

# STK544UC63K-E

## Intelligent Power Module (IPM), 600 V, 10 A

The STK544UC63K-E is a fully-integrated inverter power stage consisting of a high-voltage driver, six IGBT's and a thermistor, suitable for driving permanent magnet synchronous (PMSM) motors, brushless-DC (BLDC) motors and AC asynchronous motors. The IGBT's are configured in a 3-phase bridge with separate emitter connections for the lower legs for maximum flexibility in the choice of control algorithm. The power stage has a full range of protection functions including cross-conduction protection, external shutdown and under-voltage lockout functions. An internal comparator and reference connected to the over-current protection circuit allows the designer to set the over-current protection level.

### Features

- Three-phase 10 A/600 V IGBT Module with Integrated Drivers
- Built-in Under Voltage Protection
- Cross-conduction Protection
- ITRIP Input to Shut Down All IGBTs
- Integrated Bootstrap Diodes and Resistors
- Thermistor for Substrate Temperature Measurement
- UL1557 Certification (File Number: E339285)
- These Devices are Pb-Free and are RoHS Compliant

### Typical Applications

- Industrial Drives
- Industrial Pumps
- Industrial Fans
- Industrial Automation

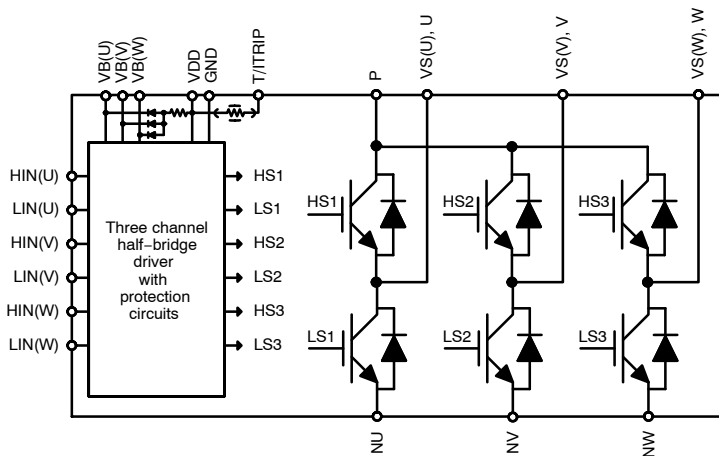
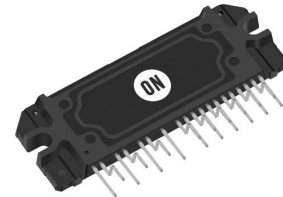


Figure 1. Functional Diagram



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SIP23 62x21.8  
CASE 127FC

### MARKING DIAGRAM



STK544UC63K = Specific Device Code  
ZZZ = Assembly Lot Code  
A = Assembly Location  
T = Test Location  
Y = Year  
WW = Work Week

Device marking is on package top side

### ORDERING INFORMATION

| Device        | Package                           | Shipping (Qty/Packing) |
|---------------|-----------------------------------|------------------------|
| STK544UC63K-E | SIP23<br>62x21.8FP-4<br>(Pb-Free) | 80/Box                 |

# STK544UC63K-E

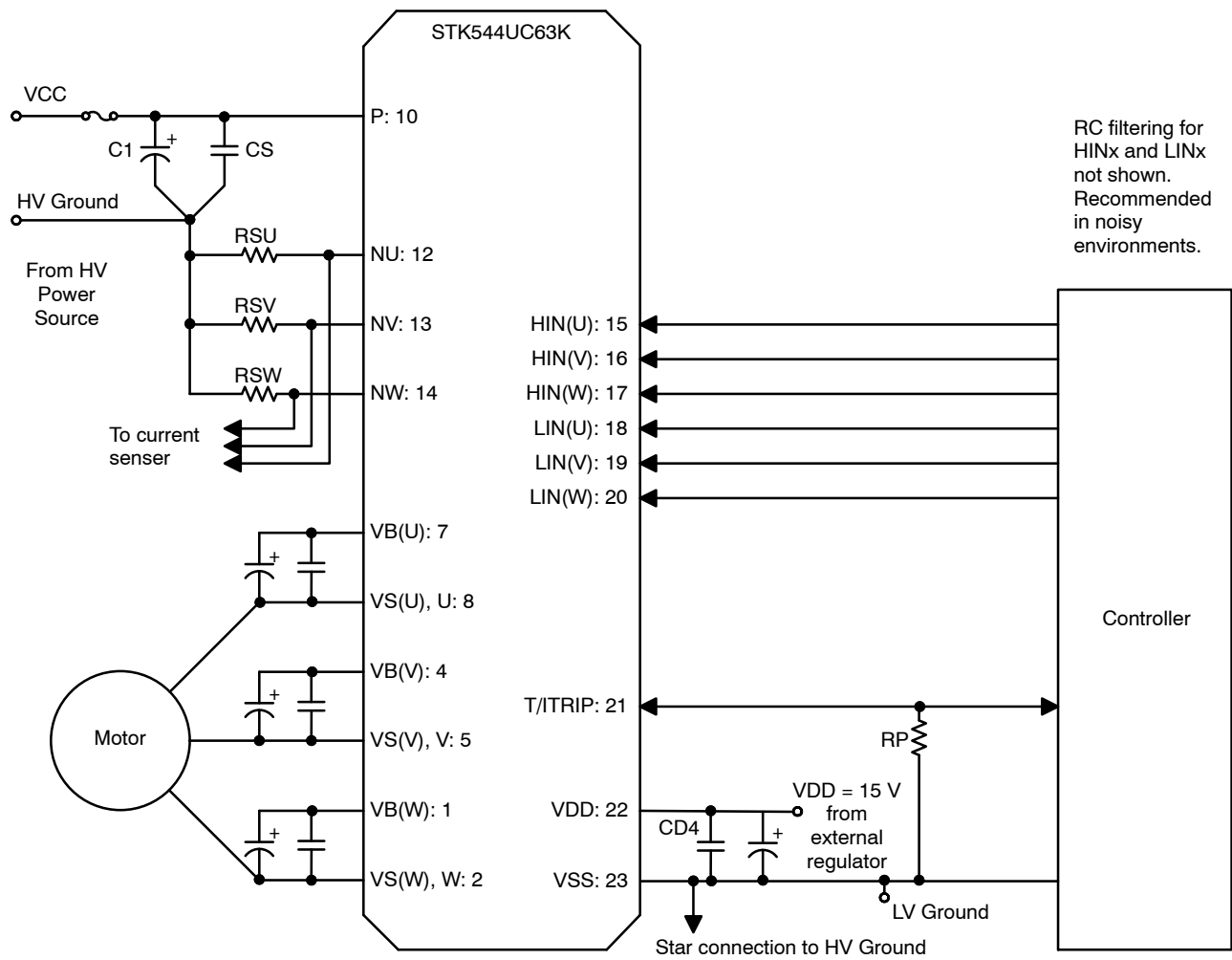


Figure 2. Application Schematic

# STK544UC63K-E

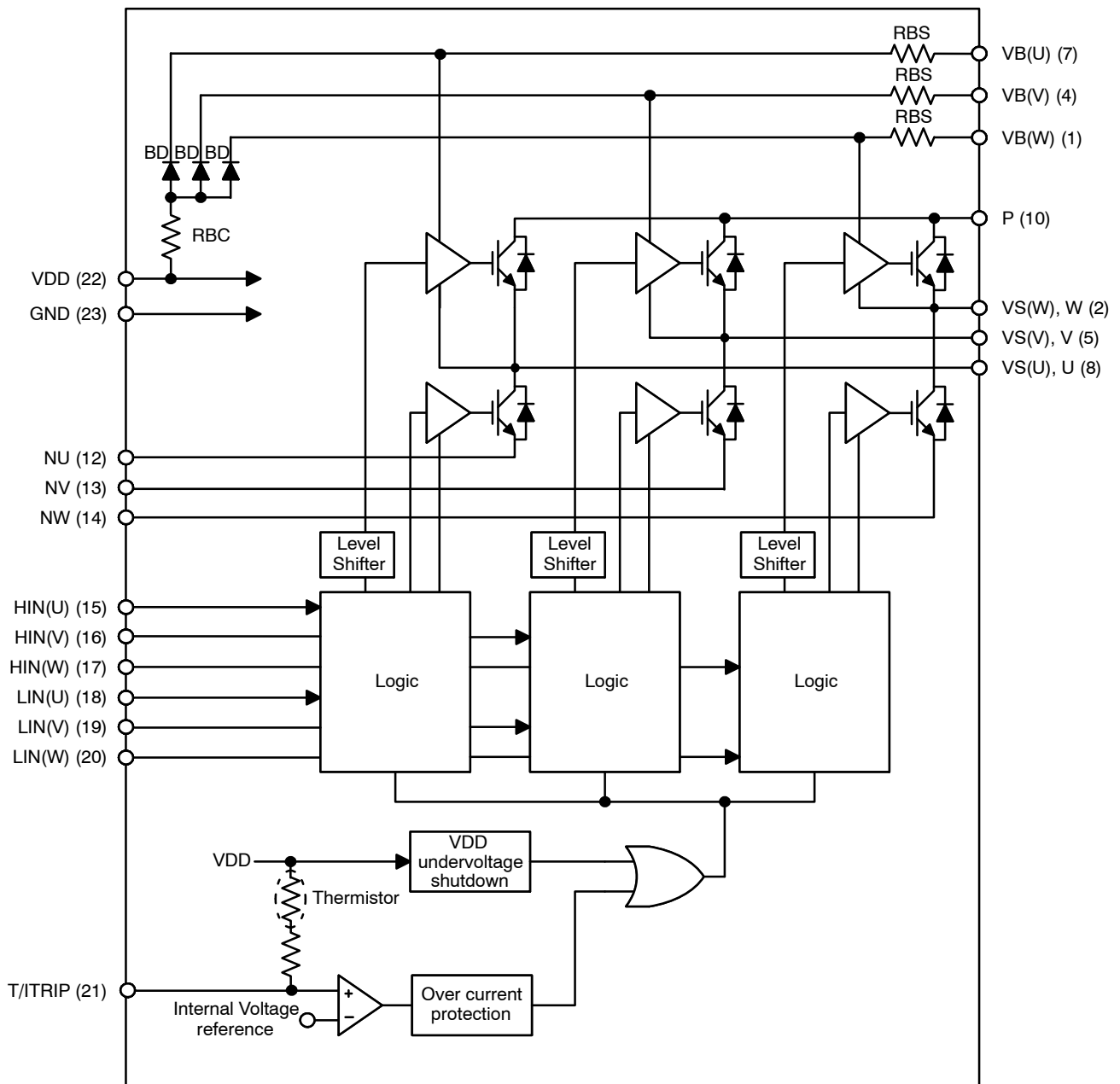


Figure 3. Simplified Block Diagram

# STK544UC63K-E

## PIN DESCRIPTION

| Pin No. | Name     | Description                                                             |
|---------|----------|-------------------------------------------------------------------------|
| 1       | VB(W)    | High Side Floating Supply Voltage for W phase                           |
| 2       | VS(W), W | Internally connected to W phase high side driver ground. W phase output |
| 4       | VB(V)    | High Side Floating Supply voltage for V phase                           |
| 5       | VS(V), V | Internally connected to V phase high side driver ground. V phase output |
| 7       | VB(U)    | High Side Floating Supply voltage for U phase                           |
| 8       | VS(U), U | Internally connected to U phase high side driver ground. U phase output |
| 10      | P        | Positive Bus Input Voltage                                              |
| 12      | NU       | Low Side Emitter Connection – Phase U                                   |
| 13      | NV       | Low Side Emitter Connection – Phase V                                   |
| 14      | NW       | Low Side Emitter Connection – Phase W                                   |
| 15      | HIN(U)   | Logic Input High Side Gate Driver – Phase U                             |
| 16      | HIN(V)   | Logic Input High Side Gate Driver – Phase V                             |
| 17      | HIN(W)   | Logic Input High Side Gate Driver – Phase W                             |
| 18      | LIN(U)   | Logic Input Low Side Gate Driver – Phase U                              |
| 19      | LIN(V)   | Logic Input Low Side Gate Driver – Phase V                              |
| 20      | LIN(W)   | Logic Input Low Side Gate Driver – Phase W                              |
| 21      | T/ITRIP  | Temperature Monitor and Shut-down pin                                   |
| 22      | VDD      | +15 V Main Supply                                                       |
| 23      | VSS      | Negative Main Supply                                                    |

1. Pins 3, 6, 9 and 11 are not present

## ABSOLUTE MAXIMUM RATINGS (at Tc = 25°C) (Note 2)

| Symbol             | Rating                     | Conditions                                                          | Value         | Unit |
|--------------------|----------------------------|---------------------------------------------------------------------|---------------|------|
| V <sub>CC</sub>    | Supply voltage             | P to NU, NV, NW, surge < 500 V (Note 3)                             | 450           | V    |
| V <sub>CE</sub>    | Collector-emitter voltage  | P to U, V, W; U to NU; V to NV; W to NW                             | 600           | V    |
| I <sub>o</sub>     | Output current             | P, U, V, W, NU, NV, NW terminal current                             | ±10           | A    |
|                    |                            | P, U, V, W, NU, NV, NW terminal current, Tc = 100°C                 | ±5            | A    |
| I <sub>op</sub>    | Output peak current        | P, U, V, W, NU, NV, NW terminal current, pulse width 1 ms           | ±20           | A    |
| P <sub>d</sub>     | Maximum power dissipation  | IGBT per 1 channel                                                  | 20            | W    |
| V <sub>BS</sub>    | Gate driver supply voltage | VB(U) to VS(U), VB(V) to VS(V), VB(W) to VS(W), VDD to VSS (Note 4) | -0.3 to +20.0 | V    |
| V <sub>IN</sub>    | Input signal voltage       | HIN(U), HIN(V), HIN(W), LIN(U), LIN(V), LIN(W)                      | -0.3 to +7.0  | V    |
| V <sub>ITRIP</sub> | ITRIP terminal voltage     | T/ITRIP terminal                                                    | VSS to +5.0   | V    |
| T <sub>j</sub>     | Junction temperature       | IGBT, FRD                                                           | 150           | °C   |
| T <sub>stg</sub>   | Storage temperature        |                                                                     | -40 to +125   | °C   |
| T <sub>c</sub>     | Operating case temperature | IPM case temperature                                                | -40 to +100   | °C   |
| MT                 | Tightening torque          | Case mounting screws                                                | 0.9           | Nm   |
| Vis                | Isolation voltage          | 50 Hz sine wave AC 1 minute (Note 5)                                | 2000          | Vrms |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

- Refer to ELECTRICAL CHARACTERISTICS, RECOMMENDED OPERATING RANGES and/or APPLICATION INFORMATION for Safe Operating parameters.
- This surge voltage developed by the switching operation due to the wiring inductance between P and NU, NV, NW terminal.
- VBS = VB(U) to VS(U), VB(V) to VS(V), VB(W) to VS(W).
- Test conditions: AC2500V, 1 s.

# STK544UC63K-E

## RECOMMENDED OPERATING CONDITIONS

| Symbol               | Rating                      | Conditions                                        | Min  | Typ | Max  | Unit |
|----------------------|-----------------------------|---------------------------------------------------|------|-----|------|------|
| V <sub>CC</sub>      | Supply voltage              | P to NU, NV, NW                                   | 0    | 280 | 450  | V    |
| V <sub>BS</sub>      | Gate driver supply voltage  | VB(U) to VS(U), VB(V) to VS(V),<br>VB(W) to VS(W) | 13.0 | 15  | 17.5 | V    |
| V <sub>DD</sub>      |                             | VDD to VSS                                        | 14.0 | 15  | 16.5 | V    |
| V <sub>IN(ON)</sub>  | ON-state input voltage      | HIN(U), HIN(V), HIN(W), LIN(U),<br>LIN(V), LIN(W) | 0    | –   | 0.3  | V    |
| V <sub>IN(OFF)</sub> | OFF-state input voltage     |                                                   | 3.0  | –   | 5.0  | V    |
| f <sub>PWM</sub>     | PWM frequency               |                                                   | 1    | –   | 20   | kHz  |
| DT                   | Dead time                   | Turn-off to Turn-on (external)                    | 0.5  | –   | –    | μs   |
| PWIN                 | Allowable input pulse width | ON and OFF                                        | 1    | –   | –    | μs   |
|                      | Tightening torque           | 'M3' type screw                                   | 0.6  | –   | 0.9  | Nm   |

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

## ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C, V<sub>BIAS</sub> (V<sub>BS</sub>, V<sub>DD</sub>) = 15 V unless otherwise noted)

| Symbol | Parameter | Test Condition | Min | Typ | Max | Unit |
|--------|-----------|----------------|-----|-----|-----|------|
|--------|-----------|----------------|-----|-----|-----|------|

### POWER OUTPUT SECTION

|                      |                                         |                                              |   |     |      |      |
|----------------------|-----------------------------------------|----------------------------------------------|---|-----|------|------|
| I <sub>CE</sub>      | Collector-emitter leakage current       | V <sub>CE</sub> = 600 V                      | – | –   | 0.1  | mA   |
| I <sub>R(BD)</sub>   | Bootstrap diode reverse current         | V <sub>R(DB)</sub> = 600 V                   | – | –   | 0.1  | mA   |
| V <sub>CE(SAT)</sub> | Collector to emitter saturation voltage | I <sub>C</sub> = 10 A, T <sub>j</sub> = 25°C | – | 2.1 | 2.7  | V    |
|                      |                                         | I <sub>C</sub> = 5 A, T <sub>j</sub> = 100°C | – | 1.7 | –    | V    |
| V <sub>F</sub>       | Diode forward voltage                   | I <sub>F</sub> = 10 A, T <sub>j</sub> = 25°C | – | 2.2 | 2.8  | V    |
|                      |                                         | I <sub>F</sub> = 5 A, T <sub>j</sub> = 100°C | – | 1.7 | –    | V    |
| V <sub>F(BD)</sub>   | Bootstrap diode forward voltage         | I <sub>F</sub> = 0.1 A                       | – | 2.0 | –    | V    |
| R <sub>BC</sub>      | Bootstrap circuit resistance            | Resistor value for common boot charge line   | – | 2   | –    | Ω    |
| R <sub>BS</sub>      |                                         | Resistor value for separate boot charge line | – | 10  | –    | Ω    |
| θ <sub>j-c(T)</sub>  | Junction to case thermal resistance     | IGBT                                         | – | 4.9 | 6.2  | °C/W |
| θ <sub>j-c(D)</sub>  |                                         | FRD                                          | – | 8.5 | 10.6 | °C/W |

### DRIVER SECTION

|                                          |                                                                                        |                                                          |      |      |      |    |
|------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------|------|------|------|----|
| ID                                       | Gate driver consumption current                                                        | V <sub>BS</sub> = 15 V (Note 6), per driver              | –    | 0.08 | 0.4  | mA |
| ID                                       |                                                                                        | V <sub>DD</sub> = 15 V, total                            | –    | 2.0  | 4.0  | mA |
| V <sub>IN H</sub>                        | High level Input voltage                                                               | HIN(U), HIN(V), HIN(W), LIN(U), LIN(V),<br>LIN(W) to VSS | 2.5  | –    | –    | V  |
| V <sub>IN L</sub>                        | Low level Input voltage                                                                |                                                          | –    | –    | 0.8  | V  |
| I <sub>IN+</sub>                         | Logic 0 input leakage current                                                          |                                                          | 76   | 118  | 160  | μA |
| I <sub>IN–</sub>                         | Logic 1 input leakage current                                                          |                                                          | 97   | 150  | 203  | μA |
| V <sub>ITRIP</sub>                       | ITRIP threshold voltage                                                                | T/ITRIP to VSS                                           | 3.67 | 4.17 | 4.67 | V  |
| t <sub>ITRIP</sub>                       | ITRIP to shutdown propagation delay                                                    |                                                          | 0.8  | 1.1  | 1.4  | μs |
| t <sub>ITRIPBL</sub>                     | ITRIP blanking time                                                                    |                                                          | –    | 0.9  | –    | μs |
| FLTCLR                                   | FAULT clearance delay time                                                             | Automatic reset after protection                         | 6    | 9    | 12   | ms |
| DT                                       | Dead time (Internal dead time injected by driver)                                      |                                                          | 220  | 300  | 380  | μs |
| V <sub>CCUV+</sub><br>V <sub>BSUV+</sub> | V <sub>DD</sub> and V <sub>BS</sub> supply undervoltage positive going input threshold |                                                          | 10.5 | 11.1 | 11.7 | V  |
| V <sub>CCUV–</sub><br>V <sub>BSUV–</sub> | V <sub>DD</sub> and V <sub>BS</sub> supply undervoltage negative going input threshold |                                                          | 10.3 | 10.9 | 11.5 | V  |

# STK544UC63K-E

## ELECTRICAL CHARACTERISTICS (Tc = 25°C, VBIAS (VBS, VDD) = 15 V unless otherwise noted)

| Symbol           | Parameter                                          | Test Condition | Min  | Typ | Max | Unit |
|------------------|----------------------------------------------------|----------------|------|-----|-----|------|
| VCCUVH<br>VBSUVH | VDD and VBS supply undervoltage lockout hysteresis |                | 0.14 | 0.2 | –   | V    |

## SWITCHING CHARACTER

|       |                                   |                         |             |      |     |    |
|-------|-----------------------------------|-------------------------|-------------|------|-----|----|
| tON   | Switching time                    | IC = 10 A, Tj = 25°C    | –           | 0.35 | 0.7 | μs |
| tOFF  |                                   |                         | –           | 0.45 | 0.8 | μs |
| EON   | Turn-on switching loss            | IC = 5 A, Tj = 25°C     | –           | 89   | –   | μJ |
| EOFF  | Turn-off switching loss           |                         | –           | 74   | –   | μJ |
| ETOT  | Total switching loss              |                         | –           | 163  | –   | μJ |
| EON   | Turn-on switching loss            | IC = 5 A, Tj = 100°C    | –           | 125  | –   | μJ |
| EOFF  | Turn-off switching loss           |                         | –           | 82   | –   | μJ |
| ETOT  | Total switching loss              |                         | –           | 207  | –   | μJ |
| EREC  | Diode reverse recovery energy     | IC = 5 A, Tj = 100°C    | –           | 40   | –   | μJ |
| tRR   | Diode reverse recovery time       |                         | –           | 150  | –   | ns |
| RBSOA | Reverse bias safe operating area  | IC = 20 A, VCE = 450 V  | Full Square |      |     |    |
| SCSOA | Short circuit safe operating area | VCE = 400 V, Tj = 150°C | 5           | –    | –   | μs |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

6. VBS = VBU to U, VBV to V, VBW to W

TYPICAL CHARACTERISTICS INV SECTION

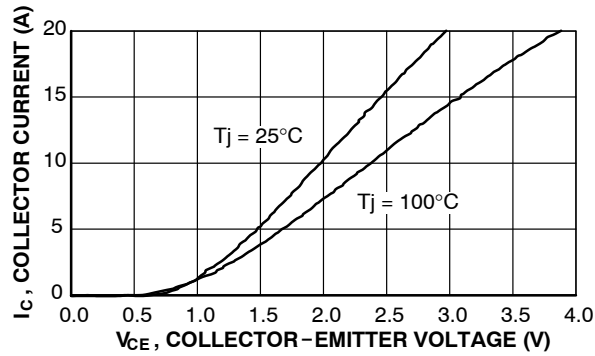


Figure 4.  $V_{CE}$  versus  $I_C$  for Different Temperatures ( $V_{DD} = 15\text{ V}$ )

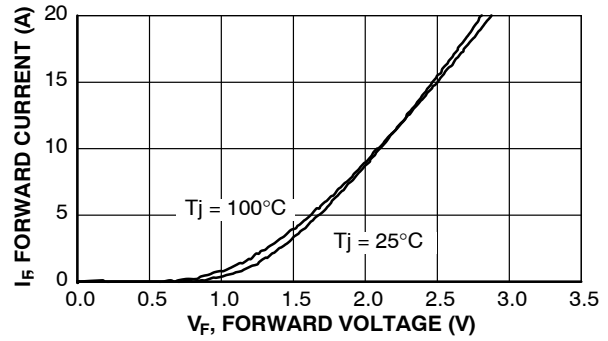


Figure 5.  $V_F$  versus  $I_F$  for Different Temperatures

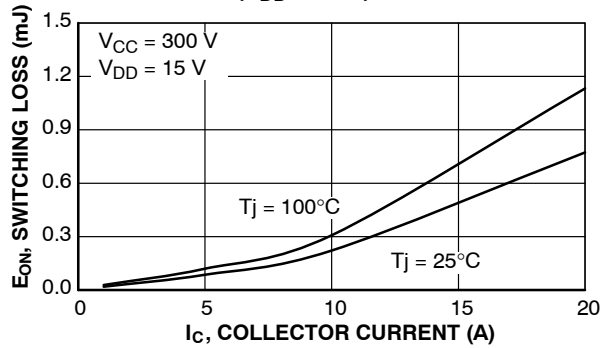


Figure 6.  $E_{ON}$  versus  $I_C$  for Different Temperatures

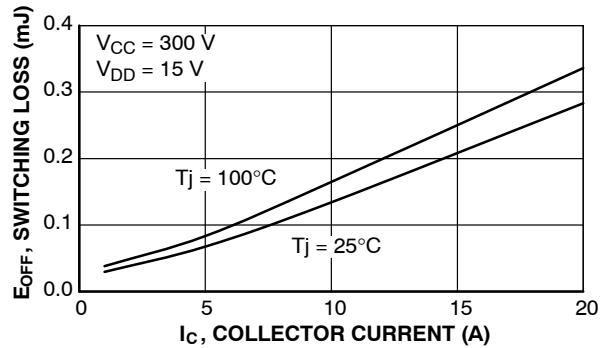


Figure 7.  $E_{OFF}$  versus  $I_C$  for Different Temperatures

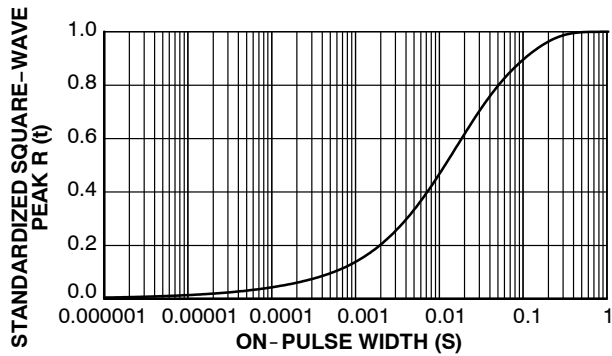


Figure 8. Thermal Impedance Plot

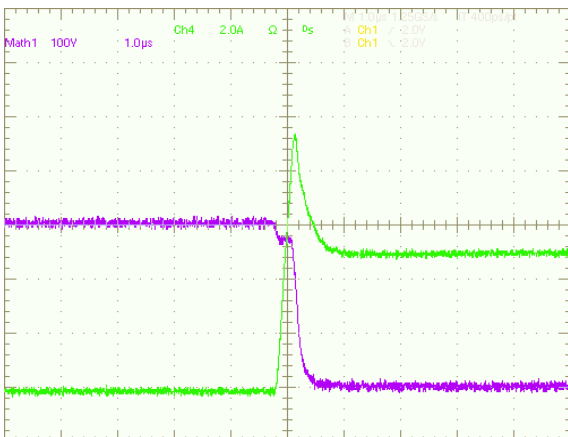


Figure 9. Turn-on Waveform  $T_j = 100^\circ\text{C}$ ,  $V_{CC} = 300\text{ V}$

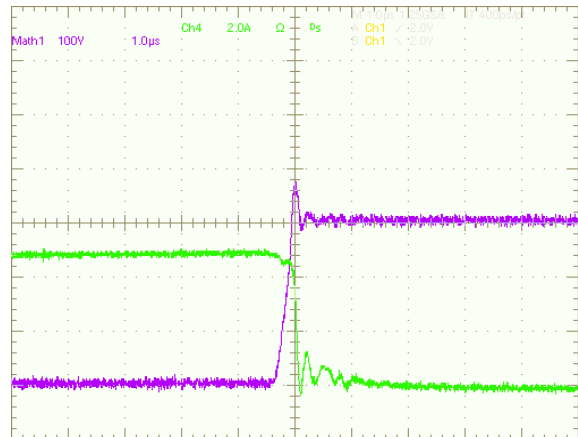
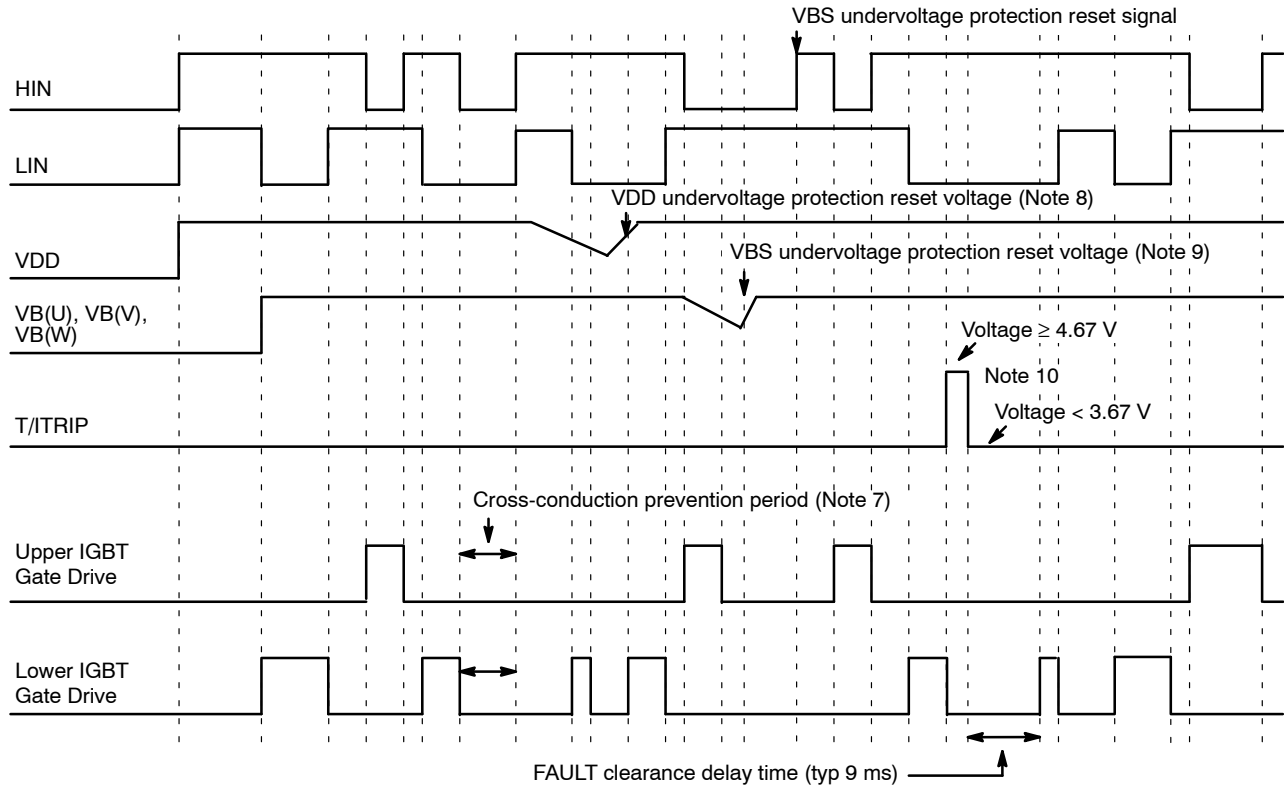


Figure 10. Turn-off Waveform  $T_j = 100^\circ\text{C}$ ,  $V_{CC} = 300\text{ V}$

# APPLICATIONS INFORMATION

## Input/Output Timing Chart



**Figure 11. Input/Output Timing Chart**

### NOTES:

7. This section of the timing diagram shows the effect of cross-conduction prevention.
8. This section of the timing diagram shows that when the voltage on  $V_{DD}$  decreases sufficiently all gate output signals will go low, switching off all six IGBTs. When the voltage on  $V_{DD}$  rises sufficiently, normal operation will resume.
9. This section shows that when the bootstrap voltage on  $VB(U)$  ( $VB(V)$ ,  $VB(W)$ ) drops, the corresponding high side output  $U$  ( $V$ ,  $W$ ) is switched off. When the voltage on  $VB(U)$  ( $VB(V)$ ,  $VB(W)$ ) rises sufficiently, normal operation will resume.
10. This section shows that when the voltage on  $ITRIP$  exceeds the threshold, all IGBT's are turned off. Normal operation resumes later after the over-current condition is removed.

## Input/Output Logic Table

**Table 1. INPUT/OUTPUT LOGIC TABLE**

| INPUT |     |         | OUTPUT         |               |                |
|-------|-----|---------|----------------|---------------|----------------|
| HIN   | LIN | T/ITRIP | High Side IGBT | Low Side IGBT | U, V, W        |
| L     | H   | L       | ON             | OFF           | P              |
| H     | L   | L       | OFF            | ON            | NU, NV, NW     |
| H     | H   | L       | OFF            | OFF           | High Impedance |
| L     | L   | L       | OFF            | OFF           | High Impedance |
| X     | X   | H       | OFF            | OFF           | High Impedance |

# Thermistor Characteristics

Table 2. THERMISTOR CHARACTERISTICS

| Symbol           | Parameter               | Condition               | Min   | Typ  | Max  | Unit |
|------------------|-------------------------|-------------------------|-------|------|------|------|
| R <sub>25</sub>  | Resistance              | T <sub>th</sub> = 25°C  | 99    | 100  | 101  | kΩ   |
| R <sub>125</sub> |                         | T <sub>th</sub> = 125°C | 2.40  | 2.52 | 2.65 | kΩ   |
| B                | B-Constant (25 to 50°C) |                         | -4207 | 4250 | 4293 | K    |
|                  | Temperature Range       |                         | -40   | -    | +125 | °C   |

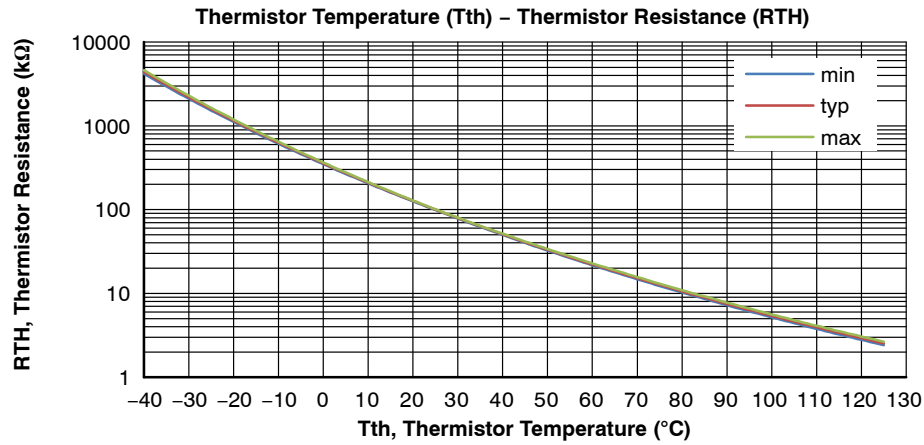


Figure 12. Thermistor Resistance versus Thermistor Temperature

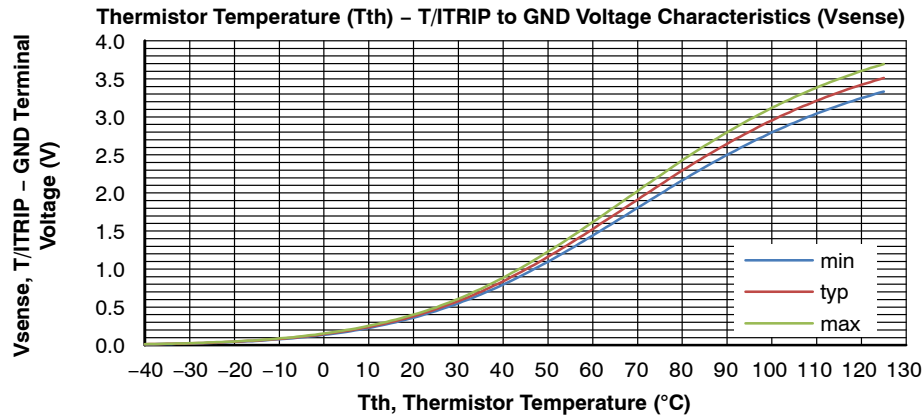


Figure 13. Thermistor Voltage versus Thermistor Temperature  
Conditions: R<sub>P</sub> = 4.3 kΩ 1% Pull-down and V<sub>DD</sub> = 15.0 V (See below)

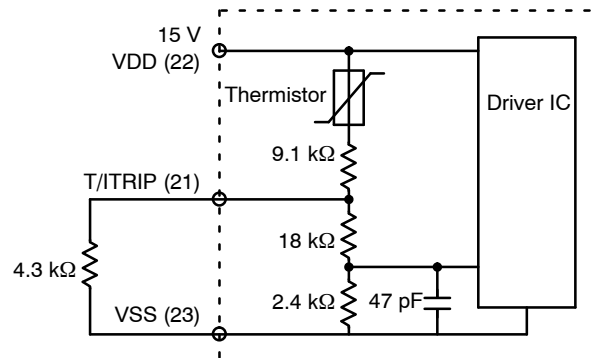


Figure 14. Sample Application Circuit for Temperature Monitoring

# STK544UC63K-E

## TEST CIRCUITS

### • $I_{CE}$ , $I_R(DB)$

|   | U+ | V+ | W+ | U- | V- | W- |
|---|----|----|----|----|----|----|
| A | 10 | 10 | 10 | 8  | 5  | 2  |
| B | 8  | 5  | 2  | 12 | 13 | 14 |

U+, V+, W+: High side phase

U-, V-, W-: Low side phase

|   | U(DB) | V(DB) | W(DB) |
|---|-------|-------|-------|
| A | 7     | 4     | 1     |
| B | 23    | 23    | 23    |

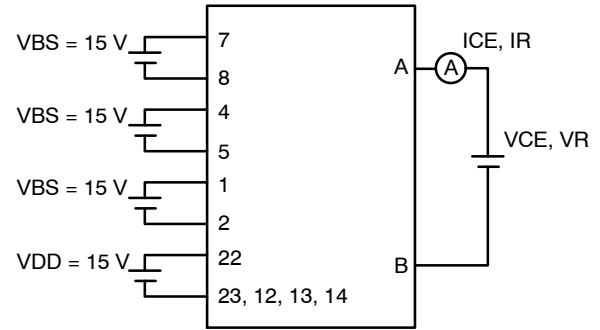


Figure 15. Test Circuit for  $I_{CE}$

### • $V_{CE(sat)}$ (Test by pulse)

|   | U+ | V+ | W+ | U- | V- | W- |
|---|----|----|----|----|----|----|
| A | 10 | 10 | 10 | 8  | 5  | 2  |
| B | 8  | 5  | 2  | 12 | 13 | 14 |
| C | 15 | 16 | 17 | 18 | 19 | 20 |

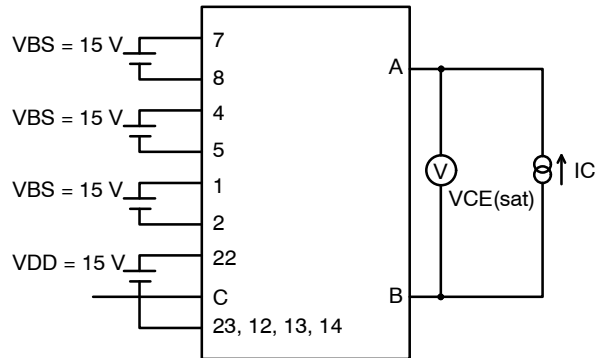


Figure 16. Test Circuit for  $V_{CE(sat)}$

### • $V_F$ (Test by pulse)

|   | U+ | V+ | W+ | U- | V- | W- |
|---|----|----|----|----|----|----|
| A | 10 | 10 | 10 | 8  | 5  | 2  |
| B | 8  | 5  | 2  | 12 | 13 | 14 |

|   | U(DB) | V(DB) | W(DB) |
|---|-------|-------|-------|
| A | 7     | 4     | 1     |
| B | 22    | 22    | 22    |

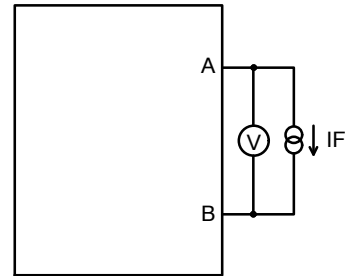


Figure 17. Test Circuit for  $V_F$

### • $I_D$

|   | VBS U+ | VBS V+ | VBS W+ | V <sub>DD</sub> |
|---|--------|--------|--------|-----------------|
| A | 7      | 4      | 1      | 22              |
| B | 8      | 5      | 2      | 23              |

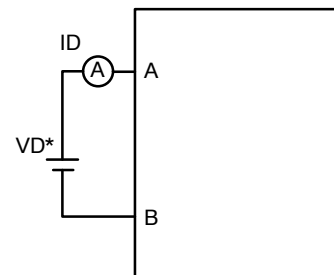


Figure 18. Test Circuit for  $I_D$

# STK544UC63K-E

- Switching time (The circuit is a representative example of the lower side U phase.)

|   | U+ | V+ | W+ | U- | V- | W- |
|---|----|----|----|----|----|----|
| A | 10 | 10 | 10 | 10 | 10 | 10 |
| B | 12 | 13 | 14 | 12 | 13 | 14 |
| C | 8  | 5  | 2  | 10 | 10 | 10 |
| D | 12 | 13 | 14 | 8  | 5  | 2  |
| E | 15 | 16 | 17 | 18 | 19 | 20 |

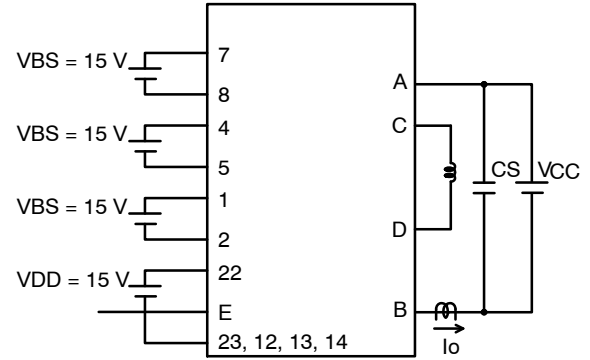
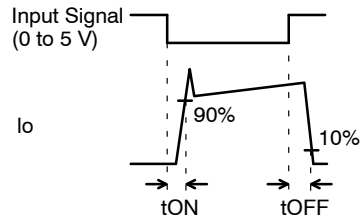


Figure 19. Test Circuit for Switching Time

### SIP23, 62x21.8 FP-4

#### CASE 127FC

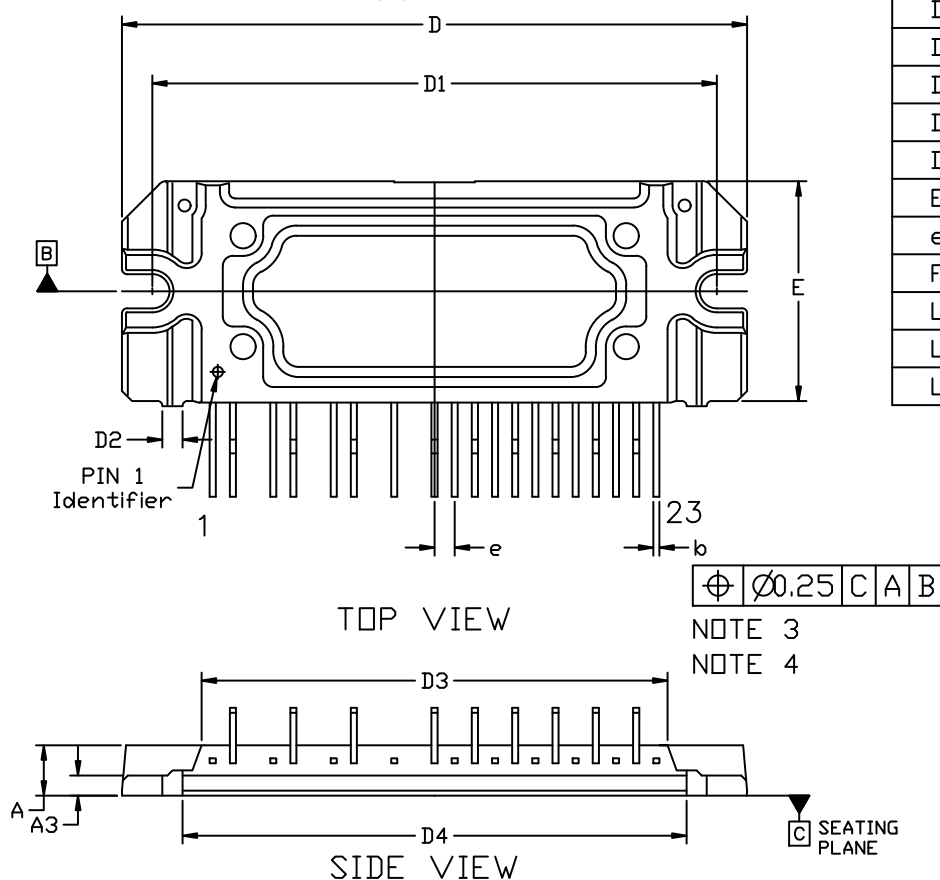
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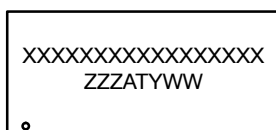
#### NOTES:

1. DIMENSIONING AND TOLERANCING PER. ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSION *b* and *c* APPLY TO THE PLATED LEADS AND ARE MEASURED BETWEEN 1.00 AND 2.00 FROM THE LEAD TIP.
4. POSITION OF THE LEAD IS DETERMINED AT THE ROOT OF THE LEAD WHERE IT EXITS THE PACKAGE BODY.
5. PIN 1 IDENTIFICATION IS A MIRRORED SURFACE INDENT.
6. MISSING PINS ARE 3,6,9 and 11.

| DIM | MILLIMETERS |      |      |
|-----|-------------|------|------|
|     | MIN.        | NOM. | MAX. |
| A   | 4.5         | 5.0  | 5.5  |
| A1  | 2.7         | 3.2  | 3.7  |
| A2  | 4.5         | 5.0  | 5.5  |
| A3  | 1.5         | 2.0  | 2.5  |
| b   | 0.55        | 0.6  | 0.8  |
| c   | 0.45        | 0.5  | 0.7  |
| D   | 61.5        | 62.0 | 62.5 |
| D1  | 55.5        | 56.0 | 56.5 |
| D2  | 1.5         | 2.0  | 2.5  |
| D3  | 45.7        | 46.2 | 46.7 |
| D4  | 49.5        | 50.0 | 50.5 |
| E   | 21.3        | 21.8 | 22.3 |
| e   | 2.0 REF     |      |      |
| F   | 2.9         | 3.4  | 3.9  |
| L   | 8.5         | 9.0  | 9.5  |
| L1  | 3.8         | 4.3  | 4.8  |
| L2  | 0.0         | 0.5  | 1.0  |



#### GENERIC MARKING DIAGRAM\*



XXXX = Specific Device Code  
 ZZZ = Assembly Lot Code  
 AT = Assembly & Test Location  
 Y = Year  
 WW = Work Week

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "•", may or may not be present. Some products may not follow the Generic Marking.

|                  |                     |                                                                                                                                                                                  |
|------------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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| DESCRIPTION:     | SIP23, 62x21.8 FP-4 | PAGE 1 OF 1                                                                                                                                                                      |

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