

### Plug N Drive™ Integrated Power Module for Appliance Motor Drive

### Description

International Rectifier's IRAMS10UP60A is an Integrated Power Module developed and optimized for electronic motor control in appliance applications such as washing machines and refrigerators. Plug N Drive technology offers an extremely compact, high performance AC motor-driver in a single isolated package for a very simple design.

A built-in temperature monitor and over-temperature/over-current protection, along with the short-circuit rated IGBTs and integrated under-voltage lockout function, deliver high level of protection and fail-safe operation.

The integration of the bootstrap diodes for the high-side driver section, and the single polarity power supply required to drive the internal circuitry, simplify the utilization of the module and deliver further cost reduction advantages.

### Features

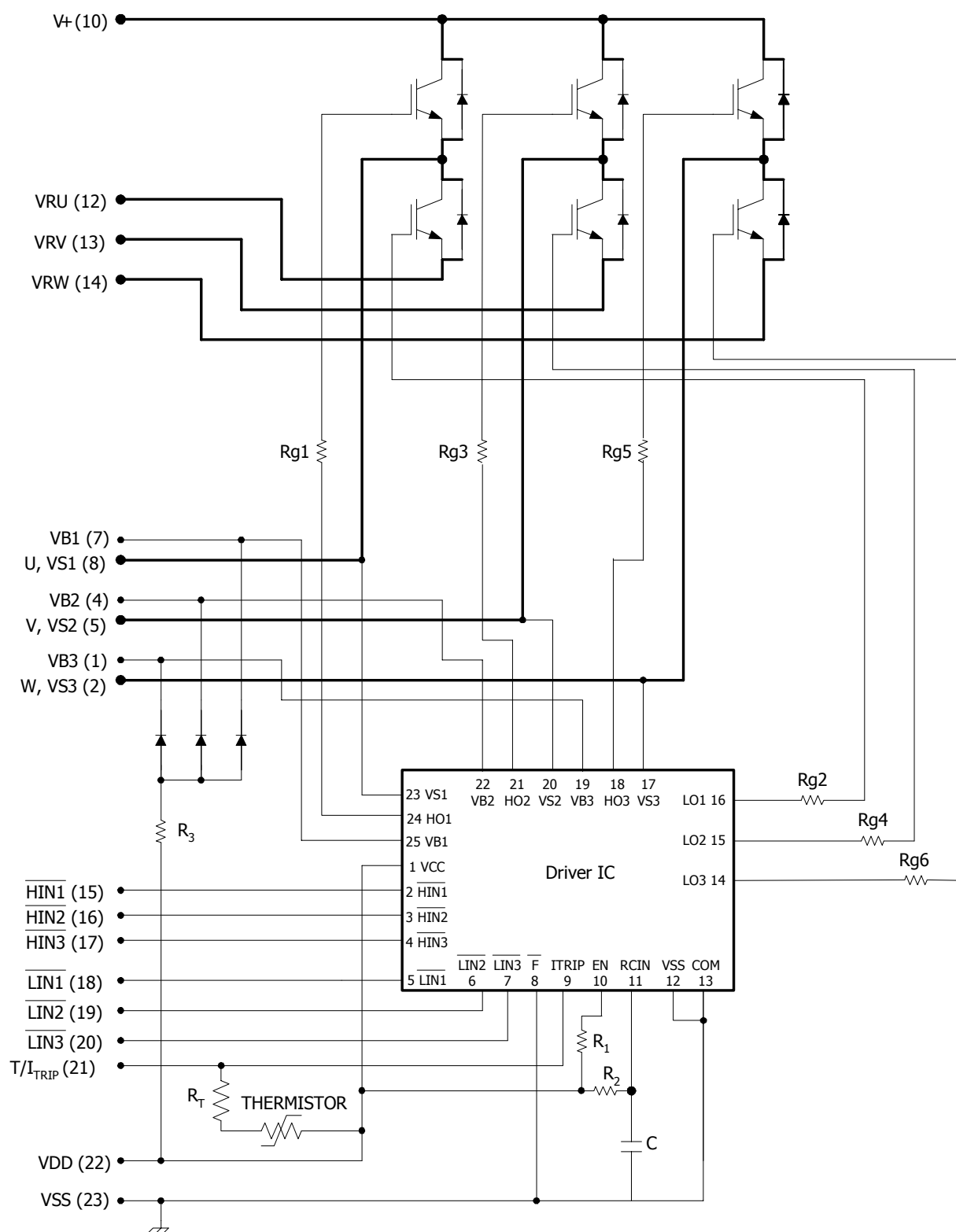
- Integrated Gate Drivers and Bootstrap Diodes.
- Temperature Monitor
- Temperature and Overcurrent shutdown
- Fully Isolated Package.
- Low VCE (on) Non Punch Through IGBT Technology
- Under-voltage lockout for all channels
- Matched propagation delay for all channels
- Low side IGBT emitter pins for current control
- Schmitt-triggered input logic
- Cross-conduction prevention logic
- Lower di/dt gate driver for better noise immunity
- Recognized by UL (E252584), RoHS Compliant

### Absolute Maximum Ratings



| Parameter                       | Description                                         | Max. Value  | Units            |
|---------------------------------|-----------------------------------------------------|-------------|------------------|
| $V_{CES}$                       | Maximum IGBT Blocking Voltage                       | 600         | V                |
| $V^+$                           | Positive Bus Input Voltage                          | 450         |                  |
| $I_O @ T_C = 25^\circ\text{C}$  | RMS Phase Current                                   | 10          | A                |
| $I_O @ T_C = 100^\circ\text{C}$ | RMS Phase Current                                   | 5           |                  |
| $I_{pk}$                        | Maximum Peak Phase Current ( $t_p < 100\text{ms}$ ) | 15          |                  |
| $F_p$                           | Maximum PWM Carrier Frequency                       | 20          | kHz              |
| $P_d$                           | Maximum Power dissipation per Phase                 | 20          | W                |
| $V_{iso}$                       | Isolation Voltage (1min)                            | 2000        | $V_{RMS}$        |
| $T_J$ (IGBT & Diodes)           | Operating Junction temperature Range                | -40 to +150 | $^\circ\text{C}$ |
| $T_J$ (Driver IC)               | Operating Junction temperature Range                | -40 to +150 |                  |
| T                               | Mounting torque Range (M3 screw)                    | 0.8 to 1.0  | Nm               |

## Internal Electrical Schematic - IRAMS10UP60A



## Inverter Section Electrical Characteristics @ $T_J = 25^\circ\text{C}$

| Symbol                          | Parameter                                      | Min | Typ  | Max  | Units               | Conditions                                                           |
|---------------------------------|------------------------------------------------|-----|------|------|---------------------|----------------------------------------------------------------------|
| $V_{(BR)CES}$                   | Collector-to-Emitter Breakdown Voltage         | 600 | ---  | ---  | V                   | $V_{IN}=0V, I_C=20\mu A$                                             |
| $\Delta V_{(BR)CES} / \Delta T$ | Temperature Coeff. Of Breakdown Voltage        | --- | 0.57 | ---  | V/ $^\circ\text{C}$ | $V_{IN}=0V, I_C=1.0mA$<br>( $25^\circ\text{C} - 150^\circ\text{C}$ ) |
| $V_{CE(ON)}$                    | Collector-to-Emitter Saturation Voltage        | --- | 1.7  | 2.0  | V                   | $I_C=5A, T_J=25^\circ\text{C}, V_{DD}=15V$                           |
|                                 |                                                | --- | 2.0  | 2.4  |                     | $I_C=5A, T_J=150^\circ\text{C}$                                      |
| $I_{CES}$                       | Zero Gate Voltage Collector Current-to-Emitter | --- | 5    | 15   | $\mu A$             | $V_{IN}=5V, V^+=600V$                                                |
|                                 |                                                | --- | 10   | 40   |                     | $V_{IN}=5V, V^+=600V, T_J=150^\circ\text{C}$                         |
| $I_{lk\_module}$                | Zero Gate Phase-to-Phase Current               | --  | --   | 50   | $\mu A$             | $V_{IN}=5V, V^+=600V$                                                |
| $V_{FM}$                        | Diode Forward Voltage Drop                     | --- | 1.8  | 2.35 | V                   | $I_C=5A$                                                             |
|                                 |                                                | --- | 1.3  | 1.7  |                     | $I_C=5A, T_J=150^\circ\text{C}$                                      |

## Inverter Section Switching Characteristics

| Symbol    | Parameter                         | Min         | Typ | Max | Units   | Conditions                                                                                     |
|-----------|-----------------------------------|-------------|-----|-----|---------|------------------------------------------------------------------------------------------------|
| $E_{on}$  | Turn-On Switching Loss            | ---         | 200 | 235 | $\mu J$ | $I_C=5A, V^+=400V$                                                                             |
| $E_{off}$ | Turn-Off Switching Loss           | ---         | 75  | 100 |         | $V_{DD}=15V, L=1mH$                                                                            |
| $E_{tot}$ | Total Switching Loss              | ---         | 275 | 335 |         | See CT1 $T_J=25^\circ\text{C}$                                                                 |
| $E_{on}$  | Turn-on Switching Loss            | ---         | 300 | 360 | $\mu J$ | $T_J=150^\circ\text{C}$                                                                        |
| $E_{off}$ | Turn-off Switching Loss           | ---         | 135 | 165 |         | Energy losses include "tail" and diode reverse recovery                                        |
| $E_{tot}$ | Total Switching Loss              | ---         | 435 | 525 |         |                                                                                                |
| $E_{rec}$ | Diode Reverse Recovery energy     | ---         | 30  | 40  | $\mu J$ | $T_J=150^\circ\text{C}, V^+=400V, V_{DD}=15V, I_F=5A, L=1mH$                                   |
| $t_{rr}$  | Diode Reverse Recovery time       | ---         | 100 | 145 | ns      |                                                                                                |
| RBSOA     | Reverse Bias Safe Operating Area  | FULL SQUARE |     |     |         | $T_J=150^\circ\text{C}, I_C=5A, V_P=600V$<br>$V^+=480V, V_{DD}=+15V \text{ to } 0V$<br>See CT3 |
| SCSOA     | Short Circuit Safe Operating Area | 10          | --- | --- | $\mu s$ | $T_J=150^\circ\text{C}, V_P=600V, V^+=360V, V_{DD}=+15V \text{ to } 0V$<br>See CT2             |

## Thermal Resistance

| Symbol        | Parameter                                                                 | Min | Typ | Max | Units              | Conditions                                                                 |
|---------------|---------------------------------------------------------------------------|-----|-----|-----|--------------------|----------------------------------------------------------------------------|
| $R_{th(J-C)}$ | Junction to case thermal resistance, each IGBT under inverter operation.  | --- | 4.2 | 4.7 | $^\circ\text{C}/W$ | Flat, greased surface.<br>Heatsink compound thermal conductivity - $1W/mK$ |
| $R_{th(J-C)}$ | Junction to case thermal resistance, each Diode under inverter operation. | --- | 5.5 | 6.5 | $^\circ\text{C}/W$ |                                                                            |
| $R_{th(C-S)}$ | Thermal Resistance case to sink                                           | --- | 0.1 | --- | $^\circ\text{C}/W$ |                                                                            |

**Absolute Maximum Ratings Driver Function**

Absolute Maximum Ratings indicate substaines limits beyond which damage to the device may occur. All voltage parameters are absolute voltages referenced to  $V_{SS}$  (Note 1)

| Symbol       | Definition                                  | Min  | Max | Units |
|--------------|---------------------------------------------|------|-----|-------|
| $V_{S1,2,3}$ | High Side offset voltage                    | -0.3 | 600 | V     |
| $V_{B1,2,3}$ | High Side floating supply voltage           | -0.3 | 20  | V     |
| $V_{DD}$     | Low Side and logic fixed supply voltage     | -0.3 | 20  | V     |
| $V_{IN}$     | Input voltage LIN, HIN, T/I <sub>TRIP</sub> | -0.3 | 7   | V     |
| $T_J$        | Juction Temperature                         | -40  | 150 | °C    |

**Recommended Operating Conditions Driver Function**

The Input/Output logic timing diagram is shown in Figure 1. For proper operation the device should be used within the recommended conditions. All voltages are absolute referenced to  $V_{SS}$ . The  $V_S$  offset is tested with all supplies biased at 15V differential (Note 1). All input pin ( $V_{IN}$ ) and  $I_{TRIP}$  are clamped with a 5.2V zener diode and pull-up resistor to  $V_{DD}$

| Symbol       | Definition                               | Min      | Max        | Units |
|--------------|------------------------------------------|----------|------------|-------|
| $V_{B1,2,3}$ | High side floating supply voltage        | $V_S+12$ | $V_S+20$   | V     |
| $V_{S1,2,3}$ | High side floating supply offset voltage | Note 2   | 450        |       |
| $V_{DD}$     | Low side and logic fixed supply voltage  | 12       | 20         | V     |
| $V_{ITRIP}$  | T/I <sub>TRIP</sub> input voltage        | $V_{SS}$ | $V_{SS}+5$ |       |
| $V_{IN}$     | Logic input voltage LIN, HIN             | $V_{SS}$ | $V_{SS}+5$ | V     |

**Static Electrical Characteristics Driver Function**

$V_{BIAS}$  ( $V_{CC}$ ,  $V_{BS1,2,3}$ )=15V, unless otherwise specified. The  $V_{IN}$  and  $I_{IN}$  parameters are referenced to  $V_{SS}$  and are applicable to all six channels. (Note 1)

| Symbol                     | Definition                                                            | Min  | Typ  | Max  | Units |
|----------------------------|-----------------------------------------------------------------------|------|------|------|-------|
| $V_{IN,th+}$               | Positive going input threshold                                        | 3.0  | ---  | ---  | V     |
| $V_{IN,th-}$               | Negative going input threshold                                        | ---  | ---  | 0.8  | V     |
| $V_{CCUV+}$<br>$V_{BSUV+}$ | $V_{CC}$ and $V_{BS}$ supply undervoltage<br>Positive going threshold | 10.6 | 11.1 | 11.6 | V     |
| $V_{CCUV-}$<br>$V_{BSUV-}$ | $V_{CC}$ and $V_{BS}$ supply undervoltage<br>Negative going threshold | 10.4 | 10.9 | 11.4 | V     |
| $V_{CCUVH}$<br>$V_{BSUVH}$ | $V_{CC}$ and $V_{BS}$ supply undervoltage<br>$I_{lockout}$ hysteresis | ---  | 0.2  | ---  | V     |
| $I_{QBS}$                  | Quiescent $V_{BS}$ supply current                                     | ---  | 70   | 120  | μA    |
| $I_{QCC}$                  | Quiscent $V_{CC}$ supply current                                      | ---  | 1.6  | 2.3  | mA    |
| $I_{LK}$                   | Offset Supply Leakage Current                                         | ---  | ---  | 50   | μA    |
| $I_{IN+}$                  | Input bias current (OUT=LO)                                           | ---  | 100  | 220  | μA    |
| $I_{IN+}$                  | Input bias current (OUT=HI)                                           | ---  | 200  | 300  | μA    |
| $V(I_{TRIP})$              | $I_{TRIP}$ threshold Voltage (OUT=HI or OUT=LO)                       | 3.85 | 4.3  | 4.75 | V     |

## Dynamic Electrical Characteristics

$V_{DD}=V_{BS}=V_{BIAS}=15V$ ,  $I_o=1A$ ,  $V_D=9V$ ,  $PWM_{IN}=2kHz$ ,  $V_{IN\_ON}=V_{IN\_th+}$ ,  $V_{IN\_OFF}=V_{IN\_th-}$

$T_A=25^{\circ}C$ , unless otherwise specified

| Symbol       | Definition                                                            | Min | Typ | Max | Units |
|--------------|-----------------------------------------------------------------------|-----|-----|-----|-------|
| $T_{ON}$     | Input to output propagation turn-on delay time (see fig. 11)          | -   | 470 | -   | ns    |
| $T_{OFF}$    | Input to output propagation turn-off delay time (see fig. 11)         | -   | 615 | -   | ns    |
| $D_T$        | Dead Time                                                             | -   | 300 | -   | ns    |
| $I/T_{Trip}$ | $T/I_{Trip}$ to six switch to turn-off propagation delay (see fig. 2) | -   | 750 | -   | ns    |
| $T_{FCLTRL}$ | Post $I_{Trip}$ to six switch to turn-off clear time (see fig. 2)     | -   | 9   | -   | ms    |

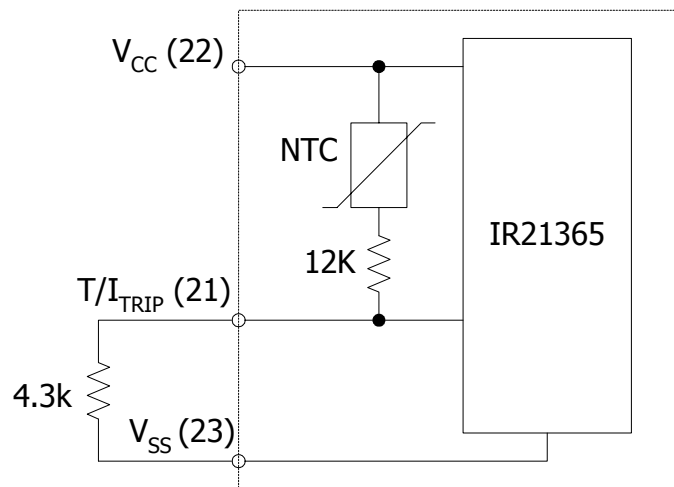
## Internal NTC - Thermistor Characteristics

| Parameter                         | Typ                     | Units           | Conditions                         |
|-----------------------------------|-------------------------|-----------------|------------------------------------|
| $R_{25}$ Resistance               | 100 +/- 5%              | k $\Omega$      | $T_C = 25^{\circ}C$                |
| $R_{125}$ Resistance              | 2.522 + 17.3 % /- 14.9% | k $\Omega$      | $T_C = 125^{\circ}C$               |
| B B-Constant (25-50 $^{\circ}C$ ) | 4250 +/- 3%             | k               | $R_2 = R_1 e^{[B(1/T_2 - 1/T_1)]}$ |
| Temperature Range                 | -40 / 125               | $^{\circ}C$     |                                    |
| Typ. Dissipation constant         | 1                       | mW/ $^{\circ}C$ | $T_C = 25^{\circ}C$                |

Note 1: For more details, see IR21365 data sheet

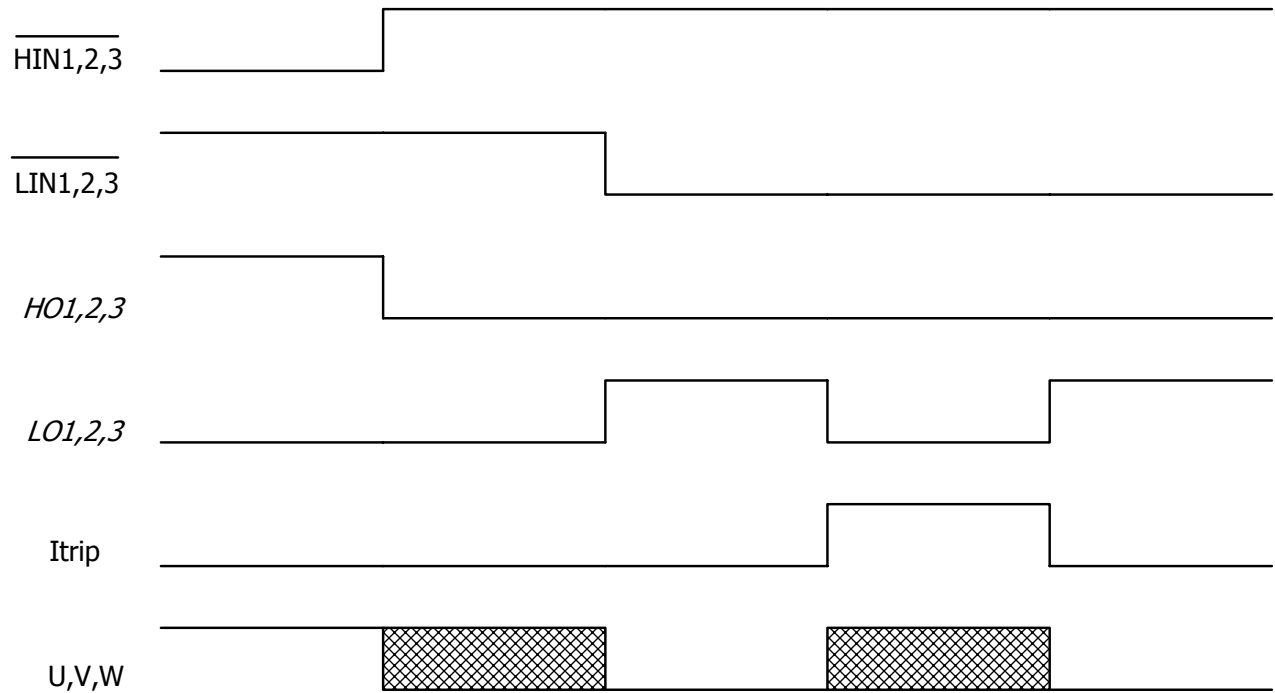
Note 2: Logic operational for  $V_S$  from  $V^-$ -5V to  $V^+$ +600V. Logic stata held for  $V_S$  from  $V^-$ -5V to  $V^-$ - $V_{BS}$ . (Please refer to DT97-3 for more details)

## Thermistor Built-in IRAMS10UP60A

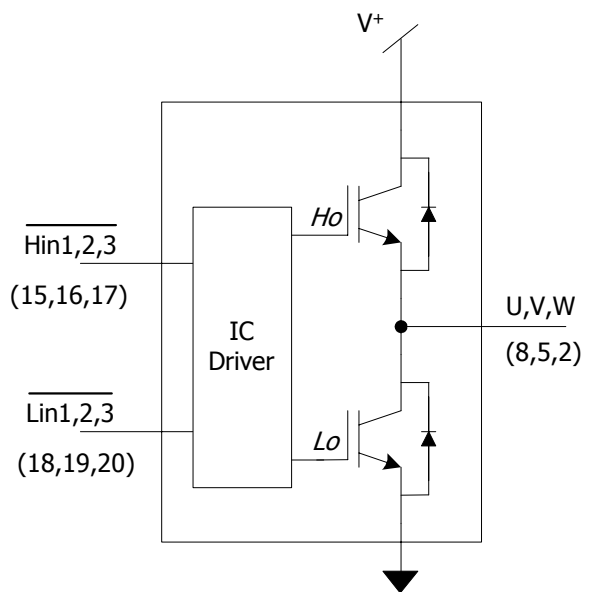


Note 3: The Maximum recommended sense voltage at the  $T/I_{TRIP}$  terminal under normal operating conditions is 3.3V.

Figure1. Input/Output Timing Diagram

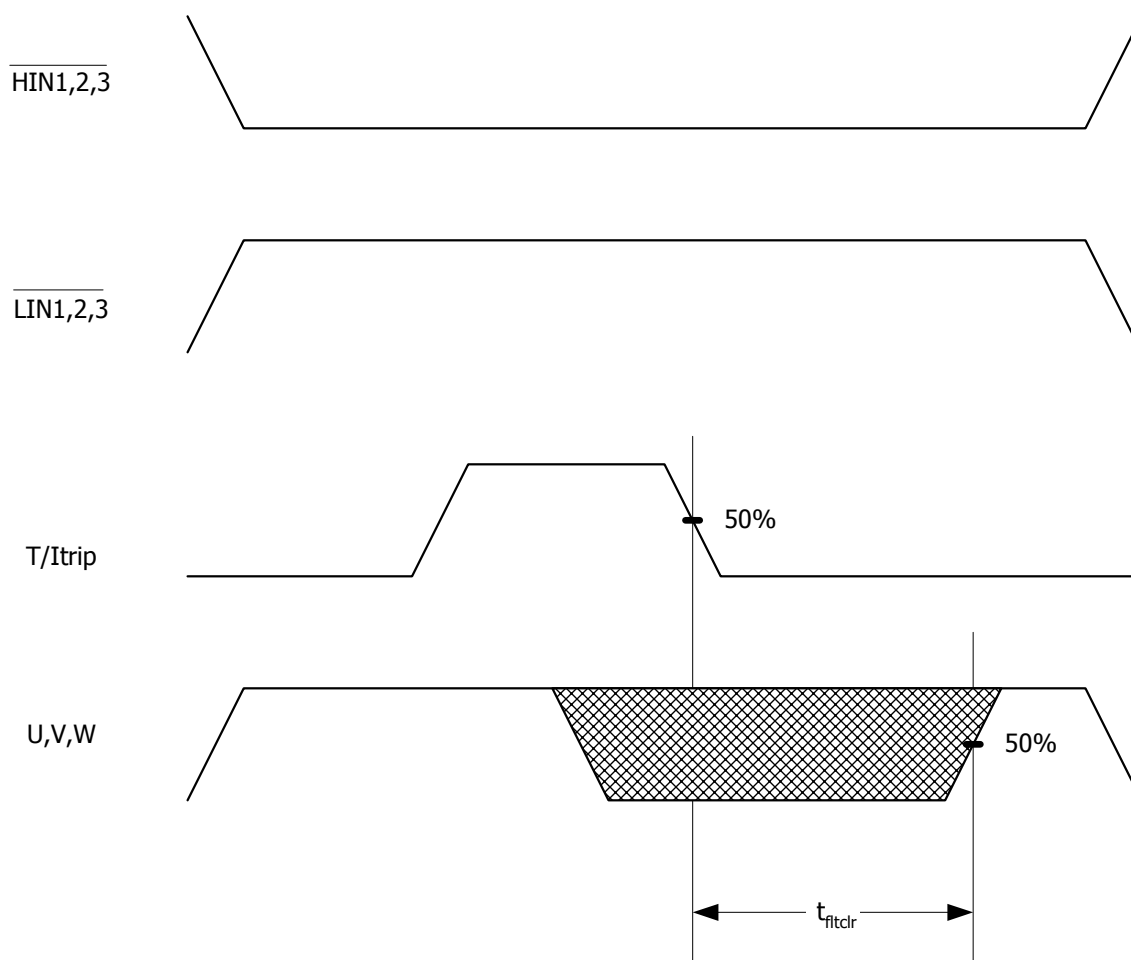


Note 4: The shaded area indicates that both high-side and low-side switches are off and therefore the half-bridge output voltage would be determined by the direction of current flow in the load.



| Itrip | $\overline{HIN1,2,3}$ | $\overline{LIN1,2,3}$ | U,V,W |
|-------|-----------------------|-----------------------|-------|
| 0     | 0                     | 1                     | Vbus  |
| 0     | 1                     | 0                     | 0     |
| 0     | 1                     | 1                     | X     |
| 1     | X                     | X                     | X     |

Figure 2.  $T/I_{Trip}$  Timing Waveform



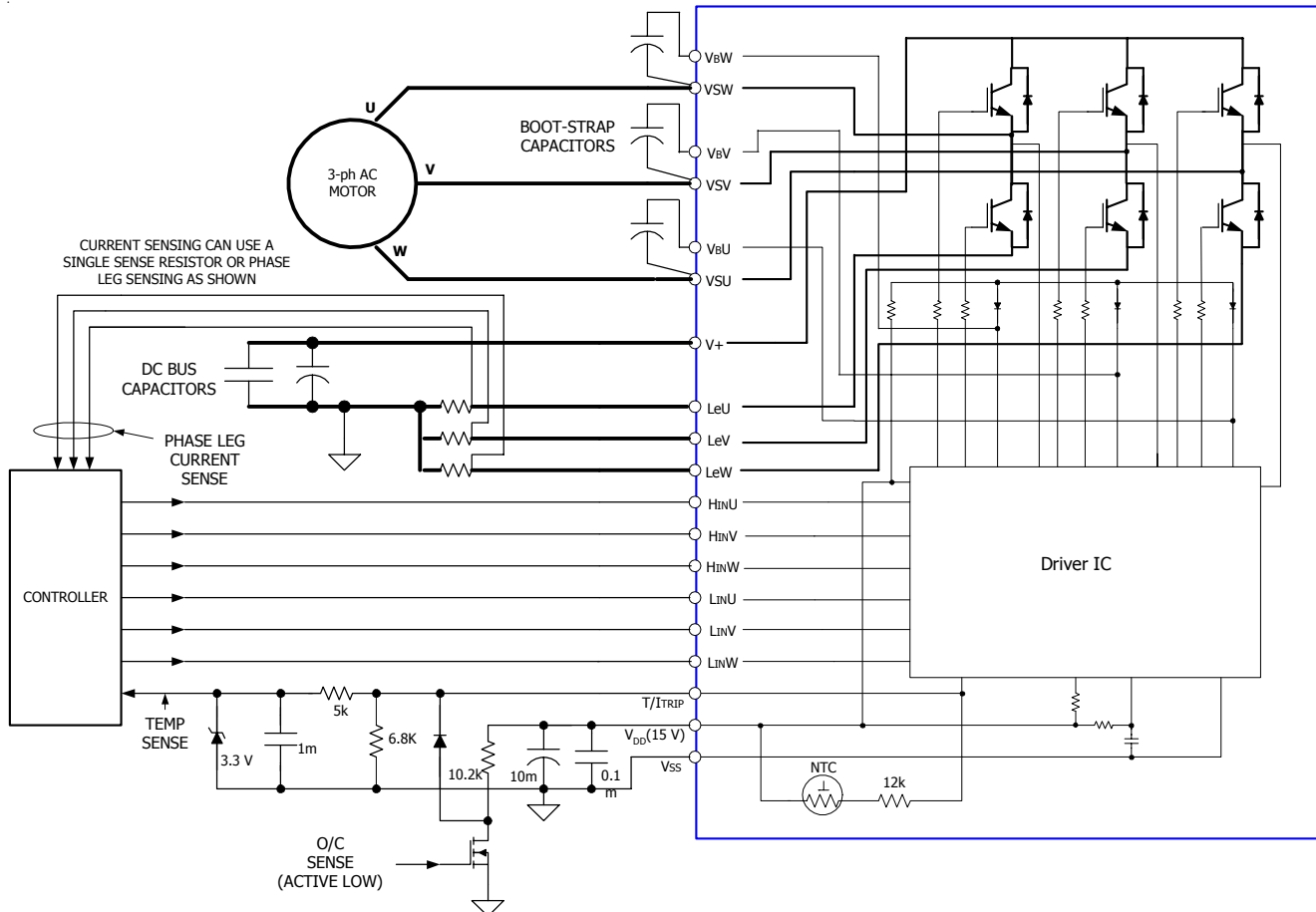
Note 5: The shaded area indicates that both high-side and low-side switches are off and therefore the half-bridge output voltage would be determined by the direction of current flow in the load.

## Module Pin-Out Description

| Pin | Name    | Description                                         |
|-----|---------|-----------------------------------------------------|
| 1   | VB3     | High Side Floating Supply Voltage 3                 |
| 2   | W, VS3  | Output 3 - High Side Floating Supply Offset Voltage |
| 3   | na      | none                                                |
| 4   | VB2     | High Side Floating Supply voltage 2                 |
| 5   | V, VS2  | Output 2 - High Side Floating Supply Offset Voltage |
| 6   | na      | none                                                |
| 7   | VB1     | High Side Floating Supply voltage 1                 |
| 8   | U, VS1  | Output 1 - High Side Floating Supply Offset Voltage |
| 9   | na      | none                                                |
| 10  | V+      | Positive Bus Input Voltage                          |
| 11  | na      | none                                                |
| 12  | LE1     | Low Side Emitter Connection - Phase 1               |
| 13  | LE2     | Low Side Emitter Connection - Phase 2               |
| 14  | LE3     | Low Side Emitter Connection - Phase 3               |
| 15  | HIN1    | Logic Input High Side Gate Driver - Phase 1         |
| 16  | HIN2    | Logic Input High Side Gate Driver - Phase 2         |
| 17  | HIN3    | Logic Input High Side Gate Driver - Phase 3         |
| 18  | LIN1    | Logic Input Low Side Gate Driver - Phase 1          |
| 19  | LIN2    | Logic Input Low Side Gate Driver - Phase 2          |
| 20  | LIN3    | Logic Input Low Side Gate Driver - Phase 3          |
| 21  | T/Itrip | Temperature Monitor and Shut-down Pin               |
| 22  | VCC     | +15V Main Supply                                    |
| 23  | VSS     | Negative Main Supply                                |



## Typical Application Connection IRAMS10UP60A



1. Electrolytic bus capacitors should be mounted as close to the module bus terminals as possible to reduce ringing and EMI problems. Additional high frequency ceramic capacitor mounted close to the module pins will further improve performance.
2. In order to provide good decoupling between  $V_{CC}$ -Gnd and  $V_B$ - $V_{SS}$  terminals, the capacitors shown connected between these terminals should be located very close to the module pins. Additional high frequency capacitors, typically 0.1 $\mu$ F, are strongly recommended.
3. Value of the boot-strap capacitors depends upon the switching frequency. Their selection should be made based on IR design tip DN 98-2a, application note AN-1044 or Figure 9.
4. Low inductance shunt resistors should be used for phase leg current sensing. Similarly, the length of the traces between pins 12, 13 and 14 to the corresponding shunt resistors should be kept as small as possible.
5. Over-current sense signal can be obtained from external hardware detecting excessive instantaneous current in inverter.

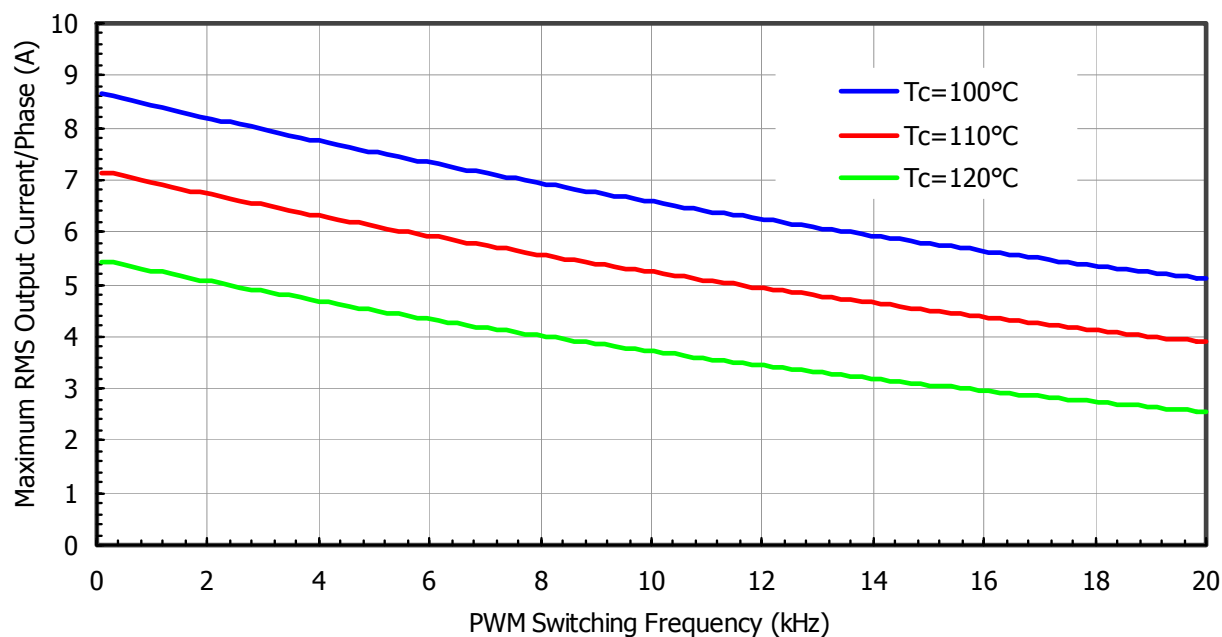


Figure 3. Maximum sinusoidal phase current as function of switching frequency  
 $V_{\text{BUS}}=400\text{V}$ ,  $T_j=150^\circ\text{C}$ , Modulation Depth=0.8, PF=0.6

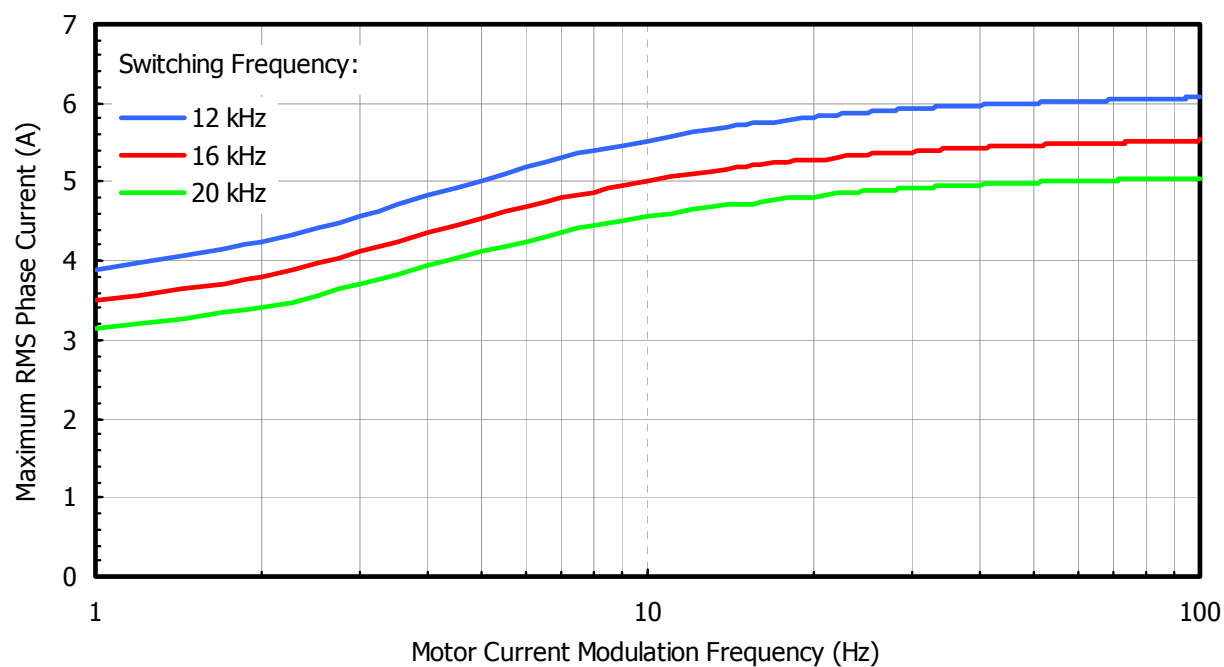


Figure 4. Maximum sinusoidal phase current as function of modulation frequency  
 $V_{\text{BUS}}=400\text{V}$ ,  $T_j=150^\circ\text{C}$ ,  $T_c=100^\circ\text{C}$ , Modulation Depth=0.8, PF=0.6

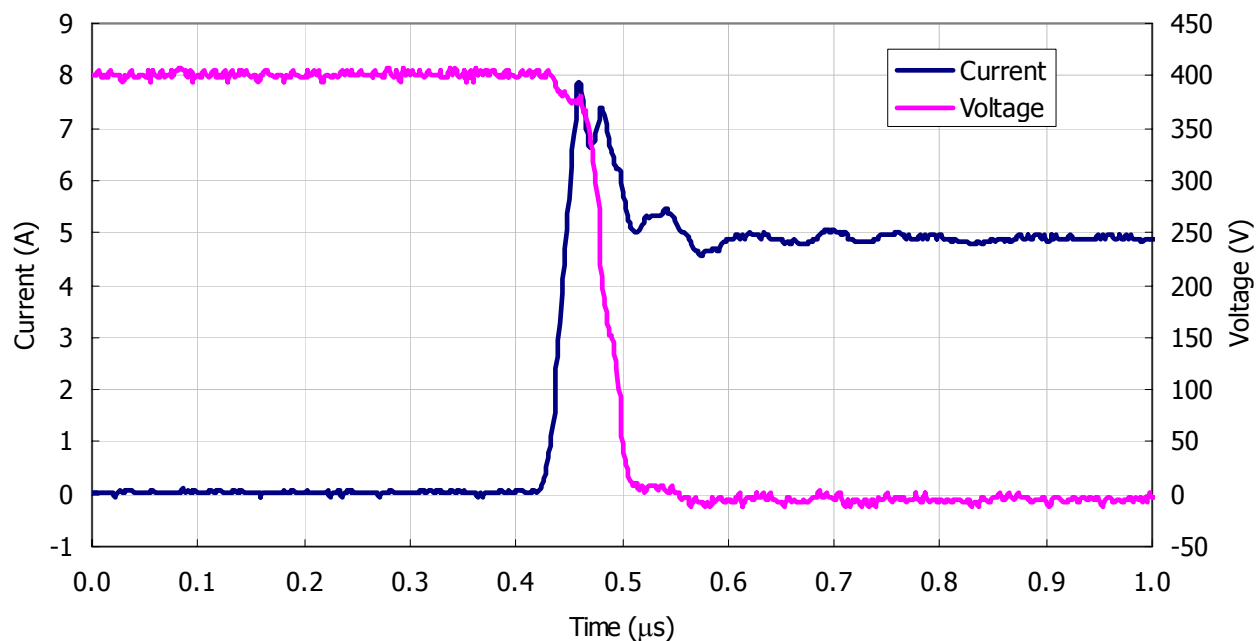


Figure 5. IGBT Turn-on. Typical turn-on waveform @ $T_j=125^{\circ}\text{C}$ ,  $V_{\text{BUS}}=400\text{V}$

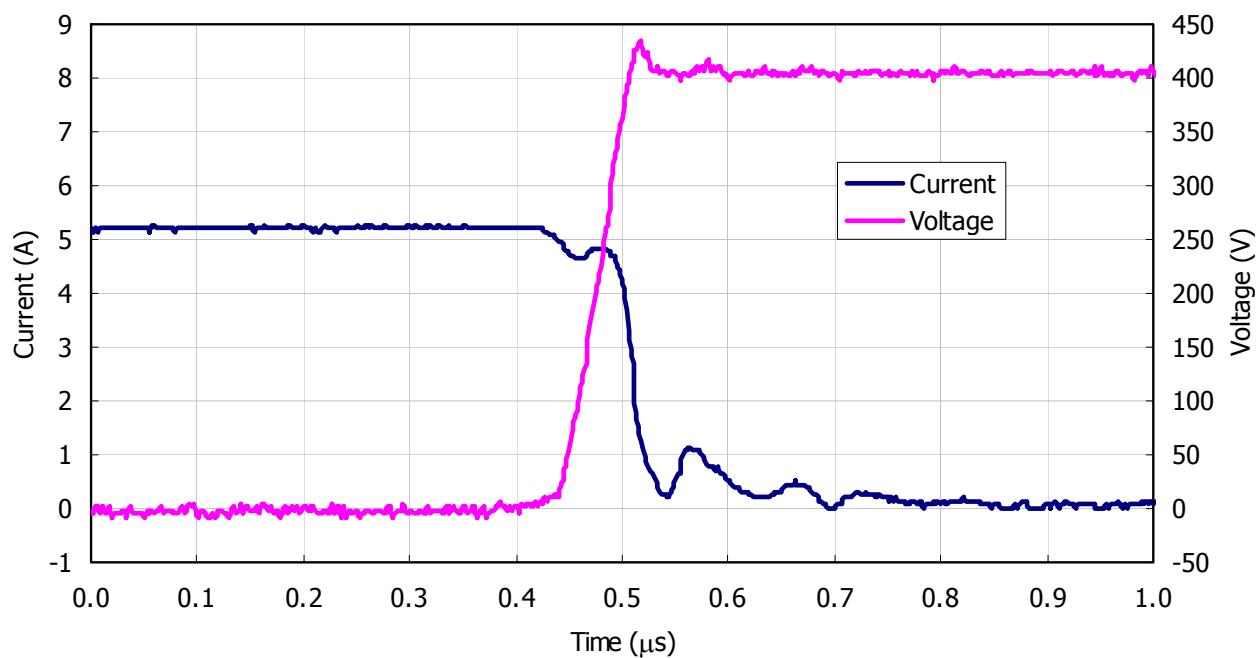


Figure 6. IGBT Turn-off. Typical turn-off waveform @ $T_j=125^{\circ}\text{C}$ ,  $V_{\text{BUS}}=400\text{V}$

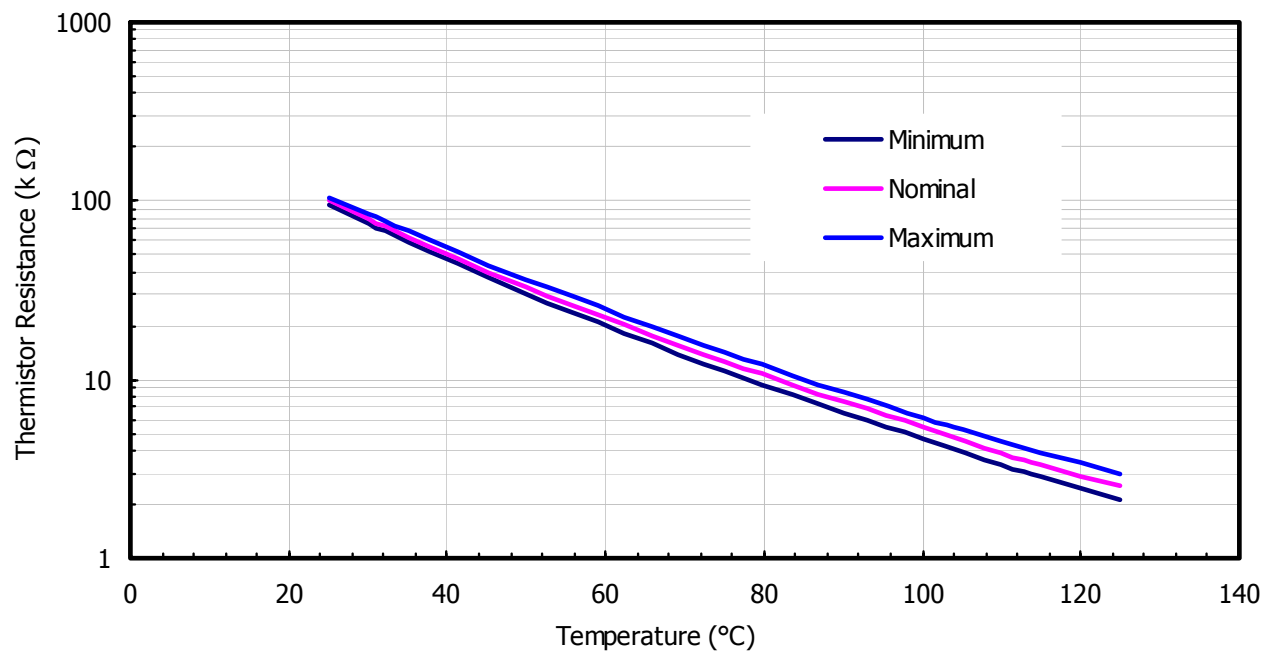


Figure 7. Variation of thermistor resistance with temperature

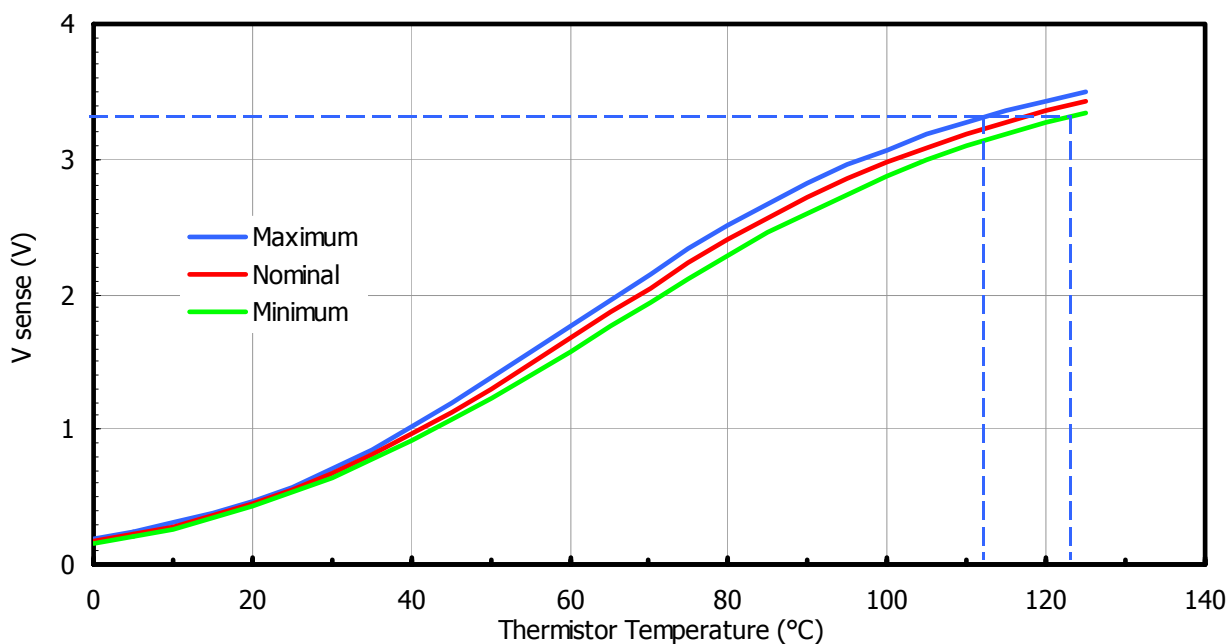


Figure 8. Variation of temperature sense voltage with thermistor temperature using external bias resistance of  $4.3\text{K}\Omega$ ,  $V_{CC}=15\text{V}$

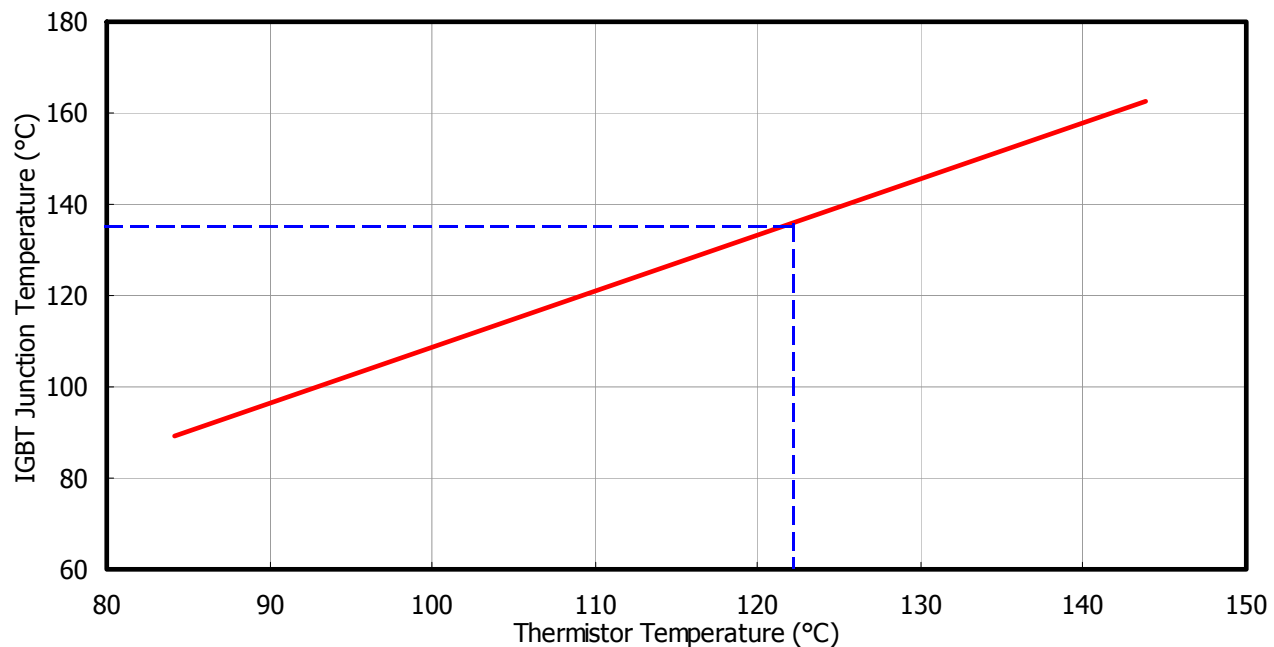


Figure 9. Estimated maximum IGBT junction temperature with thermistor temperature

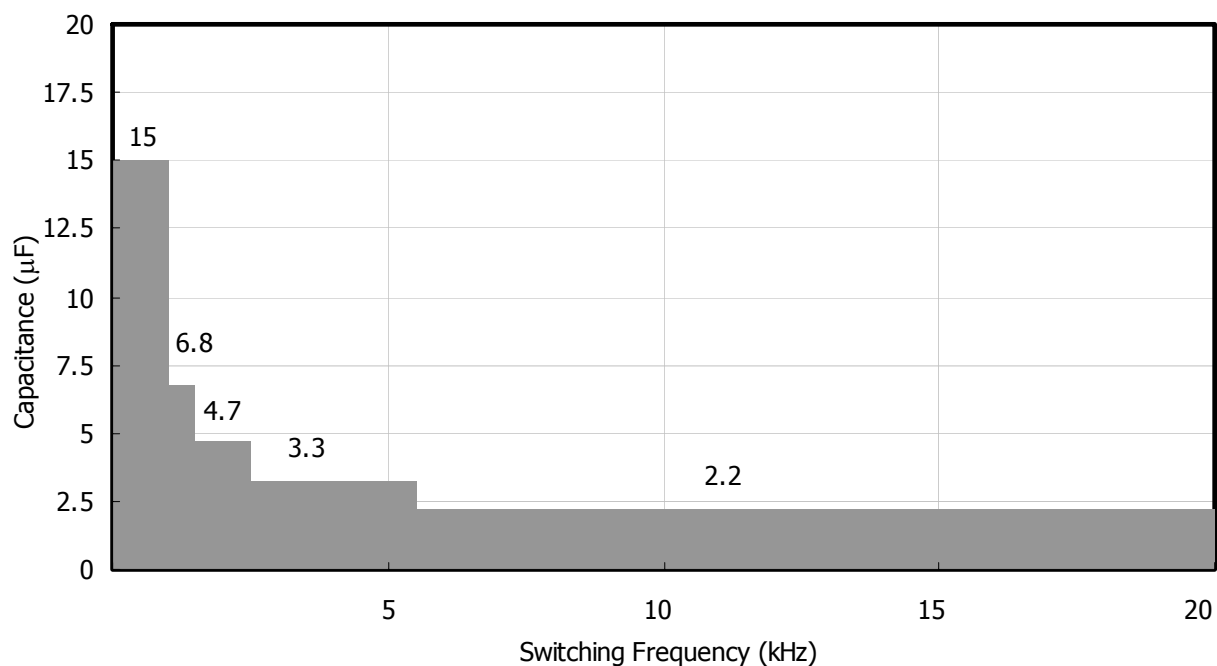


Figure 10. Recommended minimum Bootstrap Capacitor value Vs Switching Frequency

Figure 11. Switching Parameter Definitions

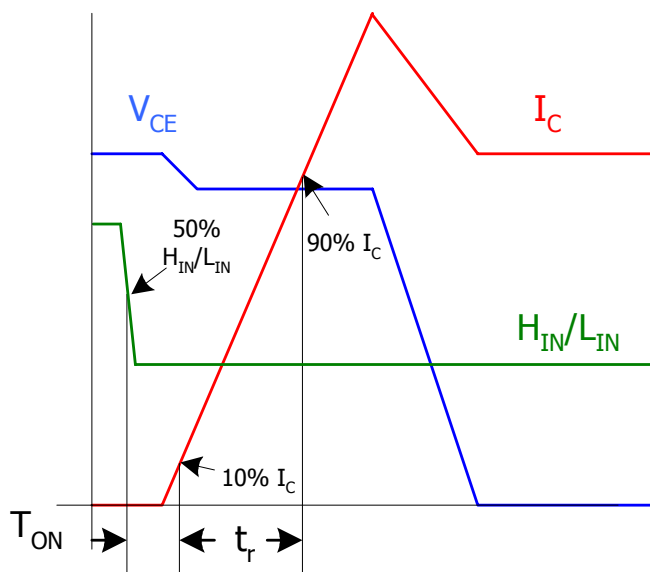


Figure 11a. Input to Output propagation turn-on delay time

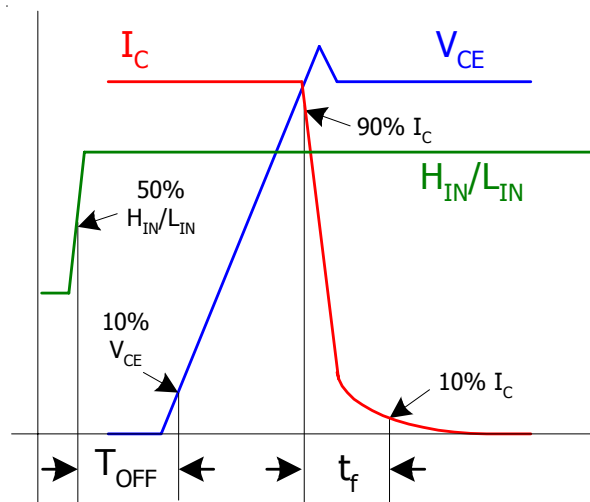


Figure 11b. Input to Output propagation turn-off delay time

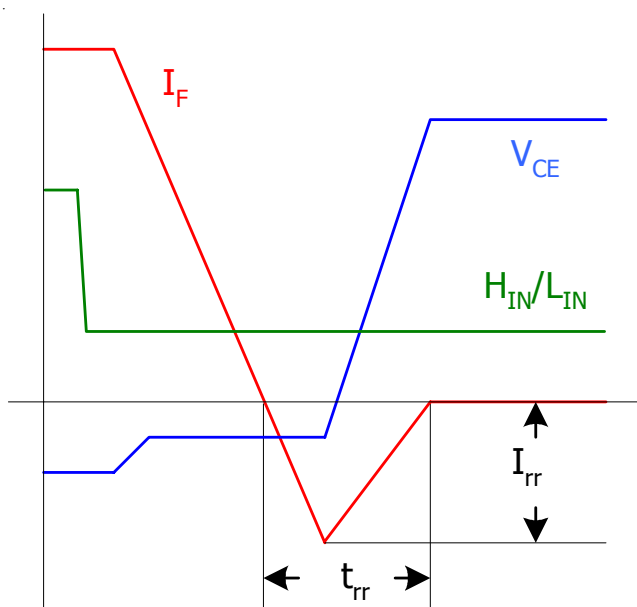


Figure 11c. Diode Reverse Recovery

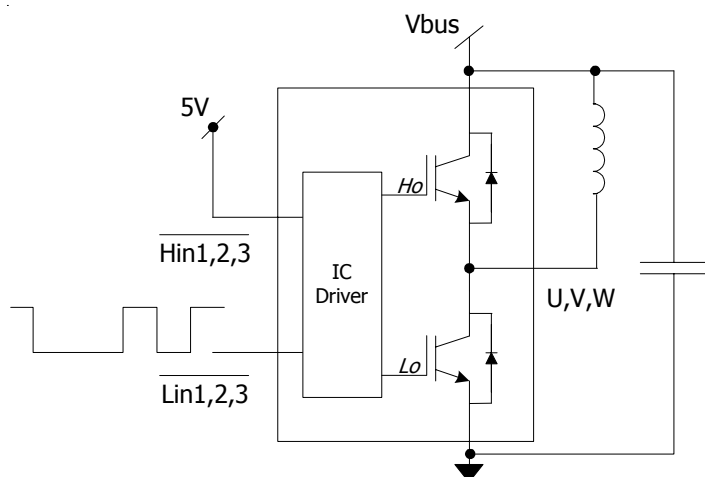


Figure CT1. Switching Loss Circuit

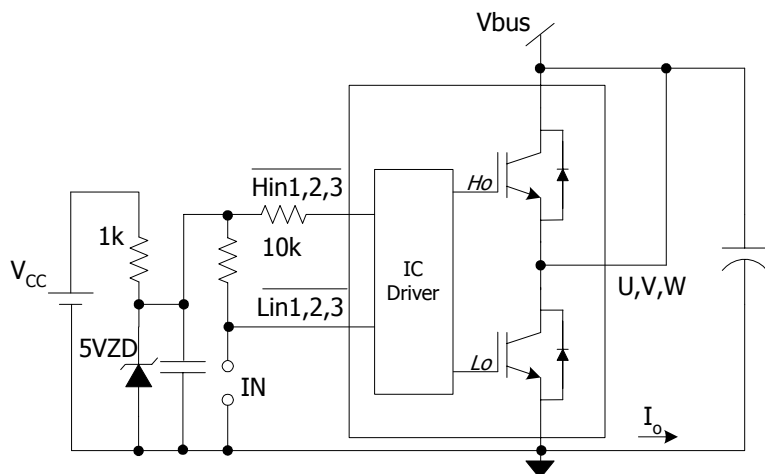


Figure CT2. S.C.SOA Circuit

IN PWM=4 $\mu$ s

Io

$V_p$ =Peak Voltage on the IGBT die

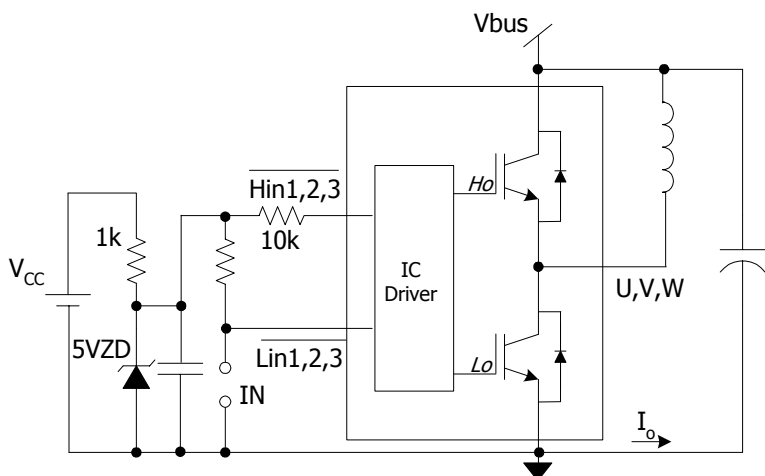


Figure CT3. R.B.SOA Circuit

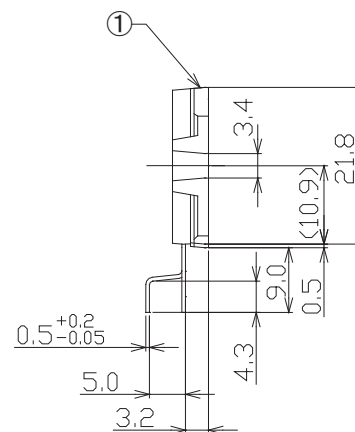
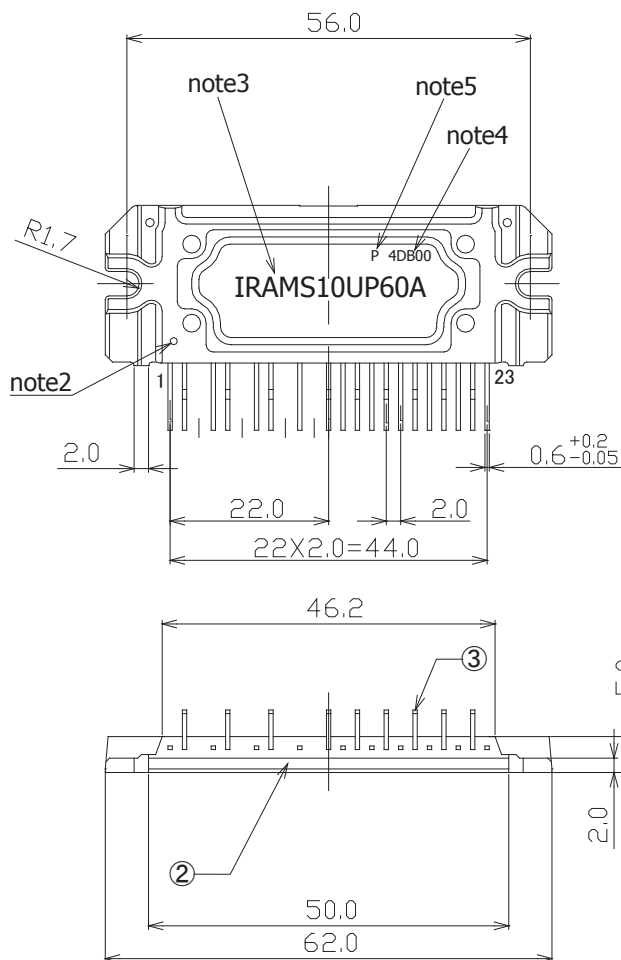
IN

Io

$V_p$ =Peak Voltage on the IGBT die

## Package Outline IRAMS10UP60A

missing pin : 3,6,9,11



note1: Unit Tolerance is  $\pm 0.5$ mm,  
Unless Otherwise Specified.

note2: Mirror Surface Mark indicates Pin1 Identification.

note3: Part Number Marking.  
Characters Font in this drawing differs from  
Font shown on Module.

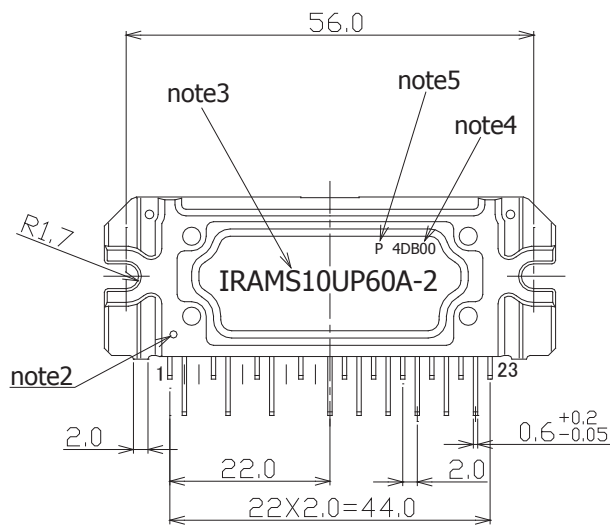
note4: Lot Code Marking.  
Characters Font in this drawing differs from  
Font shown on Module.

note5: "P" Character denotes Lead Free.  
Characters Font in this drawing differs from  
Font shown on Module.

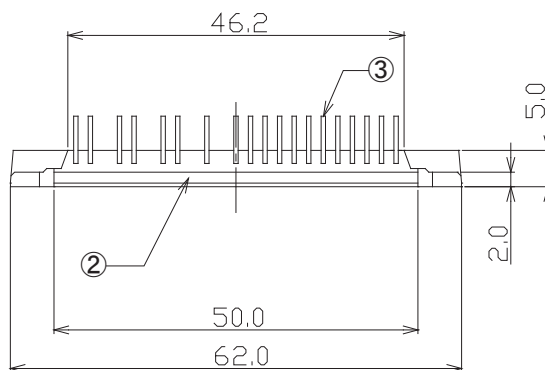
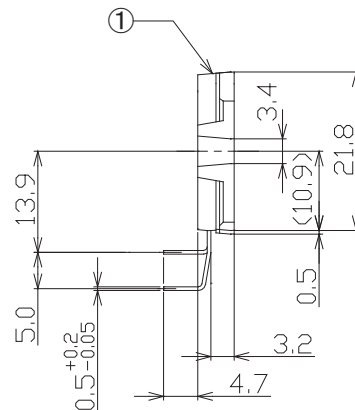
Dimensions in mm  
For mounting instruction see AN-1049



## Package Outline IRAMS10UP60A-2



missing pin : 3,6,9,11



- note1: Unit Tolerance is  $\pm 0.5\text{mm}$ ,  
Unless Otherwise Specified.
- note2: Mirror Surface Mark indicates Pin1 Identification.
- note3: Part Number Marking.  
Characters Font in this drawing differs from  
Font shown on Module.
- note4: Lot Code Marking.  
Characters Font in this drawing differs from  
Font shown on Module.
- note5: "P" Character denotes Lead Free.  
Characters Font in this drawing differs from  
Font shown on Module.

Dimensions in mm  
For mounting instruction see AN-1049

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- Помощь Конструкторского Отдела и консультации квалифицированных инженеров;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- При необходимости вся продукция военного и аэрокосмического назначения проходит испытания и сертификацию в лаборатории (по согласованию с заказчиком);
- Поставка специализированных компонентов военного и аэрокосмического уровня качества (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Actel, Aeroflex, Peregrine, VPT, Syfer, Eurofarad, Texas Instruments, MS Kennedy, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Компания «Океан Электроники» является официальным дистрибьютором и эксклюзивным представителем в России одного из крупнейших производителей разъемов военного и аэрокосмического назначения «JONHON», а так же официальным дистрибьютором и эксклюзивным представителем в России производителя высокотехнологичных и надежных решений для передачи СВЧ сигналов «FORSTAR».



## JONHON

«JONHON» (основан в 1970 г.)

Разъемы специального, военного и аэрокосмического назначения:

(Применяются в военной, авиационной, аэрокосмической, морской, железнодорожной, горно- и нефтедобывающей отраслях промышленности)

«FORSTAR» (основан в 1998 г.)

ВЧ соединители, коаксиальные кабели,  
кабельные сборки и микроволновые компоненты:

(Применяются в телекоммуникациях гражданского и специального назначения, в средствах связи, РЛС, а так же военной, авиационной и аэрокосмической отраслях промышленности).



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