TOSHIBA

Discrete IGBTs

PRODUCT GUIDE

1. Features and Structure

- Low carrier accumulation, excellent frequency and switching characteristics
- Large forward-bias and reverse-bias safe operating areas (FBSOA and RBSOA), high damage resistance
- MOSFET-like high input impedance characteristics enable voltage drive

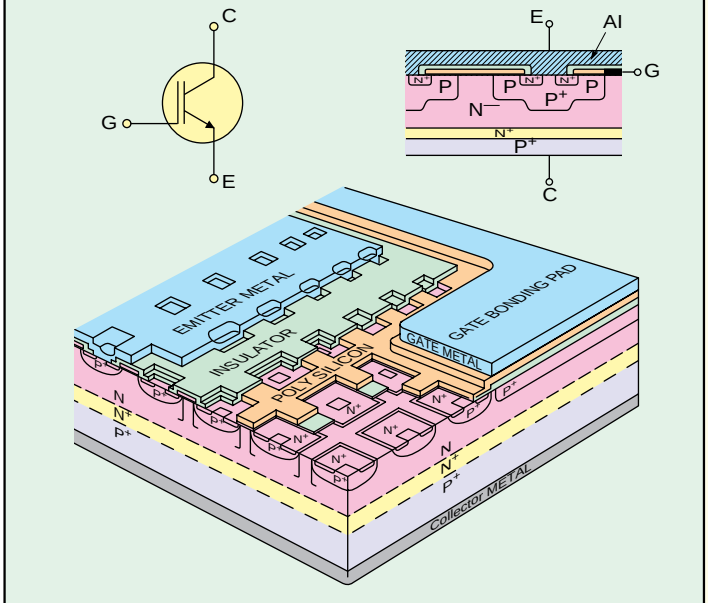
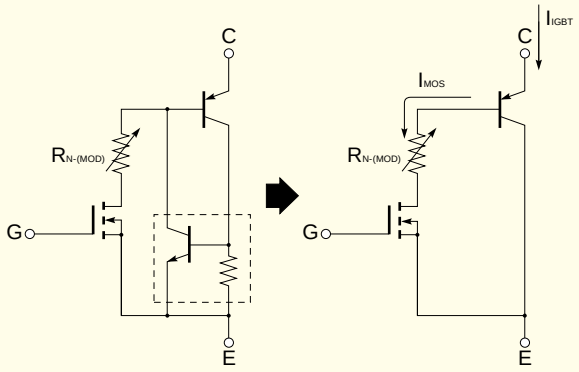
Features

Rated at 1500 V and 80 A, Toshiba discrete insulated gate bipolar transistors (IGBTs) are excellent as power converters in such diverse applications as motor drives, uninterruptible power supply (UPS) units and induction heaters. Toshiba IGBTs help to make equipment efficient reliable and compact.

Some features of Toshiba IGBTs are:
(1) High speeds
(2) Low ON-voltage
(3) High-efficiency diode
(4) Enhancement-Mode
(5) A variety of package types is available

Construction

Toshiba IGBTs have a basic four-layer structure with a P+ substrate (collector electrode) added to an N-channel MOSFET drain (N+ buffer). To avoid IGBT failure, the base of the PNP transistor is connected directly to the NPN transistor, thus minimizing circuit operation. This is shown in the equivalent circuit diagram below.

Structure	Equivalent Circuit
	

2. IGBT Engineering Advances

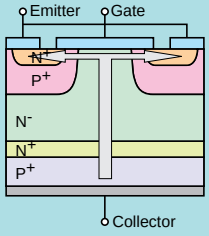
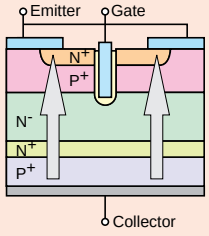
Power MOSFETs have long provided both high-speed and high-input impedance. However, various disadvantages such as increased resistance with increased breakdown voltage, as well as difficulties handling high breakdown voltages and high currents, are also associated with MOSFETs.
The cross-section of the IGBT on the previous page shows how IGBT resistance is reduced by injecting holes into the N^- layer from the P^+ substrate collector to change the conductivity.

Toshiba have miniaturized unit cells and optimized wafers to decrease V_{CE}(sat) switching loss. The following data demonstrates the progress made thus far:

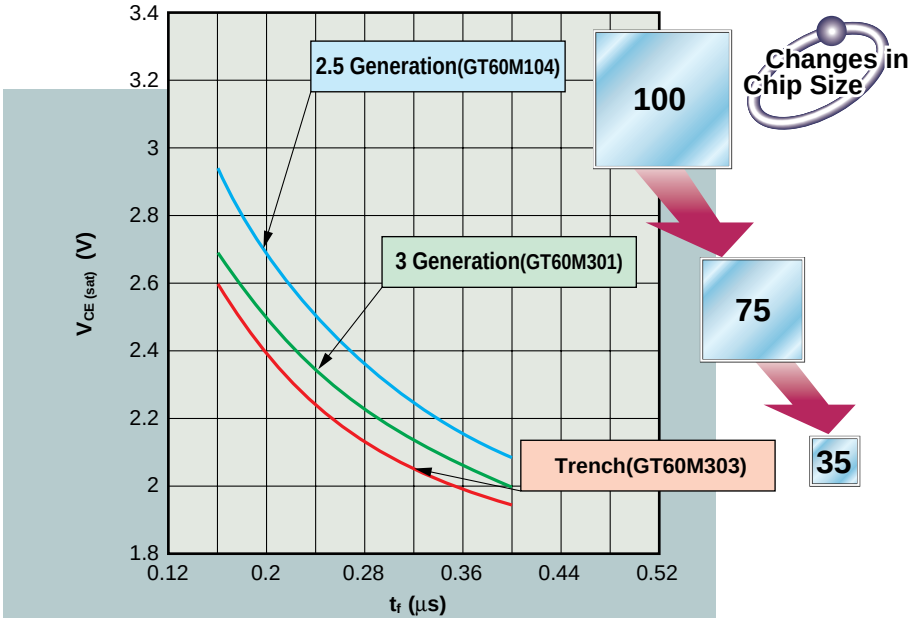
2.5th-generation IGBTs (V_{CE}(sat) = 2.5V Type)
↓
3rd-generation IGBTs (V_{CE}(sat) = 2.3V Type)
↓
Trench IGBTs (V_{CE}(sat) = 2.1V Type)

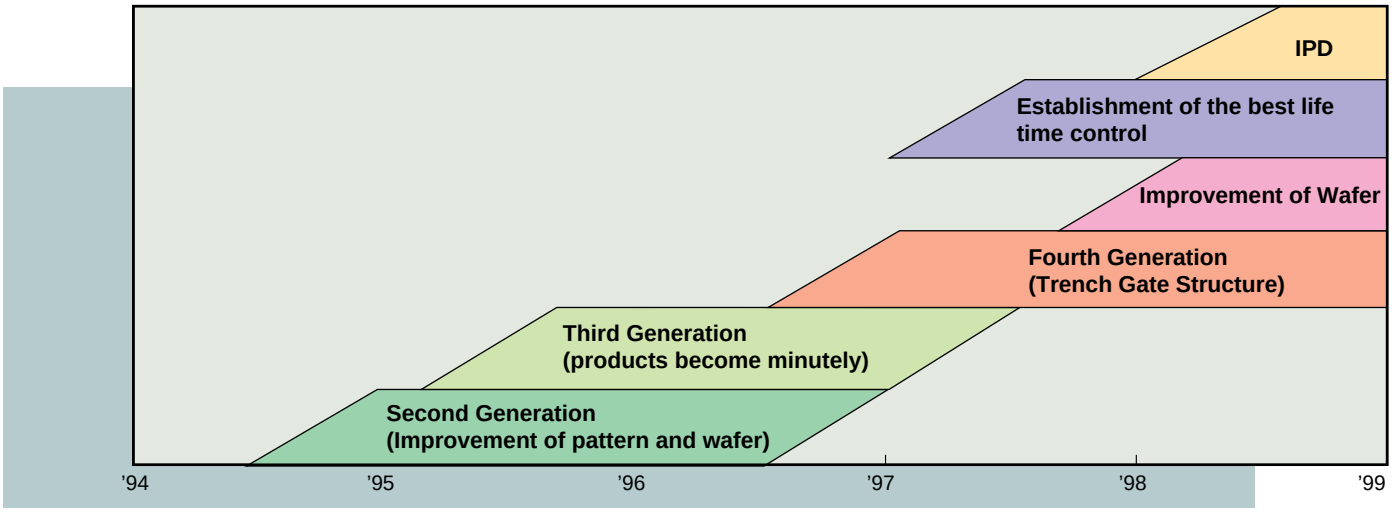
In addition to wafer optimization, Toshiba are applying trench gater technology and developing improved lifetime control to optimize the V_{CE}(sat) versus switching speed trade-off.

Toshiba is also working on an intelligent power device (IPD) which uses other peripheral units such as driver circuits and protection circuits.

Gate Process		Plane		Trench
Generation		2.5 generation	3 generation	
Structure				
V_{CE}(sat)(@600 V)		2.5 V Typ.	2.1 V Typ.	(1.6 V Typ.)
Cell Size	~900 V	1.00	0.43	0.06
	1200 V	1.00	0.75	–

Trade-Off Characteristics Evolution (V_{CES} = 900 V Type)





3. Discrete IGBT Line-up

IGBTs for industrial Inverters

Collector-Emitter Voltage V_{CES}(V)	Collector Current Ic(A)							
	50A	30A	25A	20A	15A	10A	8A	5A
600V	●GT50J301★ ●GT50J102	□GT30J301★ □GT30J101 △GT30J311★	□GT25J101 ◎GT25J102	□GT20J301★ □GT20J101 △GT20J311★	◆GT15J301★ ○GT15J311★ □GT15J101 ◆GT15J102 ○GT15J103	□GT10J301★ △GT10J311★ ◆GT10J303★ ○GT10J312★	◆GT8J101 ○GT8J102	◆GT5J301★ ○GT5J311★
1200V			●GT25Q301★ ●GT25Q101 ●GT25Q102		□GT15Q301★ □GT15Q101 □GT15Q102 △GT15Q311★	□GT10Q301★ □GT10Q101	□GT8Q101 ○GT8Q102	

IGBTs for microwave ovens, rice cockers and induction heaters

Collector Current Ic(A)	Collector-Emitter Voltage V_{CES}(A)			
	1500V	900V (1000V)	600V	400V
80A			●GT80J101A	
60A		●(GT60N321★) ●GT60M303★ ●GT60M302★ ●GT60M301★ ●GT60M104		
50A			●GT50J322★	●GT50G321★
40A	●GT40T301★ ●GT40T101	●GT40M301★ ◎GT40M101		◇GT40G121
30A			◎GT30J322★	
15A		◎GT15M321★		

Built-in FRD ★

Under development

- ● TO-3P(LH)
- □ TO-3P(N)
- ◎ TO-3P(N)IS
- △ TO-3PSM
- ◆ TO-220(NIS)
- ○ TO-220 FL/SM
- ◇ TO-220AB
- ■ DP

IGBTs for strobes

Collector Peak Current Icp(A)	Gate Drive minimum Voltage V_{GE}(V)			
	4V	4.5V	12V	20V
170A				○GT25G101 ◆GT15G101
150A	■GT8G121	■GT8G103	○GT25G102	
130A		■GT5G103	■GT5G102 ○GT20G102	◆GT10G101 ○GT20G101

4. Product Number Format

(Example) GT 60 M 3 03 A

- A — Version
- 03 — Type number
- 3 — 1: N-channel, 2: P-channel, 3: N-channel with built-in flywheel diode
- M — Withstand voltage rating (see Table 1)
- 60 — Collector current rating (DC)
- GT — Discrete IGBT

Table 1

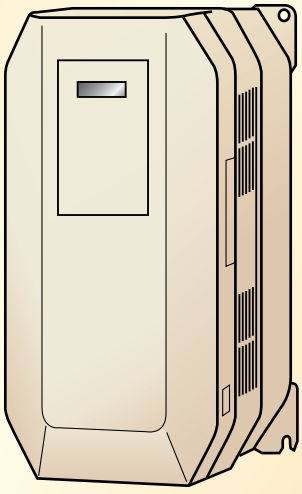
Mark	Voltage (V)	Mark	Voltage (V)
C	150	M	900
D	200	N	1000
E	250	P	1100
F	300	Q	1200
G	400	R	1300
H	500	S	1400
J	600	T	1500
K	700	U	1600
L	800	V	1700

5. Characteristics

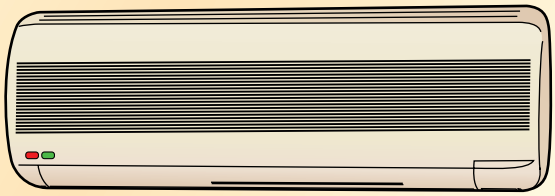
1. Industrial Inverters

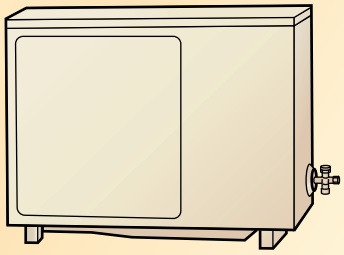
Discrete IGBTs are used in a wide range of high-frequency switching applications, ranging from industrial inverters to home appliances.

General-Purpose Inverters



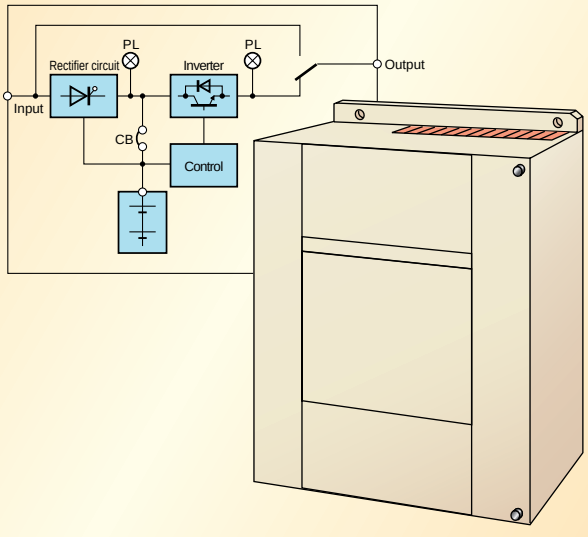
Inverter Air Conditioners





Inverter Washing Maschines

UPS



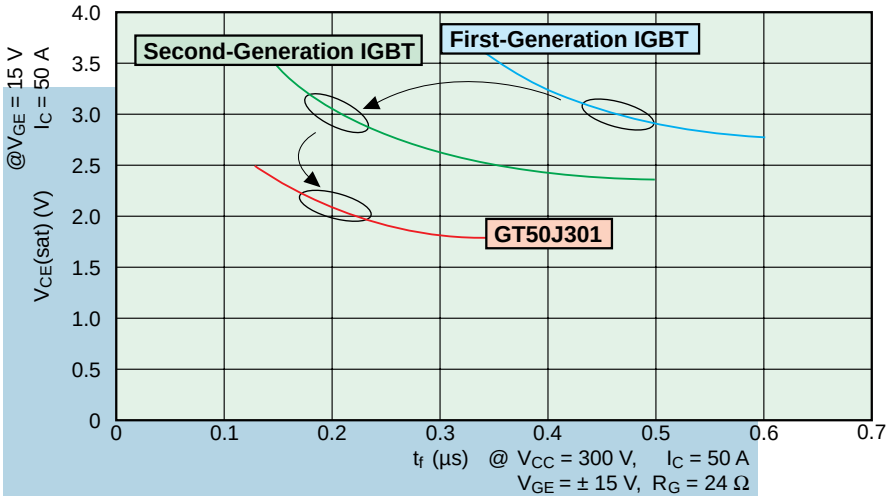
Characteristics

The following section discusses the characteristics of third-generation IGBTs which are used for high-speed switching. The GT50J301, whoes characteristic values are typical of those for this class of IGBT, is used as a benchmark for comparison.

Low V_{CE}(sat)

A miniaturization process reduces the V_{CE}(sat) level and the amount of heat generated during operation.

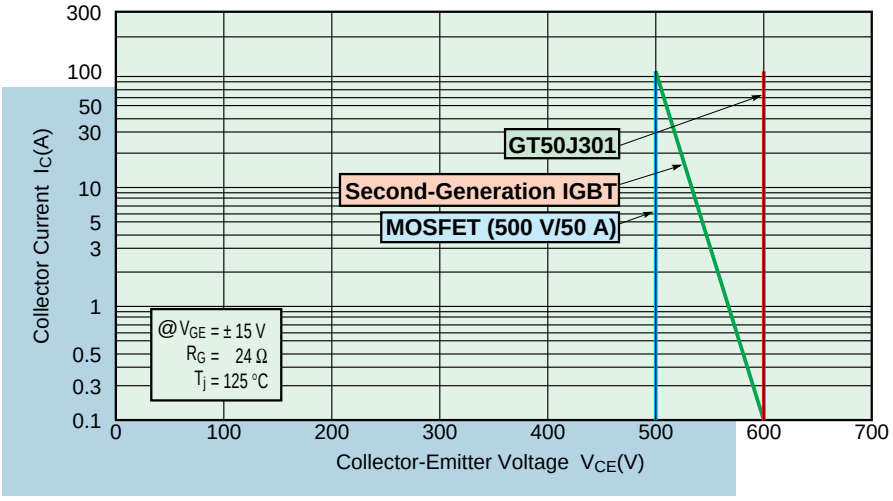
●V_{CE}(sat) vs. t_f Trade-off



Wide R.B.S.O.A

Third-generation IGBTs are guaranteed to have a wide reverse-bias safe operating area (RBSOA). This counters the effect of surge voltages which can occur during switching.

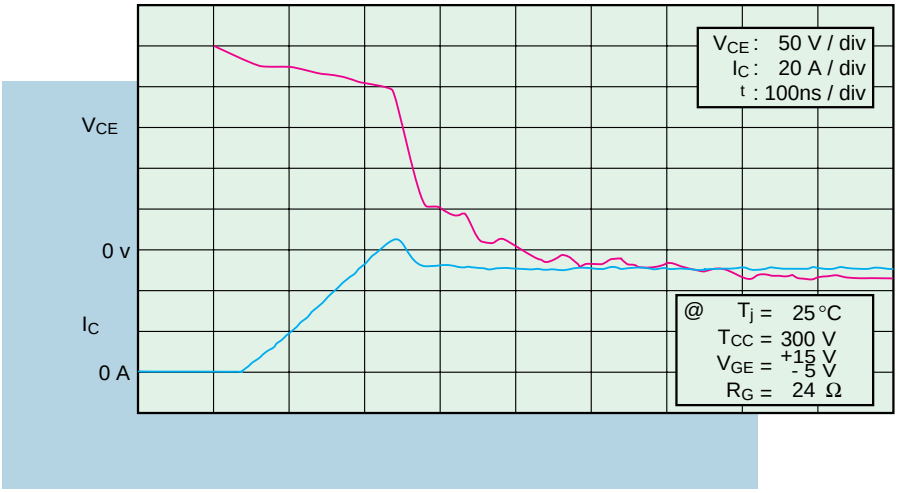
●Reverse-Bias Safe Operating Area



Low Noise & Low t_{rr}

A built-in diode provides fast and smooth reverse recovery (time) while generating less noise and heat.

●Turn-on Waveform

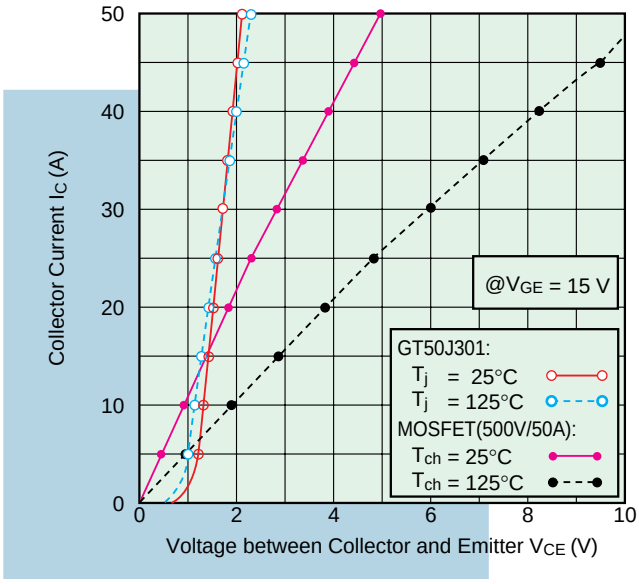


Characteristics

As shown below, third-generation IGBT is low-loss and low-noise when it use for inverter applications because of high-speed switching time, Low-saturation voltage and high-efficiency diodes.

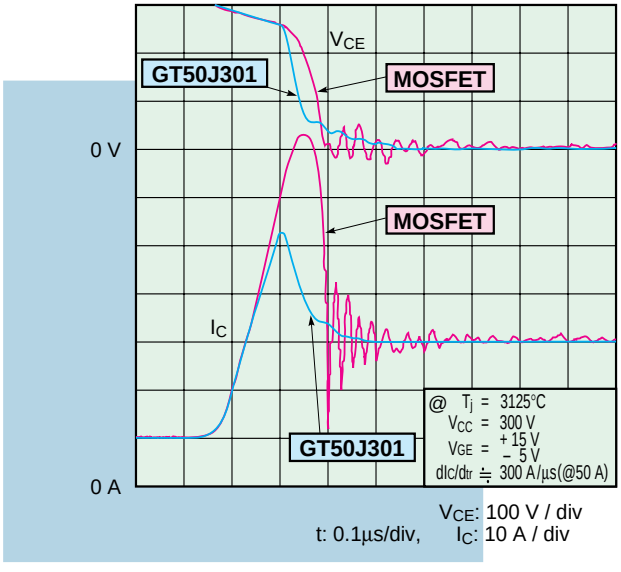
Saturation voltage does not rise, even at high temperatures.

● I_C - V_{CE}



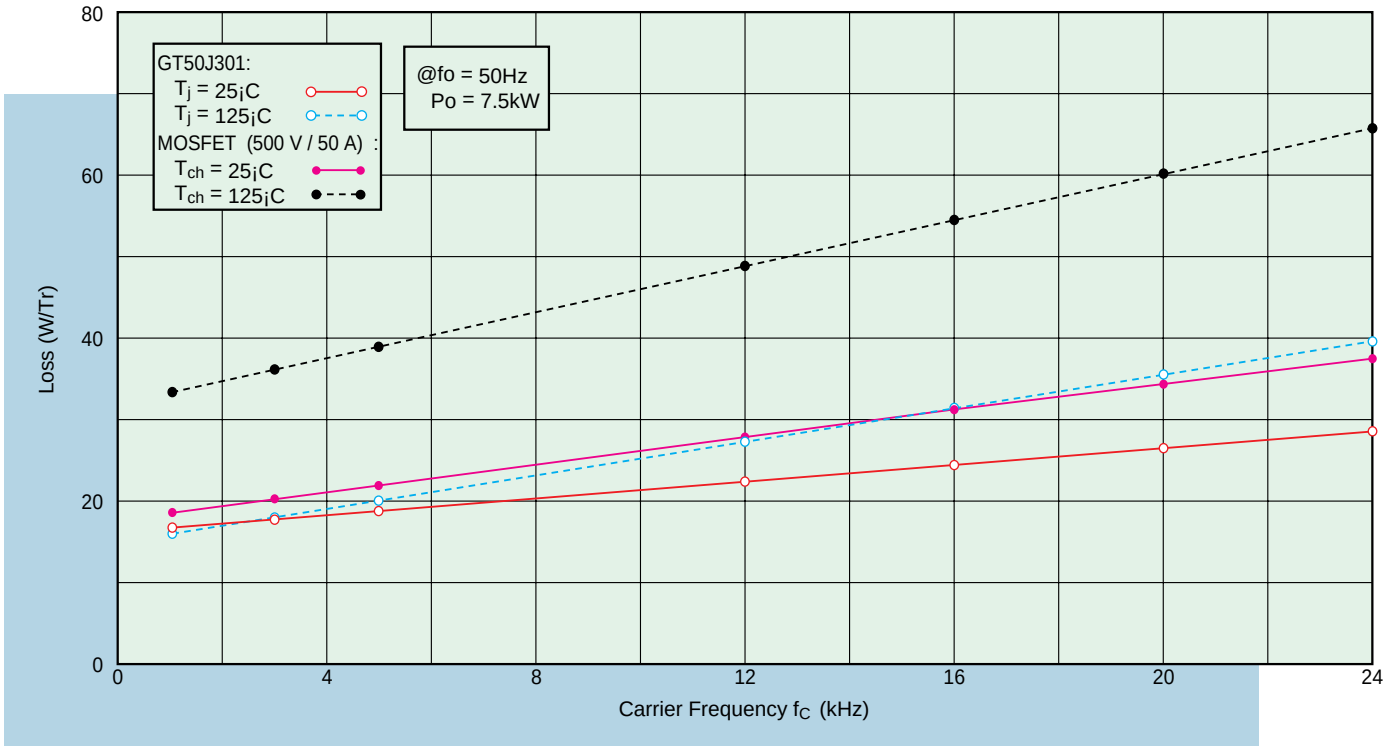
The internal diode recovers smoothly. Surging is minimized.

● Turn-on waveform



Simulation data of inverter application

● Power loss-f_c



●Second-Generation IGBTs

Product No.	V_{CES} (V)	I_C (A)	P_C (W)	V_{CE}(sat) (V) max	I_C (A)	t_f (s) max	Internal FRD	Package	Remarks
GT8J101	600	8	30	4	8	0.35	—	TO-220(NIS)	
GT8J102		8	50		8	0.35	—	TO-220SM	
GT15J101		15	100		15	0.35	—	TO-3P(N)	
GT15J102		15	35		15	0.35	—	TO-220SM	
GT15J103		15	70		15	0.35	—	TO-220SM	
GT25J101		25	150		25	0.35	—	TO-3P(N)	
GT25J102		25	80		25	0.35	—	TO-3P(N)IS	
GT8Q101	1200	8	100		8	0.50	—	TO-3P(N)	
GT8Q102		8	50		8	0.50	—	TO-220SM	
GT15Q101		15	150		15	0.50	—	TO-3P(N)	
GT25Q101		25	200		25	0.50	—	TO-3P(L)	

●Third-Generation IGBTs with Built-in FRDs, V_{CES}=600V

High capability to withstand breakdown voltage. The line will also include surface-mount devices which enable miniaturization of equipment.

Product No.	V_{CES} (V)	I_C (A)	P_C (W)	V_{CE}(sat) (V) max	I_C (A)	t_f (s) max	Package	Remarks
GT5J311	600	5	50	2.7	5	0.30	TO-220SM	Built-in FRD
GT5J301		5	25		5		TO-220(NIS)	
GT10J303		10	30		10		TO-220(NIS)	
GT10J312		10	60		10		TO-220SM	
GT10J301		10	90		10		TO-3P (N)	
GT10J311		10	80		10		TO-3P (SM)	
GT15J301		15	35		15		TO-220(NIS)	
GT15J311		15	70		15		TO-220SM	
GT20J301		20	130		20		TO-3P (N)	
GT20J311		20	120		20		TO-3P (SM)	
GT30J301		30	155		30		TO-3P (N)	
GT30J311		30	145		30		TO-3P (SM)	
GT50J301		50	200		50		TO-3P (LH)	

●Third-Generation IGBTs without Built-in FRDs, V_{CES}=600V

Product No.	V_{CES} (V)	I_C (A)	P_C (W)	V_{CE}(sat) (V) max	I_C (A)	t_f (s) max	Package	Remarks
*GT20J101	600	20	130	2.7	20	0.30	TO-3P (N)	Under development
*GT30J101		30	155		30		TO-3P (N)	
GT50J102		50	200		50		TO-3P (LH)	

●Third-Generation IGBTs with Built-in FRDs, V_{CES}=1200V

Product No.	V_{CES} (V)	I_C (A)	P_C (W)	V_{CE}(sat) (V) max	I_C (A)	t_f (s) max	Package	Remarks
GT10Q301	1200	10	140	2.7	10	0.32	TO-3P (N)	New Products
GT15Q301		15	170		15		TO-3P (N)	
GT15Q311		15	160		15		TO-3P (SM)	
GT25Q301		25	200		25		TO-3P (LH)	

●Third-Generation IGBTs without Built-in FRDs, V_{CES}=1200V

Product No.	V_{CES} (V)	I_C (A)	P_C (W)	V_{CE}(sat) (V) max	I_C (A)	t_f (s) max	Package	Remarks
*GT10Q101	1200	10	140	2.7	10	0.32	TO-3P (N)	Under development
*GT15Q102		15	170		15		TO-3P (N)	
*GT25Q102		25	200		25		TO-3P (LH)	

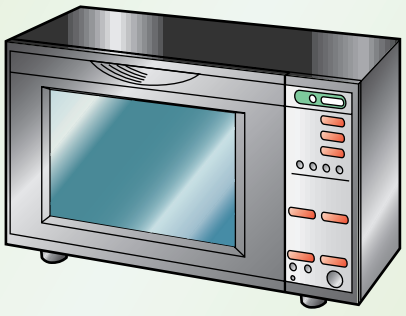
*: Unden development

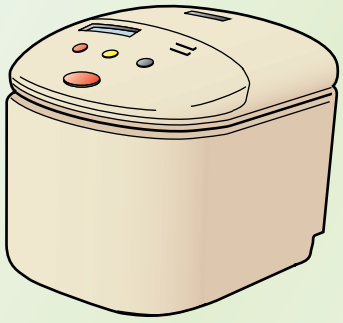
2. Microwave Ovens, Rice Cookers and Induction Heaters

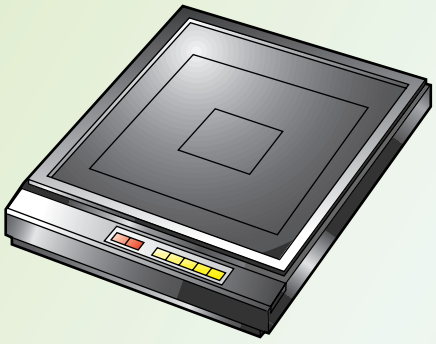
Soft-switching circuits (current and voltage resonance type) that exhibit low switching loss are used in applications such as induction heaters (IHs) and IH rice cookers and microwave ovens.

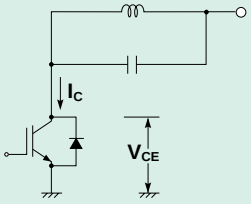
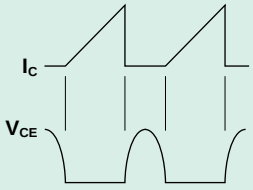
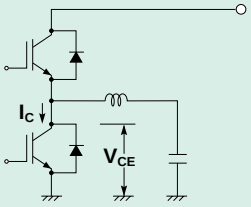
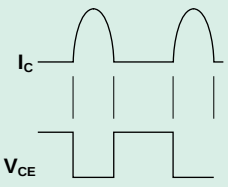
Toshiba offers a line of IGBTs with optimally low V_{CE}(sat) and high switching speed which are especially suited to soft-switching circuits.

Microwave Ovens | IH Rice Cookers | Induction Heaters







AC Input Voltage	Circuit	IGBT Rating
100 V to 120 V	Valtage Resonance  Waveform 	V_{CES} = 900 V to 1000 V I_C = 15 A to 60 A
200 V to 240 V		V_{CES} = 1500 V I_C = 40 A
200 V to 240 V	Current Resonance  Waveform 	V_{CES} = 400 V to 600 V I_C = 30 A to 80 A

●IGBTs and Diodes for Voltage Resonance Circuits (with soft switching)

IGBT

AC Input Voltage	Device	V_{CES} / I_C	FRD	t_f (s) max	V_{CE} (sat) (V) max	V_{GE} / I_C	Package	Remarks
100 V to 120 V	GT15M321	900 V / 15 A	○	0.4	2.5	15 V / 15 A	TO-3P(N)IS	New products
	GT40M101	900 V / 40 A		0.4	3.4	15 V / 40 A	TO-3P(N)IS	
	GT40M301	900 V / 40 A	○	0.4	3.4	15 V / 40 A	TO-3P (LH)	
	GT60M301	900 V / 60 A	○	0.4	3.4	15 V / 60 A	TO-3P (LH)	
	GT60M302	900 V / 60 A	○	0.37	3.3	15 V / 60 A	TO-3P (LH)	
	GT60M303	900 V / 60 A	○	0.4	2.7	15 V / 60 A	TO-3P (LH)	
	GT60N321	1000 V / 60 A	○	0.4	2.8	15 V / 60 A	TO-3P (LH)	New products
200 V to 240 V	GT40T101	1500 V / 40 A		0.4	5.0	15 V / 40 A	TO-3P (LH)	
	GT40T301	1500 V / 40 A	○	0.4	5.0	15 V / 40 A	TO-3P (LH)	New products

High-Speed Rectifiers (FRDs)

AC Input Voltage	Device	V_{RRM} / I_{FSM}	C_j (pF) typ.	t_f (s) max	V_{FM} (V) max	I_F	Package	Remarks
100 V to 120 V	S5J12	900 V / 120 A	30	3.0	2.0	15 A	TO-220(NIS)	
200 V to 240 V	S5J25	1500 V / 120 A	75	3.0	2.5	30 A	TO-3P (N)	
	S5J53	1500 V / 120 A	75	2.0	2.5	30 A	TO-220(NIS)	
100 V to 240 V	S5783F	900 V / 250 A	60	3.5	1.6	60 A	TO-3P(N)IS	

● IGBTs and Diodes for Current Resonance Circuits (with soft switching)

IGBT

AC Input Voltage	Device	V_{CES} / I_C	FRD	t_f (s) max	V_{CE} (sat) (V) max	V_{GE} / I_C	Package	Remarks
200 V to 240 V	GT80J101A	600 V / 80 A		0.40	3.0	15 V / 80 A	TO-3P (LH)	
	GT50G321	400 V / 50 A	○	0.40	2.5	15 V / 60 A	TO-3P (LH)	New products
	GT50J102	600 V / 50 A		0.30	2.7	15 V / 50 A	TO-3P (LH)	
	GT50J301	600 V / 50 A	○	0.30	2.7	15 V / 50 A	TO-3P (LH)	
	GT50J322	600 V / 50 A	○	0.40	2.8	15 V / 50 A	TO-3P (LH)	
	GT40G121	400 V / 40 A		0.40	2.5	15 V / 60 A	TO-220AB	New products
	GT30J322	600 V / 30 A	○	0.40	2.8	15 V / 50 A	TO-3P(N)IS	

High-Efficiency Diodes (HEDs)

AC Input Voltage	Device	V_{RRM} / I_{FSM}	C_j (pF) typ.	t_{rr} (ns) max	V_{FM} (V) max	I_F	Package	Remarks
200 V to 240 V	20JL2C41	600 V / *100 A	*50	*50	*2.0	*10 A	TO-3P (N)	
	30JL2C41	600 V / *150 A	*70	*50	*2.0	*15 A	TO-3P (N)	

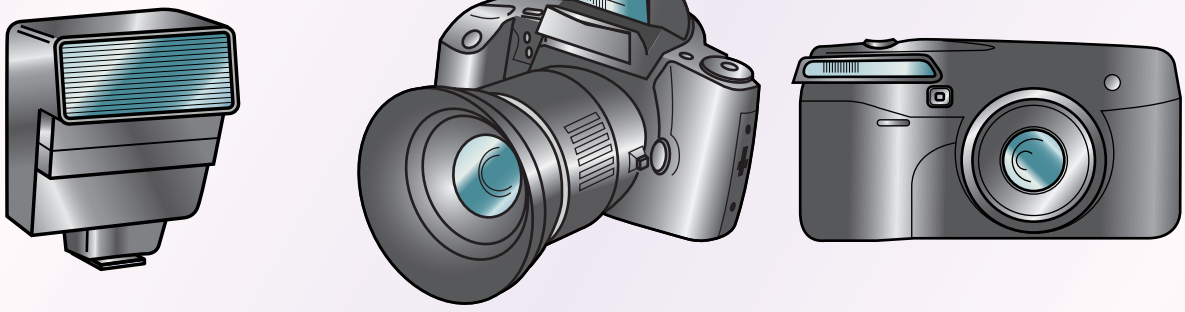
* Rating indicates only for a single stack device.

3. Strobes

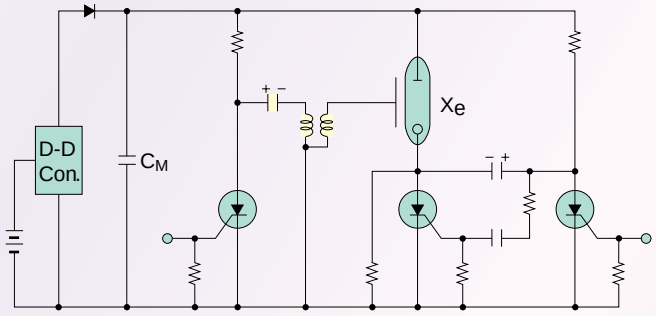
Thyristors previously used in strobe control circuits are today increasingly being replaced by IGBTs which have the following advantages.

- As a voltage-controlled device, the IGBT requires few drive circuit components.
- The small circuits possible with IGBTs fit compactly into small camera bodies.
- Strobe flash IGBTs are capable of switching large currents.

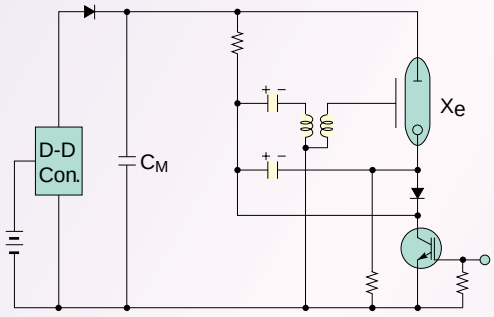
Dedicated Strobe | Single-Lens Reflex Camera | Compact Camera



Replacing thyristors with an IGBT simplifies the circuit and reduces parts count.



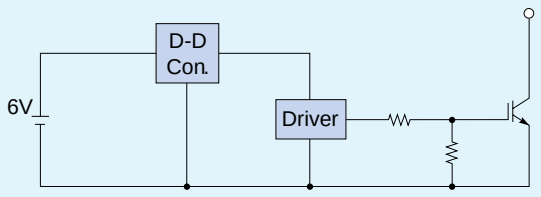
Thyristors



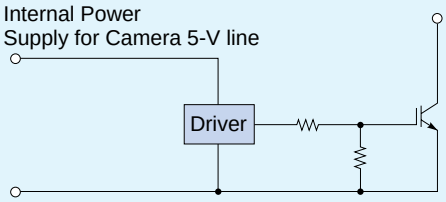
IGBT

4-V to 4.5 V Gate Drive Series

The IGBT can be operated using a 4·5-V gate drive voltage.
A gate drive power supply can be used as the common 5-V internal power supply in a camera, enabling the power supply circuitry to be simplified.
To protect against insulator layer of the gates, zener diodes are included between the gate and emitter.



Gate Drive Voltage
12-V to 20-V circuit



Gate Drive Voltage
5-V circuit

Product No.	V_{CES} / I_{CP}	V_{CE} (sat) max (V)	V_{GE} / I_C	P_C (W)	Package	Remarks
GT5G103	400 V / 130 A	8	4.5 V / 130 A	20	DP	
GT8G103	400 V / 150 A	8	4.5 V / 150 A	20	DP	
GT8G121	400 V / 150 A	7	4.0 V / 150 A	20	DP	New Products

12-V Gate Drive Series

Product No.	V_{CES} / I_{CP}	V_{CE} (sat) max (V)	V_{GE} / I_C	P_C (W)	Package	Remarks
GT5G102	400 V / 130 A	8	12 V / 130 A	20	DP	
GT20G102	400 V / 130 A	8	12 V / 130 A	60	TO-220FL	
GT25G102	400 V / 150 A	8	12 V / 150 A	75	TO-220FL	

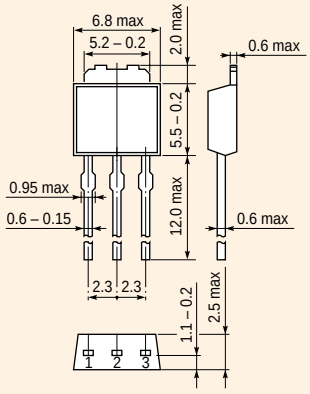
20-V Gate Drive Series

Product No.	V_{CES} / I_{CP}	V_{CE} (sat) max (V)	V_{GE} / I_C	P_C (W)	Package	Remarks
GT10G101	400V / 130 A	8	20V / 130 A	30	TO-220(NIS)	
GT20G101	400V / 130 A	8	20V / 130 A	60	TO-220FL	
GT15G101	400V / 170 A	8	20V / 170 A	40	TO-220(NIS)	
GT25G101	400V / 170 A	8	20V / 170 A	60	TO-220FL	

6. Package Dimensions

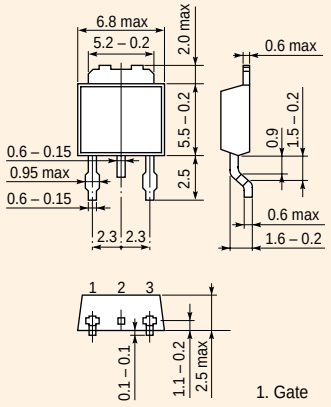
unit: mm

DP (Straight Lead)



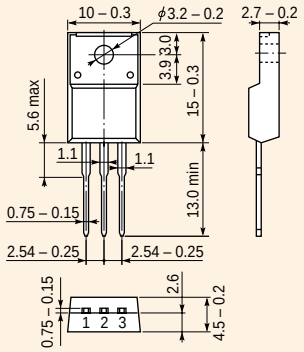
1. Gate
2. Collector
3. Emitter

DP (Lead Forming)



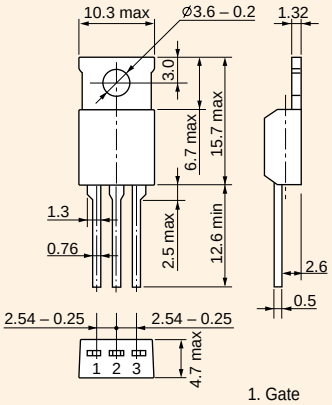
1. Gate
2. Collector
3. Emitter

TO-220 (NIS)



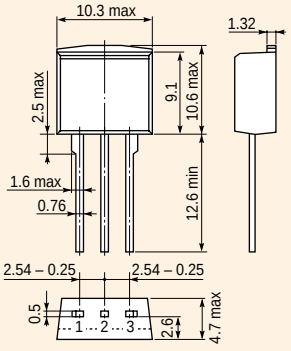
1. Gate
2. Collector
3. Emitter

TO-220AB



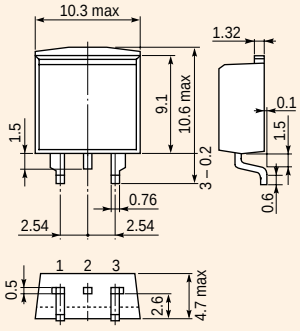
1. Gate
2. Collector
3. Emitter

TO-220FL



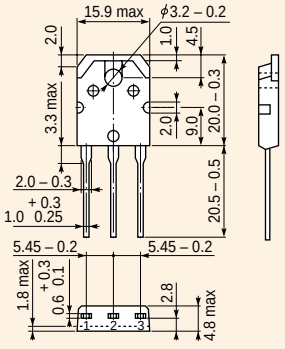
1. Gate
2. Collector
3. Emitter

TO-220SM



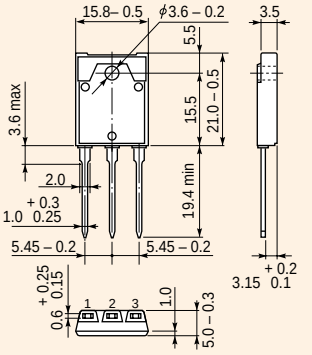
1. Gate
2. Collector
3. Emitter

TO-3P (N)



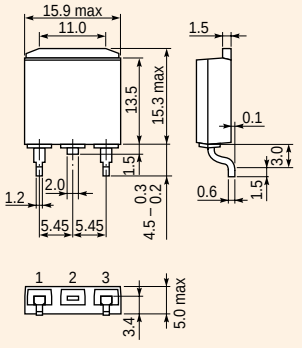
1. Gate
2. Collector
3. Emitter

TO-3P (N) IS



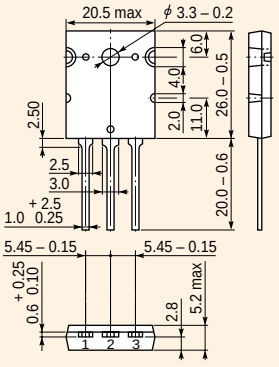
1. Gate
2. Collector
3. Emitter

TO-3P (SM)



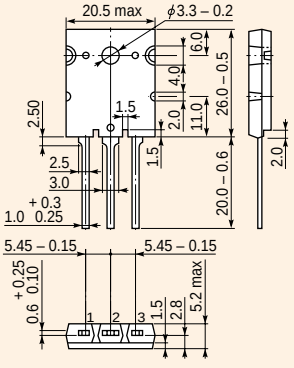
1. Gate
2. Collector
3. Emitter

TO-3P (L)



1. Gate
2. Collector
3. Emitter

TO-3P (LH)



1. Gate
2. Collector
3. Emitter

7. Final-phase and Discontinued Products

The following products are in stock but are being phased out of production.
Substitute products are shown which can be used in their place.

Product No.	Electrical Characteristics				Package	Substitute Product	Electrical Characteristics				Package
	V_{CES} (V)	I_C (A)	V_{CE} (sat) (V) max	t_f (s) max			V_{CES} (V)	I_C (A)	V_{CE} (sat) (V) max	t_f (s) max	
GT5G101	400	130	8.0	1.70*	NPM	GT5G102	400	130	8.0	2.00*	DP
GT8G101	400	130	8.0	2.00*	NPM	GT5G103	400	130	8.0	2.00*	DP
GT8G102	400	150	8.0	2.00*	NPM	GT8G121	400	150	8.0	2.00*	DP
GT8N101	1000	8	4.0	1.00	TO-3P (N)	GT8Q101	1200	8	4.0	0.50	TO-3P (N)
GT15N101	1000	15	4.0	1.00	TO-3P (N)	GT15Q101	1200	15	4.0	0.50	TO-3P (N)
GT25H101	500	25	4.0	1.00	TO-3P (N)	GT25J101	600	25	4.0	0.35	TO-3P (N)
GT50G101	400	100	8.0	3.00	TO-3P (N)	GT10G101	400	130	8.0	6.00	TO-220 (NIS)
GT50G102	400	100	8.0	3.00	TO-3P (N)	GT10G101	400	130	8.0	6.00	TO-220 (NIS)
GT50J101	600	50	4.0	3.35	TO-3P (L)	GT50J102	600	50	2.7	0.30	TO-3P (LH)
GT50L101	800	50	4.0	0.70	TO-3P (L)	GT60M303	900	60	3.4	0.40	TO-3P (LH)
GT50M101	900	50	5.0	0.40	TO-3P (LH)	GT60M303	900	60	3.4	0.40	TO-3P (LH)
GT50Q101	1200	50	4.0	0.50	IH Package	GT40T301	1500	40	5.0	0.40	TO-3P (LH)
GT50S101	1400	50	7.2	0.38	IH Package	GT40T301	1500	40	5.0	0.40	TO-3P (LH)
GT50T101	1500	50	5.5	0.40	IH Package	GT40T301	1500	40	5.0	0.40	TO-3P (LH)
GT60J101	600	60	4.0	0.35	TO-3P (L)	GT50J102	600	50	2.7	0.35	TO-3P (LH)
GT60M101	900	60	4.0	0.70	TO-3P (LH)	GT60M303	900	60	3.4	0.40	TO-3P (LH)
GT60M102	900	60	3.8	0.40	TO-3P (L)	GT60M303	900	60	3.4	0.40	TO-3P (LH)
GT60M103	900	60	3.6	0.40	TO-3P (LH)	GT60M303	900	60	3.4	0.40	TO-3P (LH)
GT75G101	400	150	8.0	3.00	TO-3P (L)	GT15G101	400	170	8.0	6.00	TO-220 (NIS)

*: Typical value

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