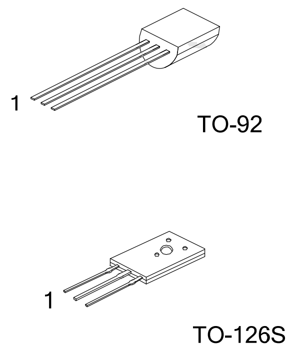
UTC UNISONIC TECHNOLOGIES CO., LTD

MJE13002-E — *NPN EPITAXIAL SILICON TRANSISTOR*

HIGH VOLTAGE FAST-SWITCHING NPN POWER TRANSISTOR



■ DESCRIPTION

The UTC **MJE13002-E** designed for use in high–volatge, high speed,power switching in inductive circuit, It is particularly suited for 115 and 220V switchmode applications such as switching regulator's,inverters, DC-DC converter, Motor control, Solenoid/Relay drivers and deflection circuits.

■ FEATURES

*Collector-Emitter Sustaining Voltage:
V_{CEO} (sus)=300V.
*Collector-Emitter Saturation Voltage:
$V_{CE(sat)}$=1.0V(Max.) @I_C=1.0A, I_B =0.25A
*Switch Time- tf =0.7μs(Max.) @Ic=1.0A.

■ ORDERING INFORMATION

Ordering Number		Package	Pin Assignment			Packing
Lead Free	Halogen Free		1	2	3	
MJE13002L-E-x-T6S-K	MJE13002G-E-x-T6S-K	TO-126S	B	C	E	Bulk
MJE13002L-E-x-T92-B	MJE13002G-E-x-T92-B	TO-92	B	C	E	Tape Box
MJE13002L-E-x-T92-K	MJE13002G-E-x-T92-K	TO-92	B	C	E	Bulk
MJE13002L-E-x-T92-R	MJE13002G-E-x-T92-R	TO-92	B	C	E	Tape Reel

MJE13002L-E-x-T6S-K	
(1) Packing Type	(1) B: Tape Box, K: Bulk, R: Tape Reel
(2) Package Type	(2) T6S: TO-126S, T92: TO-92
(3) Rank	(3) x: refer to Classification of h_{FE1}
(4) Lead Free	(4) L: Lead Free, G: Halogen Free

■ ABSOLUTE MAXIMUM RATINGS

PARAMETER			SYMBOL	RATINGS	UNIT
Collector-Emitter Voltage			$V_{CEO(SUS)}$	300	V
Collector-Emitter Voltage			V_{CEV}	600	V
Emitter Base Voltage			V_{EBO}	9	V
Collector Current	Continuous		I_C	1.5	A
	Peak (1)		I_{CM}	3	
Base Current	Continuous		I_B	0.75	A
	Peak (1)		I_{BM}	1.5	
Emitter Current	Continuous		I_E	2.25	A
	Peak (1)		I_{EM}	4.5	
Total Power Dissipation	TA=25°C	TO-92	P_D	1.0	Watts MW/°C
		TO-126S		1.4	
	Derate above 25°C	TO-92		8	
		TO-126S		11.2	
	TC=25°C	TO-92		5	Watts MW/°C
		TO-126S		40	
	Derate above 25°C	TO-92		40	
		TO-126S		320	
Junction Temperature			T_J	150	°C
Storage Temperature			T_{STG}	-65 to +150	°C

■ THERMAL CHARACTERISTICS

PARAMETER		SYMBOL	RATINGS	UNIT
Junction to Case	TO-92	θ_{JC}	25	°C/W
	TO-126S		3.12	
Junction to Ambient	TO-92	θ_{JA}	122	°C/W
	TO-126S		89	
Maximum Load Temperature for Soldering Purposes: 1/8” from Case for 5 Seconds		T_L	275	°C

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

2. Designer 's Data for “Worst Case” Conditions – The Designer 's Data Sheet permits the design of most circuits entirely from the information presented. SOA Limit curves – representing boundaries on device characteristics – are given to facilitate “Worst case” design.

■ ELECTRICAL CHARACTERISTICS (T_C=25°C, unless otherwise specified)

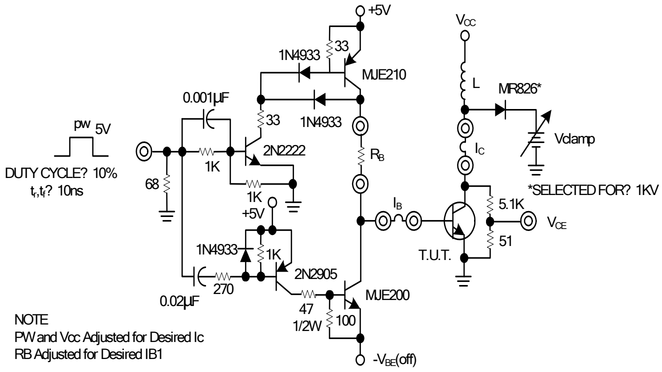
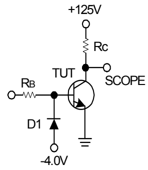
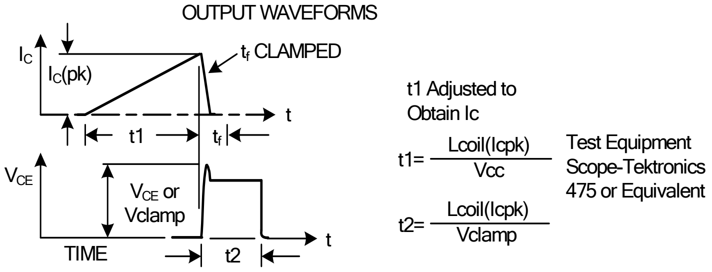
PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
OFF CHARACTERISTICS (1)						
Collector-Emitter Sustaining Voltage	$V_{CEO(SUS)}$	I_C=10 mA , I_B=0	300			
Collector Cutoff Current	I_{CEV}	V_{CEV}=Rated Value, V_{BE}(off)=1.5 V			1	
		V_{CEV}=Rated Value, V_{BE}(off)=1.5V,Tc=100°C			5	
SECOND BREAKDOWN						
DC Current Gain	h_{FE1}	I_C=0.5 A, V_{CE}=2 V	8		40	
	h_{FE2}	I_C=1 A, V_{CE}=2 V	5		25	
	h_{FE3}	I_C=200mA, V_{CE}=10V	9		40	
Collector-Emitter Saturation Voltage	$V_{CE(SAT)}$	I_C=0.5A, I_B=0.1A			0.8	V
		I_C=1A, I_B=0.2A			1.8	V
		I_C=1.5A, I_B=0.5A			3	V
Base-Emitter Saturation Voltage	$V_{BE(SAT)}$	I_C=0.5A, I_B=0.1A			1	V
		I_C=1A, I_B=0.25 A			1.2	V
DYNAMIC CHARACTERISTICS						
Current-Gain-Bandwidth Product	f_T	I_C=100mA, V_{CE}=10 V, f=1MHz	4	10		MHz
Output Capacitance	Cob	V_{CB}=10V, I_E=0, f=0.1MHz		21		pF
SWITCHING CHARACTERISTICS (TABLE 1)						
Delay Time	t_d	V_{CC}=125V, I_C=1A, I_{B1}=I_{B2}=0.2A, t_P=25μs, Duty Cycle≤1%		0.05	0.1	μs
Rise Time	t_r			0.5	1	μs
Storage Time	t_s			2	4	μs
Fall Time	t_f			0.4	0.7	μs
INDUCTIVE LOAD, CLAMPED (TABLE 1, FIGURE 7)						
Storage Time	t_{sv}	I_C=1A,Vclamp=300V, I_{B1}=0.2A,V_{BE}(off)=5V,T_C=100°C		1.7	4	μs
Crossover Time	t_c			0.29	0.75	μs
Fall Time	t_{fi}			0.15		μs

■ CLASSIFICATION OF h_{FE1}

RANK	A	B	C	D	E	F
RANGE	8 ~ 16	15 ~ 21	20 ~ 26	25 ~ 31	30 ~ 36	35 ~ 40

■ APPLICATION INFORMATION

Table 1.Test Conditions for Dynamic Performance

<table>
<tr><td></td><td>Reverse Bias Safe Operating Area and Inductive Switching</td><td>Resistive Switching</td></tr>
<tr><td>Test Circuits</td><td>
</td><td>
</td></tr>
<tr><td>Circuit Values</td><td>Coil Data : GAP for 30 mH/2 A
V_{CC}=20V
Ferroxcube core #6656 Lcoil=50mH
Vclamp=300V
Full Bobbin (~ 200 Turns) #20</td><td>V_{CC}=125V
R_C=125Ω
D1=1N5820 or Equiv.
R_B=47Ω</td></tr>
<tr><td>Test Waveforms</td><td>Output Waveforms


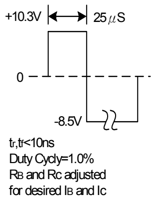
t1 Adjusted to Obtain Ic
$t1=\frac{Lcoil(Icpk)}{Vcc}$
$t2=\frac{Lcoil(Icpk)}{Vclamp}$
Test Equipment Scope-Tektronics 475 or Equivalent</td><td>
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Table 2. Typical Inductive Switching Performance

I_C (AMP)	T_C (°C)	T_{SV} (μs)	T_{RV} (μs)	T_{FI} (μs)	T_{TI} (μs)	T_C (μs)
0.5	25 100	1.3 1.6	0.23 0.26	0.30 0.30	0.35 0.40	0.30 0.36
1	25 100	1.5 1.7	0.10 0.13	0.14 0.26	0.05 0.06	0.16 0.29
1.5	25 100	1.8 3	0.07 0.08	0.10 0.22	0.05 0.08	0.16 0.28

Note: All Data Recorded in the inductive Switching Circuit Table 1

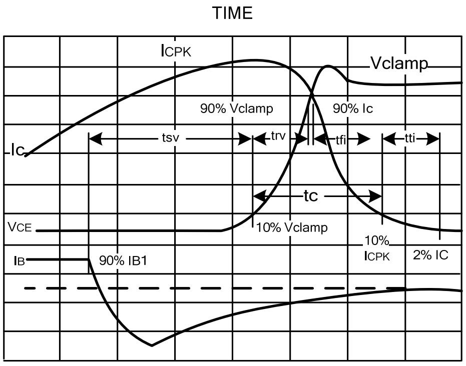


Fig 1. Inductive Switching Measurements

■ SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase, However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each wave form to determine the total switching time, For this reason, the following new terms have been defined.

t_{SV}=Voltage Storage Time, 90% IB1 to 10% Vclamp
t_{RV}=Voltage Rise Time, 10-90% Vclamp
t_{FI}=Current Fall Time, 90-10% I_C
t_{TI}=Current Tail, 10-2% I_C
t_C=Crossover Time, 10% Vclamp to 10% I_C

An enlarged portion of the inductive switching waveforms is shown in Figure 1 to aid in the visual identity of these terms.

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

PSWT=1/2 VccIc (tc)f

In general, trv + tfi≒tc. However, at lower test currents this relationship may not be valid.

As is common with most switching transistor, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a “SWITCHMODE” transistor are the inductive switching speeds (tc and tsv) which are guaranteed at 100°C.

RESISTIVE SWITCHING PERFORMANCE

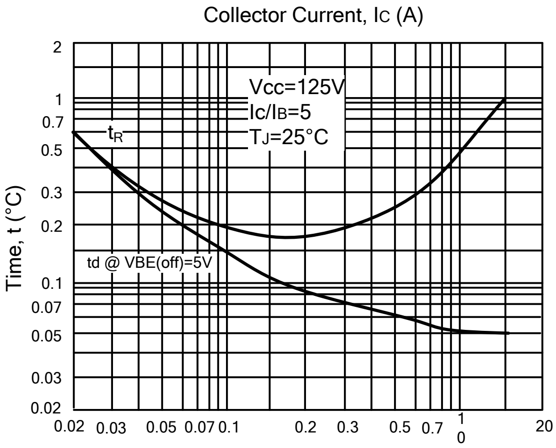


Fig 2. Turn-On Time

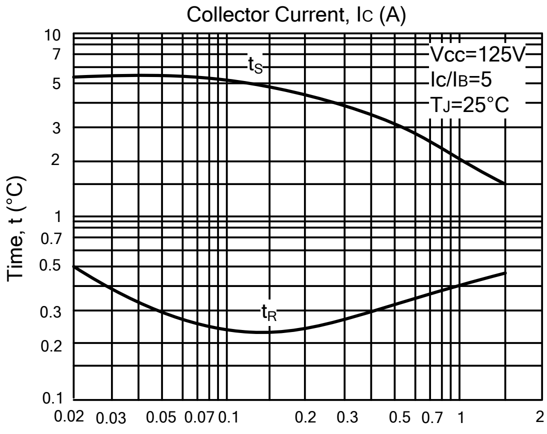


Fig 3. Turn-Off Time

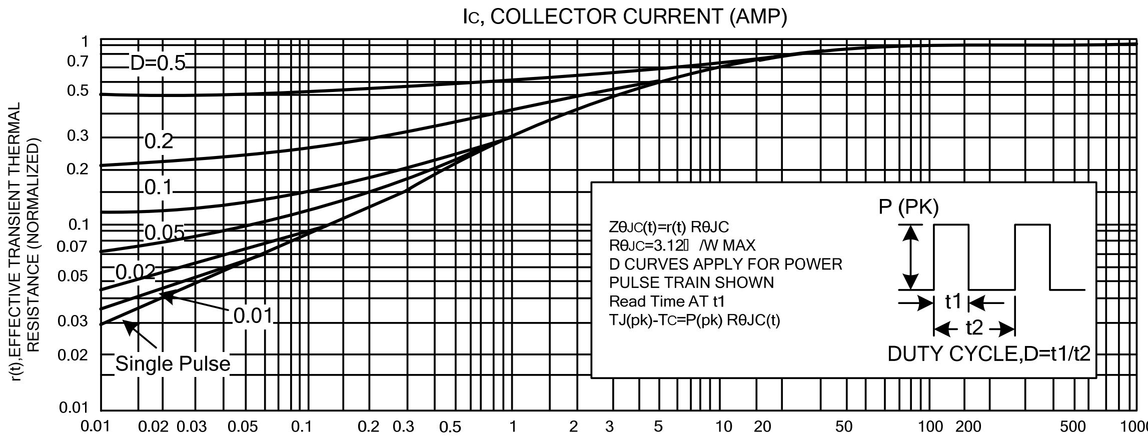


Fig 4. Thermal Response

■ SAFE OPERATING AREA INFORMATION

FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second break-down. Safe operating area curves indicate Ic – VCE 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 Tc=25°C; TJ(pk) is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when Tc≧25°C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 5 may be found at any case tem-perature by using the appropriate curve on Figure 7.

T_J(pk) may be calculated from the data in Figure 5. 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 conditions during re-verse biased turn–off. This rating is verified under clamped conditions so that the device is never subjected to an ava-lanche mode. Figure 6 gives RBSOA characteristics.

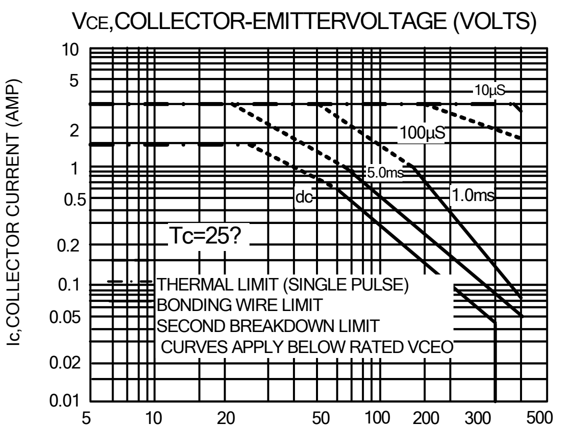


Fig 5. Active Region Safe Operating Area

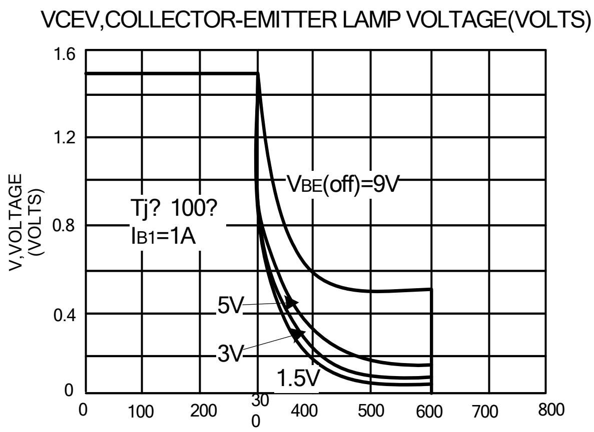


Fig 6. Reverse Bias Safe Operating Area

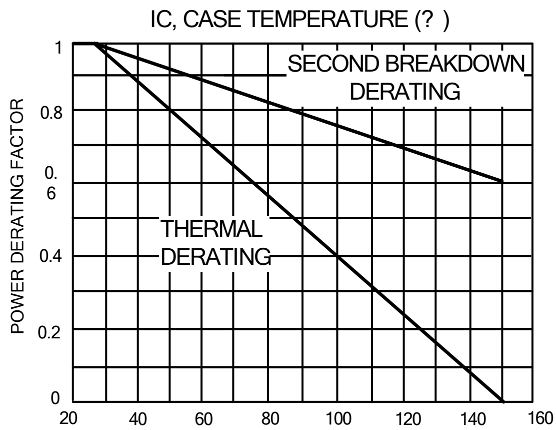
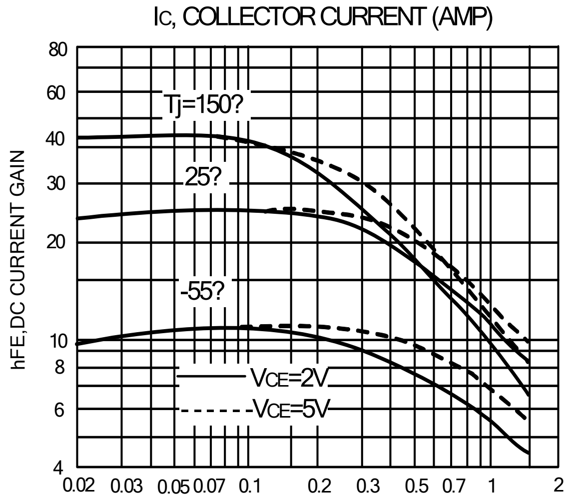
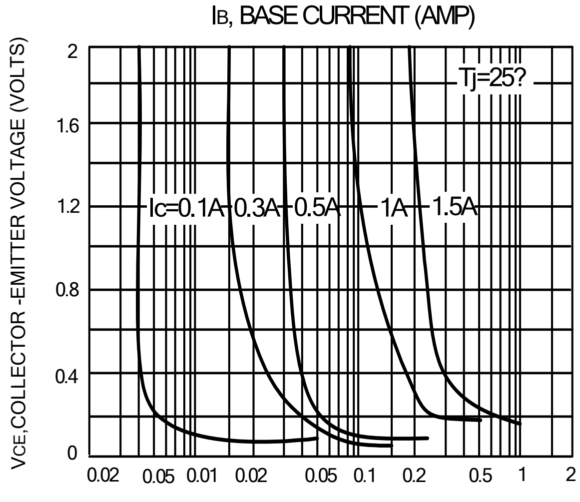


Fig 7. Forward Bias Power Derating

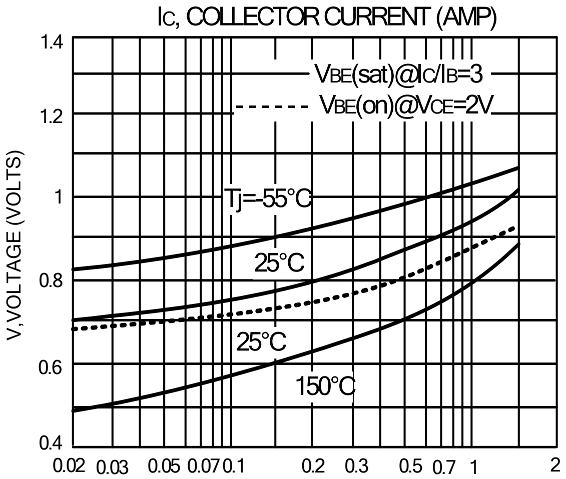
■ TYPICAL CHARACTERISTICS



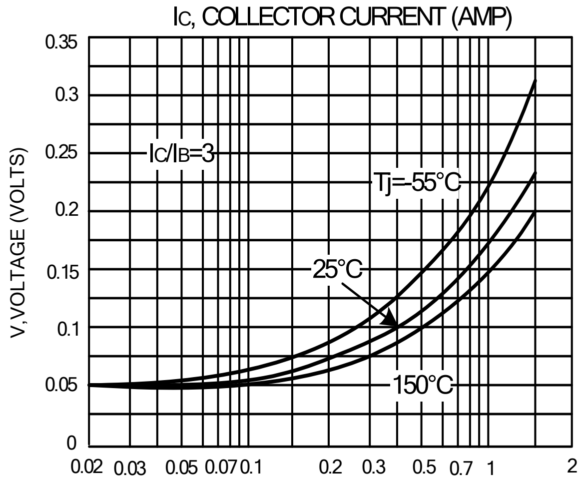
DC Current Gain



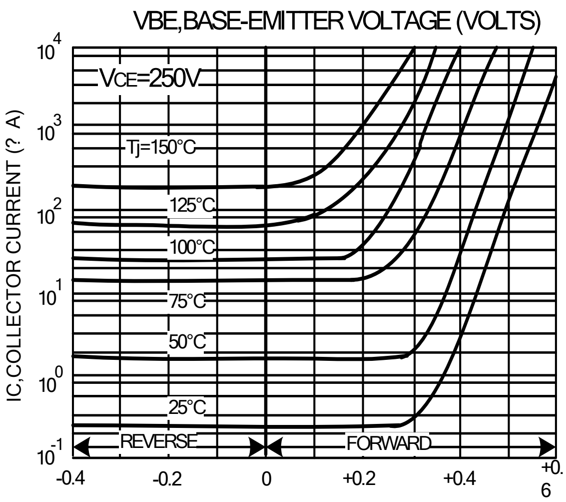
Collector Saturation Region



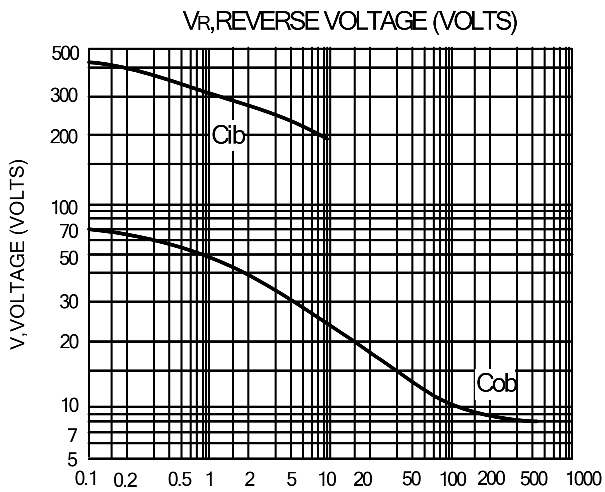
Base-Emitter Voltage



Collector-Emitter Saturation Region



Collector Cutoff Region



Capacitance