

## MOSFET DRIVER WITH PROTECTION AND DIAGNOSTIC

### Features

- Bootstrap and charge pump
- Over temperature shutdown (with Ptc interface)
- Short circuit protection (Vds detection)
- Reverse battery protection (turns On the MOSFET)
- Ground loss protection
- Diagnostic
- ESD protection

### Description

The AUIR3200S is a high side mosfet driver for very low Rdson automotive application. It offers over-current, over-temperature protection and diagnostic. The over-current protection is done by monitoring the Vds voltage, the threshold is programmable by external resistor. The over-temperature protection uses a thermal sensor. The AUIR3200S offers diagnostic on the input pin.

### Product Summary

Operating voltage 6-36V  
Vgate 6V

### Package

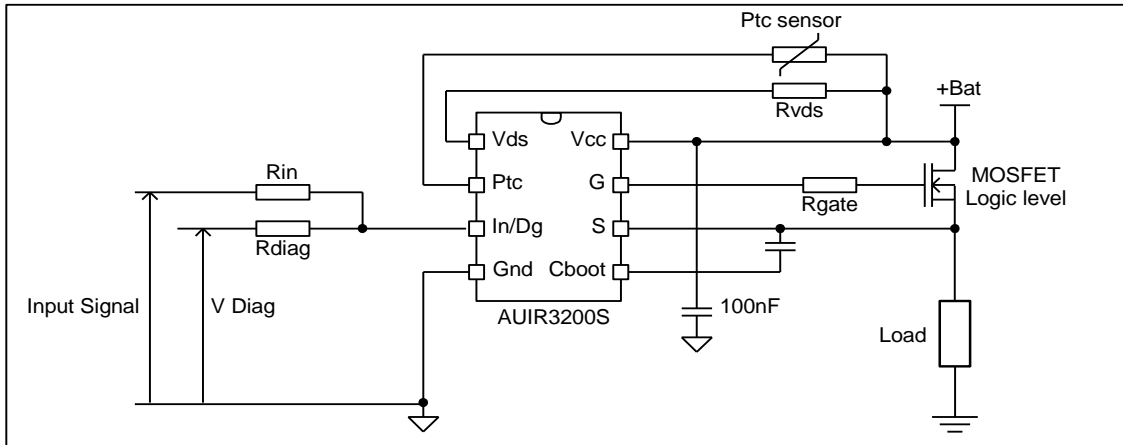


SO8

### Ordering Information

| Base Part Number | Package Type | Standard Pack |          | Complete Part Number |
|------------------|--------------|---------------|----------|----------------------|
|                  |              | Form          | Quantity |                      |
| AUIR3200S        | SOIC-8 leads | Tape and Reel | 2500     | AUIR3200STR          |

## Typical Connection



## Absolute Maximum Ratings

Absolute maximum ratings indicate sustained limits beyond which damage to the device may occur. All voltage parameters are referenced to Ground lead. (Tj = -40°C..150°C unless otherwise specified).

| Symbol     | Parameter                              | Min. | Max. | Units |
|------------|--|------|------|-------|
| Vcc-gnd    | Maximum Vcc voltage                    | -0.3 | 60   | V     |
| Vcc-Vds    | Maximum Vds pin voltage                | -0.3 | 5.5  |       |
| Vcc-Vptc   | Maximum Ptc pin voltage                | -0.3 | 5.5  |       |
| Vin-gnd    | Maximum IN pin voltage                 | -0.3 | 5.5  |       |
| Vcc-Vs     | Maximum S pin voltage                  | -0.3 | 60   |       |
| Vcboot-Vs  | Maximum Cboot pin voltage              | -0.3 | 8    |       |
| Vcc cont.  | Maximum continuous Vcc voltage         | —    | 36   | °C    |
| Tj max.    | Maximum operating junction temperature | -40  | 150  |       |
|            | Maximum storage temperature            | -55  | 150  |       |
| Tsoldering | Soldering temperature (10 seconds)     | —    | 300  |       |

## Thermal Characteristics

| Symbol | Parameter                              | Typ. | Max. | Units |
|--------|--|------|------|-------|
| Rth    | Thermal resistance junction to ambient | 100  | —    | °C/W  |

## Recommended Operating Conditions

| Symbol | Parameter                                    | Min. | Max. | Units |
|--------|--|------|------|-------|
| VIH    | High level input voltage                     | 2.7  | 5.5  | V     |
| VIL    | Low level input voltage                      | 0    | 0.9  |       |
| Rin    | Recommended resistor in series with IN pin   | 10   | 15   | kΩ    |
| Rdiag  | Recommended resistor in series with Diag pin | 4    | 15   |       |
| Rvds   | Maximum recommended Rvds, see page 7         | —    | 2.9  |       |

## Static Electrical Characteristics

T<sub>j</sub>=-40°C..125°C, V<sub>cc</sub>=6-36V (unless otherwise specified), typical value are given for V<sub>cc</sub>=14V and T<sub>j</sub>=25°C.

| Symbol               | Parameter   | Min. | Typ. | Max. | Units | Test Conditions   |
|----------------------|---|------|------|------|-------|---|
| V <sub>cc op.</sub>  | Operating voltage range   | 6    | —    | 36   | V     |   |
| I <sub>cc Off</sub>  | Supply current in sleep mode T <sub>j</sub> =25°C               | —    | 1    | 5    | μA    | V <sub>cc</sub> =14V, V <sub>in</sub> =0V   |
| I <sub>cc On</sub>   | Supply current when On  | —    | 10   | 15   | mA    | V <sub>in</sub> =5V, V <sub>ptc</sub> =V <sub>bat</sub> , V <sub>ds</sub> =V <sub>bat</sub> |
| V <sub>IH</sub>      | IN High threshold voltage                                       | —    | 2    | 2.6  | V     |   |
| V <sub>IL</sub>      | IN Low threshold voltage  | 0.5  | 1.7  | 2.1  |       |   |
| I <sub>n hyst.</sub> | Input hysteresis  | 0.2  | 0.5  | 1    |       |   |
| I <sub>in on</sub>   | On state input current  | —    | 33   | 50   | μA    | V <sub>in</sub> =5V   |
| V <sub>gs</sub>      | Gate output voltage   | 5    | 5.7  | 7    | V     | I <sub>gs</sub> =0μA  |
| V <sub>gs rev</sub>  | Gate output voltage during reverse battery T <sub>j</sub> =25°C | 4.5  | 5.6  | 7    |       | I <sub>gs</sub> =50μA, V <sub>bat</sub> =14V  |
| V <sub>in, off</sub> | Input voltage when the part is in fault mode                    | —    | 0.25 | 0.4  |       | I <sub>dg</sub> =300μA  |

## Protection Characteristics

T<sub>j</sub>=-40°C..125°C, V<sub>cc</sub>=6-36V (unless otherwise specified), typical value are given for V<sub>cc</sub>=14V and T<sub>j</sub>=25°C.

| Symbol                  | Parameter   | Min. | Typ. | Max. | Units | Test Conditions   |
|-------------------------|---|------|------|------|-------|---|
| I <sub>vds</sub>        | V <sub>ds</sub> current reference                                     | 0.7  | 0.8  | 0.91 | mA    | V <sub>cc</sub> -V <sub>ds</sub> =0V, T <sub>j</sub> =-40°C |
|                         |   | 0.84 | 0.93 | 1.05 |       | V <sub>cc</sub> -V <sub>ds</sub> =0V, T <sub>j</sub> =25°C  |
|                         |   | 1    | 1.15 | 1.33 |       | V <sub>cc</sub> -V <sub>ds</sub> =0V, T <sub>j</sub> =125°C |
| V <sub>ds offset</sub>  | V <sub>ds</sub> comparator offset                                     | -10  | 0    | 10   | mV    |   |
| T <sub>blank on</sub>   | V <sub>ds</sub> detection blanking time during turn on                | 15   | 22   | 35   | μs    |   |
| T <sub>diag</sub>       | Diagnostic time   | —    | 10   | —    | ms    | see figure 6  |
| T <sub>sleep</sub>      | Time to enter in sleep mode   | 7    | 15   | 30   |       |   |
| T <sub>reset</sub>      | Time to enter in sleep mode and reset the fault                       | —    | 5    | —    |       |   |
| T <sub>wkp</sub>        | Time to leave the sleep mode  | —    | —    | 0.5  | μs    | R <sub>in</sub> =10k<br>see figure 7 & 8                    |
| T <sub>pwr on rst</sub> | Power on reset duration T <sub>j</sub> =25°C                          | 40   | 100  | 200  |       |   |
| UV                      | Under voltage threshold   | —    | 5.2  | 5.9  | V     |   |
| T <sub>UV hold</sub>    | Time to keep UV detection active                                      | 150  | 350  | 600  | μs    |   |
| P <sub>tc_sensor</sub>  | Ptc sensor threshold value when over temperature                      | 1.3  | 5    | 14.3 | kΩ    | see page 2 & 8  |
| R <sub>ptc</sub>        | Pull down resistor on the PTC pin                                     | 4    | 10   | 20   |       | Built-in resistor<br>See page 6                             |
| V <sub>ptc</sub>        | PTC comparator voltage threshold (V <sub>cc</sub> -V <sub>ptc</sub> ) | 1.5  | 2    | 2.5  | V     | V <sub>in</sub> =5V, V <sub>cc</sub> =14V                   |

## Switching Characteristics

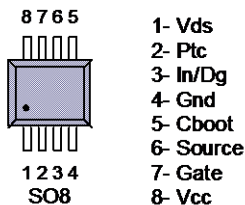
Tj=-40..125°C, Vcc=6..36V (unless otherwise specified), typical value are given for Vcc=14V and Tj=25°C.

| Symbol       | Parameter                         | Min. | Typ. | Max. | Units | Test Conditions       |
|--------------|-----------------------------------|------|------|------|-------|-----------------------|
| Tdon         | Turn-on delay to 20% of Vgs       | —    | 1.6  | —    | μs    | Qg=220nc,<br>Rgate=0Ω |
| Tr           | Rise time 20% to 80% of Vgs       | —    | 1    | —    |       |                       |
| Tdoff        | Turn off delay time to 80% of Vgs | —    | 2    | —    |       |                       |
| Tf           | Fall time from 80% to 20% of Vgs  | —    | 1    | —    | mA    | Vgs=0V                |
| Igs+         | Gate output high pulsed current   | 100  | 160  | —    |       | Vgs=5.7V              |
| Igs-         | Gate output low pulsed current    | 100  | 130  | —    |       |                       |
| Iboot        | Cboot capacitor charge current    | 0.35 | 0.8  | —    | A     |                       |
| Vboot-Source | Cboot capacitor charge voltage    | 5.6  | 6    | —    | V     |                       |

## True Table

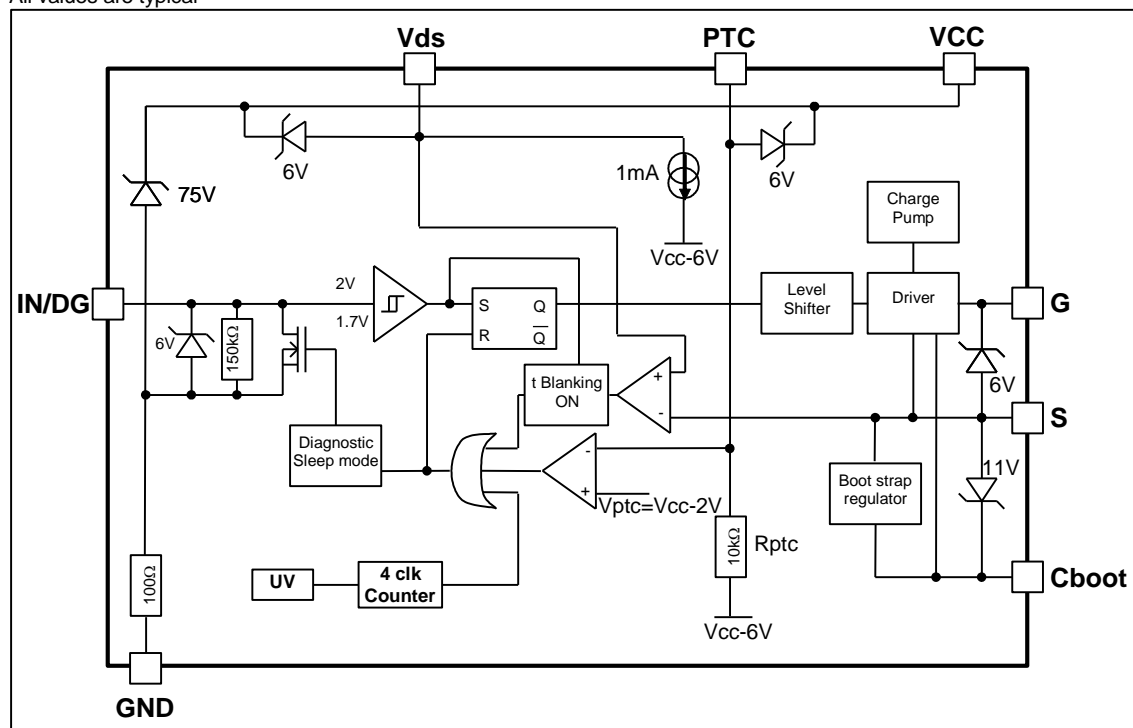
| Operating Conditions | IN | OUT | DG |
|----------------------|----|-----|----|
| Normal ON            | H  | H   | H  |
| Normal OFF           | L  | L   | L  |
| Short circuit to Gnd | H  | L   | L  |
| Short circuit to Gnd | L  | L   | L  |
| Over-temperature     | H  | L   | L  |
| Over-temperature     | L  | L   | L  |

## Lead Assignments



## Functional Block Diagram

All values are typical



## Over-current protection

The over-current protection is done by monitoring the Vds voltage of the Mosfet.

The threshold is adjusted by connecting the appropriate resistor between Vcc and Vds pin => Rvds.

Below the formula to set the appropriate over-current threshold:

$$I_{sd\_threshold} = \frac{I_{vds} \times R_{vds}}{R_{dsOn}}$$

We advise to you to take low tolerance resistor for Rvds for optimize the precision of your current level protection.

The AUIR3200S doesn't have feedback of the Mosfet temperature. We take in the consideration that Tcase of AUIR3200S will be almost the same like the Tcase of Mosfet. The current Ivds has a positive temperature coefficient to compensate the positive temperature coefficient of the RdsOn of the Mosfet.

The above formula is only valid when the Mosfet is fully ON. Therefore during the turn on of the MOSFET, the time 'Tblank on' disables the vds protection until the Mosfet is fully ON.

Therefore a maximum resistor is specified for Rvds in the recommended section. With a higher resistor, the part will latch.

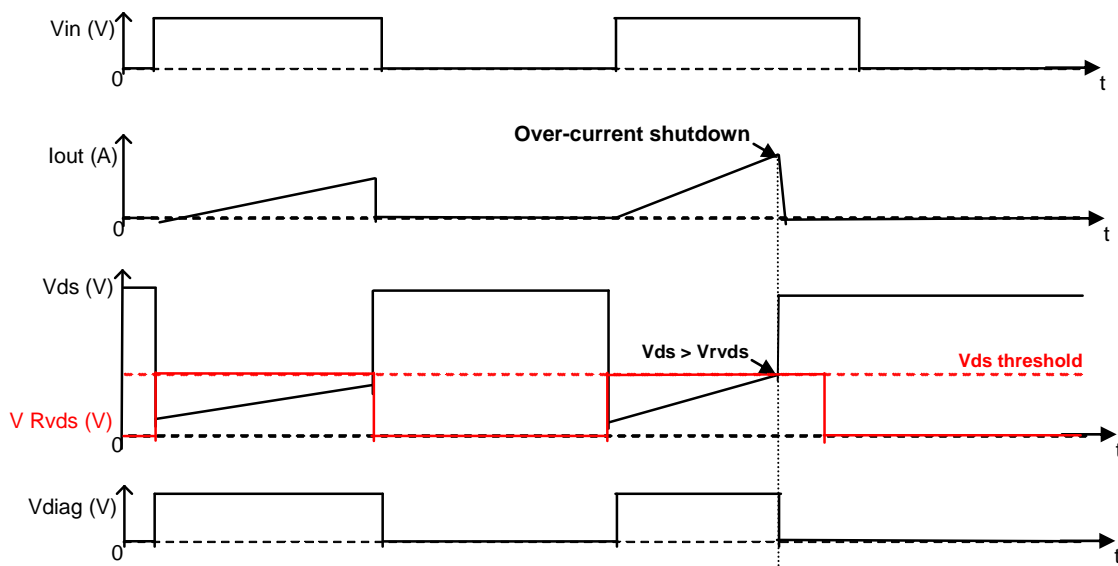
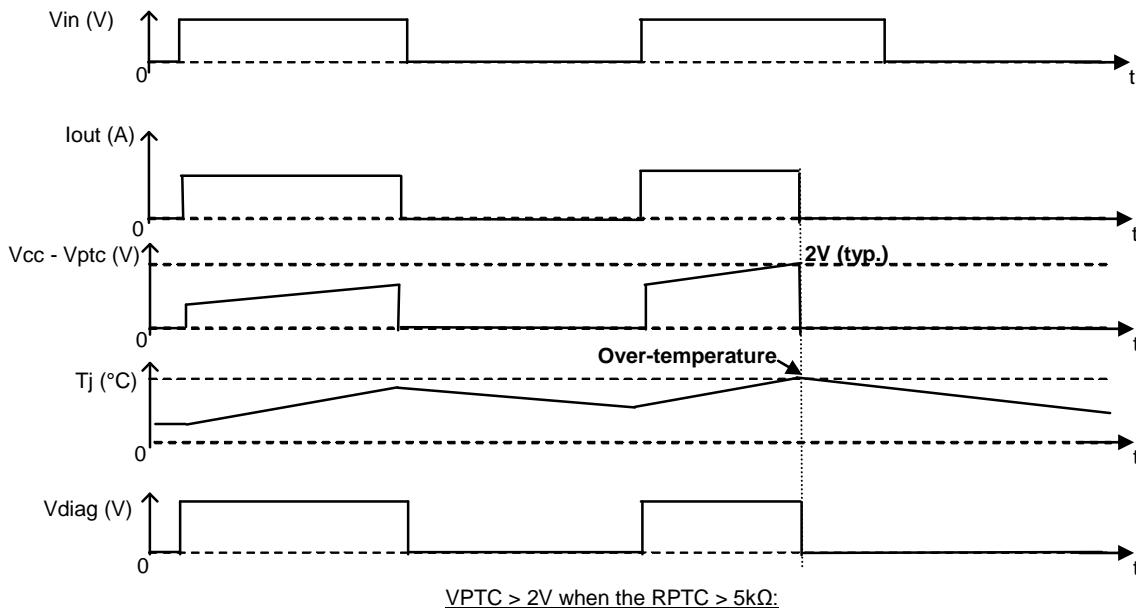


Figure 1: Protection Vds

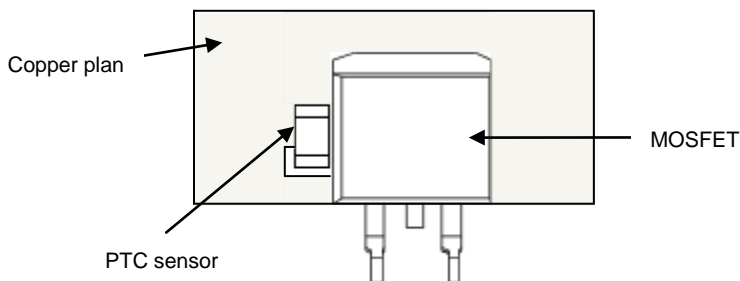
## Over-temperature protection

The temperature protection uses a PTC sensor connected to the tab or the drain of the Mosfet depending on the mounting. This sensor will increase with the temperature. When his value is above 5k $\Omega$  (typical value) the protection will be activated.



**Figure 2: Protection PTC**

For optimize the precision of the protection it is important to maximize the thermal interface between the sensor and the junction. The PTC sensor needs to be placed the closest possible of the MOSFET and to be surrounded by copper. The connection with AUIR3200S could be doing by a trace in bottom side of the PCB.



**Figure 3: Layout example (top side)**



The PTC protection could be activated if PTC sensor is higher than  $1.3\text{k}\Omega$  (see page 4: 'Ptc sensor' characteristic).

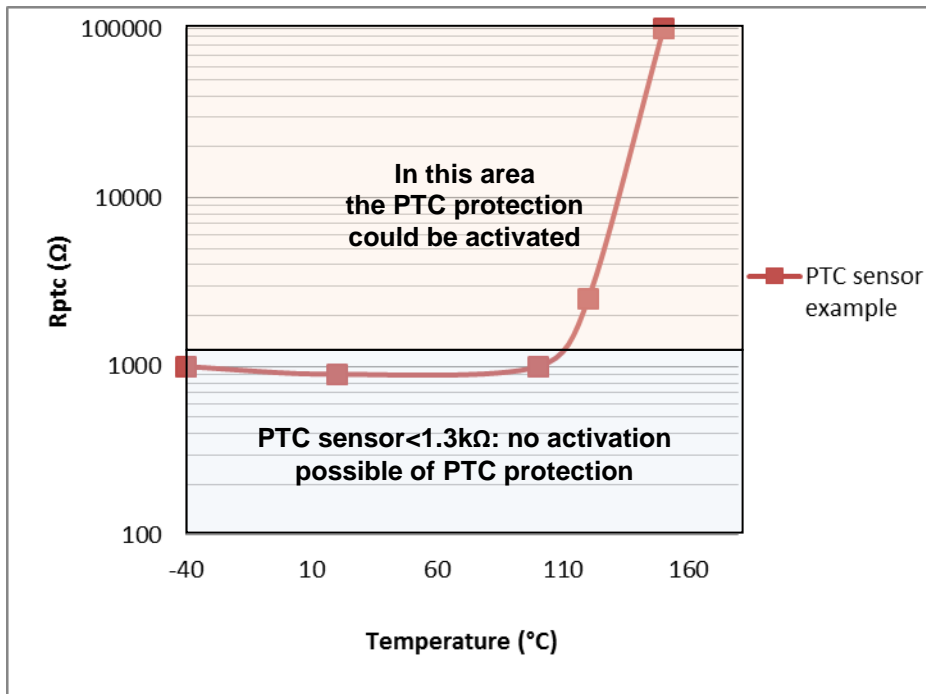


Figure 4: Typical PTC curve (R<sub>ptc</sub> vs Temperature)

## Protection evaluation

The PTC sensor, the  $V_{ds}$  threshold and the Mosfet must be chosen in order to not exceed the maximum junction temperature of the Mosfet during a short circuit.

Protection is evaluated by switching the Mosfet on different currents and by evaluating the junction temperature when the Mosfet is switched off by the protections.

This evaluation gives the following drawing.

- For high impedance short circuit,  $V_{ds}$  is smaller than  $V_{ds}$  threshold, so the over-temperature will act.
- For low impedance short circuit, the  $V_{ds}$  protection will switch off the Mosfet.

At the transition current between the 2 protections the junction temperature of the Mosfet is the maximum and should be lower than the maximum rating.

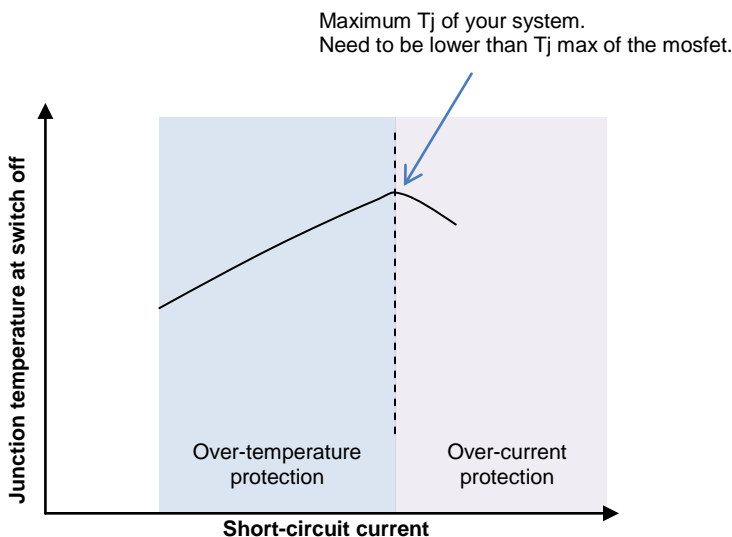


Figure 5: Protection evaluation

## Sleep\_mode / Diagnostic

Sleep\_mode block manages the diagnostic and the sleep\_mode. The device enters in sleep mode if input is inactive during a delay higher than  $T_{sleep}$ .

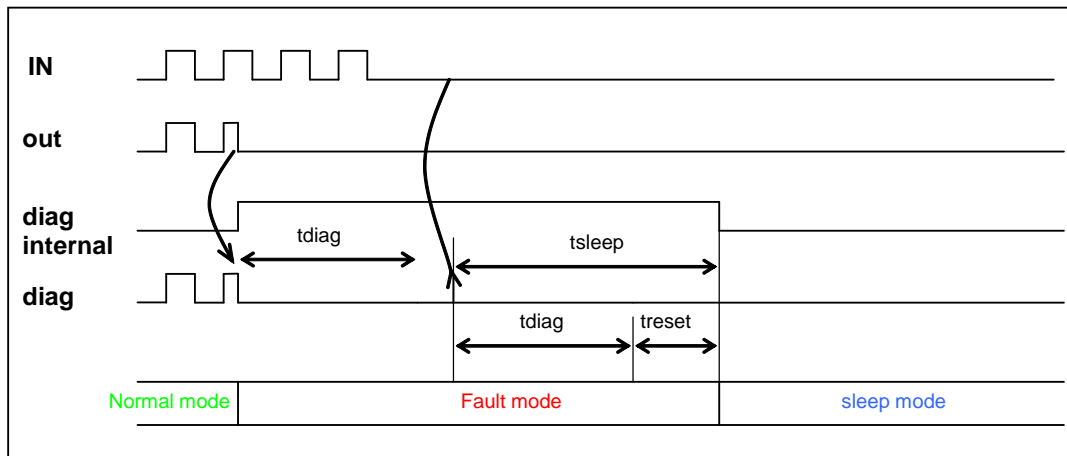


Figure 6

## Wake up sequence

To wake up the part from the sleep mode, the input must be activated at least during  $T_{wkp}$ , then the bootstrap regulator is switched on and the bootstrap capacitor is charged. The output will not be activated during  $T_{pw}$  on rst.

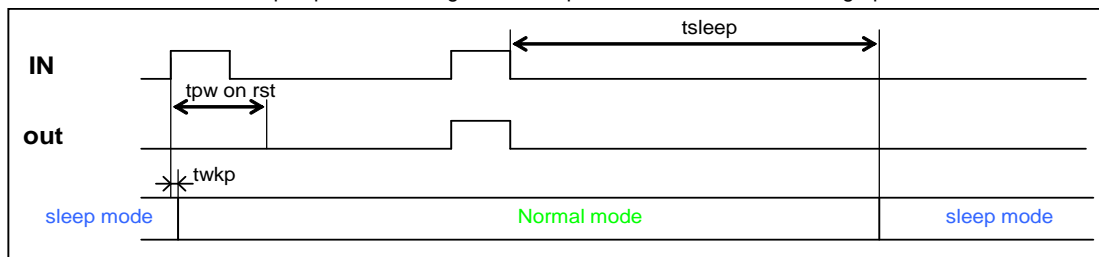


Figure 7

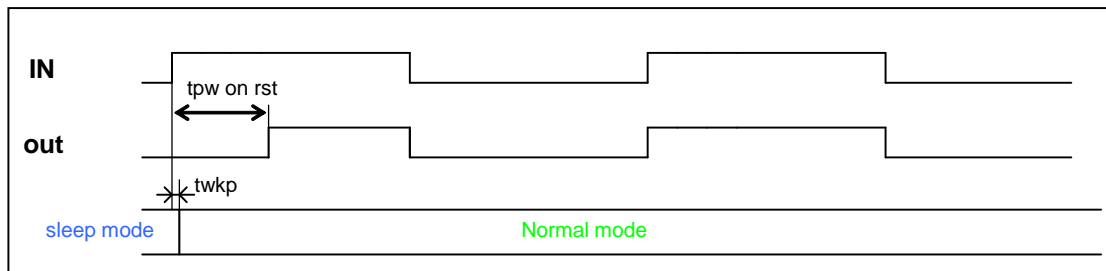


Figure 8

## Bootstrap

The bootstrap capacitor provides the necessary current to the driver in order to charge the gate mosfet capacitor to the right voltage level.

A design rule to select the bootstrap capacitor value is to choose 10 times the gate capacitance.

You can find in the Mosfet datasheet 'Qg max' for a specific Vgs.

Below the formula to set the appropriate Cboot value:

$$C_{boot} = 10 \times \frac{Q_{g \max}}{V_{gs}}$$

The AUIR3200S integrates a bootstrap regulator to maintain a fixed voltage (Vboot=6V) on the bootstrap capacitor for any battery voltage.

The regulator is off during the sleep mode to reduce the current consumption.

The power on reset is necessary to charge the bootstrap capacitor before turns on the power mosfet. The bootstrap capacitor gets its charge through the load. So the time to charge it depends of the load.

But the power on reset doesn't monitor the bootstrap capacitor voltage. Its time is set internally to allow starting the most of load without implement a special sequence:

The power on reset is long enough to charge the bootstrap capacitor before turns on the power mosfet.

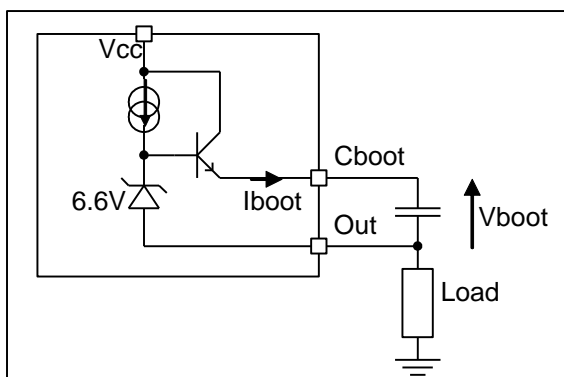


Figure 9

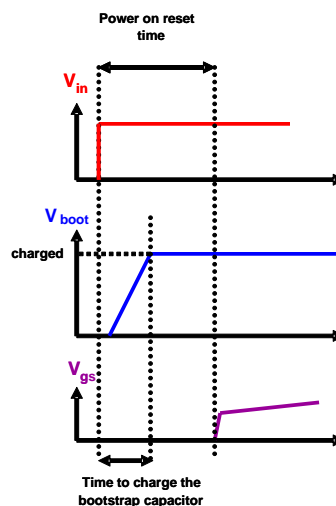


Figure 10

If the inductance of the load is too important, the power on reset is not enough long to charge completely the bootstrap capacitor before turns on the power mosfet.

So the micro-processor need to implement a special sequence to start the device without activates the output power mosfet.

The micro-processor send one short pulse ( $T_{wkp\ max} < \text{short pulse} < T_{pwr\_on\_rst\ min}$ ) then wait for the bootstrap capacitor is totally charged and after provide the appropriate duty cycle.

The bootstrap charge depends of the battery voltage, the bootstrap capacitor value and the inductance load value.

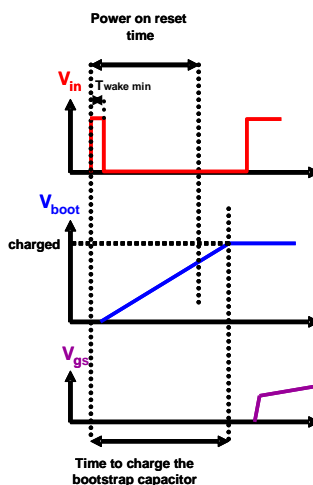
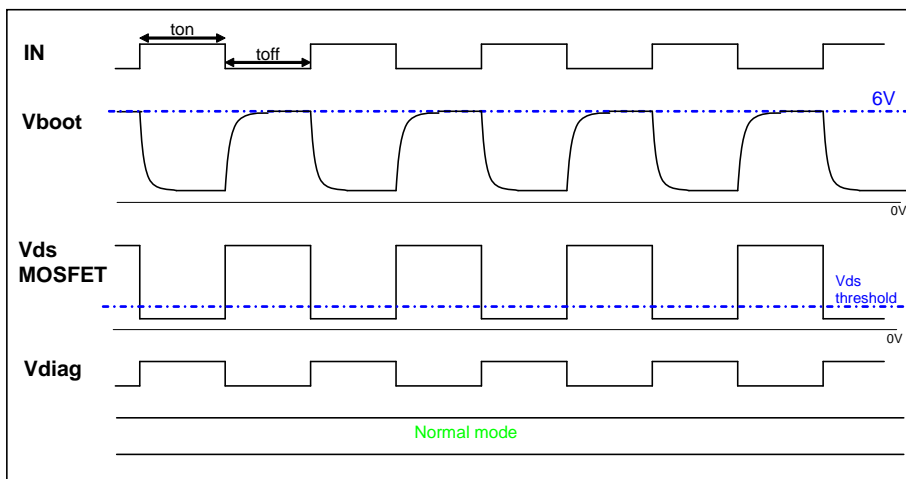


Figure 11

## IN frequency and duty cycle

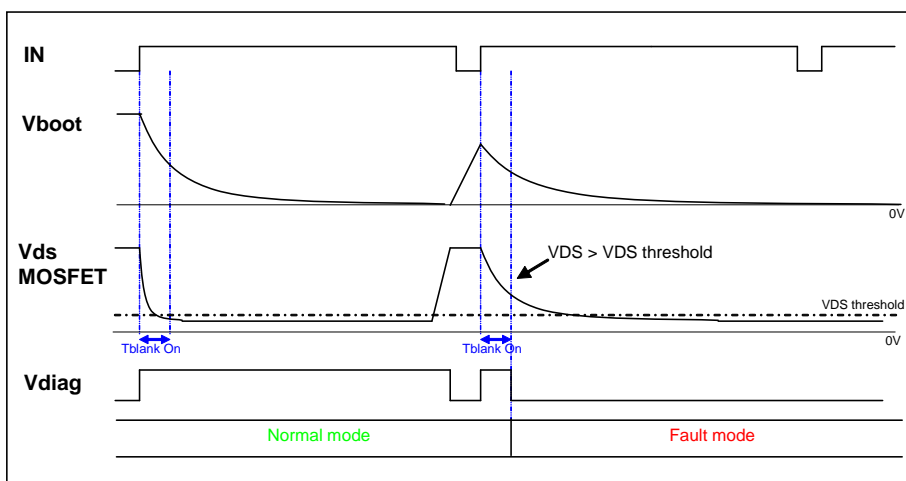
The  $V_{ds}$  protection is not active if the time ON is lower than  $T_{blank\ on}$ .  
So the minimum time ON ( $t_{on}$ ) is ' $T_{blank\ on\ max}$ ' to be sure that this protection will be active.

The times OFF ( $t_{off}$ ) needs to be setup for assure that the capacitor bootstrap will be recharged up to 6V. The bootstrap time charge depends of the bootstrap capacitor value and the inductance load value.



**Figure 12**

If the capacitor is discharged at the turn ON of the MOSFET, the AUIR3200S will detect a fault (VDS protection) after  $T_{blank\ ON}$  because the MOSFET won't be fully ON.



**Figure 13**

## Under voltage protection in short-circuit mode

During short circuit condition, it may happen that the supply voltage drops below the under voltage before the short is detected by the  $V_{ds}$  protection due to the blanking time 'Tblank on'.

In under voltage condition the AUIR3200S turns off the MOSFET. The time 'Tblank On' is reset.

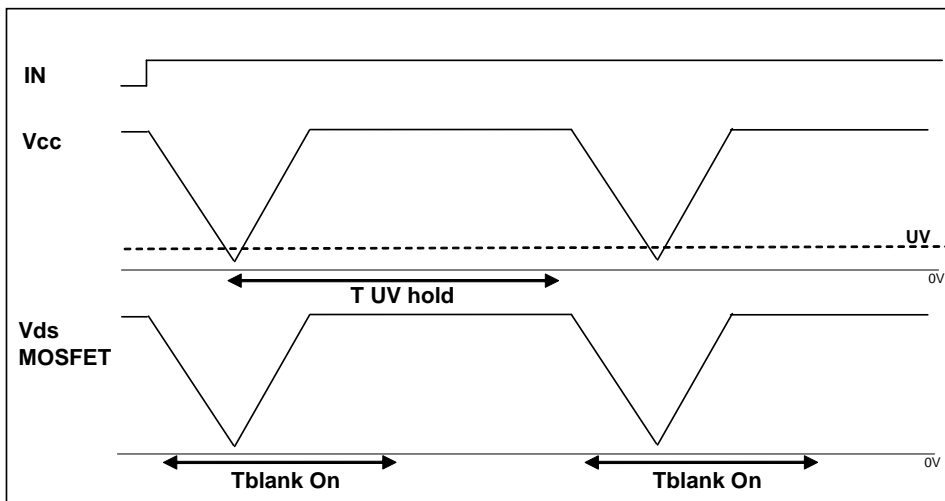


Figure 14

In order to detect the short circuit condition, the AUIR3200S has a counter and after 4 'under voltage' detections, the part is latched and the fault diagnostic is activated. The counter is reset when the part goes to sleep mode.

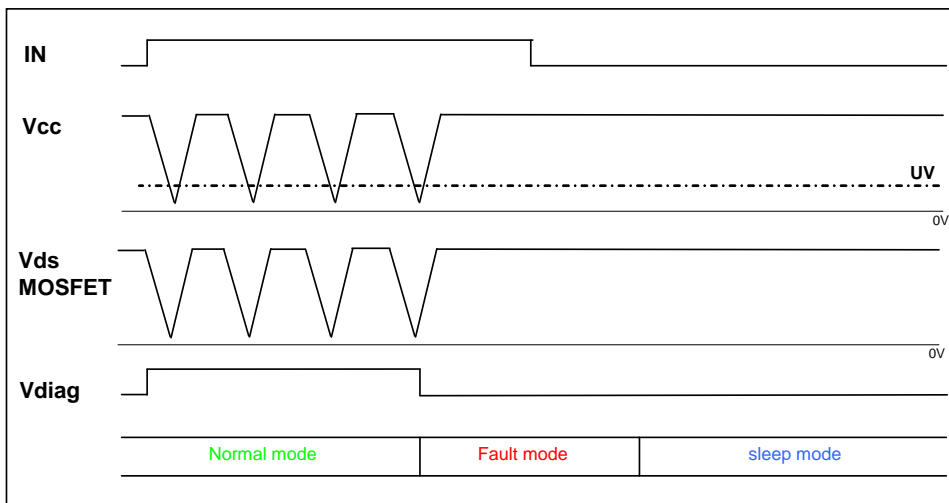
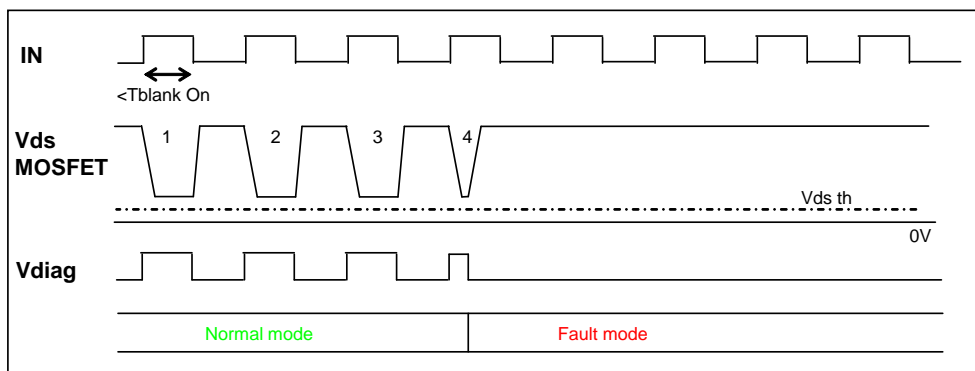


Figure 15

## PWM operation ( $T_{on} < T_{blank\ on}$ )

PWM operation is also possible. The bootstrap feature allows fast switching. When the  $T_{on}$  is shorter than the  $T_{blank\ on}$ , the  $V_{ds}$  protection is no longer activated. In order to protect the Power Mosfet, the AUIR3200S integrates a counter which is incremented by the input signal and reset when the  $V_{ds}$  voltage is below the  $V_{ds}$  threshold. The counter latches off the AUIR3200S after 4 activations. During PWM operation (  $T_{on} < T_{blank\ on}$  ) on a short circuit, the  $V_{ds}$  is always above the  $V_{ds}$  threshold and 4 activations on the input will latch the AUIR3200S and the fault diagnostic is activated.



**Figure 16**



## Parameters curves: typical value

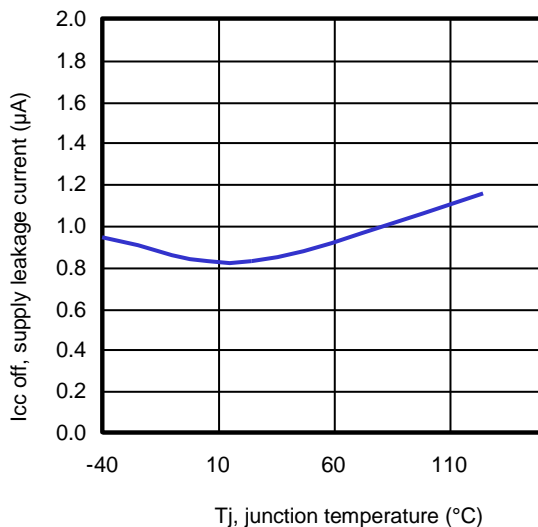


Figure 17:  $I_{cc\ off}$  ( $\mu A$ ) Vs  $T_j$  ( $^{\circ}C$ ) ( $V_{cc}=14V$ ,  $V_{in}=0V$ )

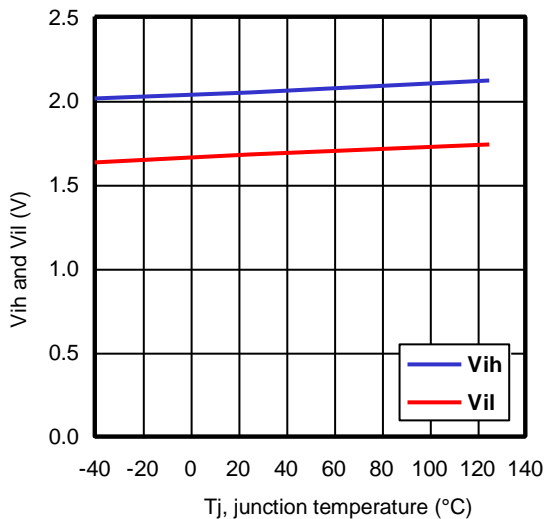


Figure 18:  $V_{ih}$  and  $V_{il}$  (V) Vs  $T_j$  ( $^{\circ}C$ )

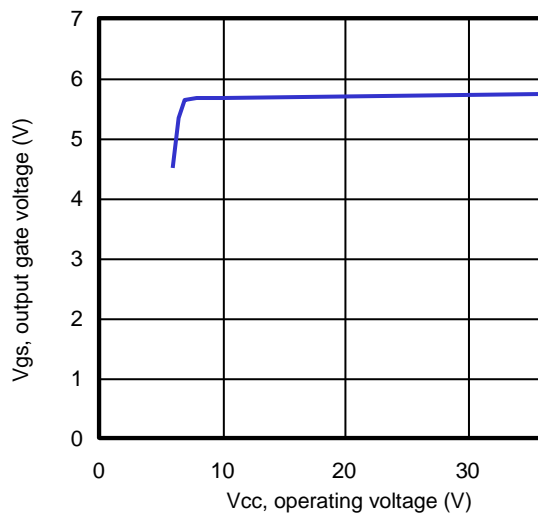
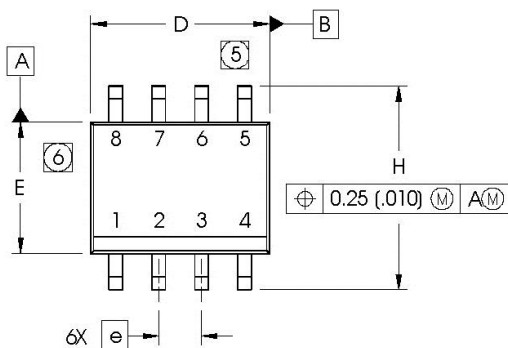


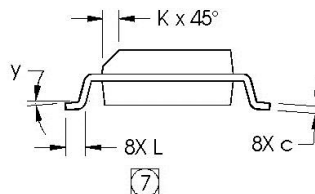
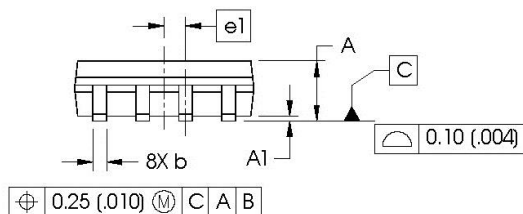
Figure 19:  $V_{gs}$  vs  $V_{cc}$  with  $I_{vgS}=50\mu A$

## Case Outline – SO8

Dimensions are shown in millimeters (inches)

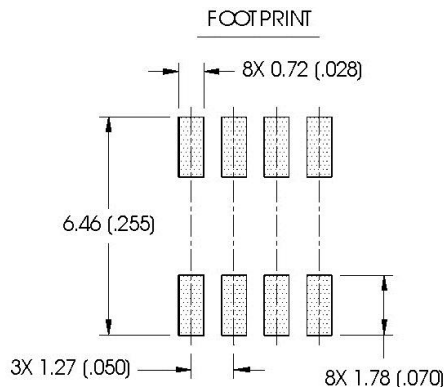


| DIM | INCHES     |       | MILLIMETERS |      |
|-----|------------|-------|-------------|------|
|     | MIN        | MAX   | MIN         | MAX  |
| A   | .0532      | .0688 | 1.35        | 1.75 |
| AI  | .0040      | .0098 | 0.10        | 0.25 |
| b   | .013       | .020  | 0.33        | 0.51 |
| c   | .0075      | .0098 | 0.19        | 0.25 |
| D   | .189       | .1968 | 4.80        | 5.00 |
| E   | .1497      | .1574 | 3.80        | 4.00 |
| e   | .050 BASIC |       | 1.27 BASIC  |      |
| e1  | .025 BASIC |       | 0.635 BASIC |      |
| H   | .2284      | .2440 | 5.80        | 6.20 |
| K   | .0099      | .0196 | 0.25        | 0.50 |
| L   | .016       | .050  | 0.40        | 1.27 |
| y   | 0°         | 8°    | 0°          | 8°   |

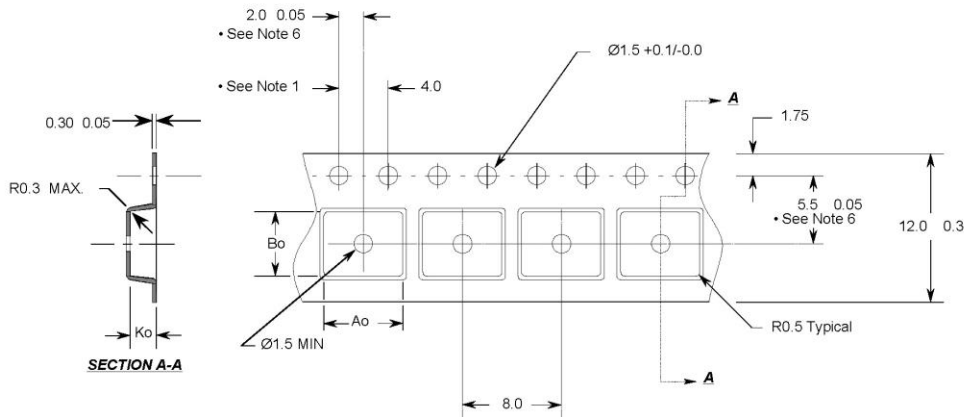


### NOTES:

1. DIMENSIONING & TOLERANCING PER ASME Y14.5M-1994.
2. CONTROLLING DIMENSION: MILLIMETER
3. DIMENSIONS ARE SHOWN IN MILLIMETERS (INCHES).
4. OUTLINE CONFORMS TO JEDEC OUTLINE MS-012AA.
5. DIMENSION DOES NOT INCLUDE MOLD PROTRUSIONS. MOLD PROTRUSIONS NOT TO EXCEED 0.15 (.006).
6. DIMENSION DOES NOT INCLUDE MOLD PROTRUSIONS. MOLD PROTRUSIONS NOT TO EXCEED 0.25 (.010).
7. DIMENSION IS THE LENGTH OF LEAD FOR SOLDERING TO A SUBSTRATE.



## Tape & Reel SO8



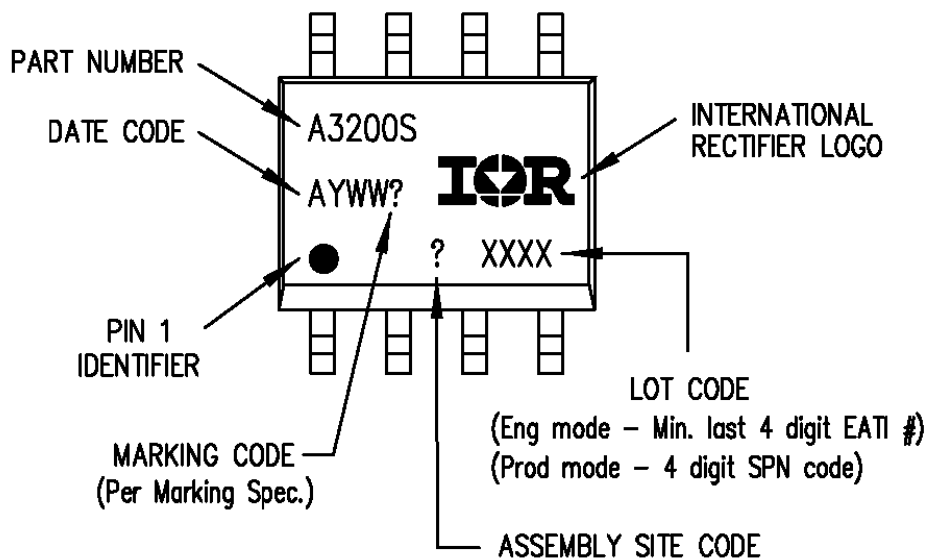
### Notes:

1. 10 sprocket hole pitch cumulative tolerance 0.2
2. Camber not to exceed 1mm in 100mm
3. Material: Black Conductive Advantek Polystyrene
4. Ao and Bo measured on a plane 0.3mm above the bottom of the pocket
5. Ko measured from a plane on the inside bottom of the pocket to the top surface of the carrier.
6. Pocket position relative to sprocket hole measured as true position of pocket, not pocket hole.

Ao = 6.4 mm  
Bo = 5.2 mm  
Ko = 2.1 mm

- All Dimensions in Millimeters -

## Part Marking Information



## TOP MARKING (LASER)

## Qualification Information<sup>†</sup>

|                                   |                      |   |   |
|-----------------------------------|----------------------|---|---|
| <b>Qualification Level</b>        |                      | Automotive<br>(per AEC-Q100)  |   |
|                                   |                      | Comments: This family of ICs has passed an Automotive qualification. IR's Industrial and Consumer qualification level is granted by extension of the higher Automotive level. |   |
| <b>Moisture Sensitivity Level</b> |                      | SOIC8N  | MSL2 260°C<br>(per IPC/JEDEC J-STD-020) |
| <b>ESD</b>                        | Machine Model        | Class M1B(+/-100V)<br>(per AEC-Q100-003)  |   |
|                                   | Human Body Model     | Class H1C (+/-1500V)<br>(per AEC-Q100-002)  |   |
|                                   | Charged Device Model | Class C4 (+/-1000V)<br>(per AEC-Q100-011)   |   |
| <b>IC Latch-Up Test</b>           |                      | Class II, Level A<br>(per AEC-Q100-004)   |   |
| <b>RoHS Compliant</b>             |                      | Yes   |   |

†

Qualification standards can be found at International Rectifier's web site <http://www.irf.com/>

**Published by**  
**Infineon Technologies AG**  
**81726 München, Germany**  
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**Revision History**

| <b>Revision</b> | <b>Date</b>                      | <b>Notes/Changes</b>  |
|-----------------|----------------------------------|---|
| A               | November, 2 <sup>nd</sup> 2012   | Initial release   |
| B               | January, 3 <sup>rd</sup> 2013    | Add max Rvds  |
| D               | April, 24 <sup>th</sup> 2015     | Add 'Rptc sensor' parameter<br>Add explanation for current protection<br>and temperature protection |
| E1              | June, 3 <sup>th</sup> 2015       | Add Vgs max and Vgs rev max   |
| E3              | September, 24 <sup>th</sup> 2015 | IFX template  |
| E4              | October, 2 2015                  | Twkp max added  |
| 1.1             | May 02, 2016                     | Ground loss protection<br>Update revision name  |

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