



ON Semiconductor®

## ISL9V5036S3S / ISL9V5036P3 / ISL9V5036S3

### EcoSPARK® 500mJ, 360V, N-Channel Ignition IGBT

#### General Description

The ISL9V5036S3S, ISL9V5036P3, and ISL9V5036S3 are the next generation IGBTs that offer outstanding SCIS capability in the D<sup>2</sup>-Pak (TO-263) and TO-220 plastic package. These devices are intended for use in automotive ignition circuits, specifically as coil drivers. Internal diodes provide voltage clamping without the need for external components.

EcoSPARK® devices can be custom made to specific clamp voltages. Contact your nearest ON Semiconductor sales office for more information.

Formerly Developmental Type 49443

#### Applications

- Automotive Ignition Coil Driver Circuits
- Coil-On Plug Applications

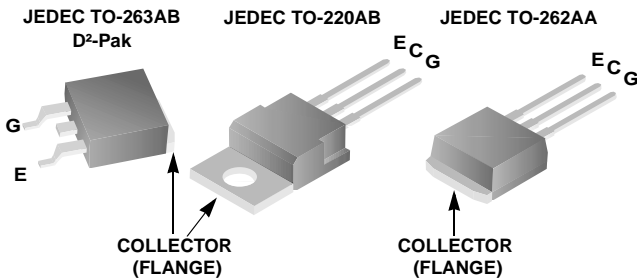
#### Features

- Industry Standard D<sup>2</sup>-Pak package
- SCIS Energy = 500mJ at T<sub>J</sub> = 25°C
- Logic Level Gate Drive
- Qualified to AEC Q101
- RoHS Compliant

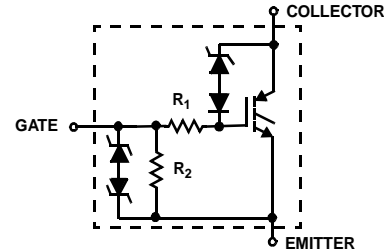


ISL9V5036S3S / ISL9V5036P3 / ISL9V5036S3

#### Package



#### Symbol



#### Device Maximum Ratings T<sub>A</sub> = 25°C unless otherwise noted

| Symbol               | Parameter   | Ratings    | Units |
|----------------------|---|------------|-------|
| BV <sub>CER</sub>    | Collector to Emitter Breakdown Voltage (I <sub>C</sub> = 1 mA)                    | 390        | V     |
| BV <sub>ECS</sub>    | Emitter to Collector Voltage - Reverse Battery Condition (I <sub>C</sub> = 10 mA) | 24         | V     |
| E <sub>SCIS25</sub>  | At Starting T <sub>J</sub> = 25°C, I <sub>SCIS</sub> = 38.5A, L = 670 μHy         | 500        | mJ    |
| E <sub>SCIS150</sub> | At Starting T <sub>J</sub> = 150°C, I <sub>SCIS</sub> = 30A, L = 670 μHy          | 300        | mJ    |
| I <sub>C25</sub>     | Collector Current Continuous, At T <sub>C</sub> = 25°C, See Fig 9                 | 46         | A     |
| I <sub>C110</sub>    | Collector Current Continuous, At T <sub>C</sub> = 110°C, See Fig 9                | 31         | A     |
| V <sub>GEM</sub>     | Gate to Emitter Voltage Continuous  | ±10        | V     |
| P <sub>D</sub>       | Power Dissipation Total T <sub>C</sub> = 25°C                                     | 250        | W     |
|                      | Power Dissipation Derating T <sub>C</sub> > 25°C                                  | 1.67       | W/°C  |
| T <sub>J</sub>       | Operating Junction Temperature Range  | -40 to 175 | °C    |
| T <sub>STG</sub>     | Storage Junction Temperature Range  | -40 to 175 | °C    |
| T <sub>L</sub>       | Max Lead Temp for Soldering (Leads at 1.6mm from Case for 10s)                    | 300        | °C    |
| T <sub>pkg</sub>     | Max Lead Temp for Soldering (Package Body for 10s)                                | 260        | °C    |
| ESD                  | Electrostatic Discharge Voltage at 100pF, 1500Ω                                   | 4          | kV    |

**Package Marking and Ordering Information**

| Device Marking | Device        | Package  | Reel Size | Tape Width | Quantity |
|----------------|---------------|----------|-----------|------------|----------|
| V5036S         | ISL9V5036S3ST | TO-263AB | 330mm     | 24mm       | 800      |
| V5036P         | ISL9V5036P3   | TO-220AA | Tube      | N/A        | 50       |
| V5036S         | ISL9V5036S3   | TO-262AA | Tube      | N/A        | 50       |
| V5036S         | ISL9V5036S3S  | TO-263AB | Tube      | N/A        | 50       |

**Electrical Characteristics**  $T_A = 25^\circ\text{C}$  unless otherwise noted

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Units |
|--------|-----------|-----------------|-----|-----|-----|-------|
|--------|-----------|-----------------|-----|-----|-----|-------|

**Off State Characteristics**

|            |  |  |                           |          |     |          |               |
|------------|--|--|---------------------------|----------|-----|----------|---------------|
| $BV_{CER}$ | Collector to Emitter Breakdown Voltage | $I_C = 2\text{mA}$ , $V_{GE} = 0$ ,<br>$R_G = 1\text{K}\Omega$ , See Fig. 15<br>$T_J = -40$ to $150^\circ\text{C}$ | 330                       | 360      | 390 | V        |               |
| $BV_{CES}$ | Collector to Emitter Breakdown Voltage | $I_C = 10\text{mA}$ , $V_{GE} = 0$ ,<br>$R_G = 0$ , See Fig. 15<br>$T_J = -40$ to $150^\circ\text{C}$              | 360                       | 390      | 420 | V        |               |
| $BV_{ECS}$ | Emitter to Collector Breakdown Voltage | $I_C = -75\text{mA}$ , $V_{GE} = 0\text{V}$ ,<br>$T_C = 25^\circ\text{C}$  | 30                        | -        | -   | V        |               |
| $BV_{GES}$ | Gate to Emitter Breakdown Voltage      | $I_{GES} = \pm 2\text{mA}$   | $\pm 12$                  | $\pm 14$ | -   | V        |               |
| $I_{CER}$  | Collector to Emitter Leakage Current   | $V_{CER} = 250\text{V}$ ,<br>$R_G = 1\text{K}\Omega$ ,<br>See Fig. 11  | $T_C = 25^\circ\text{C}$  | -        | -   | 25       | $\mu\text{A}$ |
|            |  |  | $T_C = 150^\circ\text{C}$ | -        | -   | 1        | mA            |
| $I_{ECS}$  | Emitter to Collector Leakage Current   | $V_{EC} = 24\text{V}$ , See<br>Fig. 11   | $T_C = 25^\circ\text{C}$  | -        | -   | 1        | mA            |
|            |  |  | $T_C = 150^\circ\text{C}$ | -        | -   | 40       | mA            |
| $R_1$      | Series Gate Resistance                 |  | -                         | 75       | -   | $\Omega$ |               |
| $R_2$      | Gate to Emitter Resistance             |  | 10K                       | -        | 30K | $\Omega$ |               |

**On State Characteristics**

|               |   |  |  |   |      |      |   |
|---------------|---|--|--|---|------|------|---|
| $V_{CE(SAT)}$ | Collector to Emitter Saturation Voltage | $I_C = 10\text{A}$ ,<br>$V_{GE} = 4.0\text{V}$ | $T_C = 25^\circ\text{C}$ ,<br>See Fig. 4 | - | 1.17 | 1.60 | V |
| $V_{CE(SAT)}$ | Collector to Emitter Saturation Voltage | $I_C = 15\text{A}$ ,<br>$V_{GE} = 4.5\text{V}$ | $T_C = 150^\circ\text{C}$                | - | 1.50 | 1.80 | V |

**Dynamic Characteristics**

|              |                                   |  |                           |      |   |     |   |
|--------------|-----------------------------------|--|---------------------------|------|---|-----|---|
| $Q_{G(ON)}$  | Gate Charge                       | $I_C = 10\text{A}$ , $V_{CE} = 12\text{V}$ ,<br>$V_{GE} = 5\text{V}$ , See Fig. 14 | -                         | 32   | - | nC  |   |
| $V_{GE(TH)}$ | Gate to Emitter Threshold Voltage | $I_C = 1.0\text{mA}$ ,<br>$V_{CE} = V_{GE}$ ,<br>See Fig. 10                       | $T_C = 25^\circ\text{C}$  | 1.3  | - | 2.2 | V |
|              |                                   |  | $T_C = 150^\circ\text{C}$ | 0.75 | - | 1.8 | V |
| $V_{GEP}$    | Gate to Emitter Plateau Voltage   | $I_C = 10\text{A}$ , $V_{CE} = 12\text{V}$   | -                         | 3.0  | - | V   |   |

**Switching Characteristics**

|               |                                       |   |   |      |     |               |
|---------------|---------------------------------------|---|---|------|-----|---------------|
| $t_{d(ON)R}$  | Current Turn-On Delay Time-Resistive  | $V_{CE} = 14\text{V}$ , $R_L = 1\Omega$ ,<br>$V_{GE} = 5\text{V}$ , $R_G = 1\text{K}\Omega$ ,<br>$T_J = 25^\circ\text{C}$ , See Fig. 12   | - | 0.7  | 4   | $\mu\text{s}$ |
| $t_{rR}$      | Current Rise Time-Resistive           |   | - | 2.1  | 7   | $\mu\text{s}$ |
| $t_{d(OFF)L}$ | Current Turn-Off Delay Time-Inductive | $V_{CE} = 300\text{V}$ , $L = 2\text{mH}$ ,<br>$V_{GE} = 5\text{V}$ , $R_G = 1\text{K}\Omega$ ,<br>$T_J = 25^\circ\text{C}$ , See Fig. 12 | - | 10.8 | 15  | $\mu\text{s}$ |
| $t_{fL}$      | Current Fall Time-Inductive           |   | - | 2.8  | 15  | $\mu\text{s}$ |
| SCIS          | Self Clamped Inductive Switching      | $T_J = 25^\circ\text{C}$ , $L = 670\mu\text{H}$ ,<br>$R_G = 1\text{K}\Omega$ , $V_{GE} = 5\text{V}$ , See<br>Fig. 1 & 2                   | - | -    | 500 | mJ            |

**Thermal Characteristics**

|                 |                                  |                        |   |   |     |                    |
|-----------------|----------------------------------|------------------------|---|---|-----|--------------------|
| $R_{\theta JC}$ | Thermal Resistance Junction-Case | TO-263, TO-220, TO-262 | - | - | 0.6 | $^\circ\text{C/W}$ |
|-----------------|----------------------------------|------------------------|---|---|-----|--------------------|

Typical Characteristics

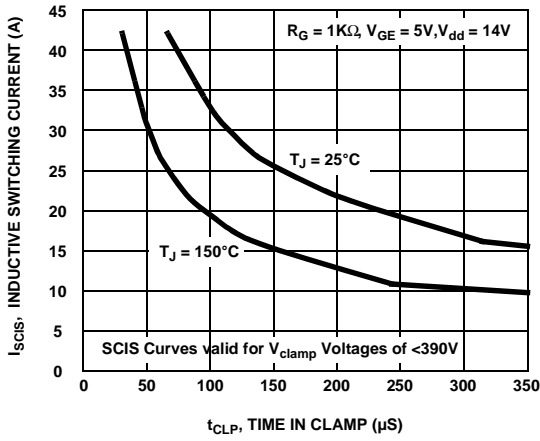


Figure 1. Self Clamped Inductive Switching Current vs Time in Clamp

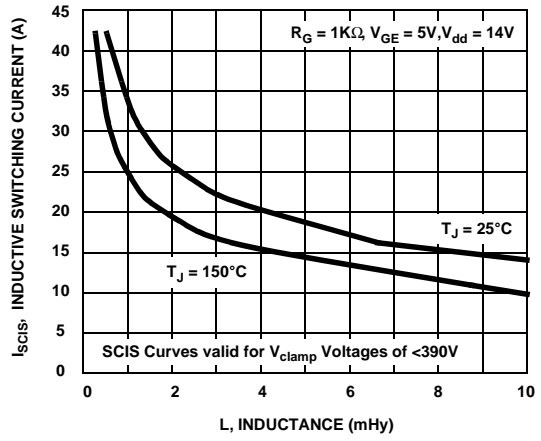


Figure 2. Self Clamped Inductive Switching Current vs Inductance

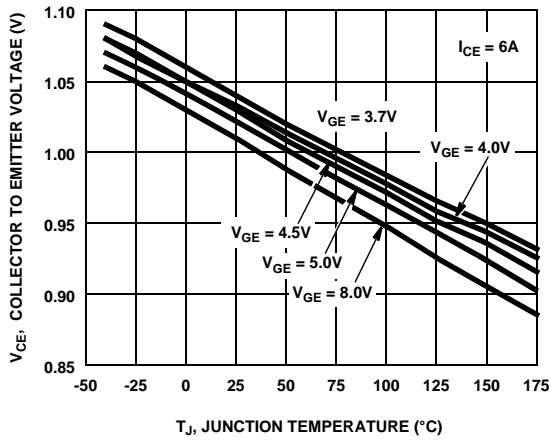


Figure 3. Collector to Emitter On-State Voltage vs Junction Temperature

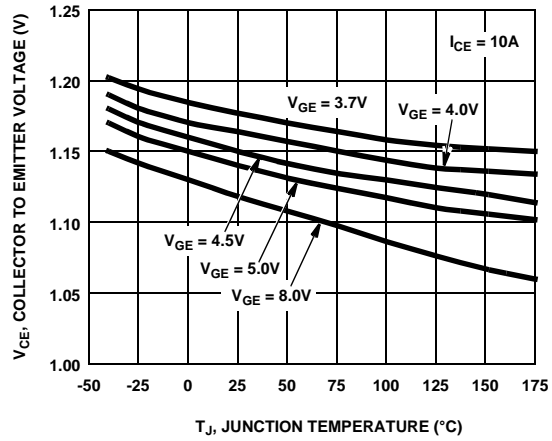


Figure 4. Collector to Emitter On-State Voltage vs Junction Temperature

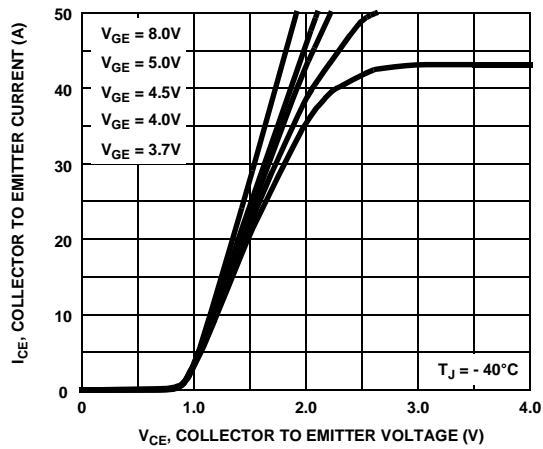


Figure 5. Collector Current vs Collector to Emitter On-State Voltage

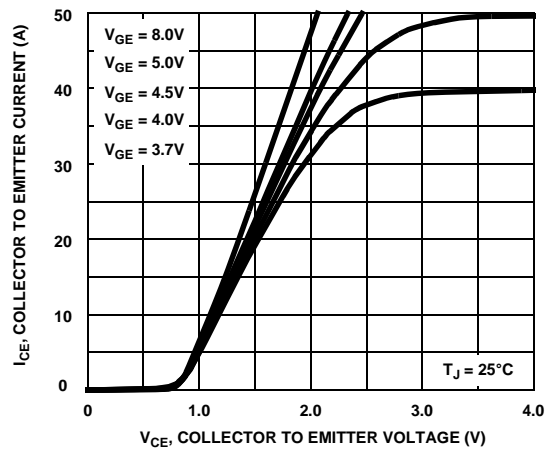


Figure 6. Collector Current vs Collector to Emitter On-State Voltage

Typical Characteristics (Continued)

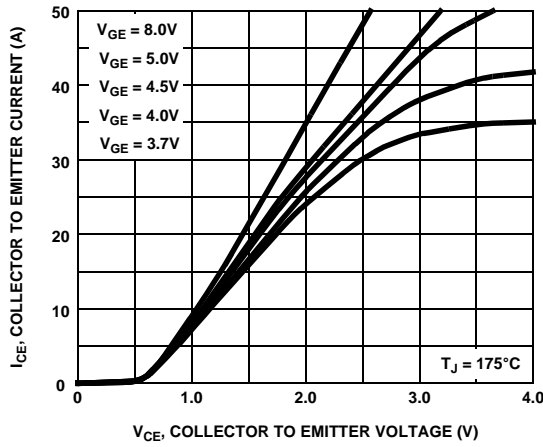


Figure 7. Collector to Emitter On-State Voltage vs Collector Current

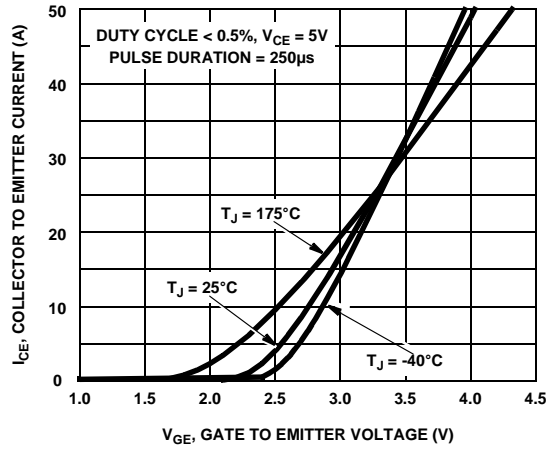


Figure 8. Transfer Characteristics

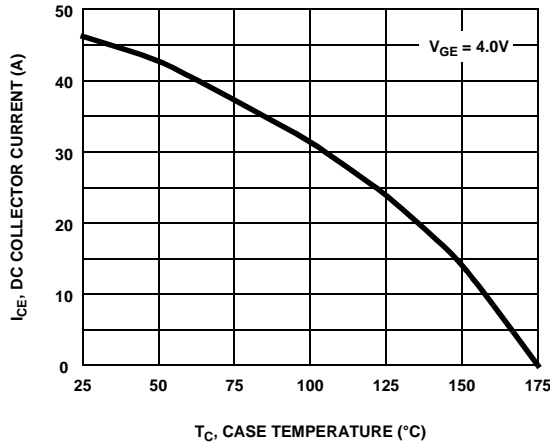


Figure 9. DC Collector Current vs Case Temperature

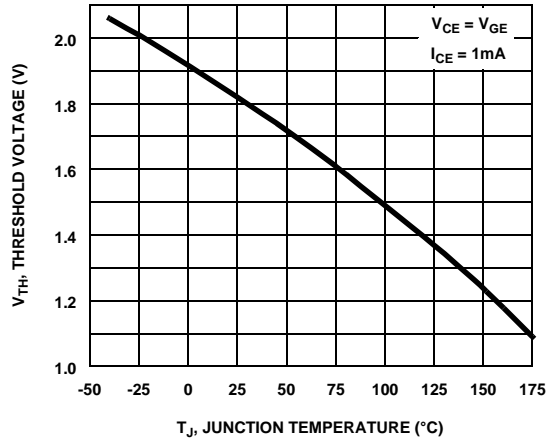


Figure 10. Threshold Voltage vs Junction Temperature

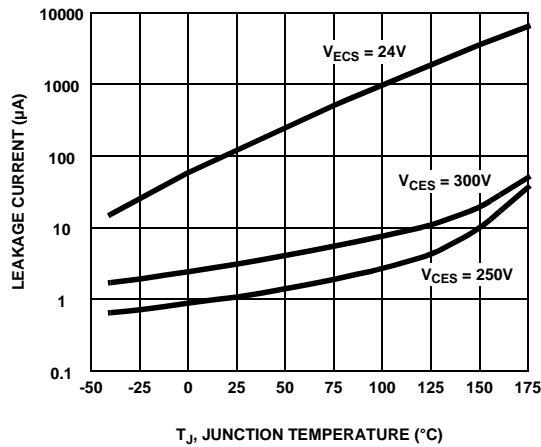


Figure 11. Leakage Current vs Junction Temperature

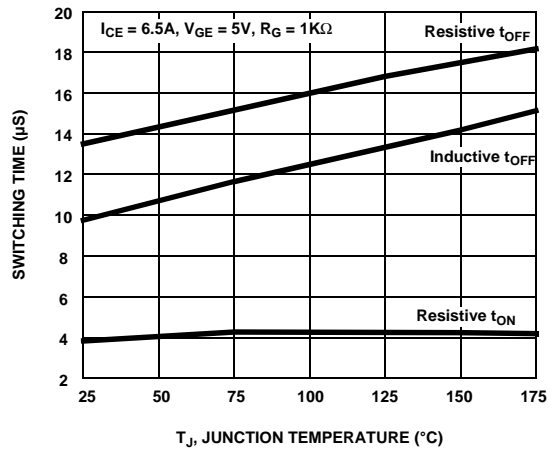
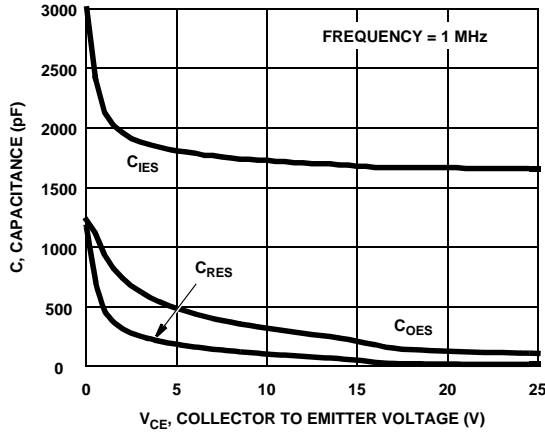
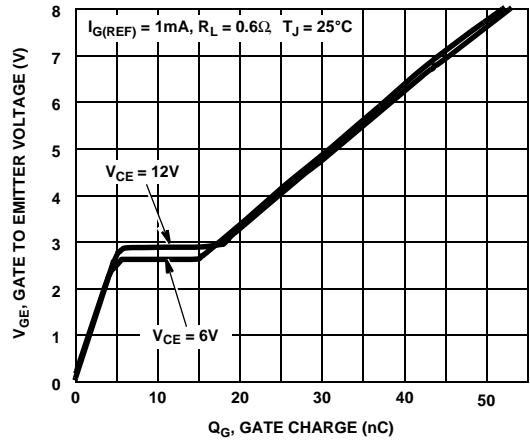


Figure 12. Switching Time vs Junction Temperature

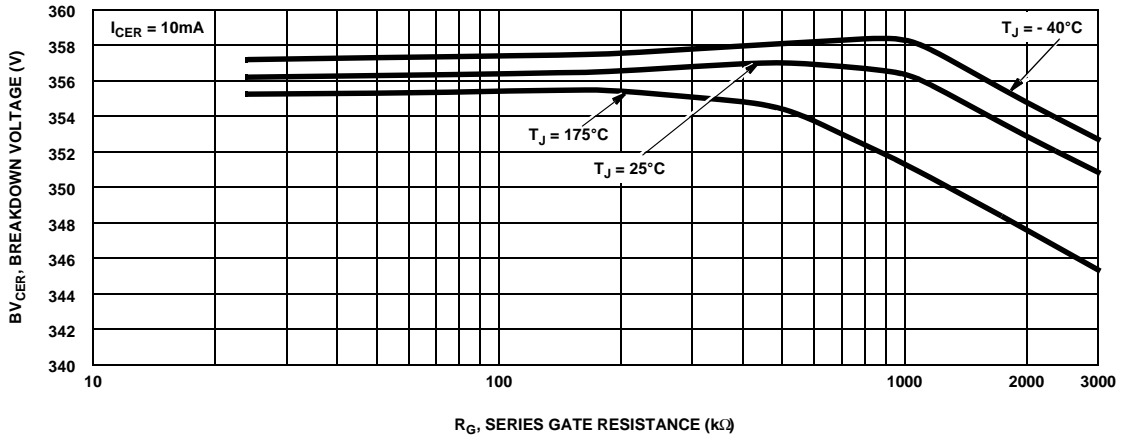
**Typical Characteristics** (Continued)



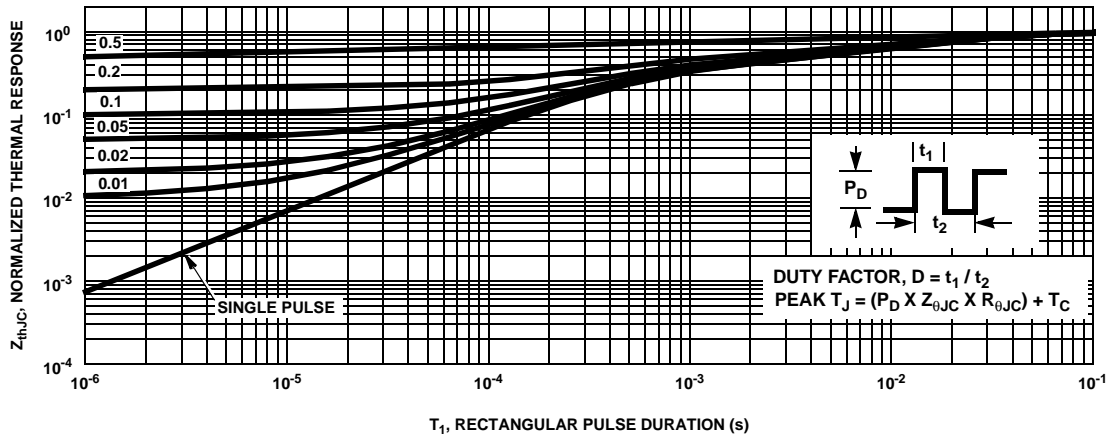
**Figure 13. Capacitance vs Collector to Emitter Voltage**



**Figure 14. Gate Charge**



**Figure 15. Breakdown Voltage vs Series Gate Resistance**



**Figure 16. IGBT Normalized Transient Thermal Impedance, Junction to Case**

Test Circuits and Waveforms

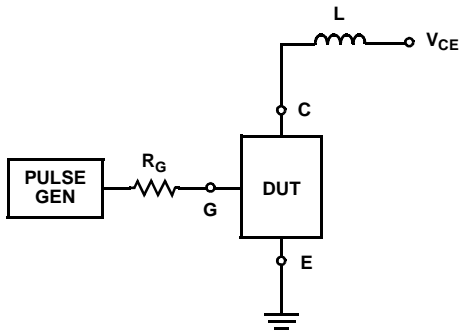


Figure 17. Inductive Switching Test Circuit

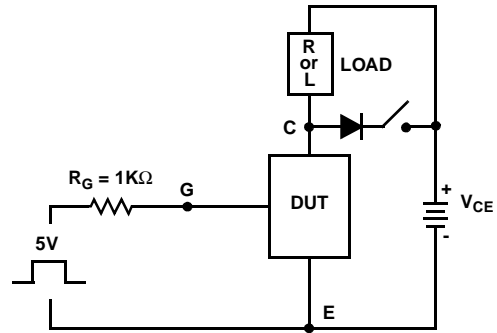


Figure 18.  $t_{ON}$  and  $t_{OFF}$  Switching Test Circuit

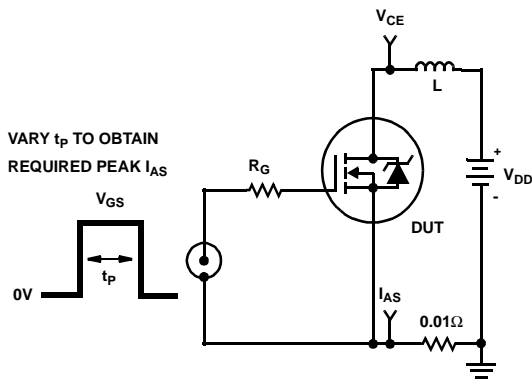


Figure 19. Energy Test Circuit

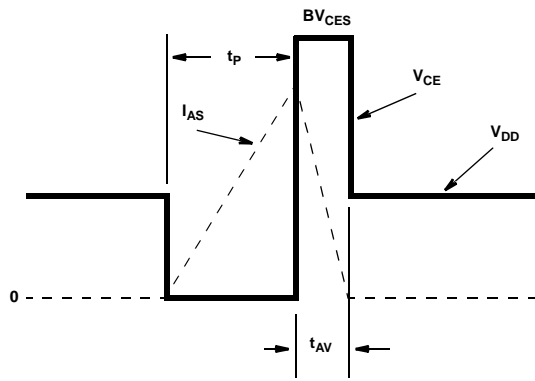


Figure 20. Energy Waveforms

**SPICE Thermal Model**

REV 1 May 2002

ISL9V5036S3S / ISL9V3536P3 / ISL9V5036S3

CTHERM1 th 6 4.0e2  
 CTHERM2 6 5 3.6e-3  
 CTHERM3 5 4 4.9e-2  
 CTHERM4 4 3 3.2e-1  
 CTHERM5 3 2 3.0e-1  
 CTHERM6 2 tl 1.6e-2

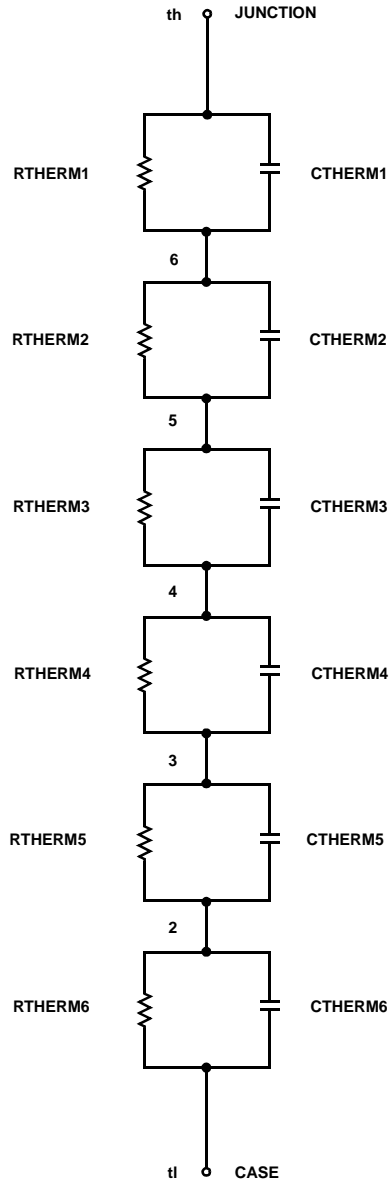
RTHERM1 th 6 1.0e-2  
 RTHERM2 6 5 1.4e-1  
 RTHERM3 5 4 1.0e-1  
 RTHERM4 4 3 9.0e-2  
 RTHERM5 3 2 9.4e-2  
 RTHERM6 2 tl 1.9e-2

**SABER Thermal Model**

SABER thermal model  
 ISL9V5036S3S / ISL9V5036P3 / ISL9V5036S3  
 template thermal\_model th tl  
 thermal\_c th, tl

```
{
ctherm.ctherm1 th 6 = 4.0e2
ctherm.ctherm2 6 5 = 3.6e-3
ctherm.ctherm3 5 4 = 4.9e-2
ctherm.ctherm4 4 3 = 3.2e-1
ctherm.ctherm5 3 2 = 3.0e-1
ctherm.ctherm6 2 tl = 1.6e-2
```

```
rtherm.rtherm1 th 6 = 1.0e-2
rtherm.rtherm2 6 5 = 1.4e-1
rtherm.rtherm3 5 4 = 1.0e-1
rtherm.rtherm4 4 3 = 9.0e-2
rtherm.rtherm5 3 2 = 9.4e-2
rtherm.rtherm6 2 tl = 1.9e-2
}
```



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