

# 2N6975, 2N6976, 2N6977, 2N6978

April 1995

5A, 400V and 500V N-Channel IGBTs

### Features

- 5A, 400V and 500V
- $V_{CE(ON)}$  2V
- $T_{FI}$  1 $\mu$ s, 0.5 $\mu$ s
- Low On-State Voltage
- Fast Switching Speeds
- High Input Impedance

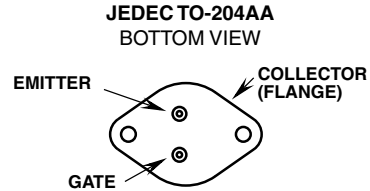
### Applications

- Power Supplies
- Motor Drives
- Protection Circuits

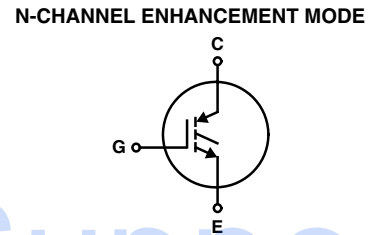
### Description

The 2N6975, 2N6976, 2N6977 and the 2N6978 are n-channel enhancement-mode insulated gate bipolar transistors (IGBTs) designed for high-voltage, low on-dissipation applications such as switching regulators and motor drivers. These types can be operated directly from low-power integrated circuits.

### Package



### Terminal Diagram



### PACKAGING AVAILABILITY

| PART NUMBER | PACKAGE  | BRAND |
|-------------|----------|-------|
| 2N6975      | TO-204AA |       |
| 2N6976      | TO-204AA |       |
| 2N6977      | TO-204AA |       |
| 2N6978      | TO-204AA |       |

NOTE: When ordering, use the entire part number.

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

|                                                                | 2N6975/2N6977<br>(Note 1) | 2N6976/2N6978<br>(Note 1) | UNITS               |
|----------------------------------------------------------------|---------------------------|---------------------------|---------------------|
| Collector-Emitter Voltage . . . . .                            | 400                       | 500                       | V                   |
| Collector-Gate Voltage ( $R_{GE} = 1M\Omega$ ) . . . . .       | 400                       | 500                       | V                   |
| Reverse Collector-Emitter Voltage . . . . .                    | 5                         | 5                         | V                   |
| Gate-Emitter Voltage . . . . .                                 | $\pm 20$                  | $\pm 20$                  | V                   |
| Collector Current Continuous . . . . .                         | 5                         | 5                         | A                   |
| Collector Current Pulsed . . . . .                             | 10                        | 10                        | A                   |
| Power Dissipation Total at $T_C = +25^\circ\text{C}$ . . . . . | 100                       | 100                       | W                   |
| Power Dissipation Derating $T_C > +25^\circ\text{C}$ . . . . . | 0.8                       | 0.8                       | W/ $^\circ\text{C}$ |
| Operating and Storage Junction Temperature Range . . . . .     | -55 to +150               | -55 to +150               | $^\circ\text{C}$    |

NOTE:

1. JEDEC registered value.

### 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 |           |           |           |           |           |           |           |

## Specifications 2N6975, 2N6976, 2N6977, 2N6978

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

| PARAMETERS                                                                                           | SYMBOL          | TEST CONDITIONS                                                                                                                                           | LIMITS                   |                           |                 |                            | UNIT S               |
|------------------------------------------------------------------------------------------------------|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|---------------------------|-----------------|----------------------------|----------------------|
|                                                                                                      |                 |                                                                                                                                                           | 2N6975/2N6977            |                           | 2N6976/2N6978   |                            |                      |
|                                                                                                      |                 |                                                                                                                                                           | MIN                      | MAX                       | MIN             | MAX                        |                      |
| Collector-Emitter Breakdown Voltage                                                                  | $BV_{CES}$      | $I_C = 1\text{ mA}, V_{GE} = 0$                                                                                                                           | 400<br>(Note 1)          | $-\infty$                 | 500<br>(Note 1) | -                          | V                    |
| Gate Threshold Voltage                                                                               | $V_{GE(TH)}$    | $V_{GE} = V_{CE}, I_C = 1\text{ mA}$                                                                                                                      | $2^{\infty}$<br>(Note 1) | 4.5<br>(Note 1)           | 2<br>(Note 1)   | $4.5^{\infty}$<br>(Note 1) | V                    |
| Zero Gate Voltage Collector Current                                                                  | $I_{CES}$       | $V_{CE} = 400\text{ V}$                                                                                                                                   | -                        | 250<br>(Note 1)           | -               | -                          | $\mu\text{A}$        |
|                                                                                                      |                 | $V_{CE} = 500\text{ V}$                                                                                                                                   | -                        | -                         | -               | 250<br>(Note 1)            | $\mu\text{A}$        |
|                                                                                                      |                 | $T_C = +125^{\circ}\text{C}$                                                                                                                              | -                        | -                         | -               | -                          | $\mu\text{A}$        |
|                                                                                                      |                 | $V_{CE} = 400\text{ V}$                                                                                                                                   | -                        | $\infty 1000$<br>(Note 1) | -               | -                          | $\mu\text{A}$        |
|                                                                                                      |                 | $V_{CE} = 500\text{ V}$                                                                                                                                   | -                        | -                         | -               | 1000<br>(Note 1)           | $\mu\text{A}$        |
| Gate-Emitter Leakage Current                                                                         | $I_{GES}$       | $V_{GE} = \pm 20\text{ V}, V_{CE} = 0\text{ V}$                                                                                                           | -                        | 100<br>(Note 1)           | -               | 100<br>(Note 1)            | ns                   |
| Reverse Collector-Emitter Leakage Current                                                            | $I_{ECS}$       | $R_{GE} = 0\Omega, V_{EC} = 5\text{ V}$                                                                                                                   | -                        | 5<br>(Note 1)             | -               | 5<br>(Note 1)              | mA                   |
| Collector-Emitter On Voltage                                                                         | $V_{CE(ON)}$    | $I_C = 5\text{ A}, V_{GE} = 10\text{ V}$                                                                                                                  | -                        | 2<br>(Note 1)             | -               | 2<br>(Note 1)              | V                    |
|                                                                                                      |                 | $I_C = 10\text{ A}, V_{GE} = 20\text{ V}$                                                                                                                 | -                        | 2.5                       | -               | 2.5                        | V                    |
| Gate-Emitter Plateau Voltage                                                                         | $V_{GEP}$       | $I_C = 5\text{ A}, V_{CE} = 10\text{ V}$                                                                                                                  | 3.4<br>(Note 1)          | 6.8<br>(Note 1)           | 3.4<br>(Note 1) | 6.8<br>(Note 1)            | V                    |
| On-State Gate Charge                                                                                 | $Q_{G(ON)}$     | $I_C = 5\text{ A}, V_{CE} = 10\text{ V}$                                                                                                                  | 12<br>(Note 1)           | 25<br>(Note 1)            | 12<br>(Note 1)  | 25<br>(Note 1)             | nC                   |
| Turn-On Delay Time                                                                                   | $t_{D(ON)}$     | $I_C = 5\text{ A}$<br>$V_{CE(CL P)} = 300\text{ V}$<br>$L = 50\mu\text{ H}$<br>$T_J = +125^{\circ}\text{C}$<br>$V_{GE} = 10\text{ V}$<br>$R_G = 50\Omega$ | 50 Max                   |                           |                 |                            | ns                   |
| Rise Time                                                                                            | $t_R$           |                                                                                                                                                           | 50 Max                   |                           |                 |                            | ns                   |
| Turn-Off Delay Time                                                                                  | $t_{D(OFF)}$    |                                                                                                                                                           | 400 Max<br>(Note 1)      |                           |                 |                            | ns                   |
| Fall Time                                                                                            | $t_{FI}$        |                                                                                                                                                           | 2N6975<br>2N6976         | 1000 Max<br>(Note 1)      |                 |                            | ns                   |
|                                                                                                      |                 |                                                                                                                                                           | 2N6977<br>2N6978         | 500 Max<br>(Note 1)       |                 |                            | ns                   |
| Turn-Off Energy Loss per Cycle<br>(Off Switching Dissipation=<br>$W_{OFF} \times \text{Frequency}$ ) | $W_{OFF}$       | 2N6975<br>2N6976                                                                                                                                          | 1000 Max<br>(Note 1)     |                           |                 | $\mu\text{J}$              |                      |
|                                                                                                      |                 | 2N6977<br>2N6978                                                                                                                                          | 500 Max<br>(Note 1)      |                           |                 | $\mu\text{J}$              |                      |
| Thermal Resistance Junction-to-Case                                                                  | $R_{\theta JC}$ |                                                                                                                                                           | 1.25<br>(Note 1)         |                           |                 |                            | $^{\circ}\text{C/W}$ |

**NOTE:**

1. JEDEC registered value.

Typical Performance Curves

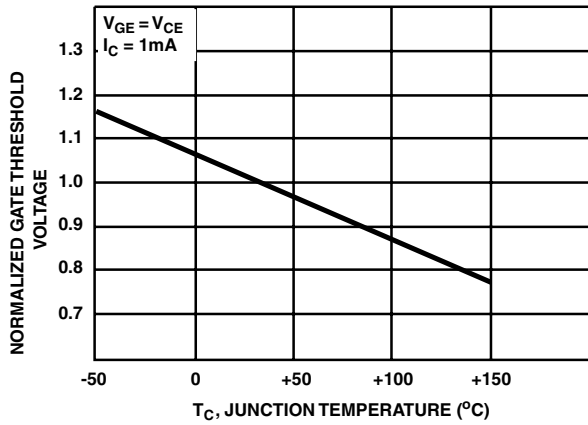


FIGURE 1. TYPICAL NORMALIZED GATE THRESHOLD VOLTAGE AS A FUNCTION OF JUNCTION TEMPERATURE FOR ALL TYPES

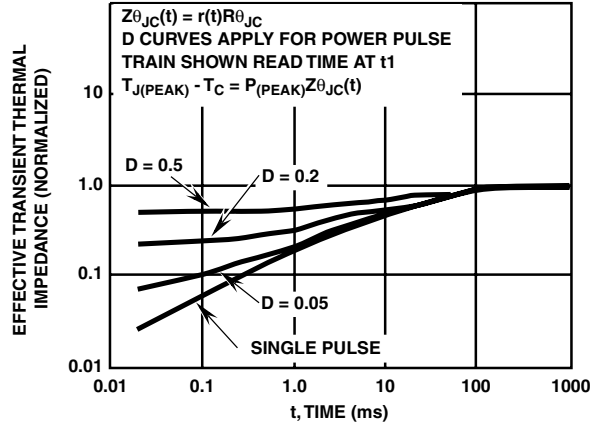


FIGURE 2. NORMALIZED THERMAL RESPONSE CHARACTERISTICS FOR ALL TYPES

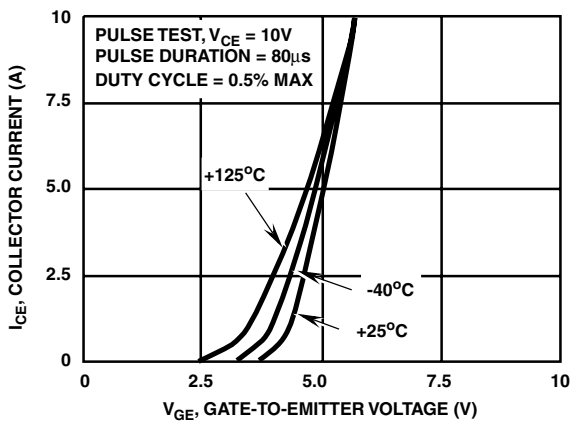


FIGURE 3. TYPICAL TRANSFER CHARACTERISTICS FOR ALL TYPES

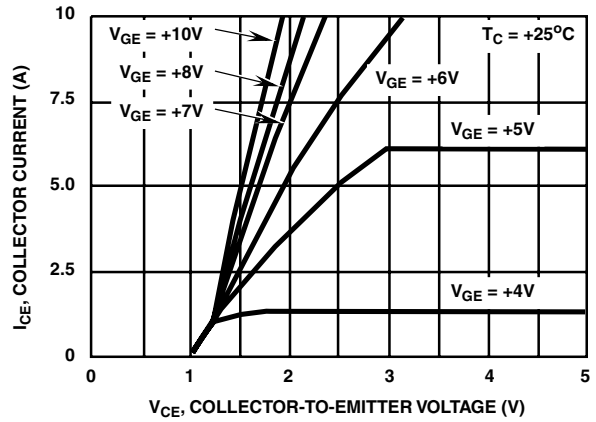


FIGURE 4. TYPICAL SATURATION CHARACTERISTICS FOR ALL TYPES

2N6975, 2N6976, 2N6977, 2N6978

Typical Performance Curves (Continued)

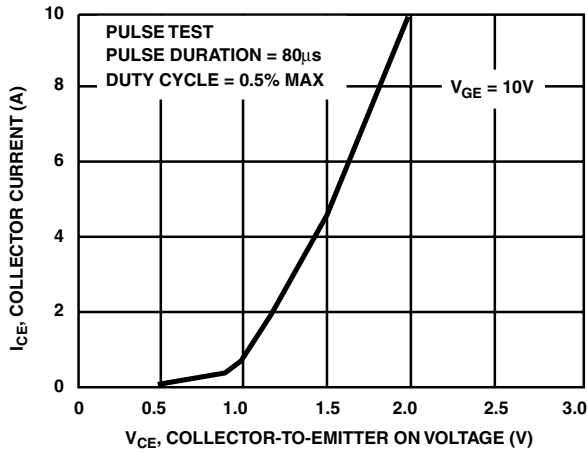


FIGURE 5. TYPICAL COLLECTOR-TO-EMITTER ON-VOLTAGE AS A FUNCTION OF COLLECTOR CURRENT FOR ALL TYPES

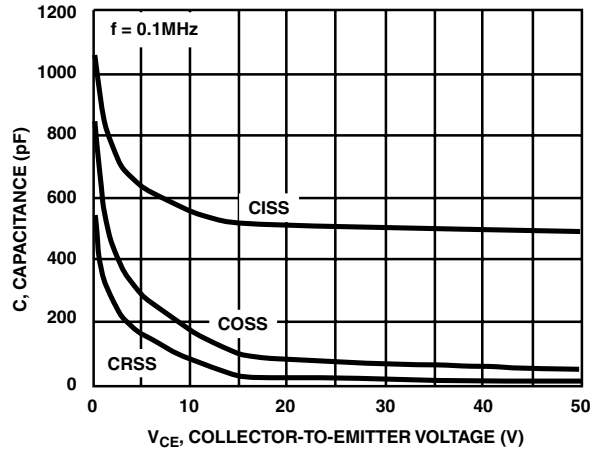


FIGURE 6. CAPACITANCE AS A FUNCTION OF COLLECTOR-TO-EMITTER VOLTAGE FOR ALL TYPES

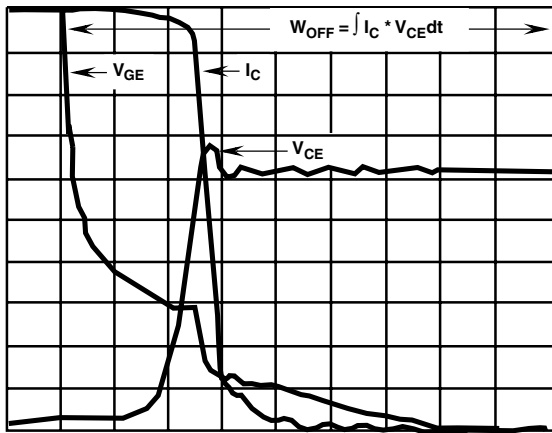
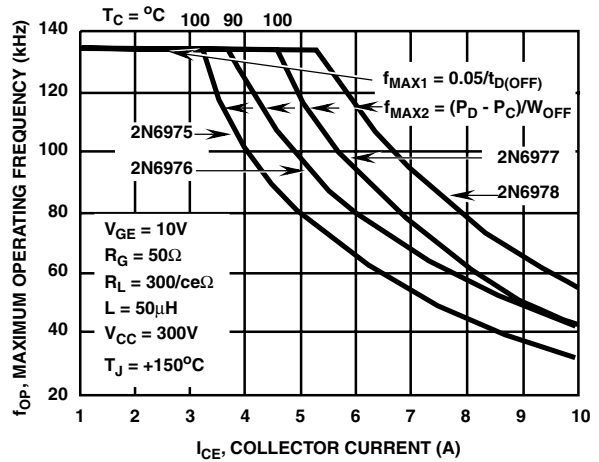


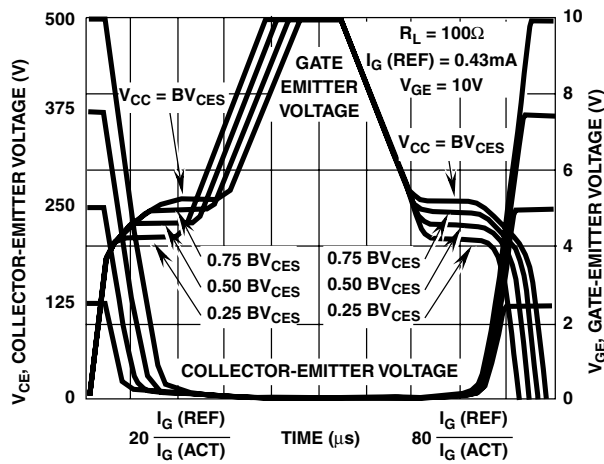
FIGURE 7. TYPICAL INDUCTIVE SWITCHING WAVEFORMS



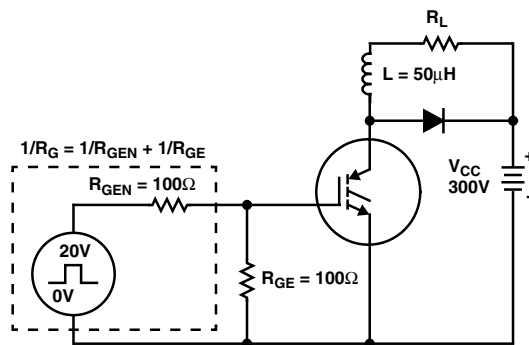
P<sub>D</sub>: ALLOWABLE DISSIPATION  
P<sub>C</sub>: CONDUCTION DISSIPATION

FIGURE 8. MAXIMUM OPERATING FREQUENCY vs COLLECTOR CURRENT (TYPICAL)

**Typical Performance Curves** (Continued)



**FIGURE 9. NORMALIZED SWITCHING WAVEFORMS AT CONSTANT GATE CURRENT (REFER TO APPLICATION NOTES AN7254 AND AN7260)**



**FIGURE 10. INDUCTIVE SWITCHING TEST CIRCUIT**

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| Bottomless <sup>TM</sup>          | FAST <sub>r</sub> <sup>TM</sup>  | POP <sup>TM</sup>                | SuperSOT <sup>TM</sup> -6 |
| CoolFET <sup>TM</sup>             | GlobalOptoisolator <sup>TM</sup> | PowerTrench <sup>®</sup>         | SuperSOT <sup>TM</sup> -8 |
| CROSSVOLT <sup>TM</sup>           | GTO <sup>TM</sup>                | QFET <sup>TM</sup>               | SyncFET <sup>TM</sup>     |
| DenseTrench <sup>TM</sup>         | HiSeC <sup>TM</sup>              | QS <sup>TM</sup>                 | TinyLogic <sup>TM</sup>   |
| DOMET <sup>TM</sup>               | ISOPLANAR <sup>TM</sup>          | QT Optoelectronics <sup>TM</sup> | UHC <sup>TM</sup>         |
| EcoSPARK <sup>TM</sup>            | LittleFET <sup>TM</sup>          | Quiet Series <sup>TM</sup>       | UltraFET <sup>®</sup>     |
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