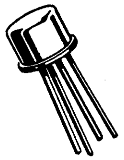
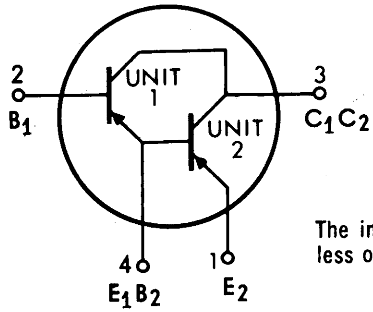
2N4974 (SILICON)
2N4975



CASE 34A
(TO-12)

PNP silicon annular darlington amplifiers contain two PNP silicon annular transistors connected as a darlington amplifier.



The input unit is identified as Unit 1 regardless of terminal numbering.

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

Numerical subscripts refer to unit number

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (Base 1 and Base 2 open)	V_{CE2}	30	Vdc
Collector-Base Voltage	V_{CB1}	40	Vdc
Emitter-Base Voltage	V_{E2B1}	10	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.57	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 14.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Typ	Unit
Thermal Resistance, Junction to Case Output Device Driver Device	θ_{JC}	 60 85	°C/W
Thermal Resistance, Junction to Junction	θ_{JJ}	30	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Numerical subscripts refer to unit number, lead 4 open unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage * (I_C = 10 mAdc, E_2B_1 termination open)	BV_{CE2} *	30	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc)	BV_{CB1O}	40	50	-	Vdc
Emitter-Base Breakdown Voltage (I_{B1} = 10 μAdc)	BV_{E2B1O}	10	12.5	-	Vdc
Collector Cutoff Current (V_{CB1} = 30 Vdc)	I_{CB1O}	-	0.5	10	nAdc
Emitter Cutoff Current (V_{E2B1} = 5.0 Vdc)	I_{E2B1O}	-	0.15	10	nAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				-
(I_C = 1.0 μAdc, V_{CE2} = 5.0 Vdc) 2N4974		5,000	9,000	-	
2N4975		1,000	4,000	-	
(I_C = 1.0 μAdc, V_{CE2} = 5.0 Vdc, T_A = -55°C) 2N4974		-	2,000	-	
2N4975		-	1,000	-	
(I_C = 10 μAdc, V_{CE2} = 5.0 Vdc) 2N4974		10,000	15,000	-	
2N4975		5,000	9,000		
(I_C = 10 μAdc, V_{CE2} = 5.0 Vdc, T_A = -55°C) 2N4974		-	3,500	-	
2N4975		-	2,000	-	
(I_C = 100 μAdc, V_{CE2} = 5.0 Vdc) 2N4974		20,000	30,000	-	
2N4975		10,000	20,000	-	
(I_C = 1.0 mAdc, V_{CE2} = 5.0 Vdc) 2N4974		25,000	50,000	-	
2N4975		15,000	30,000		
(I_C = 10 mAdc, V_{CE2} = 5.0 Vdc)* 2N4974		30,000	60,000	150,000	
2N4975		15,000	30,000	75,000	
(I_C = 10 mAdc, V_{CE2} = 5.0 Vdc, T_A = -55°C)* 2N4974		-	15,000	-	
2N4975		-	10,000	-	
(I_C = 100 mAdc, V_{CE2} = 5.0 Vdc)* 2N4974		25,000	50,000	-	
2N4975		15,000	30,000	-	
(I_C = 500 mAdc, V_{CE2} = 5.0 Vdc)* 2N4974		15,000	25,000	-	
2N4975		5,000	10,000	-	
(I_C = 1.0 Adc, V_{CE2} = 5.0 Vdc)* 2N4974		2,000	4,000	-	
2N4975		1,000	2,000	-	
Collector-Emitter Saturation Voltage * (I_C = 500 mAdc, I_{B1} = 1.0 mAdc)	$V_{CE2(sat)}$*	-	1.4	2.0	Vdc
Base-Emitter Voltage * (I_C = 500 mAdc, I_{B1} = 1.0 mAdc)	V_{B1E2}*	-	2.0	2.7	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE2} = 5.0 Vdc, f = 100 MHz)	f_T	175	275	-	MHz
Output Capacitance (V_{CB1} = 10 Vdc, I_{E2} = 0, f = 140 kHz)	C_{ob1}	-	4.0	8.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}				-
2N4974		25,000	-	-	
2N4975		15,000	-	-	
Noise Figure (I_C = 1.0 mAdc, V_{CB1} = 10 Vdc, R_S = 10 k ohms, BW = 15.7 kHz)	NF	-	3.0	6.0	dB

* Pulse Test: Pulse width ≦ 300 μs, duty cycle ≦ 2%

2N5334 (SILICON)
2N5335

HIGH-SPEED NPN SILICON POWER TRANSISTORS

. . . designed for fast switching and amplifier applications.

- Total Switching Time – 1.15 μs Max
- High Current Switching Specified at 1.0 Adc –
  t_{on} = 100 ns Max
  t_{off} = 1.05 μs Max
- Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.7 Vdc (Max) @ I_C = 2.0 Adc

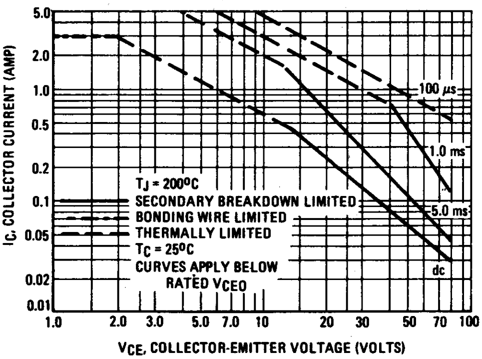
MAXIMUM RATINGS

Rating	Symbol	2N5334	2N5335	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	8.0		Vdc
Collector Current - Continuous	I_C	3.0		Adc
Base Current - Continuous	I_B	0.5		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	6.0 34		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	29.1	°C/W

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA

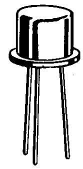


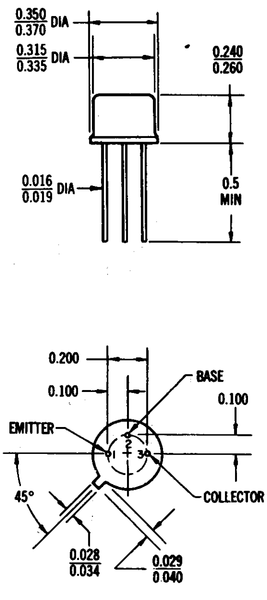
There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \le 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 3. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

3 AMPERE POWER TRANSISTORS

60-80 VOLTS
6 WATTS





TO-39
CASE 79

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 50 mAdc, I_B = 0)	2N5334 2N5335	$BV_{CEO(sus)}$*	60 80	- -	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C) (V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5334 2N5335 2N5334 2N5335	I_{CEX}	- - - -	1.0 1.0 500 500	μAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0)	2N5334 2N5335	I_{CBO}	- -	5.0 5.0	μAdc
Emitter Cutoff Current (V_{BE} = 8.0 Vdc, I_C = 0)		I_{EBO}	-	100	μAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}*	30 15	150 -	-
Collector-Emitter Saturation Voltage* (I_C = 2.0 Adc, I_B = 0.2 Adc)		$V_{CE(sat)}$*	-	0.7	Vdc
Base-Emitter Saturation Voltage* (I_C = 2.0 Adc, I_B = 0.2 Adc)		$V_{BE(sat)}$*	-	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 0.1 Adc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	60	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	75	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	250	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 20 Vdc, $V_{EB(off)}$ = 3.7 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc) (See Figure 2)	t_d	-	50	ns
Rise Time		t_r	-	50	ns
Storage Time		t_s	-	950	ns
Fall Time		t_f	-	100	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – SWITCHING TIME CIRCUIT

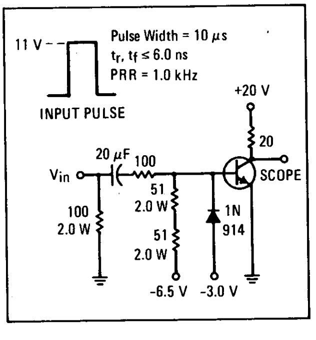
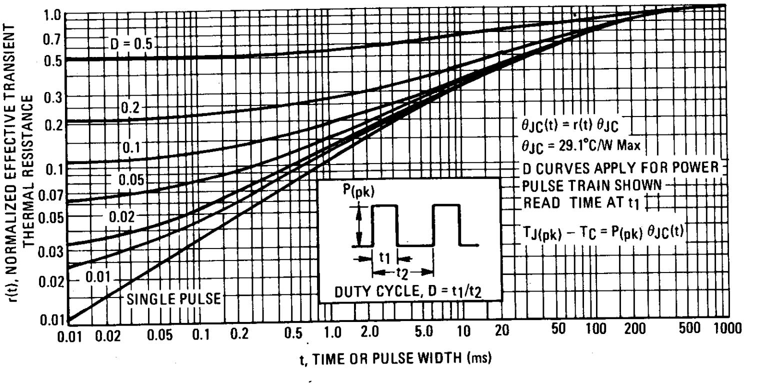


FIGURE 3 – THERMAL RESPONSE

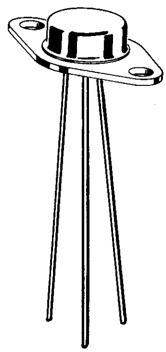


PNP SILICON ANNULAR EPITAXIAL TRANSISTOR

. . . designed for high-voltage, high-speed saturated switching at collector currents of 1 Ampere or below. Ideally suited for inverters, deflection circuits and servo amplifiers.

- High Collector-Emitter Sustaining Voltage — $BV_{CEO(sus)}$ = 300 Vdc (Min) @ I_C = 10 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.3 Vdc (Typ) @ I_C = 500 mAdc
- Fast Turn-On Time — t_{on} = 60 ns (Typ) @ V_{CC} = 100 Vdc, I_C = 1.0 Adc
- Fast Turn-Off Time — t_{off} = 280 ns (Typ) @ V_{CC} = 100 Vdc, I_C = 1.0 Adc

PNP SILICON SWITCHING TRANSISTOR

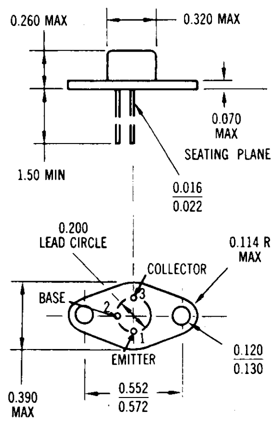


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CB}	300	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current - Continuous	I_C	3.0	Adc
Base Current - Continuous	I_B	1.0	Adc
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	30 240	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	4.16	°C/W

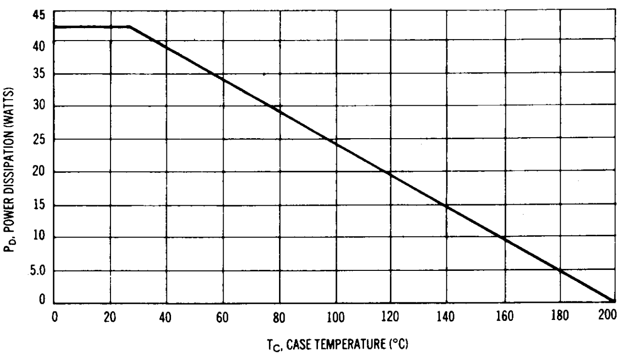


Collector Connected to Case

Case 39

TO-37

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves Are Indicated By Figure 5. All Limits Are Applicable And Must Be Observed.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	$BV_{CEO(sus)}$	300	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	300	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 200 Vdc, $V_{BE(off)}$ = 0.5 Vdc, T_A = 100°C) (V_{CE} = 300 Vdc, $V_{BE(off)}$ = 0.5 Vdc)	I_{CEX}	- -	100 10	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0) (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	- -	100 100	nAdc μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 500 μAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C) (I_C = 500 mAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	45 50 40 20 25 10	- - - - 100 -	-
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{CE(sat)}$	- - -	0.3 1.0 3.0	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{BE(sat)}$	- - -	1.0 1.3 1.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 70 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	50	-	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	60	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	-	600	pF

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 100 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc) (See Figure 2)	t_d	-	50	ns
Rise Time		t_r	-	100	ns
Storage Time	(V_{CC} = 100 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc) (See Figure 2)	t_s	-	600	ns
Fall Time		t_f	-	100	ns

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

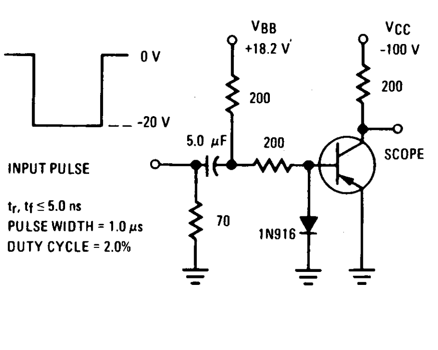


FIGURE 3 – TURN-ON TIME

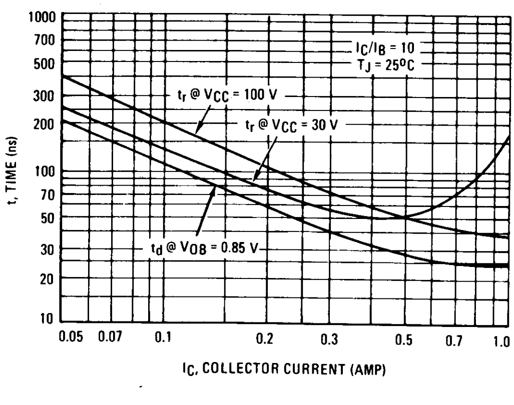


FIGURE 4 – THERMAL RESPONSE

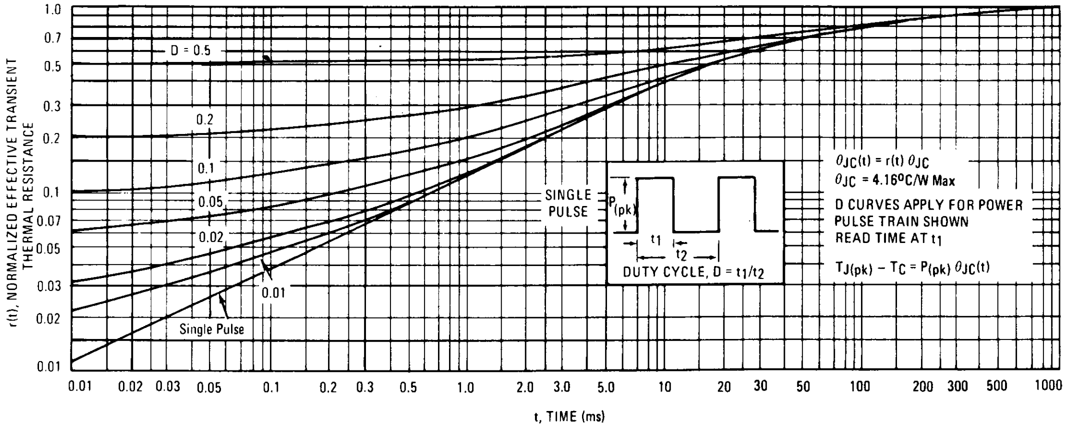
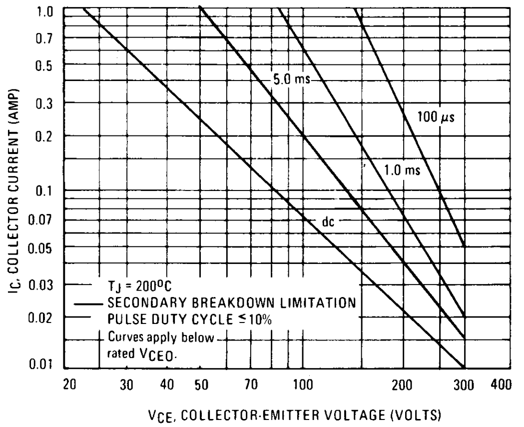


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C—V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200°C$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 – TURN-OFF TIME

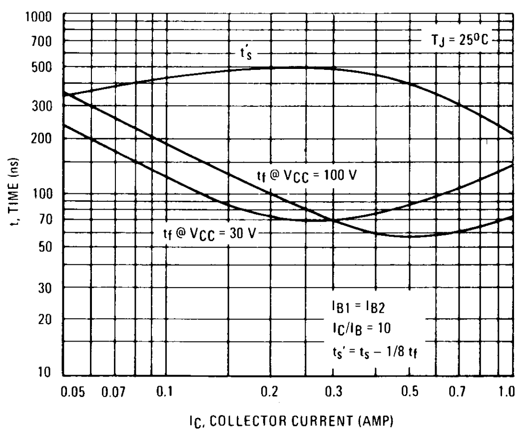
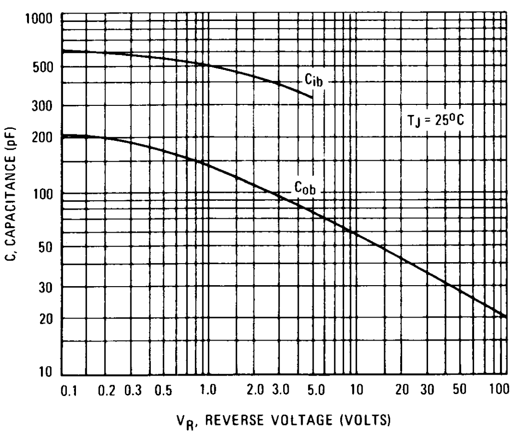


FIGURE 7 – CAPACITANCES



TYPICAL DC CHARACTERISTICS

FIGURE 8 – DC CURRENT GAIN

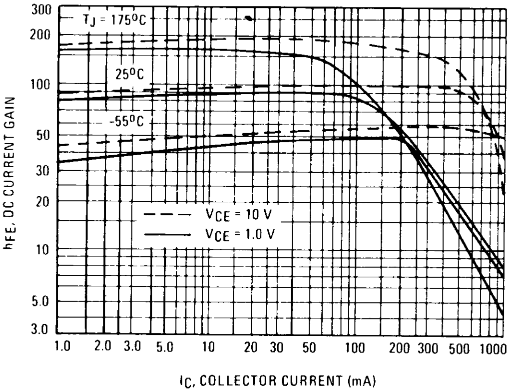


FIGURE 9 – COLLECTOR SATURATION REGION

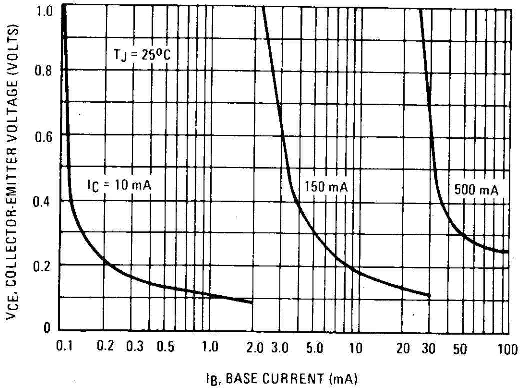


FIGURE 10 – EFFECTS OF BASE-EMITTER RESISTANCE

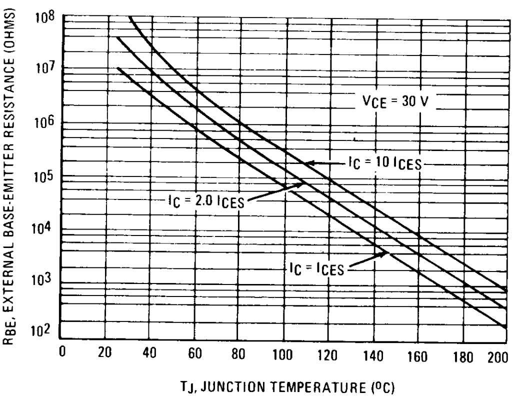


FIGURE 11 – "ON" VOLTAGES

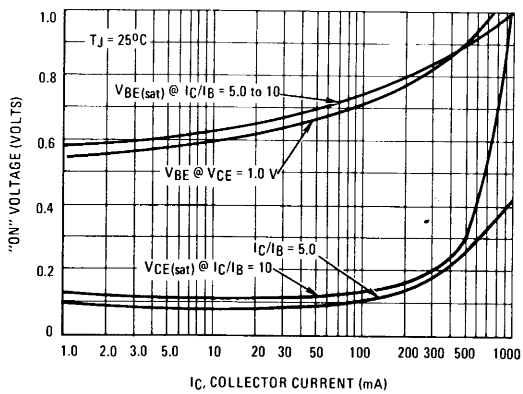


FIGURE 12 – COLLECTOR CUT-OFF REGION

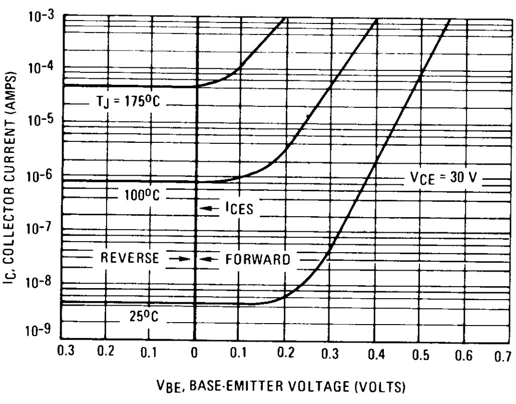
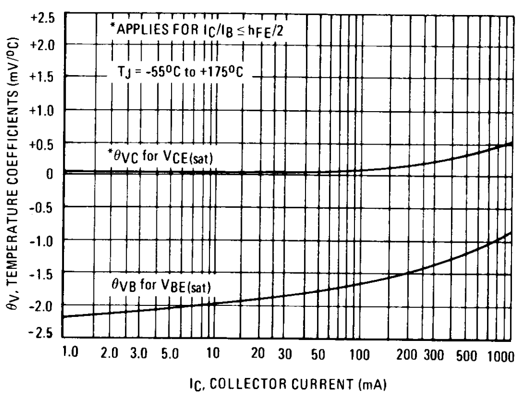


FIGURE 13 – TEMPERATURE COEFFICIENTS



2N5477 (SILICON)
thru
2N5480

MEDIUM-POWER NPN SILICON TRANSISTORS

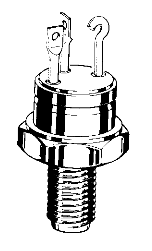
. . . designed for switching and wide-band amplifier applications.

- Low Collector Emitter Saturation Voltage – $V_{CE(sat)} = 1.2$ Vdc (Max) @ $I_C = 7.0$ Adc
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact, High Dissipation TO-59 Case
- Collector Common to Case

7 AMPERE POWER TRANSISTORS

NPN SILICON

80-100 VOLTS
60 WATTS

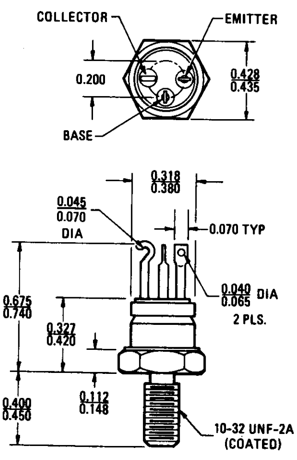


MAXIMUM RATINGS

Rating	Symbol	2N5477 2N5478	2N5479 2N5480	Unit
Collector-Emitter Voltage	V_{CEO}	80	100	Vdc
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous	I_C	7.0		Adc
Base Current - Continuous	I_B	1.0		Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	60 343		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

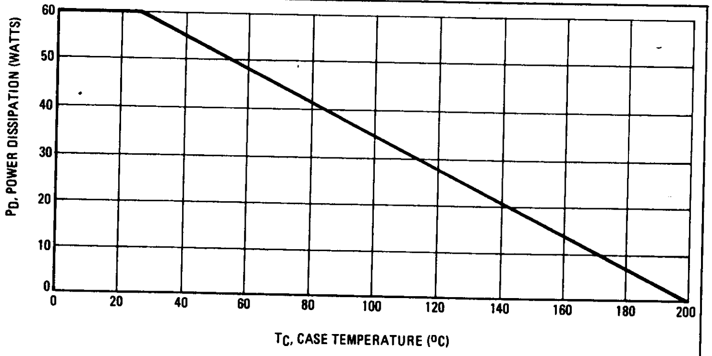
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.91	°C/W



CASE 160 A
(TO-59)

Collector Common To Case

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage* (I_C = 50 mAdc, I_B = 0)	2N5477, 2N5478 2N5479, 2N5480	-	$BV_{CEO(sus)}$*	80 100	- -	Vdc
Collector Cutoff Current (V_{CE} = 75 Vdc, I_B = 0) (V_{CE} = 90 Vdc, I_B = 0)	2N5477, 2N5478 2N5479, 2N5480	-	I_{CEO}	- -	100 100	μAdc
Collector Cutoff Current (V_{CE} = 75 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 75 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C) (V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5477, 2N5478 2N5479, 2N5480 2N5477, 2N5478 2N5479, 2N5480	12	I_{CEX}	- - - -	10 10 1.0 1.0	μAdc mAdc
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)		-	I_{CBO}	-	10	μAdc
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0)		-	I_{EBO}	-	100	μAdc
ON CHARACTERISTICS						
DC Current Gain* (I_C = 500 mAdc, V_{CE} = 2.0 Vdc) (I_C = 2.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N5477, 2N5479 2N5478, 2N5480 2N5477, 2N5479 2N5478, 2N5480 2N5477, 2N5479 2N5478, 2N5480	8	h_{FE}*	30 60 30 60 20 40	- - 120 240 - -	-
Collector-Emitter Saturation Voltage* (I_C = 2.0 Adc, I_B = 0.2 Adc) (I_C = 7.0 Adc, I_B = 0.7 Adc)		9, 11, 13	$V_{CE(sat)}$*	- -	0.7 1.2	Vdc
Base-Emitter Saturation Voltage* (I_C = 2.0 Adc, I_B = 0.2 Adc) (I_C = 7.0 Adc, I_B = 0.7 Adc)		11, 13	$V_{BE(sat)}$*	- -	1.2 2.0	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		-	f_T	30	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		7	C_{ob}	-	250	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		7	C_{ib}	-	1,000	pF
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 40 Vdc, $V_{EB(off)}$ = 3.0 Vdc, I_C = 2.0 Adc, I_{B1} = 200 mAdc)	2,3	t_d	-	100	ns
Rise Time			t_r	-	100	ns
Storage Time	(V_{CC} = 40 Vdc, I_C = 2.0 Adc, I_{B1} = I_{B2} = 200 mAdc)	2,6	t_s	-	2.0	μs
Fall Time			t_f	-	200	ns

* Pulse Test: Pulse Width ≈ 300 μs, Duty Cycle ≈ 2.0%.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

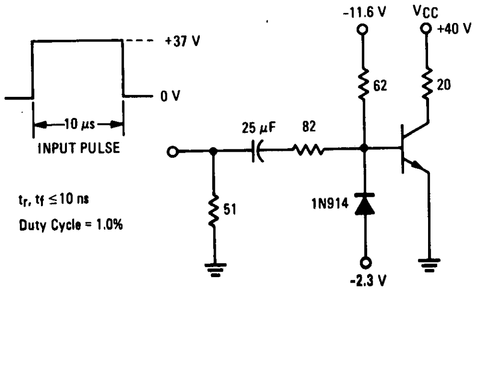


FIGURE 3 – TURN-ON TIME

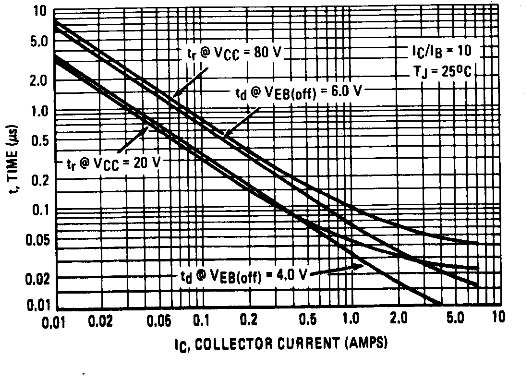


FIGURE 4 – THERMAL RESPONSE

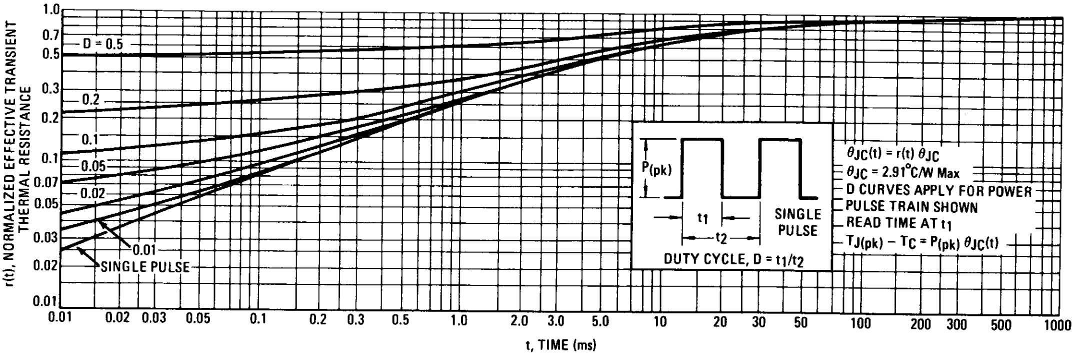
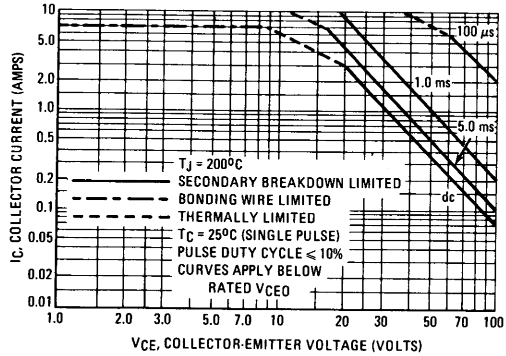


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 – TURN-OFF TIME

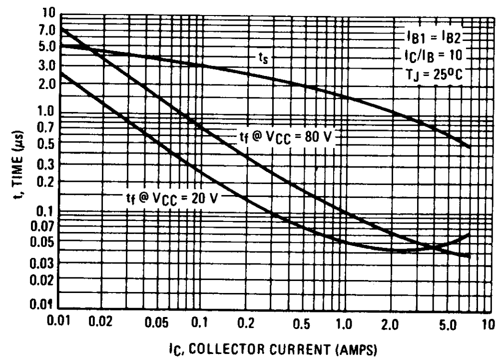


FIGURE 7 – CAPACITANCE versus VOLTAGE

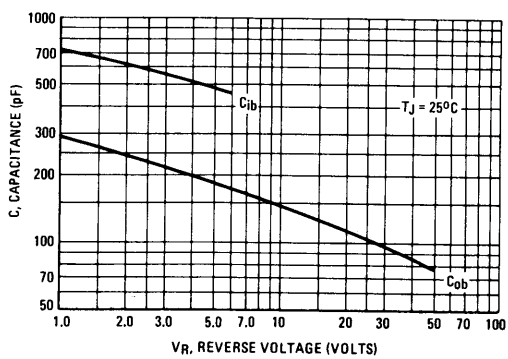


FIGURE 8 – DC CURRENT GAIN

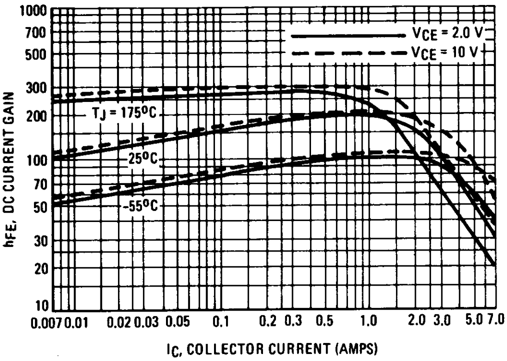


FIGURE 9 – COLLECTOR SATURATION REGION

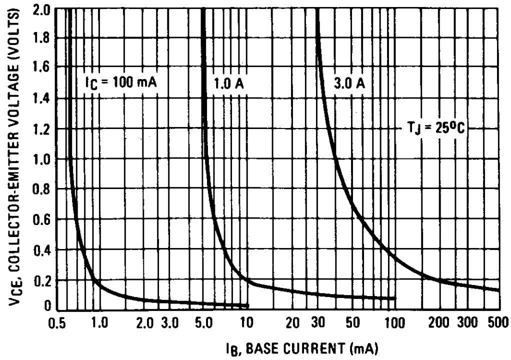


FIGURE 10 – EFFECTS OF BASE EMITTER RESISTANCE

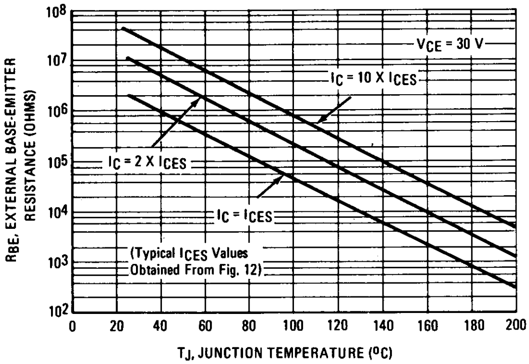


FIGURE 11 – "ON" VOLTAGES

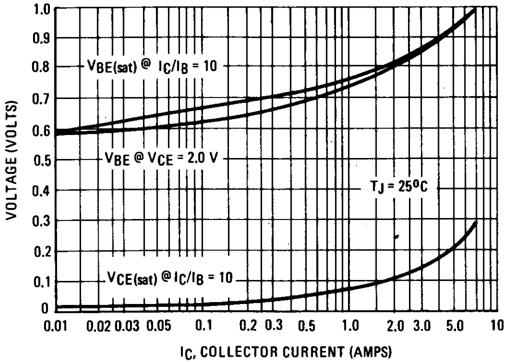


FIGURE 12 – COLLECTOR CUT-OFF REGION

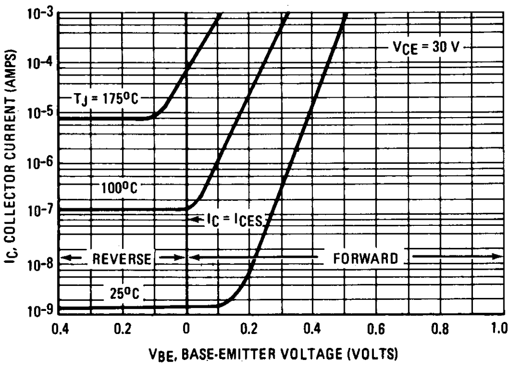
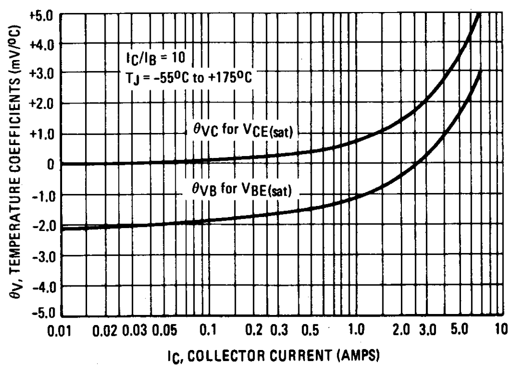
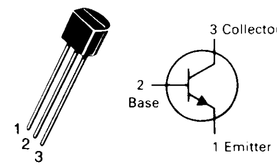


FIGURE 13 – TEMPERATURE COEFFICIENTS



2N6428,A

CASE 29-04, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	50	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc)	I_{CEO}	—	0.025	μA
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	0.01	μA
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	0.01	μA
ON CHARACTERISTICS				
DC Current Gain (V_{CE} = 5.0 Vdc, I_C = 0.01 mAdc) (V_{CE} = 5.0 Vdc, I_C = 0.1 mAdc) (V_{CE} = 5.0 Vdc, I_C = 1.0 mAdc) (V_{CE} = 5.0 Vdc, I_C = 10 mAdc)	h_{FE}	 250 250 250 250	 — 650 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc) (I_C = 100 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 — —	 0.2 0.6	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	0.56	0.66	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 V, f = 100 MHz)	f_T	100	700	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	8.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{ie}	3.0	30	kΩ
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{re}	2.0	20	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	200	800	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{oe}	5.0	50	μmhos

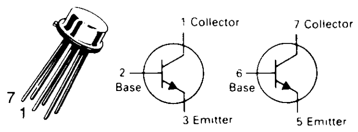
NOISE FIGURE/TOTAL NOISE VOLTAGE CHARACTERISTICS

		NF Max (1)	V_T Max (1)	NF Max (2)	V_T Max (2)	NF Max (3)	V_T Max (3)	Unit	
Noise Figure/Voltage (V_{CE} = 5.0 V, I_C = 0.1 mA, T_A = 25°C)	2N6428	3.0	18.1	6.0	5700	3.5	4.3	dB	nV
	2N6428A	2.0	16.2	4.0	4600	3.0	4.1	dB	nV

(1) R_S = 10 kΩ, BW = 1.0 Hz, f = 100 Hz
(2) R_S = 50 kΩ, BW = 15.7 kHz, f = 10 Hz–10 kHz
(3) R_S = 500 Ω, BW = 1.0 Hz, f = 10 Hz

2N6502

CASE 654-07, STYLE 1



DUAL SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CES}	80		Vdc
Collector-Base Voltage	V_{CBO}	80		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
		One Die	**All Die Equal Power**	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	600 3.42	650 3.7	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.1 12	3.0 17.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	58.3	°C/W
Thermal Resistance, Junction to Ambient(1)	$R_{\theta JA}$	292	270	°C/W
		Junction to Ambient	**Junction to Case**	
Coupling Factor		85	40	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100$ μAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	80	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$)	I_{CBO}	—	1.7	μAdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			—
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		50	150	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)		30	—	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		10	—	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)		—	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)		—	0.5	
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	0.8	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	250	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	—	10	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	—	65	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 30 Vdc, V_{BE} = 3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_{on}	—	35	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	—	60	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

TYPICAL DC CHARACTERISTICS

FIGURE 1 — DC CURRENT GAIN

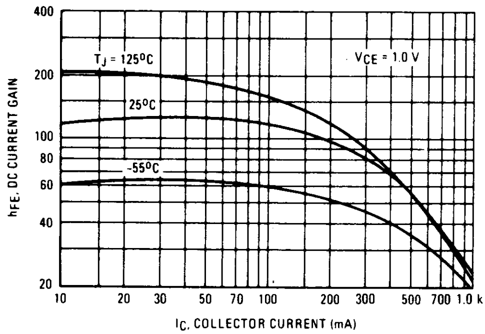


FIGURE 2 — "ON" VOLTAGES

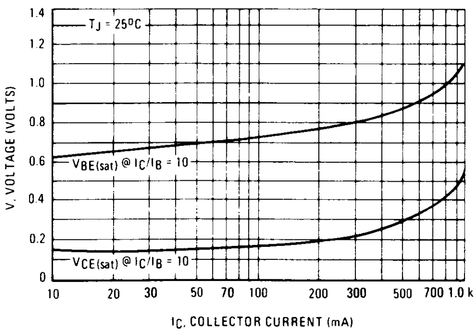


FIGURE 3 – COLLECTOR SATURATION REGION

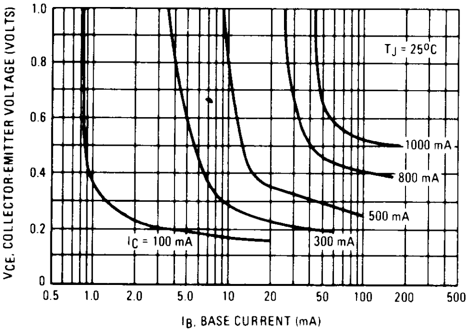
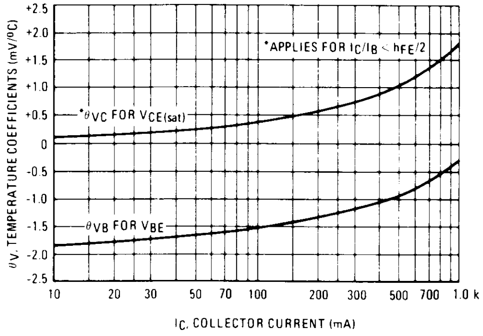


FIGURE 4 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT

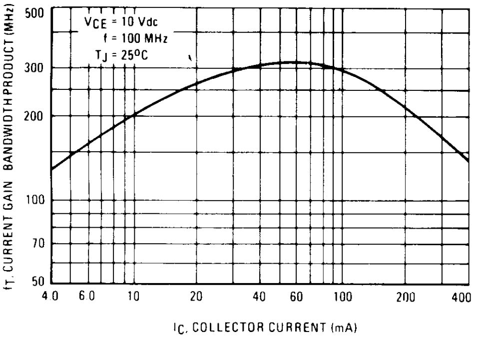


FIGURE 6 – CAPACITANCE

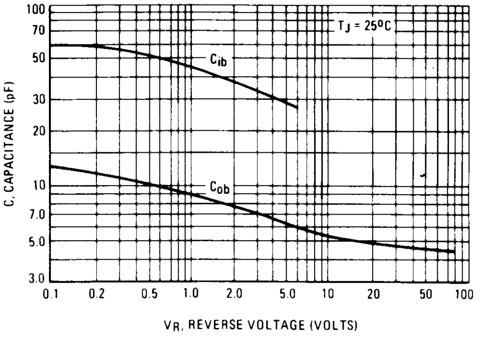


FIGURE 7 – TURN-ON TIME

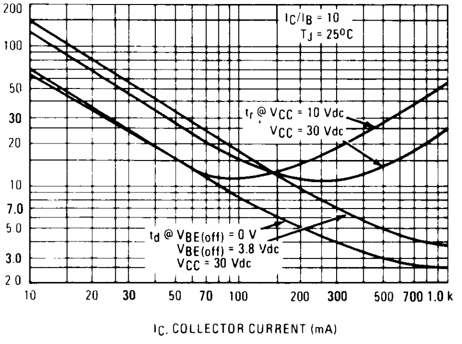


FIGURE 8 – TURN-OFF TIME

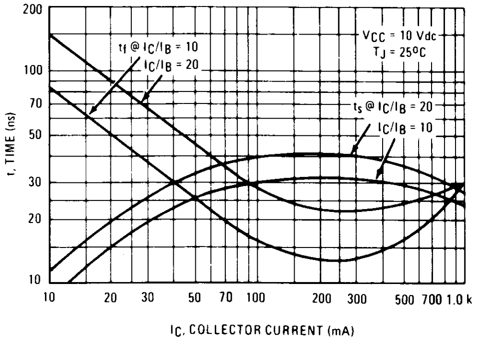


FIGURE 9 – SWITCHING TIME TEST CIRCUIT

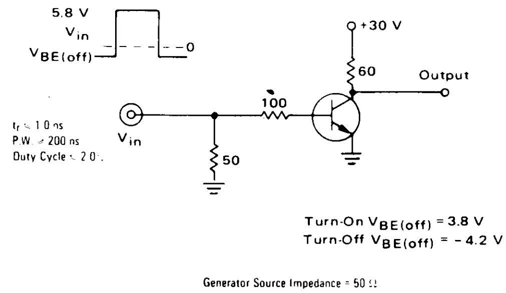
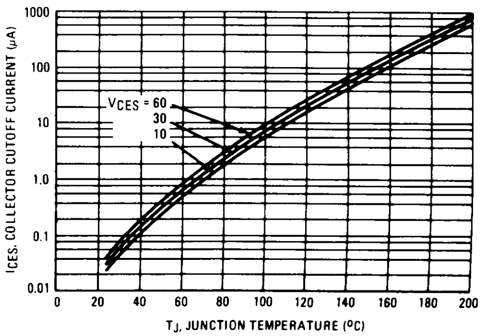


FIGURE 10 – COLLECTOR CUTOFF CURRENT



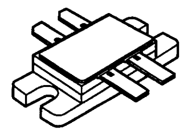
2N6985

The RF Line
NPN Silicon Push-Pull RF Power Transistor

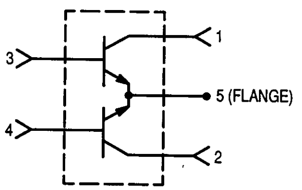
125 W, 30 to 400 MHz
CONTROLLED "Q"
BROADBAND PUSH-PULL
RF POWER TRANSISTOR
NPN SILICON

. . . designed primarily for wideband large-signal output and driver amplifier stages in the 30 to 400 MHz frequency range.

- Specified 28 Volt, 400 MHz Characteristics —
  Output Power = 125 W
  Typical Gain = 10 dB (Class C), 11 dB (Class AB)
  Efficiency = 55% (Typ)
- Hermetic Package to Meet Stringent Environmental Requirements
- Built-In Input Impedance Matching Networks for Broadband Operation
- Push-Pull Configuration Reduces Even Numbered Harmonics
- Gold Metallization System for High Reliability
- 100% Tested for Load Mismatch



CASE 382, STYLE 1



The 2N6985 is two transistors in a single package with separate base and collector leads and emitters common. This arrangement provides the designer with a space saving device capable of operation in a push-pull configuration.

MAXIMUM RATINGS*

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	16	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	270 1.54	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.65	°C/W

NOTE:
1. These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF push-pull amplifiers.

* Indicates JEDEC Registered Data.

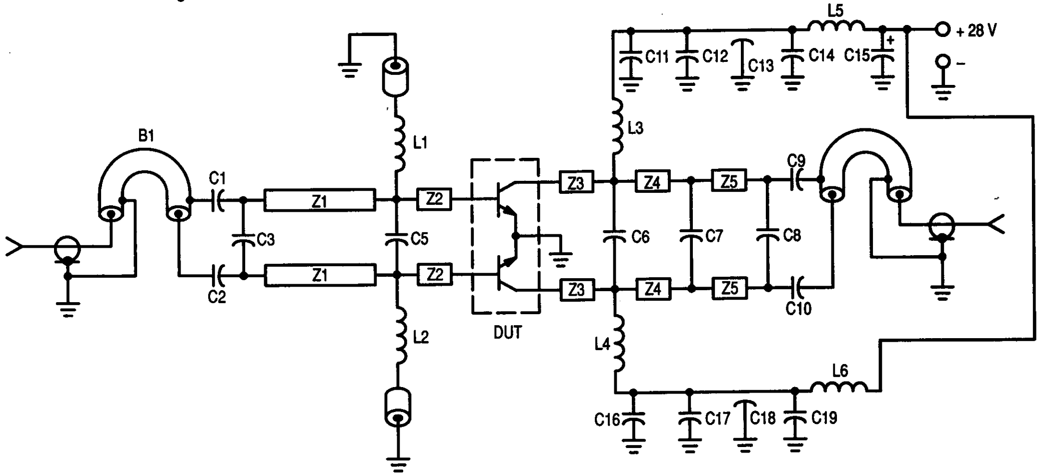
2

ELECTRICAL CHARACTERISTICS* (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (1)					
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	5.0	mAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	100	—
DYNAMIC CHARACTERISTICS (1)					
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	75	115	pF
FUNCTIONAL TESTS (2) — See Figure 1					
Common-Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 125 W, f = 400 MHz)	G_{pe}	8.0	10	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 125 W, f = 400 MHz)	η	50	55	—	%
Load Mismatch (V_{CC} = 28 Vdc, P_{out} = 125 W, f = 400 MHz, VSWR = 30:1, all phase angles)	ψ	No Degradation in Output Power			

NOTES:
1. Each transistor chip measured separately.
2. Both transistor chips operating in push-pull amplifier.

* Indicates JEDEC Registered Data.



C1, C2 — 240 pF, 100 Mil Chip Cap (ATC) or Equivalent
C3 — 4.7 pF, 100 Mil Chip Cap (ATC) or Equivalent
C8 — 12 pF, 100 Mil Chip Cap (ATC) or Equivalent
C5 — 27 pF, 100 Mil Chip Cap (ATC) or Equivalent
C6 — 20 pF, 100 Mil Chip Cap (ATC) or Equivalent
C7 — 12 pF, 100 Mil Chip Cap (ATC) or Equivalent
C9, C10 — 270 pF, 100 Mil Chip Cap (ATC) or Equivalent
C11, C12, C16, C17 — 470 pF 100 Mil Chip Cap (ATC) or Equivalent
C13, C18 — 680 pF Feedthru
C14, C19 — 0.1 μF Erie Redcap or Equivalent
C15 — 20 μF, 50 V
L1, L2 — 0.15 μH Molded Choke With Ferrite Bead
L3, L4 — 2-1/2 Turns #20 AWG, 0.200 ID
L5, L6 — 3-1/2 Turns #18 AWG, 0.200 ID

B1 — Balun, 50 Ω Semi-Rigid Coaxial Cable 86 Mil OD, 2″ L
B2 — Balun, 50 Ω Semi-Rigid Coaxial Cable 86 Mil OD, 2″ L
Z1 — Microstrip Line 650 Mil L x 125 Mil W
Z2 — Microstrip Line 220 Mil L x 125 Mil W
Z3 — Microstrip Line 280 Mil L x 125 Mil W
Z4 — Microstrip Line 300 Mil L x 125 Mil W
Z5 — Microstrip Line 450 Mil L x 125 Mil W
Board Material — 0.06″ Teflon-Fiberglass, ε_r = 2.55, 2 oz. Cu. CLAD, Double Sided

Figure 1. 400 MHz Test Fixture

CLASS C

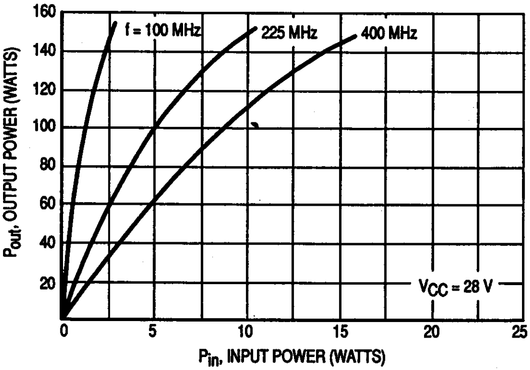


Figure 2. Output Power versus Input Power

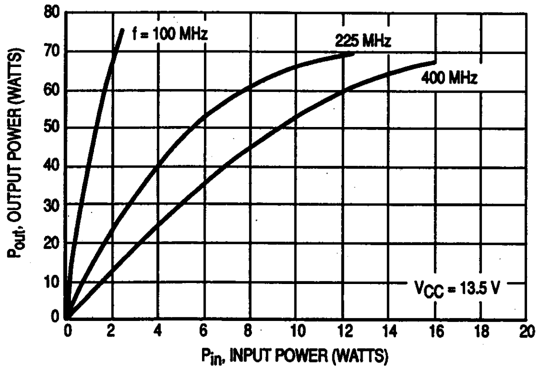


Figure 3. Output Power versus Input Power

CLASS C

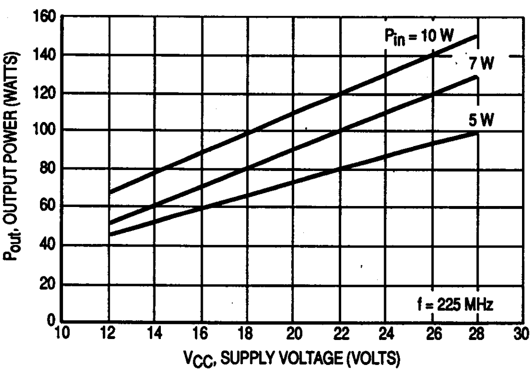


Figure 4. Output Power versus Supply Voltage

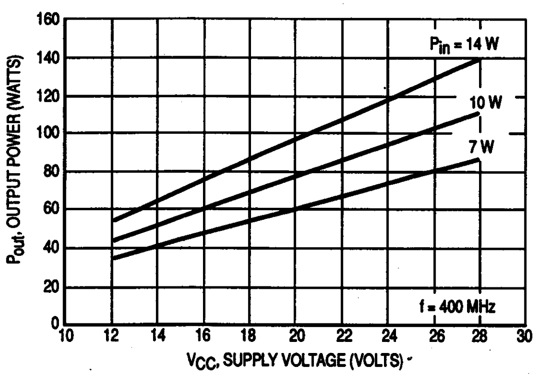


Figure 5. Output Power versus Supply Voltage

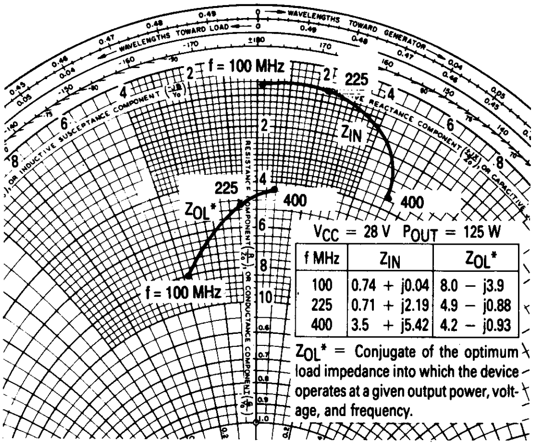


Figure 6. Series Equivalent Input/Output Impedance

Input and output impedances are measured from base to base and collector to collector respectively.

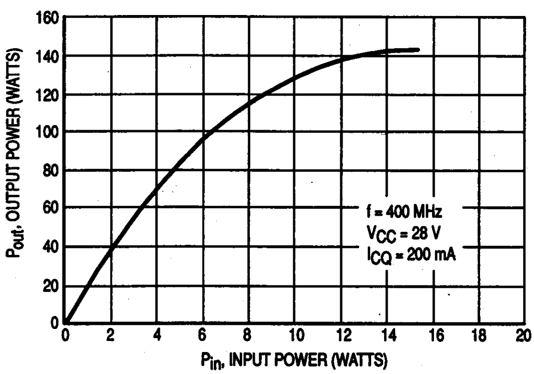


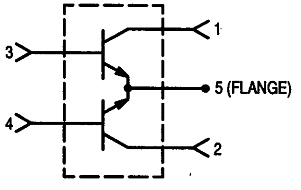
Figure 7. Class AB Output Power versus Input Power

2N6986

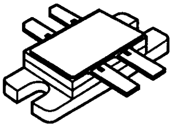
The RF Line
NPN Silicon Push-Pull RF Power Transistor

... designed primarily for wideband large-signal output and driver amplifier stages in the 30 to 500 MHz frequency range.

- Specified 28 Volt, 500 MHz Characteristics —
  Output Power = 100 W
  Typical Gain = 10.3 dB (Class AB); 9.0 dB (Class C)
  Efficiency = 55% (Typ)
- Built-In Input Impedance Matching Networks for Broadband Operation
- Push-Pull Configuration Reduces Even Numbered Harmonics
- Gold Metallization System for High Reliability
- 100% Tested for Load Mismatch
- Hermetic Package to Meet Stringent Environmental Requirements



100 W, 30 to 500 MHz
CONTROLLED "Q"
BROADBAND PUSH-PULL
RF POWER TRANSISTOR
NPN SILICON



CASE 382, STYLE 1

The 2N6986 is two transistors in a single package with separate base and collector leads and emitters common. This arrangement provides the designer with a space saving device capable of operation in a push-pull configuration.

MAXIMUM RATINGS*

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	16	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	270 1.54	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.65	°C/W

NOTE:
1. These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF push-pull amplifiers.

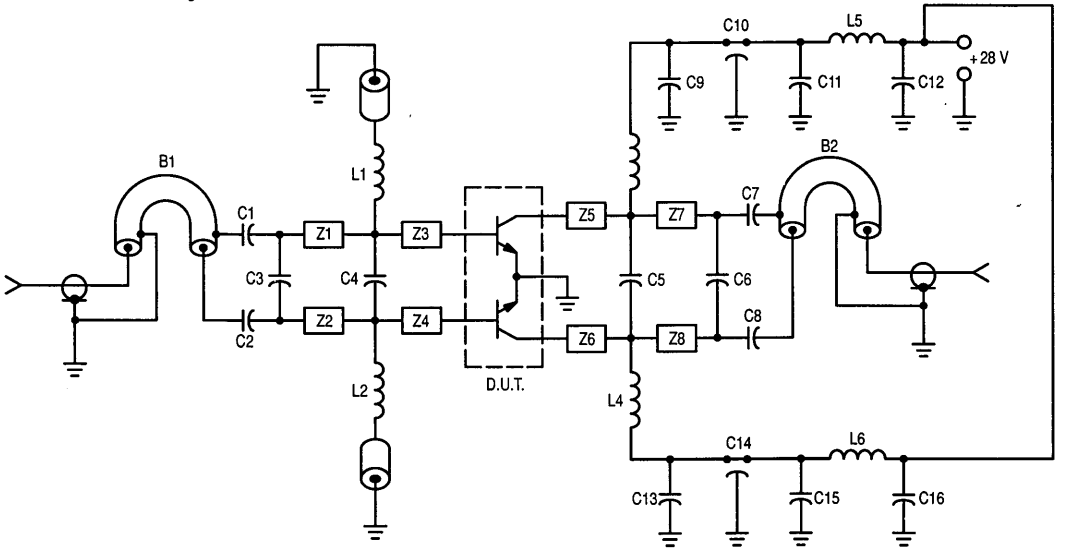
* Indicates JEDEC Registered Data.

ELECTRICAL CHARACTERISTICS* (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (1)					
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	5.0	mAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	100	—
DYNAMIC CHARACTERISTICS (1)					
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	75	115	pF
FUNCTIONAL TESTS (2) — See Figure 1					
Common-Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 100 W, f = 500 MHz)	G_{pe}	7.5	9.0	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 100 W, f = 500 MHz)	η	50	55	—	%
Load Mismatch (V_{CC} = 28 Vdc, P_{out} = 100 W, f = 500 MHz, VSWR = 30:1, all phase angles)	ψ	No Degradation in Output Power			

NOTES:
1. Each transistor chip measured separately.
2. Both transistor chips operating in push-pull amplifier.

* Indicates JEDEC Registered Data.



C1, C2, C7, C8 — 240 pF 100 mil Chip Cap
C3 — 12 pF 100 mil Chip Cap
C4 — 10 pF 100 mil Chip Cap
C5 — 36 pF 100 mil Chip Cap
C6 — 12 pF 100 mil Chip Cap
C9, C13 — 1000 pF 100 mil Chip Cap
C10, C14 — 680 pF Feedthru Cap
C11, C15 — 0.1 µF Ceramic Disc Cap
C12, C16 — 50 µF 50 V

L1, L2 — 0.15 µH Molded Choke with Ferrite Bead
L3, L4 — 2-1/2 Turns #20 AWG 0.200″ ID
L4, L5, L6 — 3-1/2 Turns #18 AWG 0.200″ ID
B1, B2 — Balun 50 Ω Semi Rigid Coax, 86 mil OD, 2″ Long
Z1, Z2 — 450 mil Long x 125 mil W. Microstrip
Z3, Z4 — 340 mil Long x 125 mil W. Microstrip
Z5, Z6 — 280 mil Long x 125 mil W. Microstrip
Z7, Z8 — 600 mil Long x 125 mil W. Microstrip
Board Material — 0.03″ Teflon-Fiberglass, ε_r = 2.55, 2 oz. Copper Clad both sides.

Figure 1. 500 MHz Test Fixture

CLASS C

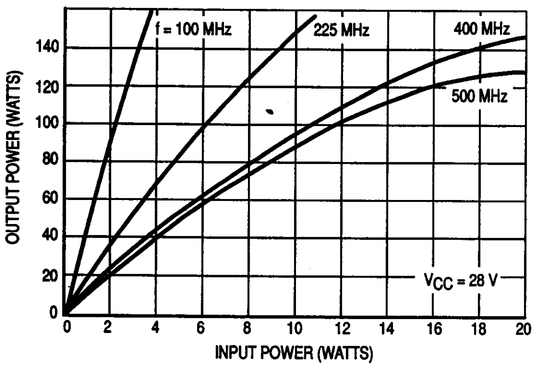


Figure 2. Output Power versus Input Power

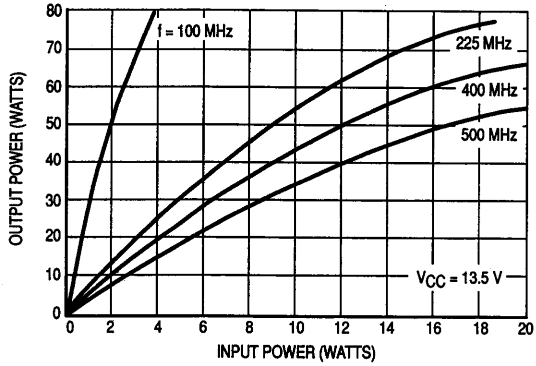


Figure 3. Output Power versus Input Power

CLASS C

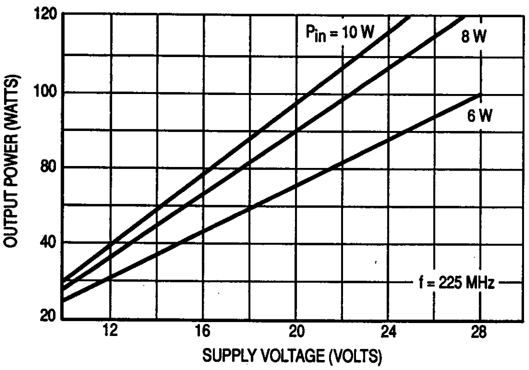


Figure 4. Output Power versus Supply Voltage

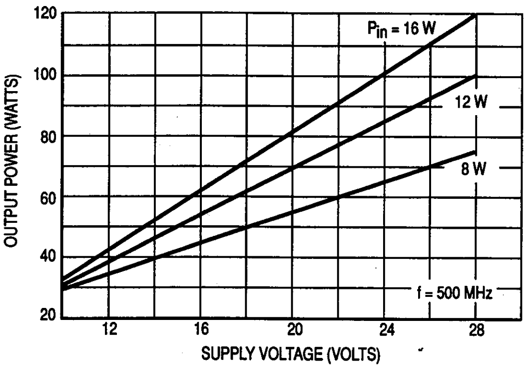
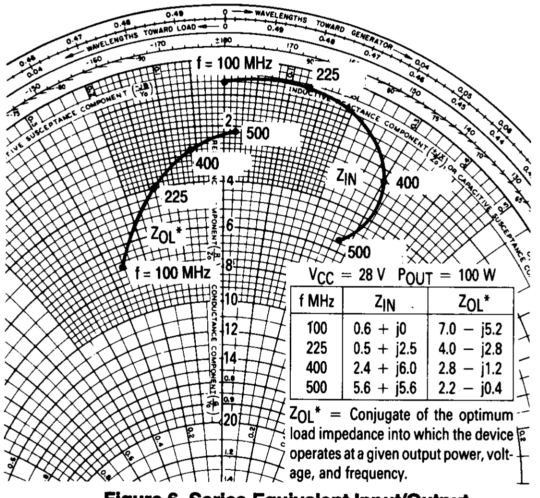


Figure 5. Output Power versus Supply Voltage



f MHz	Z_{IN}	Z_{OL}*
100	0.6 + j0	7.0 − j5.2
225	0.5 + j2.5	4.0 − j2.8
400	2.4 + j6.0	2.8 − j1.2
500	5.6 + j5.6	2.2 − j0.4

Figure 6. Series Equivalent Input/Output Impedance

Input and output impedances are measured from base to base and collector to collector respectively.

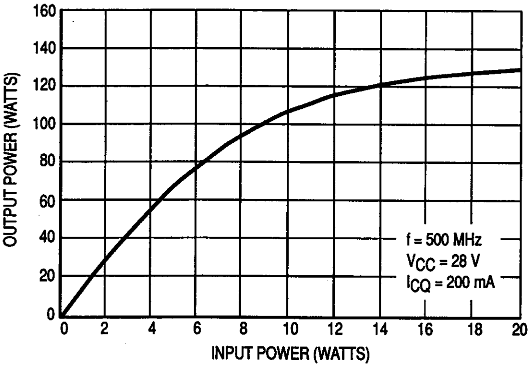


Figure 7. Class AB Output Power versus Input Power