

### Features

- Integrated analog input Class D audio amplifier in a small 5 x 6 mm PQFN package
- High peak music power output
- No mechanical heatsink required
- Split or single power supply
- Differential or single-ended input
- Over-current, over-temperature and under voltage protections with self-reset function
- Start and stop click noise reduction
- High noise immunity
- RoHS compliant

### Typical Applications

- Home theatre systems
- Docking station audio systems
- PC audio systems
- Musical instruments
- Karaoke amplifiers
- Game consoles
- Powered speaker systems
- General purpose audio power amplifiers

### Product Summary

Topology	Half-Bridge, Full-Bridge
*IR4301 Output power (Typical, THD+N=10%)	160 W/ 4 Ω
	120 W/ 3 Ω
*IR4321 Output power (Typical, THD+N=10%)	90 W/ 4 Ω
	135 W/ 2 Ω
*IR4311 Output power (Typical, THD+N=10%)	35 W/ 4 Ω
	45 W/ 3 Ω
*Residual noise (AES-17, IHF-A, typical)	250 µVrms
*THD+N (1kHz, 1W, 4 Ω, typical)	0.02 %

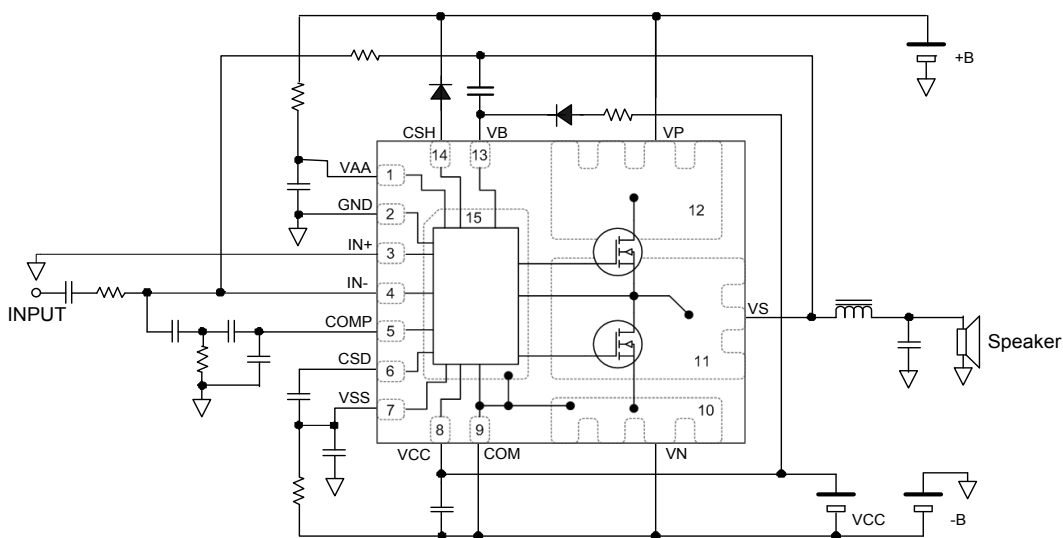
\* In typical application example

### Package



5x6mm PQFN22

### Typical Connection



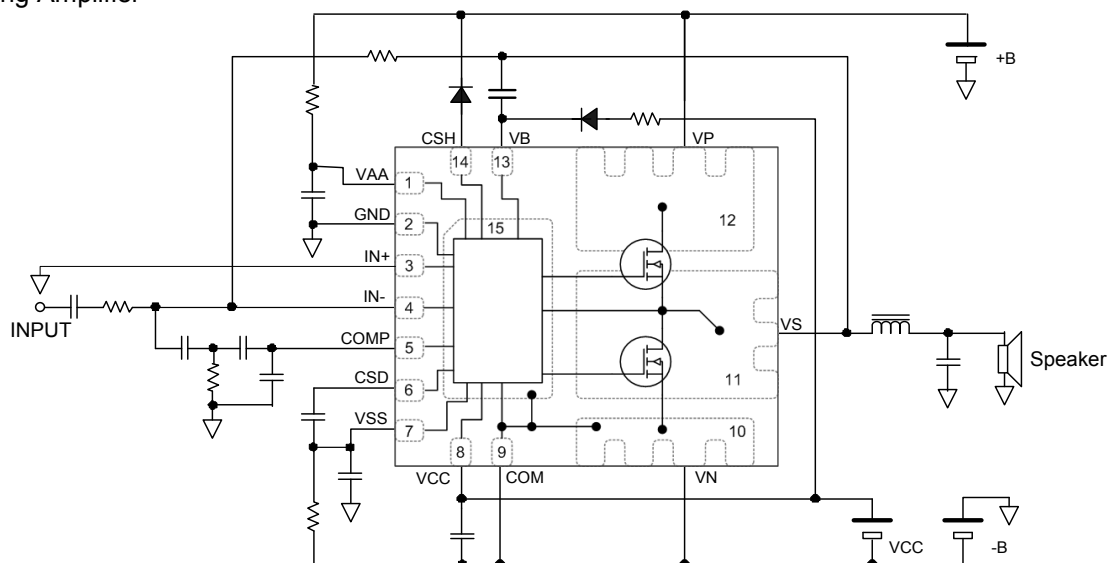
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## Description

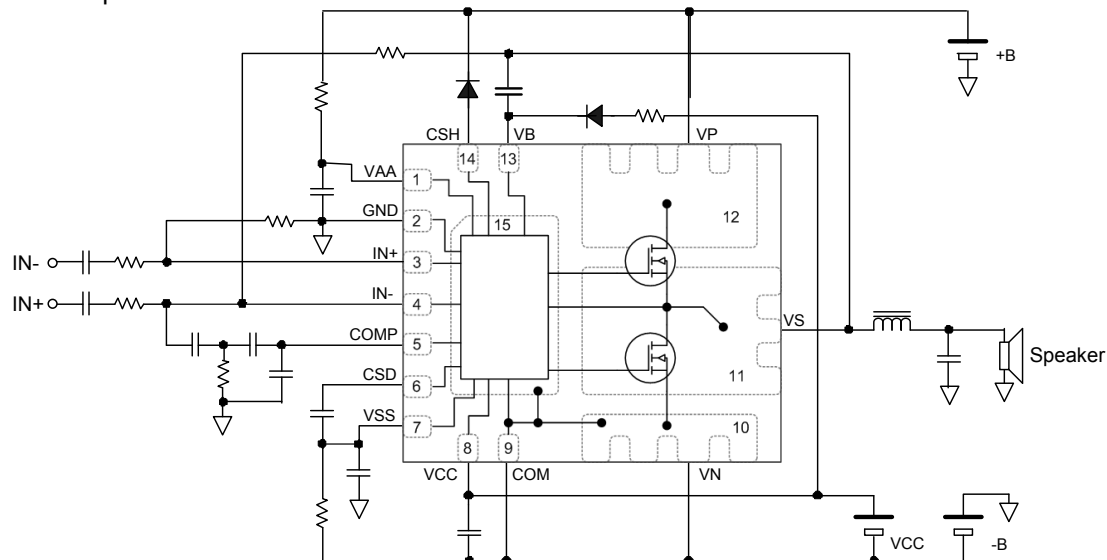
The IR43x1 integrates PWM controller and digital audio MOSFETs forming a high performance Class D audio amplifier. As a result of fully optimized MOSFETs co-packed with a dedicated controller IC, the IR43X1 operates without mechanical heatsink attached in a typical music playback usage. High voltage ratings and noise immunity in the controller IC ensures reliable operation over various environmental conditions. A small 5x6 mm PQFN package enhances the benefit of smaller size of Class D topology. The IR43x1 are a lead-free, ROHS compliant.

## Typical Connection Diagram

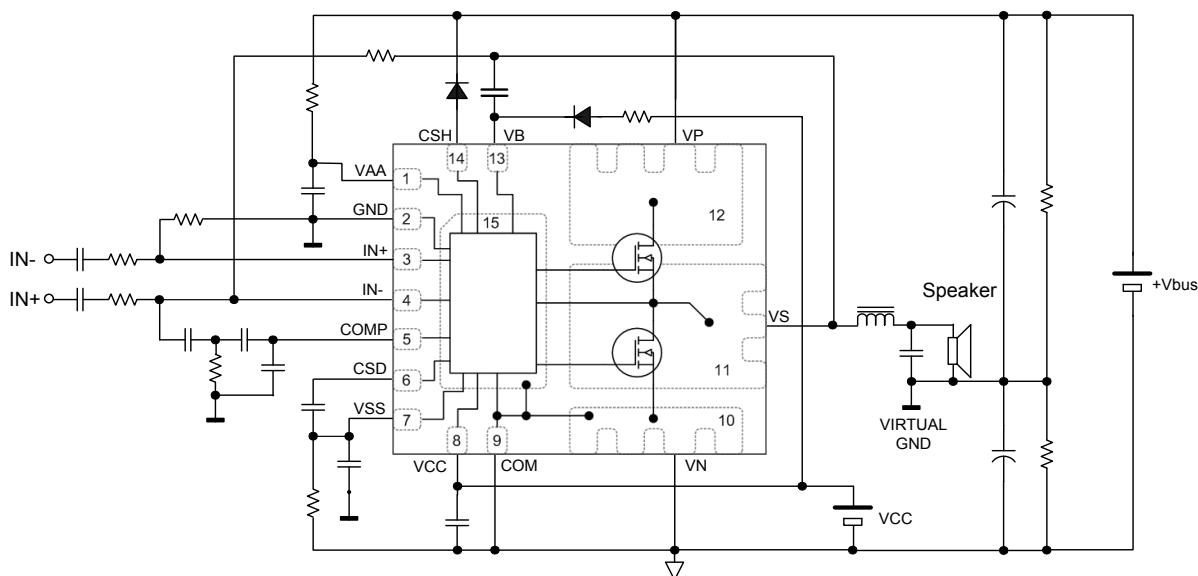
### 1. Inverting Amplifier



### 2. Differential Amplifier



### 3. Single Power Supply



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

Qualification Level		Industrial <sup>††</sup>
		Comments: This family of ICs has passed JEDEC's Industrial qualification. IR's Consumer qualification level is granted by extension of the higher Industrial level.
Moisture Sensitivity Level		MSL2 (per IPC/JEDEC J-STD-020C)
ESD	Machine Model	Class B (per JEDEC standard EIA/JESD22-A115)
	Human Body Model	Class 2 (per EIA/JEDEC standard JESD22-A114)
IC Latch-Up Test		Class I, Level A (per JESD78)
RoHS Compliant		Yes

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

<sup>††</sup> Higher qualification ratings may be available should the user have such requirements. Please contact your International Rectifier sales representative for further information.

<sup>†††</sup> Higher MSL ratings may be available for the specific package types listed here. Please contact your International Rectifier sales representative for further information.

## 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 <sub>P</sub>	VP pin positive power supply rail voltage	IR4301	-	80	V
		IR4321	-	60	
		IR4311	-	40	
V <sub>B</sub>	High side floating supply voltage	IR4301	-0.3	95	
		IR4321	-0.3	75	
		IR4311	-0.3	55	
V <sub>CSH</sub>	CSH pin input voltage		V <sub>S</sub> -0.3	V <sub>B</sub> +0.3	
V <sub>S</sub>	High side floating supply voltage <sup>††</sup>		V <sub>B</sub> -15	V <sub>B</sub> +0.3	
V <sub>CC</sub>	Low side supply voltage <sup>††</sup>		-0.3	15	
V <sub>AA</sub>	Floating input positive supply voltage <sup>††</sup>	IR4301	-0.3	100	
		IR4321	-0.3	70	
		IR4311	-0.3	50	
V <sub>SS</sub>	Floating input negative supply voltage <sup>††</sup>		-1 (See I <sub>SSZ</sub> )	GND +0.3	mA
V <sub>IN+</sub>	Floating input supply ground voltage		V <sub>SS</sub> -0.3	V <sub>AA</sub> +0.3	
I <sub>IN</sub>	Input current between IN- and IN+ pins <sup>†</sup>		-	±3	V
V <sub>CSD</sub>	CSD pin input voltage		V <sub>SS</sub> -0.3	V <sub>AA</sub> +0.3	
V <sub>COMP</sub>	COMP pin input voltage		V <sub>SS</sub> -0.3	V <sub>AA</sub> +0.3	mA
I <sub>AAZ</sub>	Floating input supply zener clamp current <sup>††</sup>		-	20	
I <sub>SSZ</sub>	Floating input negative supply zener clamp current <sup>††</sup>		-	20	
I <sub>CCZ</sub>	Low side supply zener clamp current <sup>†††</sup>		-	20	
I <sub>BSZ</sub>	Floating supply zener clamp current <sup>†††</sup>		-	20	
dV <sub>S</sub> /dt	Allowable V <sub>S</sub> voltage slew rate		-	50	V/ns
dV <sub>SS</sub> /dt	Allowable V <sub>SS</sub> voltage slew rate <sup>†††</sup>		-	50	V/ms
I <sub>D</sub> @ 25°C	Continuous output current, from VP to VS, VS to VN, V <sub>CC</sub> =10V, V <sub>B</sub> -V <sub>S</sub> =10V	IR4301	-	6.5	A
		IR4321	-	7.0	
		IR4311	-	3.6	
I <sub>D</sub> @ 100°C	Continuous output current, from VP to VS, VS to VN, V <sub>CC</sub> =10V, V <sub>B</sub> -V <sub>S</sub> =10V	IR4301	-	5.4	
		IR4321	-	5.8	
		IR4311	-	2.9	
I <sub>DM</sub>	Pulsed output current, from VP to VS, VS to VN, V <sub>CC</sub> =10V, V <sub>B</sub> -V <sub>S</sub> =10V <sup>††††</sup>	IR4301	-	26	
		IR4321	-	28	
		IR4311	-	15	
Pd	Power dissipation <sup>††††</sup> @ T <sub>C</sub> = 25°C	IR4301	-	31	W
		IR4321	-	31	
		IR4311	-	9	

Rth <sub>JC</sub>	Thermal resistance, junction to case <sup>†††</sup>	IR4301	-	4	°C/W
		IR4321	-	4	
		IR4311	-	13	
T <sub>JIC</sub>	Control IC junction temperature	-	-	150	°C
T <sub>JFET</sub>	FET junction temperature	-	-	150	
T <sub>S</sub>	Storage Temperature	-55	-	150	
T <sub>L</sub>	Lead temperature (Soldering, 10 seconds)	-	-	300	

† IN- and IN+ contain clamping diodes between the two pins.

†† V<sub>AA</sub> -V<sub>SS</sub>, V<sub>CC</sub>-COM and V<sub>B</sub>-V<sub>S</sub> contain internal shunt zener diodes. Please 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. V<sub>SS</sub>=15V to 200V.

†††† Per MOSFET

††††† Repetitive rating, pulse width limited by max. junction temperature

## Recommended Operating Conditions

For proper operation, the device should be used within the recommended conditions below. The  $V_{SS}$  and  $V_S$  offset ratings are tested with supplies biased at  $COM=VN$ ,  $V_{AA}-V_{SS}=9.6V$ ,  $V_{CC}=12V$  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
$V_P$	Positive power supply rail voltage, without heatsink	IR4301	-	62	V
		IR4321	-	50	
		IR4311	-	32	
	Positive power supply rail voltage, with heatsink	IR4301	-	68	
		IR4321	-	50	
		IR4311	-	32	
$V_B$	High side floating supply absolute voltage		$V_S + 10$	$V_S + 14$	
$V_S$	High side floating supply offset voltage	IR4301	†	80	
		IR4321	†	60	
		IR4311	†	40	
$V_{AA}$	Floating input positive supply voltage <sup>††</sup>		$V_{SS} + 4.5$	$V_{SS} + 15$	
$V_{SS}$	Floating input negative supply voltage <sup>††</sup>	IR4301	0	80	mA
		IR4321	0	60	
		IR4311	0	40	
$I_{AAZ}$	Floating input supply zener clamp current <sup>††</sup>		1	15	mA
$I_{SSZ}$	Floating input negative supply zener clamp current <sup>††</sup>		1	15	
$V_{CC}$	Low side fixed supply voltage		10	15	V
$V_{IC}$	IN- and IN+ pins common mode input voltage		$V_{SS} + 2$	$V_{AA} - 2$	
$V_{IN-}$	Inverting input voltage		$V_{IN+} - 0.5$	$V_{IN+} + 0.5$	
$V_{CSD}$	CSD pin input voltage		$V_{SS}$	$V_{AA}$	
$V_{COMP}$	COMP pin input voltage		$V_{SS}$	$V_{AA}$	
$C_{COMP}$	COMP pin phase compensation capacitor to GND		1	-	nF
$V_{CSH}$	CSH pin input voltage		$V_S$	$V_B$	V
$dV_{SS}/dt$	Allowable $V_{SS}$ voltage slew rate upon power-up <sup>†††</sup>		-	50	V/ms
$f_{SW}$	Switching Frequency		-	500	kHz
$T_A$	Ambient Temperature		-40	100	°C

† Logic operational for  $V_S$  equal to -5V to +80V. Logic state held for  $V_S$  equal to -5V to -VBS.

†† GND input voltage is limited by  $I_{AAZ}$  and  $I_{SSZ}$ .

†††  $V_{SS}$  ramps up from 0V to 70V.

## Electrical Characteristics

$V_{CC}, V_{BS} = 12\text{ V}$ ,  $V_{SS} = V_S = V_N = \text{COM} = 0\text{ V}$ ,  $V_{AA} = 9.6\text{ V}$  and  $T_A = 25^\circ\text{C}$  unless otherwise specified.

Symbol	Definition	Min	Typ	Max	Units	Test Conditions
<b>Low Side Supply</b>						
$UV_{CC+}$	Vcc supply UVLO positive threshold	8.4	8.9	9.4	V	
$UV_{CC-}$	Vcc supply UVLO negative threshold	8.2	8.7	9.2	V	
$UV_{CCHYS}$	$UV_{CC}$ hysteresis	-	0.2	-	V	
$I_{QCC}$	Low side quiescent current	-	-	3	mA	
$I_{CC}$	Low side operating current	-	5	-	mA	$f=400\text{kHz}$
$V_{CLAMPL}$	Low side zener diode clamp voltage	14.7	15.3	16.2	V	$I_{CC}=5\text{mA}$
<b>High Side Floating Supply</b>						
$UV_{BS+}$	High side well UVLO positive threshold	8.0	8.5	9.0	V	
$UV_{BS-}$	High side well UVLO negative threshold	7.8	8.3	8.8	V	
$UV_{BSHYS}$	$UV_{BS}$ hysteresis	-	0.2	-	V	
$I_{QBS}$	High side quiescent current	-	-	2.4	mA	
$V_{CLAMPH}$	High side zener diode clamp voltage	14.7	15.3	16.2	V	$I_{BS}=5\text{mA}$
<b>Floating Input Supply</b>						
$UV_{AA+}$	$VA+$ , $VA-$ floating supply UVLO positive threshold from $V_{SS}$	8.2	8.7	9.2	V	$V_{SS}=0\text{V}$ , GND pin floating
$UV_{AA-}$	$VA+$ , $VA-$ floating supply UVLO negative threshold from $V_{SS}$	7.7	8.2	8.7	V	$V_{SS}=0\text{V}$ , GND pin floating
$UV_{AAHYS}$	$UV_{AA}$ hysteresis	-	0.5	-	V	$V_{SS}=0\text{V}$ , GND pin floating
$I_{QAA0}$	Floating Input positive quiescent supply current	-	1	2	mA	$V_{AA}=9.6\text{V}$ , $V_{SS}=0\text{V}$ , $V_{CSD}=V_{SS}$
$I_{QAA1}$	Floating Input positive quiescent supply current	-	2	3	mA	$V_{AA}=9.6\text{V}$ , $V_{SS}=0\text{V}$ , $V_{CSD}=V_{AA}$
$I_{QAA2}$	Floating Input positive quiescent supply current	-	2.5	4	mA	$V_{AA}=9.6\text{V}$ , $V_{SS}=0\text{V}$ , $V_{CSD}=\text{GND}$
$I_{LKM}$	Floating input side to Low side leakage current	-	-	50	$\mu\text{A}$	$V_{AA}=V_{SS}=V_{GND}=100\text{V}$
$V_{CLAMP+}$	$V_{AA}$ floating supply zener diode clamp voltage, positive, with respect to GND	4.9	5.1	5.4	V	$I_{AA}=5\text{mA}$ , $I_{SS}=5\text{mA}$ , $V_{GND}=0\text{V}$ , $V_{CSD}=V_{SS}$
$V_{CLAMP-}$	$V_{SS}$ floating supply zener diode clamp voltage, negative, with respect to GND	-5.4	-5.1	-4.9	V	$I_{AA}=5\text{mA}$ , $I_{SS}=5\text{mA}$ , $V_{GND}=0\text{V}$ , $V_{CSD}=V_{SS}$



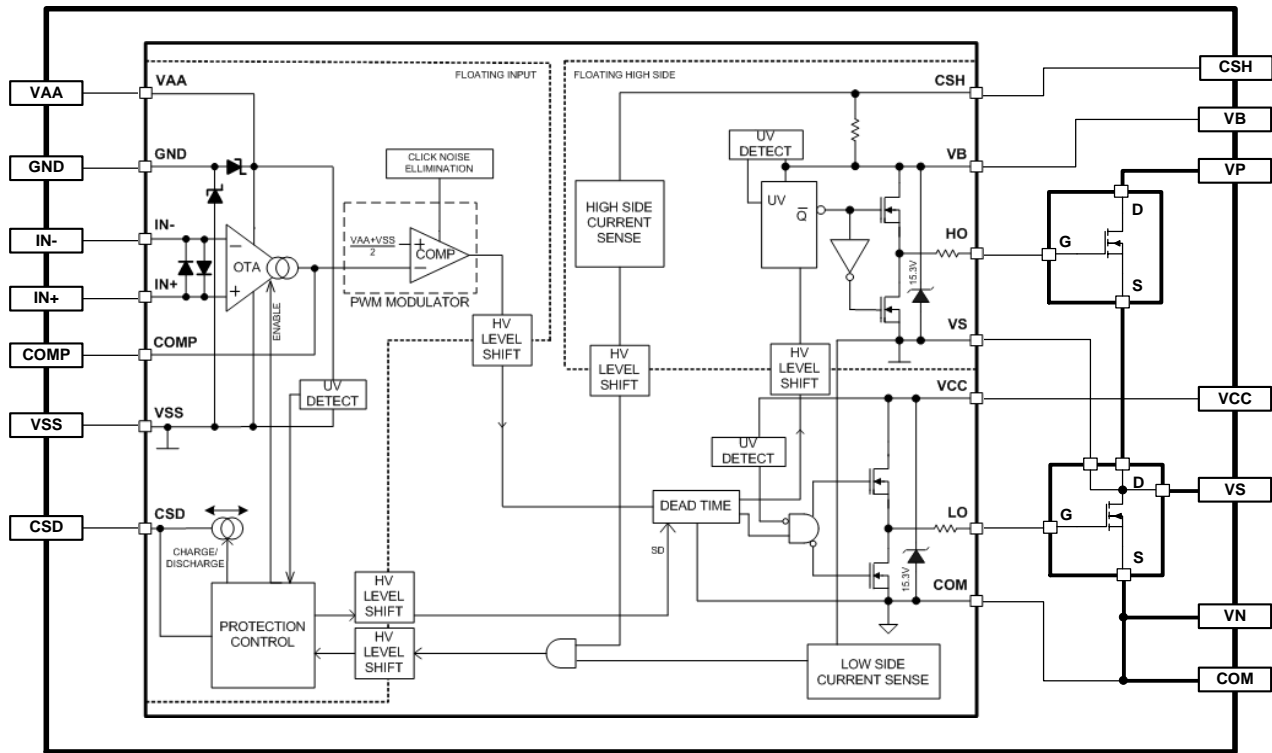
**Electrical Characteristics (cont'd)**
 $V_{CC}, V_{BS} = 12\text{ V}$ ,  $V_{SS} = V_S = V_N = \text{COM} = 0\text{V}$ ,  $V_{AA} = 9.6\text{V}$  and  $T_A = 25^\circ\text{C}$  unless otherwise specified.

Symbol	Definition	Min	Typ	Max	Units	Test Conditions
<b>Audio Input</b> ( $V_{GND}=0$ , $V_{AA}=4.8\text{V}$ , $V_{SS}=-4.8\text{V}$ )						
$V_{OS}$	Input offset voltage	-18	0	18	mV	
$I_{BIN}$	Input bias current	-	-	40	nA	
GBW	Small signal bandwidth	-	9	-	MHz	$C_{COMP}=1\text{nF}$ , $R_f=0$
$g_m$	OTA transconductance	-	10	-	mS	$V_{IN+}=0\text{V}$ , $V_{IN-}=10\text{mV}$
$G_V$	OTA gain	50	-	-	dB	
<b>PWM</b>						
$V_{th_{PWM}}$	PWM comparator threshold in COMP	-	$(V_{AA} - V_{SS})/2$	-	V	
$f_{OTA}$	COMP pin star-up local oscillation frequency	0.7	1.0	1.5	MHz	$V_{CSD} = \text{GND}$
$T_{on}$	COMP to VS rising edge propagation delay	-	370	-	ns	
$T_{off}$	COMP to VS trailing edge propagation delay	-	320	-	ns	
DT	Deadtime: Low-side turn-off to High-side turn-on ( $DT_{LO-HO}$ ) & High-side turn-off to Low-side turn-on ( $DT_{HO-LO}$ )	-	50	-	ns	$V_P=30\text{V}$ , $V_N=-30\text{V}$
<b>Power MOSFET (FET1, FET2) (IR4301)</b>						
$V_{(BR)DSS}$	Drain-to-Source breakdown voltage	80	-	-	V	$V_{GS}=0\text{V}$ , $I_D=250\mu\text{A}$
$R_{DS(ON)}$	FET on resistance	-	39	50	m $\Omega$	$V_{GS}=10\text{V}$ , $I_D=3.3\text{A}$
Qg	Total gate charge	-	7.3	-	nC	
$I_{LK0}$	VP leakage current, $V_S=V_N$	-	-	20	$\mu\text{A}$	$V_P=80\text{V}$ , $V_{CSD}=V_{SS}$
$I_{LK1}$	VP leakage current, $V_S=V_P$	-	-	50	$\mu\text{A}$	
<b>Power MOSFET (FET1, FET2) (IR4321)</b>						
$V_{(BR)DSS}$	Drain-to-Source breakdown voltage	60	-	-	V	$V_{GS}=0\text{V}$ , $I_D=250\mu\text{A}$
$R_{DS(ON)}$	FET on resistance	-	30	40	m $\Omega$	$V_{GS}=10\text{V}$ , $I_D=3.3\text{A}$
Qg	Total gate charge	-	8.3	-	nC	
$I_{LK0}$	VP leakage current, $V_S=V_N$	-	-	20	$\mu\text{A}$	$V_P=60\text{V}$ , $V_{CSD}=V_{SS}$
$I_{LK1}$	VP leakage current, $V_S=V_P$	-	-	50	$\mu\text{A}$	
<b>Power MOSFET (FET1, FET2) (IR4311)</b>						
$V_{(BR)DSS}$	Drain-to-Source breakdown voltage	40	-	-	V	$V_{GS}=0\text{V}$ , $I_D=250\mu\text{A}$
$R_{DS(ON)}$	FET on resistance	-	44	56	m $\Omega$	$V_{GS}=10\text{V}$ , $I_D=3.6\text{A}$
Qg	Total gate charge	-	4.5	-	nC	
$I_{LK0}$	VP leakage current, $V_S=V_N$	-	-	20	$\mu\text{A}$	$V_P=40\text{V}$ , $V_{CSD}=V_{SS}$
$I_{LK1}$	VP leakage current, $V_S=V_P$	-	-	50	$\mu\text{A}$	

**Electrical Characteristics (cont'd)**
 $V_{CC}, V_{BS} = 12\text{ V}$ ,  $V_{SS} = V_S = V_N = \text{COM} = 0\text{ V}$ ,  $V_{AA} = 9.6\text{ V}$  and  $T_A = 25^\circ\text{C}$  unless otherwise specified.

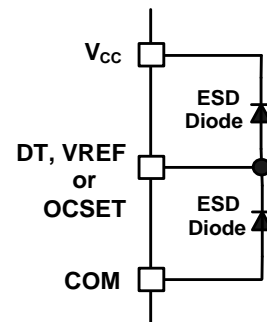
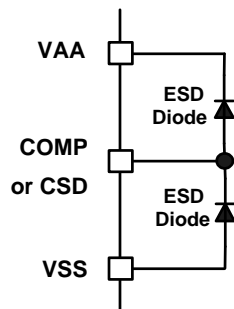
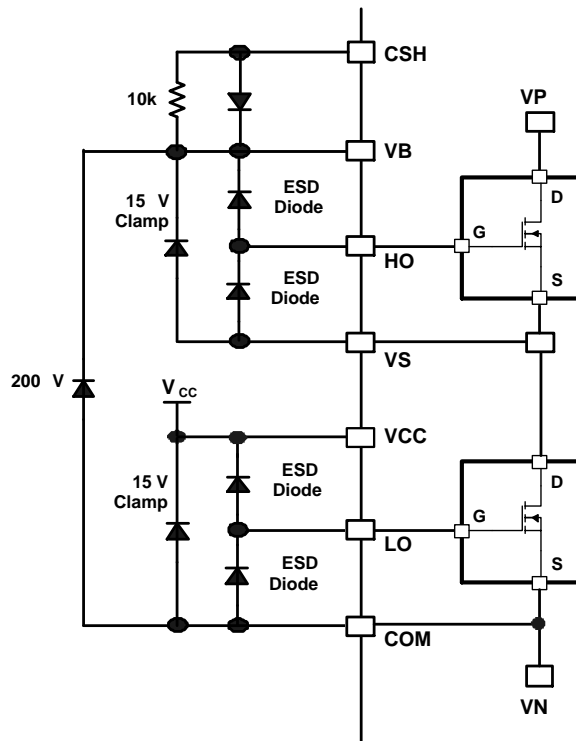
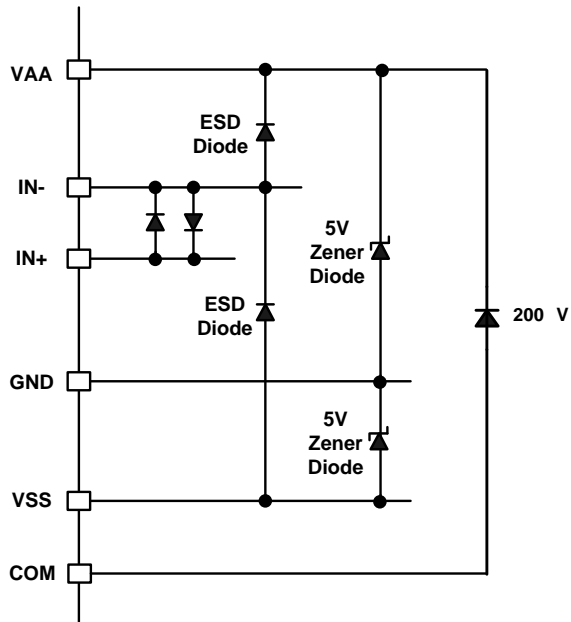
Symbol	Definition	Min	Typ	Max	Units	Test Conditions
<b>Protection</b>						
$I_{OCP}$	Positive OC threshold	-	16	-	A	
$I_{OCN}$	Negative OC threshold	-	-16	-	A	
$V_{th1}$	CSD pin shutdown release threshold	$0.62 \times V_{AA}$	$0.70 \times V_{AA}$	$0.78 \times V_{AA}$	V	
$V_{th2}$	CSD pin self-reset threshold	$0.26 \times V_{AA}$	$0.30 \times V_{AA}$	$0.34 \times V_{AA}$	V	
$I_{CSD+}$	CSD pin discharge current	70	100	130	$\mu\text{A}$	$V_{CSD} = V_{SS} + 4.8\text{ V}$
$I_{CSD-}$	CSD pin charge current	70	100	130	$\mu\text{A}$	$V_{CSD} = V_{SS} + 4.8\text{ V}$
$t_{SD}$	Shutdown propagation delay from $V_S < V_{th1}$ to Shutdown	-	-	250	ns	$\text{COMP} = V_{SS}$
$t_{OCP}$	Propagation delay time from $I_O > I_{OCP}$ to Shutdown	-	-	500	ns	$\text{COMP} = V_{SS}$
$t_{OCN}$	Propagation delay time from $I_O < I_{OCN}$ to Shutdown	-	-	500	ns	$\text{COMP} = V_{SS}$
$T_{SD}$	Over temperature shutdown threshold in controller IC	-	105	-	$^\circ\text{C}$	
$T_{SDHYS}$	Over temperature shutdown threshold hysteresis	-	7	-	$^\circ\text{C}$	

## Functional Block Diagram



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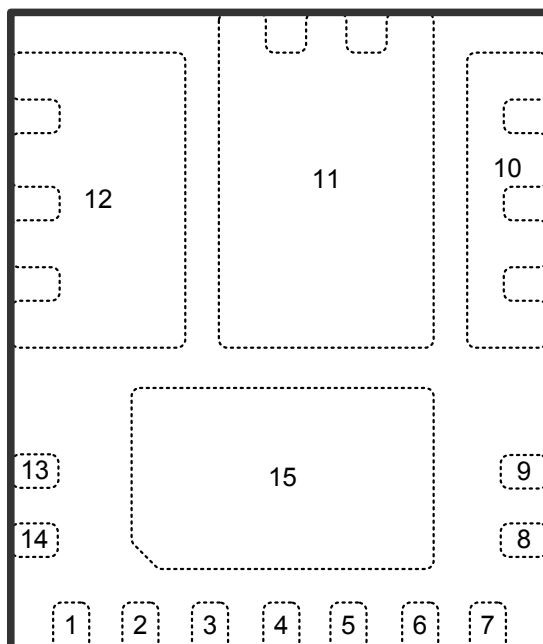
## Input/Output Pin Equivalent Circuit Diagrams



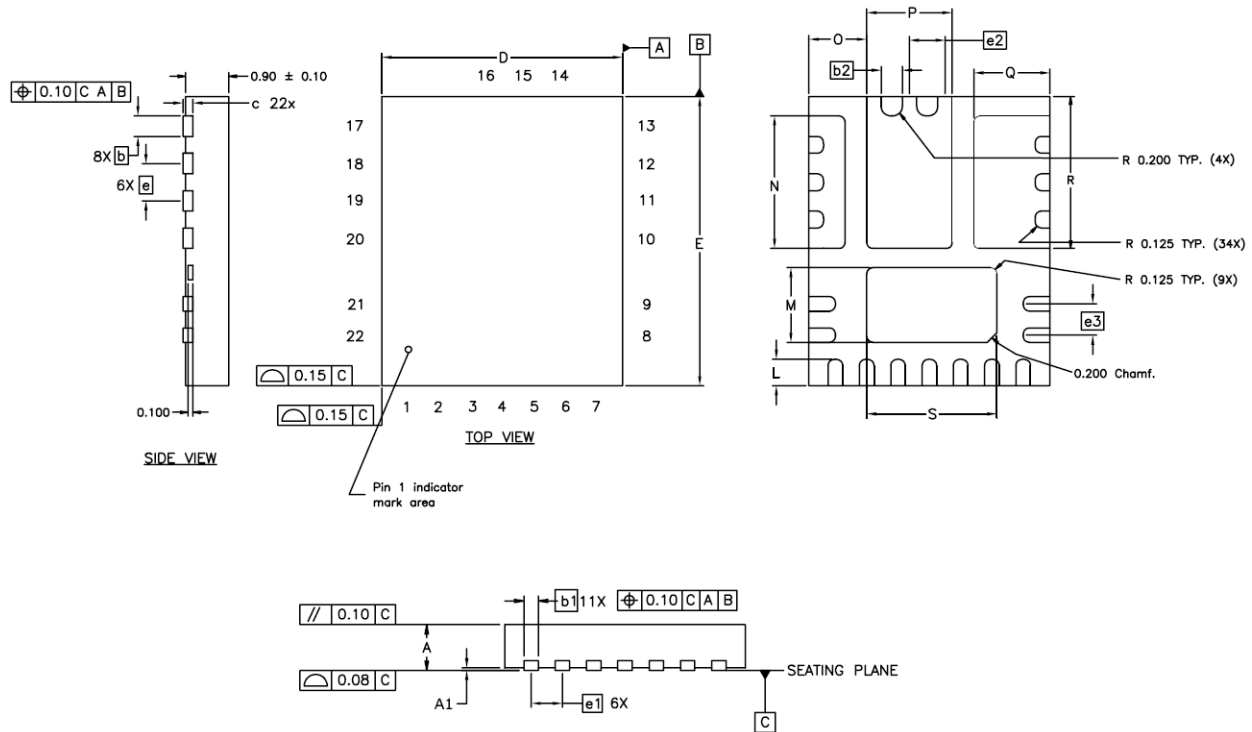
## Lead Definitions

Pin #	Symbol	Description
1	VAA	Floating input positive supply
2	GND	GND for internal shunt zener diodes to VAA and VSS
3	IN+	Analog non-inverting input
4	IN-	Analog inverting input
5	COMP	PWM comparator input
6	CSD	Shutdown timing capacitor / shutdown input
7	VSS	Floating input negative supply
8	VCC	Low side supply
9	COM	Low side supply return, internally connected to VN
10	VN	Negative power supply, internally connected to COM externally
11	VS	PWM output
12	VP	Positive power supply
13	VB	High side floating supply, referenced to VS
14	CSH	High side over current sensing input, referenced to VS
15	SUB	Internally connected to COM (Do not use as supply return)

## Lead Assignments (Top View)



## Package Details



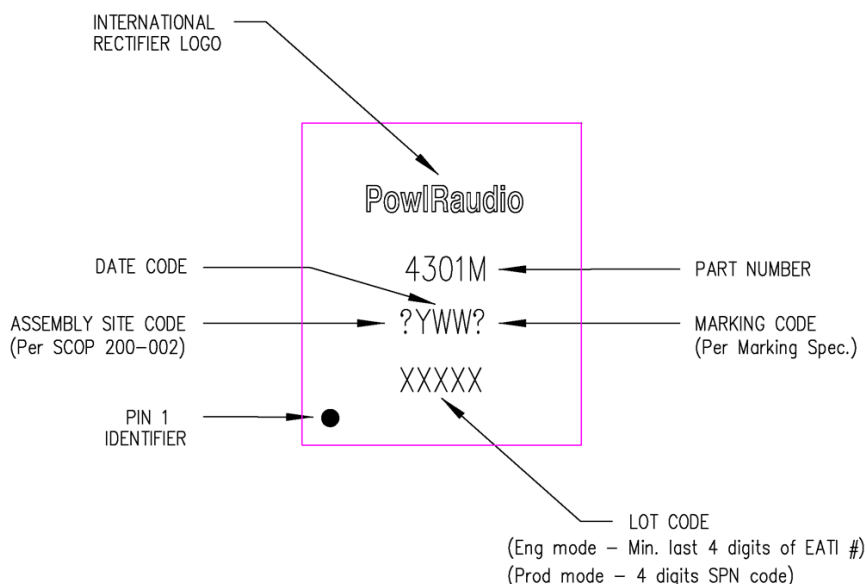
Outline PQFN 5x6 D

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	0.800	1.000	.0315	.0394
A1	0.000	0.050	.0000	.0020
b	0.375	0.475	.0148	.0187
b1	0.250	0.350	.0098	.0138
b2	0.388	0.488	.0153	.0192
c	0.203 REF.		.0080 REF.	
D	5.000 BASIC		.1969 BASIC	
E	6.000 BASIC		.2362 BASIC	
e	0.775 BASIC		.0305 BASIC	
e1	0.650 BASIC		.0256 BASIC	
e2	0.738 BASIC		.0291 BASIC	
e3	0.650 BASIC		.0256 BASIC	
L	0.500	0.600	.0197	.0236
M	1.500	1.600	.0591	.0630
N	2.700	2.800	.1063	.1102
O	1.150	1.250	.0453	.0492
P	1.725	1.825	.0679	.0719
Q	1.525	1.625	.0600	.0640
R	3.100	3.200	.1220	.1260
S	2.650	2.750	.1043	.1083

## Board Mounting Information

Refer to Application Note AN-1170 Audio Power Quad Flat No-Lead (PQFN) Board Mounting Application Note.

## Part Marking Information



## Ordering Information

Base Part Number	Package Type	Standard Pack		Complete Part Number
		Form	Quantity	
IR4301M	PQFN22 5x6mm	Tape and Reel	4000	IR4301MTRPBF
IR4321M	PQFN22 5x6mm	Tape and Reel	4000	IR4321MTRPBF
IR4311M	PQFN22 5x6mm	Tape and Reel	4000	IR4311MTRPBF

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