MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

2N6648
See Page 3-195

2N6833
2N6834

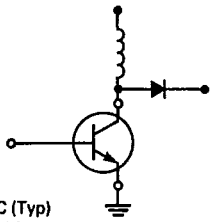
Designer's Data Sheet

SWITCHMODE III SERIES
NPN SILICON POWER TRANSISTORS

These transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications.

Typical Applications:

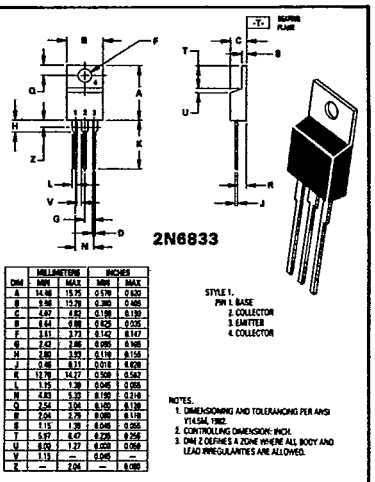
- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits
- Fast Turn-Off Times
  - 50 ns Inductive Fall Time — 75°C (Typ)
  - 70 ns Inductive Crossover Time — 75°C (Typ)
  - 500 ns Inductive Storage Time — 75°C (Typ)
- Operating Temperature Range -65 to +150°C
- 100°C Performance Specified for:
  - Reverse-Biased SOA with Inductive Loads
  - Switching Times with Inductive Loads
  - Saturation Voltages
  - Leakage Currents



5.0 AMPERE

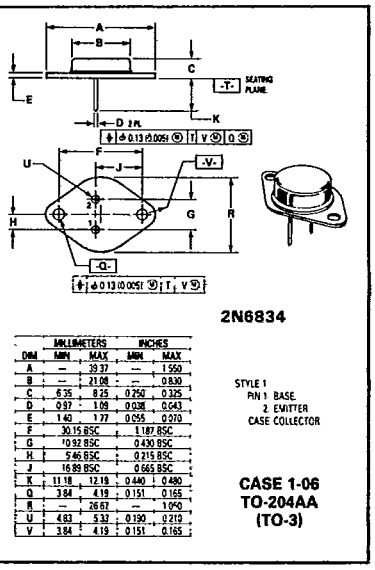
NPN SILICON POWER TRANSISTORS

450 VOLTS
80 and 125 WATTS



2N6833

CASE 221A-04
TO-220AB



2N6834

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

MAXIMUM RATINGS

Rating	Symbol	2N6833	2N6834	Unit
Collector-Emitter Voltage*	$V_{CEO(sus)}$	450		Vdc
Collector-Emitter Voltage*	V_{CEV}	850		Vdc
Emitter Base Voltage*	V_{EB}	6.0		Vdc
Collector Current — Continuous*	I_C	5.0		Adc
— Peak (1)	I_{CM}	10		
Base Current — Continuous*	I_B	4.0		Adc
— Peak (1)	I_{BM}	8.0		
Total Power Dissipation @ T_C = 25°C*	P_D	80	125	Watts
@ T_C = 100°C*		32	71.5	
Derate above 25°C*		0.64	0.714	W/°C
Operating and Storage Junction Temperature Range*	T_J, T_{stg}	-65 to +150	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N6833	2N6834	Unit
Thermal Resistance, Junction to Case*	$R_{\theta JC}$	1.56	1.40	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds*	T_L	275		°C

(1) Pulse Test: Pulse Width = 5.0 ms, Duty Cycle ≤ 10%.
*Indicate JEDEC Registered Data

Designer's Data for "Worst Case" Conditions

The Designer's 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.

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (Table 2) (I_C = 100 mA, I_B = 0)	$V_{CEO(sus)}$	450*	—	—	Vdc
Collector Cutoff Current (V_{CEV} = 850 Vdc, $V_{BE(off)}$ = 1.5 Vdc) (V_{CEV} = 850 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 100°C)	I_{CEV}	— —	— —	0.25* 1.5*	mAdc
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 15* and 16*			
Clamped Inductive SOA with Base Reverse Biased	RBSOA	See Figure 17			
ON CHARACTERISTICS (1)					
Collector-Emitter Saturation Voltage (I_C = 1.5 Adc, I_B = 0.15 Adc) (I_C = 3.0 Adc, I_B = 0.4 Adc) (I_C = 3.0 Adc, I_B = 0.4 Adc, T_C = 100°C)	$V_{CE(sat)}$	— — —	— — —	1.0 2.5* 2.5*	Vdc
Base-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 0.4 Adc) (I_C = 3.0 Adc, I_B = 0.4 Adc, T_C = 100°C)	$V_{BE(sat)}$	— —	— —	1.5* 1.5	Vdc
DC Current Gain (I_C = 3.0 Adc, V_{CE} = 5.0 Vdc) (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	7.5* 5.0	— —	30* —	—
DYNAMIC CHARACTERISTICS (2)					
Current Gain - Bandwidth Product (V_{CE} = 10 Vdc, I_C = 0.25 Adc, f_{test} = 10 MHz)	f_T	15*	—	75*	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f_{test} = 1.0 kHz)	C_{ob}	20*	—	200*	pF

SWITCHING CHARACTERISTICS

Resistive Load (Table 1)							
Delay Time	(I_C = 3.0 Adc, V_{CC} = 250 Vdc, I_{B1} = 0.4 Adc, PW = 30 μs, Duty Cycle ≤2.0%)	(I_{B2} = 0.8 Adc, R_{B2} = 8.0 Ω)	t_d	—	30	100*	ns
Rise Time			t_r	—	100	300*	
Storage Time			t_s	—	1000	3000*	
Fall Time			t_f	—	60	300*	
Storage Time		($V_{BE(off)}$ = 5.0 Vdc)	t_s	—	400	—	
Fall Time			t_f	—	130	—	
Inductive Load (Table 2)							
Storage Time	(I_C = 3.0 Adc, I_{B1} = 0.4 Adc, $V_{BE(off)}$ = 5.0 Vdc, $V_{CE(pk)}$ = 400 Vdc)	(T_C = 100°C)	t_{sv}	—	500	1600*	ns
Fall Time			t_{fi}	—	100	200*	
Crossover Time			t_c	—	120	250*	
Storage Time		(T_C = 150°C)	t_{sv}	—	600	—	
Fall Time			t_{fi}	—	120	—	
Crossover Time			t_c	—	160	—	

(1) Pulse Test PW = 300 μs, Duty Cycle ≤2%.
(2) $f_T = |h_{fe}| \cdot f_{test}$
*Indicates JEDEC Registered Limit

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TYPICAL STATIC CHARACTERISTICS

FIGURE 1 — DC CURRENT GAIN

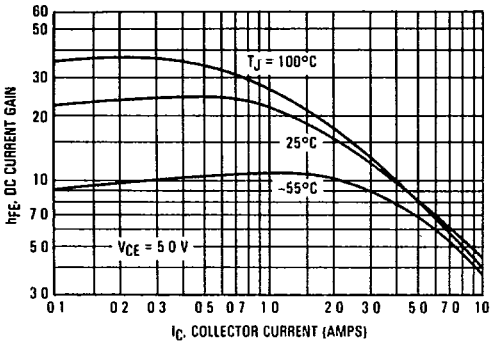


FIGURE 2 — COLLECTOR SATURATION REGION

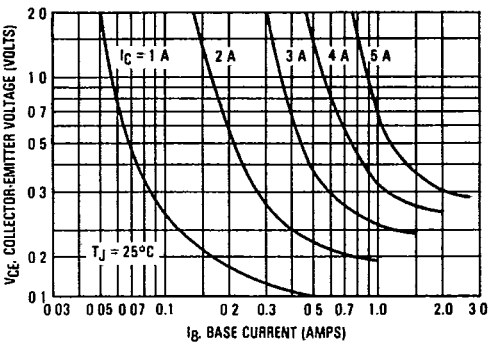


FIGURE 3 — COLLECTOR-EMITTER SATURATION VOLTAGE

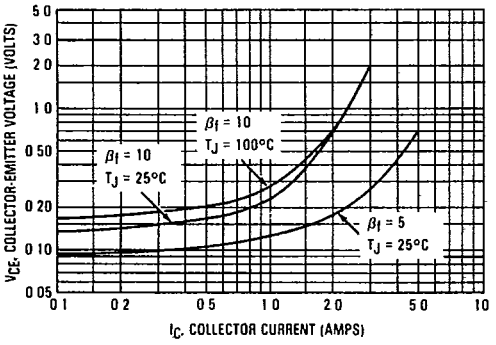


FIGURE 4 — BASE-EMITTER VOLTAGE

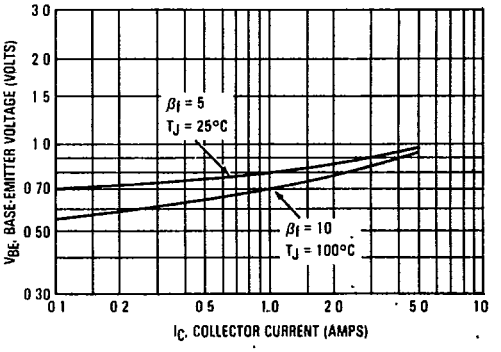


FIGURE 5 — COLLECTOR CUTOFF REGION

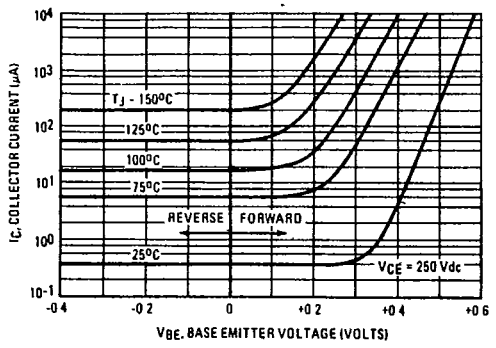
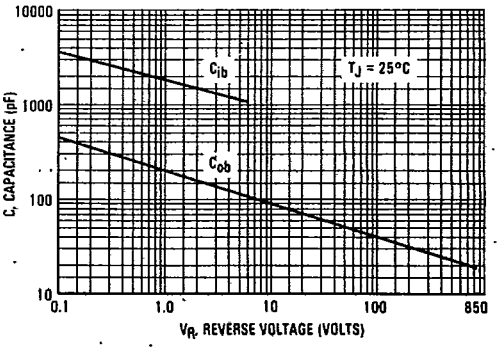


FIGURE 6 — CAPACITANCE



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 7 — STORAGE TIME

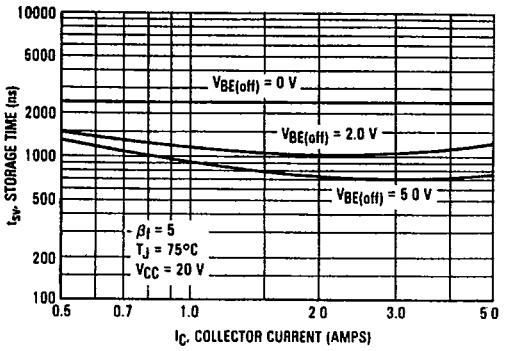


FIGURE 8 — STORAGE TIME

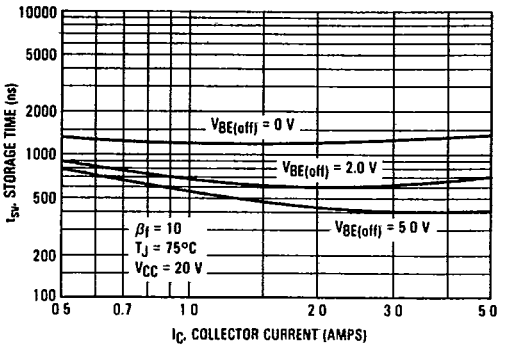


FIGURE 9 — COLLECTOR CURRENT FALL TIME

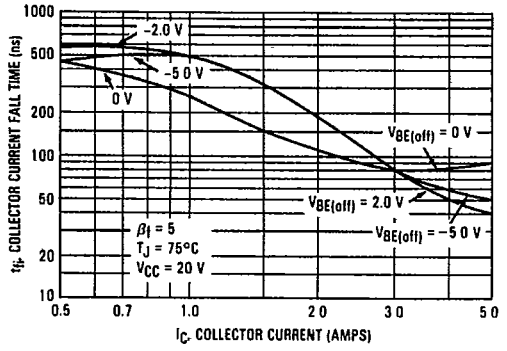


FIGURE 10 — COLLECTOR CURRENT FALL TIME

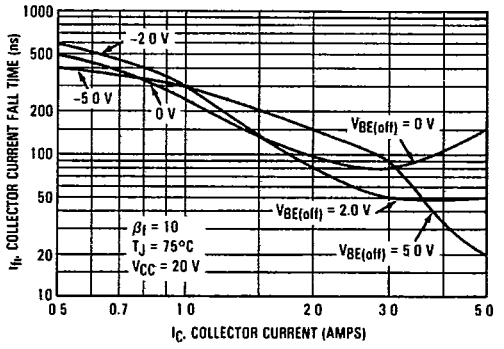


FIGURE 11 — CROSSOVER TIME

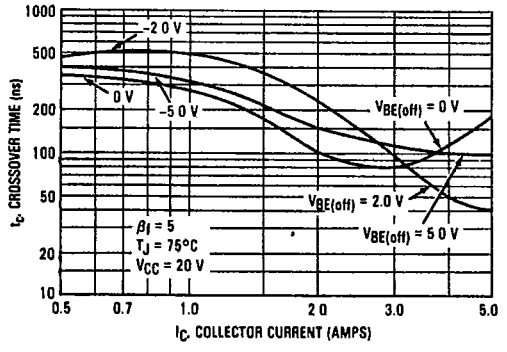


FIGURE 12 — CROSSOVER TIME

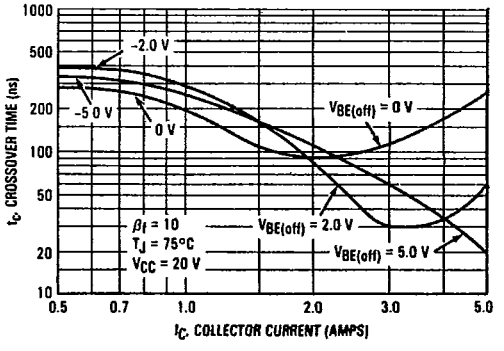


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FIGURE 13 — INDUCTIVE SWITCHING MEASUREMENTS

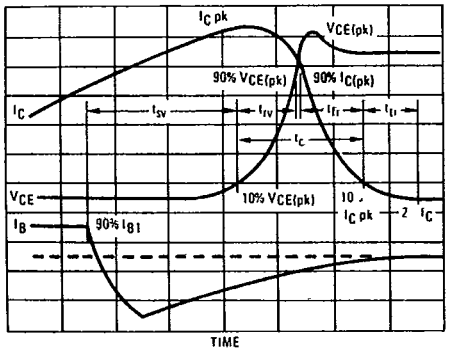
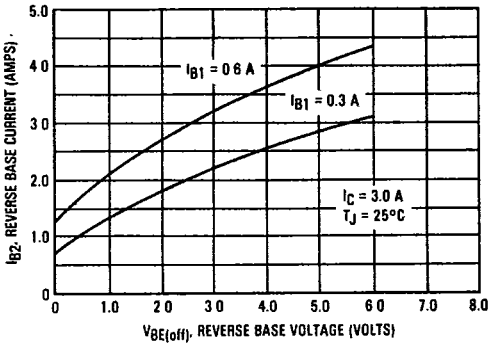


FIGURE 14 — PEAK REVERSE BASE CURRENT



GUARANTEED SAFE OPERATING AREA LIMITS

FIGURE 15 — MAXIMUM FORWARD BIAS SAFE OPERATING AREA (2N6833)

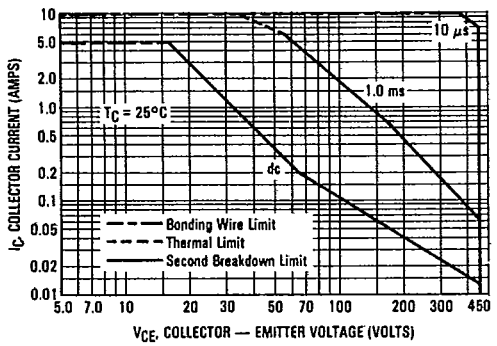
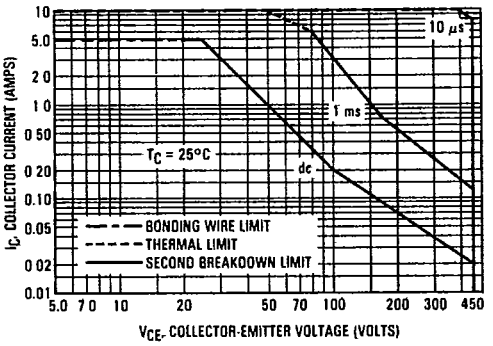


FIGURE 16 — MAXIMUM FORWARD BIAS SAFE OPERATING AREA (2N6834)



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 15 and 16 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 15 and 16 may be found at any case temperature by using the appropriate curve on Figures 18 or 19.

$T_{J(pk)}$ may be calculated from the data in Figures 20 or 21. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base-to-emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable putting reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 17 gives the RBSOA characteristics.

FIGURE 17 — MAXIMUM REVERSE BIAS SAFE OPERATING AREA

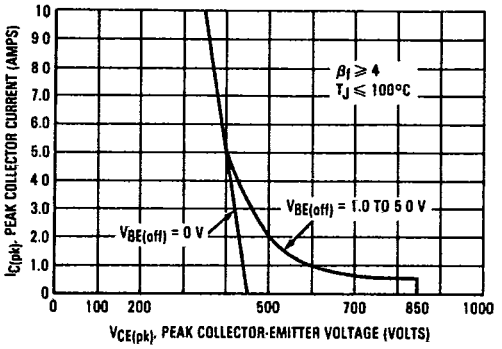


FIGURE 18 — POWER DERATING (2N6833)

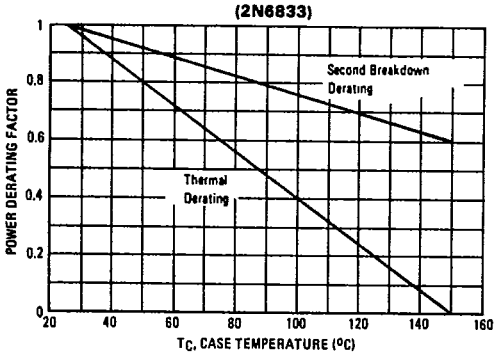


FIGURE 19 — POWER DERATING (2N6834)

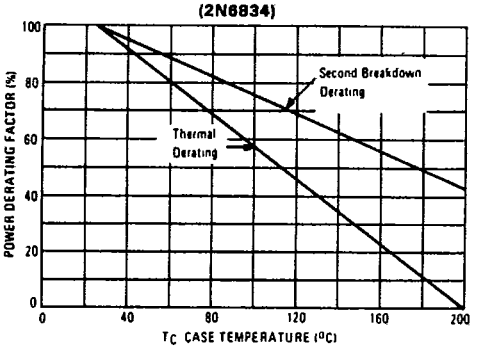
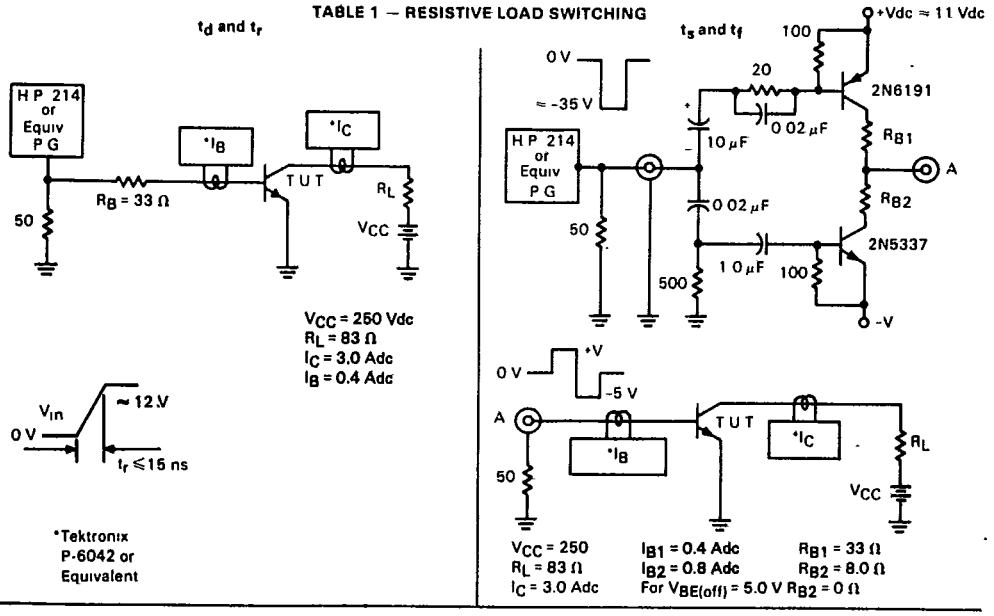


TABLE 1 — RESISTIVE LOAD SWITCHING



*Note Adjust -V to obtain desired $V_{BE(off)}$ at Point A

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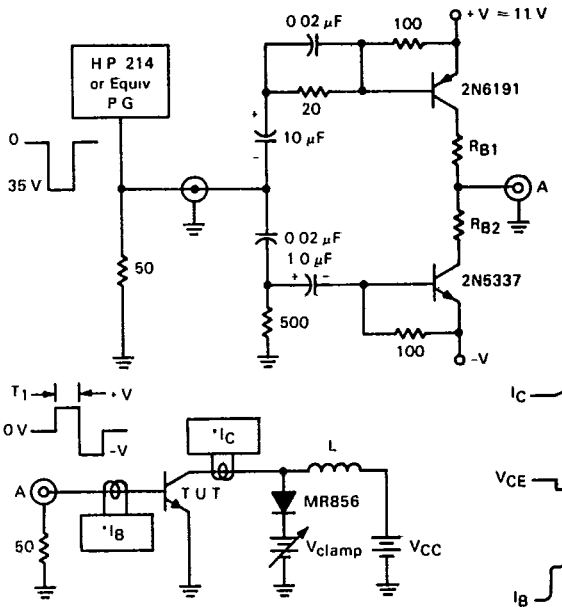
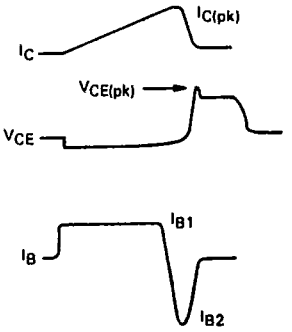
TABLE 2 — INDUCTIVE LOAD SWITCHING





$T_1 \approx \frac{L_{coil}(I_{Cpk})}{V_{CC}}$

T_1 adjusted to obtain $I_{C(pk)}$

$V_{(BR)CEO}$
L = 10 mH
$R_{B2} = \infty$
V_{CC} = 20 Volts

*Tektronix P-6042 or Equivalent

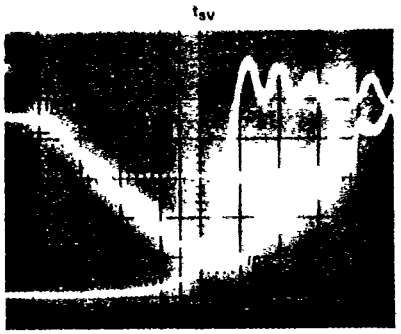
Inductive Switching
L = 200 μH
R_{B2} = 0
V_{CC} = 20 Volts
R_{B1} selected for desired I_{B1}

Scope - Tektronix 7403 or Equivalent

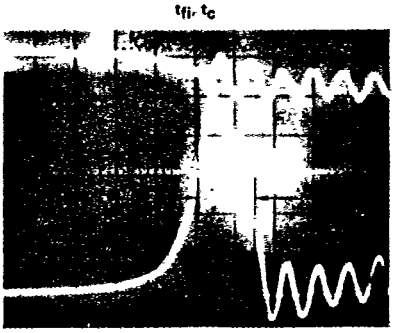
RBSOA
L = 200 μH
R_{B2} = 0
V_{CC} = 20 Volts
R_{B1} selected for desired I_{B1}

Note: Adjust -V to obtain desired $V_{BE(off)}$ at Point A.

TYPICAL INDUCTIVE SWITCHING WAVEFORMS



$I_{C(pk)}$ = 3.0 Amps
I_{B1} = 0.4 Amp
$V_{BE(off)}$ = 5.0 Volts
$V_{CE(pk)}$ = 400 Volts
T_C = 25°C
Time Base = 20 ns/cm



$I_{C(pk)}$ = 3.0 Amps
I_{B1} = 0.4 Amp
$V_{BE(off)}$ = 5.0 Volts
$V_{CE(pk)}$ = 400 Volts
T_C = 25°C
Time Base = 20 ns/cm

THERMAL RESPONSE

FIGURE 20 — 2N6833

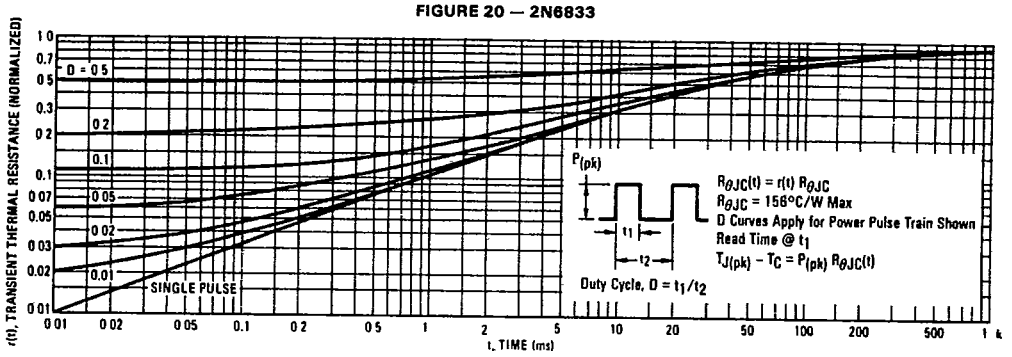
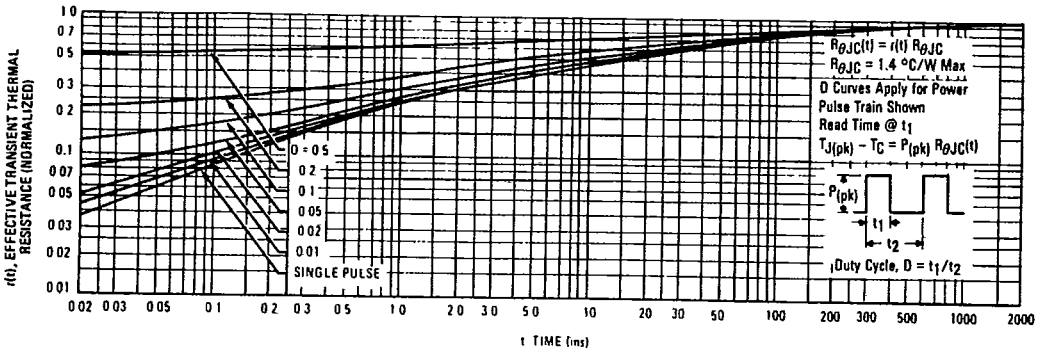


FIGURE 21 — 2N6834



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