FSC POWER DEVICES SOLUTION

I G B T

JAN.10,2001

北京韶光科技有限公司

Why FSC IGBTs ?

IGBT is voltage controlled power transistor similar to power MOSFET in operation. FSC IGBTs offers the best power solution in high power & medium frequency applications due to its superior performance to both of BJT & power MOSFET.

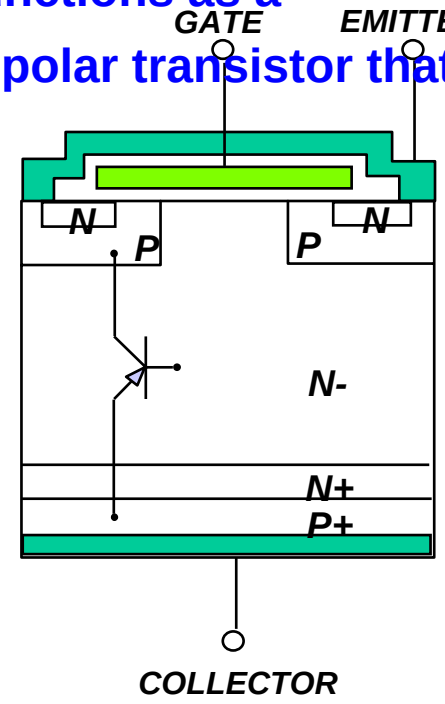
FSC IGBT is designed by optimized internal structure for low Rds(on) & fast switching which can be realized especially by proper method of ' life time killing'. Recently, FSC is introducing new IGBT of SDB process in Market.
SDB is FSC's own unique process and new design concept mainly for 1200V IGBT, by which customer can get the best effect of trade off between Vce(sat) & Tf.

FSC has plan to widen its IGBT product line up from discrete type to IPM and hope to provide market with best power solution for consumer systems(IH applications, white & brown goods etc) to industry usage(motor drive control, UPS etc) Now, FSC IGBT is specific to such various applications as motor control, camera strobe etc due to its characteristics, ' short circuit rated ' and ' logic level ' IGBTs respectively.

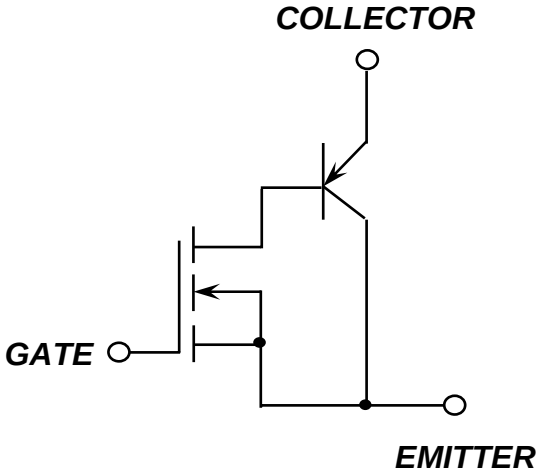
FSC IGBT, the right power solution for customers' satisfaction !

Construction & Operation of IGBT

The operation of the IGBT simply can be treated as a partitioning of an n-channel MOSFET and a PNP bipolar transistor. The IGBT functions as a bipolar transistor that is supplied base current by a MOSFET



Structure Of IGBT



Equivalent Circuit

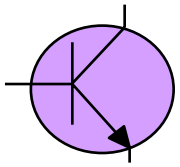
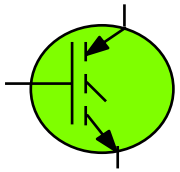
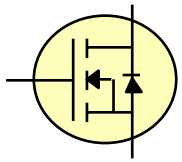
What`s a IGBT ?

IGBT(Insulated Gate Bipolar Transistor) is a voltage-controlled power transistor, similar to the power MOSFET in operation and construction.

These devices offer superior performance to the bipolar transistors. They are more cost-effective solution in high power, wide range of frequency applications

Comparison Table

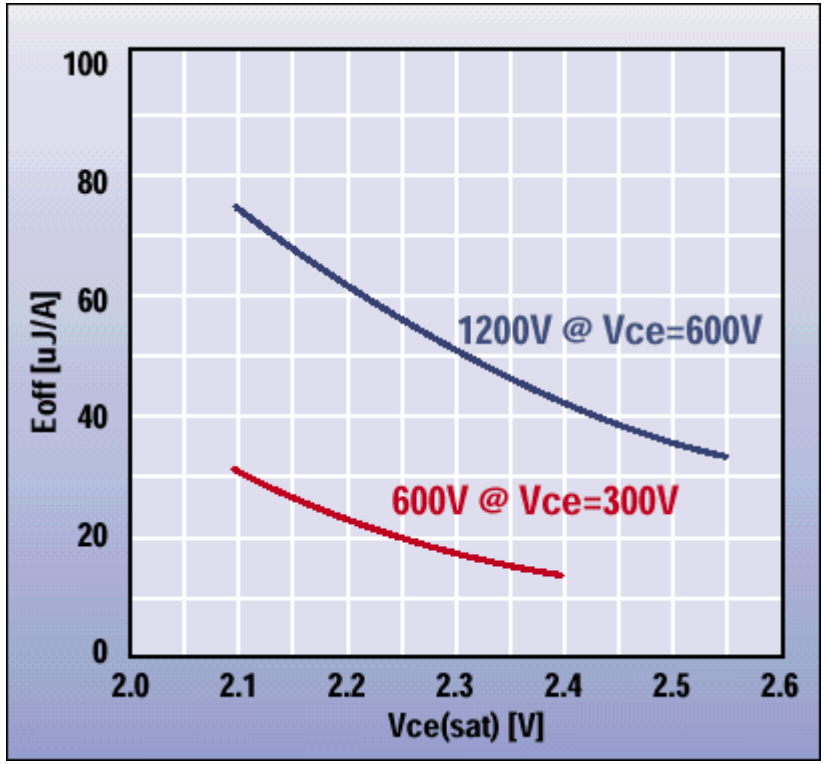
※ Same Rating (V,A)

ITEM	T R	I G B T	MOSFET
SYMBOL			
CONTROL PARAMETER CONTROL POWER CONTROL CIRCUIT	CURRENT HIGH COMPLEX	VOLTAGE LOW SIMPLE	VOLTAGE LOW SIMPLE
ON-RESISTANCE SWITCHING SPEED SWITCHING LOSS	LOW SLOW HIGH	LOW MEDIUM MEDIUM	HIGH FAST LOW

FAIRCHILD IGBT Trade-Off

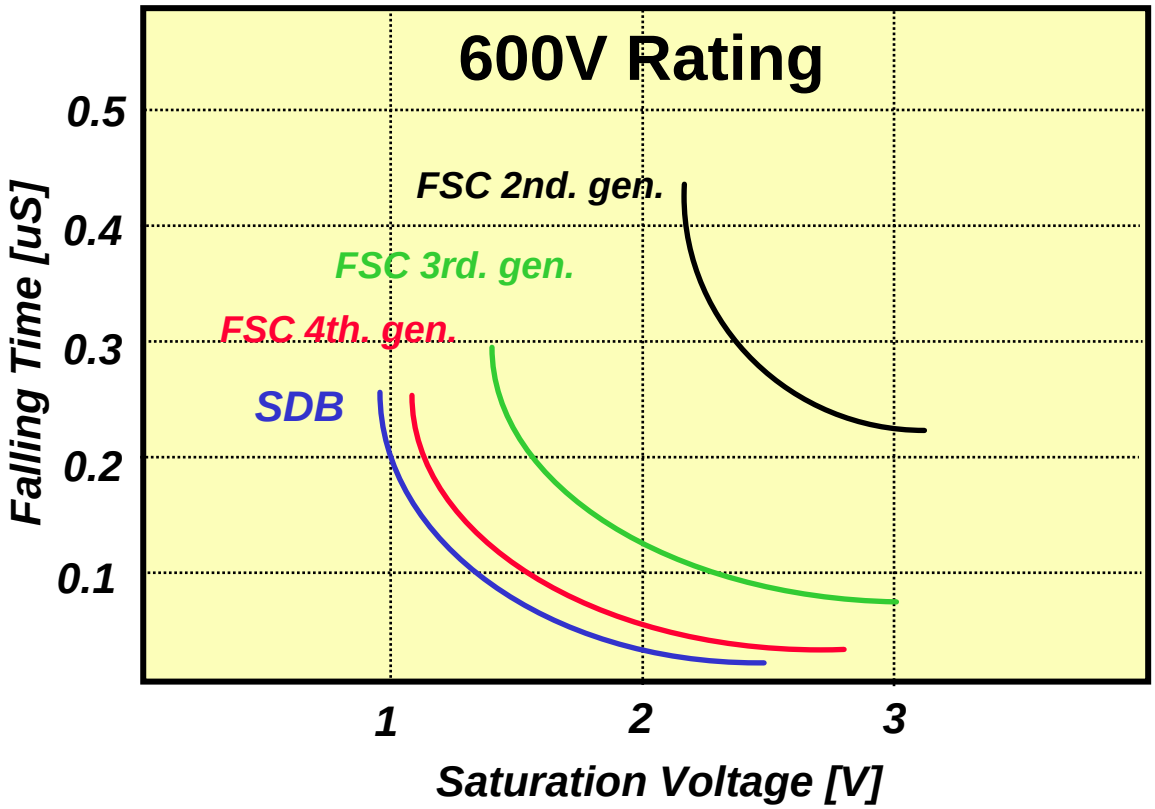
Fairchild's IGBT offer superior electrical performance in a wide range of industrial standard packages. The IGBT have been enhanced to provide high reliability and quality in all applications.

- **High Performance**
  - *- Low Saturation Voltage*
  - *- High Speed Switching*
  - *- Low Turn-off Energy*
- **Increased Ruggedness**
  - *- Latch-Free Characteristics*
  - *- Short-Circuit Immunity*
- **High Current**
  - *- Easy to Parallel Operation*
  - *- Positive Temperature Coefficient*

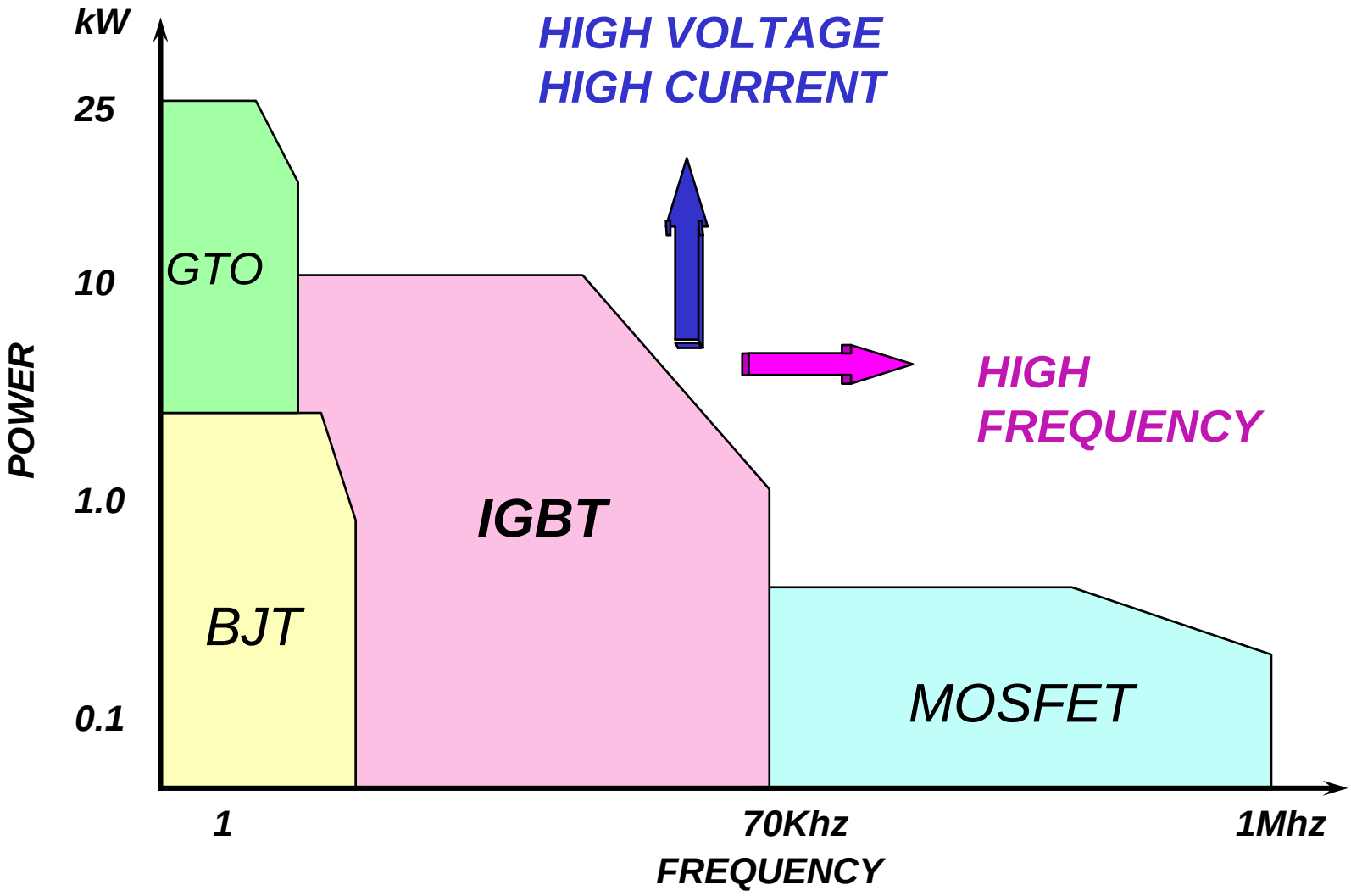


Design Point For FSC IGBT

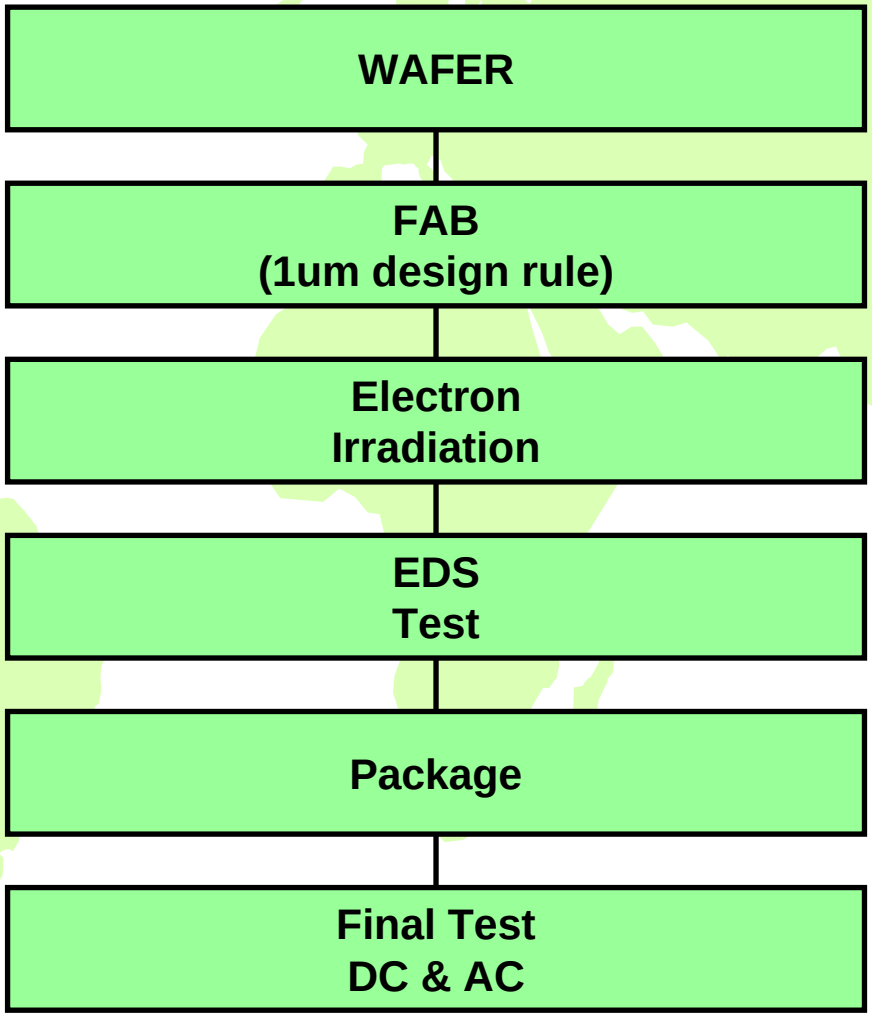
- ***Optimization of Cell Structure For Fast Switching, Low On Loss***
- ***Optimization of Chip Process Not To Latch For Operation Within The Data Sheet Limit.***
- **Improvement of Trade-off**



IGBT`s Functional Range

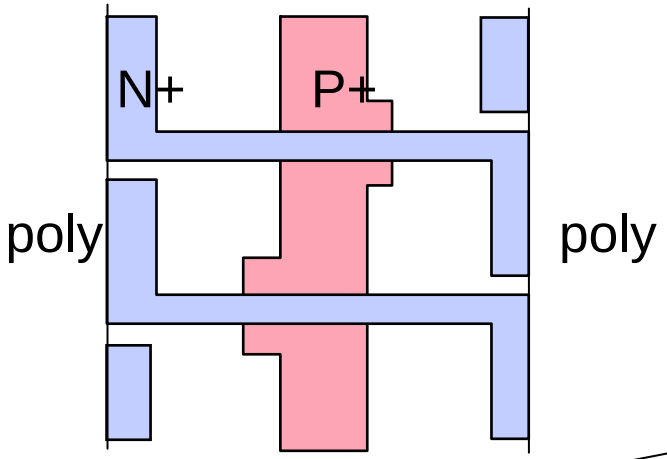


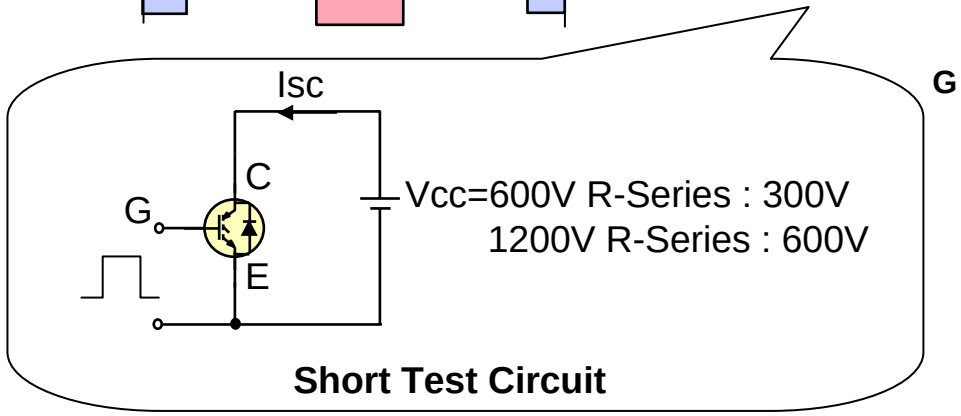
IGBT Process Flowchart



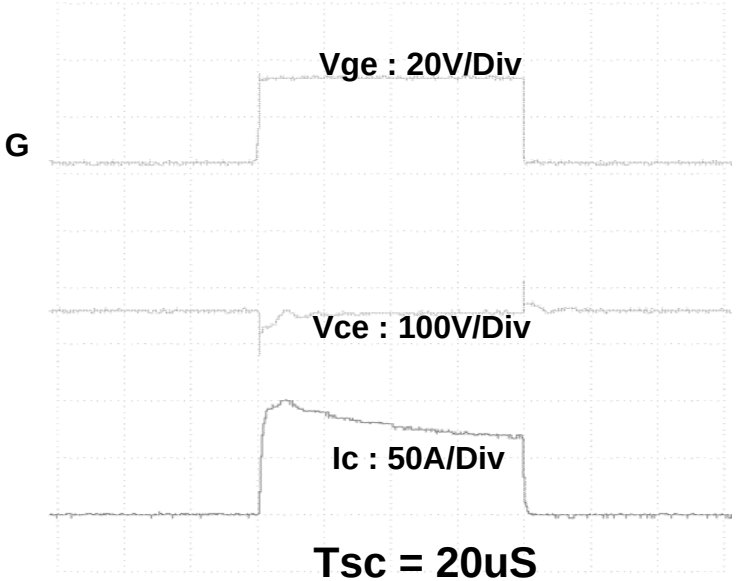
Short Circuit Current Protection & Performanc

- ☞ Optimization of EBR
- ☞ P+ diverter





G

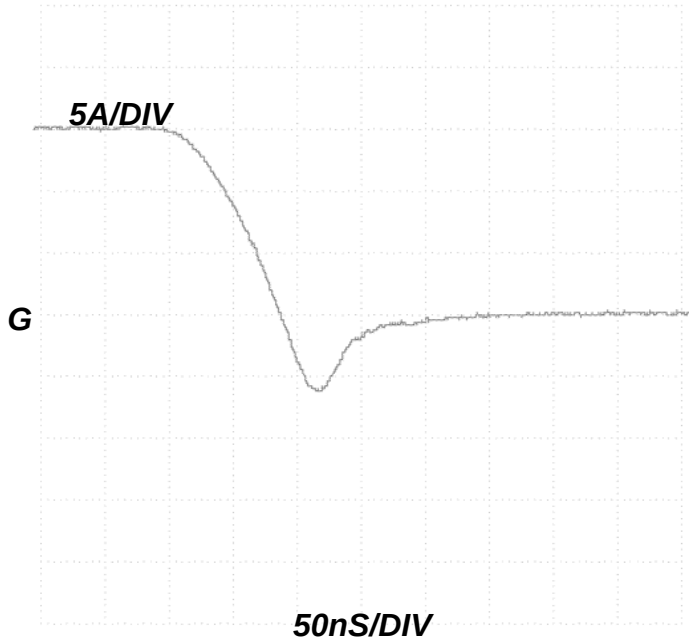


G

S.C.S.O.A @ 125℃

FSC FRD T_{RR} Characteristics

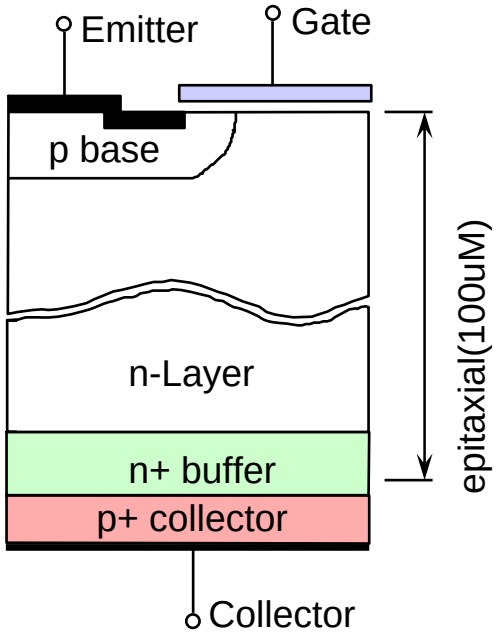
- Improved Free Wheeling Diode Characteristics
  .Reduced diode Qrr (Reverse Recovery Charge)
  .Soft Recovery for Low Diode Recovery dv/dt



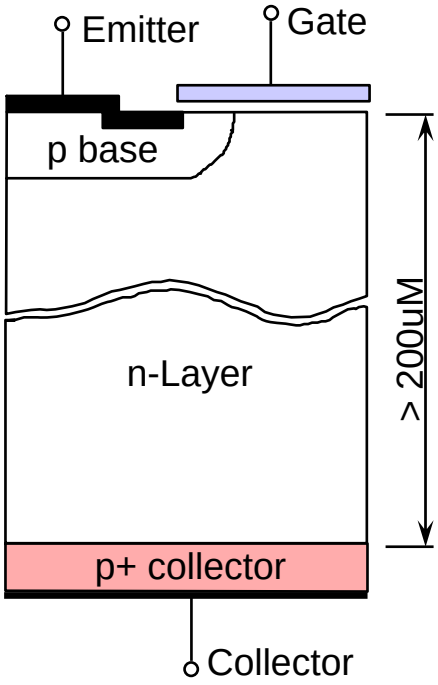
High performance Characteristic

Cross Sectional view

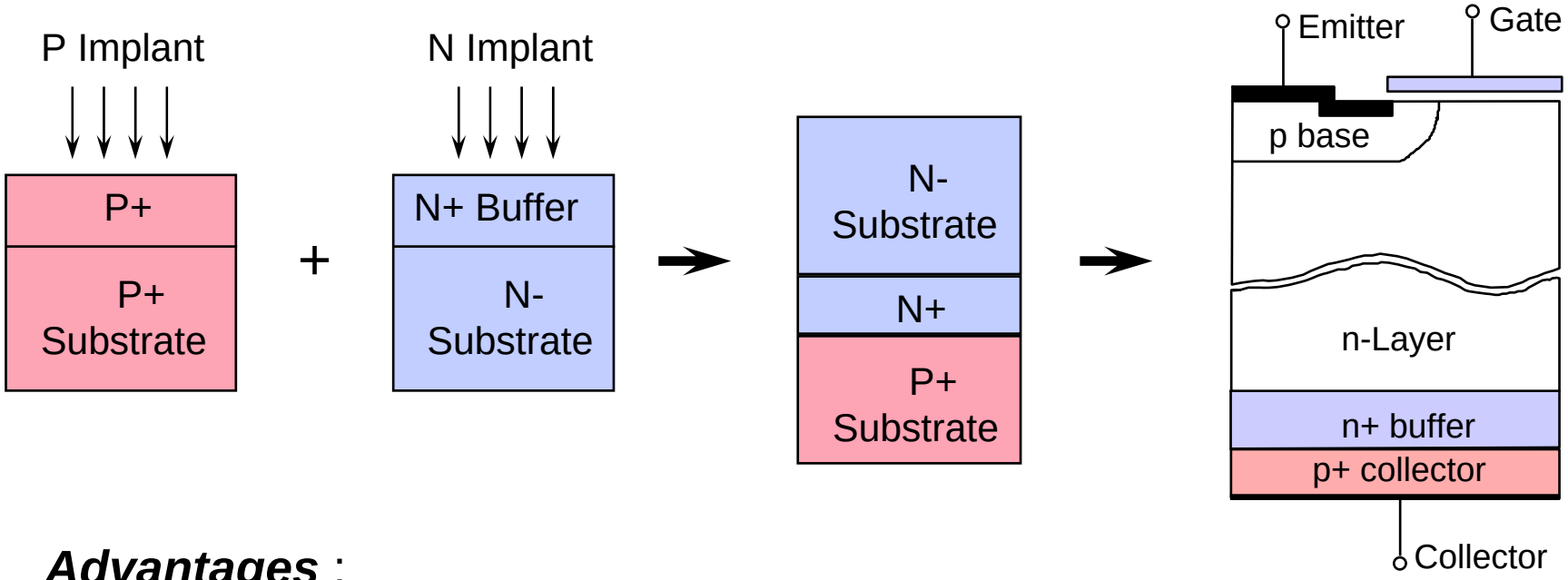
- PT(Punch Through)



- NPT(Non Punch Through)



SDB(Silicon-Direct-Bonding) IGBT



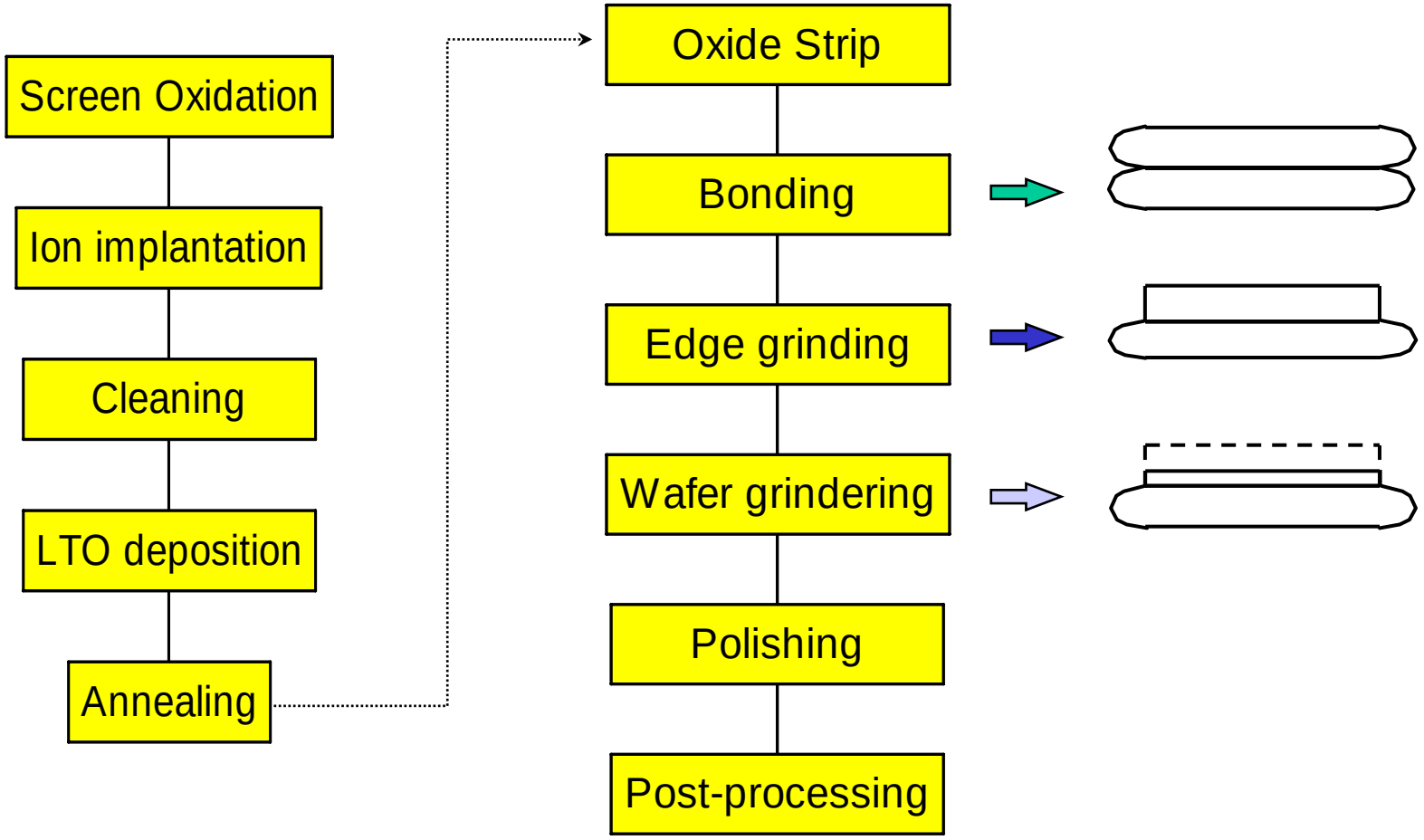
Advantages :

1. Less wafer dispersion(n-layer)
   - ☞ Less dispersion of IGBT characteristics
2. Control of hole injection efficiency
   - ☞ Optimization of trade-off (Vce(sat) vs. Tf)
   - ☞ No additional increase of turn-off energy at high temperature

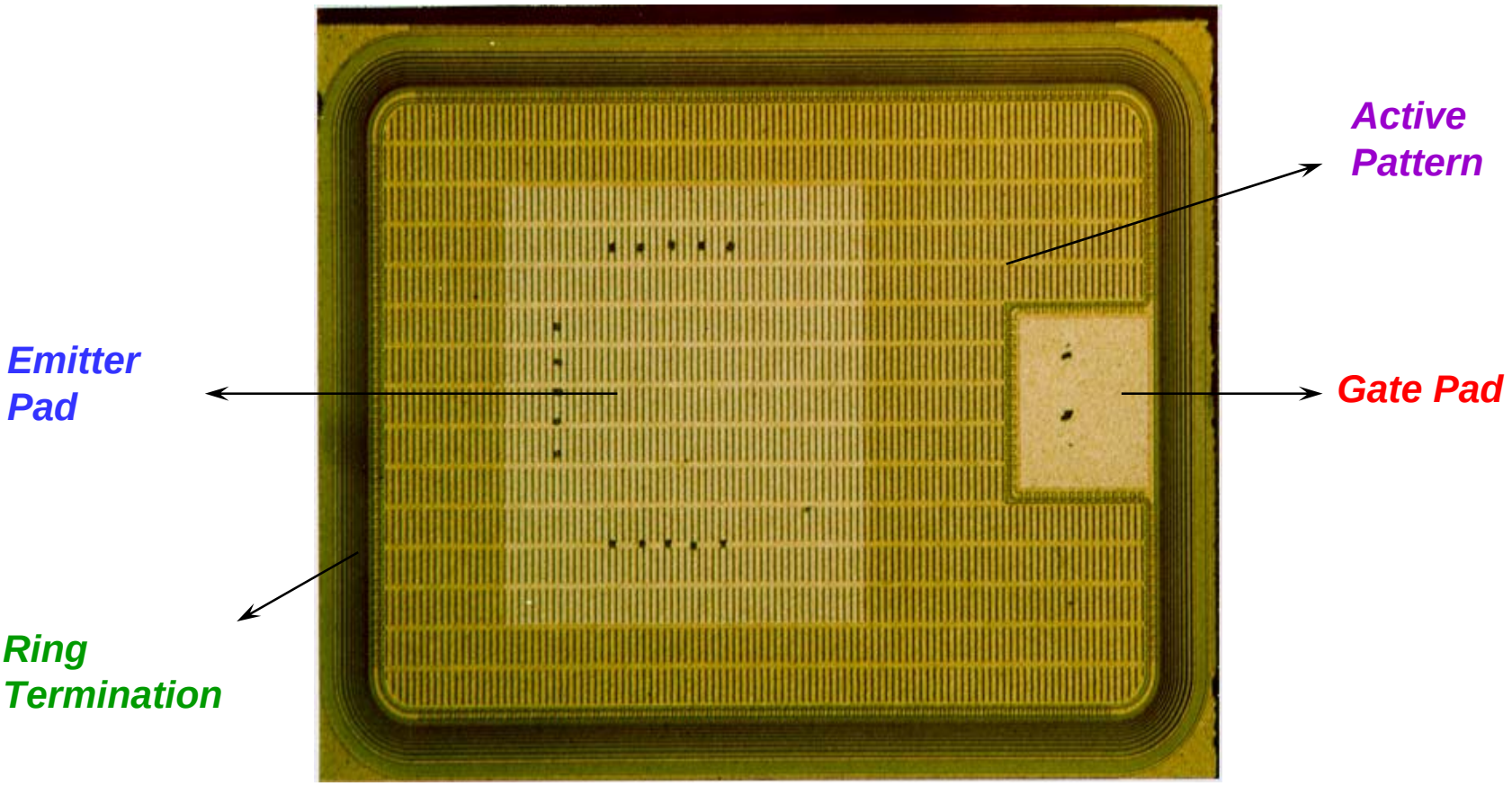
Comparison Table

ITEMS	PT	NPT	SDB
Vce(sat)	low	high	low
Turn Off Energy	low	high long tail current	very low
RBSOA	narrow	wide	wide
SCSOA	narrow	wide	wide
Parallel Connecting	not easy NTC	easy PTC	easy PTC
Hot Leakage Current	big	small	medium
Life Time Control	electronic irradiation	no	yes
Current Density	high	low	high
Manufacturing Cost	expensive	inexpensive	inexpensive

SDB Wafer Process

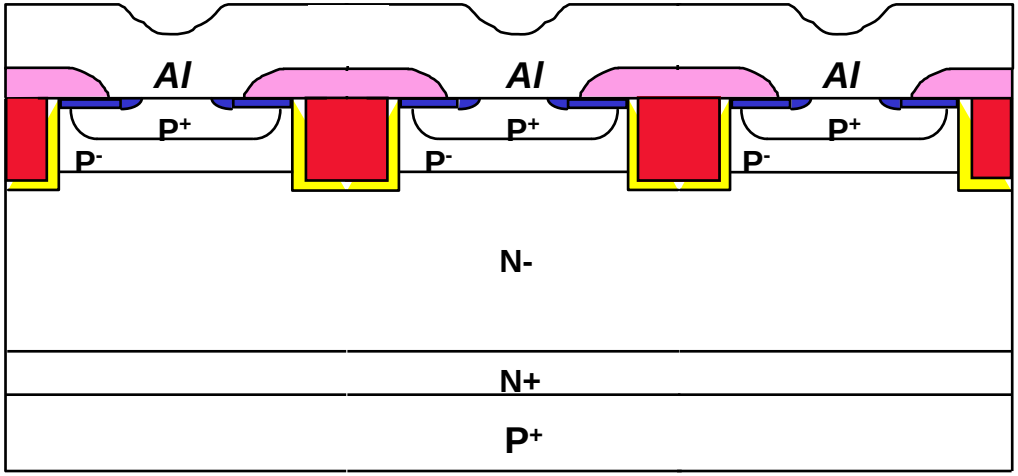


SDB 1200V 10A Chip Top View



(5100um x 5250um)

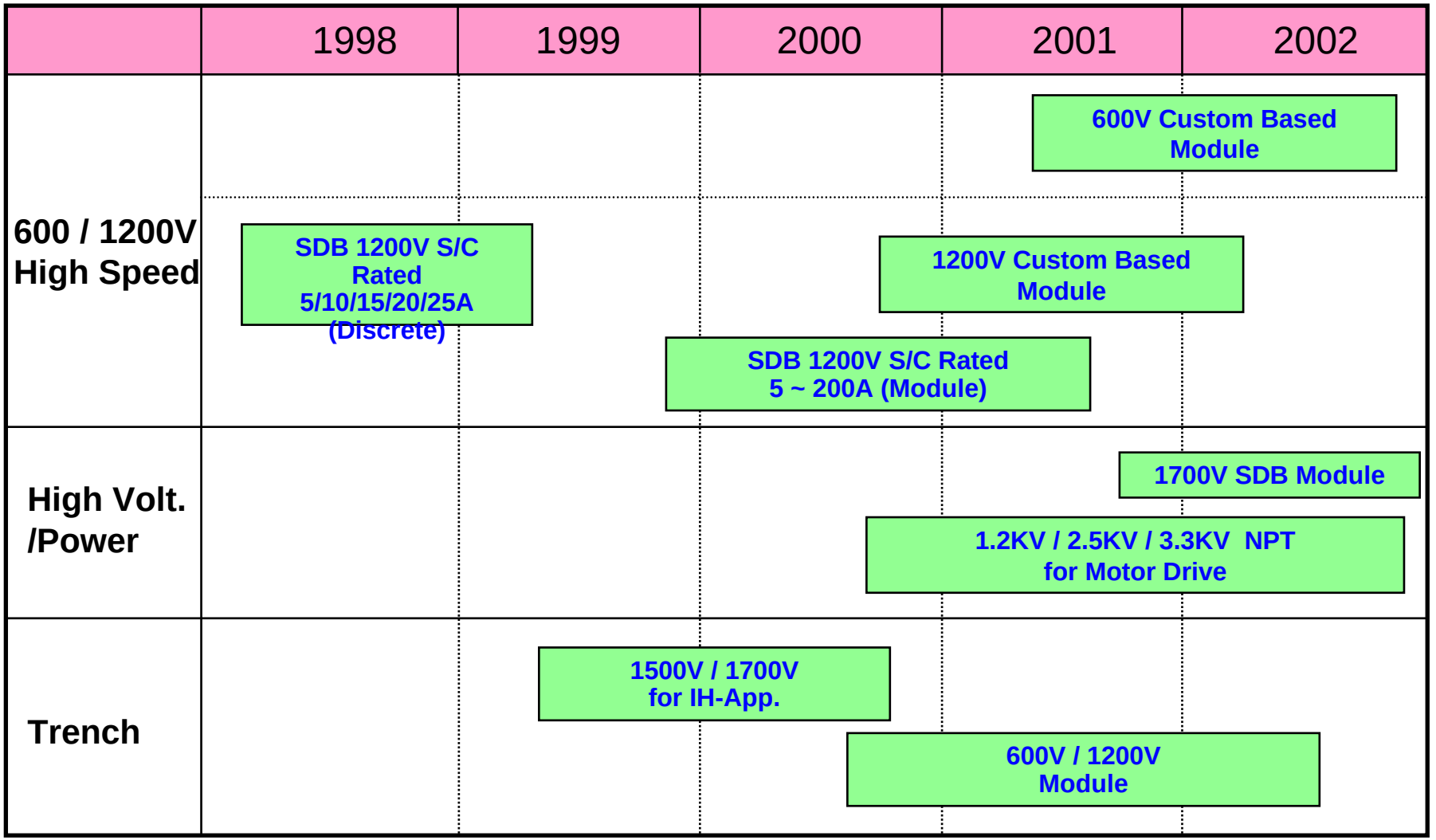
Trench IGBT



DEVICE NAME	BV_{ces}[V]	I_c[A]	$V_{ce(sat)}$[V]	t_f[uS](typ.)	Applications
SGR15N40L	400	130	4.5	2.0	Camera Strobe
FGS15N40L	400	130	4.5	2.0	Camera Strobe
SGR20N40L	400	150	4.5	2.0	Camera Strobe
SGL60N90DG3	900	60	2.0	0.25	Induction Heating

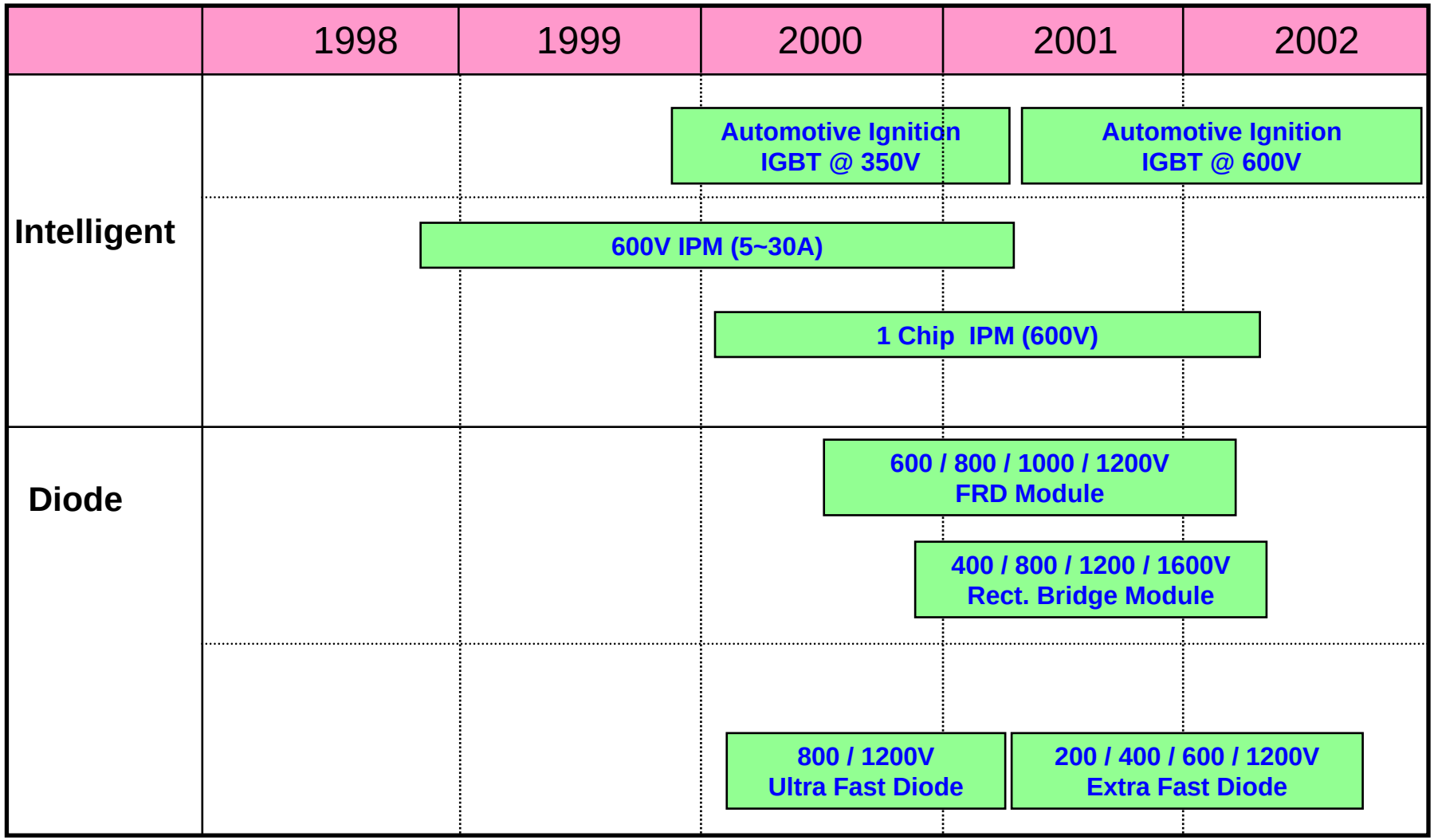
IGBT Developmental Midterm Roadmap

Confidential



IGBT Developmental Midterm Roadmap

Confidential



IGBTs Line -up

■ Discrete Series

Major Applications	DEVICE	V_{CES}[V]	I_C[A]	$V_{CE(sat)}$[V] (typ.)	T_f[us] (typ.)	PKG	C/S
High Speed Switchings Power Supply Lamp Ballast	SGP/SGR6N60UF	600	3	2.1	0.08	TO-220/D-PAK	NOW
	SGP13N60UF		7	2.1	0.08	TO-220	NOW
	SGP23N60UF		12	2.1	0.08	TO-220	NOW
	SGP/SGH40N60UF		20	2.1	0.08	TO-220/TO-3P	NOW
	SGH80N60UF		40	2.1	0.08	TO-3P	NOW
General Purpose Inverters Robotics, Servo Controls @ Consumer Power Source	SGP5N60RUF	600	5	2.2	0.12	TO-220	NOW
	SGP10N60RUF		10	2.2	0.12	TO-220	NOW
	SGP15N60RUF		15	2.2	0.12	TO-220	NOW
	SGH20N60RUF		20	2.2	0.12	TO-220	NOW
	SGH30N60RUF		30	2.2	0.12	TO-3P	NOW
General Purpose Inverters Robotics, Servo Controls @ Industrial Power Source	SGH5N120RUF	120 0	5	2.3	0.12	TO-3P	NOW
	SGH10N120RUF		10	2.3	0.12	TO-3P	NOW
	SGH15N120RUF		15	2.3	0.12	TO-3P	NOW
	SGH20N120RUF		20	2.3	0.12	TO-3P	NOW
	SGL25N120RUF		25	2.3	0.12	TO-264	NOW

■ Co-Pak Series

Major Applications	DEVICE	V_{CES}[V]	I_C[A]	$V_{CE(sat)}$[V] (typ.)	T_f[us] (typ.)	PKG	C/S
High Speed Switchings Power Suppy Lamp Ballast	SGR2N60UFD	600	1.2	2.1	0.10	D-PAK	NOW
	SGP6N60UFD		3	2.1	0.08	TO-220	NOW
	SGP/S13N60UFD		7	2.1	0.08	TO-220/TO-220F	NOW
	SGP/S23N60UFD		12	2.1	0.08		NOW
	SGH23N60UFD		12	2.1	0.08	TO-220/TO-220F	NOW
	SGH40N60UFD		20	2.1	0.08		NOW
	SGH80N60UFD		40	2.1	0.08	TO-3P TO-3P	NOW
General Purpose Inverters Robotics, Servo Controls @ Consumer Power Source	SGP5N60RUFD	600	5	2.2	0.12	TO-3P	NOW
	SGP/S10N60RUFD		10	2.2	0.12		NOW
	SGH15N60RUFD		15	2.2	0.12	TO-220	NOW
	SGH20N60RUFD		20	2.2	0.12	TO-220/TO-220F	NOW
	SGH30N60RUFD		30	2.2	0.12		NOW
	SGL50N60RUFD		50	2.2	0.12	TO-3P	NOW
	SGL160N60UFD		80	2.1	0.12	TO-3P TO-3P	NOW
General Purpose Inverters Robotics, Servo Controls @ Industrial Power Source	SGH5N120RUFD	1200	5	2.3	0.12	TO-264	NOW
	SGH10N120RUFD		10	2.3	0.12	TO-264	NOW
	SGH15N120RUFD		15	2.3	0.12		NOW
	SGH20N120RUFD		20	2.3	0.12	TO-3P	NOW
	SGL25N120RUFD		25	2.3	0.12	TO-3P TO-3P TO-3P TO-264	NOW

■ OTHERS

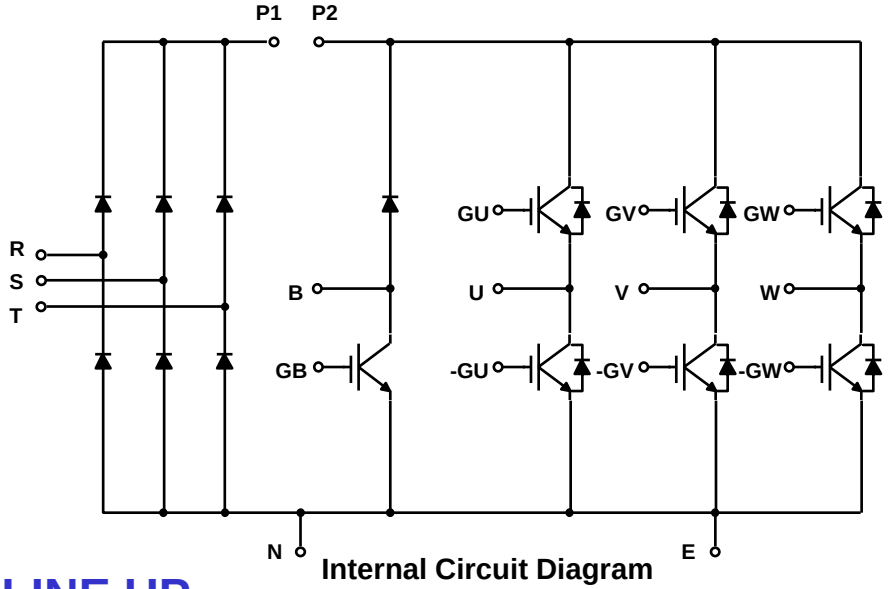
Major Applications	DEVICE	V_{CES}[V]	I_C[A]	$V_{CE(sat)}$[V] (typ.)	T_f[us] (typ.)	PKG	C/S
Automotive	FGP20N40CL	350	20A	1.5	2.0	TO-220	2Q, 2001
Camera Strobe	SGR/SGU15N40L	400	130	4.5	2.0	D-PAK/I-PAK	NOW
	SGR/SGU20N40L		150	4.5	2.0	D-PAK/I-PAK	NOW
	FGS15N40L		130	4.5	2.0	8SOP	NOW
High Voltage SMPS	SGL5N150UF	1500	10	3.0	0.08	TO-264	1Q, 2001
Induction Heating (Jar, Cooker, MWO...)	SGF15N90D	900	15	2.0	0.25	TO-3PF	NOW
	SGL60N90DG3		60	2.0	0.25	TO-264	NOW
	SGL40N150D *	1500	40	3.7	0.20	TO-264	NOW
	FGL40N150D		40	3.5	100	TO-264	NOW
	FGL60N150D		60	3.5	100	TO-264	NOW
	FGL60N170D	1700	60	5.0	100	TO-264	#
	FGL80N170D		80	5.0	150	TO-264	NOW #

*** : Will be EOL**
 # : Optional Device (Line-up Plan)

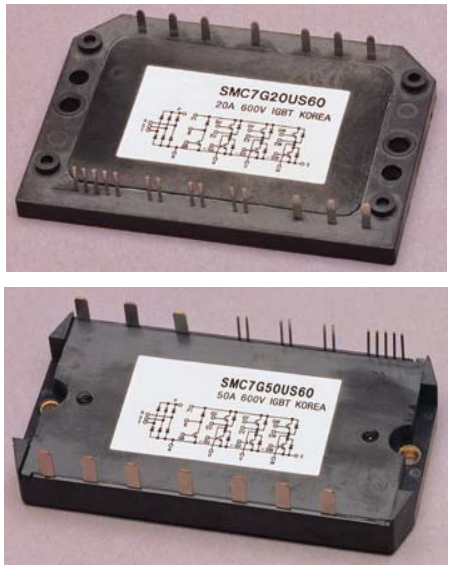
C&C 7-PAK Module

UL Approval : E209204

- 3 Phase Rectifier + Brake + 3 Phase Inverter



Internal Circuit Diagram



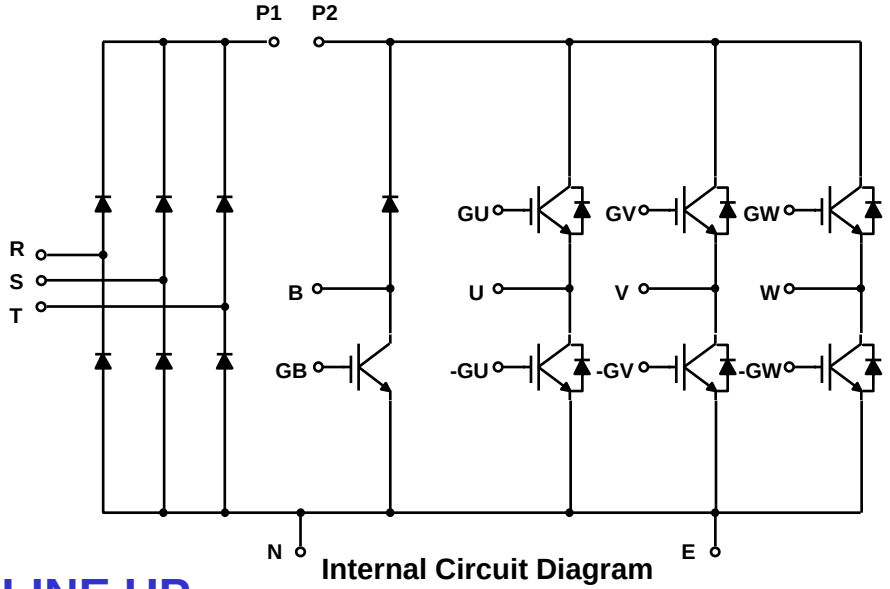
- LINE UP

DEVICE NAME	*BV_{ces}[V]*	*I_c[A]*	*$V_{ce(sat)}$[V] typ.*	*t_f [uS] typ.*	*STATUS*
FMC7G10US60	*600*	*10*	*2.0*	*0.1*	*NOW*
FMC7G15US60	*600*	*15*	*2.0*	*0.1*	*NOW*
FMC7G20US60	*600*	*20*	*2.0*	*0.1*	*NOW*
FMC7G30US60	*600*	*30*	*2.0*	*0.1*	*NOW*
FMC7G50US60	*600*	*50*	*2.0*	*0.1*	*NOW*

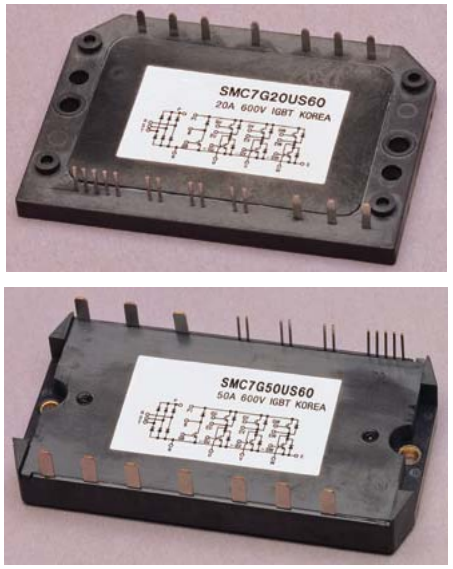
C&C 7-PAK Module

UL Approval : E209204

- 3 Phase Rectifier + Brake + 3 Phase Inverter



Internal Circuit Diagram



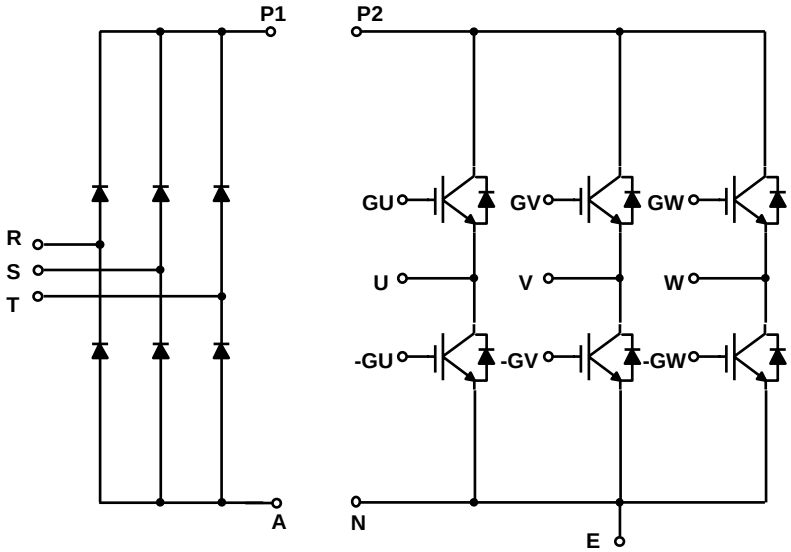
- LINE UP

DEVICE NAME	BV_{ces}[V]	I_c[A]	$V_{ce(sat)}$[V]typ.	t_f[uS]typ.	STATUS
FMC7G5US120	1200	5	2.3	0.15	2Q, 2001
FMC7G10US120	1200	10	2.3	0.15	2Q, 2001
FMC7G15US120	1200	15	2.3	0.15	2Q, 2001
FMC7G20US120	1200	20	2.3	0.15	2Q, 2001
FMC7G25US120	1200	25	2.3	0.15	2Q, 2001

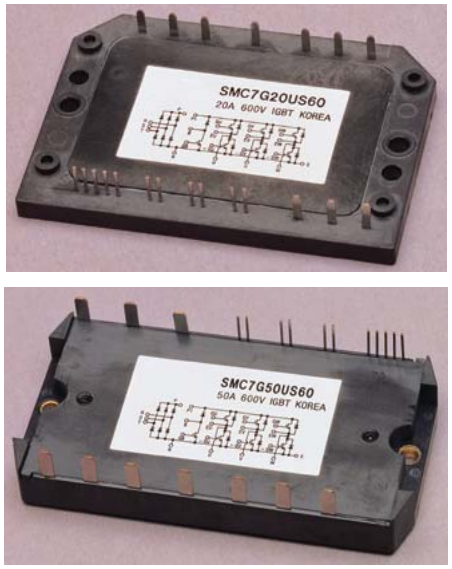
C&C 6-PAK Module

UL Approval : E209204

- 3 Phase Rectifier + 3 Phase Inverter



Internal Circuit Diagram



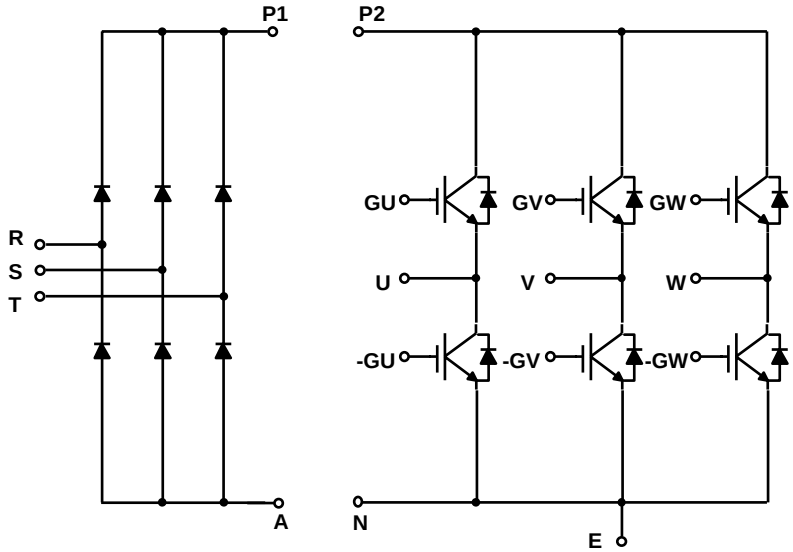
- LINE UP

DEVICE NAME	BV_{ces}[V]	I_c[A]	$V_{ce(sat)}$[V]typ.	t_f[uS]typ.	STATUS
FMC6G5US120	1200	5	2.3	0.15	2Q, 2001
FMC6G10US120	1200	10	2.3	0.15	2Q, 2001
FMC6G15US120	1200	15	2.3	0.15	2Q, 2001
FMC6G20US120	1200	20	2.3	0.15	2Q, 2001
FMC6G25US120	1200	25	2.3	0.15	2Q, 2001

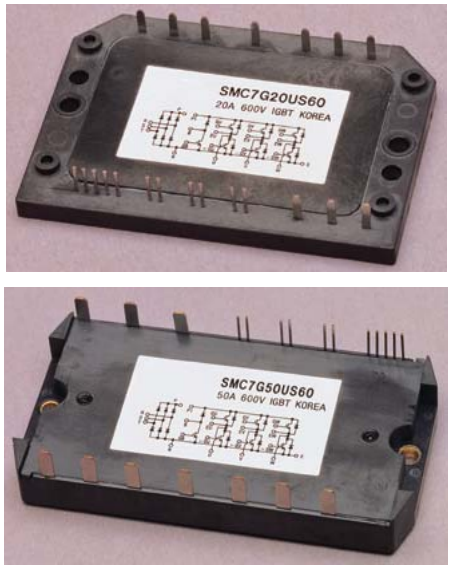
C&C 6-PAK Module

UL Approval : E209204

- 3 Phase Rectifier + 3 Phase Inverter



Internal Circuit Diagram



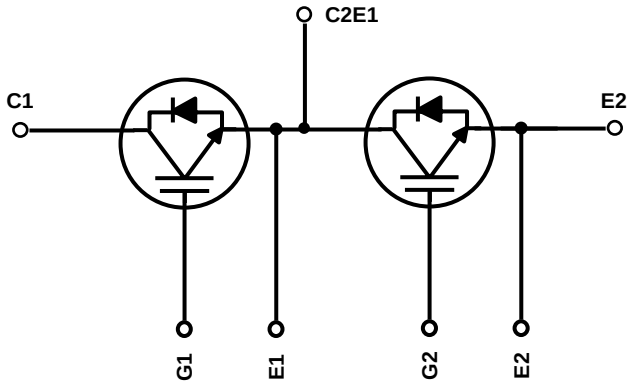
- LINE UP

DEVICE NAME	BV_{ces}[V]	I_c[A]	$V_{ce(sat)}$[V]typ.	t_f[uS]typ.	STATUS
FMC6G10US60	600	10	2.0	0.1	NOW
FMC6G15US60	600	15	2.0	0.1	NOW
FMC6G20US60	600	20	2.0	0.1	NOW
FMC6G30US60	600	30	2.0	0.1	NOW
FMC6G50US60	600	50	2.0	0.1	NOW

Standard Module (2-PAK, 7PM-AA)

UL Approval : E209204

- Simple Drive By Gate Voltage
- High Switching Speed , Low Saturation Voltage
- Motor Application Inverter,UPS, Welding Machine



Internal Circuit Diagram

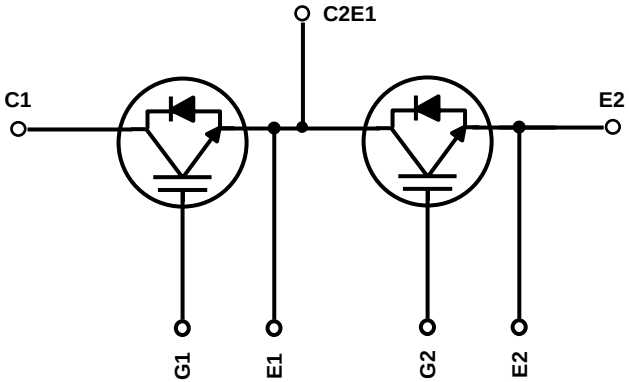
- LINE UP

DEVICE NAME	BV_{ces}[V]	I_c[A]	$V_{ce(sat)}$ [v]typ.	t_f [uS]typ.	STATUS
FM2G50US60	600	50	2.1	0.1	NOW
FM2G75US60	600	75	2.1	0.1	NOW
FM2G100US60	600	100	2.1	0.1	NOW
FM2G50US120	1200	50	2.3	0.15	2Q, 2001
FM2G75US120	1200	75	2.3	0.15	2Q, 2001

Standard Module (2-PAK, 7PM-BB)

UL Approval : E209204

- Simple Drive By Gate Voltage
- High Switching Speed , Low Saturation Voltage
- Motor Application Inverter,UPS, Welding Machine



Internal Circuit Diagram

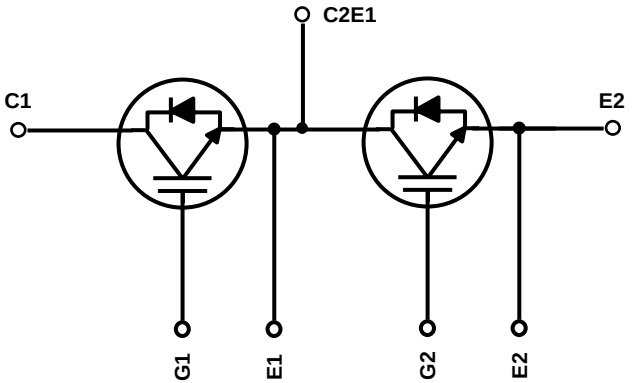
- LINE UP

DEVICE NAME	BV_{ces}[V]	I_c[A]	$V_{ce(sat)}$ [V]typ.	t_f [uS]typ.	STATUS
FM2G150US60	600	150	2.1	0.1	NOW
FM2G200US60	600	200	2.1	0.1	NOW
FM2G300US60	600	300	2.1	0.1	NOW
FM2G100US120	1200	100	2.3	0.15	2Q, 2001
FM2G150US120	1200	150	2.3	0.15	2Q, 2001

Standard Module (2-PAK, 7PM-EA)

UL Approval : E209204

- Simple Drive By Gate Voltage
- High Switching Speed , Low Saturation Voltage
- Motor Application Inverter,UPS, Welding Machine



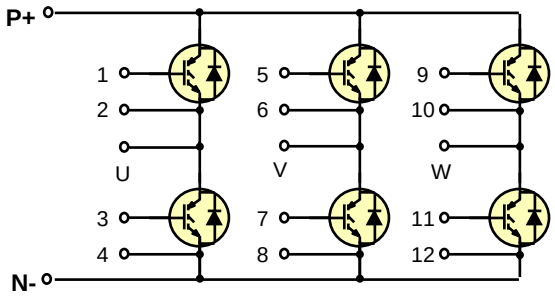
Internal Circuit Diagram

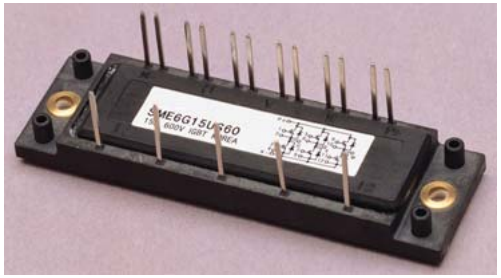
- LINE UP

DEVICE NAME	BV_{ces}[V]	I_c[A]	$V_{ce(sat)}$ [V]typ.	t_f [uS]typ.	STATUS
FM2G400US60	600	400	2.1	0.15	NOW
FM2G200US120	1200	200	2.3	0.15	2Q, 2001

COM-PAK SIX Module (17PM-BA)

- Simple Drive By Gate Voltage
- High Switching Speed , Low Saturation Voltage
- Suitable Structure For 3 Phase Motor Application

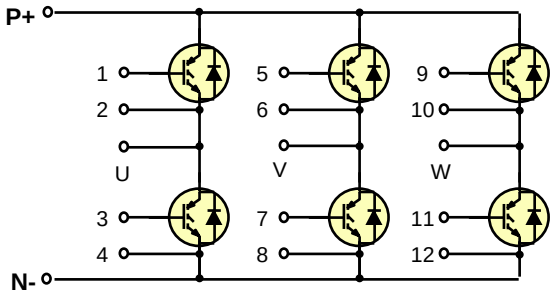


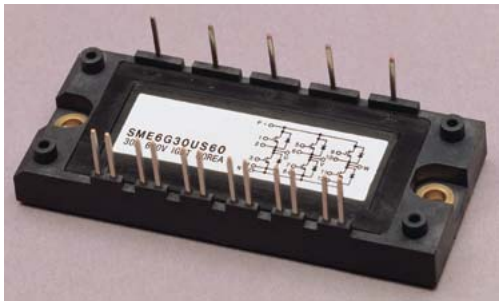


TYPE	NAME	BV_{ces} [V]	I_c [A]	$V_{ce(sat)}$ [V] typ.	t_f[uS] typ.	C/S
3Phase (6 IN 1)	FME6G10US60	600	10	2.2	0.12	3Q,2001
	FME6G15US60	600	15	2.2	0.12	3Q,2001
	FME6G5US120	1200	5	2.3	0.15	2Q, 2001
	FME6G10US120	1200	10	2.3	0.15	2Q, 2001

COM-PAK SIX Module (17PM-CA)

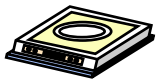
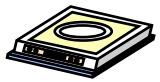
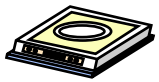
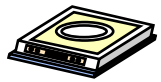
- Simple Drive By Gate Voltage
- High Switching Speed , Low Saturation Voltage
- Suitable Structure For 3 Phase Motor Application





TYPE	NAME	BV_{ces} [V]	I_c [A]	$V_{ce(sat)}$ [V] Typ.	T_f [Us] typ.	C/S
3Phase (6 IN 1)	FME6G20US60	600	20	2.2	0.12	3Q,2001
	FME6G30US60	600	30	2.2	0.12	3Q,2001
	FME6G15US120	1200	15	2.3	0.15	2Q, 2001
	FME6G20US120	1200	20	2.3	0.15	2Q, 2001
	FME6G25US120	1200	25	2.3	0.15	2Q, 2001

Fairchild IGBT's for IH-Application

Device	SGF15N90D	SGL60N90DG3	SGL40N150D	FGL40N150D	FGL60N150D※	FGL60N170D	FGL80N170D※
Rating	900V 15A	900V 60A	1500V 40A	1500V 40A	1500V 60A	1700V 60A	1700V 60A
Vce(sat)	2.0V	2.0V	3.7V	3.5V	3.5V	5.0V	5.0V
Tf typ.	250nS	250nS	180nS	100nS	100nS	100nS	150nS
SMPL	Now	Now	Now	Now	-	Now	-
PKG	TO-3PF	TO-264	TO-264	TO-264	TO-264	TO-264	TO-264
FRD	O	O	O	O	O	O	O
	CO-PAK	CO-PAK	CO-PAK	CO-PAK	CO-PAK	CO-PAK	CO-PAK
Symbol							
Sys. Input	AC 110V	AC 110V	AC 220V	AC 220V	AC 220V	AC 220V	AC 220V
Remark			Will be EOL				
IH-Jar							
IH-							
Cooker							
MWO							

※ : Optional Device (Line-up Plan)

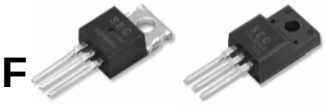
Discrete & Module Packages

Discrete

- D-PAK
  I-PAK

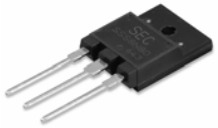
- D^2-PAK
  I^2-PAK

- TO-220
  TO-220F



- TO-3P

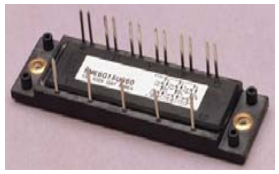
- TO-3F

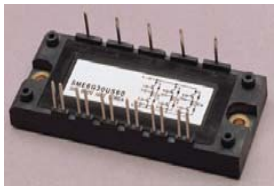


- TO-264

Module

- 6-PAK
  (Compact Type)



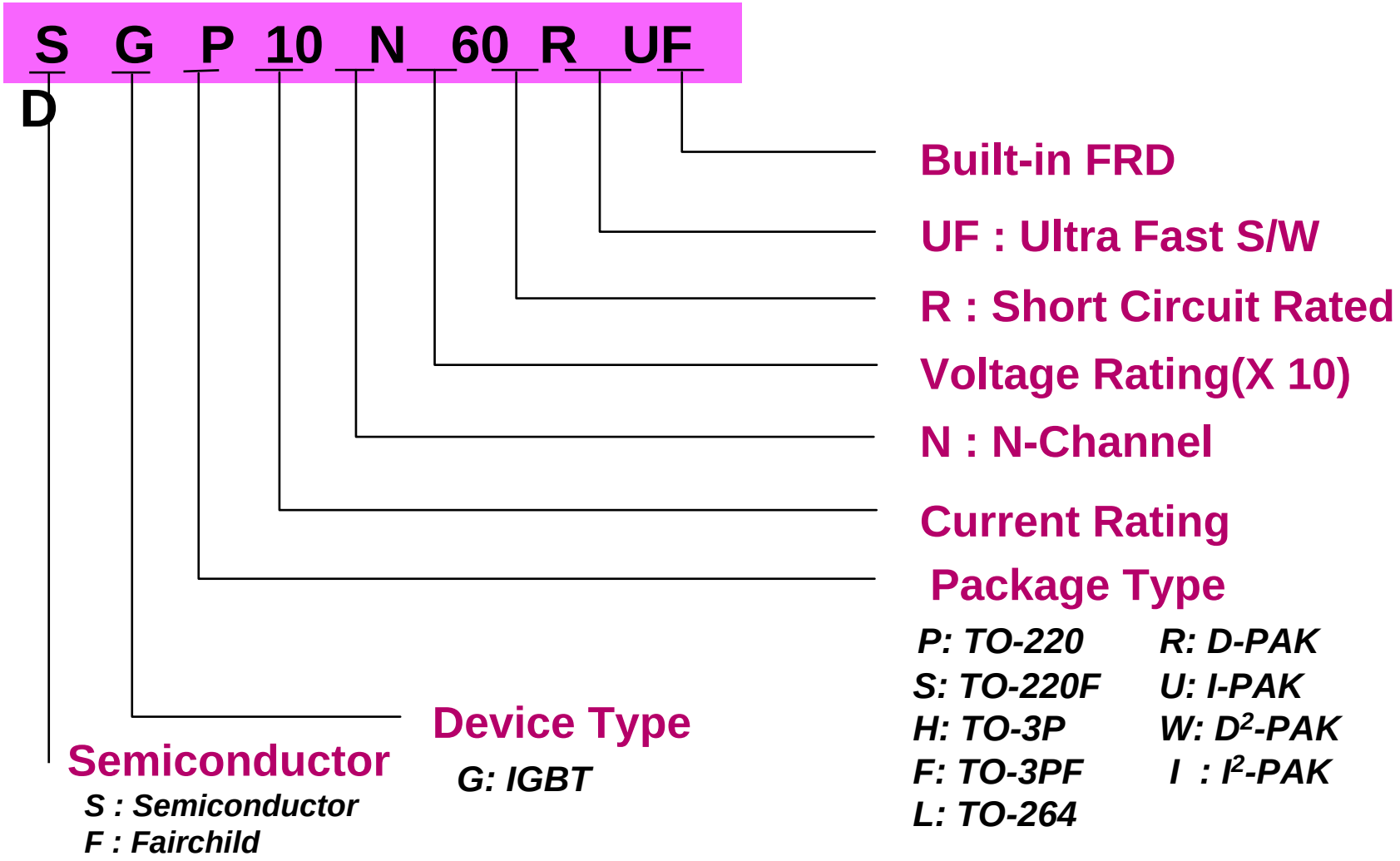


- 7-PAK
  (Complex Type)

- 2-PAK
  (Molding Type)

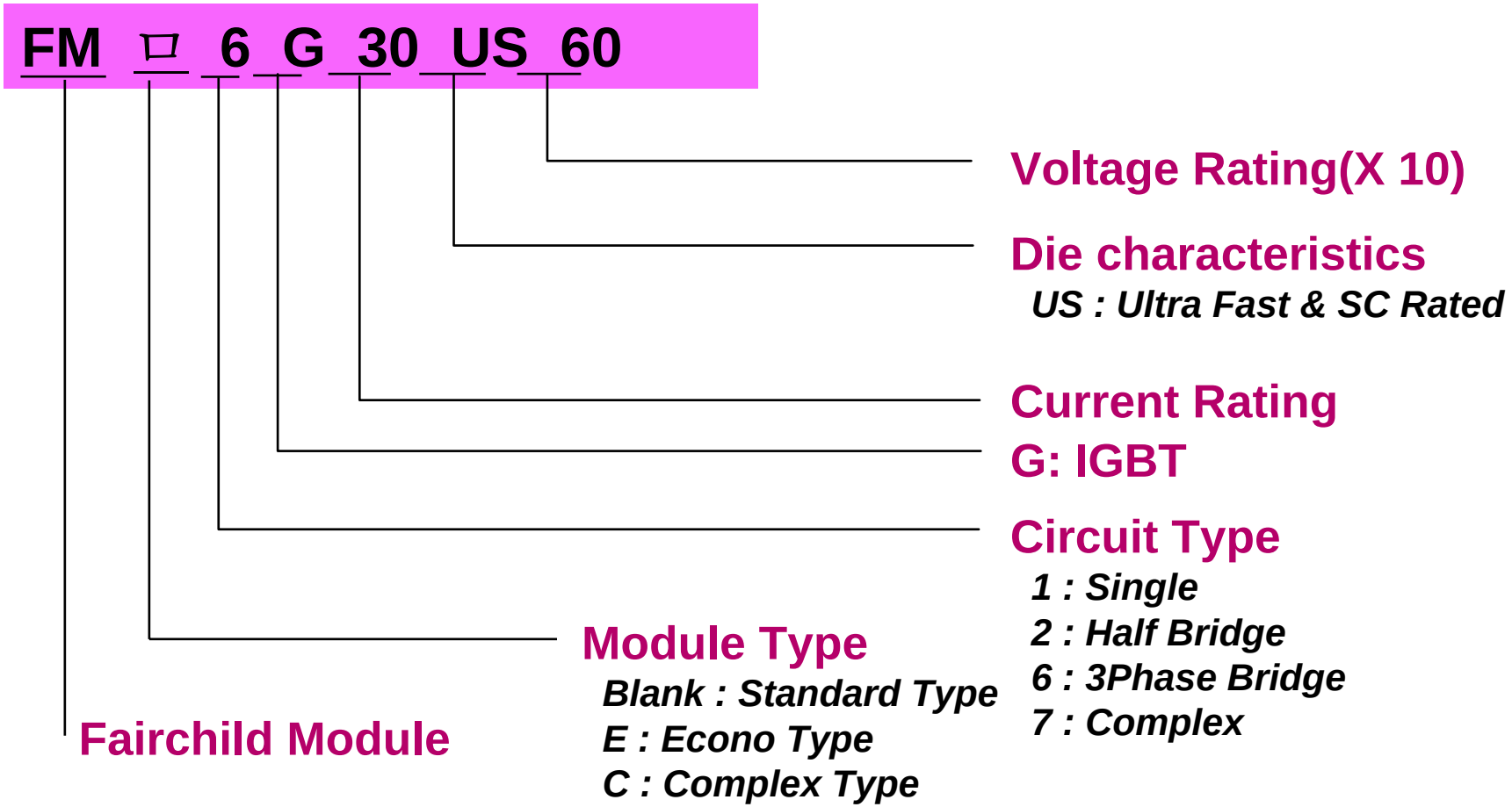
Ordering Information

■ Discrete



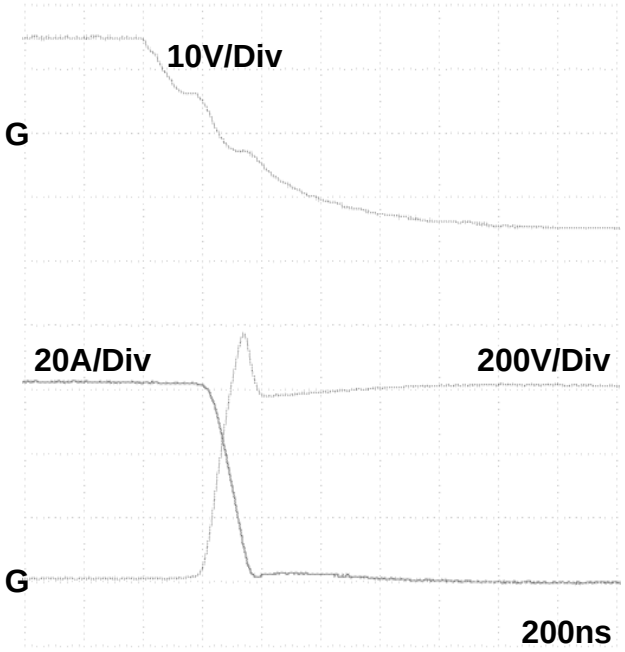
Ordering Information

■ Module

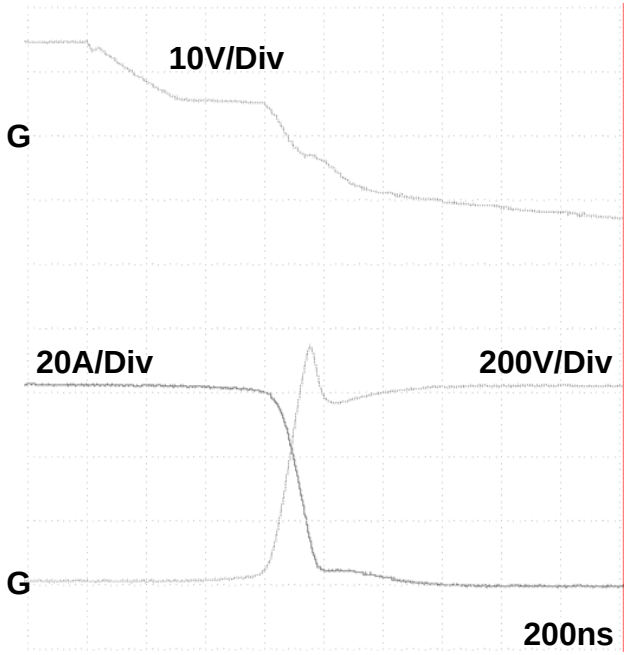


FC vs. FUJI Benchmarking

DEVICE	*BV_{ces} [V]*	*I_c [A]*	*$V_{ce(sat)}$ [V] typ.*	*t_f [ns] typ.*	*Remark*
FGL60N170D	*1745*	*60*	*4.5*	*115*	*Built in FRD*
1MBH60-170	*1950*	*60*	*5.6*	*135*	*Without FRD*



FGL60N170D



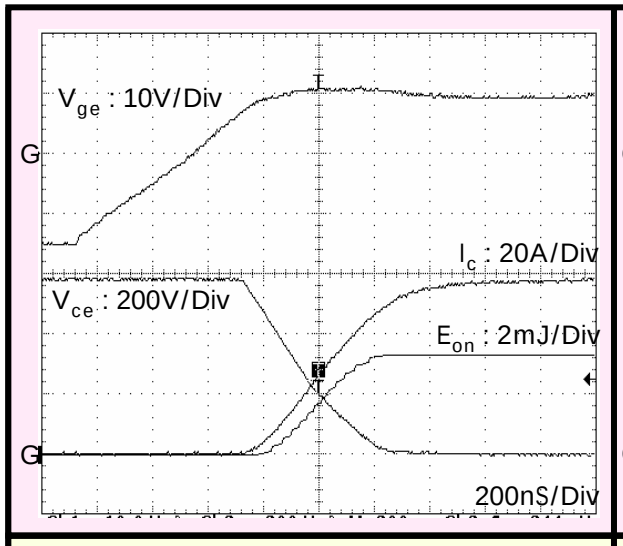
1MBH60-170

FSC 900V IGBT Benchmarking

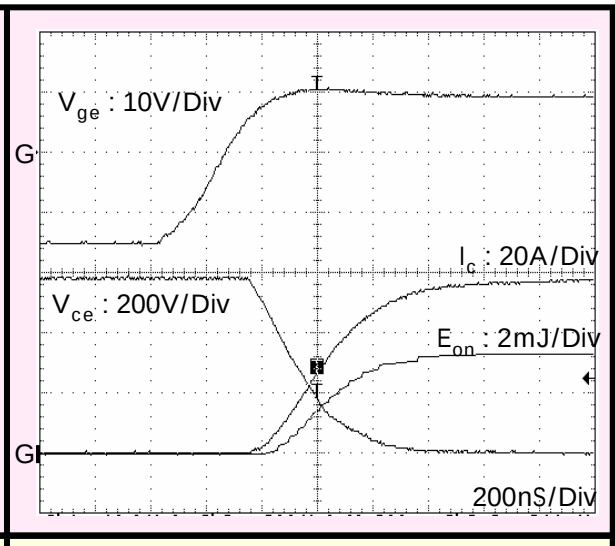
Device	BV_{ces} [V]	$V_{ce(sat)}$ [V] @A	$V_{ce(sat)}$ [V] @B	V_F [V]	T_{don} [nS]	t_r [nS]	E_{on} [mJ]	t_{doff} [nS]	t_f [nS]	E_{off} [mJ]	t_{rr} [nS]
SGL60N90DG3 #1	1060	1.60	2.09	2.09	240	458	1.66	380	210	3.12	300
SGL60N90DG3 #2	1082	1.40	2.13	2.13	240	438	1.52	376	200	3.24	288
GT60M303 #1	?	1.35	2.01	2.01	172	451	1.78	368	225	3.28	456
GT60M303 #2	?	1.43	2.12	2.12	156	447	1.67	380	209	3.16	448
CT60AM-18B #1	1086	1.44	2.17	2.17	156	382	1.10	456	280	3.40	224
CT60AM-18B #2	1098	1.60	2.50	2.50	184	385	1.12	440	228	3.24	216

※. Test Conditions (T_a = 25℃)

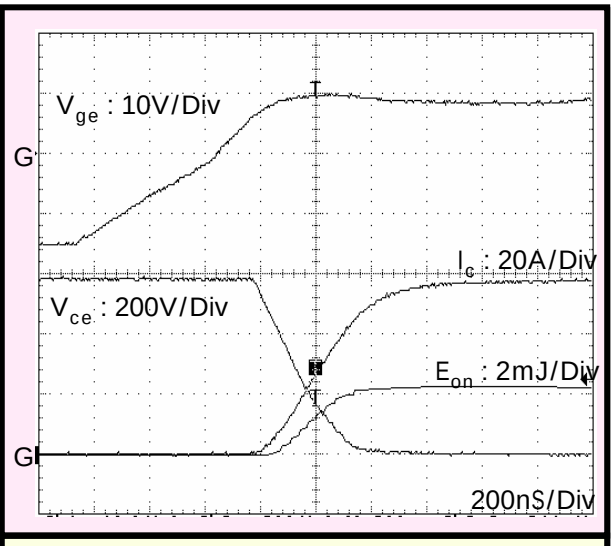
- BV_{ces} : I_c = 1mA, V_{ge} = 0V
- $V_{ce(sat)}$: I_c = 10A, V_{ge} = 15V@A, I_c = 60A, V_{ge} = 15V@B
- V_F : I_F = 15A
- T_{rr} : I_F = 15A, V_R = 200V, di/dt = -200A/uS
- S/W : V_{cc} = 600V, I_c = 60A, R_g = 51Ω, R- Load



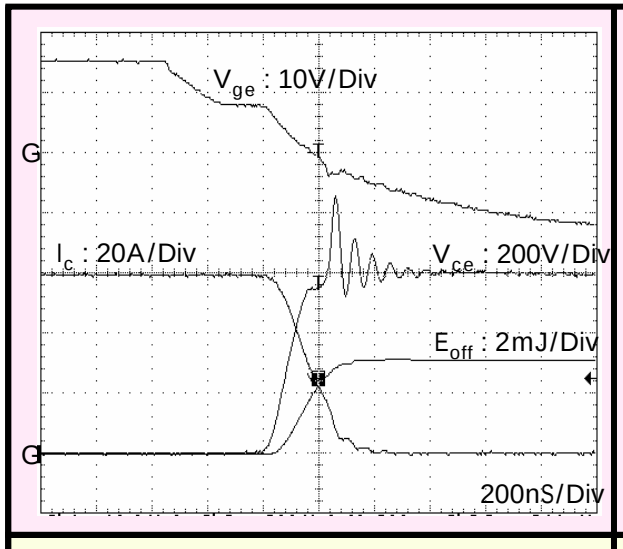
T_{on} of SGL60N90DG3



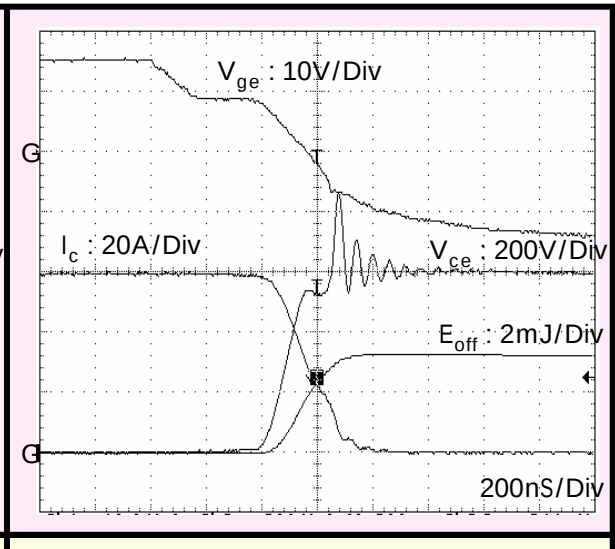
T_{on} of GT60M303



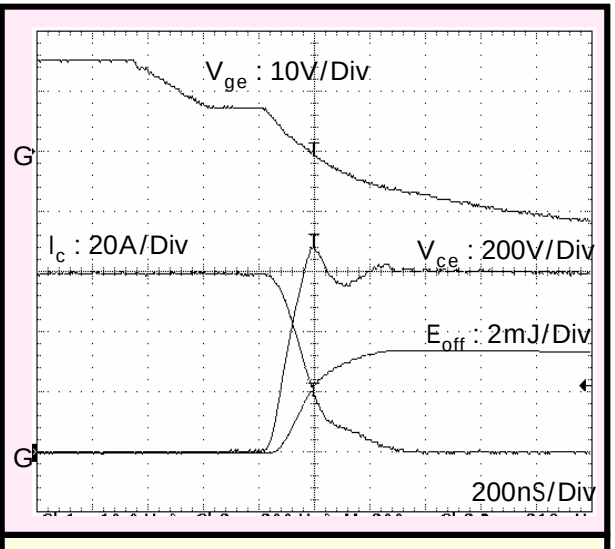
T_{on} of CT60AM-18B



T_{off} of SGL60N90DG3

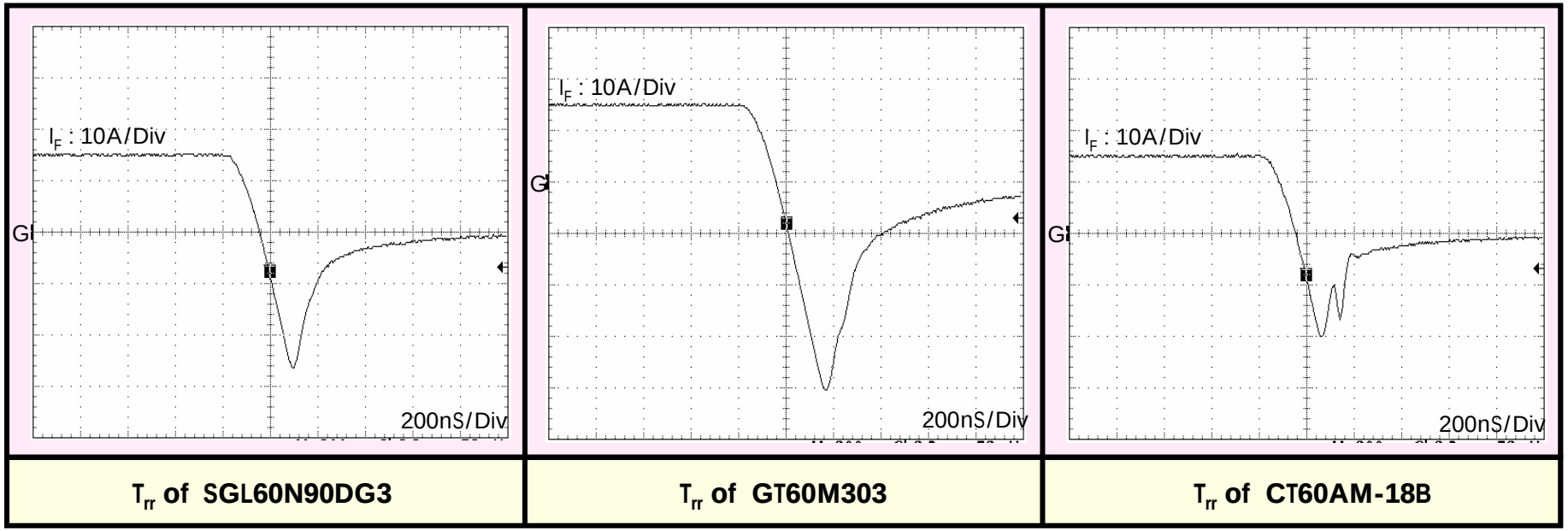


T_{off} of GT60M303



T_{off} of CT60AM-18B

FSC 900V IGBT FRD Benchmarking



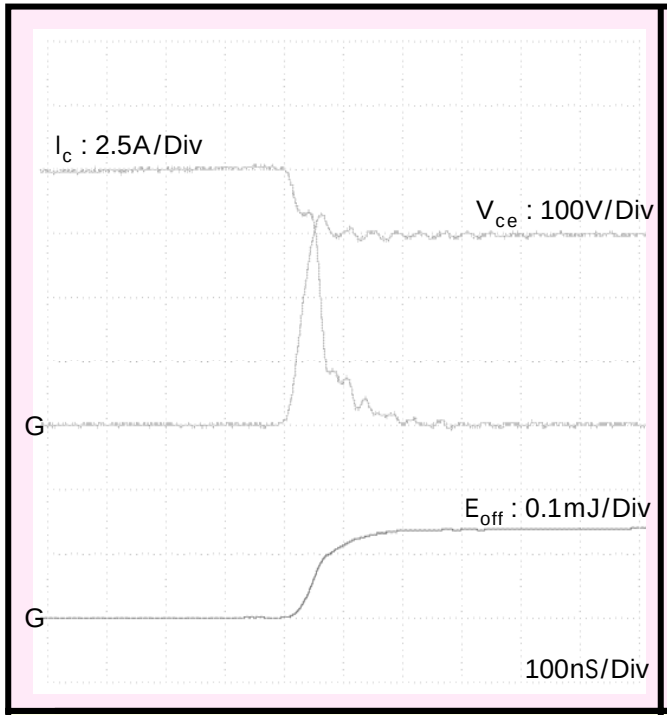
T_{rr} of SGL60N90DG3	T_{rr} of GT60M303	T_{rr} of CT60AM-18B

※. Test Conditions (T_a = 25℃)

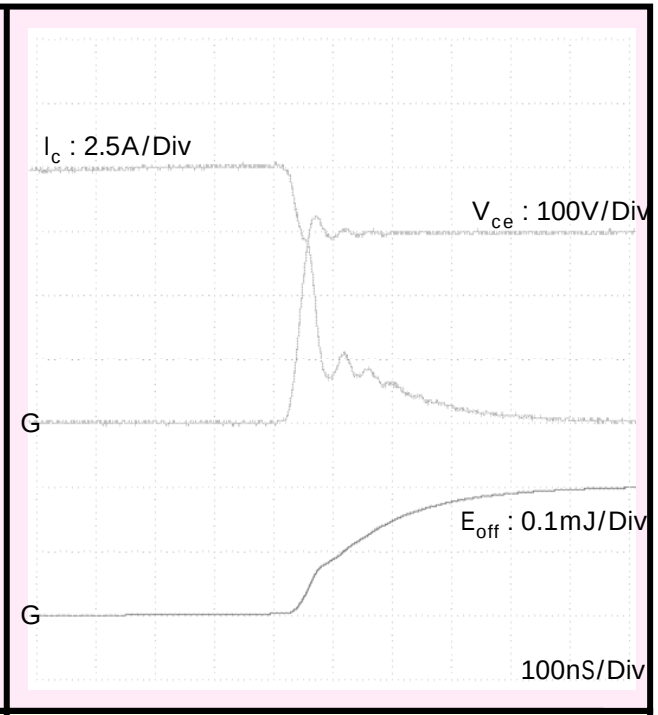
- T_{rr} : I_F = 15A, V_R = 200V, di/dt = -200A/uS

FSC 600V 10A C&C MODULE B/M

Device	BV_{ces} [V]	I_c [A]	$V_{ce(sat)}$ [V]	t_f [nS]	E_{off} [mJ]
FMC7G10US60	665	10	2.17	92	0.13
CM10MDL-12H	748	10	2.33	102	0.20



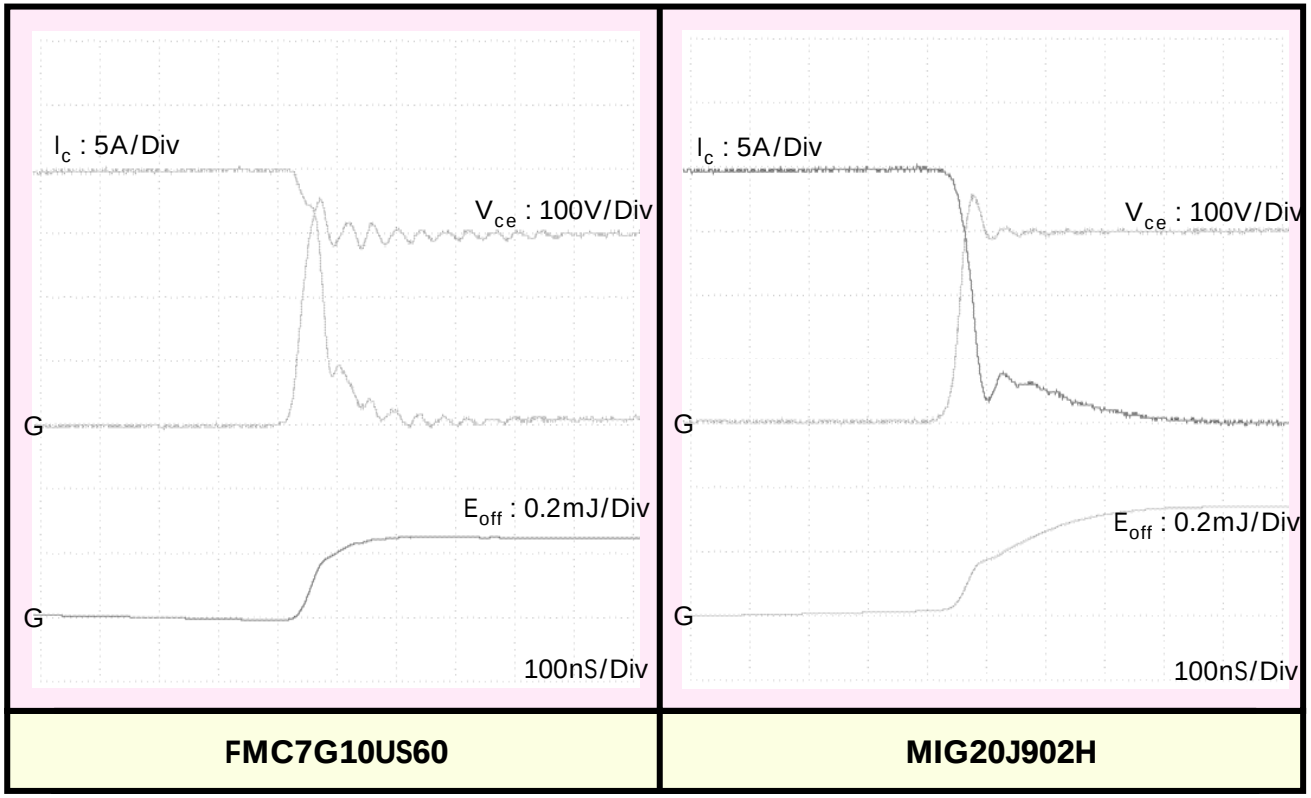
FMC7G10US60



CM10MDL-12H

FSC 600V 20A C&C MODULE B/M

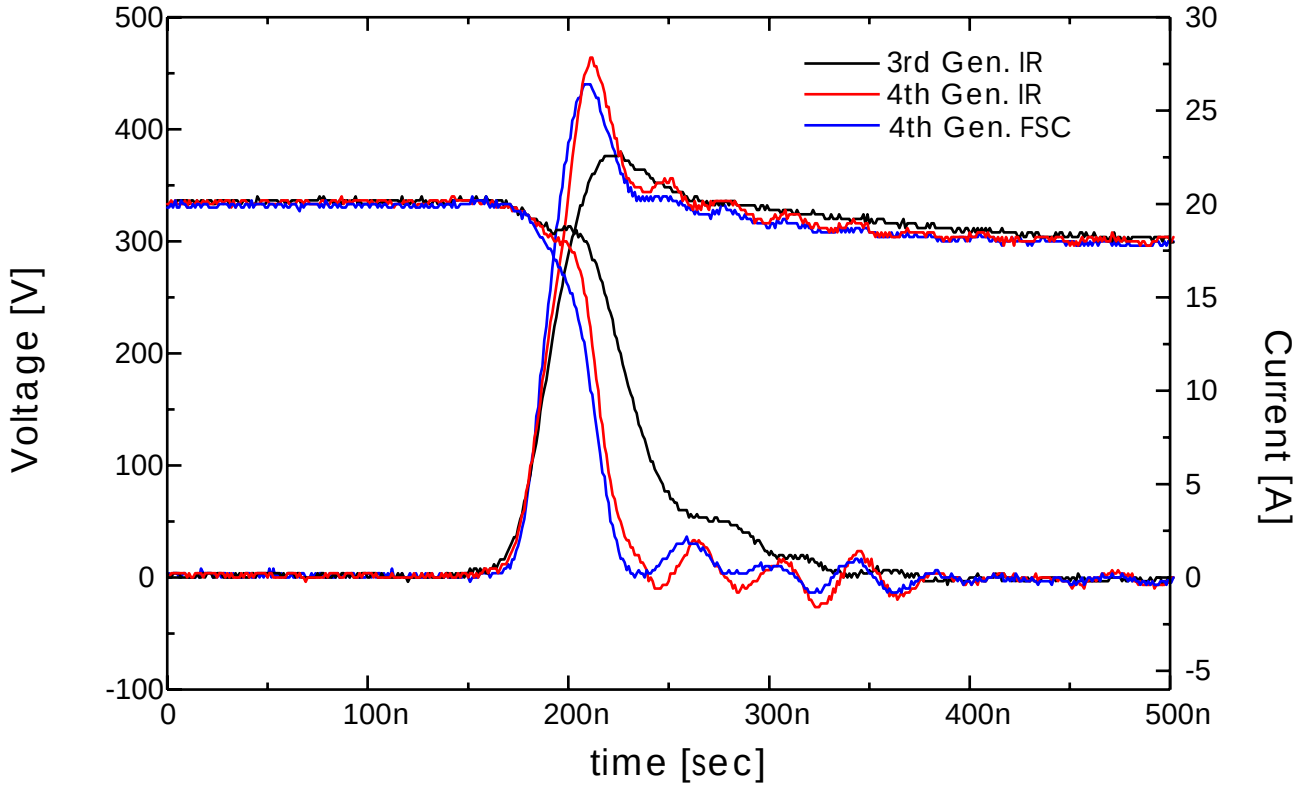
Device	BV_{ces} [V]	I_c [A]	$V_{ce(sat)}$ [V]	t_f [nS]	E_{off} [mJ]
FMC7G20US60	679	20	2.34	88	0.23
MIG20J902H	729	20	2.88	100	0.28



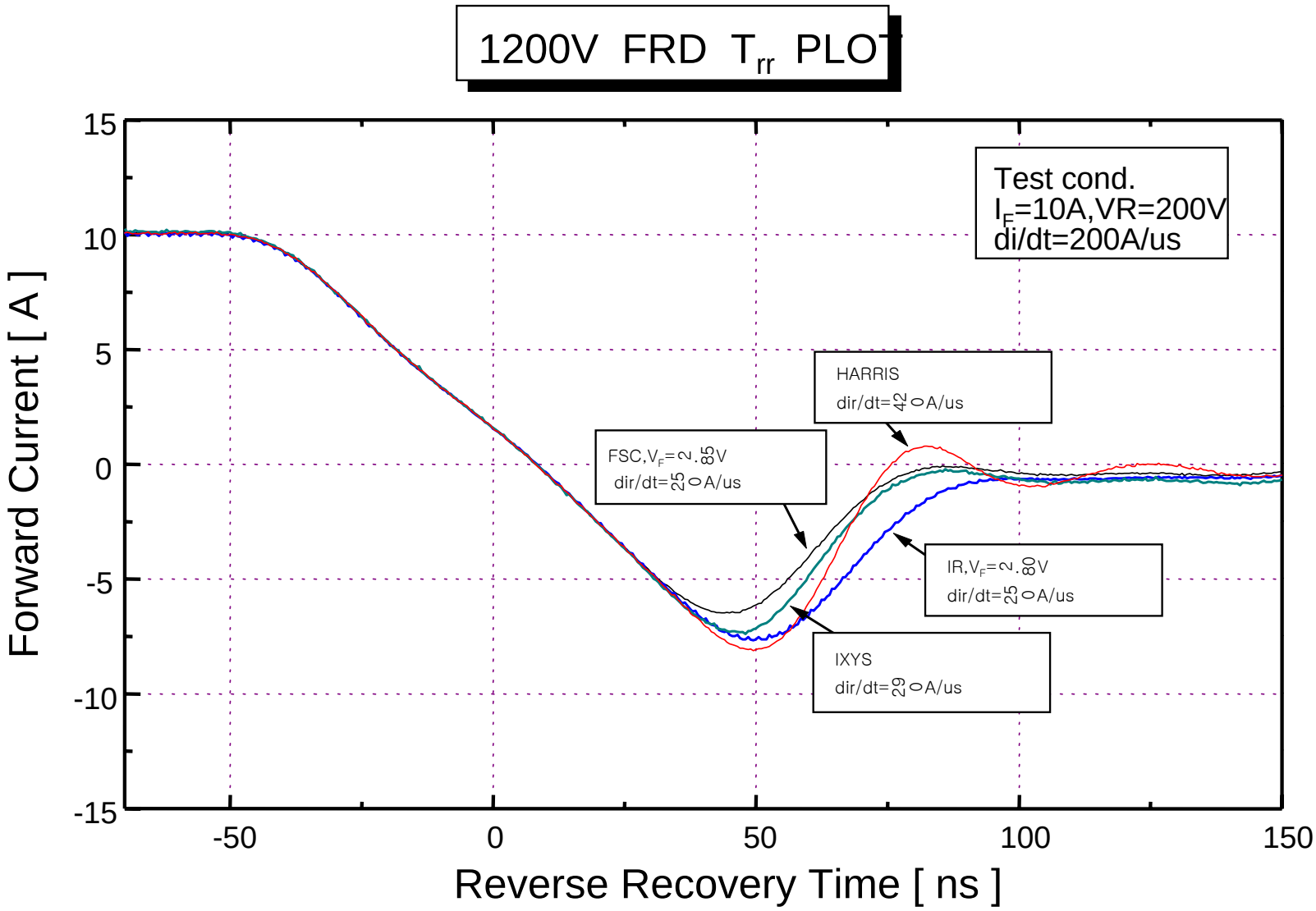
FMC7G10US60	MIG20J902H

FSC vs. IR Benchmarking

DEVICE NAME	BV_{ces}(V)	I_c(A)	$V_{ce(sat)}$ (V)typ.	t_f (nS)typ.	Chip Size
IRGPC40U (3rd Gen.)	680	20	2.1	82	100
IRG4PC40W (4th Gen.)	660	20	1.95	34	100
SGH40N60UF	672	20	2.0	32	98



FSC 1200V FRD Benchmarking

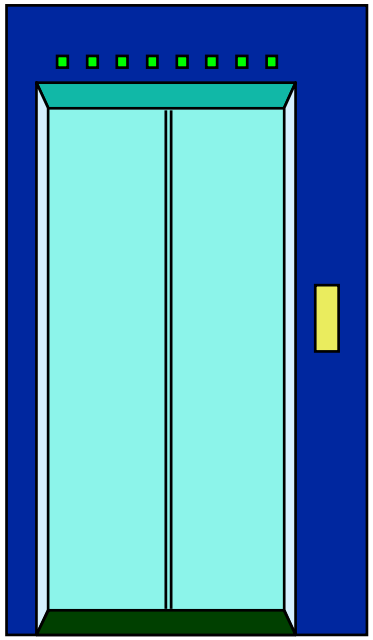


IGBT Applications

IGBT

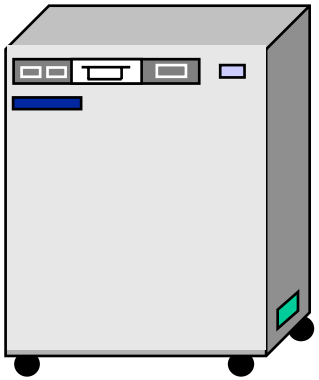
Module&Discrete

Industrial Application

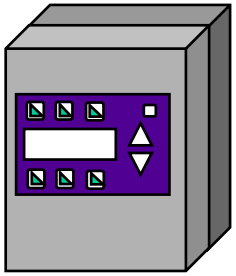


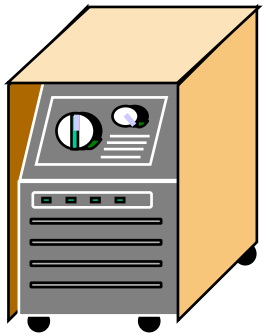
Elevator

Power Supply
- UPS, SMPS



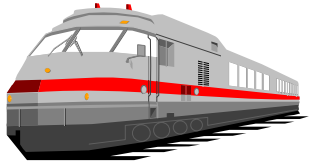
F.A.
- Inverter,
AC servo,
Robotics





Welding
machine

Transportation
-Ignition control,
Battery charger



IGBT Applications

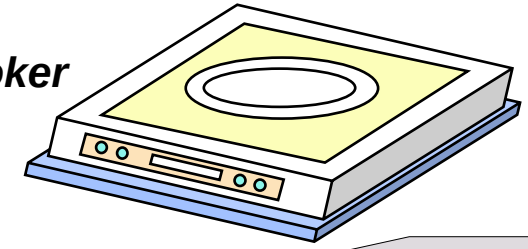
IGBT

Module&Discrete

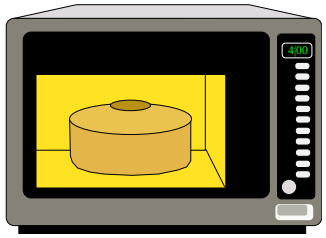
Consumer Electronic Application

IH-Jar (Rice Cooker)

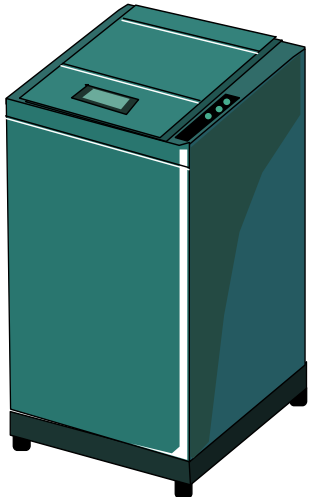
IH-Cooker



MWO

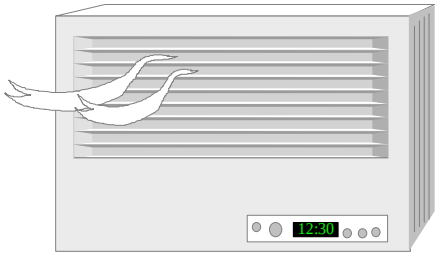


Camera Strobo



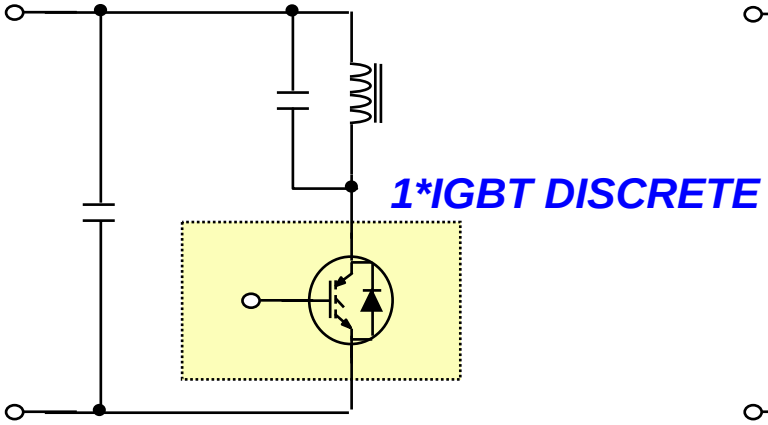
Washing machine

Inverter Air-conditioner

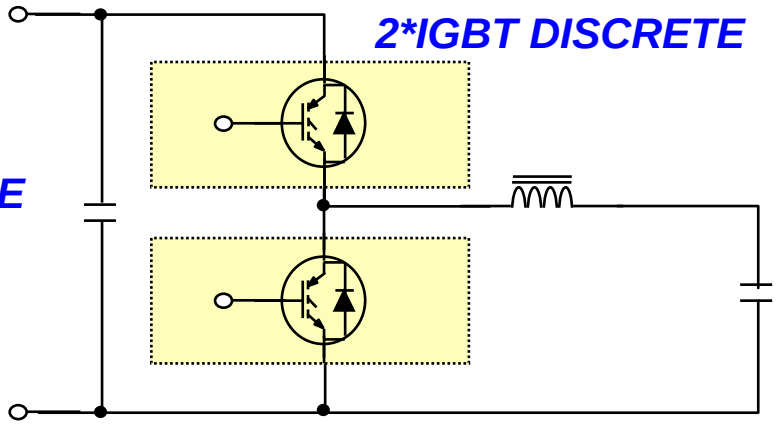


Applicational Examples (I)

- HOME APPLIANCE (IH-JAR,IH-COOKER,MWO..)
- PACKAGE TYPE : TO-220,TO-3P,TO-264 (SGP..,SGH...,SGL...)
- CURRENT RATING : 30 ~ 60A



SINGLE ENDED TYPE
(V_{CE} : 900 ~ 1700V)

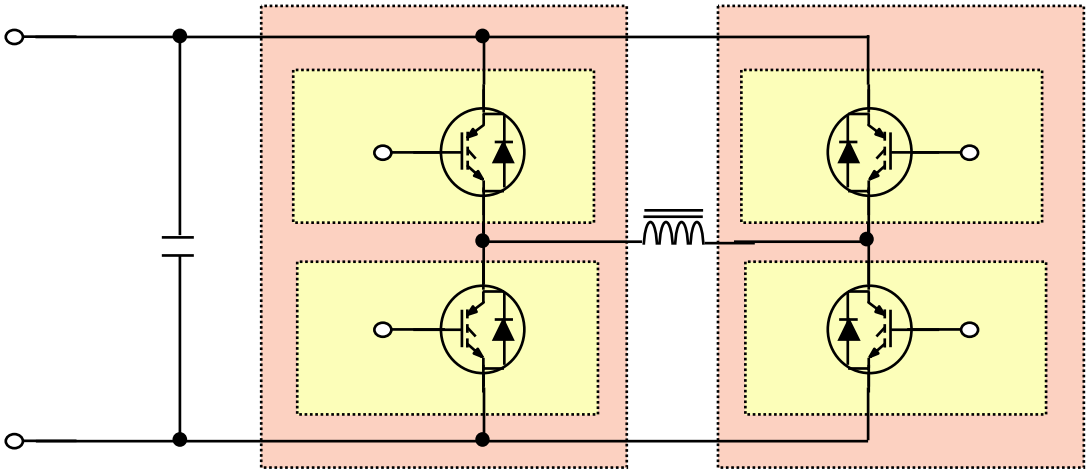


HALF BRIDGE TYPE
(V_{CE} : 600V)

Applicational Examples (II)

- INDUSTRIAL EQUP. (WELDING,UPS,IH HEATER)
- PACKAGE TYPE : 2-PAK,1-PAK MODULE(SM2G...,SM1G....)
- CURRENT RATING : 50 ~ 600A, VOLTAGE RATING : 600V,1200V

4*1-PAK IGBT MODULE
2*2-PAK IGBT MODULE

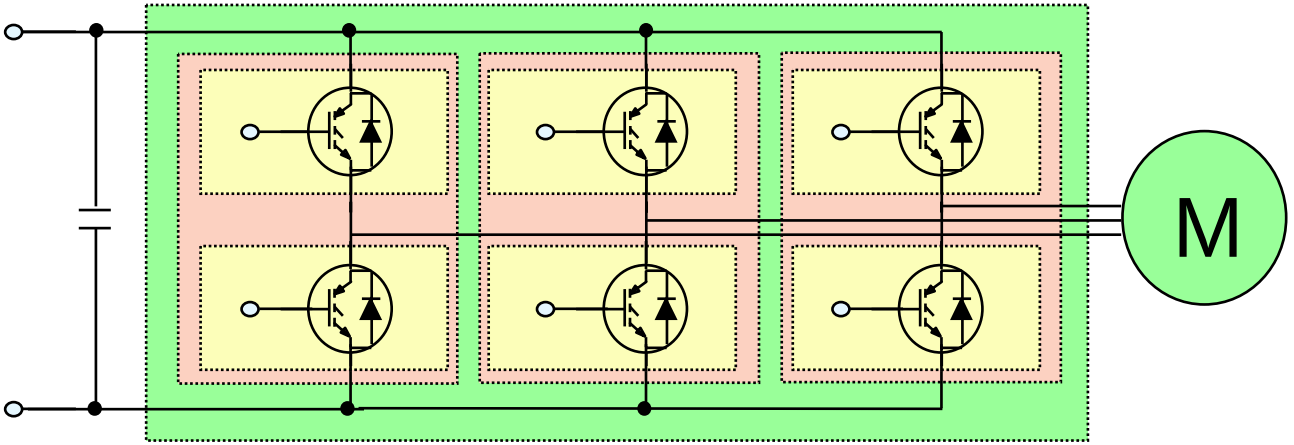


FULL BRIDGE TYPE

Applicational Examples (III)

- 3PHASE MOTOR DRIVE.(INVERTER,FREQUENCY CONVERTER)
- PACKAGE TYPE : 6-PAK,2-PAK,1-PAK MODULE(SM6G...,SM2G...,SM1G....)
- CURRENT RATING : 50 ~ 600A, VOLTAGE RATING : 600V,1200V

6*Discrete CO-PAK
1*6-PAK IGBT MODULE
3*2-PAK IGBT MODULE
6*1-PAK IGBT MODULE



3 PHASE BRIDGE TYPE

What`s Advantage?

- Wide Products(Application Specific Device Available)
  - Fast Switching type(UF - Series)
  - Short Circuit Type(RUF - Series)
  - Low Saturation Type
  - Soft Recovery Rate(dv/dt)
- Aggressive Pricing
- Pin to Pin Compatible(to World Wide Company)
- Reliability & Quality (ISO9000, 9001, 14001, QS9000,UL)
- On Time and Stable Delivery
- Fast Turn Around
- Technical Leader in High Voltage(SDB)