

# IRS2461S

## 400V Class D Audio Amplifier Controller

### Features

- Single channel integrated analog input Class D audio amplifier driver
- 400V high voltage gate driver stage
- Differential or single-ended input
- Versatile protection control enabling latched, non-latched, or host controlled shutdown function
- Programmable over current protection
- Programmable dead-time generation
- External thermal sensor input
- Click noise reduction
- Under voltage protection
- High noise immunity

### Product summary

Product feature	Key specification
Topology	Half-Bridge/Full-Bridge
$V_{\text{OFFSET (max)}}$	+/- 200 V
$I_{\text{O+}}$ & $I_{\text{O-}}$ (typical)	0.5 A & 0.6 A
Selectable deadtime	165/225/280/340 ns
DC offset	<18 mV
OC protection delay	500 ns (max)
Shutdown propagation delay	250 ns (max)
Error amplifier open loop gain	>60 dB

### Potential applications

- High voltage high power Class D audio amplifier
- High voltage high power PWM amplifier

### Product validation

Qualified for industrial applications according to the relevant JEDEC47/20/22

### Ordering information

Base Part Number	Package Type	Standard Pack	
		Form and Quantity	
IRS2461S	20 Lead SOICWB	Tape and Reel	1000

# 400V Class D Audio Amplifier Controller

## Description

### Description

The IRS2461S integrates high voltage, high performance Class D audio amplifier drivers with PWM modulator and protections. In conjunction with external MOSFET, the IRS2461S forms a single channel Class D audio amplifier. The IRS2461S is designed with floating analog inputs and protection control interface pins convenient for half bridge applications. High and low side MOSFETs are protected from over current conditions by a programmable over current protection. Essential elements of PWM modulator section allow flexible system design. The IRS2461S is a lead-free, ROHS compliant.

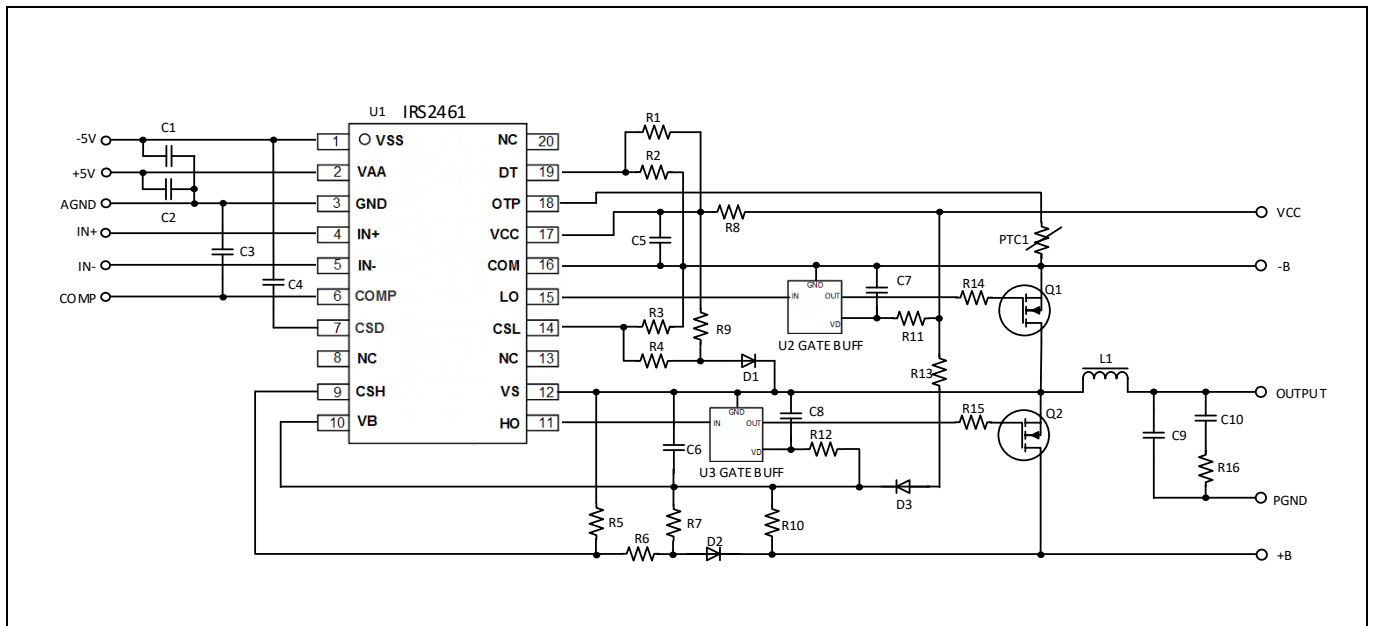


Figure 1 Typical application

# 400V Class D Audio Amplifier Controller

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# 1 Pin configuration and functionality

The pin configuration is shown in Figure 2 and the functions are described in Table A.

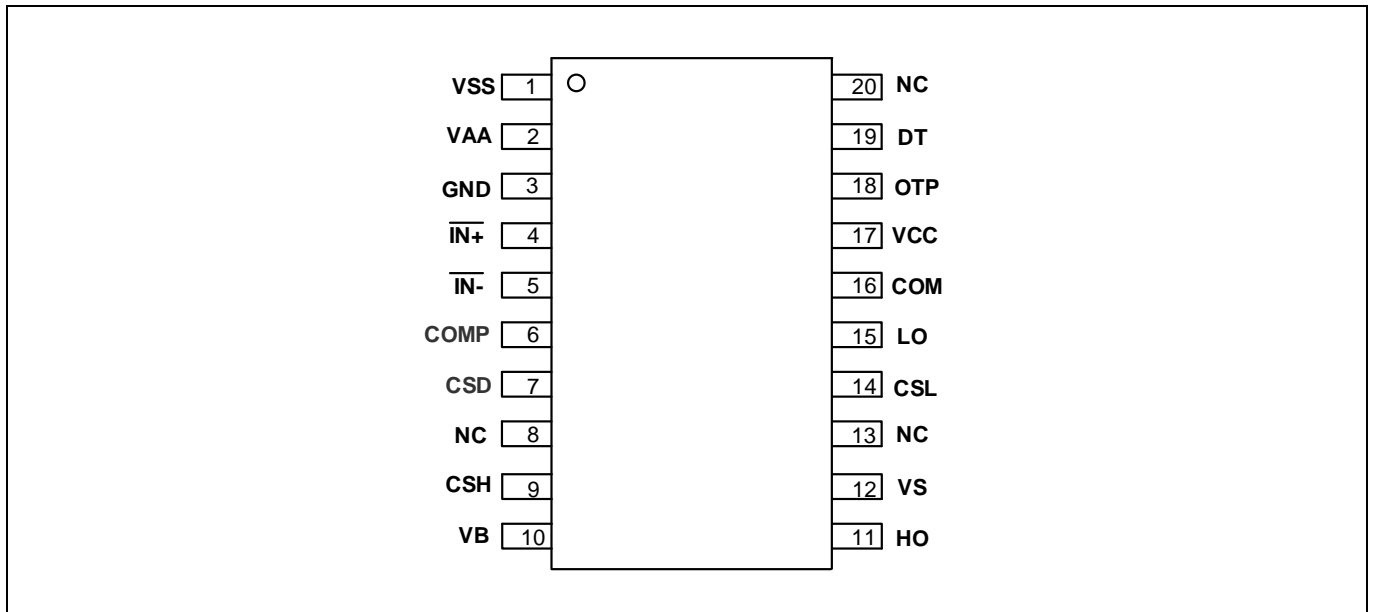
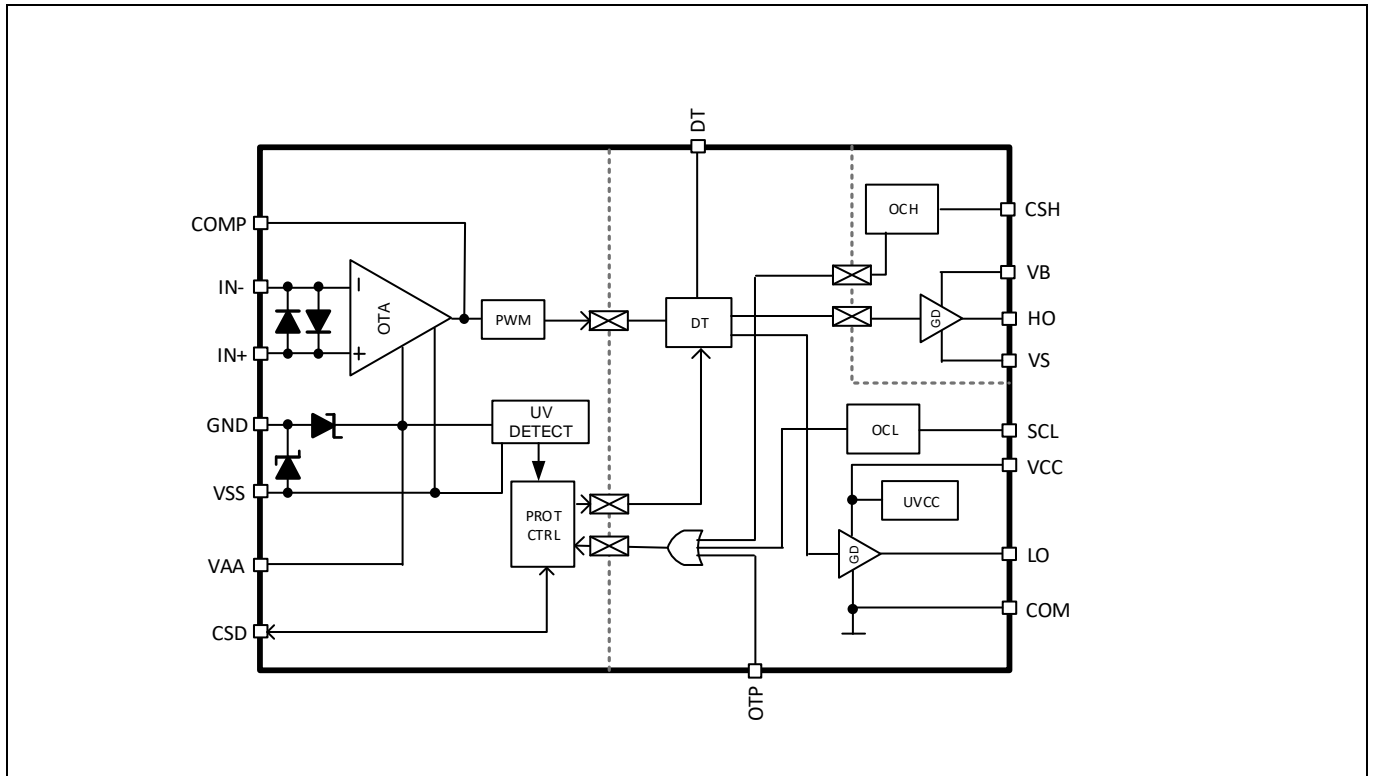


Figure 2 Pin configuration

Table A Pin definitions and functions

Pin	Symbol	Pin type	Function
1	VSS	Input	Floating input negative supply
2	VAA	Input	Floating input positive supply
3	GND	Input	Input reference GND
4	IN+	Input	Non-inverting analog input
5	IN-	Input	Inverting analog input
6	COMP	Input/output	PWM comparator input
7	CSD	Input/output	Protection control
8	NC	-	
9	CSH	Input	High side over current sensing input, referenced to VS
10	VB	Input	High side floating supply
11	HO	Output	High side output
12	VS	Input	High side floating supply return
13	NC	-	
14	CSL	Input	Low side over current sensing input, referenced to COM
15	LO	Output	Low side output
16	COM	Input	Low side gate drive supply return
17	VCC	Input	Low side gate drive supply
18	OTP	Input	OTP sensor input
19	DT	Input	Deadtime program, reference to COM
20	NC	-	

## 2 Functional block diagram



**Figure 3 Functional block diagram**

### 3 Qualification Information

<b>Qualification Level</b>		Industrial
<b>Moisture Sensitivity Level</b>		MSL3 (per IPC/JEDEC J-STD-020C)
<b>ESD</b>	<b>Machine Model</b>	Class B (per JEDEC standard EIA/JESD22-A115)
	<b>Human Body Model</b>	Class 1B (per EIA/JEDEC standard JESD22-A114)
	<b>Charge Device Model</b>	Class 0B (per EIA/JEDEC standard JESD22-C101)
<b>IC Latch-Up Test</b>		Class I, Level A (per JESD78)
<b>RoHS Compliant</b>		Yes

## 4 Characteristics

### 4.1 Package Characteristic

Symbol	Definition	Min	Max	Units
P <sub>d</sub>	Maximum power dissipation @ T <sub>A</sub> ≤ +25°C <sup>†††</sup>	-	1.14	W
R <sub>th,JA</sub>	Thermal resistance, Junction to ambient <sup>†††</sup>	-	65.8	°C/W
T <sub>J</sub>	Junction Temperature	-	150	°C
T <sub>S</sub>	Storage Temperature	-55	150	°C
T <sub>L</sub>	Lead temperature (Soldering, 10 seconds)	-	300	°C

††† According to JESD51-5. JEDEC still air chamber.

## 4.2 Absolute Maximum Ratings

Absolute Maximum Ratings indicate sustained limits beyond which damage to the device may occur. All voltage parameters are absolute voltages referenced to COM=VN; all currents are defined positive into any lead. The Thermal Resistance and Power Dissipation ratings are measured under board mounted and still air conditions.

Symbol	Definition	Min	Max	Units
$V_B$	High side floating supply voltage	-0.3	415	V
$V_S$	High side floating supply voltage <sup>††</sup>	$V_{Bn} - 15$	$V_{Bn} + 0.3$	V
$V_{HO}$	High side floating output voltage	$V_{Sn} - 0.3$	$V_{Bn} + 0.3$	V
$V_{CSH}$	CSH pin input voltage	$V_{Sn} - 0.3$	$V_{Bn} + 0.3$	V
$V_{CC}$	$V_{CC}$ low side fixed supply voltage <sup>††</sup>	-0.3	15.5	V
$V_{LO}$	Low side output voltage	-0.3	$V_{CC} + 0.3$	V
$V_{AA}$	Floating input positive supply voltage <sup>††</sup>	(See $I_{AAZ}$ )	210	V
$V_{SS}$	Floating input negative supply voltage <sup>††</sup>	-1 (See $I_{SSZ}$ )	$V_{AA} + 0.3$	V
$V_{GND}$	Floating input supply ground voltage	$V_{SS} - 0.3$	$V_{AA} + 0.3$	V
$I_{IN-}$	Inverting input current <sup>†</sup>	-	$\pm 3$	mA
$V_{CSD}$	SD pin input voltage	$V_{SS} - 0.3$	$V_{AA} + 0.3$	V
$V_{COMP}$	COMP pin input voltage	$V_{SS} - 0.3$	$V_{AA} + 0.3$	V
$V_{CLK}$	CLK pin input voltage	$V_{SS} - 0.3$	$V_{AA} + 0.3$	V
$V_{DT}$	DT pin input voltage	-0.3	$V_{CC} + 0.3$	V
$V_{OTP}$	OTP pin input voltage	-0.3	$V_{CC} + 0.3$	V
$V_{CSL}$	CSL pin input voltage	-0.3	$V_{CC} + 0.3$	V
$I_{AAZ}$	Floating input positive supply zener clamp current <sup>††</sup>	-	10	mA
$I_{CCZ}$	Low side $V_{CC}$ supply zener clamp current <sup>††</sup>	-	10	mA
$I_{BSZ}$	Floating supply zener clamp current <sup>††</sup>	-	10	mA
$dV_S/dt$	Allowable $V_S$ voltage slew rate	-	50	V/ns
$dV_{SS}/dt$	Allowable $V_{SS}$ voltage slew rate <sup>†††</sup>	-	50	V/ms

† IN- contains clamping diode to GND.

†† VAA-VSS, VCC-COM, VB-VS contain internal shunt zener diodes. Note that the voltage ratings of these can be limited by the clamping current.

††† For the rising and falling edges of step signal of 10V. VSS=15V to 200V.



### 4.3 Operating Conditions

For proper operation, the device should be used within the recommended conditions below. The  $V_S$  and COM offset ratings are tested with supplies biased at  $V_{AA}-V_{SS}=10V$ ,  $V_{CC}=12V$ , and  $V_B-V_S=12V$ . All voltage parameters are absolute voltages referenced to COM; all currents are defined positive into any lead.

Symbol	Definition	Min	Max	Units
$V_B$	High side floating supply absolute voltage	$V_{Sn} + 10$	$V_{Sn} + 14$	V
$V_S$	High side floating supply offset voltage	(Note1)	400	V
$V_{AA}$	Floating input supply voltage	$V_{SS} + 4.5$	$V_{SS} + 15$	V
$I_{AAZ}$	Floating input positive supply zener clamp current	1	11	mA
$V_{SS}$	Floating input supply absolute voltage	0	200	V
$V_{HO}$	High side floating output voltage	$V_S$	$V_B$	V
$V_{CC}$	Low side fixed supply voltage	10	14	V
$V_{LO}$	Low side output voltage	0	$V_{CC}$	V
$V_{GND}$	GND pin input voltage	$V_{SS}$ (Note2)	$V_{AA}$ (Note2)	V
$V_{IN-}$	Inverting input voltage	$V_{GND} - 0.5$ (Note2)	$V_{GND} + 0.5$ (Note2)	V
$V_{CSD}$	CSD pin input voltage	$V_{SS}$	$V_{AA}$	V
$V_{COMP}$	COMP pin input voltage	$V_{SS}$	$V_{AA}$	V
$C_{COMP}$	COMP pin phase compensation capacitor to GND	2.2	-	nF
$V_{CLK}$	CLK pin input voltage	$V_{SS}$	$V_{AA}$	V
$V_{DT}$	DT pin input voltage	0	$V_{CC}$	V
$V_{OTP}$	OTP pin input voltage	0	$V_{CC}$	V
$V_{CSH}$	CSH pin input voltage	$V_{Sn}$	$V_{Bn}$	V
$V_{CSL}$	CSL pin input voltage	0	$V_{CC}$	V
$dV_{SS}/dt$	Allowable $V_{SS}$ voltage slew rate upon power-up (Note3)	-	50	V/ms
$f_{SW}$	Switching frequency	-	800	kHz
$f_{CLK}$	CLK frequency (Note4)	-	800	kHz
$T_A$	Ambient Temperature	-40	125	°C

(Note 1) Logic operational for  $V_S$  equal to  $-5V$  to  $+400V$ . Logic state held for  $V_S$  equal to  $-5V$  to  $-V_{BS}$ .

(Note 2) GND input voltage is limited by IIN-n.

(Note 3)  $V_{SS}$  ramps up from  $0V$  to  $200V$ .

(Note 4) The CLK input frequency needs to be within  $\pm 10\%$  of self-oscillating frequency in order to synchronize PWM in a typical self-oscillating application.

(Note 4) The CLK input frequency needs to be within  $\pm 10\%$  of self-oscillating frequency in order to synchronize PWM in a typical self-oscillating application.

## Characteristics

## 4.4 Electrical Characteristics

VCC=VBS=VDT=12V, VSS=VS=COM=0V, VGND=5V, VAA=10V, CL=1nF and TA=25°C unless otherwise specified.

Symbol	Definition	Min	Typ	Max	Units	Test Conditions
<b>Low Side Supply</b>						
UV <sub>CC+</sub>	V <sub>CC</sub> supply UVLO positive threshold	8.4	8.9	9.4	V	
UV <sub>CC-</sub>	V <sub>CC</sub> supply UVLO negative threshold	8.2	8.7	9.2	V	
UV <sub>CC</sub> HYS	UV <sub>CC</sub> hysteresis	-	0.2	-	V	
I <sub>QCC</sub>	Low side quiescent current	-	-	6	mA	V <sub>DT</sub> =V <sub>CC</sub>
V <sub>CLAMPL</sub>	Low side zener diode clamp voltage	14.7	15.3	16.2	V	I <sub>CC</sub> =5mA
<b>High Side Floating Supply</b>						
UV <sub>BS+</sub>	High side well UVLO positive threshold	8.0	8.5	9.0	V	
UV <sub>BS-</sub>	High side well UVLO negative threshold	7.8	8.3	8.8	V	
UV <sub>BS</sub> HYS	UV <sub>BS</sub> hysteresis	-	0.2	-	V	
I <sub>QBS</sub>	High side quiescent current	-	-	1	mA	
I <sub>LKH</sub>	High to Low side leakage current	-	-	50	μA	V <sub>B</sub> =V <sub>S</sub> =400V
V <sub>CLAMPH</sub>	High side zener diode clamp voltage	14.7	15.3	16.2	V	I <sub>BS</sub> =5mA
<b>Floating Input Supply</b>						
UV <sub>AA+</sub>	V <sub>AA</sub> floating supply UVLO positive threshold from V <sub>SS</sub>	8.2	8.7	9.2	V	GND pin floating
UV <sub>AA-</sub>	V <sub>AA</sub> floating supply UVLO negative threshold from V <sub>SS</sub>	7.7	8.2	8.7	V	GND pin floating
UV <sub>AA</sub> HYS	UV <sub>AA</sub> hysteresis	-	0.5	-	V	GND pin floating
I <sub>QAASD</sub>	Floating Input positive quiescent supply current in shutdown mode	-	2	3	mA	V <sub>CSD</sub> =V <sub>GND</sub>
I <sub>QAA0</sub>	Floating Input positive quiescent supply current, positive input	-	4	6	mA	V <sub>IN-</sub> =V <sub>SS</sub> +5.2V
I <sub>QAA1</sub>	Floating Input positive quiescent supply current, negative input	-	3	4	mA	V <sub>IN-</sub> =V <sub>SS</sub> +4.8V
I <sub>QAAST</sub>	Floating Input positive quiescent supply current in start-up mode	-	3	4	mA	V <sub>CSD</sub> =V <sub>GND</sub> +2.5V
I <sub>LKM</sub>	Floating input side to Low side leakage current	-	-	50	μA	V <sub>AA</sub> =V <sub>SS</sub> =V <sub>GND</sub> =100V
V <sub>CLAMPM</sub>	Floating supply zener diode clamp voltage	14.7	15.3	16.2	V	I <sub>AA</sub> =5mA, V <sub>CSD</sub> =V <sub>GND</sub>

Characteristics

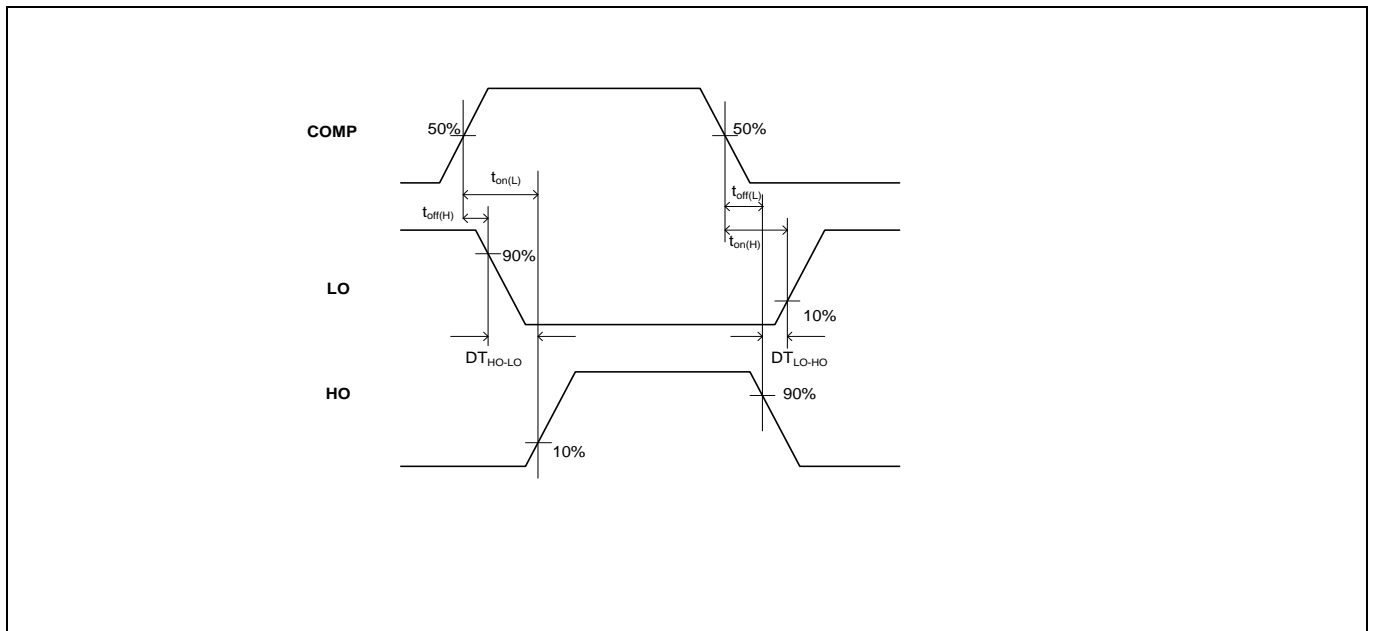
Symbol	Definition	Min	Typ	Max	Units	Test Conditions
<b>Audio Input</b> (GND=0V, V <sub>AA</sub> =5V, V <sub>SS</sub> =-5V, COM =V <sub>CC</sub> =-5V, V <sub>S</sub> =CSH=-5V, DT=-5V)						
V <sub>Os</sub>	Input offset voltage	-18	0	18	mV	
I <sub>BIN</sub>	Input bias current	-	-	40	nA	
GBW	Small signal bandwidth	-	5 Note 1	-	MHz	C <sub>COMPn</sub> =2.2nF, Rf=10k, Note 1
V <sub>COMP</sub>	OTA Output voltage	V <sub>AA</sub> -1	-	V <sub>SS</sub> +1	V	
g <sub>m</sub>	OTA transconductance	80	200	260	mS	V <sub>IN</sub> =10mV
G <sub>v</sub>	OTA gain	60	-	-	dB	
V <sub>Nrms</sub>	OTA input noise voltage	-	250	-	mVrms	BW=20kHz, Resolution BW=22Hz Fig.8
SR	Slew rate	-	±5	-	V/us	C <sub>COMP</sub> =2.2nF
CMRR	Common-mode rejection ratio	-	60	-	dB	
PSRR	Supply voltage rejection ratio	-	65	-	dB	
<b>PWM Comparator</b>						
V <sub>thPWM</sub>	PWM comparator threshold in COMP	-	(V <sub>AA</sub> - V <sub>SS</sub> )/2	-	V	
f <sub>OTA</sub>	COMP pin star-up local oscillation frequency	-	0.6	-	MHz	V <sub>CSD</sub> =V <sub>GND</sub> +2.5V
<b>Protection</b>						
V <sub>thOCL</sub>	Low side OC threshold in V <sub>CSL</sub>	1.1	1.2	1.3	V	
V <sub>thOCH</sub>	High side OC threshold in V <sub>CSH</sub>	1.1+ Vs	1.2+ Vs	1.3+ Vs	V	V <sub>S</sub> =400V
V <sub>th1</sub>	CSD pin shutdown release threshold	0.52xV <sub>AA-GND</sub>	0.68xV <sub>AA-GND</sub>	0.84xV <sub>AA-GND</sub>	V	
V <sub>th2</sub>	CSD pin self reset threshold	0.26xV <sub>AA-GND</sub>	0.30xV <sub>AA-GND</sub>	0.34xV <sub>AA-GND</sub>	V	
I <sub>CSD+</sub>	CSD pin discharge current	70	100	130	µA	V <sub>CSD</sub> = V <sub>GND</sub> + 2.4V
I <sub>CSD-</sub>	CSD pin charge current	70	100	130	µA	V <sub>CSD</sub> = V <sub>GND</sub> + 2.4V
t <sub>SSD</sub>	Shutdown propagation delay from V <sub>CSD</sub> < V <sub>GND</sub> + V <sub>th1</sub> to Shutdown	-	140	250	ns	
t <sub>OCH</sub>	Propagation delay time from V <sub>CSHn</sub> > V <sub>thOCHn</sub> to Shutdown	-	400	500	ns	
t <sub>OCL</sub>	Propagation delay time from V <sub>sn</sub> > V <sub>thOCL</sub> to Shutdown	-	270	350	ns	
V <sub>OTP</sub>	OTP pin input threshold	-	2.8	-	V	
I <sub>OTP</sub>	OTP bias sourcing current	-	0.6	-	mA	OTP=0V

Characteristics

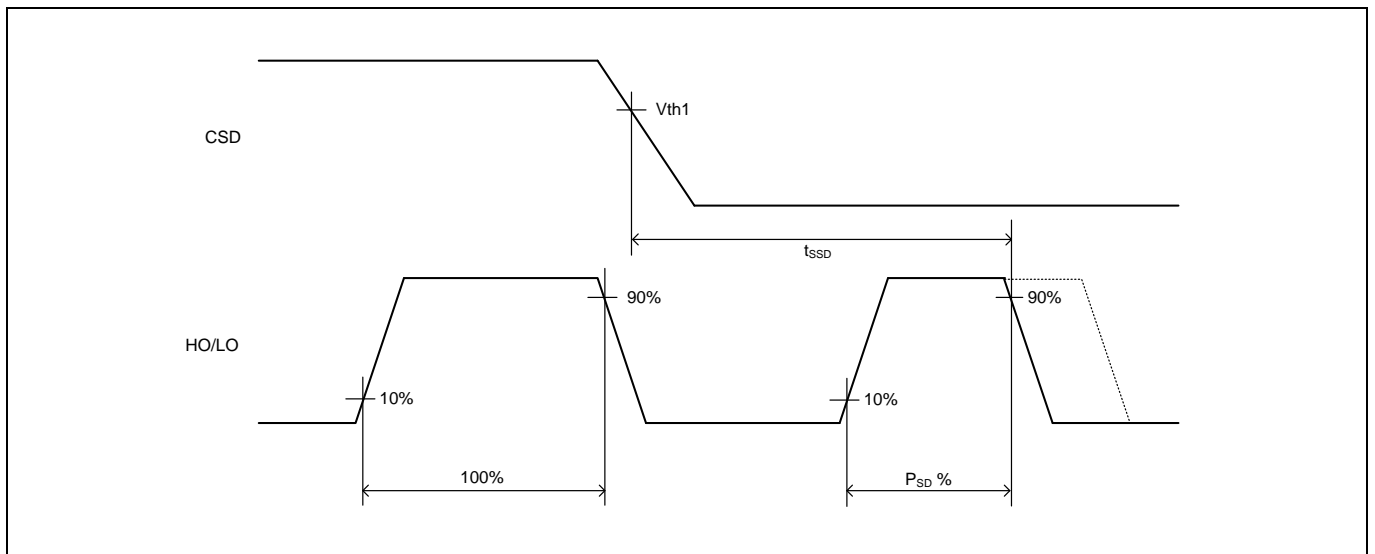
Symbol	Definition	Min	Typ	Max	Units	Test Conditions
<b>Gate Driver</b>						
Io+	Output high short circuit current (Source)	-	0.5	-	A	Vo=0V, PW≤10μS, Note 1
Io-	Output low short circuit current (Sink)	-	0.6	-	A	Vo=12V, PW≤10μS, Note 1
VoL	Low level output voltage LO – COM, HO - VS	-	-	0.1	V	Io=0A
VoH	High level output voltage VCC – LO, VB - HO	-	-	1.4	V	
Ton0	High and low side turn-on propagation delay	-	505	-	ns	V <sub>DT</sub> = COM
Toff0	High and low side turn-off propagation delay	270	340	410	ns	
Toffskw	Toff skew, Toffhon – Tofflon	-30	0	30	ns	
tr	Turn-on rise time	-	12	25	ns	
tf	Turn-off fall time	-	12	25	ns	
DT1	Deadtime: LOn turn-off to HOn turn-on (DT <sub>LO-HO</sub> ) & HOn turn-off to LOn turn-on (DT <sub>HO-LO</sub> )	130	165	200	ns	V <sub>DT</sub> >V <sub>DT1</sub> , V <sub>DTM</sub> =COM
DT2	Deadtime: LOn turn-off to HOn turn-on (DT <sub>LO-HO</sub> ) & HOn turn-off to LOn turn-on (DT <sub>HO-LO</sub> )	180	225	270	ns	V <sub>DT1</sub> >V <sub>DT</sub> > V <sub>DT2</sub> , V <sub>DTM</sub> =COM
DT3	Deadtime: LOn turn-off to HOn turn-on (DT <sub>LO-HO</sub> ) & HOn turn-off to LOn turn-on (DT <sub>HO-LO</sub> )	225	280	335	ns	V <sub>DT2</sub> >V <sub>DT</sub> > V <sub>DT3</sub> , V <sub>DTM</sub> =COM
DT4	Deadtime: LOn turn-off to HOn turn-on (DT <sub>LO-HO</sub> ) & HO turn-off to LOn turn-on (DT <sub>HO-LO</sub> ) V <sub>DT</sub> = V <sub>DT4</sub>	275	340	405	ns	V <sub>DT</sub> <V <sub>DT3</sub> , V <sub>DTM</sub> =COM
V <sub>DT1</sub>	DT mode select threshold 1	0.51xVcc	0.57xVcc	0.63xVcc	V	V <sub>DTM</sub> =COM
V <sub>DT2</sub>	DT mode select threshold 2	0.32xVcc	0.36xVcc	0.40xVcc	V	
V <sub>DT3</sub>	DT mode select threshold 3	0.21xVcc	0.23xVcc	0.25xVcc	V	

Note 1 Guaranteed by design, but not tested in production.

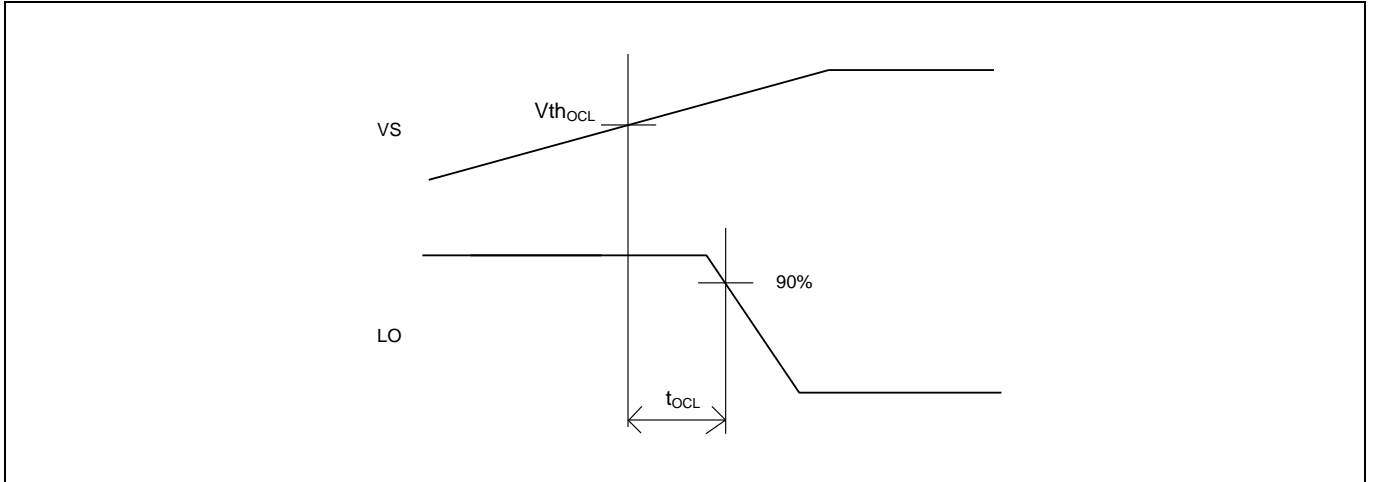
**4.5 Waveform definitions**



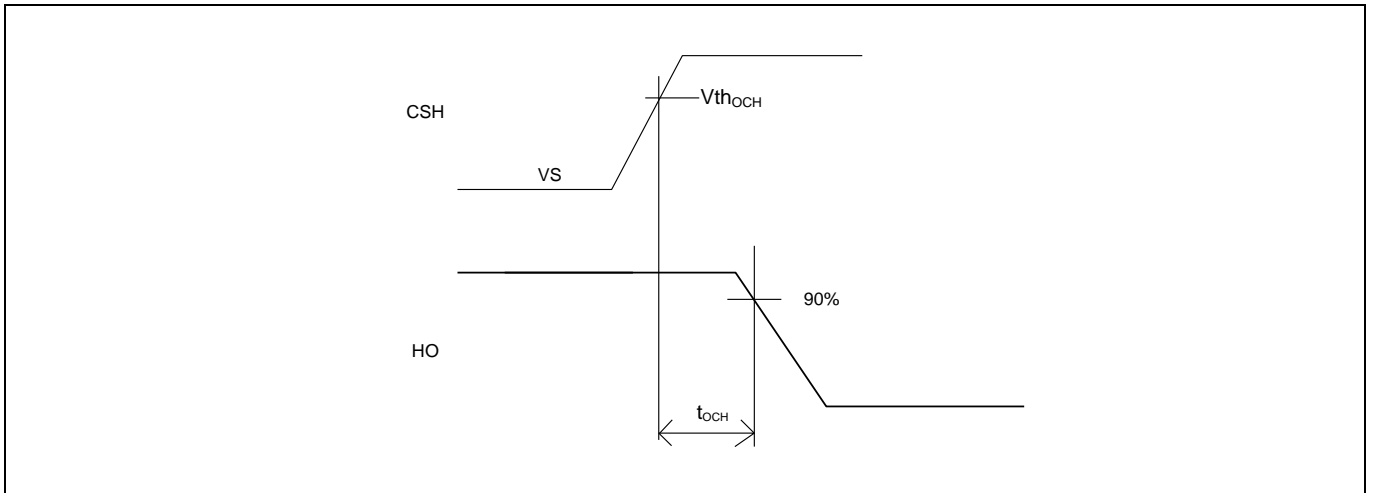
**Figure 4 Switching time waveform definitions**



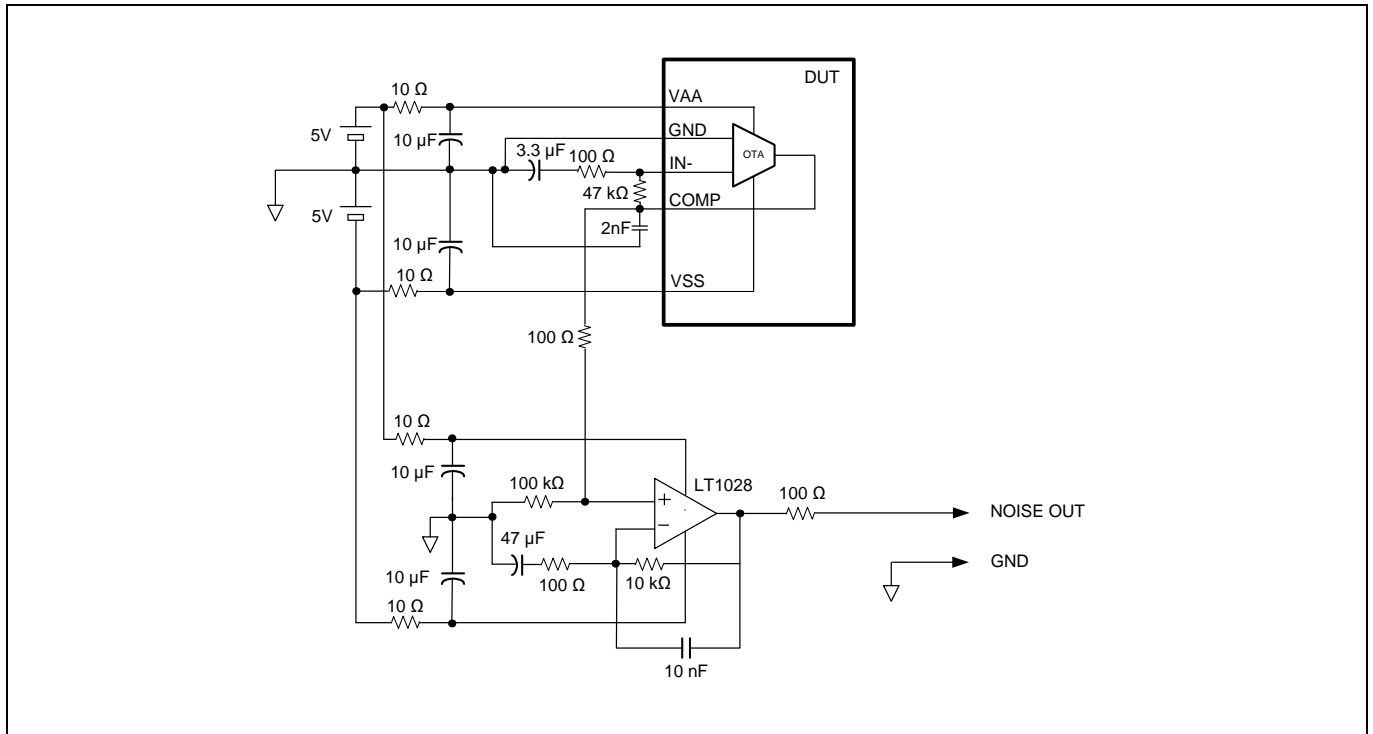
**Figure 5 CSD to shutdown waveform definitions**



**Figure 6**  $V_S > V_{thOCL}$  to shutdown waveform

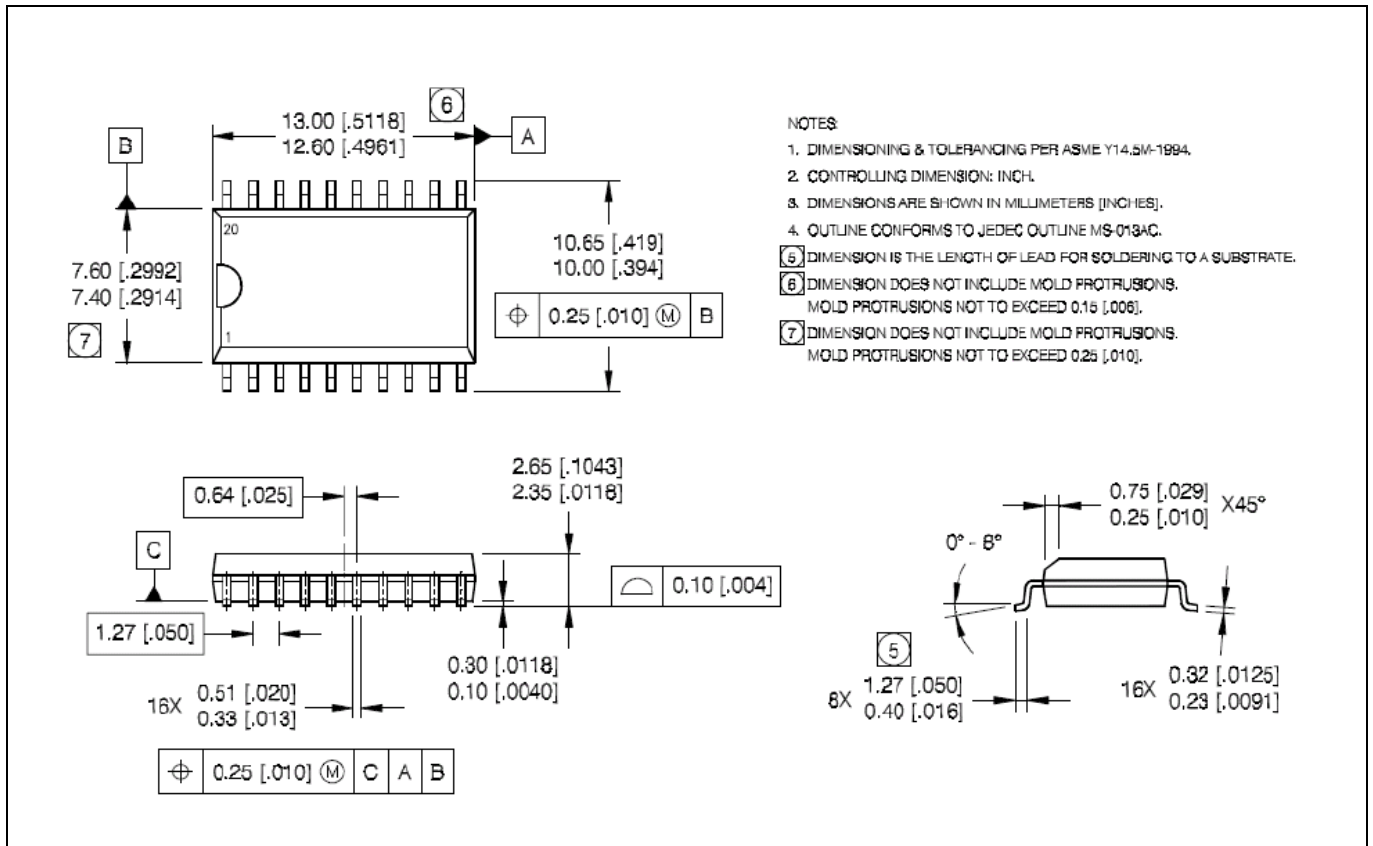


**Figure 7**  $V_{CSH} > V_{thOCH}$  to shutdown waveform



**Figure 8** OTA input noise voltage measuring circuit

## 5 Package dimensions



**Figure 9 20 Lead SOIC (wide body)**



Marking

## 6 Marking

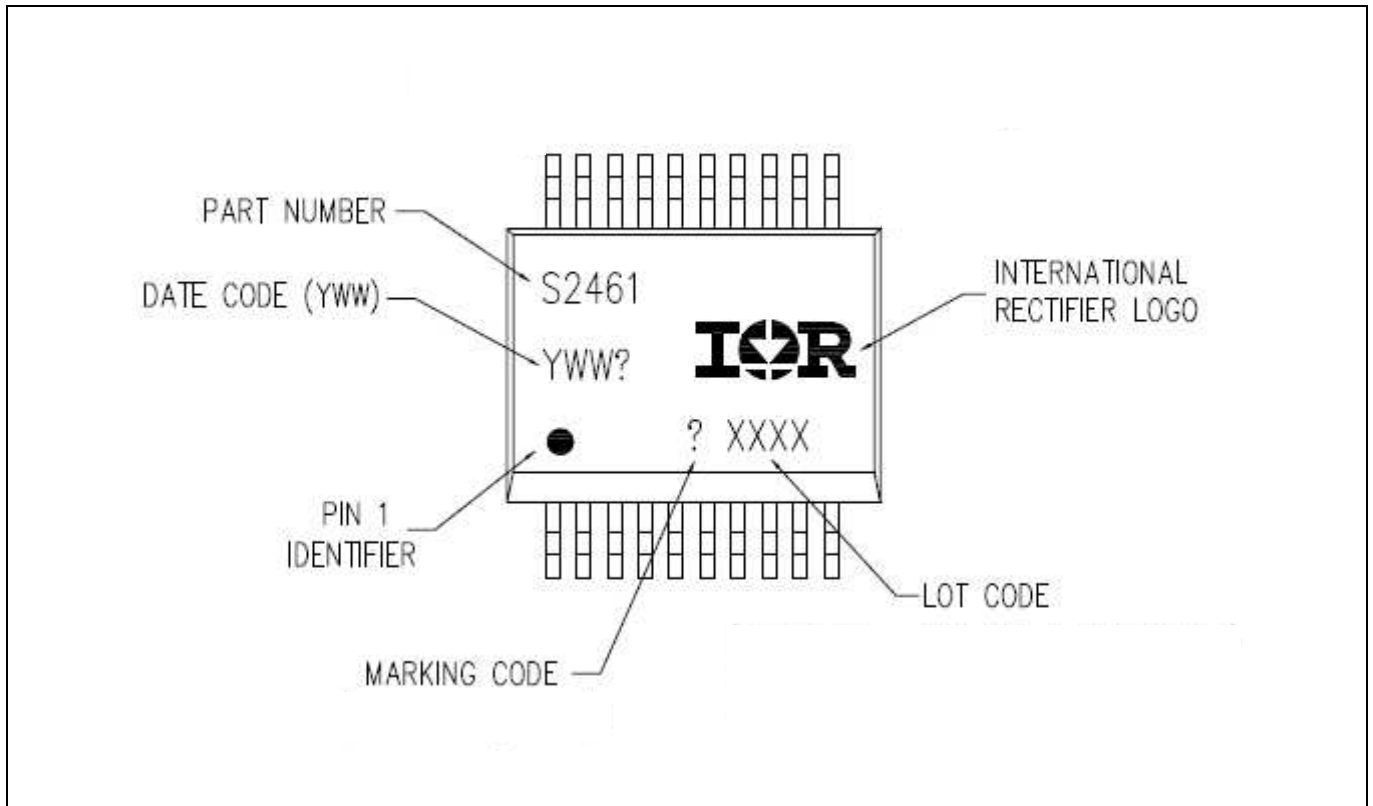


Figure 10 Top marking (laser)

## Revision History

IRS2461S

**Revision: 2019-06-04, Rev. 2.3**

Previous Revision

Revision	Date	Subjects (major changes since last revision)
1.2	2018-06-26	unified part name to IRS2461S
2.3	2019-06-04	added ton(typ)

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