIME TEST CIRCUIT

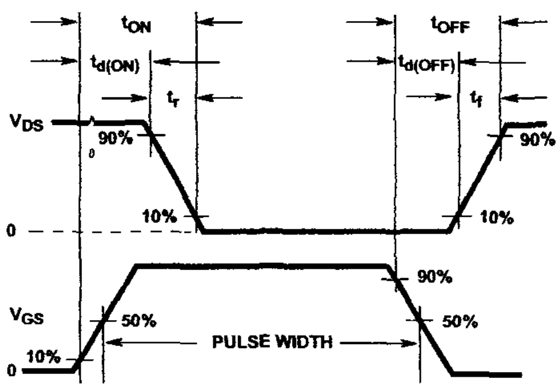


FIGURE 18. RESISTIVE SWITCHING WAVEFORMS

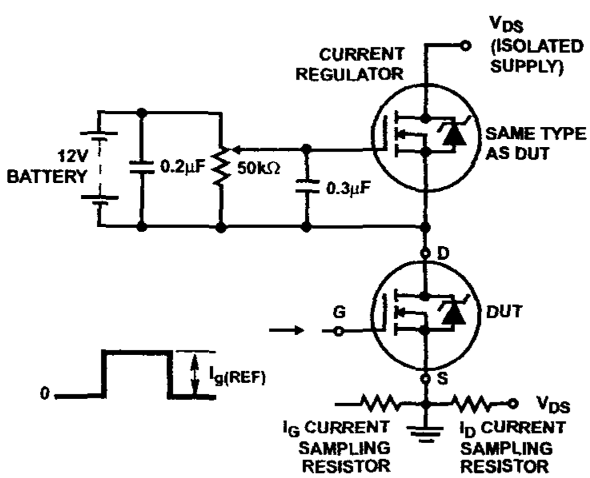


FIGURE 19. GATE CHARGE TEST CIRCUIT

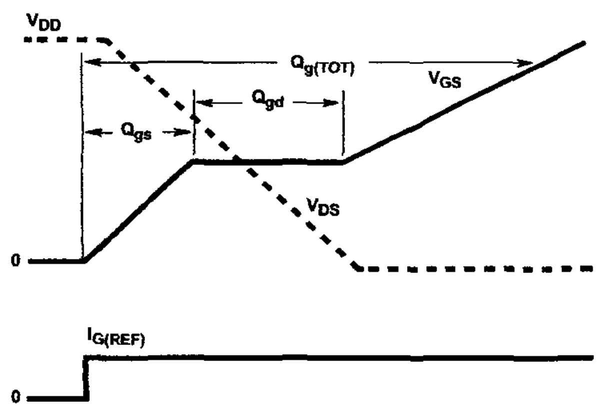


FIGURE 20. GATE CHARGE WAVEFORMS

National Semiconductor

August 2000

LM124/LM224/LM324/LM2902 Low Power Quad Operational Amplifiers

General Description

The LM124 series consists of four independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

Application areas include transducer amplifiers, DC gain blocks and all the conventional op amp circuits which now can be more easily implemented in single power supply systems. For example, the LM124 series can be directly operated off of the standard +5V power supply voltage which is used in digital systems and will easily provide the required interface electronics without requiring the additional ±15V power supplies.

Unique Characteristics

- In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage
- The unity gain cross frequency is temperature compensated
- The input bias current is also temperature compensated

Advantages

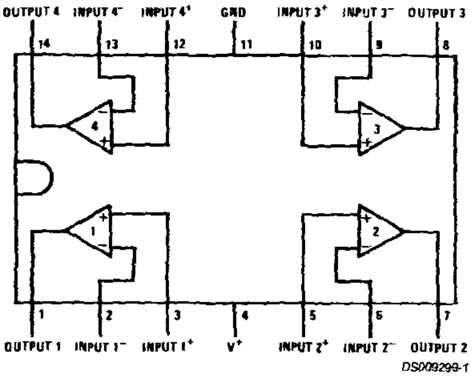
- Eliminates need for dual supplies
- Four internally compensated op amps in a single package
- Allows directly sensing near GND and V_{OUT} also goes to GND
- Compatible with all forms of logic
- Power drain suitable for battery operation

Features

- Internally frequency compensated for unity gain
- Large DC voltage gain 100 dB
- Wide bandwidth (unity gain) 1 MHz (temperature compensated)
- Wide power supply range: Single supply 3V to 32V or dual supplies ±1.5V to ±16V
- Very low supply current drain (700 μA)—essentially independent of supply voltage
- Low input biasing current 45 nA (temperature compensated)
- Low input offset voltage 2 mV and offset current: 5 nA
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- Large output voltage swing 0V to V^+ − 1.5V

Connection Diagram

Dual-In-Line Package



Top View

Order Number LM124J, LM124AJ, LM124J/883 (Note 2), **LM124AJ/883** (Note 1), **LM224J, LM224AJ, LM324J, LM324M, LM324MX, LM324AM, LM324AMX, LM2902M, LM2902MX, LM324N, LM324AN, LM324MT, LM324MTX or LM2902N LM124AJRQML and LM124AJRQMLV**(Note 3)

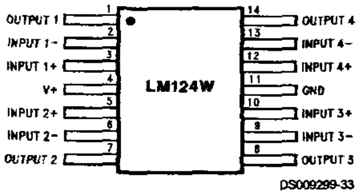
See NS Package Number J14A, M14A or N14A

Note 1: LM124A available per JM38510/11006

Note 2: LM124 available per JM38510/11005

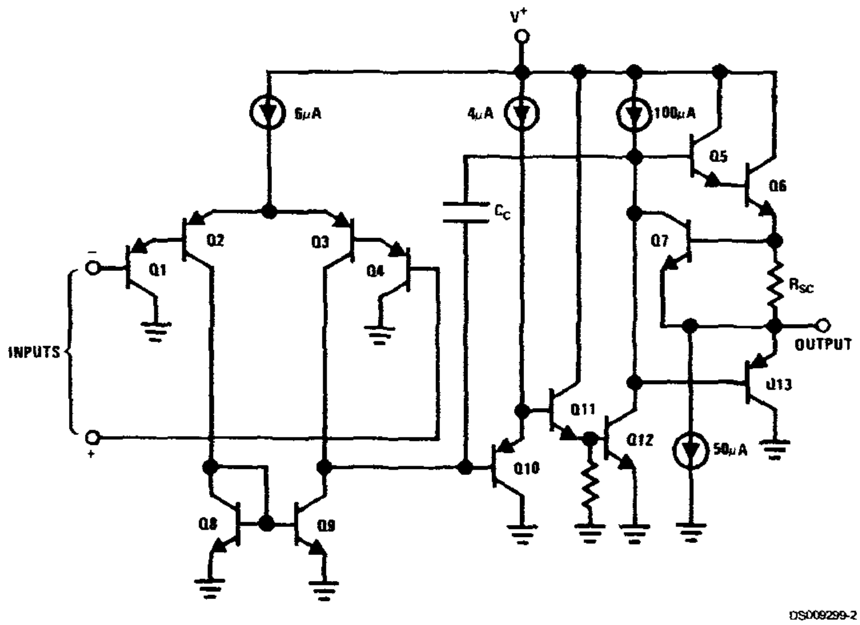
Connection Diagram (Continued)

Note 3: See STD Mil DWG 5962R99504 for Radiation Tolerant Device



Order Number LM124AW/883, LM124AWG/883, LM124W/883 or LM124WG/883
LM124AWRQML and LM124AWRQMLV(Note 3)
See NS Package Number W14B
LM124AWGRQML and LM124AWGRQMLV(Note 3)
See NS Package Number WG14A

Schematic Diagram (Each Amplifier)



Absolute Maximum Ratings (Note 12)

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

	LM124/LM224/LM324 LM124A/LM224A/LM324A	LM2902
Supply Voltage, V^+	32V	26V
Differential Input Voltage	32V	26V
Input Voltage	−0.3V to +32V	−0.3V to +26V
Input Current		
(V_{IN} < −0.3V) (Note 6)	50 mA	50 mA
Power Dissipation (Note 4)		
Molded DIP	1130 mW	1130 mW
Cavity DIP	1260 mW	1260 mW
Small Outline Package	800 mW	800 mW
Output Short-Circuit to GND		
(One Amplifier) (Note 5)		
$V^+ \leq 15V$ and T_A = 25°C	Continuous	Continuous
Operating Temperature Range		−40°C to +85°C
LM324/LM324A	0°C to +70°C	
LM224/LM224A	−25°C to +85°C	
LM124/LM124A	−55°C to +125°C	
Storage Temperature Range	−65°C to +150°C	−65°C to +150°C
Lead Temperature (Soldering, 10 seconds)	260°C	260°C
Soldering Information		
Dual-In-Line Package		
Soldering (10 seconds)	260°C	260°C
Small Outline Package		
Vapor Phase (60 seconds)	215°C	215°C
Infrared (15 seconds)	220°C	220°C

See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering surface mount devices.

ESD Tolerance (Note 13)	250V	250V

Electrical Characteristics

V^+ = +5.0V, (Note 7), unless otherwise stated

Parameter	Conditions	LM124A			LM224A			LM324A			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
ut Offset Voltage	(Note 8) T_A = 25°C		1	2		1	3		2	3	mV
ut Bias Current ote 9)	$I_{IN(+)}$ or $I_{IN(-)}$, V_{CM} = 0V, T_A = 25°C		20	50		40	80		45	100	nA
ut Offset Current	$I_{IN(+)}$ or $I_{IN(-)}$, V_{CM} = 0V, T_A = 25°C		2	10		2	15		5	30	nA
ut Common-Mode tage Range (Note 10)	V^+ = 30V, (LM2902, V^+ = 26V), T_A = 25°C	0		V^+−1.5	0		V^+−1.5	0		V^+−1.5	V
pply Current	Over Full Temperature Range $R_L = \infty$ On All Op Amps										mA
	V^+ = 30V (LM2902 V^+ = 26V)		1.5	3		1.5	3		1.5	3	
	V^+ = 5V		0.7	1.2		0.7	1.2		0.7	1.2	
ge Signal tage Gain	V^+ = 15V, $R_L \geq 2k\Omega$, (V_O = 1V to 11V), T_A = 25°C	50	100		50	100		25	100		V/mV
nmon-Mode ection Ratio	DC, V_{CM} = 0V to V^+ − 1.5V, T_A = 25°C	70	85		70	85		65	85		dB

Electrical Characteristics (Continued)

V^+ = +5.0V, (Note 7), unless otherwise stated

Parameter	Conditions	LM124A Min	LM124A Typ	LM124A Max	LM224A Min	LM224A Typ	LM224A Max	LM324A Min	LM324A Typ	LM324A Max	Units
Power Supply Rejection Ratio	V^+ = 5V to 30V (LM2902, V^+ = 5V to 26V), T_A = 25°C	65	100		65	100		65	100		dB
Amplifier-to-Amplifier Coupling (Note 11)	f = 1 kHz to 20 kHz, T_A = 25°C (Input Referred)		−120			−120			−120		dB
Output Current — Source	V_{IN}^+ = 1V, V_{IN}^- = 0V, V^+ = 15V, V_O = 2V, T_A = 25°C	20	40		20	40		20	40		mA
Output Current — Sink	V_{IN}^- = 1V, V_{IN}^+ = 0V, V^+ = 15V, V_O = 2V, T_A = 25°C	10	20		10	20		10	20		mA
Output Current — Sink	V_{IN}^- = 1V, V_{IN}^+ = 0V, V^+ = 15V, V_O = 200 mV, T_A = 25°C	12	50		12	50		12	50		μA
Short Circuit to Ground	(Note 5) V^+ = 15V, T_A = 25°C		40	60		40	60		40	60	mA
Input Offset Voltage	(Note 8)			4			4			5	mV
V_{OS} Drift	R_S = 0Ω		7	20		7	20		7	30	μV/°C
Input Offset Current	$I_{IN(+)} - I_{IN(-)}$, V_{CM} = 0V			30			30			75	nA
I_{OS} Drift	R_S = 0Ω		10	200		10	200		10	300	pA/°C
Input Bias Current	$I_{IN(+)}$ or $I_{IN(-)}$		40	100		40	100		40	200	nA
Input Common-Mode Voltage Range (Note 10)	V^+ = +30V (LM2902, V^+ = 26V)	0		V^+-2	0		V^+-2	0		V^+-2	V
Large Signal Voltage Gain	V^+ = +15V (V_OSwing = 1V to 11V) $R_L \geq 2$ kΩ	25			25			15			V/mV
Output Voltage Swing — V_{OH}	V^+ = 30V (LM2902, V^+ = 26V), R_L = 2 kΩ	26			26			26			V
Output Voltage Swing — V_{OH}	V^+ = 30V (LM2902, V^+ = 26V), R_L = 10 kΩ	27	28		27	28		27	28		V
Output Voltage Swing — V_{OL}	V^+ = 5V, R_L = 10 kΩ		5	20		5	20		5	20	mV
Output Current — Source	V_O = 2V; V_{IN}^+ = +1V, V_{IN}^- = 0V, V^+ = 15V	10	20		10	20		10	20		mA
Output Current — Sink	V_O = 2V; V_{IN}^- = +1V, V_{IN}^+ = 0V, V^+ = 15V	10	15		5	8		5	8		mA

Electrical Characteristics

V^+ = +5.0V, (Note 7), unless otherwise stated

Parameter	Conditions	LM124/LM224 Min	LM124/LM224 Typ	LM124/LM224 Max	LM324 Min	LM324 Typ	LM324 Max	LM2902 Min	LM2902 Typ	LM2902 Max	Units
Input Offset Voltage	(Note 8) T_A = 25°C		2	5		2	7		2	7	mV
Input Bias Current (Note 9)	$I_{IN(+)}$ or $I_{IN(-)}$, V_{CM} = 0V, T_A = 25°C		45	150		45	250		45	250	nA
Input Offset Current	$I_{IN(+)}$ or $I_{IN(-)}$, V_{CM} = 0V, T_A = 25°C		3	30		5	50		5	50	nA
Input Common-Mode Voltage Range (Note 10)	V^+ = 30V, (LM2902, V^+ = 26V), T_A = 25°C	0		$V^+-1.5$	0		$V^+-1.5$	0		$V^+-1.5$	V
Supply Current	Over Full Temperature Range, $R_L = \infty$ On All Op Amps										mA
	V^+ = 30V (LM2902 V^+ = 26V)		1.5	3		1.5	3		1.5	3	mA
	V^+ = 5V		0.7	1.2		0.7	1.2		0.7	1.2	mA
Large Signal Voltage Gain	V^+ = 15V, $R_L \geq 2$kΩ, (V_O = 1V to 11V), T_A = 25°C	50	100		25	100		25	100		V/mV
Common-Mode Rejection Ratio	DC, V_{CM} = 0V to V^+ − 1.5V, T_A = 25°C	70	85		65	85		50	70		dB
Power Supply Rejection Ratio	V^+ = 5V to 30V (LM2902, V^+ = 5V to 26V),	65	100		65	100		50	100		dB

Electrical Characteristics (Continued)

V^+ = +5.0V, (Note 7), unless otherwise stated

Parameter		Conditions		LM124/LM224			LM324			LM2902			Units
				Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
		T_A = 25°C											
Amplifier-to-Amplifier Coupling (Note 11)		f = 1 kHz to 20 kHz, T_A = 25°C (Input Referred)			−120			−120			−120		dB
Output Current	Source	V_{IN}^+ = 1V, V_{IN}^- = 0V, V^+ = 15V, V_O = 2V, T_A = 25°C		20	40		20	40		20	40		mA
	Sink	V_{IN}^- = 1V, V_{IN}^+ = 0V, V^+ = 15V, V_O = 2V, T_A = 25°C		10	20		10	20		10	20		
		V_{IN}^- = 1V, V_{IN}^+ = 0V, V^+ = 15V, V_O = 200 mV, T_A = 25°C		12	50		12	50		12	50		μA
Short Circuit to Ground		(Note 5) V^+ = 15V, T_A = 25°C			40	60		40	60		40	60	mA
Input Offset Voltage		(Note 8)				7			9			10	mV
V_{OS} Drift		R_S = 0Ω			7			7			7		μV/°C
Input Offset Current		$I_{IN(+)} - I_{IN(-)}$, V_{CM} = 0V				100			150		45	200	nA
I_{OS} Drift		R_S = 0Ω			10			10			10		pA/°C
Input Bias Current		$I_{IN(+)}$ or $I_{IN(-)}$			40	300		40	500		40	500	nA
Input Common-Mode Voltage Range (Note 10)		V^+ = +30V (LM2902, V^+ = 26V)		0		V^+−2	0		V^+−2	0		V^+−2	V
Large Signal Voltage Gain		V^+ = +15V (V_OSwing = 1V to 11V) R_L ≥ 2 kΩ		25			15			15			V/mV
Output Voltage Swing	V_{OH}	V^+ = 30V (LM2902, V^+ = 26V)	R_L = 2 kΩ	26			26			22			V
			R_L = 10 kΩ	27	28		27	28		23	24		
	V_{OL}	V^+ = 5V, R_L = 10 kΩ			5	20		5	20		5	100	mV
Output Current	Source	V_O = 2V	V_{IN}^+ = +1V, V_{IN}^- = 0V, V^+ = 15V	10	20		10	20		10	20		mA
	Sink		V_{IN}^- = +1V, V_{IN}^+ = 0V, V^+ = 15V	5	8		5	8		5	8		

Note 4: For operating at high temperatures, the LM324/LM324A/LM2902 must be derated based on a +125°C maximum junction temperature and a thermal resistance of 88°C/W which applies for the device soldered in a printed circuit board, operating in a still air ambient. The LM224/LM224A and LM124/LM124A can be derated based on a +150°C maximum junction temperature. The dissipation is the total of all four amplifiers — use external resistors, where possible, to allow the amplifier to saturate of to reduce the power which is dissipated in the integrated circuit.

Note 5: Short circuits from the output to V^+ can cause excessive heating and eventual destruction. When considering short circuits to ground, the maximum output current is approximately 40 mA independent of the magnitude of V^+. At values of supply voltage in excess of +15V, continuous short-circuits can exceed the power dissipation ratings and cause eventual destruction. Destructive dissipation can result from simultaneous shorts on all amplifiers.

Note 6: This input current will only exist when the voltage at any of the input leads is driven negative. It is due to the collector-base junction of the input PNP transistors becoming forward biased and thereby acting as input diode clamps. In addition to this diode action, there is also lateral NPN parasitic transistor action on the IC chip. This transistor action can cause the output voltages of the op amps to go to the V^+voltage level (or to ground for a large overdrive) for the time duration that an input is driven negative. This is not destructive and normal output states will re-establish when the input voltage, which was negative, again returns to a value greater than −0.3V (at 25°C).

Note 7: These specifications are limited to −55°C ≤ T_A ≤ +125°C for the LM124/LM124A. With the LM224/LM224A, all temperature specifications are limited to −25°C ≤ T_A ≤ +85°C, the LM324/LM324A temperature specifications are limited to 0°C ≤ T_A ≤ +70°C, and the LM2902 specifications are limited to −40°C ≤ T_A ≤ +85°C.

Note 8: V_O ≃ 1.4V, R_S = 0Ω with V^+ from 5V to 30V; and over the full input common-mode range (0V to V^+ − 1.5V) for LM2902, V^+ from 5V to 26V.

Note 9: The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.

Note 10: The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3V (at 25°C). The upper end of the common-mode voltage range is V^+ − 1.5V (at 25°C), but either or both inputs can go to +32V without damage (+26V for LM2902), independent of the magnitude of V^+.

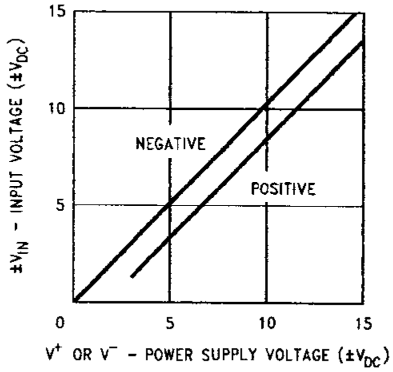
Note 11: Due to proximity of external components, insure that coupling is not originating via stray capacitance between these external parts. This typically can be detected as this type of capacitance increases at higher frequencies.

Note 12: Refer to RETS124AX for LM124A military specifications and refer to RETS124X for LM124 military specifications.

Note 13: Human body model, 1.5 kΩ in series with 100 pF.

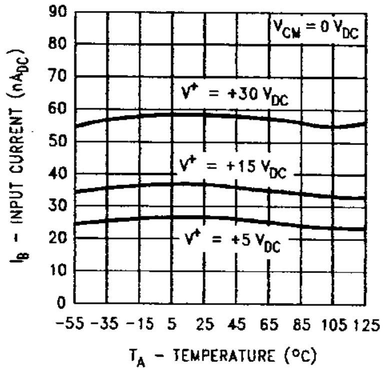
Typical Performance Characteristics

Input Voltage Range



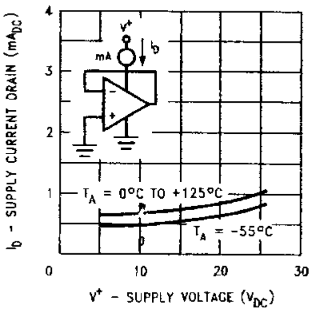
DS009299-34

Input Current



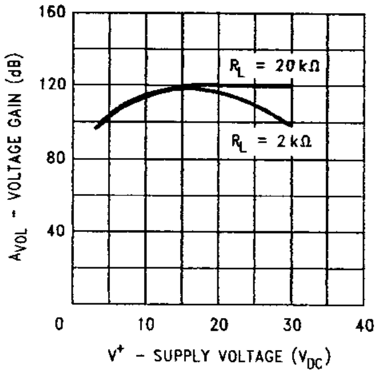
DS009299-35

Supply Current



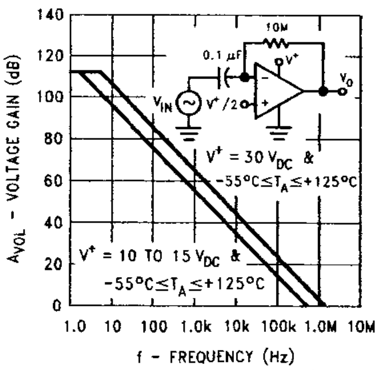
DS009299-36

Voltage Gain



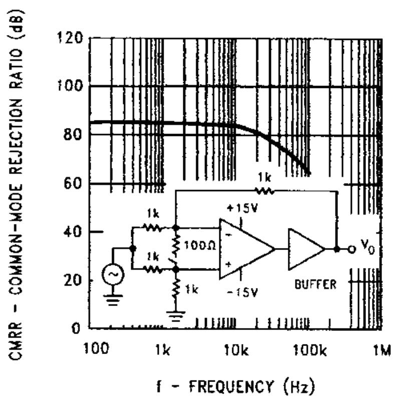
DS009299-37

Open Loop Frequency Response



DS009299-38

Common Mode Rejection Ratio



DS009299-39

BIODATA

Nama	:	Yohanes Pandu A.
NRP	:	5103099059
Tempat, Tgl. Lahir	:	Surabaya, 14–05- 1979
Agama	:	Katolik
Alamat rumah	:	Jl. Mastrip Warugunung IX / 51 Surabaya

Riwayat Pendidikan :

- Tahun 1992 Lulus SDK Indriyasana VII, Surabaya.
- Tahun 1995 Lulus SLTK Santo Yosef, Surabaya.
- Tahun 1998 Lulus SMUK St. Louis II, Surabaya.