LECTURE 24

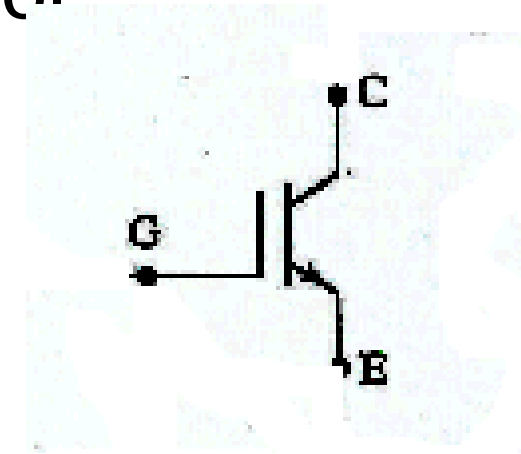
IGBT

Topics to be covered

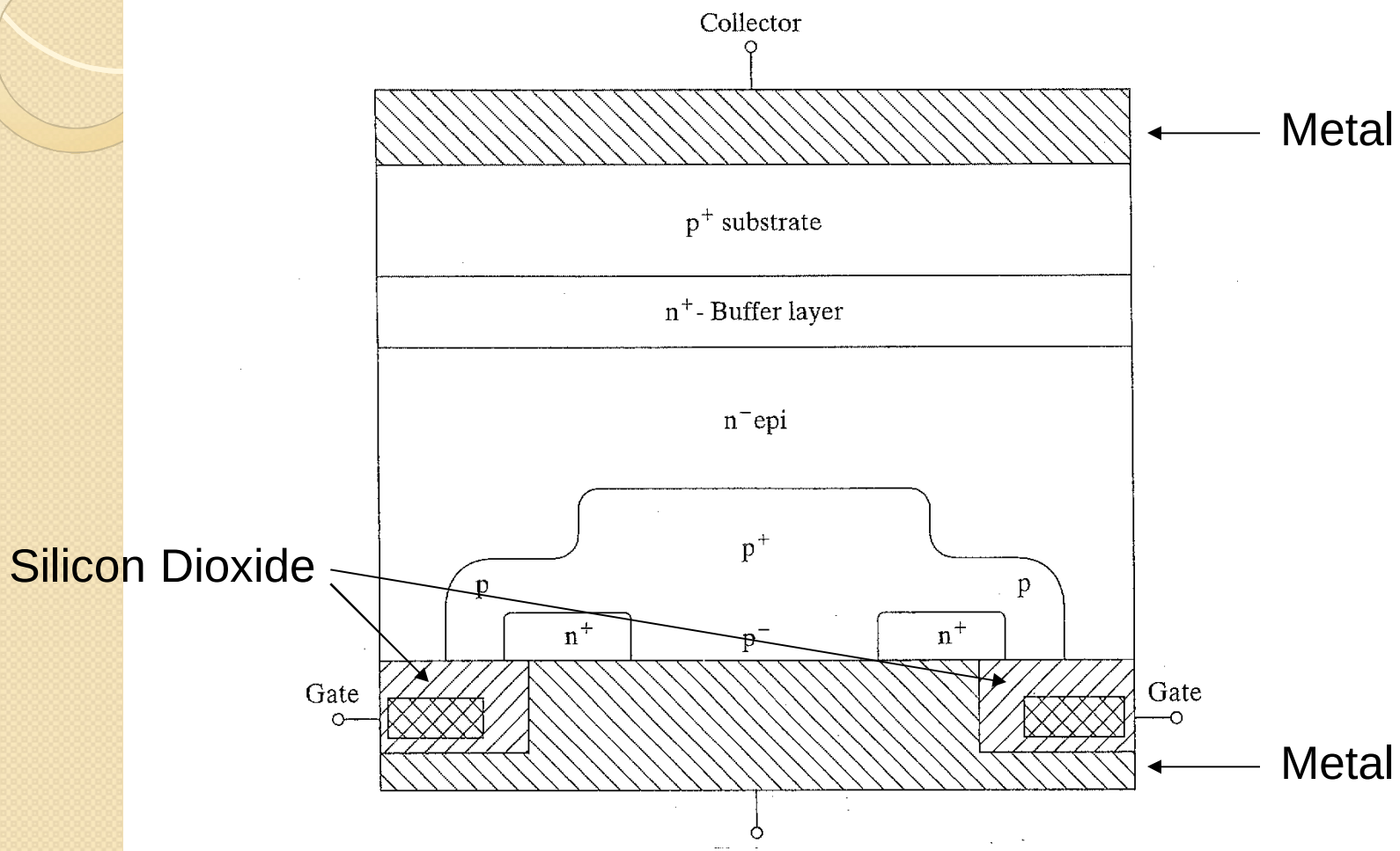
- Electrorestriction

IGBT: Insulated-Gate Bipolar Transistor

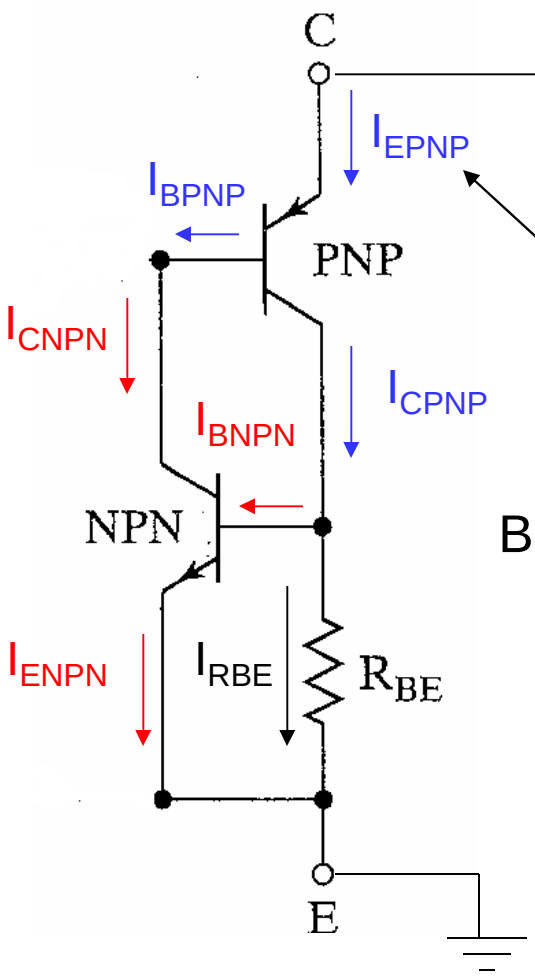
- Combination BJT and MOSFET
  - High Input Impedance (MOSFET)
  - Low On-state Conduction Losses (BJT)
- High Voltage and Current Ratings
- Symbol



Cross-Sectional View of an IGBT



IGBT Equivalent Circuit for $V_{GE}<V_T$



+

V_{CC}

Leakage Current

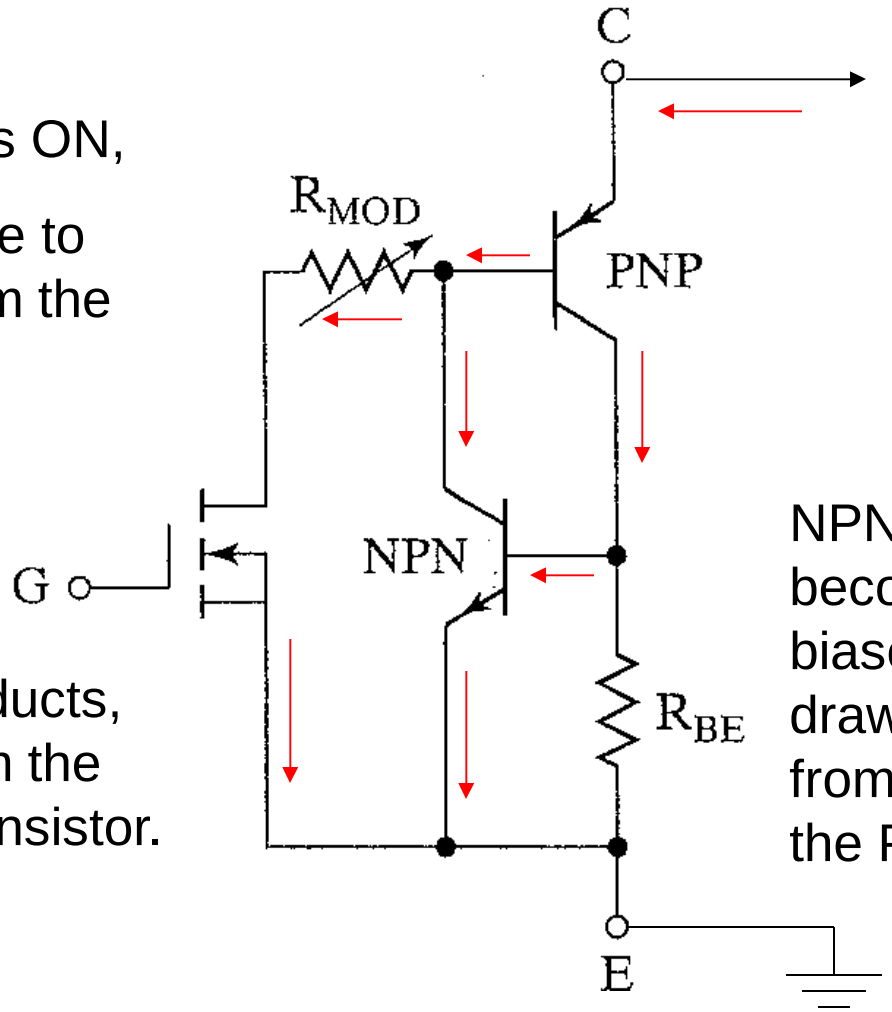
Both transistors are OFF

IGBT Equivalent Circuit for $V_{GE}>V_T$

PNP transistor turns ON,

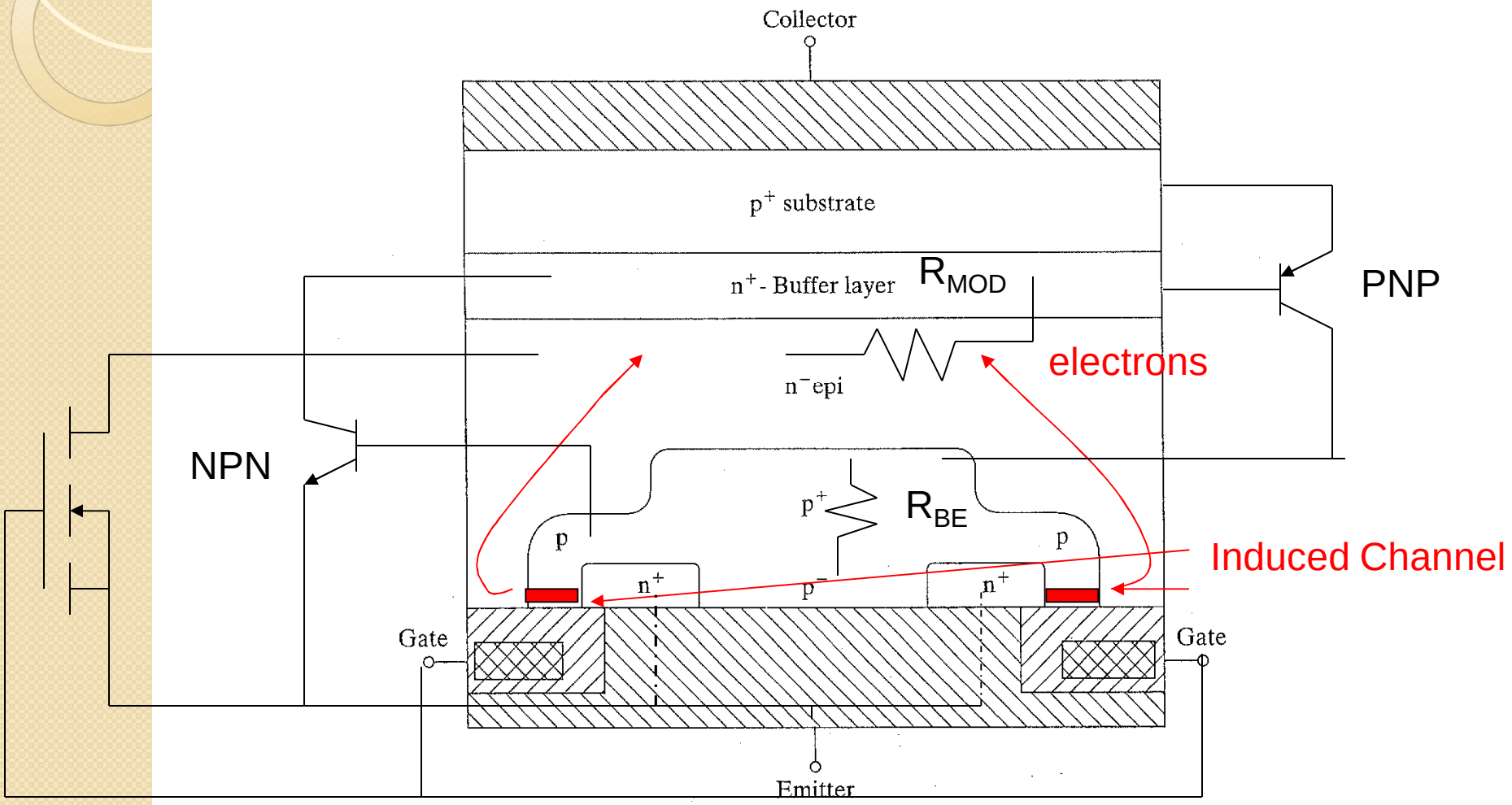
R_{MOD} decreases due to carrier injection from the PNP Emitter.

MOS transistor conducts, drawing current from the Base of the PNP transistor.



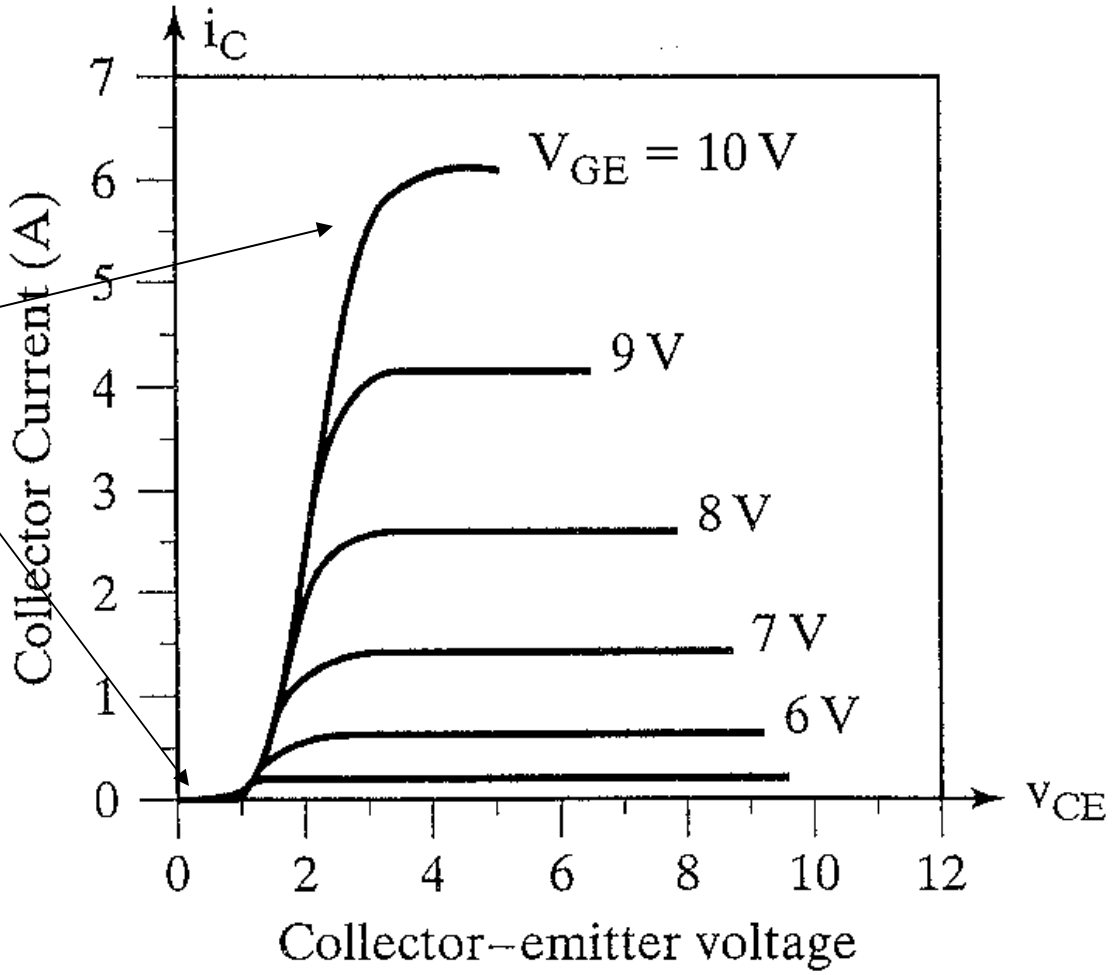
NPN Transistor becomes forward biased at the BE, drawing current from the Base of the PNP transistor.

Channel is Induced When $V_{GE}>V_T$

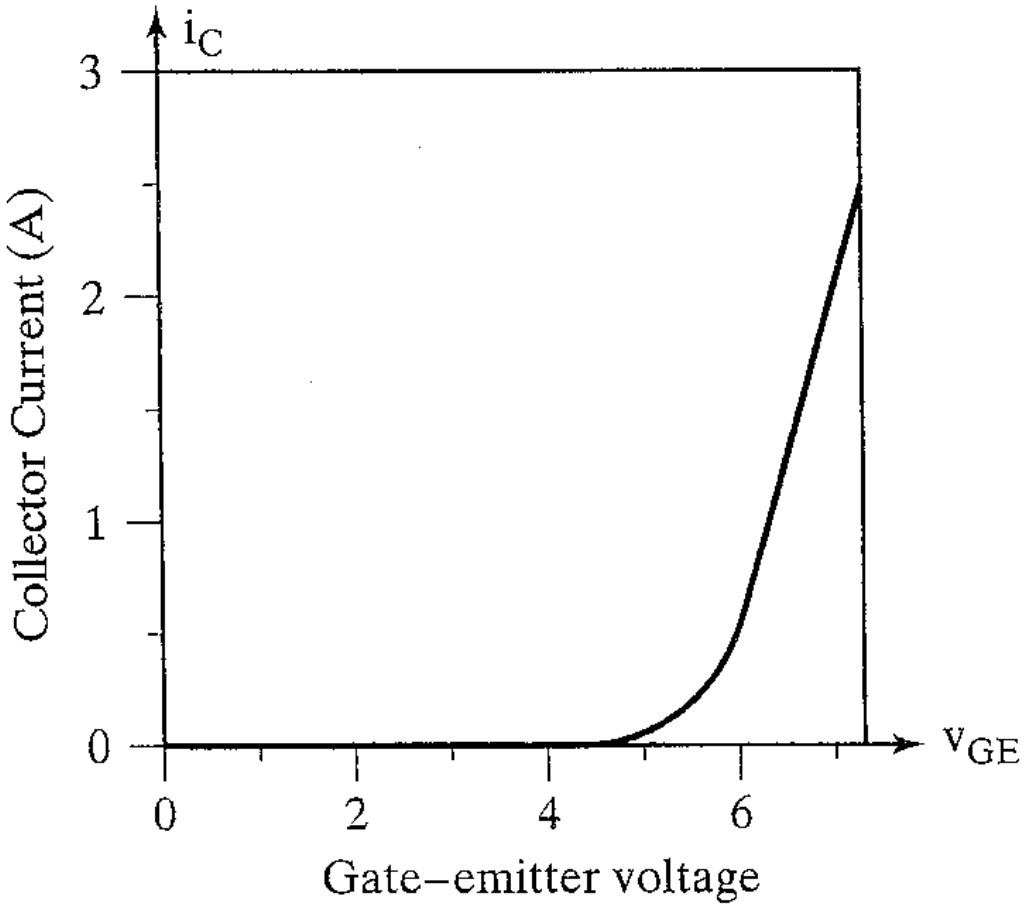


IGBT Output Characteristics

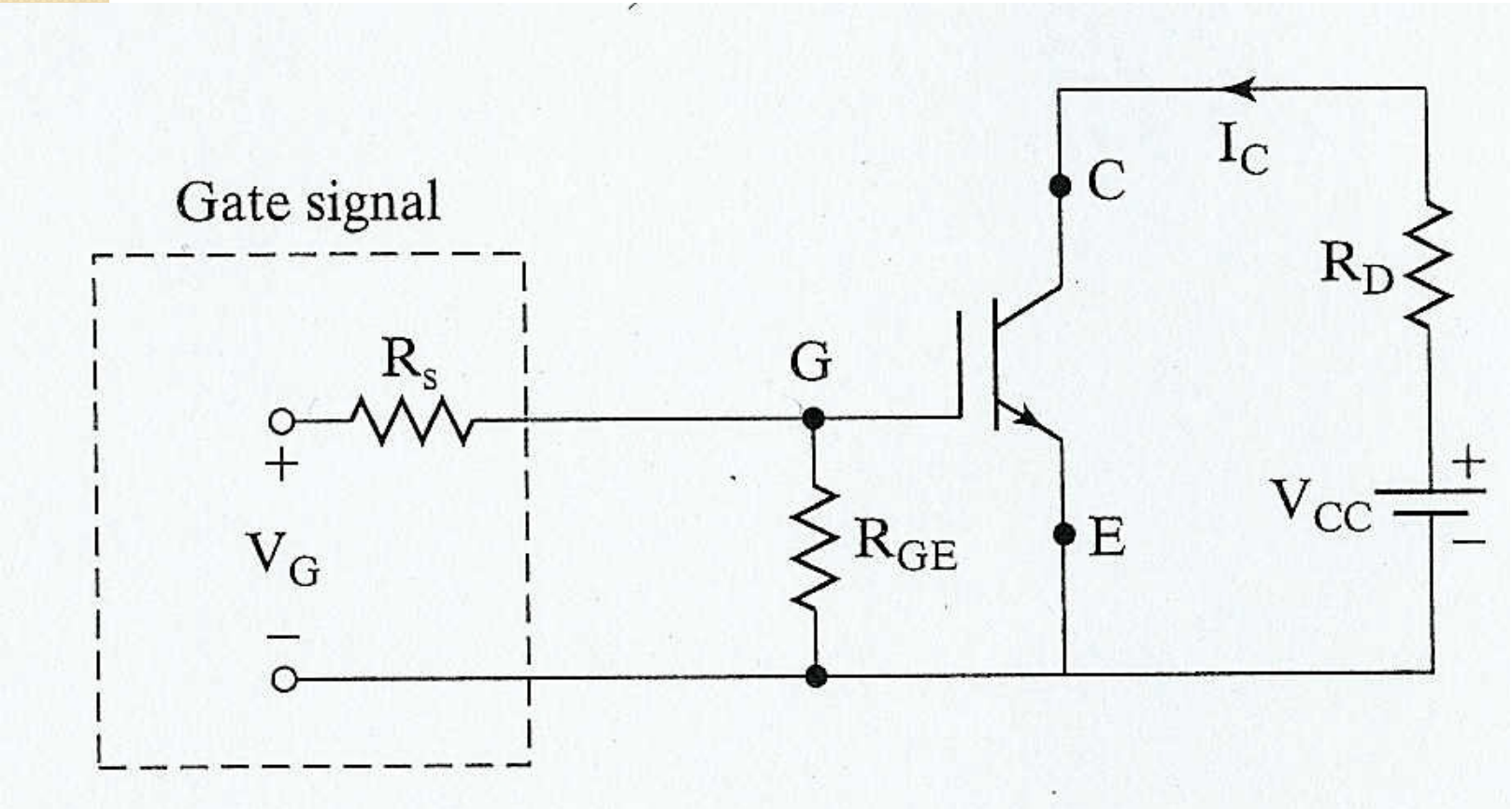
Follows an SCR characteristic



IGBT Transfer Characteristic



IGBT Used as a Switch



Fairchild FGA25N120AND IGBT

FAIRCHILD
SEMICONDUCTOR®

IGBT

FGA25N120AND

FGA25N120AND

General Description

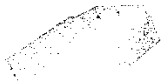
Employing NPT technology, Fairchild's AND series of IGBTs provides low conduction and switching losses. The AND series offers an solution for application such as induction heating (IH), motor control, general purpose inverters and uninterruptible power supplies (UPS).

Features

- High speed switching
- Low saturation voltage : $V_{CE(sat)}$ = 2.5 V @ I_C = 25A
- High input impedance
- CO-PAK, IGBT with FRD : t_{rr} = 235ns (typ.)

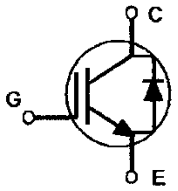
Applications

Induction Heating, UPS, AC & DC motor controls and general purpose inverters.



TO-3P

G C E



Absolute Maximum Ratings T_C = 25°C unless otherwise noted

Symbol	Description		FGA25N120AND	Units
V_{CES}	Collector-Emitter Voltage		1200	V
V_{GES}	Gate-Emitter Voltage		± 20	V
I_C	Collector Current	@ T_C = 25°C	40	A
	Collector Current	@ T_C = 100°C	25	A
$I_{CM\ (1)}$	Pulsed Collector Current		75	A
I_F	Diode Continuous Forward Current	@ T_C = 100°C	25	A
I_{FM}	Diode Maximum Forward Current		150	A
P_D	Maximum Power Dissipation	@ T_C = 25°C	310	W
	Maximum Power Dissipation	@ T_C = 100°C	125	W
T_J	Operating Junction Temperature		-55 to +150	°C
T_{stg}	Storage Temperature Range		-55 to +150	°C
T_L	Maximum Lead Temp. for soldering Purposes, 1/8" from case for 5 seconds		300	°C

Notes :
(1) Repetitive rating : Pulse width limited by max. junction temperature

Thermal Characteristics

Symbol	Parameter	Typ.	Max.	Units
$R_{\theta JC}$(IGBT)	Thermal Resistance, Junction-to-Case	--	0.4	°C/W
$R_{\theta JC}$(DIODE)	Thermal Resistance, Junction-to-Case	--	2.0	°C/W
$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient	--	40	°C/W

Electrical Characteristics of the IGBT T_C = 25°C unless otherwise noted

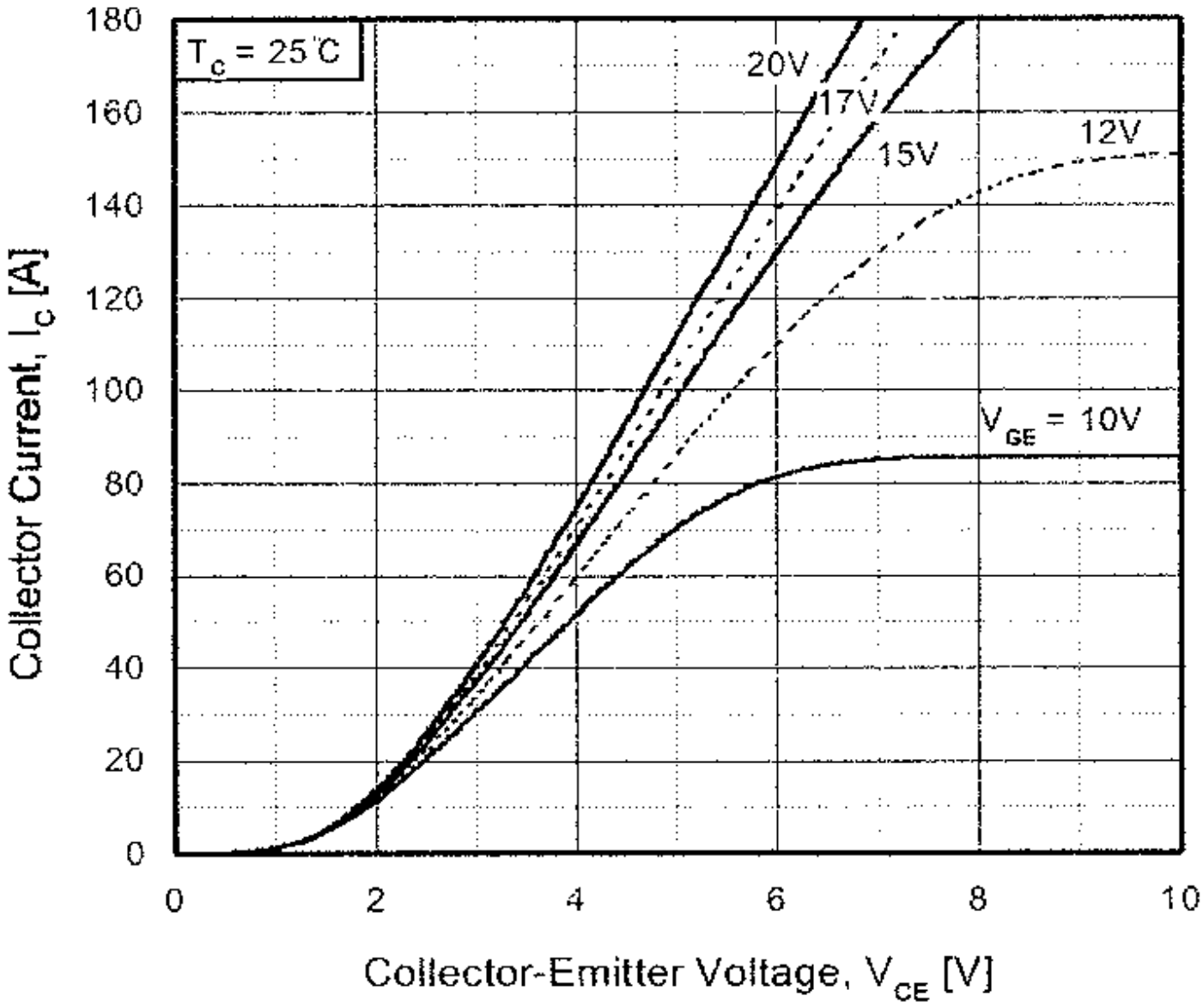
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Units
Off Characteristics						
BV_{CES}	Collector-Emitter Breakdown Voltage	V_{GE} = 0V, I_C = 3mA	1200	--	--	V
$\Delta B_{VCES}/\Delta T_J$	Temperature Coefficient of Breakdown Voltage	V_{GE} = 0V, I_C = 3mA	--	0.6	--	V/°C
I_{CES}	Collector Cut-Off Current	V_{CE} = V_{CES}, V_{GE} = 0V	--	--	3	mA
I_{GES}	G-E Leakage Current	V_{GE} = V_{GES}, V_{CE} = 0V	--	--	± 100	nA
On Characteristics						
$V_{GE(th)}$	G-E Threshold Voltage	I_C = 25mA, V_{CE} = V_{GE}	3.5	5.5	7.5	V
$V_{CE(sat)}$	Collector to Emitter Saturation Voltage	I_C = 25A, V_{GE} = 15V	--	2.5	3.2	V
		I_C = 25A, V_{GE} = 15V, T_C = 125°C	--	2.9	--	V
		I_C = 40A, V_{GE} = 15V	--	3.1	--	V
Dynamic Characteristics						
C_{ies}	Input Capacitance	V_{CE} = 30V, V_{GE} = 0V, f = 1MHz	--	2100	--	pF
C_{oes}	Output Capacitance		--	180	--	pF
C_{res}	Reverse Transfer Capacitance		--	90	--	pF

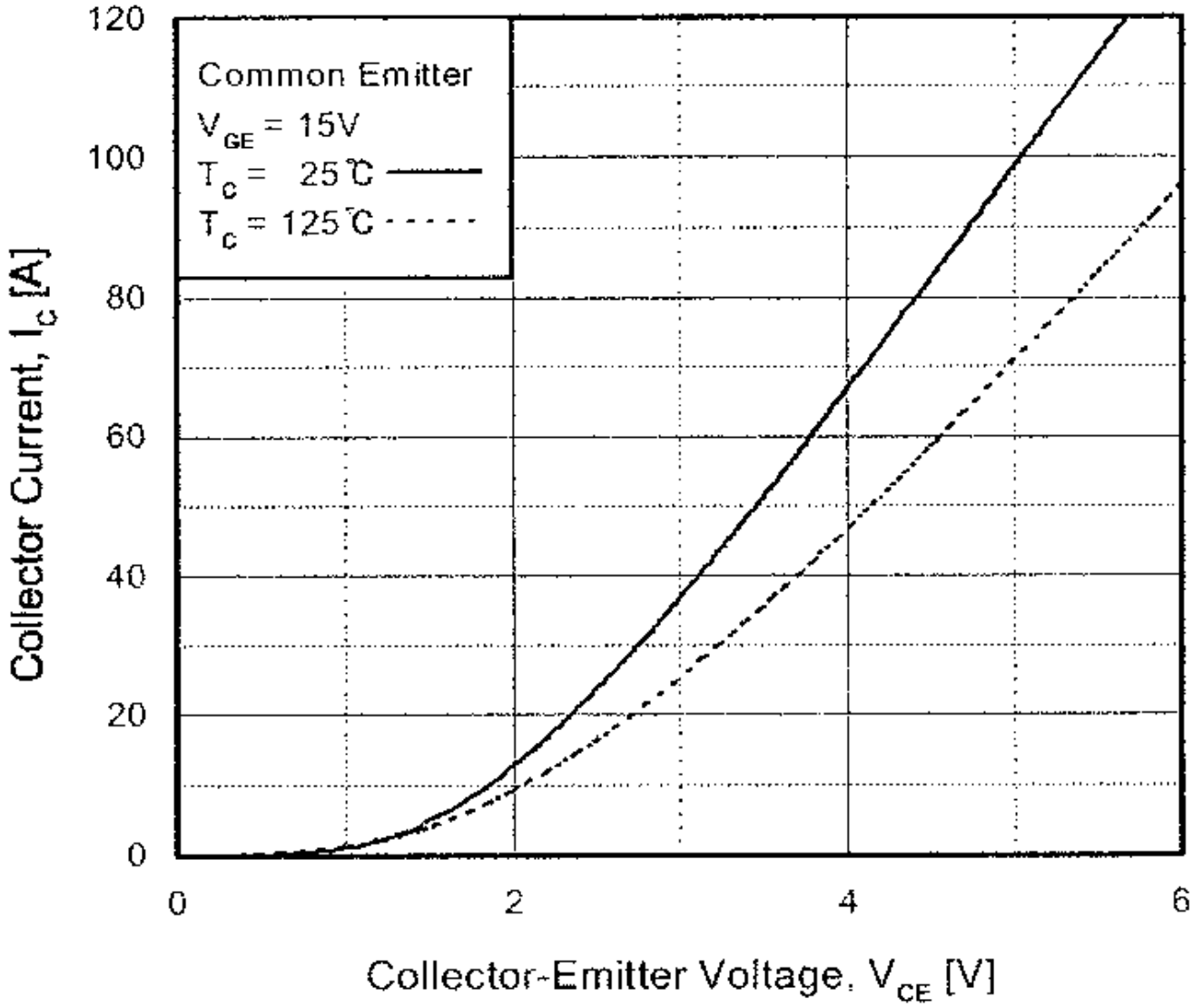
Switching Characteristics

$t_{d(on)}$	Turn-On Delay Time	V_{CC} = 600 V, I_C = 25A, R_G = 10Ω, V_{GE} = 15V, Inductive Load, T_C = 25°C	--	60	--	ns
t_r	Rise Time		--	60	--	ns
$t_{d(off)}$	Turn-Off Delay Time		--	170	--	ns
t_f	Fall Time		--	45	90	ns
E_{on}	Turn-On Switching Loss		--	4.8	7.2	mJ
E_{off}	Turn-Off Switching Loss		--	1.0	1.5	mJ
E_{ts}	Total Switching Loss		--	5.7	8.7	mJ
$t_{d(on)}$	Turn-On Delay Time	V_{CC} = 600 V, I_C = 25A, R_G = 10Ω, V_{GE} = 15V, Inductive Load, T_C = 125°C	--	60	--	ns
t_r	Rise Time		--	60	--	ns
$t_{d(off)}$	Turn-Off Delay Time		--	180	--	ns
t_f	Fall Time		--	70	--	ns
E_{on}	Turn-On Switching Loss		--	5.5	--	mJ
E_{off}	Turn-Off Switching Loss		--	1.4	--	mJ
E_{ts}	Total Switching Loss		--	6.9	--	mJ
Q_g	Total Gate Charge	V_{CE} = 600 V, I_C = 25A, V_{GE} = 15V	--	200	300	nC
Q_{ge}	Gate-Emitter Charge		--	15	23	nC
Q_{gc}	Gate-Collector Charge		--	105	160	nC
L_e	Internal Emitter Inductance	Measured 5mm from PKG	--	14	--	nH

Electrical Characteristics of DIODE T_C = 25°C unless otherwise noted

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Units
V_{FM}	Diode Forward Voltage	I_F = 25A	T_C = 25°C	--	2.0	3.0	V
			T_C = 125°C	--	2.1	--	
t_{rr}	Diode Reverse Recovery Time	I_F = 25A dI/dt = 200 A/µs	T_C = 25°C	--	235	350	ns
			T_C = 125°C	--	300	--	
I_{rr}	Diode Peak Reverse Recovery Current		T_C = 25°C	--	27	40	A
			T_C = 125°C	--	31	--	
Q_{rr}	Diode Reverse Recovery Charge		T_C = 25°C	--	3130	4700	nC
			T_C = 125°C	--	4650	--	


T_c = 25°C
20V
17V
15V
12V
V_{GE} = 10V
Collector Current, I_c [A]
Collector-Emitter Voltage, V_{CE} [V]
0
20
40
60
80
100
120
140
160
180
0
2
4
6
8
10


Common Emitter
V_{GE} = 15V
T_C = 25℃
T_C = 125℃
Collector Current, I_C [A]
120
100
80
60
40
20
0
0
2
4
6
Collector-Emitter Voltage, V_{CE} [V]