LOW QUIESCENT CURRENT BACK TO BACK MOSFET DRIVER

Features

- Very low quiescent current on and off state
- Back to back configuration
- Boost converter with integrated diode
- Standard level gate voltage
- Input active high and 3.3V compatible
- Under voltage lockout with diagnostic
- Wide operating voltage 3-36V
- Ground loss protection
- Lead-Free, Halogen Free, RoHS compliant

Applications

- Power switch for Stop and Start board net stabilizer
- Battery switch

Product Summary

Operating voltage 3-36V
Vgate 11.5V min.
I Vcc average On 45µA max. at 25°C
I Vcc average Off 35µA max. at 25°C

Package

SO8

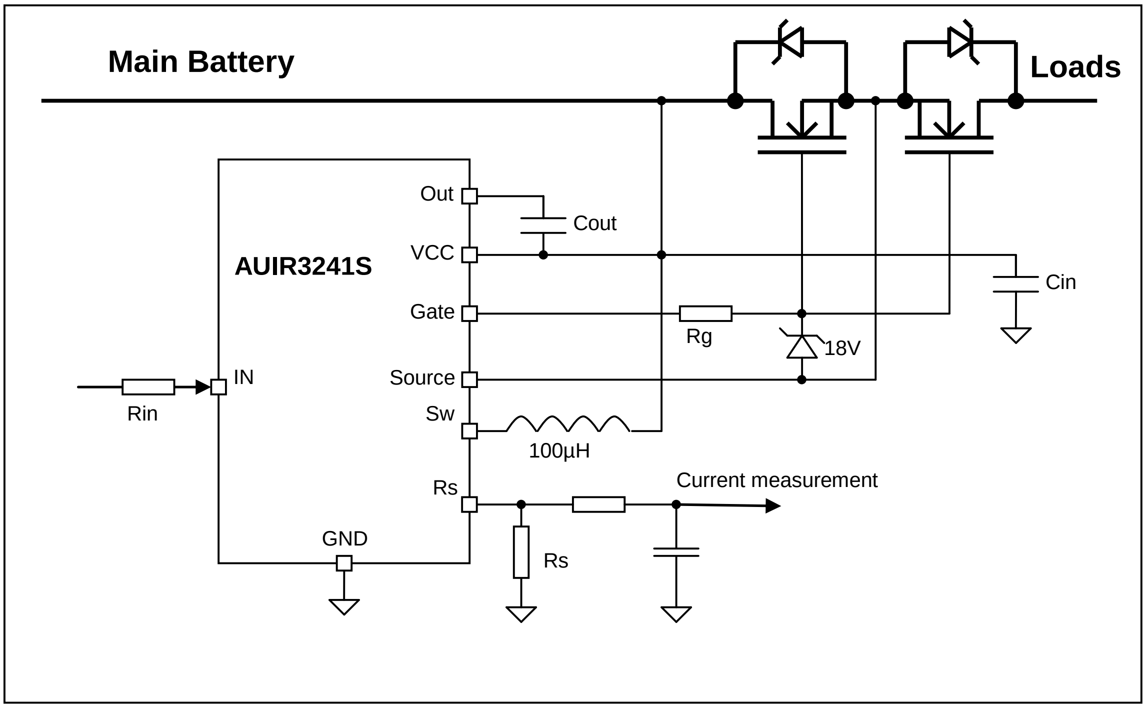
Description

The AUIR3241S is a high side Mosfet driver for back to back topology targeting back to back switch. It features a very low quiescent current both on and off state. The AUIR3241S is a combination of a boost DC/DC converter using an external inductor and a gate driver. It drives standard level Mosfet even at low battery voltage. The input controls the gate voltage. The AUIR3241S integrates an under voltage lock out protection to prevent to drive the Mosfet in linear mode.

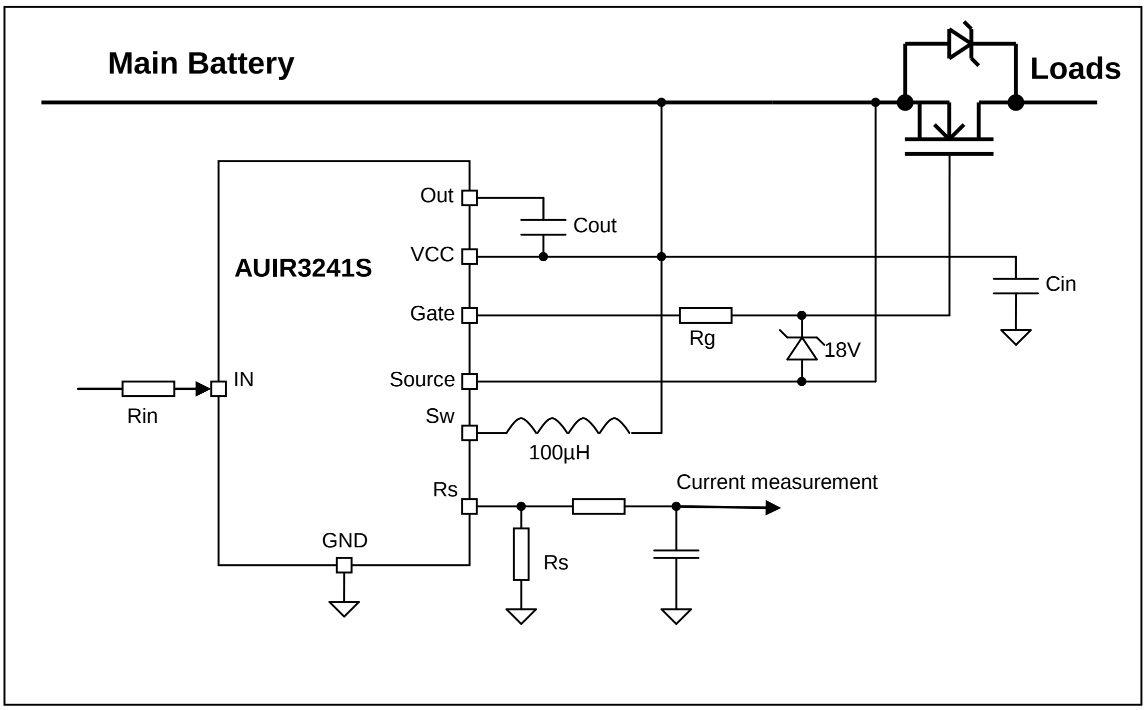
Ordering Information

Base Part Number	Package Type	Standard Pack		Complete Part Number
		Form	Quantity	
AUIR3241S	SOIC8	Tape and reel	2500	AUIR3241STR

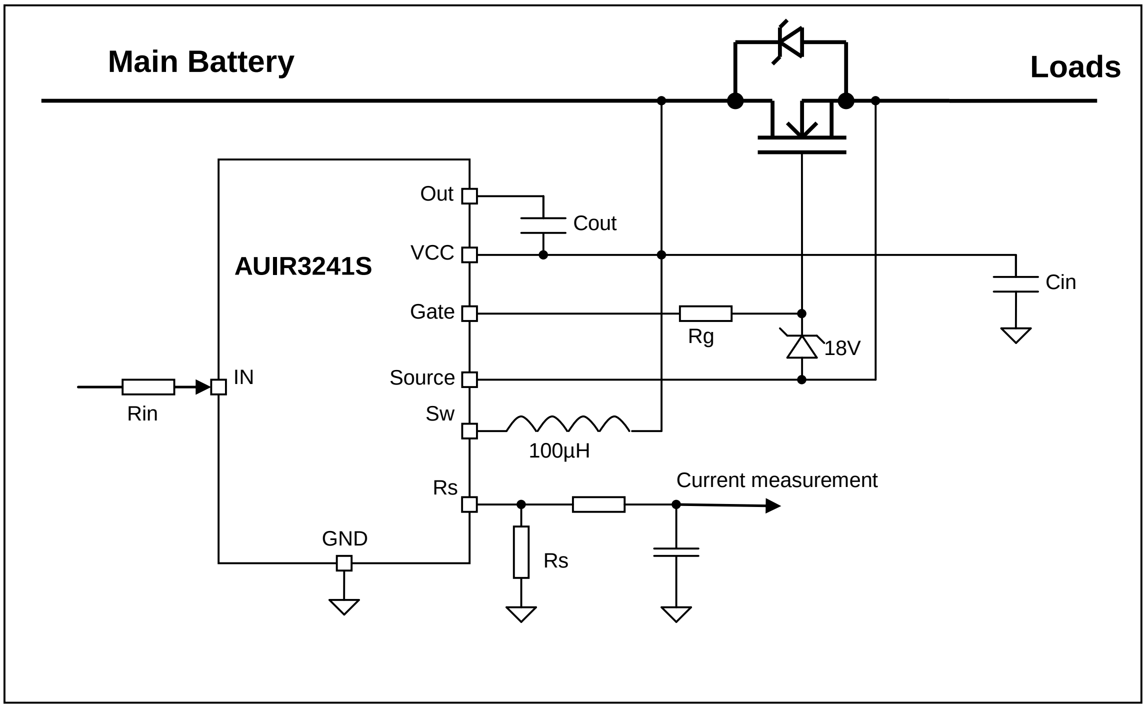
Typical Connection – Back to Back



Typical Connection – Q_diode



Typical Connection – Battery switch



Absolute Maximum Ratings

Absolute maximum ratings indicate sustained limits beyond which damage to the device may occur.

Symbol	Parameter	Min.	Max.	Units
Vcc-gnd	Maximum Vcc voltage	-0.3	65	V
Vsw-gnd	Maximum Sw voltage	Vrs-0.3	Vout+Vf	
Vsw-Vrs	Maximum Sw voltage	-0.3	65	
Vout-Vcc	Maximum Vout-Vcc voltage	-0.3	65	
Vout-gnd	Maximum Vout voltage	-0.3	65	
Vout-Vgate	Maximum Vout-Vgate voltage	-0.3	65	
Vgate-Vsource	Maximum Vgate-Vsource voltage	-0.3	75	
Vout-Vsource	Maximum Vout-Vsource voltage	-0.3	75	
Vrs-gnd	Maximum Rs pin voltage	-0.3	6	
Vin-gnd	Maximum IN pin voltage	-0.3	Vout+0.3	
Isw	Maximum continuous current in Sw pin	—	200	mA
ID	Maximum continuous current in the rectifier diode	—	200	
Rg	Minimum gate resistor	100	—	Ohm
Tj max.	Maximum operating junction temperature	-40	150	°C
	Maximum storage temperature	-55	150	

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	2.5	5.5	V
VIL	Low level input voltage	0	0.8	

Static Electrical Characteristics

Tj=-40..125°C, Vcc=6..16V (unless otherwise specified), typical value are given for Vcc=14V and Tj=25°C.

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Vcc op (ext).	Supply voltage range for extended operation (some parameters may be downgraded beyond nominal operation)	3	—	36	V	See page 11
Vcc op (nom). [1]	Supply voltage range for nominal operation	6	—	16		
Iq Vcc Off [2]	Supply current when Off, Tj=25°C	—	2	6	µA	Vin=0V,K1/K2 off, K3 on, Vout-Vcc=14V
	Supply current when Off, Tj=125°C	—	3	8		
Iq Vcc On [2]	Supply current when On, Tj=25°C	—	3	6		Vin=5V,K1/K3 off, K2 on, Vout-Vcc=14V
	Supply current when On, Tj=125°C	—	4	8		
Iq Out Off [2]	Quiescent current on Out pin, Tj=25°C	—	10	15		Vin=0V,K1/K2 off, K3 on, Vout-Vcc=14V
	Quiescent current on Out pin, Tj=125°C	—	13	25		
Iq Out On [2]	Quiescent current on Out pin, Tj=25°C	—	12	20		Vin=5V,K1/K3 off, K2 on, Vout-Vcc=14V
	Quiescent current on Out pin, Tj=125°C	—	15	30		
Vbr Out	Breakdown voltage between Out and Source	75	90	—	V	I=10mA
Vbr Gate	Breakdown voltage between Gate and Source	75	90	—		I=10mA
OV	Over-voltage protection between Vout and Gnd	50	55	62		
Iin	Input current	—	3	6	µA	Vin=5V
Vin_th	Input voltage threshold	0.8	1.5	2.5	V	
Vout_th	Output voltage threshold	11.5	12.5	14		
UV_LO	Undervoltage lockout between Vout and Vcc	6.5	8	10		See figure 7
Vout_th–UV_LO	Output voltage minus Undervoltage lockout threshold	3	4.5	—		
Vrs th	Rs threshold	0.8	1	1.3		
I latch UV_LO	Under voltage lockout Latch current between Vout and Vcc	10	25	40	mA	See page 11
Vf	Forward voltage of rectifier diode	—	0.9	1.1	V	I=100mA, Tj=25°C
Rdson K1	Rdson of K1, Tj=-40°C	—	8	13	Ω	I=100mA, Vout-Vcc=12.5V
	Rdson of K1, Tj=25°C	—	11	15		
	Rdson of K1, Tj=125°C	—	15	20		
Rdson K2	Rdson of K2, Tj=25°C	—	25	—		I=100mA
Rdson K3	Rdson of K3, Tj=25°C	—	25	—		

(1) If the part is supply outside of this range (ex: during ramp up of Vcc), other values in this table might not be guaranteed
(2) Supply current might be higher than specified during the start-up of the part (especially during the charge of Cout)

Timing Converter Characteristics

Tj=-40..125°C, Vcc=6..16V (unless otherwise specified), typical value are given for Vcc=14V and Tj=25°C.

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Toff	Off time	2	3	4	µs	See figure 4
Tdon K1	Turn-on delay of K1	—	5	—		See figure 5
Tdoff K1	Turn-off delay of K1	—	0.2	—		
POR_Delay	Power On Reset delay	200	500	1200		See figure 10
POR_Th	Power On Reset threshold	6	6.5	7.5	V	

Switching Characteristics

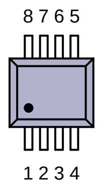
Tj=-40..125°C, Vcc=6..16V (unless otherwise specified), typical value are given for Vcc=14V and Tj=25°C.

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Tdon gate	Turn-on delay	0.5	1. 5	3	µs	
Tr gate	Rise time on gate 10% to 90% of Vout-Vcc	—	6	15		Cgate=100nF
Igate+	Gate high short circuit pulsed current	100	350	—	mA	Vgate-Vsource=0V
Tdoff gate	Turn-off delay	0.5	2	5	µs	
Tf gate	Fall time on gate 90% to 10% of Vout-Vcc	—	6	15		Cgate=100nF
Igate-	Gate low short circuit pulsed current	100	350	—	mA	Vgate-Vsource=14V
Treset	Time to reset the under voltage latches	—	1	100	µs	See page 11

Lead Definitions

Pin number	Symbol	Description
1	IN	Input pin
2	GND	Ground pin
3	RS	Current sense input pin
4	SW	Output of K1
5	Source	Connection of the source pin of the Mosfets
6	Gate	Output of the gate driver
7	Vcc	Power supply
8	Out	Output of the boost converter

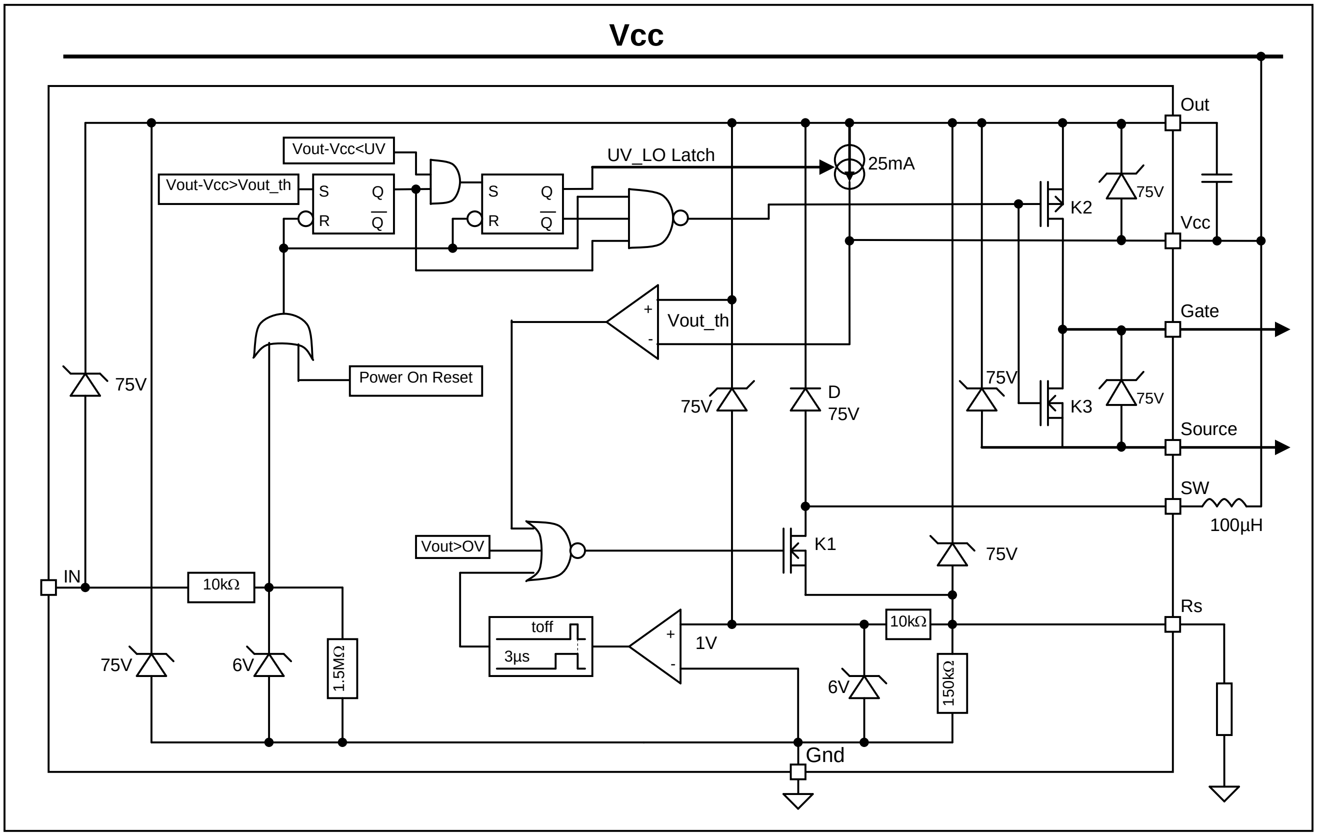
Lead Assignments



SO8

1- IN
2- GND
3- RS
4- SW
5- Source
6- Gate
7- Vcc
8- Out

Block diagram



Input Circuitry

The input control circuitry drives the output gate driver stage. The input is active high. With a low level input voltage, the gate is shorted to the source. With a high level input, the output gate driver turn on when Vout reaches Vout_th.

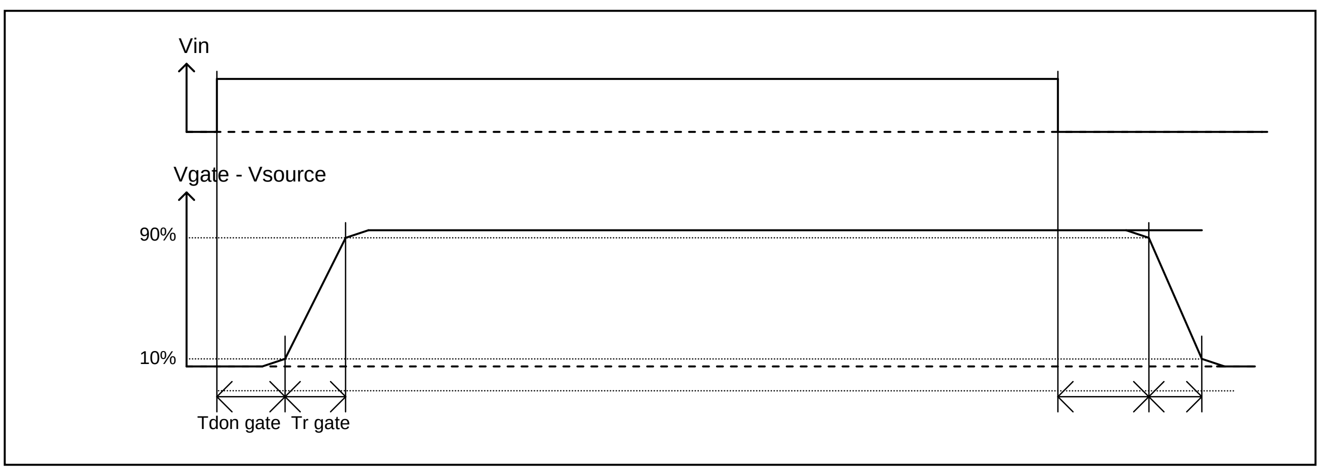


Figure 1

Description

The topology of the AUIR3241S is a boost DC/DC converter working in current mode. The DC/DC is working once the AUIR3241S is powered regardless the input level.
K1 is switched on when the gate voltage is lower than Vout threshold. When Rs pin reaches Vrs th, K1 is turned off and the inductor charges the Out capacitor through D. The system cannot restart during Toff after Vrs th has been reached. The DC/DC restart only when the Out and the Vcc voltage difference is lower than Vout_th in order to achieve low quiescent current on the power supply.
To turn off the power Mosfet, the input must be low. Then K2 is turned off and K3 shorts the gate to the source.

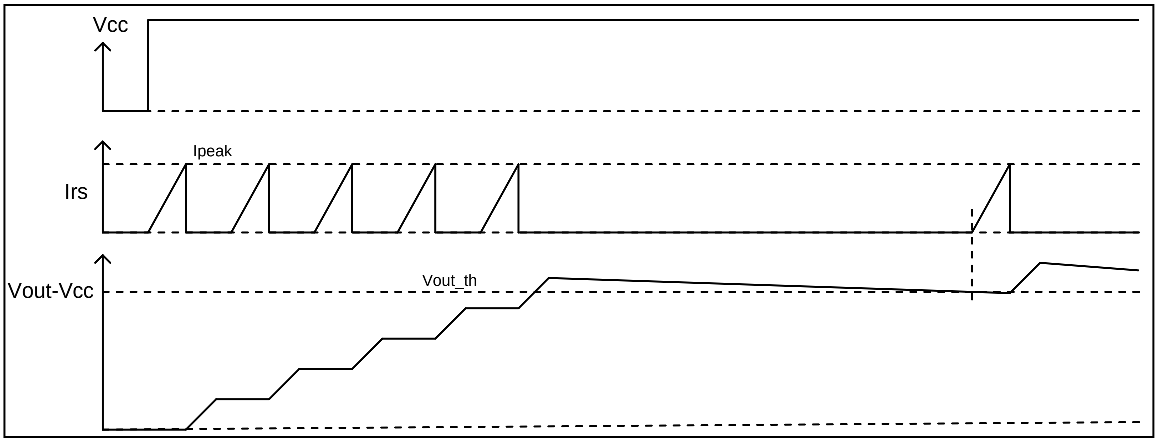


Figure 2

Parameters definition

Current definition

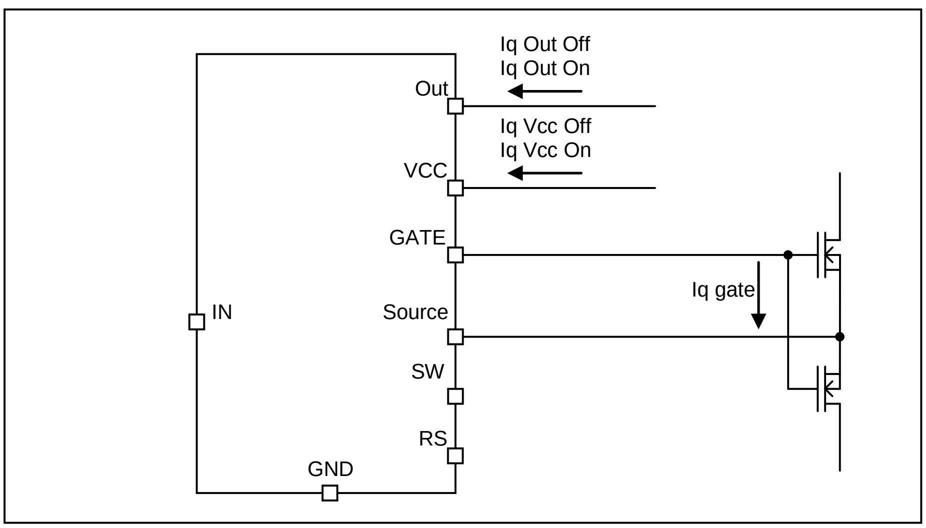


Figure 3

Timing definition

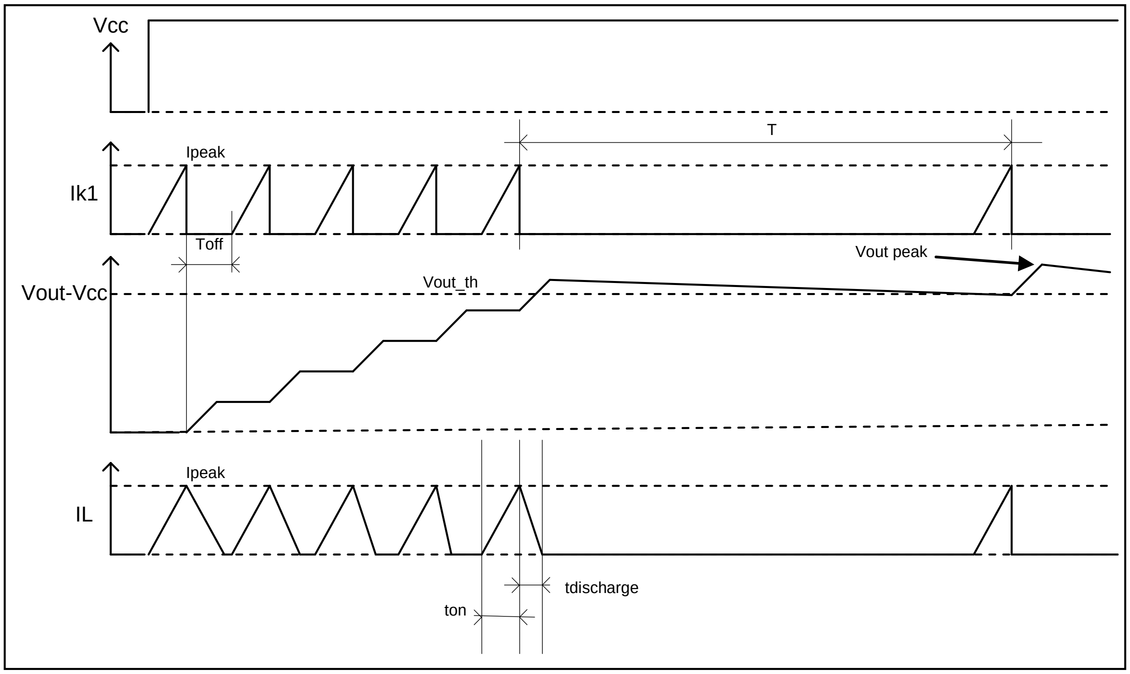


Figure 4

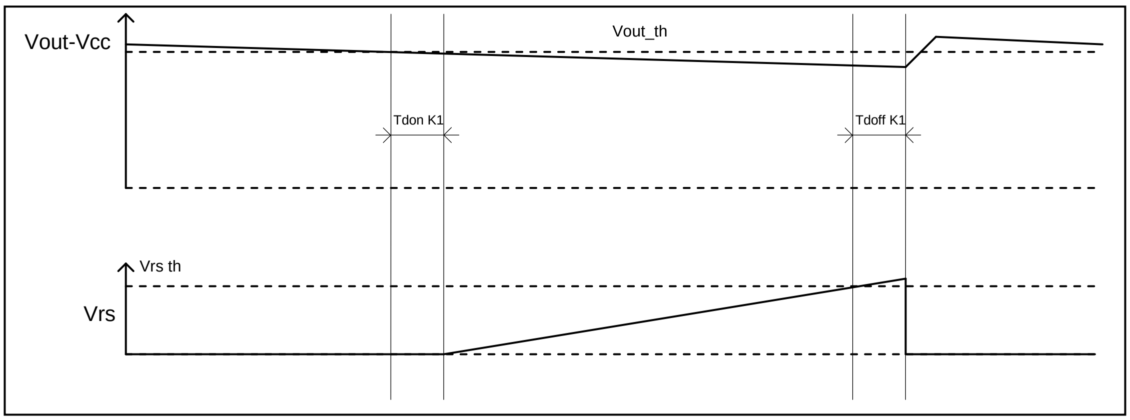


Figure 5

Low quiescent current operation when On.

The AUIR3241S is able to operate with a very low quiescent current on the Vcc pin. Nevertheless the supply current depends also on the leakage of the power mosfet named “Iq gate” on the diagram below.
The leakage current is given when K1 is off. When K1 is on, the current flowing in Vcc is the current charging the inductor. Therefore the average current on the Vcc is the combination of the current when K1 is ON and OFF. The average current on the Vcc pin can be calculated using:

$$\mathrm{I\ Vcc\ average\ on} = (\mathrm{Iq\ gate} + \mathrm{Iq\ Out\ On}) * \frac{\mathrm{Vout} - \mathrm{Vcc} + \mathrm{Vf}}{\mathrm{Vcc}} + \mathrm{Iq\ Vcc\ on} + \mathrm{Iq\ Out\ on}$$

$$\mathrm{I\ Vcc\ average\ off} = (\mathrm{Iq\ gate} + \mathrm{Iq\ Out\ Off}) * \frac{\mathrm{Vout} - \mathrm{Vcc} + \mathrm{Vf}}{\mathrm{Vcc}} + \mathrm{Iq\ Vcc\ off} + \mathrm{Iq\ Out\ off}$$

With Vout: the average voltage on the output.
$\mathrm{Vout\ average} = (\mathrm{Vout\ peak} + \mathrm{Vout\ th})/2$

Vout peak can be calculated by:

$$\mathrm{Vout\ peak} = \sqrt{\frac{\mathrm{L}}{\mathrm{Cout}} . \mathrm{Ipeak}^2 + \mathrm{Vout\ th}^2}$$

During On operation, the DC/DC works in pulse mode, meaning each time the Vout-Vcc voltage comes below 12.5V, the AUIR3241S switches on K1 to recharge the gate voltage. When the Iout leakage is low enough to maintain the DC/DC in discontinuous mode, the frequency is calculate by:

$$\mathrm{T} = \frac{\mathrm{Ipeak}^2 * \mathrm{L}}{2 * (\mathrm{Iq\ gate} + \mathrm{Iq\ Vout\ on}) * (\mathrm{Vout} - \mathrm{Vcc} + \mathrm{Vf})}$$

Peak current control

The current in the inductor is limited by the 1V comparator which monitors the voltage across Rs. Due to the delay in the loop (tdoff K1), the inductor current will exceed the threshold set by: $\frac{\mathrm{Vrsth}}{\mathrm{Rs}}$

At low voltage, the current waveform in the inductor is not anymore linear, but exponential because the sum of the resistor of K1, the inductor and RS are not any more negligible.

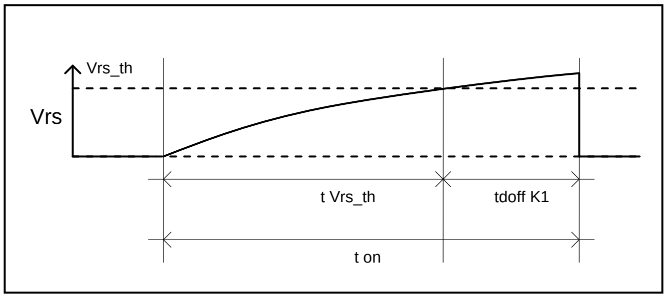


Figure 6

The peak current and ton can be calculated as follow:

$$\mathrm{t\ Vrsth} = -\frac{\mathrm{L}}{\mathrm{Rdon\ k1} + \mathrm{Rs} + \mathrm{Rl}} * \ln(1 - \frac{\mathrm{Rs} + \mathrm{Rdson\ k1} + \mathrm{Rl}}{\mathrm{Vrs\_th} * \mathrm{Rs} * \mathrm{Vcc}})$$

Where Rl is the resistor of the inductor

With : $\mathrm{t\ on} = \mathrm{t\ Vrs\_th} + \mathrm{tdoff\ K1}$

The peak current can be solved by:

$$\mathrm{Ipeak} = \frac{\mathrm{Vcc}}{\mathrm{Rdson\ k1} + \mathrm{Rs} + \mathrm{Rl}} * (1 - \mathrm{e}^{-\mathrm{ton} * \frac{\mathrm{Rdson\ k1} + \mathrm{Rs} + \mathrm{Rl}}{\mathrm{L}}})$$

The peak current must not exceed the Maximum Rating of Isw.

Output capacitor choice

The output capacitor must be chosen based on 2 criteria:

- During the turn on of K2, the voltage drop on Cout must not trigger the Under Voltage Lockout due to the gate charge of the Power Mosfet.

$$\mathrm{Cout} > \frac{\mathrm{Q\ gate\ total\ Power\ Mosfet}}{(\mathrm{Vout_{th}} - \mathrm{UV_{LO}})\ \mathrm{Min.}}$$

- When K1 turn off and the inductor is charging Cout, the peak current on the output capacitor must be limited in order to avoid having current flowing in the Gate zener diode:

$$\mathrm{Cout} > \frac{\mathrm{L} * \mathrm{Ipeak}^2 \mathrm{max}}{\mathrm{Vz\ min\ gate}^2 - \mathrm{Vout\ th\ max}^2}$$

Vz min gate is the minimum Zener voltage of the external gate Zener diode.

Minimum operating voltage

While the AUIR3241S operating voltage is specified between 3V and 36V. The 3V minimum operating voltage is when the Vcc is going down. The minimum voltage is also limited by the fact that the Rs voltage must reach the Vrsth taking account all resistors which limit the inductor current.

$$\mathrm{Vcc\ min} = \frac{\mathrm{Rdson\ k1} + \mathrm{Rs} + \mathrm{Rl}}{\mathrm{Rs}} * \mathrm{Vrsth}$$

Over-Voltage protection

The AUIR3241S integrates an over-voltage protection in order to protect K1. When Vcc exceed the Over-voltage threshold, the DC/DC is stopped.

Under voltage lockout - Diagnostic

In order to avoid to drive the Power Mosfet in linear mode, the AUIR3241S features an under voltage lockout. During the turn on, the gate will not be powered until Vout-Vcc reaches Vout th, meaning K2 is off and K3 is on. Then the AUIR3241S powers the gate of the mosfet. If Vout-Vcc goes below UV_LO, the gate is shorted to the source and the part is latched. A cycle in the input is required to reset the latch. The input must be kept low longer than Treset.

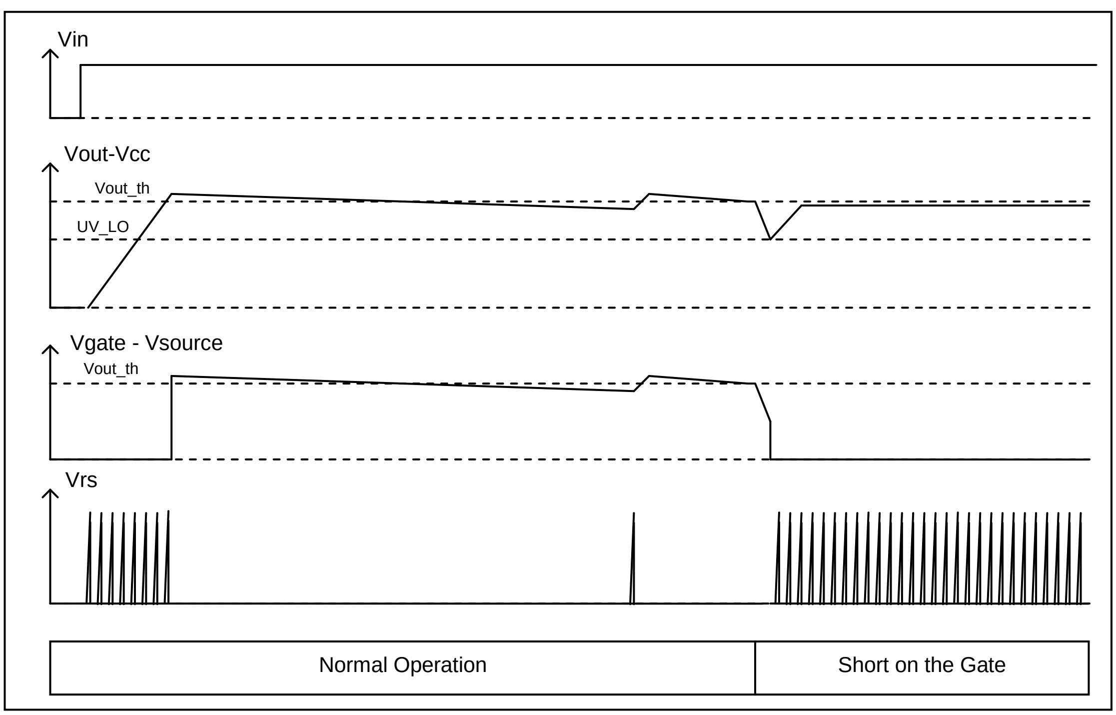


Figure 7

When the part is latched a current source (I latch UV_LO) is connected between Out and Vcc to increase the current consumption. By monitoring the current consumption the system can have a diagnostic of the output status. The diagnostic can be analog or digital.

Analog Diagnostic: Output current measurement

The average current into Rs can be measured by adding a low pass filter before the ADC of the micro controller.

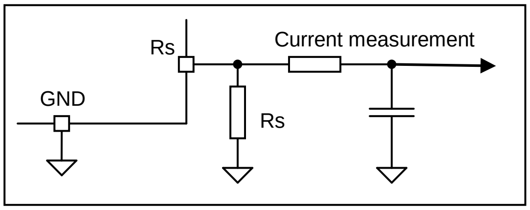


Figure 8

Then the average output current can be evaluated using :

I out av = I Rs av * Vcc / (Vout - Vcc)

Knowing the output current can be useful to do a diagnostic on the power Mosfet. If the gate is shorted, the output current will be significantly higher than in normal operation.

Digital diagnostic

By adding a diode during high current consumption mode, the output voltage can be close to 1V. Using a bipolar with a pull-up resistor will provide a digital diagnostic.

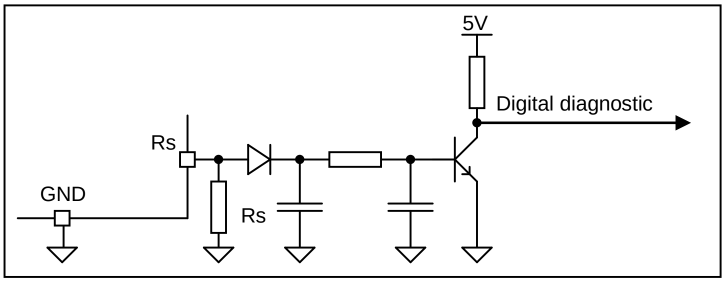


Figure 9

Power On Reset

During the power on, the AUIR3241S features a Power On Reset to guarantee a stable state of the 2 latches of the Under voltage lockout and guarantee a stable internal biasing. POR_Delay is triggered when Vout-Gnd exceeds POR_Th.

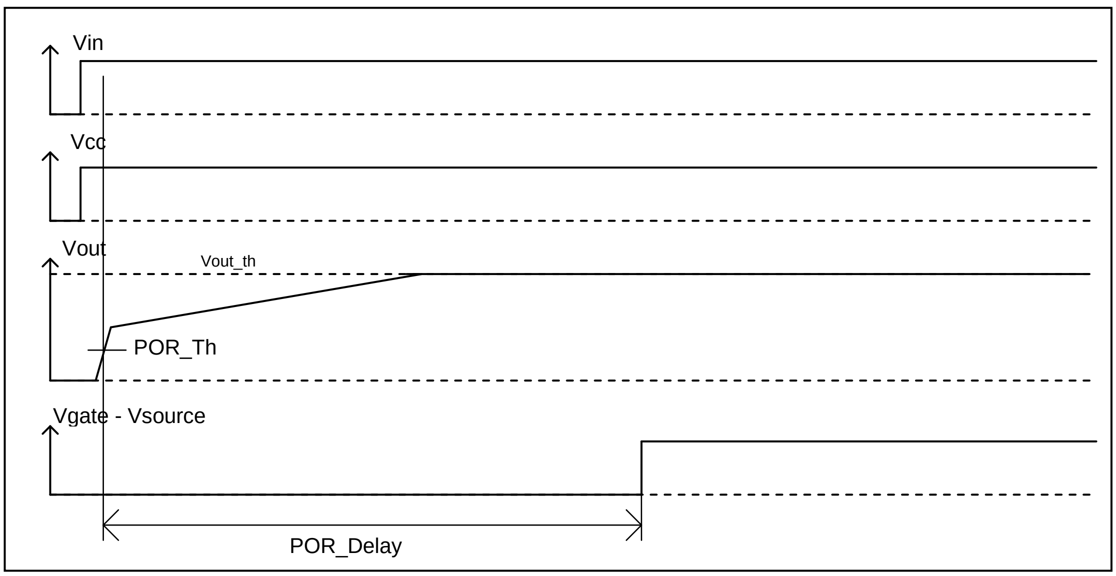


Figure 10

Figures are given for typical value, Vcc=14V and Tj=25°C otherwise specified

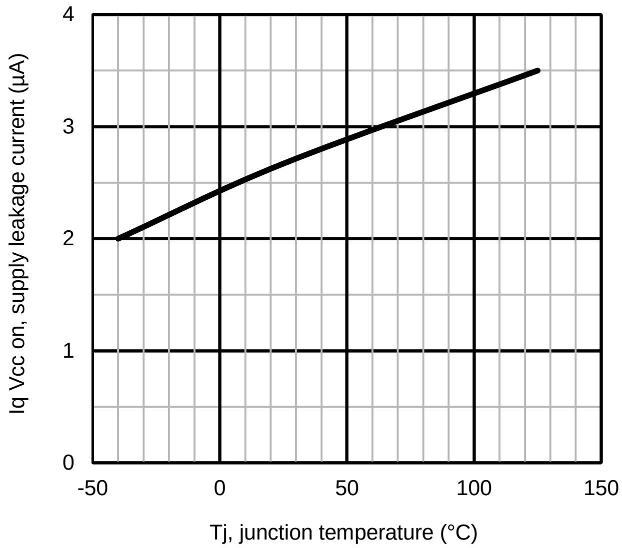


Figure 11 – Iq Vcc on (µA) Vs Tj (°C)

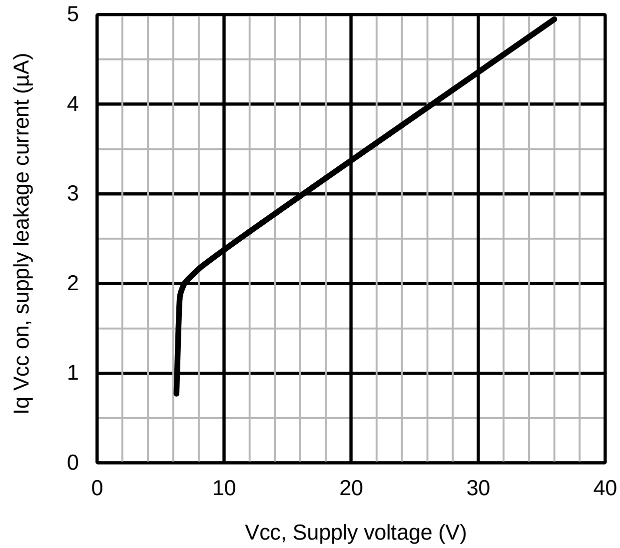


Figure 12 – Iq Vcc on (µA) Vs Vcc(V)

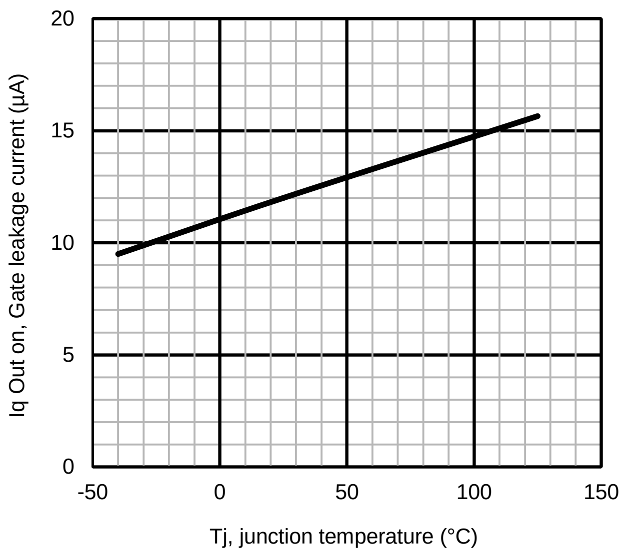


Figure 13 – Iq Out on (µA) Vs Tj (°C)

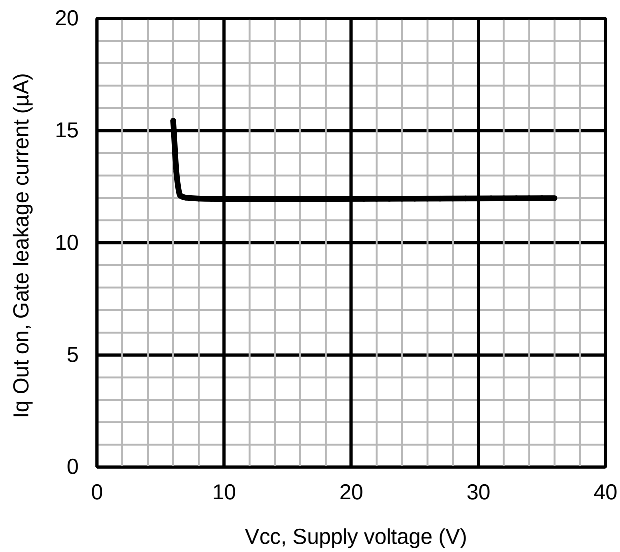


Figure 14 – Iq Out on (µA) Vs Vcc(V)

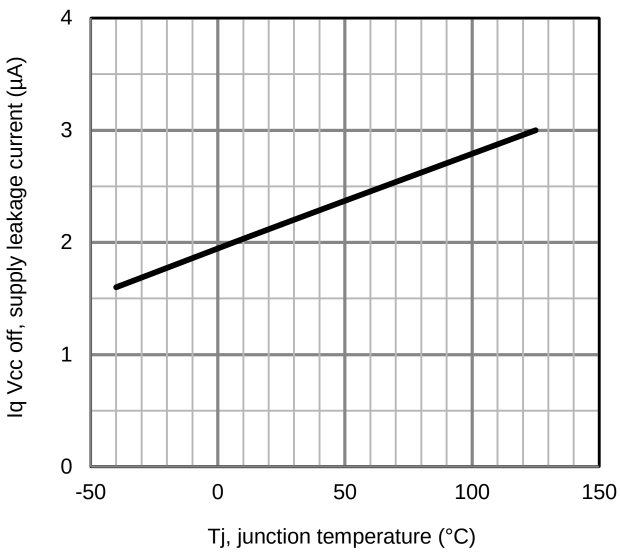


Figure 15 – Iq Vcc off (µA) Vs Tj (°C)

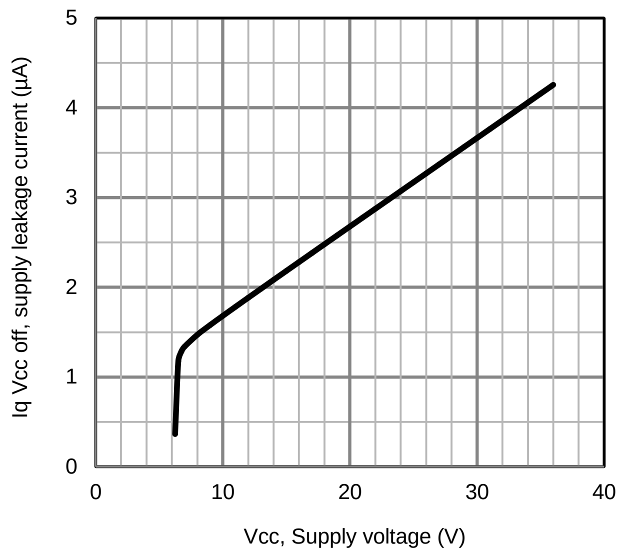


Figure 16 – Iq Vcc off (µA) Vs Vcc(V)

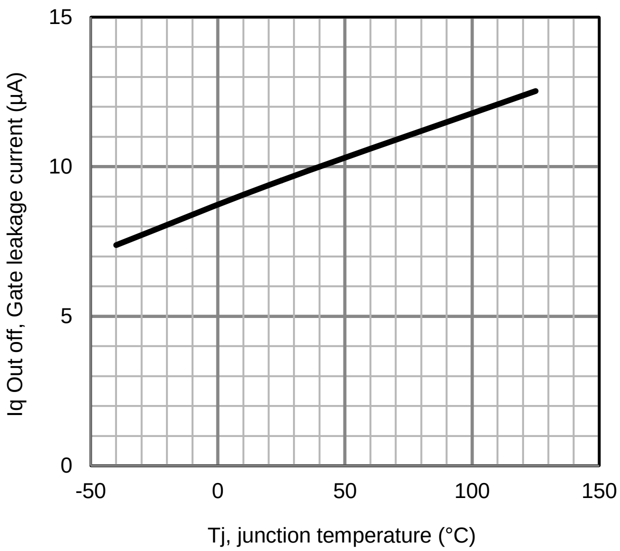


Figure 17 – Iq Out off (µA) Vs Tj (°C)

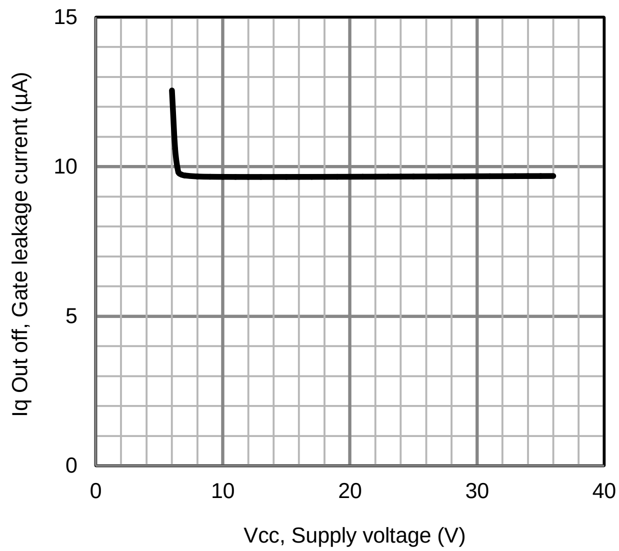
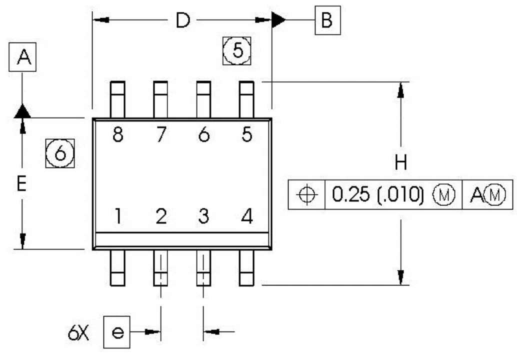


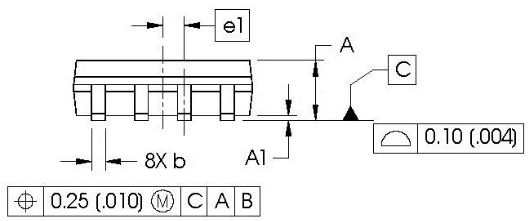
Figure 18 – Iq Out off (µA) Vs Vcc(V)

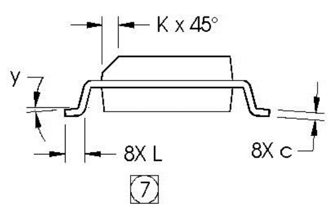
Case Outline – SO8

Dimensions are shown in millimeters (inches)



DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.0532	.0688	1.35	1.75
A1	.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	
e 1	.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:

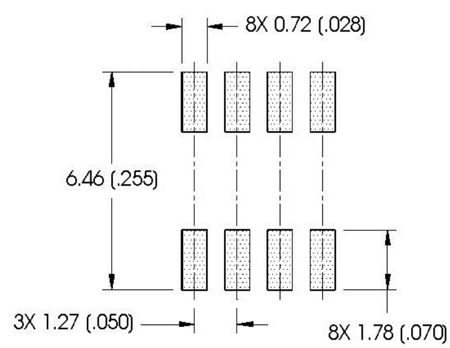
1. DIMENSIONING & TOLERANCING PER ASME Y14.5M-1994.
2. CONTROLLING DIMENSION: MILLIMETER
3. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
4. OUTLINE CONFORMS TO JEDEC OUTLINE MS-012AA.

5. DIMENSION DOES NOT INCLUDE MOLD PROTRUSIONS. MOLD PROTRUSIONS NOT TO EXCEED 0.15 [.006].

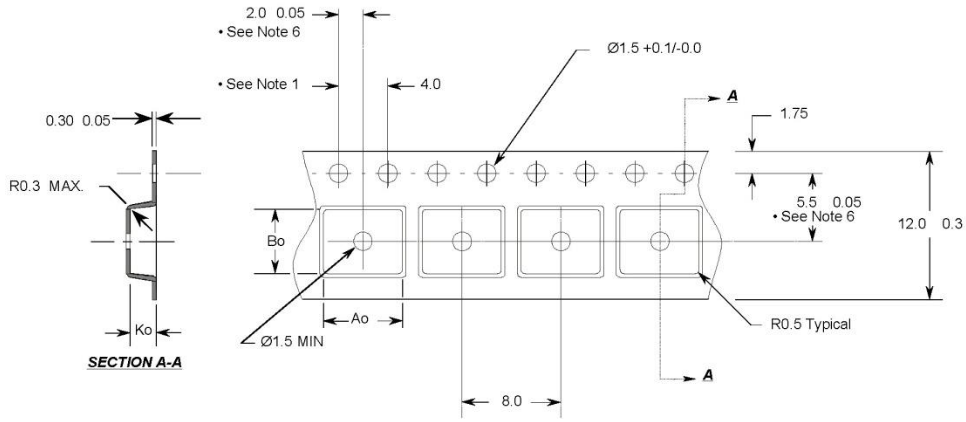
6. DIMENSION DOES NOT INCLUDE MOLD PROTRUSIONS. MOLD PROTRUSIONS NOT TO EXCEED 0.25 [.010].

7. DIMENSION IS THE LENGTH OF LEAD FOR SOLDERING TO A SUBSTRATE.

FOOTPRINT



Tape & Reel SO8

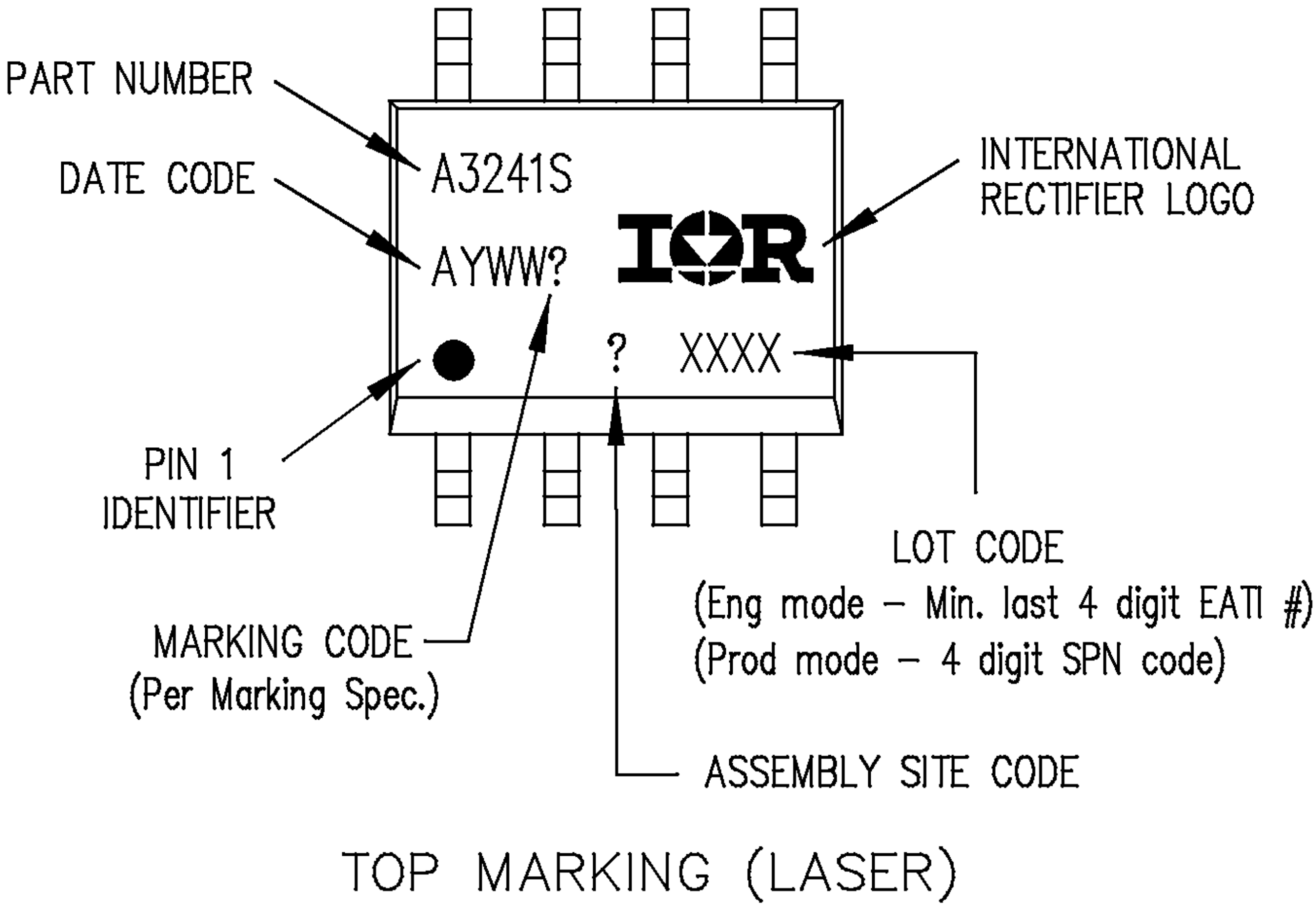


Notes:
1. 10 sprocket hole pitch cumulative tolerance 0.2
2. Camber not to exceed 1mm in 100mm
3. Material: Black Conductive Advantek Polystyrene
4. Ao and Bo measured on a plane 0.3mm above the bottom of the pocket
5. Ko measured from a plane on the inside bottom of the pocket to the top surface of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



Qualification Information

Qualification Level		Automotive (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.	
Moisture Sensitivity Level		SOIC-8L	MSL2, 260°C (per IPC/JEDEC J-STD-020)
ESD	Human Body Model	Class 1C Passed 1500V (per AEC-Q100-002)	
	Charged Device Model	Class C6 (+/-1000V) (per AEC-Q100-011)	
IC Latch-Up Test		Class II Level A (per AEC-Q100-004)	
RoHS Compliant		Yes	

Published by
Infineon Technologies AG
81726 München, Germany

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Revision History

Revision	Date	Notes/Changes
Rev 1.0	2017-04-27	Data Sheet created.
Rev 1.01	2017-09-12	Update drawing, Differentiate Vcc_op (ext) & Vcc_op (nom), add Appendixies (1) & (2) on Page 5