Data Sheet APRIL 2002

600V, SMPS Series N-Channel IGBT with Anti-Parallel Hyperfast Diode

This family of MOS gated high voltage switching devices combine the best features of MOSFETs and bipolar transistors. These devices have the high input impedance of a MOSFET and the low on-state conduction loss of a bipolar transistor. The much lower on-state voltage drop varies only moderately between 25°C and 150°C. The IGBT used is the development type TA49339. The diode used in anti-parallel is the development type TA49372.

These IGBT's are ideal for many high voltage switching applications operating at high frequencies where low conduction losses are essential. These devices have been optimized for high frequency switch mode power supplies.

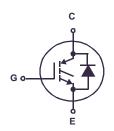
Formerly Developmental Type TA49341.

Ordering Information

PART NUMBER	PACKAGE	BRAND		
HGTG20N60A4D	TO-247	20N60A4D		
HGT4E20N60A4DS	TO-268	20N60A4DS		

NOTE: When ordering, use the entire part number.

Symbol

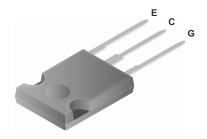


Features

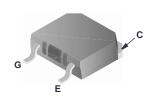
- >100kHz Operation At 390V, 20A
- 200kHz Operation At 390V, 12A
- · 600V Switching SOA Capability
- Low Conduction Loss
- Temperature Compensating SABER™ Model www.fairchildsemi.com

Packaging

JEDEC STYLE TO-247



TO-268AA



FAIRCH	IILD SEMICONDU	CTOR IGBT PRO	DUCT IS COVERI	ED BY ONE OR M	ORE OF THE FO	LLOWING U.S. PA	ATENTS
4,364,073	4,417,385	4,430,792	4,443,931	4,466,176	4,516,143	4,532,534	4,587,713
4,598,461	4,605,948	4,620,211	4,631,564	4,639,754	4,639,762	4,641,162	4,644,637
4,682,195	4,684,413	4,694,313	4,717,679	4,743,952	4,783,690	4,794,432	4,801,986
4,803,533	4,809,045	4,809,047	4,810,665	4,823,176	4,837,606	4,860,080	4,883,767
4,888,627	4,890,143	4,901,127	4,904,609	4,933,740	4,963,951	4,969,027	

HGTG20N60A4D, HGT4E20N60A4DS

Absolute Maximum Ratings $T_C = 25^{\circ}C$, Unless Otherwise Specified

	HGTG20N60A4D,		
	HGT4E20N60A4DS	UNITS	
Collector to Emitter Voltage	600	V	
Collector Current Continuous			
At $T_C = 25^{\circ}C$	70	Α	
At $T_C = 110^{\circ}C$	40	Α	
Collector Current Pulsed (Note 1)	280	Α	
Gate to Emitter Voltage ContinuousV _{GES}	±20	V	
Gate to Emitter Voltage Pulsed	±30	V	
Switching Safe Operating Area at T _J = 150 ^o C (Figure 2)	100A at 600V		
Power Dissipation Total at T _C = 25 ^o C	290	W	
Power Dissipation Derating T _C > 25 ^o C	2.32	W/oC	
Operating and Storage Junction Temperature Range	-55 to 150	°C	
Maximum Lead Temperature for Soldering	260	оС	

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

NOTE:

1. Pulse width limited by maximum junction temperature.

Electrical Specifications $T_J = 25^{\circ}C$, Unless Otherwise Specified

PARAMETER	SYMBOL	TEST (CONDITIONS	MIN	TYP	MAX	UNITS
Collector to Emitter Breakdown Voltage	BV _{CES}	$I_C = 250\mu A, V_{GE} = 0V$		600	-	-	V
Collector to Emitter Leakage Current	ICES	V _{CE} = 600V	$T_J = 25^{\circ}C$	-	-	250	μА
			$T_{J} = 125^{\circ}C$	-	-	3.0	mA
Collector to Emitter Saturation Voltage	V _{CE(SAT)}	I _C = 20A, V _{GE} = 15V	$T_J = 25^{\circ}C$	-	1.8	2.7	V
			$T_{J} = 125^{\circ}C$	-	1.6	2.0	V
Gate to Emitter Threshold Voltage	V _{GE(TH)}	$I_C = 250\mu A, V_{CE} = 600V$		4.5	5.5	7.0	V
Gate to Emitter Leakage Current	I _{GES}	V _{GE} = ±20V		-	-	±250	nA
Switching SOA	SSOA	$T_J = 150^{\circ}C$, $R_G = 3\Omega$, $V_{GE} = 15V$, $L = 100\mu$ H, $V_{CE} = 600V$		100	-	-	А
Gate to Emitter Plateau Voltage	V _{GEP}	I _C = 20A, V _{CE} = 3	300V	-	8.6	-	V
On-State Gate Charge	Q _{g(ON)}	I _C = 20A,	V _{GE} = 15V	-	142	162	nC
J.		V _{CE} = 300V	V _{GE} = 20V	-	182	210	nC
Current Turn-On Delay Time	t _d (ON)I	IGBT and Diode at $T_J = 25^{o}C$, $I_{CE} = 20A$, $V_{CE} = 390V$, $V_{GE} = 15V$, $R_{G} = 3\Omega$, $L = 500\mu H$, Test Circuit Figure 24		-	15	-	ns
Current Rise Time	t _{rl}			-	12	-	ns
Current Turn-Off Delay Time	t _d (OFF)I			-	73	-	ns
Current Fall Time	t _{fl}			-	32	-	ns
Turn-On Energy (Note 3)	E _{ON1}			-	105	-	μЈ
Turn-On Energy (Note 3)	E _{ON2}			-	280	350	μЈ
Turn-Off Energy (Note 2)	E _{OFF}			-	150	200	μЈ
Current Turn-On Delay Time	t _d (ON)I	IGBT and Diode at T_J = 125 o C, I_{CE} = 20A, V_{CE} = 390V, V_{GE} = 15V, R_{G} = 3 Ω , L = 500 μ H, Test Circuit Figure 24		-	15	21	ns
Current Rise Time	t _{rl}			-	13	18	ns
Current Turn-Off Delay Time	t _d (OFF)I			-	105	135	ns
Current Fall Time	t _{fl}			-	55	73	ns
Turn-On Energy (Note 3)	E _{ON1}			-	115	-	μJ
Turn-On Energy (Note 3)	E _{ON2}			-	510	600	μJ
Turn-Off Energy (Note 2)	E _{OFF}			-	330	500	μJ

HGTG20N60A4D, HGT4E20N60A4DS

Electrical Specifications $T_J = 25^{\circ}C$, Unless Otherwise Specified (Continued)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Diode Forward Voltage	V _{EC}	I _{EC} = 20A	-	2.3	-	V
Diode Reverse Recovery Time	t _{rr}	$I_{EC} = 20A$, $dI_{EC}/dt = 200A/\mu s$		35	-	ns
		$I_{EC} = 1A$, $dI_{EC}/dt = 200A/\mu s$	-	26	-	ns
Thermal Resistance Junction To Case	R ₀ JC IGBT		-	-	0.43	°C/W
		Diode	-	-	1.9	°C/W

NOTE:

- 2. Turn-Off Energy Loss (E_{OFF}) is defined as the integral of the instantaneous power loss starting at the trailing edge of the input pulse and ending at the point where the collector current equals zero (I_{CE} = 0A). All devices were tested per JEDEC Standard No. 24-1 Method for Measurement of Power Device Turn-Off Switching Loss. This test method produces the true total Turn-Off Energy Loss.
- 3. Values for two Turn-On loss conditions are shown for the convenience of the circuit designer. E_{ON1} is the turn-on loss of the IGBT only. E_{ON2} is the turn-on loss when a typical diode is used in the test circuit and the diode is at the same T_J as the IGBT. The diode type is specified in Figure 20.

Typical Performance Curves Unless Otherwise Specified

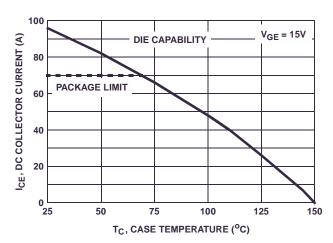


FIGURE 1. DC COLLECTOR CURRENT vs CASE TEMPERATURE

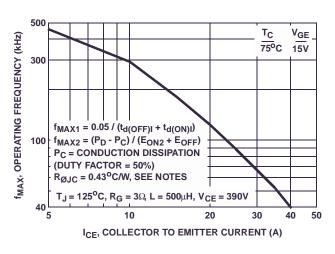


FIGURE 3. OPERATING FREQUENCY vs COLLECTOR TO EMITTER CURRENT

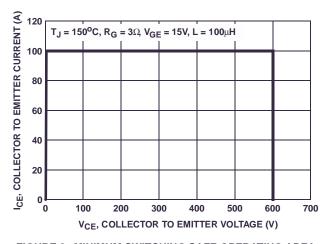


FIGURE 2. MINIMUM SWITCHING SAFE OPERATING AREA

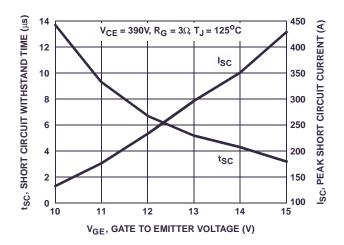


FIGURE 4. SHORT CIRCUIT WITHSTAND TIME

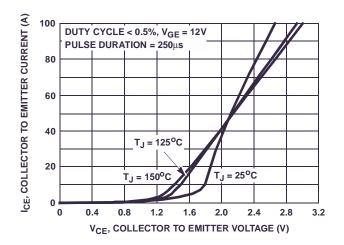


FIGURE 5. COLLECTOR TO EMITTER ON-STATE VOLTAGE

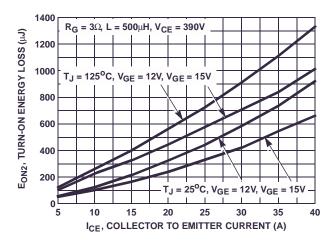


FIGURE 7. TURN-ON ENERGY LOSS vs COLLECTOR TO EMITTER CURRENT

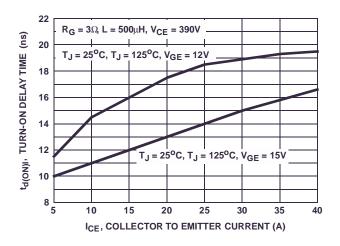


FIGURE 9. TURN-ON DELAY TIME vs COLLECTOR TO EMITTER CURRENT

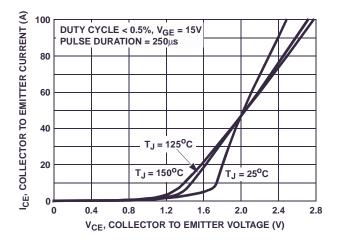


FIGURE 6. COLLECTOR TO EMITTER ON-STATE VOLTAGE

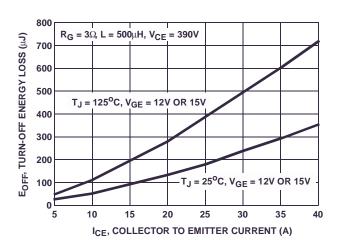


FIGURE 8. TURN-OFF ENERGY LOSS vs COLLECTOR TO EMITTER CURRENT

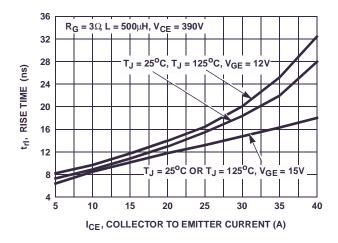


FIGURE 10. TURN-ON RISE TIME vs COLLECTOR TO EMITTER CURRENT

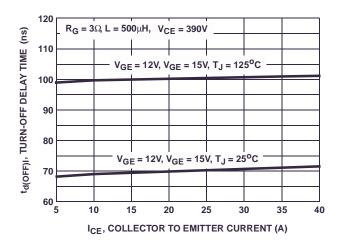


FIGURE 11. TURN-OFF DELAY TIME vs COLLECTOR TO EMITTER CURRENT

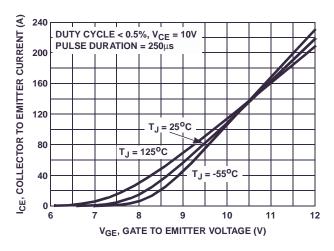


FIGURE 13. TRANSFER CHARACTERISTIC

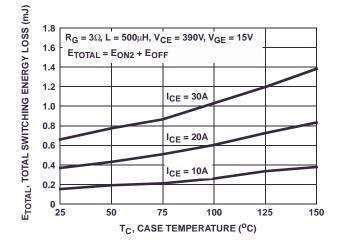


FIGURE 15. TOTAL SWITCHING LOSS vs CASE TEMPERATURE

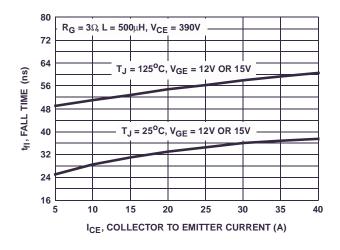


FIGURE 12. FALL TIME vs COLLECTOR TO EMITTER CURRENT

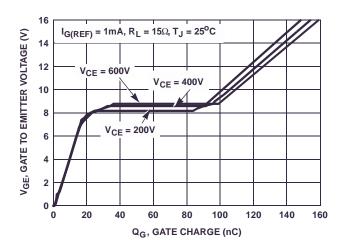


FIGURE 14. GATE CHARGE WAVEFORMS

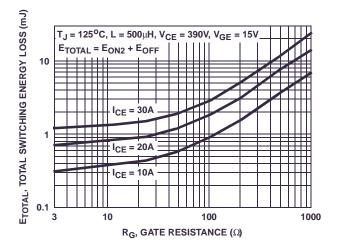


FIGURE 16. TOTAL SWITCHING LOSS vs GATE RESISTANCE

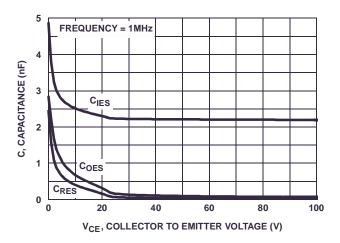


FIGURE 17. CAPACITANCE vs COLLECTOR TO EMITTER VOLTAGE

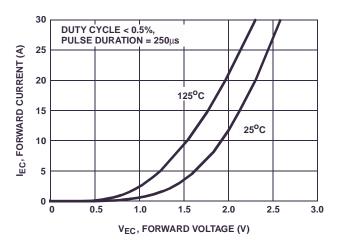


FIGURE 19. DIODE FORWARD CURRENT vs FORWARD VOLTAGE DROP

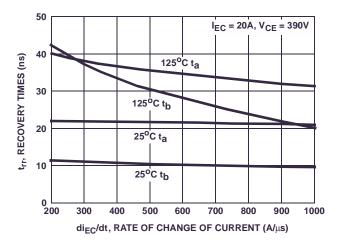


FIGURE 21. RECOVERY TIMES VS RATE OF CHANGE OF CURRENT

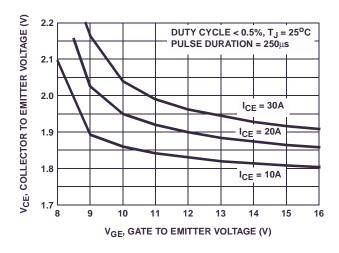


FIGURE 18. COLLECTOR TO EMITTER ON-STATE VOLTAGE VS GATE TO EMITTER VOLTAGE

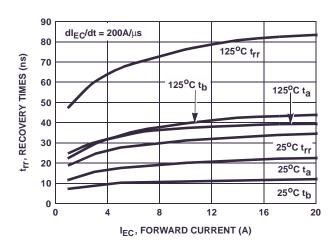


FIGURE 20. RECOVERY TIMES vs FORWARD CURRENT

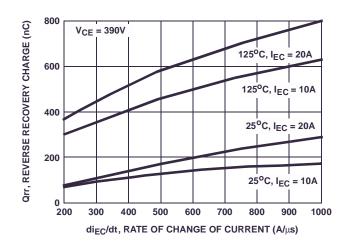


FIGURE 22. STORED CHARGE VS RATE OF CHANGE OF CURRENT

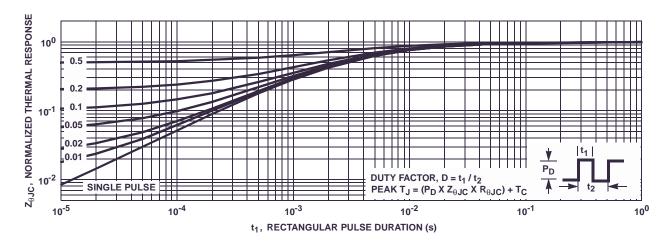


FIGURE 23. IGBT NORMALIZED TRANSIENT THERMAL RESPONSE, JUNCTION TO CASE

Test Circuit and Waveforms

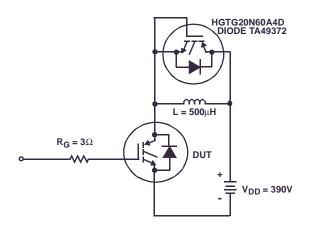


FIGURE 24. INDUCTIVE SWITCHING TEST CIRCUIT

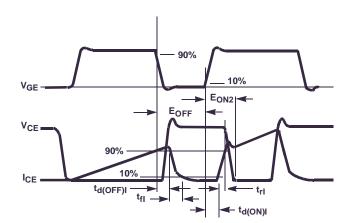


FIGURE 25. SWITCHING TEST WAVEFORMS

HGTG20N60A4D, HGT4E20N60A4DS

Handling Precautions for IGBTs

Insulated Gate Bipolar Transistors are susceptible to gate-insulation damage by the electrostatic discharge of energy through the devices. When handling these devices, care should be exercised to assure that the static charge built in the handler's body capacitance is not discharged through the device. With proper handling and application procedures, however, IGBTs are currently being extensively used in production by numerous equipment manufacturers in military, industrial and consumer applications, with virtually no damage problems due to electrostatic discharge. IGBTs can be handled safely if the following basic precautions are taken:

- Prior to assembly into a circuit, all leads should be kept shorted together either by the use of metal shorting springs or by the insertion into conductive material such as "ECCOSORBDTM LD26" or equivalent.
- When devices are removed by hand from their carriers, the hand being used should be grounded by any suitable means - for example, with a metallic wristband.
- 3. Tips of soldering irons should be grounded.
- Devices should never be inserted into or removed from circuits with power on.
- Gate Voltage Rating Never exceed the gate-voltage rating of V_{GEM}. Exceeding the rated V_{GE} can result in permanent damage to the oxide layer in the gate region.
- 6. Gate Termination The gates of these devices are essentially capacitors. Circuits that leave the gate opencircuited or floating should be avoided. These conditions can result in turn-on of the device due to voltage buildup on the input capacitor due to leakage currents or pickup.
- Gate Protection These devices do not have an internal monolithic Zener diode from gate to emitter. If gate protection is required an external Zener is recommended.

Operating Frequency Information

Operating frequency information for a typical device (Figure 3) is presented as a guide for estimating device performance for a specific application. Other typical frequency vs collector current (I_CE) plots are possible using the information shown for a typical unit in Figures 6, 7, 8, 9 and 11. The operating frequency plot (Figure 3) of a typical device shows f_{MAX1} or f_{MAX2} ; whichever is smaller at each point. The information is based on measurements of a typical device and is bounded by the maximum rated junction temperature.

 f_{MAX1} is defined by $f_{MAX1}=0.05/(t_{d(OFF)I}+t_{d(ON)I}).$ Deadtime (the denominator) has been arbitrarily held to 10% of the on-state time for a 50% duty factor. Other definitions are possible. $t_{d(OFF)I}$ and $t_{d(ON)I}$ are defined in Figure 25. Device turn-off delay can establish an additional frequency limiting condition for an application other than $T_{JM}.\ t_{d(OFF)I}$ is important when controlling output ripple under a lightly loaded condition.

 f_{MAX2} is defined by $f_{MAX2} = (P_D - P_C)/(E_{OFF} + E_{ON2}).$ The allowable dissipation (P_D) is defined by $P_D = (T_{JM} - T_C)/R_{\theta JC}.$ The sum of device switching and conduction losses must not exceed $P_D.$ A 50% duty factor was used (Figure 3) and the conduction losses (P_C) are approximated by $P_C = (V_{CE} \times I_{CE})/2.$

 E_{ON2} and E_{OFF} are defined in the switching waveforms shown in Figure 25. E_{ON2} is the integral of the instantaneous power loss (I_CE x V_CE) during turn-on and E_{OFF} is the integral of the instantaneous power loss (I_CE x V_CE) during turn-off. All tail losses are included in the calculation for E_{OFF} ; i.e., the collector current equals zero (I_CE = 0).

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