MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

MJ12020
MJ12021
MJ12022

Designer's Data Sheet

5.0, 8.0 and 15 AMPERE

NPN SILICON DEFLECTION POWER TRANSISTORS

850 VOLTS
125, 150 and 175 WATTS

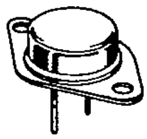
HIGH PERFORMANCE NPN DEFLECTION TRANSISTORS

These transistors are designed for high resolution video systems, such as, high density graphic displays, data terminals, video scanners . . . wherever high frequency deflection is required.

- Fast Turn-Off Times
- Maximum Storage and Fall Times Specified at 100°C
- Operating Junction Temperature Range -65°C to +200°C
- High f_T of 15 MHz

Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design.



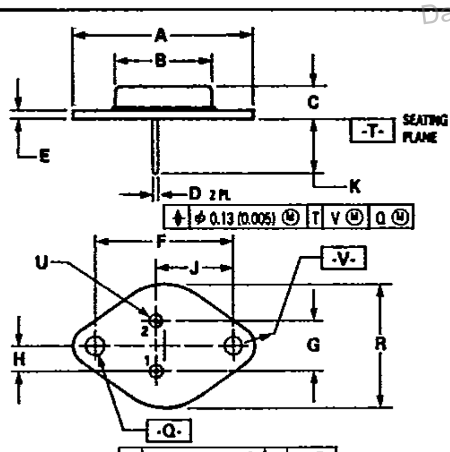
MAXIMUM RATINGS

Rating	Symbol	MJ12020	MJ12021	MJ12022	Unit
Collector-Emitter Voltage	V_{CEO}	450			Vdc
Collector-Emitter Voltage	V_{CEV}	850			Vdc
Emitter Base Voltage	V_{EB}	6.0			Vdc
Collector Current — Continuous — Peak (1)	I_C I_{CM}	5.0 10	8.0 16	15 20	Adc
Base Current — Continuous — Peak (1)	I_B I_{BM}	4.0 8.0	6.0 12	10 15	Adc
Total Power Dissipation @ T_C = 25°C @ T_C = 100°C Derate above 25°C	P_D	 125 71.5 0.714	 150 85.5 0.86	 175 100 1.0	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	MJ12020	MJ12021	MJ12022	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.4	1.17	1.0	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	T_L	275			°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. ALL RULES AND NOTES ASSOCIATED WITH REFERENCED TO 204AA OUTLINE SHALL APPLY.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	—	39.37	—	1.550
B	—	21.08	—	0.830
C	6.35	8.25	0.250	0.325
D	0.97	1.09	0.038	0.043
E	1.40	1.77	0.055	0.070
F	30.15 BSC		1.187 BSC	
G	10.92 BSC		0.430 BSC	
H	5.46 BSC		0.215 BSC	
J	16.89 BSC		0.665 BSC	
K	11.18	12.19	0.440	0.480
Q	3.84	4.19	0.151	0.165
R	—	26.67	—	1.050
U	4.83	5.33	0.190	0.210
V	3.84	4.19	0.151	0.165

STYLE 1:
PIN 1. BASE
2. EMITTER
CASE COLLECTOR

CASE 1-06
TO-204AA
(TO-3)

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (1)						
Collector-Emitter Sustaining Voltage (Table 1) (I_C = 100 mA, I_B = 0)		$V_{CEO(sus)}$	450	—	—	Vdc
Collector Cutoff Current		I_{CEV}				mAdc
(V_{CEV} = 850 Vdc, $V_{BE(off)}$ = 1.5 Vdc)			—	—	0.25	
(V_{CEV} = 850 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 100°C)			—	—	1.5	
Collector Cutoff Current (V_{CE} = 850 Vdc, R_{BE} = 50 Ω, T_C = 100°C)		I_{CER}	—	—	2.5	mAdc
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)		I_{EBO}	—	—	1.0	mAdc
SECOND BREAKDOWN						
Second Breakdown Collector Current with Base Forward Biased		$I_{S/b}$	See Figures 19, 21 or 23			
Turn-Off SOA with Base Reverse Biased		RBSOA	See Figures 20, 22 or 24			
ON CHARACTERISTICS (1)						
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 3.0 Adc, I_B = 0.6 Adc)	MJ12020		—	—	1.2	
(I_C = 5.0 Adc, I_B = 1.0 Adc)	MJ12021		—	—	1.2	
(I_C = 10 Adc, I_B = 2.0 Adc)	MJ12022		—	—	1.2	
Base Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 3.0 Adc, I_B = 0.6 Adc)	MJ12020		—	—	1.5	
(I_C = 5.0 Adc, I_B = 1.0 Adc)	MJ12021		—	—	1.5	
(I_C = 10 Adc, I_B = 2.0 Adc)	MJ12022		—	—	1.5	
DC Current Gain		h_{FE}				—
(I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)	MJ12020		5.0	—	—	
(I_C = 8.0 Adc, V_{CE} = 5.0 Vdc)	MJ12021		5.0	—	—	
(I_C = 15 Adc, V_{CE} = 5.0 Vdc)	MJ12022		5.0	—	—	
DYNAMIC CHARACTERISTICS						
Current Gain Bandwidth Product		f_T				MHz
(I_C = 0.3 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	MJ12020		15	—	—	
(I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	MJ12021		15	—	—	
(I_C = 1.3 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	MJ12022		15	—	—	
Output Capacitance		C_{ob}				pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 kHz)	MJ12020		—	—	200	
	MJ12021		—	—	350	
	MJ12022		—	—	400	

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

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

Characteristic			Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS							
MJ12020							
Inductive Switching, Clamped Drive							
Storage Time	(I_C = 3.0 Adc, I_B = 0.6 Adc, V_{CC} = 40 Vdc, $V_{BE(off)}$ = 4.0 Vdc, Pulse Width = 8.0 μs, Duty Cycle ≤ 2%) See Table 1	T_J = 25°C	t_s	—	440	1200	ns
Fall Time			t_f	—	130	300	
Storage Time		T_J = 100°C	t_s	—	550	1500	
Fall Time			t_f	—	200	500	
Inductive Switching, Series Base Inductance							
Fall Time (I_C = 3.0 Adc, I_B = 0.6 Adc, L_B = 24 μH) See Table 2			t_f	—	175	—	ns
MJ12021							
Inductive Switching, Clamped Drive							
Storage Time	(I_C = 5.0 Adc, I_B = 1.0 Adc, V_{CC} = 60 Vdc, $V_{BE(off)}$ = 4.0 Vdc, Pulse Width = 8.0 μs, Duty Cycle ≤ 2%) See Table 1	T_J = 25°C	t_s	—	550	1200	ns
Fall Time			t_f	—	100	300	
Storage Time		T_J = 100°C	t_s	—	750	1600	
Fall Time			t_f	—	180	500	
Inductive Switching, Series Base Inductance							
Fall Time (I_C = 5.0 Adc, I_B = 1.0 Adc, L_B = 24 μH) See Table 2			t_f	—	300	—	ns
MJ12022							
Inductive Switching, Clamped Drive							
Storage Time	(I_C = 10 Adc, I_B = 2.0 Adc, V_{CC} = 120 Vdc, $V_{BE(off)}$ = 4.0 Vdc, Pulse Width = 8.0 μs, Duty Cycle ≤ 2%) See Table 1	T_J = 25°C	t_s	—	820	1800	ns
Fall Time			t_f	—	100	300	
Storage Time		T_J = 100°C	t_s	—	1100	2500	
Fall Time			t_f	—	130	400	
Inductive Switching, Series Base Inductance							
Fall Time (I_C = 10 Adc, I_B = 2.0 Adc, L_B = 24 μH) See Table 2			t_f	—	350	—	ns

TYPICAL ELECTRICAL CHARACTERISTICS

MJ12020

FIGURE 1 — DC CURRENT GAIN

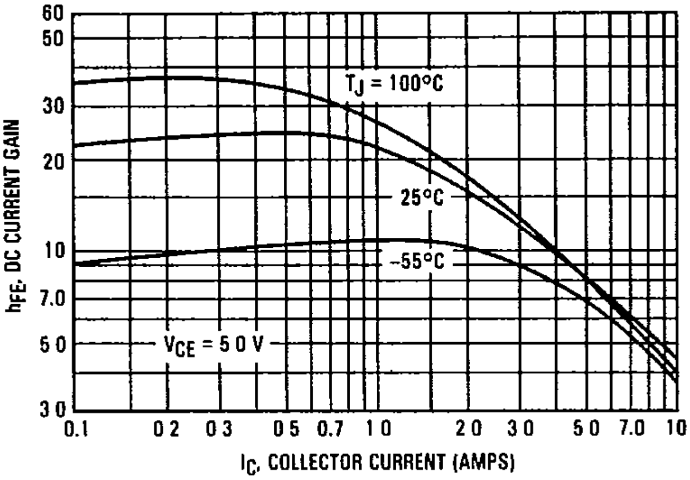
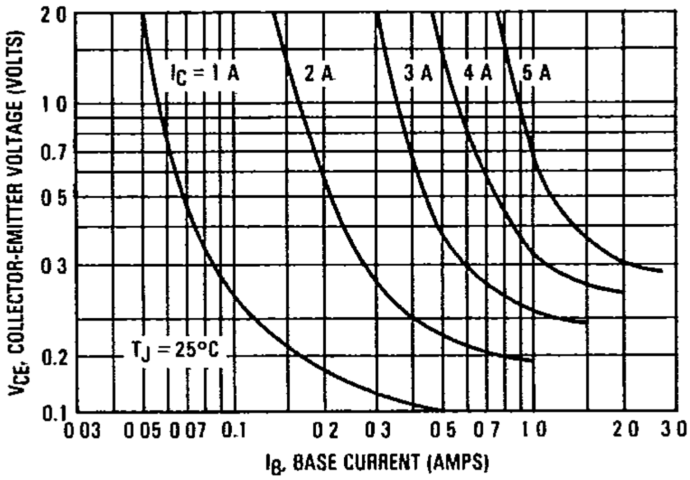


FIGURE 2 — COLLECTOR SATURATION REGION



MJ12021

FIGURE 3 — DC CURRENT GAIN

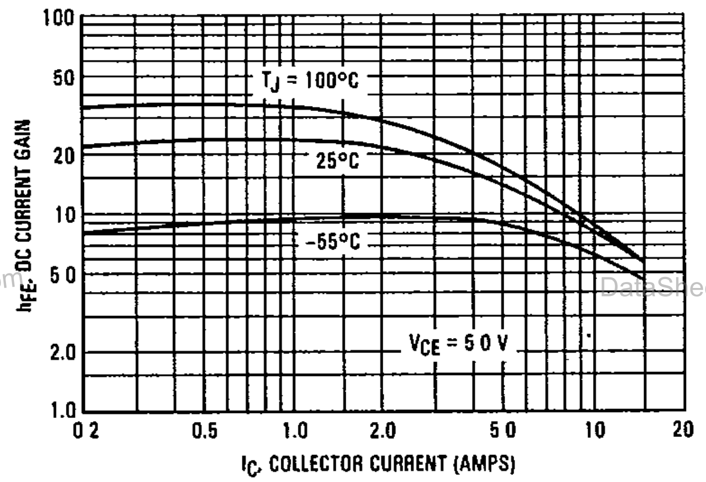
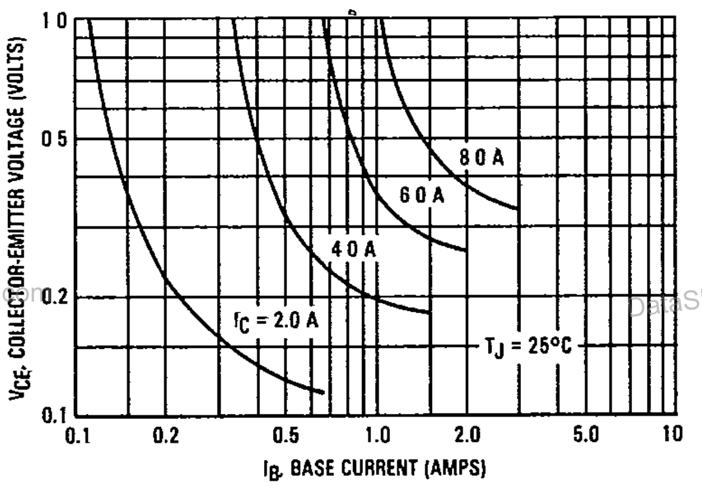


FIGURE 4 — COLLECTOR SATURATION REGION



MJ12022

FIGURE 5 — DC CURRENT GAIN

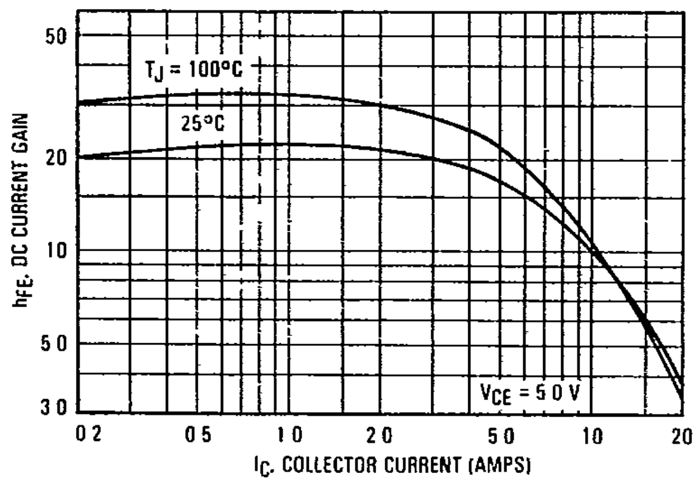
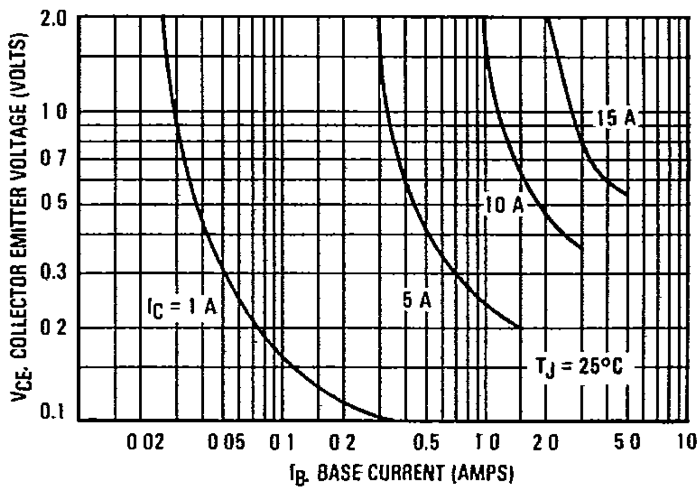


FIGURE 6 — COLLECTOR SATURATION REGION



TYPICAL ELECTRICAL CHARACTERISTICS

MJ12020

FIGURE 7 — COLLECTOR-EMITTER SATURATION VOLTAGE

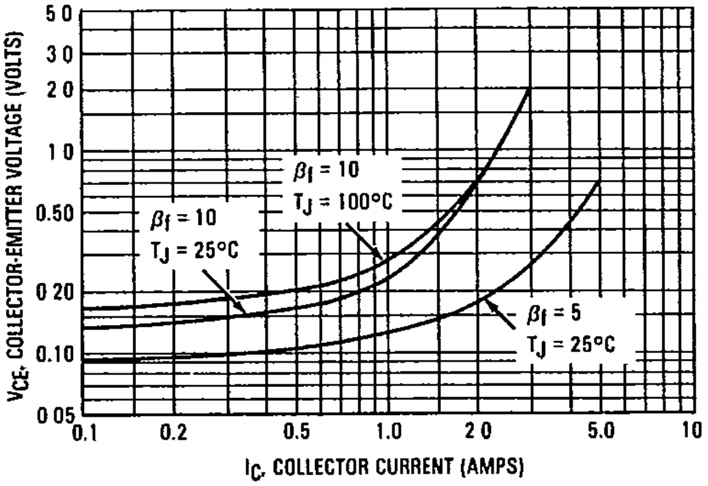
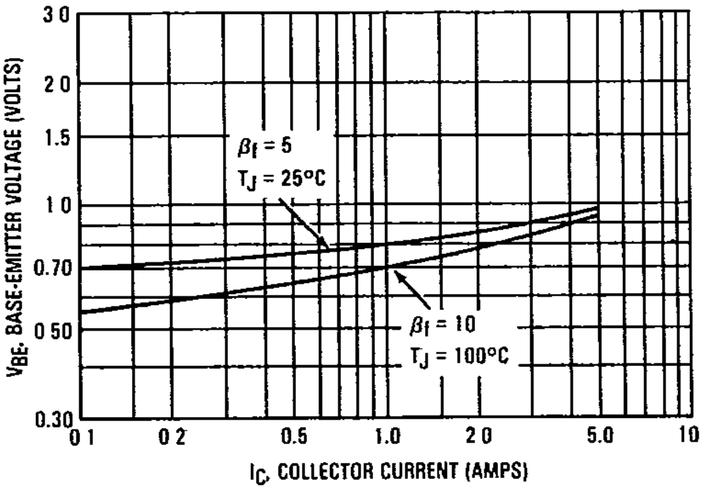


FIGURE 8 — BASE-EMITTER VOLTAGE



MJ12021

FIGURE 9 — COLLECTOR-EMITTER SATURATION VOLTAGE

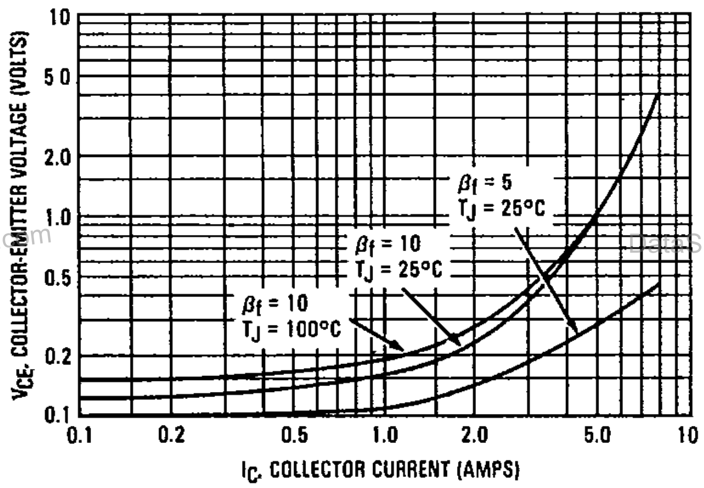
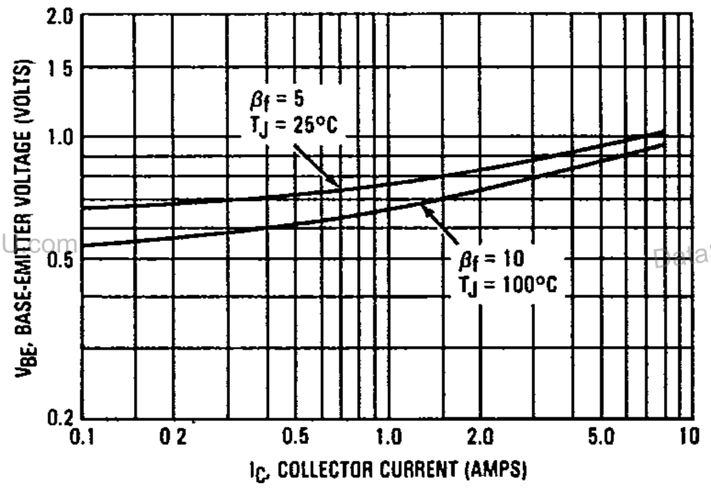


FIGURE 10 — BASE-EMITTER VOLTAGE



MJ12022

FIGURE 11 — COLLECTOR-EMITTER SATURATION VOLTAGE

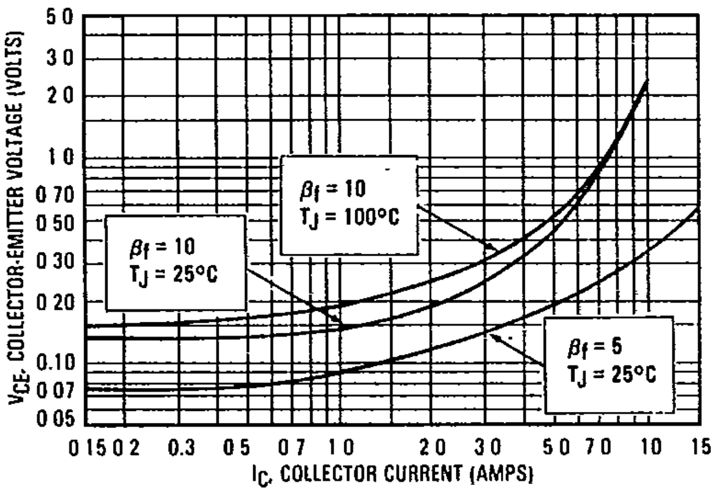
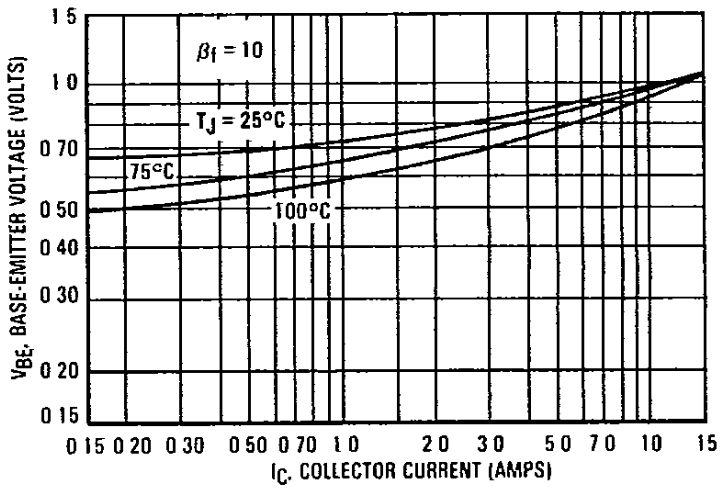


FIGURE 12 — BASE-EMITTER VOLTAGE



TYPICAL DYNAMIC CHARACTERISTICS

MJ12020

FIGURE 13 — STORAGE TIME

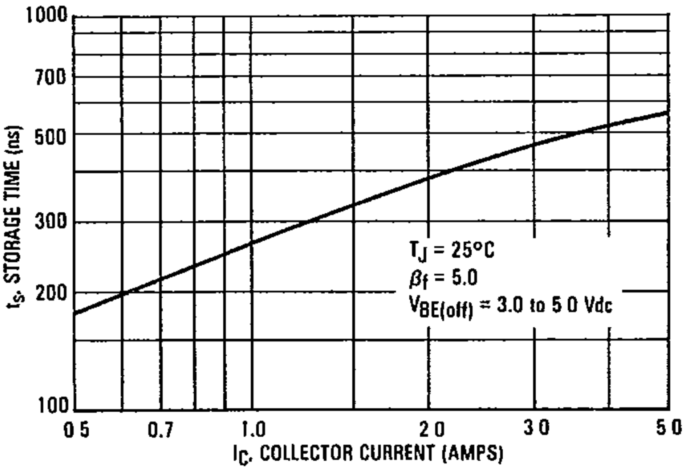
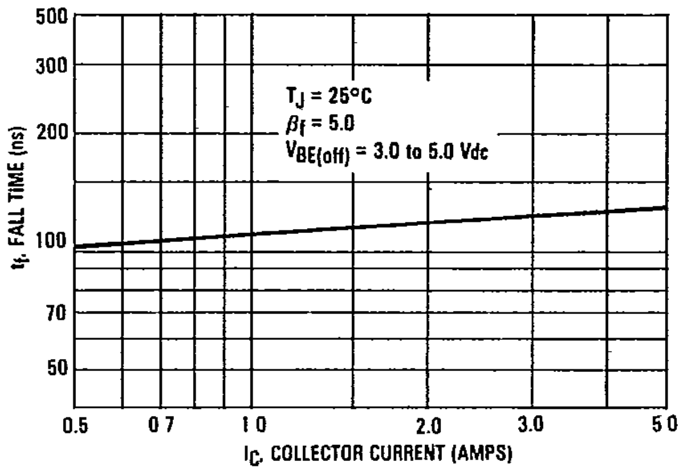


FIGURE 14 — FALL TIME



MJ12021

FIGURE 15 — STORAGE TIME

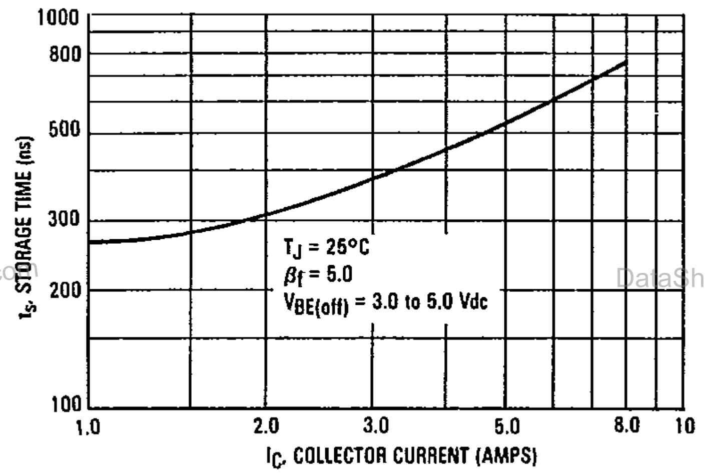
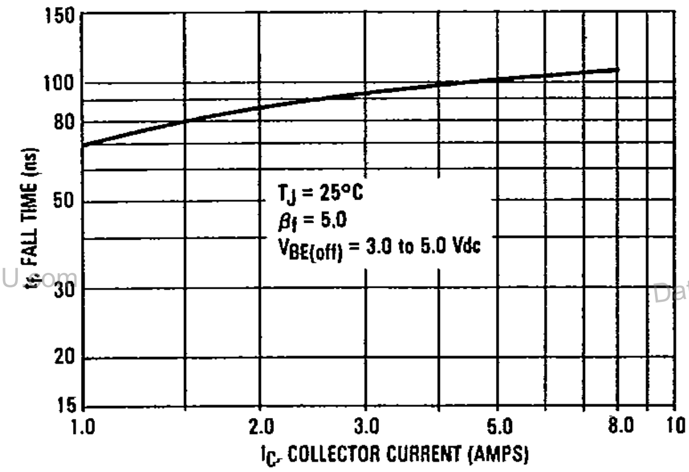


FIGURE 16 — FALL TIME



MJ12022

FIGURE 17 — STORAGE TIME

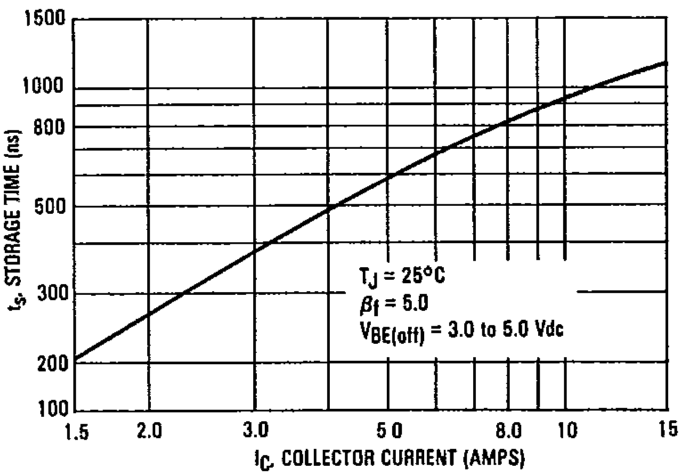
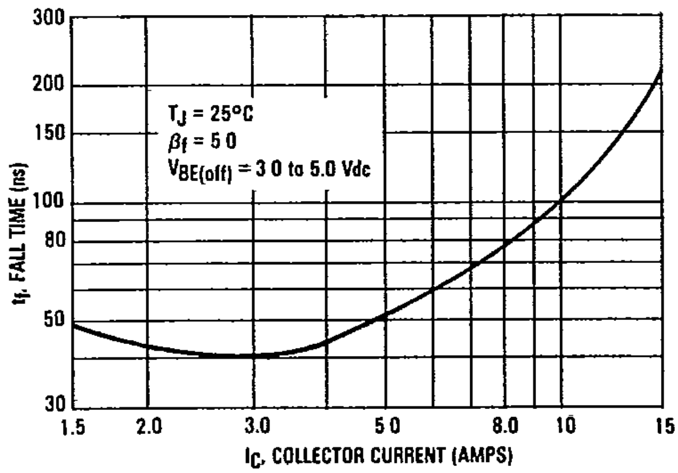


FIGURE 18 — FALL TIME



SAFE OPERATING AREA INFORMATION

MJ12020

FIGURE 19 — MAXIMUM RATED FORWARD BIAS SAFE OPERATING AREA

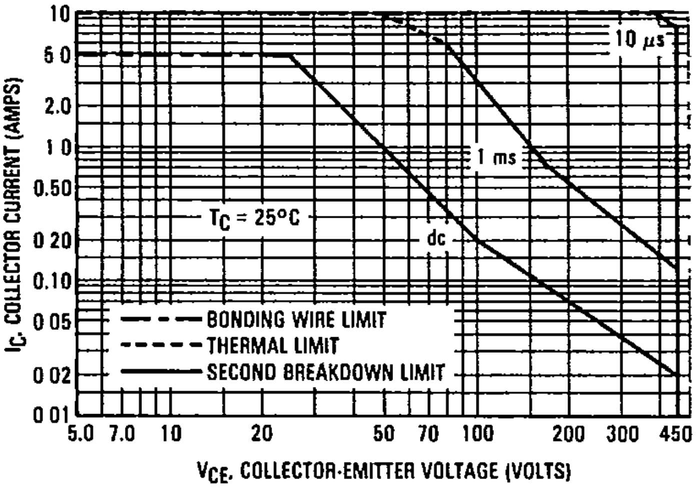
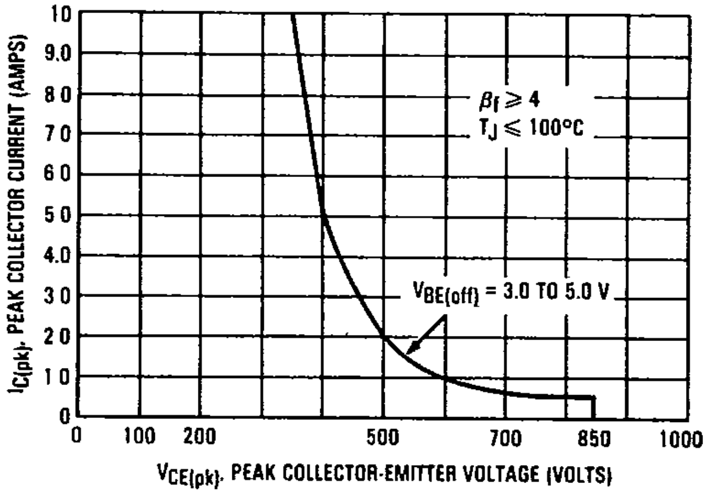


FIGURE 20 — MAXIMUM RATED TURN-OFF SAFE OPERATING AREA



MJ12021

FIGURE 21 — MAXIMUM RATED FORWARD BIAS SAFE OPERATING AREA

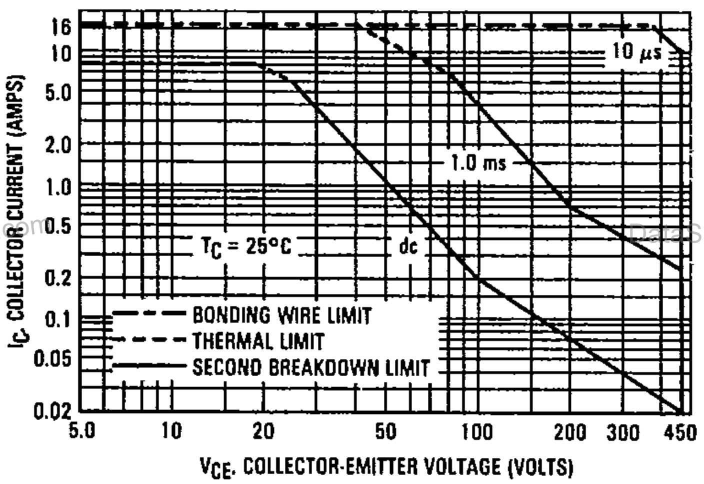
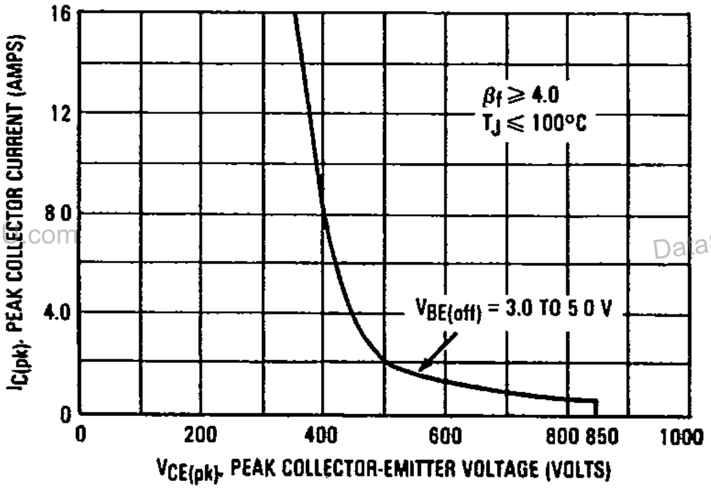


FIGURE 22 — MAXIMUM RATED TURN-OFF SAFE OPERATING AREA



MJ12022

FIGURE 23 — MAXIMUM RATED FORWARD BIAS SAFE OPERATING AREA

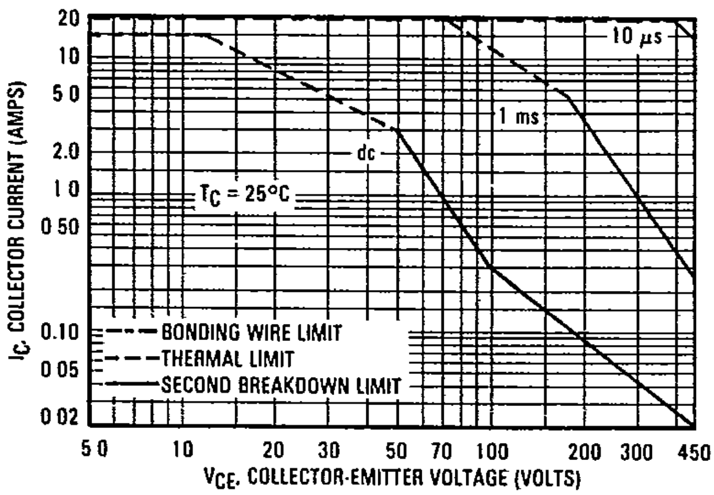
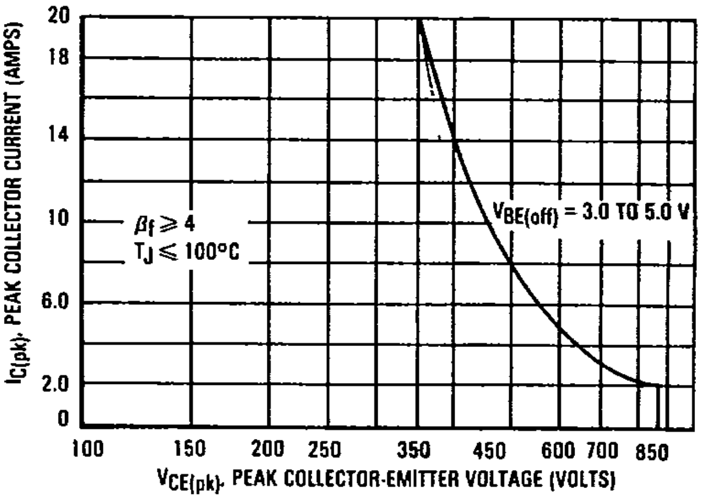


FIGURE 24 — MAXIMUM RATED TURN-OFF SAFE OPERATING AREA



SAFE OPERATING AREA INFORMATION

FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second 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 Figures 19, 21 and 23 are based on T_C = 25°C; $T_{J(pk)}$ is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when $T_C \geq 25°C$. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figures 19, 21 and 23 may be found at any case temperature by using the appropriate curve on Figure 28.

$T_{J(pk)}$ may be calculated from the data in Figures 29, 30 or 31. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

TURN-OFF

In deflection circuits, high voltage and high current normally do not occur simultaneously during turn-off with the base-emitter reverse biased. The safe level of operating these devices is specified as the Turn-Off Safe Operating Area, and represents the area the lead line may traverse during reverse biased turn off. For reliable operation, all abnormal operating conditions should be checked for operation within this area.

FIGURE 25 — CAPACITANCE VARIATION MJ12020

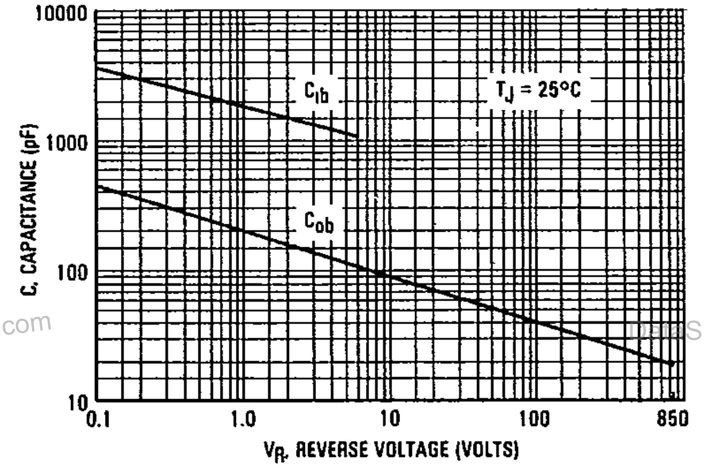


FIGURE 26 — CAPACITANCE VARIATION MJ12021

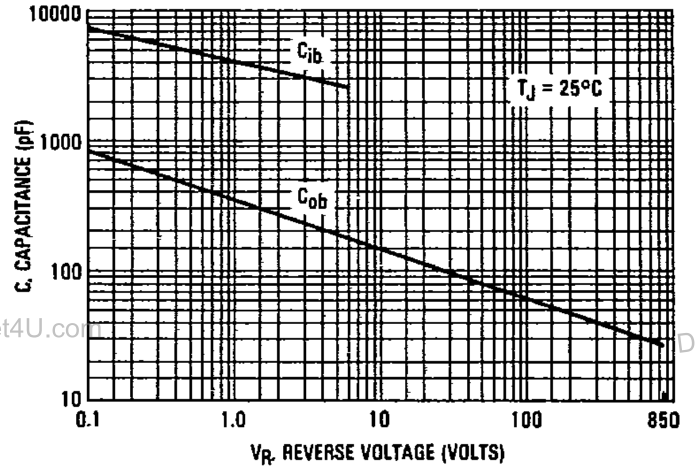


FIGURE 27 — CAPACITANCE VARIATION MJ12022

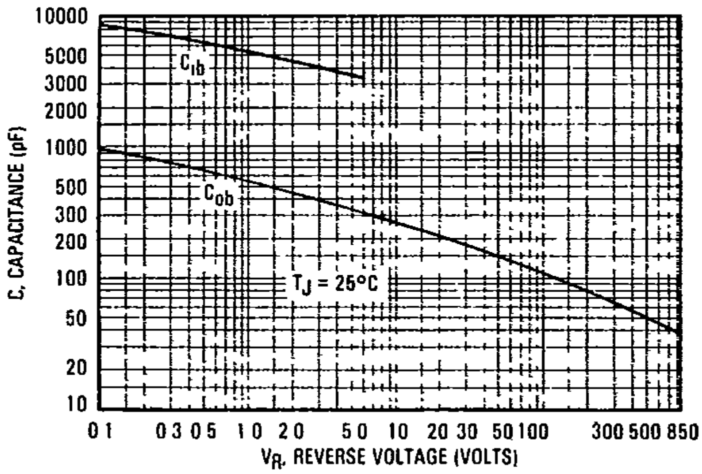
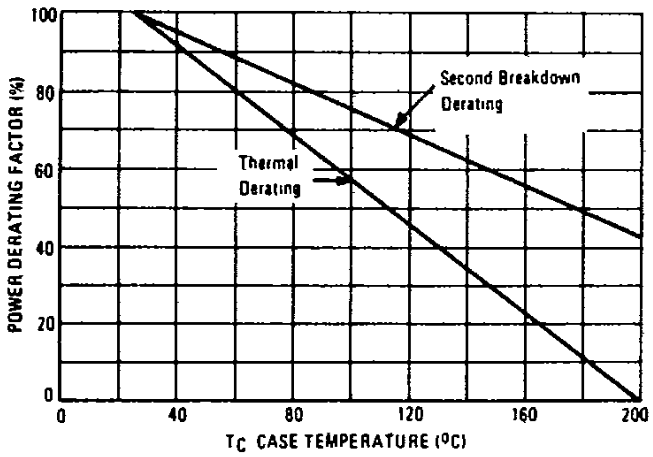


FIGURE 28 — POWER DERATING



THERMAL RESPONSE

FIGURE 29 — MJ12020

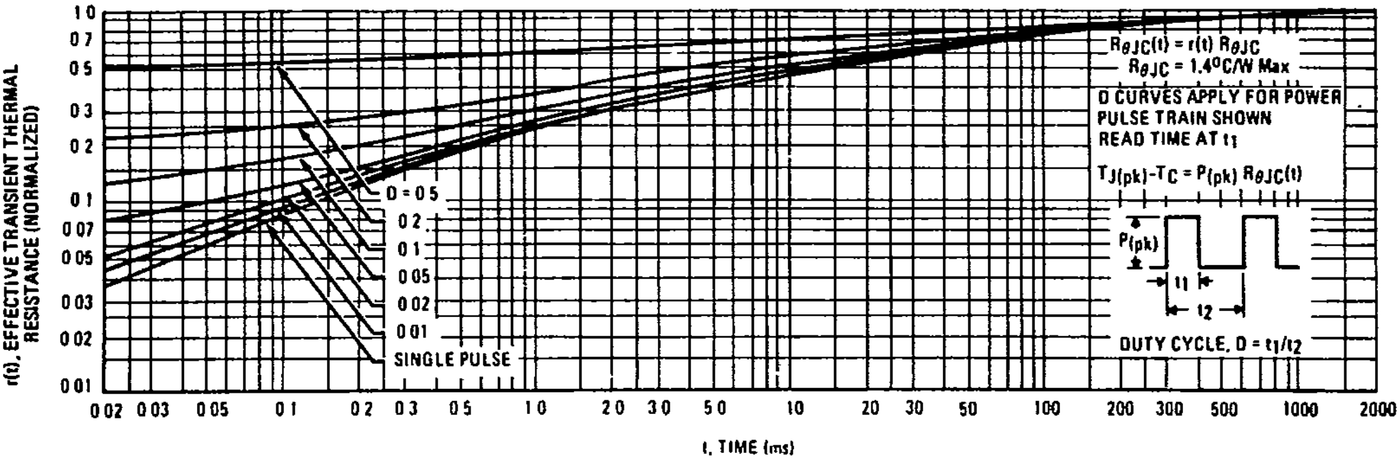


FIGURE 30 — MJ12021

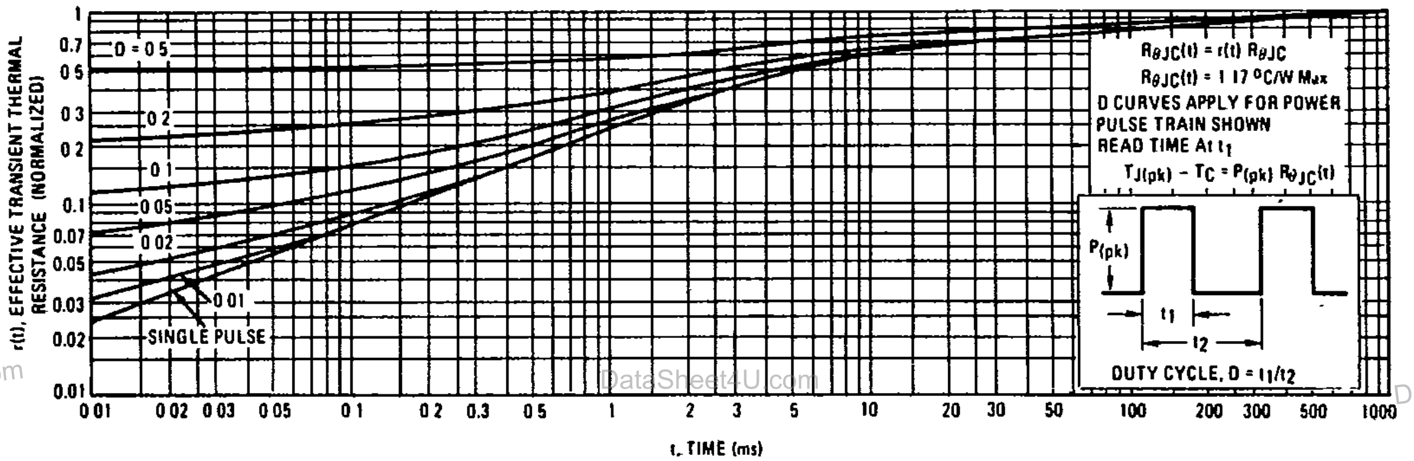


FIGURE 31 — MJ12022

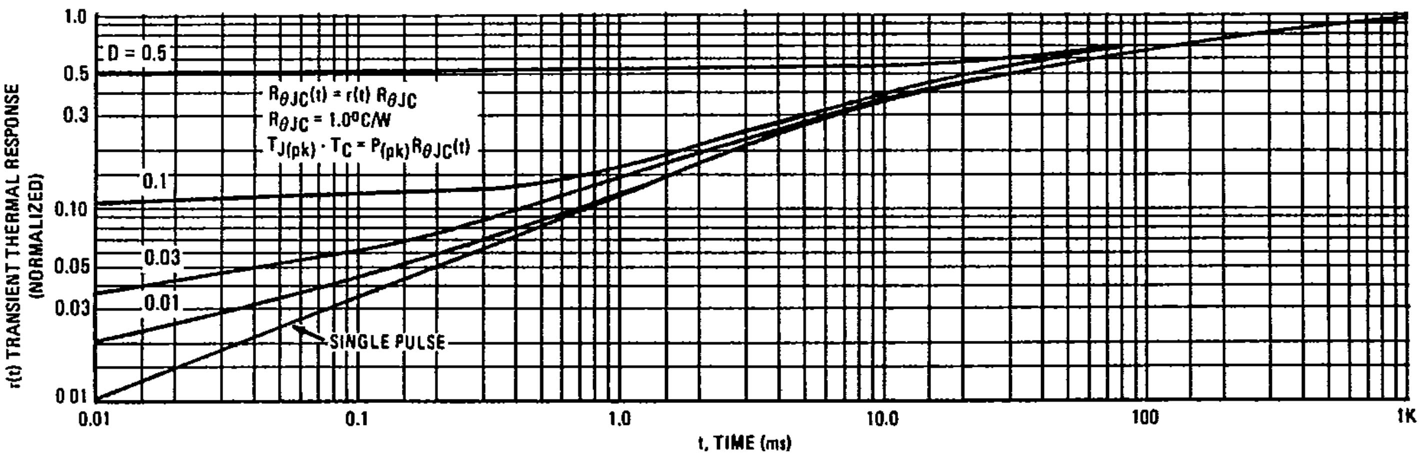
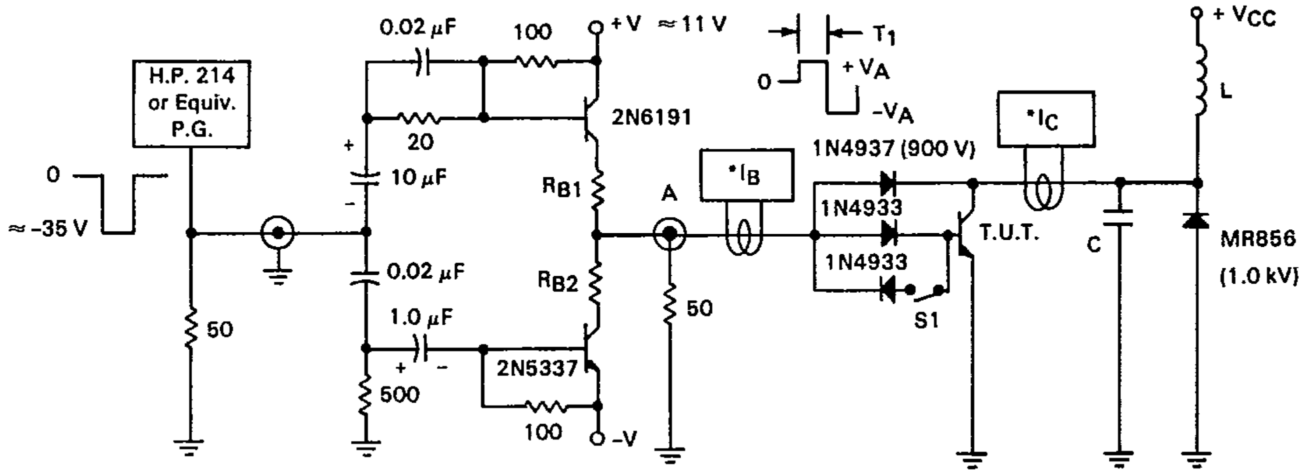


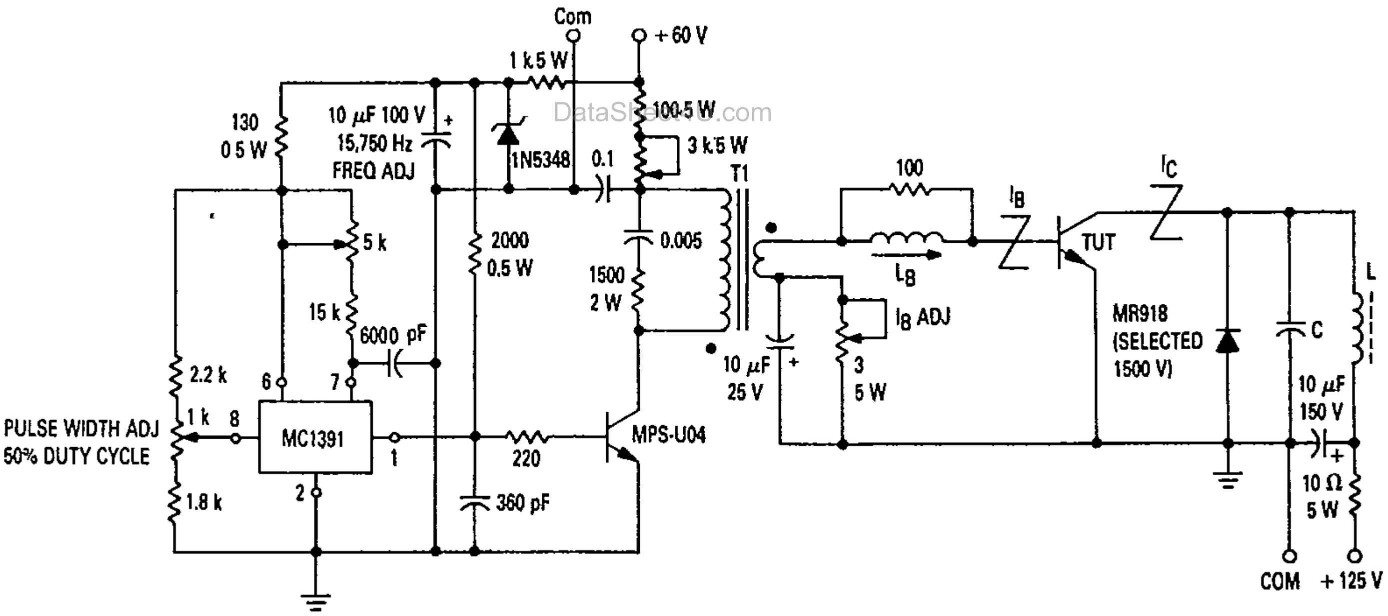
TABLE 1 — TEST CONDITIONS FOR DYNAMIC PERFORMANCE



T_1 adjusted to obtain $I_{C(pk)}$
$-V_A$ adjusted to obtain $V_{BE(off)}$

$V_{CEO(sus)}$	Inductive Switching, Clamped Drive			Turn-Off SOA		
L = 10 mH	MJ12020	MJ12021	MJ12022	MJ12020	MJ12021	MJ12022
$R_{B2} = \infty$	C = 0.003 μF	C = 0.020 μF	C = 0.036 μF	C = 0.003 μF	C = 0.020 μF	C = 0.037 μF
V_{CC} = 20 Vdc	V_{CC} = 40 Vdc	V_{CC} = 60 Vdc	V_{CC} = 120 Vdc	V_{CC} = 20 Vdc	V_{CC} = 35 Vdc	V_{CC} = 55 Vdc
S1 — Open *Tektronix P-6042 or Equivalent	L = 100 μH, S1 — Closed R_{B2} = 0, R_{B1} selected for required I_{B1} Scope — Tektronix 7403 or Equivalent			L = 100 μH R_{B2} = 0, R_{B1} selected for required I_{B1} S1 — Closed		

TABLE 2 — TEST CIRCUIT FOR INDUCTIVE SWITCHING WITH BASE INDUCTANCE



Device	V_{CC} (Volts)	$I_{C(pk)}$ (Amp)	C (μF)
MJ12020	20	3.0	0.003
MJ12021	35	5.0	0.:020
MJ12022	55	10	0.036

DRIVER TRANSFORMER (T1)

- Ferrox cube pot core #4229P-L00-3C8
- Adjust gap for primary inductance Lp = 70 mH (approximately 5 mil spacer)
- Primary 230T #28 AWG (5 layers)
- Secondary 15T #22 AWG (1 layer)
- Secondary leakage inductance should be less than 3 μH
- Use 3 mil mylar tape between each winding layer