**HARRIS** SEMICONDUCTOR

# HGTG12N60D1D

## 12A, 600V N-Channel IGBT with Anti-Parallel Ultrafast Diode

April 1995

### Features

- 12A, 600V
- Latch Free Operation
- Typical Fall Time <500ns
- Low Conduction Loss
- With Anti-Parallel Diode
- $t_{RR}$ < 60ns

### Description

The IGBT is a MOS gated high voltage switching device combining the best features of MOSFETs and bipolar transistors. The device has 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 diode used in parallel with the IGBT is an ultrafast ($t_{RR}$ < 60ns) with soft recovery characteristic.

The IGBTs are ideal for many high voltage switching applications operating at frequencies where low conduction losses are essential, such as: AC and DC motor controls, power supplies and drivers for solenoids, relays and contactors.

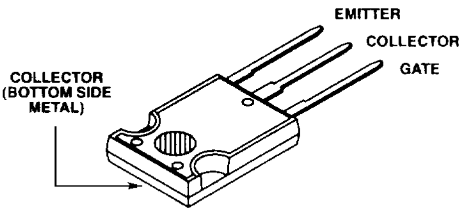
PACKAGING AVAILABILITY

| PART NUMBER | PACKAGE | BRAND |
|---|---|---|
| HGTG12N60D1D | TO-220AB | G12N60D1D |

NOTE: When ordering, use the entire part number

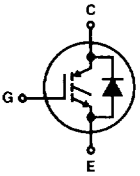
### Package

JEDEC STYLE TO-247



### Terminal Diagram

N-CHANNEL ENHANCEMENT MODE



### Absolute Maximum Ratings $T_C$ = +25°C, Unless Otherwise Specified

| | | HGTG12N60D1D | UNITS |
|---|---|---|---|
| Collector-Emitter Voltage | $BV_{CES}$ | 600 | V |
| Collector-Gate Voltage $R_{GE}$ = 1MΩ | $BV_{CGR}$ | 600 | V |
| Collector Current Continuous at $T_C$ = +25°C | $I_{C25}$ | 21 | A |
| at $T_C$ = +90°C | $I_{C90}$ | 12 | A |
| Collector Current Pulsed (Note 1) | $I_{CM}$ | 48 | A |
| Gate-Emitter Voltage Continuous | $V_{GES}$ | ±20 | V |
| Switching Safe Operating Area at $T_J$ = +150°C | SSOA | 30A at 0.8 $BV_{CES}$ | - |
| Diode Forward Current at $T_C$ = +25°C | $I_{F25}$ | 21 | A |
| at $T_C$ = +90°C | $I_{F90}$ | 12 | A |
| Power Dissipation Total at $T_C$ = +25°C | $P_D$ | 75 | W |
| Power Dissipation Derating $T_C$ > +25°C | | 0.6 | W/°C |
| Operating and Storage Junction Temperature Range | $T_J$, $T_{STG}$ | -55 to +150 | °C |
| Maximum Lead Temperature for Soldering (0.125 inches from case for 5s) | $T_L$ | 260 | °C |

NOTE:

1. Repetitive Rating: Pulse width limited by maximum junction temperature.

**HARRIS SEMICONDUCTOR IGBT PRODUCT IS COVERED BY ONE OR MORE OF THE FOLLOWING U.S. PATENTS:**

4,364,073 4,417,385 4,430,792 4,443,931 4,466,176 4,516,143 4,532,534 4,567,641
4,587,713 4,598,461 4,605,948 4,618,872 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

CAUTION: These devices are sensitive to electrostatic discharge. Users should follow proper ESD Handling Procedures.

## Electrical Specifications $T_C = +25^\circ C$, Unless Otherwise Specified

| PARAMETERS | SYMBOL | TEST CONDITIONS | | LIMITS | | | UNITS |
|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | |
| Collector-Emitter Breakdown Voltage | $BV_{CES}$ | $I_C = 280\mu A$, $V_{GE} = 0V$ | | 600 | - | - | V |
| Collector-Emitter Leakage Voltage | $I_{CES}$ | $V_{CE} = BV_{CES}$ | $T_C = +25^\circ C$ | - | - | 280 | µA |
| | | $V_{CE} = 0.8\ BV_{CES}$ | $T_C = +125^\circ C$ | - | - | 5.0 | mA |
| Collector-Emitter Saturation Voltage | $V_{CE(SAT)}$ | $I_C = I_{C90}$, $V_{GE} = 15V$ | $T_C = +25^\circ C$ | - | 1.9 | 2.5 | V |
| | | | $T_C = +125^\circ C$ | - | 2.1 | 2.7 | V |
| Gate-Emitter Threshold Voltage | $V_{GE(TH)}$ | $I_C = 250\mu A$, $V_{CE} = V_{GE}$, $T_C = +25^\circ C$ | | 3.0 | 4.5 | 6.0 | V |
| Gate-Emitter Leakage Current | $I_{GES}$ | $V_{GE} = \pm 20V$ | | - | - | ±500 | nA |
| Gate-Emitter Plateau Voltage | $V_{GEP}$ | $I_C = I_{C90}$, $V_{CE} = 0.5\ BV_{CES}$ | | - | 7.2 | - | V |
| On-State Gate Charge | $Q_{G(ON)}$ | $I_C = I_{C90}$, $V_{CE} = 0.5\ BV_{CES}$ | $V_{GE} = 15V$ | - | 45 | 60 | nC |
| | | | $V_{GE} = 20V$ | - | 70 | 90 | nC |
| Current Turn-On Delay Time | $t_{D(ON)I}$ | $L = 500\mu H$, $I_C = I_{C90}$, $R_G = 25V$, $V_{GE} = 15V$, $T_J = +150^\circ C$, $V_{CE} = 0.8\ BV_{CES}$ | | - | 100 | - | ns |
| Current Rise Time | $t_{RI}$ | | | - | 150 | - | ns |
| Current Turn-Off | $t_{D(OFF)I}$ | | | - | 430 | 600 | ns |
| Current Fall Time | $t_{FI}$ | | | - | 430 | 600 | ns |
| Turn-Off Energy (Note 1) | $W_{OFF}$ | | | - | 1.8 | - | mJ |
| Thermal Resistance IGBT | $R_{\theta JC}$ | | | - | - | 1.67 | °C/W |
| Thermal Resistance Diode | $R_{\theta JC}$ | | | - | - | 1.5 | °C/W |
| Diode Forward Voltage | $V_{EC}$ | $I_{EC} = 12A$ | | - | - | 1.50 | V |
| Diode Reverse Recovery Time | $t_{RR}$ | $I_{EC} = 12A$, $dI_{EC}/dt = 100A/\mu s$ | | - | - | 60 | ns |

NOTE:

1. Turn-off Energy Loss ($W_{OFF}$) 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 ($I_{CE} = 0A$). The HGTG12N60D1D was 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.

## Typical Performance Curves

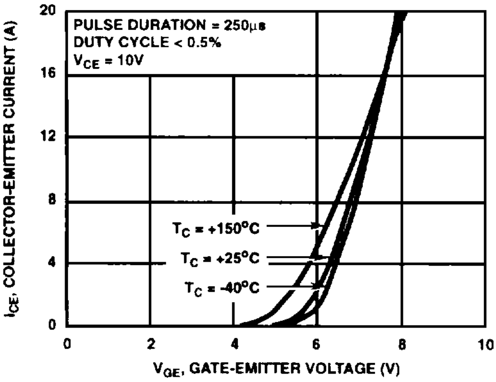


FIGURE 1. TRANSFER CHARACTERISTICS (TYPICAL)

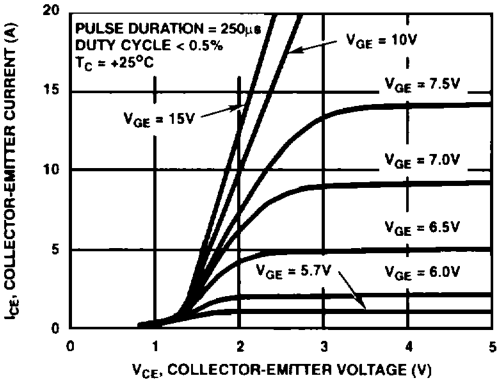


FIGURE 2. SATURATION CHARACTERISTICS (TYPICAL)

## *Typical Performance Curves* (Continued)

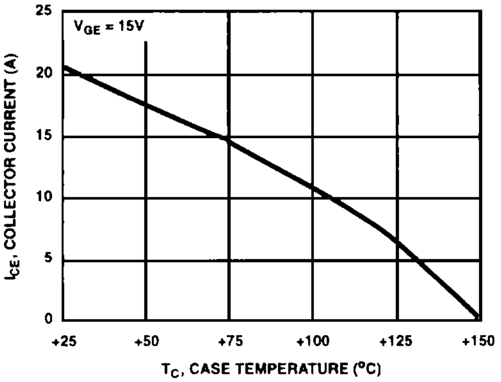


FIGURE 3. DC COLLECTOR CURRENT vs CASE TEMPERATURE

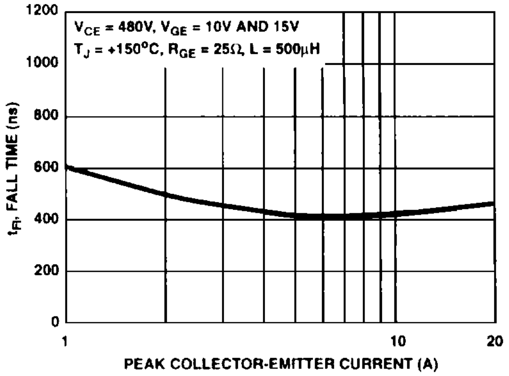


FIGURE 4. FALL TIME vs COLLECTOR-EMITTER CURRENT

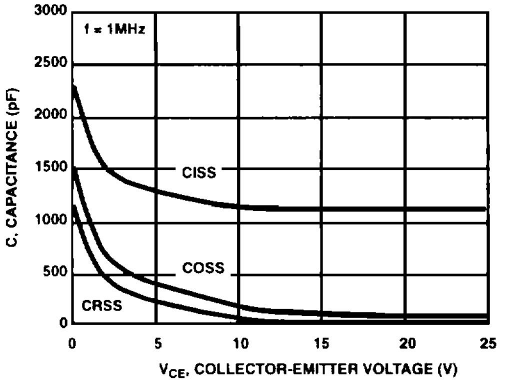


FIGURE 5. CAPACITANCE vs COLLECTOR-EMITTER VOLTAGE

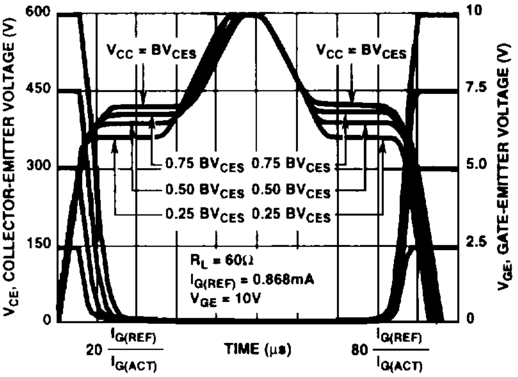


FIGURE 6. NORMALIZED SWITCHING WAVEFORMS AT CONSTANT GATE CURRENT. (REFER TO APPLICATION NOTES AN7254 AND AN7260)

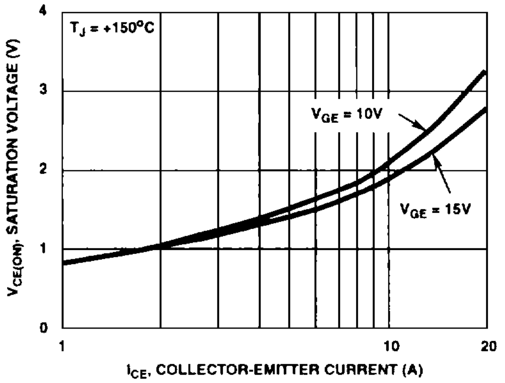


FIGURE 7. SATURATION VOLTAGE vs COLLECTOR-EMITTER CURRENT

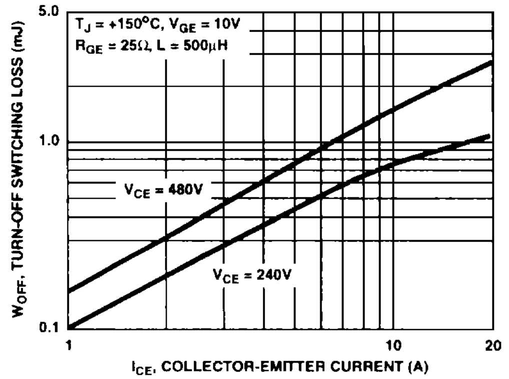


FIGURE 8. TURN-OFF SWITCHING LOSS vs COLLECTOR-EMITTER CURRENT

## *Typical Performance Curves* (Continued)

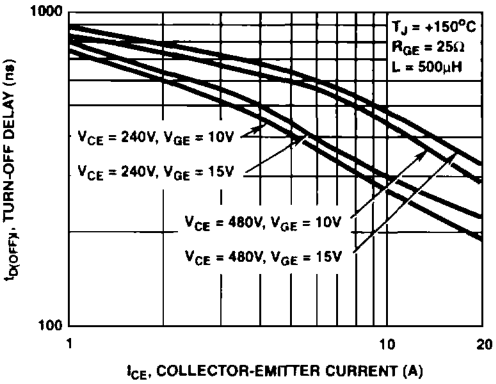
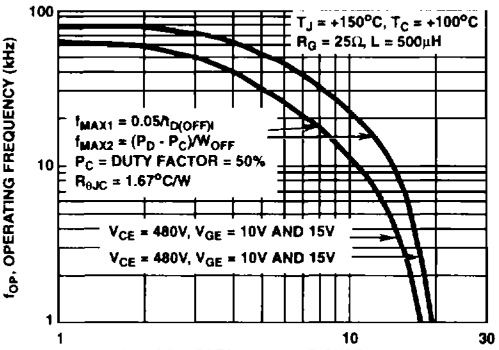


FIGURE 9. TURN-OFF DELAY vs COLLECTOR-EMITTER CURRENT



NOTE:
$P_D$ = ALLOWABLE DISSIPATION $P_C$ = CONDUCTION DISSIPATION

FIGURE 10. OPERATING FREQUENCY vs COLLECTOR-EMITTER CURRENT AND VOLTAGE

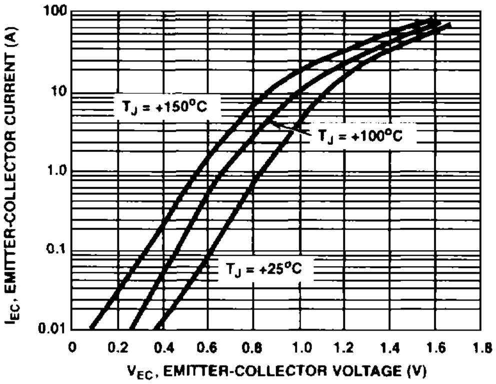


FIGURE 11. TYPICAL DIODE EMITTER-TO-COLLECTOR VOLTAGE

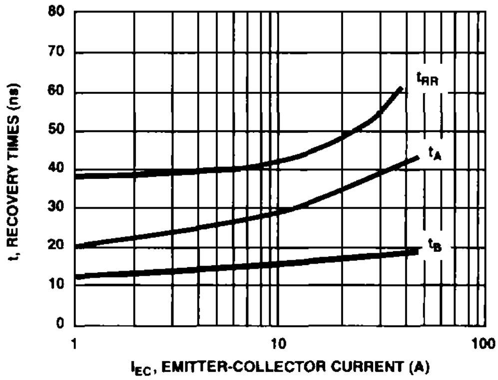


FIGURE 12. TYPICAL $t_{RR}$, $t_A$, $t_B$ vs FORWARD CURRENT

## *Operating Frequency Information*

Operating frequency information for a typical device (Figure 10) 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 7, 8 and 9. The operating frequency plot (Figure 10) 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 $f_{MAX1} = 0.05/t_{D(OFF)I}$. $t_{D(OFF)I}$ deadtime (the denominator) has been arbitrarily held to 10% of the on-state time for a 50% duty factor. Other definitions are possible. $t_{D(OFF)I}$ is defined as the time between the 90% point of the trailing edge of the input pulse and the point where the collector current falls to 90% of its maximum value. Device turn-off delay can establish an additional frequency limiting condition for an application other than $T_{JMAX}$. $t_{D(OFF)I}$ is important when controlling output ripple under a lightly loaded condition.

$f_{MAX2}$ is defined by $f_{MAX2} = (P_D - P_C)/W_{OFF}$. The allowable dissipation ($P_D$) is defined by $P_D = (T_{JMAX} - T_C)/R_{θJC}$. The sum of device switching and conduction losses must not exceed $P_D$. A 50% duty factor was used (Figure 10) so that the conduction losses ($P_C$) can be approximated by $P_C = (V_{CE} \times I_{CE})/2$. $W_{OFF}$ is defined as the sum 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).

The switching power loss (Figure 10) is defined as $f_{MAX1} \times W_{OFF}$. Turn on switching losses are not included because they can be greatly influenced by external circuit conditions and components.