TOSHIBA Bi-CMOS Linear Integrated Circuit Silicon Monolithic

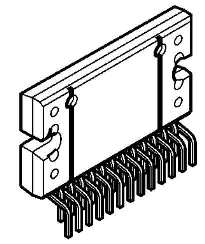
TB2921AHQ

51 W × 4-ch BTL Audio Power IC

The TB2921AHQ is a four-channel BTL power amplifier for car audio applications.

This IC has a pure complementary P-ch and N-ch DMOS output stage, offering maximum output power (P_{OUT} MAX) of 51 W.

It includes a standby switch, mute function, a high-side switch and various protection features.



HZIP25-P-1.00F

Weight: 7.7 g (typ.)

Features

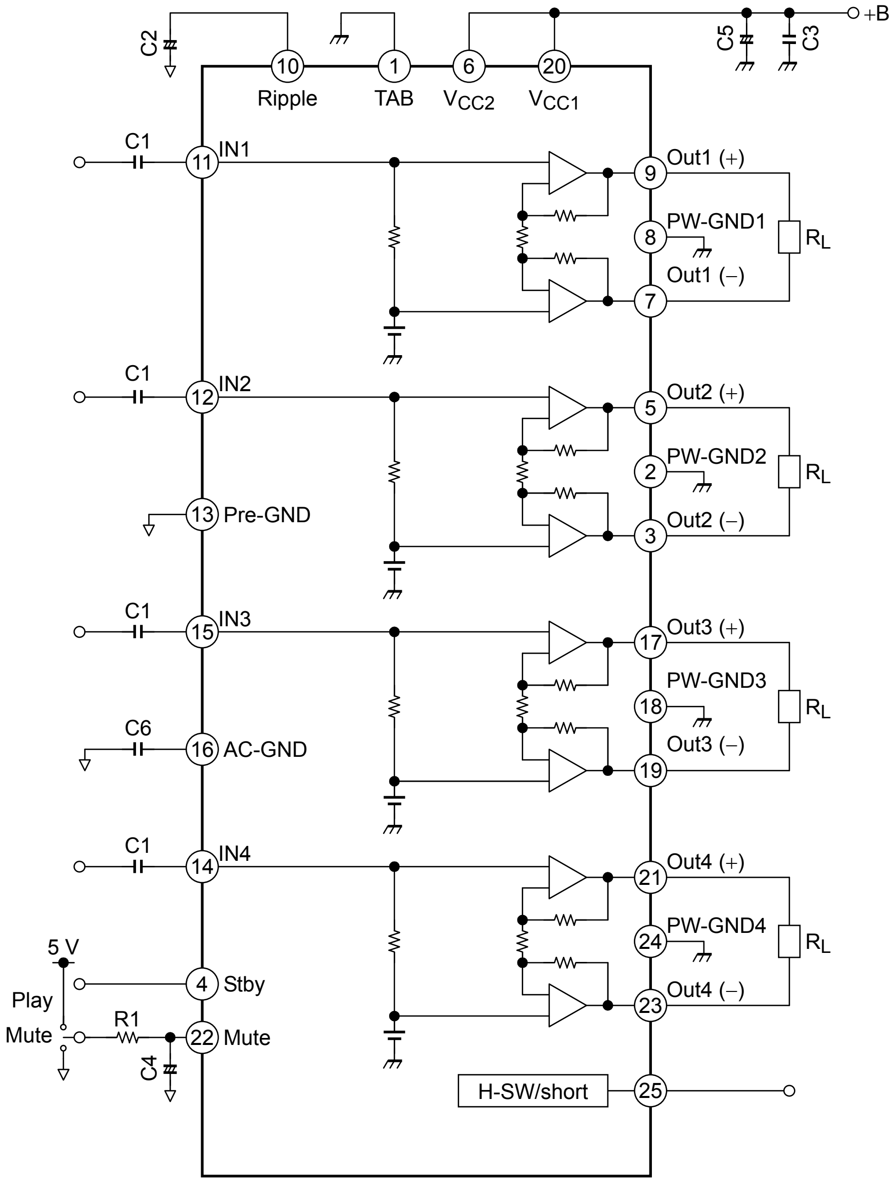
- High output power
  - P_{OUT} MAX (1) = 51 W (typ.)
    (V_{CC} = 15.2 V, f = 1 kHz, JEITA max, R_L = 4 Ω)
  - P_{OUT} MAX (2) = 45 W (typ.)
    (V_{CC} = 13.7 V, f = 1 kHz, JEITA max, R_L = 4 Ω)
  - P_{OUT} MAX (3) = 80 W (typ.)
    (V_{CC} = 14.4 V, f = 1 kHz, JEITA max, R_L = 4 Ω)
  - P_{OUT} (1) = 29 W (typ.)
    (V_{CC} = 14.4 V, f = 1 kHz, THD = 10%, R_L = 4 Ω)
  - P_{OUT} (2) = 25 W (typ.)
    (V_{CC} = 13.2 V, f = 1 kHz, THD = 10%, R_L = 4 Ω)
- Low THD: 0.005% (typ.) (V_{CC} = 13.2 V, f = 1 kHz, P_{OUT} = 5 W, R_L = 4 Ω)
- Low noise: V_{NO} = 55 μVrms (typ.)
  (V_{CC} = 13.2 V, R_g = 0 Ω, BW = 20 Hz to 20 kHz, R_L = 4 Ω)
- Standby switch (pin 4)
- Mute function (pin 22)
- High-side switch (H-SW) (pin 25)
- Various protection features
  Thermal overload; overvoltage; output short-circuits to GND, V_{CC} and across the load
- Operating supply voltage : V_{CC} (opr) = 8.0 to 18 V (R_L = 4 Ω)
  : V_{CC} (opr) = 8.0 to 16 V (R_L= 2 Ω)

Note 1: Install the device correctly. Otherwise, the device or system may be degraded, damaged or even destroyed.

Note 2: The protection features are intended to avoid output short-circuits or other abnormal conditions temporarily. It is not guaranteed that they will prevent the IC from being damaged.
Exposure to conditions beyond the guaranteed operating ranges may not activate the protection features, resulting in an IC damage due to output short-circuits.

Note 3: The protection circuit may malfunction depending on the connected speaker type due to a phase shift. The operation of the device should therefore be verified by actually connecting a speaker to its outputs. It is not recommended to connect a 2-ohm load such as a subwoofer that induces a significant phase shift, and that special care should be taken in such cases.

Block Diagram



Some of the functional blocks, circuits or constants may be omitted from the block diagram or simplified for explanatory purposes.

Detailed Description

1. Standby Switch (pin 4)

The power supply can be turned on or off via pin 4 (Stby). The threshold voltage of pin 4 is set at about 3 V_{BE} (typ.). The power supply current is about 0.01 μA (typ.) in the standby state.

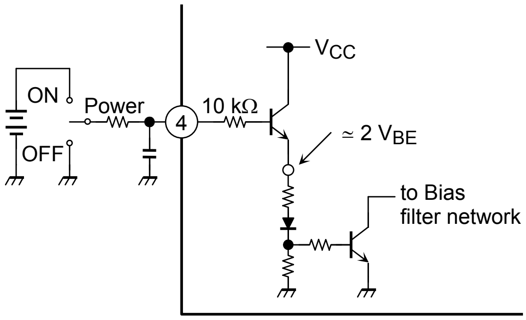


Figure 1 Setting Pin 4 High Turns on Power

Standby Control Voltage (V_{SB}): Pin 4

Standby	Power	V_{SB} (V)
ON	OFF	0 to 0.9
OFF	ON	2.9 to Vcc

Check the pop levels when the time constant of pin 4 is changed.

Benefits of the Standby Switch

(1) V_{CC} can be directly turned on or off by a microcontroller, eliminating the need for a switching relay.

(2) Since the control current is minuscule, a low-current-rated switching relay can be used.

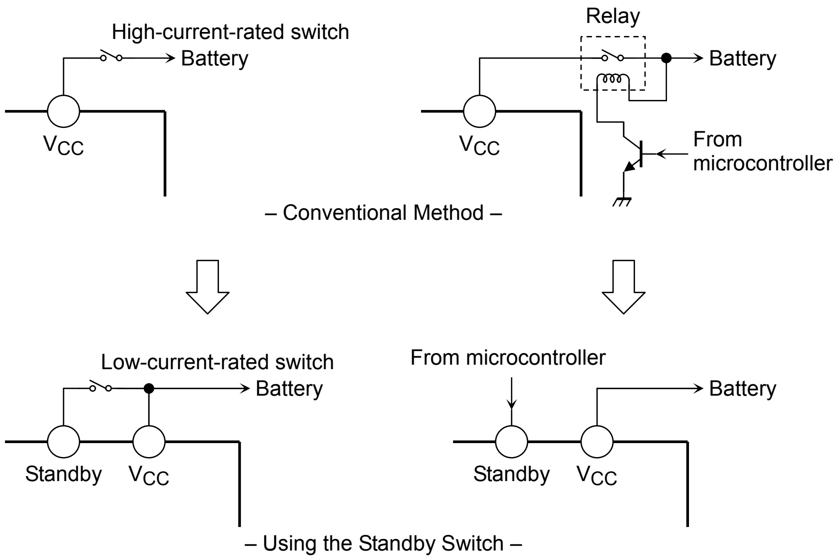


Figure 2 Standby Switch

2. Mute Function (pin 22)

The audio mute function is enabled by setting pin 22 Low. R_1 and C_4 determine the time constant of the mute function. The time constant affects pop noise generated when power or the mute function is turned on or off; thus, it must be determined on a per-application basis. (Refer to Figures 3 and 4.)
The value of the external pull-up resistor is determined, based on pop noise value.

For example, when the control voltage is changed from 5 V to 3.3 V, the pull-up resistor should be:

$$3.3\ \text{V} / 5\ \text{V} \times 47\ \text{k}\Omega = 31\ \text{k}\Omega$$

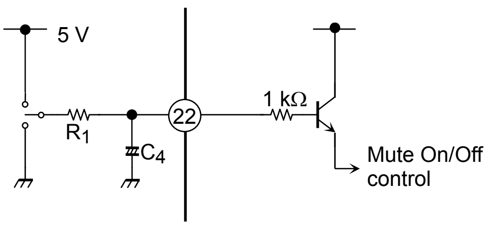


Figure 3 Mute Function

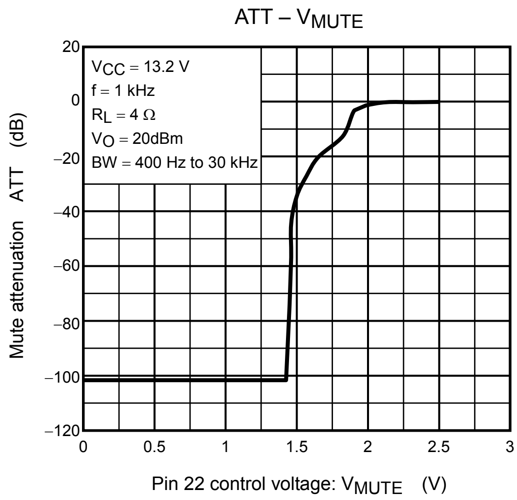


Figure 4 Mute Attenuation – V_{MUTE} (V)

3. High-Side Switch

Pin 25 of this device is used as a high-side switch to a V_{CC} power supply, which is interlocked with a standby pin. Thus, the power amplifier IC and the connected external unit (such as the hideaway unit) can be simultaneously turned on or off by using the standby switch.

4. DC Offset Detection

It is possible to use this function by setting the voltage of Pin 22 higher than 8V.
In case of Appearing output offset voltage by Generating a Large Leakage Current on the input Capacitor etc.

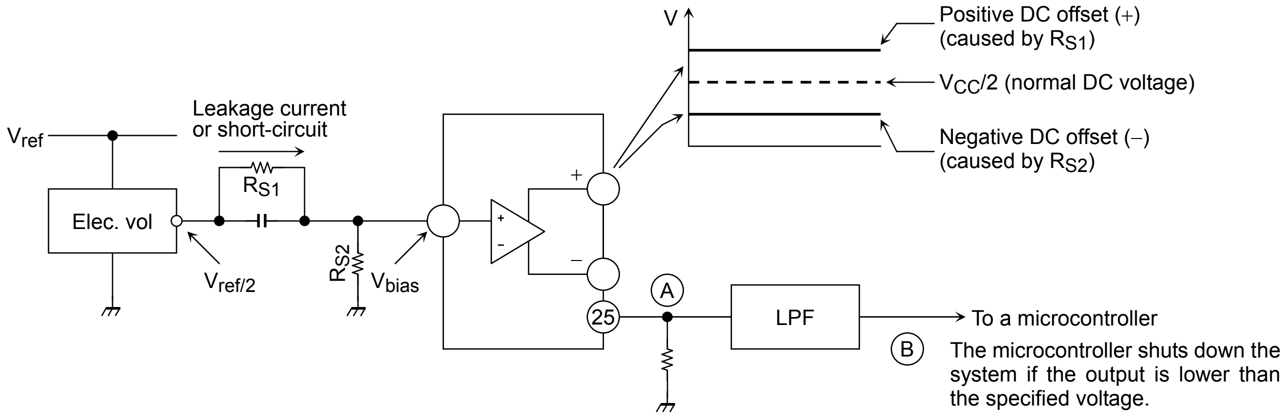
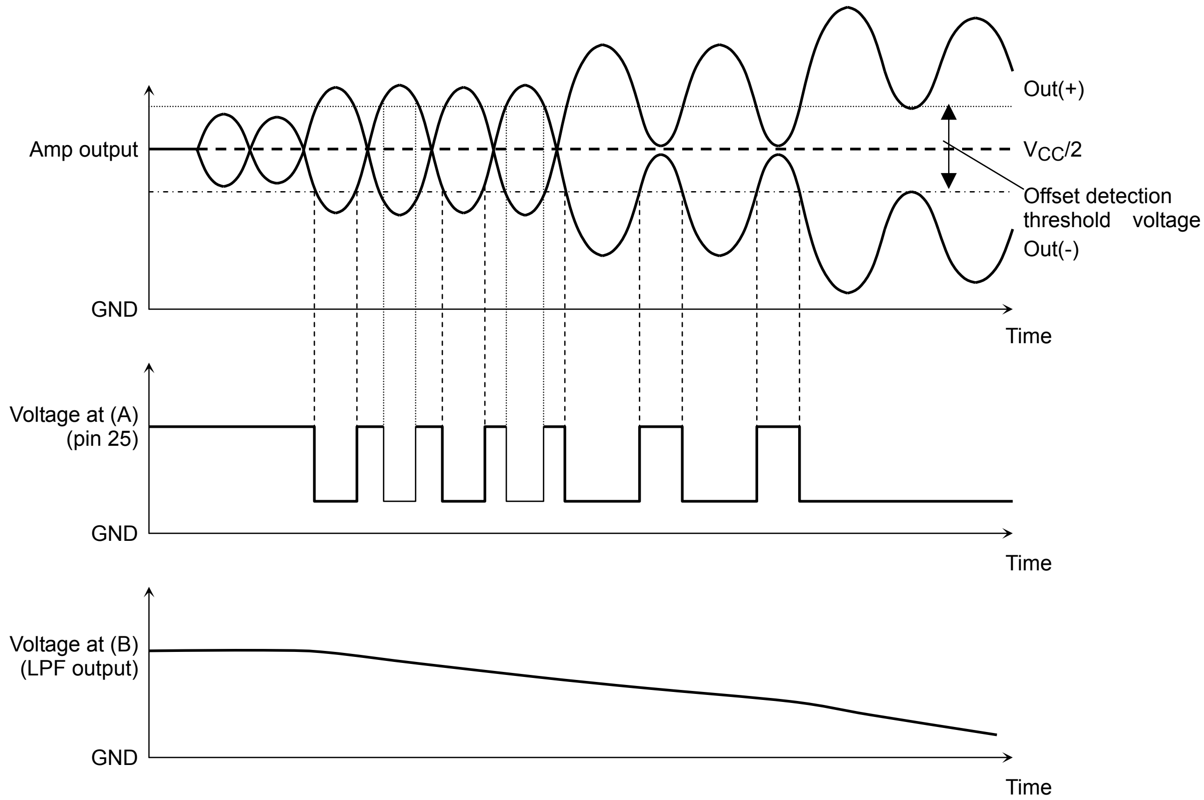


Figure 5 DC Offset Detection Mechanism



5. Pop Noise Suppression

Since the AC-GND pin (pin 16) is used as the input reference voltage pin for all amps, the ratio between the input capacitance (C1) and the AC-to-GND capacitance (C6) should be 1:4.

Also, if the power is turned OFF before the C1 and C6 batteries have been completely charged, pop noise will be generated because of the DC input unbalance.

To counteract the noise, it is recommended that a longer charging time be used for C2 as well as for C1 and C6. Note that the time which audio output takes to start will be longer, since the C2 makes the muting time (the time from when the power is turned ON to when audio output starts) is fix.

The pop noise which is generated when the muting function is turned ON/OFF will vary according to the time constant of C4.The greater the capacitance, the lower the pop noise. Note that the time from when the mute control signal is applied to C4 to when the muting function is turned ON/OFF will be longer.

6. External Component Constants

Component	Recommended Value	Purpose	Effects		Notes
			When lower than recommended value	When higher than recommended value	
C1	0.22 μF	To eliminate DC	Cut-off frequency is increased.	Cut-off frequency is reduced.	Pop noise is generated when V_{CC} is turned on.
C2	10 μF	To reduce ripple	Powering on/off is faster.	Powering on/off is slower.	
C3	0.1 μF	To provide sufficient oscillation margin	Reduces noise and provides sufficient oscillation margin		
C4	1 μF	To reduce pop noise	High pop noise. Duration until mute function is turned on/off is short.	Low pop noise. Duration until mute function is turned on/off is long.	
C5	3900 μF	Ripple filter	Power supply humming and ripple filtering.		
C6	1 μF	Reference voltage for all inputs	Pop noise is suppressed when C1: C6 = 1:4.		Pop noise is generated when V_{CC} is turned on.

Absolute Maximum Ratings (Ta = 25°C)

Characteristics	Symbol	Rating	Unit
Peak supply voltage (0.2 s)	V_{CC} (surge)	50	V
DC supply voltage	V_{CC} (DC)	25	V
Operating supply voltage	V_{CC} (opr)	18	V
Output current (peak)	I_O (peak)	9	A
Power dissipation	P_D (Note 4)	125	W
Operating temperature	T_{opr}	−40 to 85	°C
Storage temperature	T_{stg}	−55 to 150	°C

Note 4: Package thermal resistance $\theta_{j\text{-}T}$ = 1°C/W (typ.) (Ta = 25°C, with infinite heat sink)
The absolute maximum ratings of a semiconductor device are a set of specified parameter values that must not be exceeded during operation, even for an instant.
If any of these ratings are exceeded during operation, the electrical characteristics of the device may be irreparably altered and the reliability and lifetime of the device can no longer be guaranteed.
Moreover, any exceeding of the ratings during operation may cause breakdown, damage and/or degradation in other equipment. Applications using the device should be designed so that no absolute maximum rating will ever be exceeded under any operating conditions.
Before using, creating and/or producing designs, refer to and comply with the precautions and conditions set forth in this document.

Electrical Characteristics
(V_{CC} = 13.2 V, f = 1 kHz, R_L = 4 Ω, Ta = 25°C unless otherwise specified)

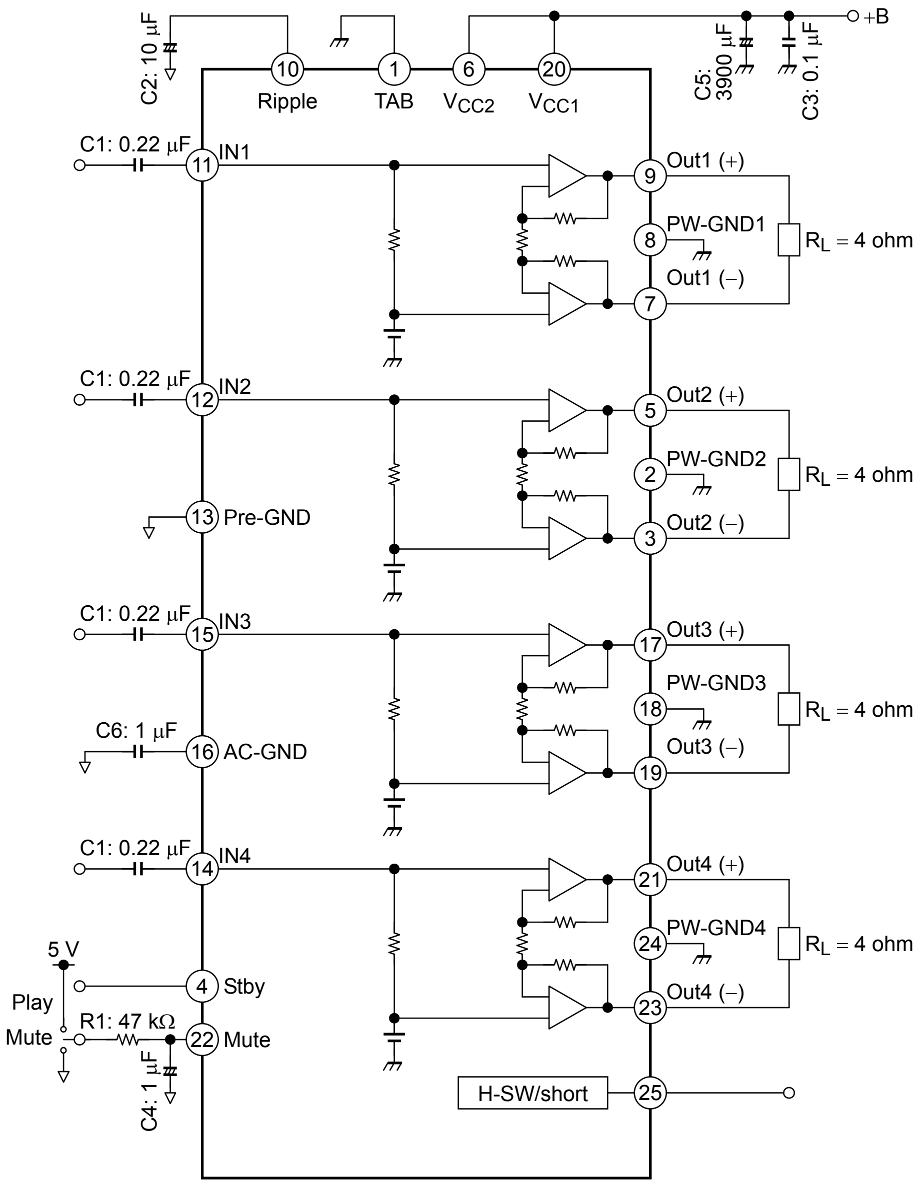
Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Quiescent supply current	I_{CCQ}	—	V_{IN} = 0	—	180	300	mA
Output power	P_{OUT} MAX (1)	—	V_{CC} = 15.2 V, max POWER	—	51	—	W
	P_{OUT} MAX (2)	—	V_{CC} = 13.7 V, max POWER	—	45	—	
	P_{OUT} MAX (3)	—	V_{CC} = 14.4 V, RL = 2 Ω max POWER	—	80	—	
	P_{OUT} (1)	—	V_{CC} = 14.4 V, THD = 10%	—	29	—	
	P_{OUT} (2)	—	THD = 10%	23	25	—	
Total harmonic distortion	THD	—	P_{OUT} = 5 W	—	0.005	0.07	%
Voltage gain	G_V	—	V_{OUT} = 0.775 Vrms	25	26	27	dB
Channel-to-channel voltage gain	ΔG_V	—	V_{OUT} = 0.775 Vrms	−1.0	0	1.0	dB
Output noise voltage	V_{NO} (1)	—	R_g = 0 Ω, DIN45405	—	60	—	μVrms
	V_{NO} (2)	—	R_g = 0 Ω, BW = 20 Hz to 20 kHz	—	55	70	
Ripple rejection ratio	R.R.	—	f_{rip} = 100 Hz, R_g = 620 Ω V_{rip} = 0.775 Vrms	50	65	—	dB
Crosstalk	C.T.	—	R_g = 620 Ω V_{OUT} = 0.775 Vrms	—	80	—	dB
Output offset voltage	V_{OFFSET}	—	—	−90	0	90	mV
Input resistance	R_{IN}	—	—	—	90	—	kΩ
Upper cut-off frequency	F_{th}	—	G_V = 26 dB, −3 dB	—	270	—	kHz
Standby current	I_{SB}	—	Standby condition,V4 = 0, V22 = 0	—	0.1	1	μA
Standby control voltage	V_{SB} H	—	POWER: ON	2.9	—	V_{CC}	V
	V_{SB} L	—	POWER: OFF	0	—	0.9	

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Mute control voltage	V_M H	—	MUTE: OFF	2.9	—	V_{CC}	V
	V_M L	—	MUTE: ON, R_1 = 47 kΩ	0	—	0.9	
Mute pin voltage for function switching of pin 25	V_M_On	—	Stb = 5 V	8	—	—	V
	V_M_Off	—		—	—	6	
Mute attenuation	ATT M	—	MUTE: ON V_{OUT} = 7.75 Vrms → Mute: OFF	85	100	—	dB

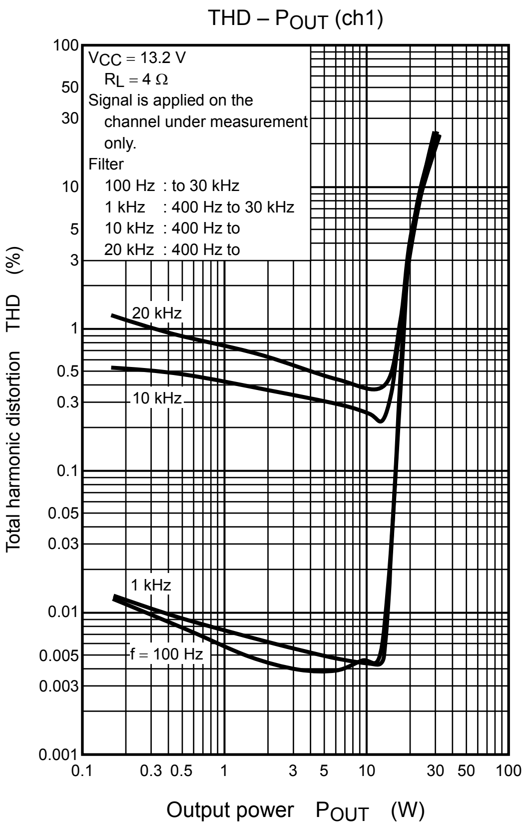
High-Side Switch/Offset detection

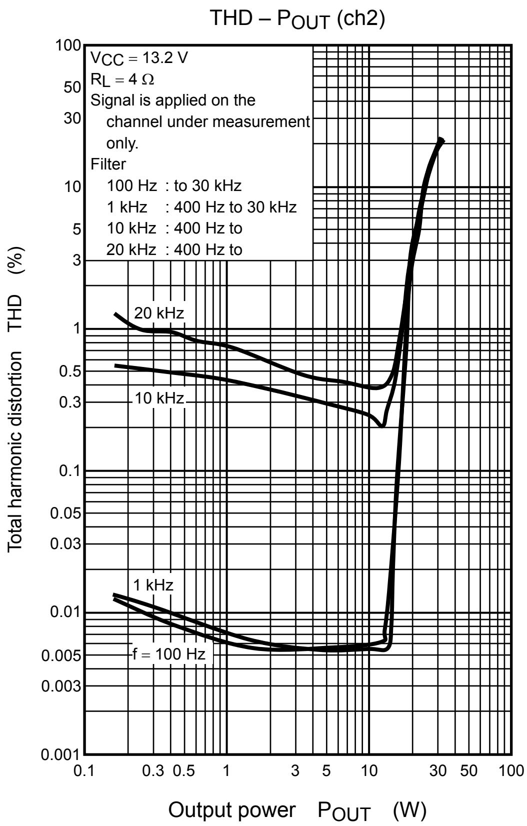
Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Maximum output current	I_O	—		400	—	—	mA
Voltage difference between V_{CC} and output	ΔV_o	—	I_O = 400 mA, +B = 9.6 V	—	0.25	0.6	V
DC offset threshold voltage	$V_{off\text{-}set}$	—	Rpull-down = 10 kΩ, V4 = 5 V, V22 = 8 V Out(+)-Out(-)	±2.5	±3.0	±3.5	V
Pin 25 voltage (at each detector ON condition)	P25-t	—	Rpull-down = 10 kΩ, V4 = 5 V, V22 = 8 V, Voffset > ±3.5 V, (pin 25 = low)	—	0	0.5	V
Pin 25 voltage (at each detector OFF condition)	P25-f	—	Rpull-down = 10 kΩ, V4 = 5 V, V22 = 8 V, Voffset < ±2.5 V (pin 25 = high)	12	13	—	V

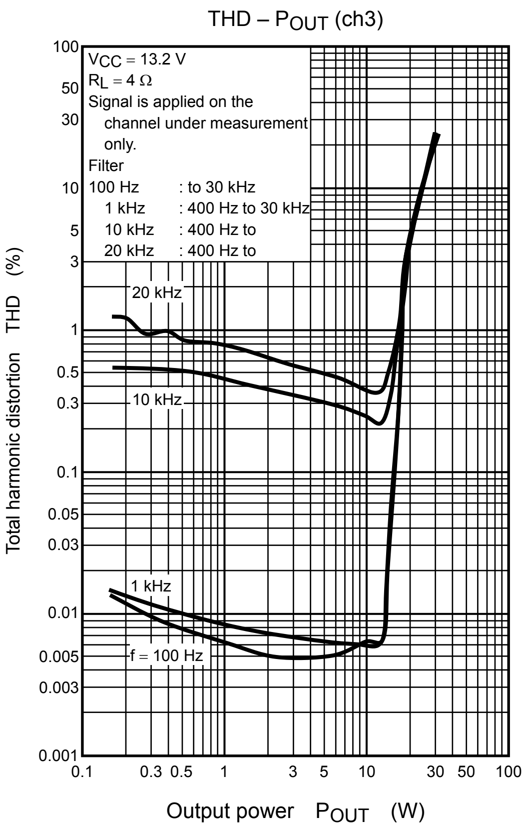
Test Circuit

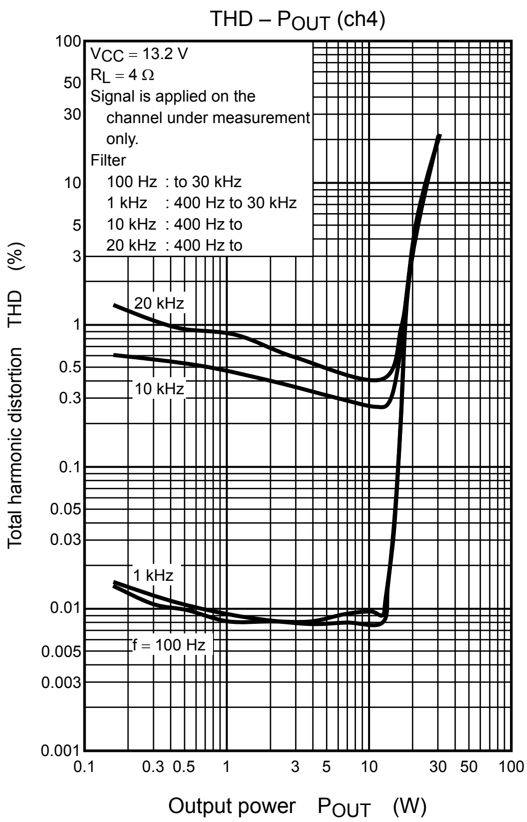


Components in the test circuit are only used to determine the device characteristics.
It is not guaranteed that the system will work properly with these components.

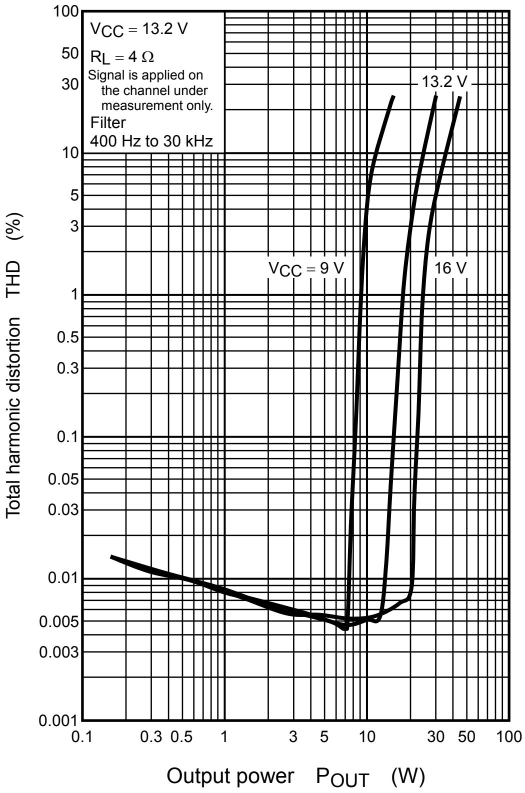

THD – POUT (ch1)
VCC = 13.2 V
RL = 4 Ω
Signal is applied on the channel under measurement only.
Filter
100 Hz : to 30 kHz
1 kHz : 400 Hz to 30 kHz
10 kHz : 400 Hz to
20 kHz : 400 Hz to
20 kHz
10 kHz
1 kHz
f = 100 Hz
Total harmonic distortion THD (%)
Output power POUT (W)


THD – POUT (ch2)
VCC = 13.2 V
RL = 4 Ω
Signal is applied on the channel under measurement only.
Filter
100 Hz : to 30 kHz
1 kHz : 400 Hz to 30 kHz
10 kHz : 400 Hz to
20 kHz : 400 Hz to
20 kHz
10 kHz
1 kHz
f = 100 Hz
Total harmonic distortion THD (%)
Output power POUT (W)

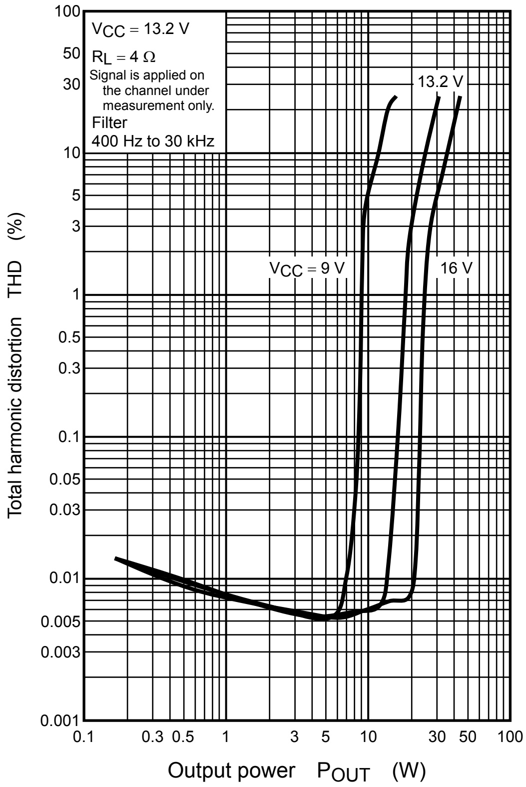

THD – POUT (ch3)
VCC = 13.2 V
RL = 4 Ω
Signal is applied on the channel under measurement only.
Filter
100 Hz : to 30 kHz
1 kHz : 400 Hz to 30 kHz
10 kHz : 400 Hz to
20 kHz : 400 Hz to
20 kHz
10 kHz
1 kHz
f = 100 Hz
Total harmonic distortion THD (%)
Output power POUT (W)


THD – POUT (ch4)
VCC = 13.2 V
RL = 4 Ω
Signal is applied on the channel under measurement only.
Filter
100 Hz : to 30 kHz
1 kHz : 400 Hz to 30 kHz
10 kHz : 400 Hz to
20 kHz : 400 Hz to
20 kHz
10 kHz
1 kHz
f = 100 Hz
Total harmonic distortion THD (%)
Output power POUT (W)

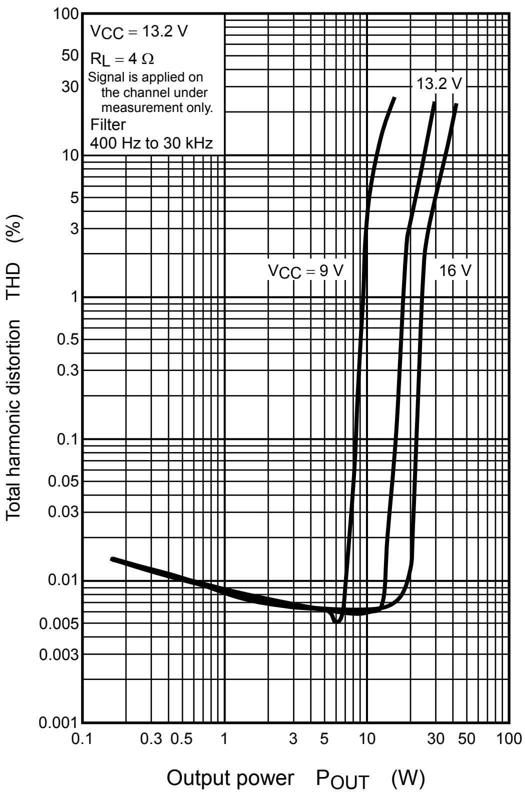
THD – P_{OUT} (ch1)



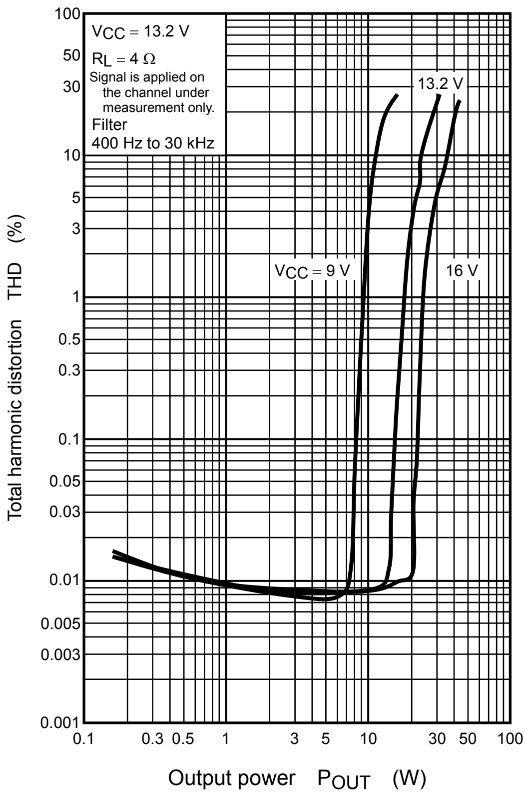
THD – P_{OUT} (ch2)

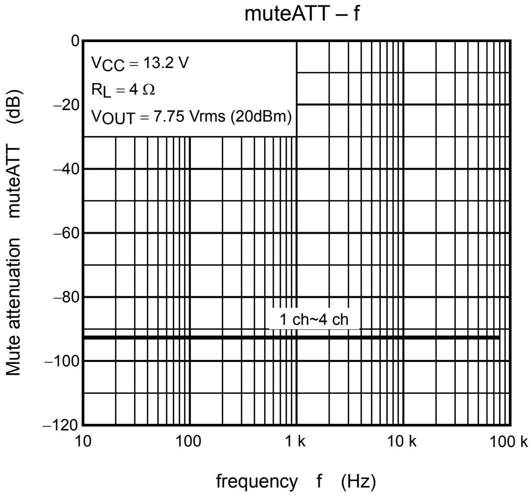


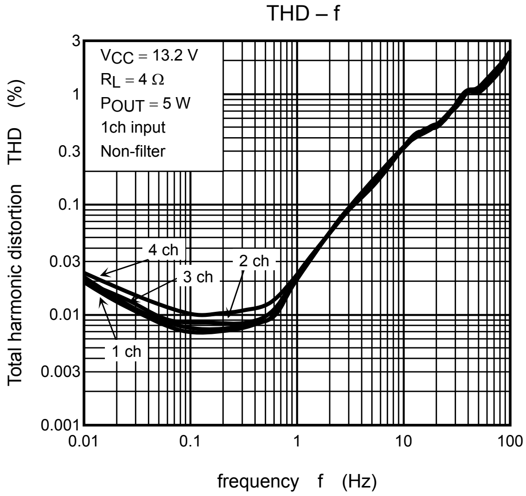
THD – P_{OUT} (ch3)

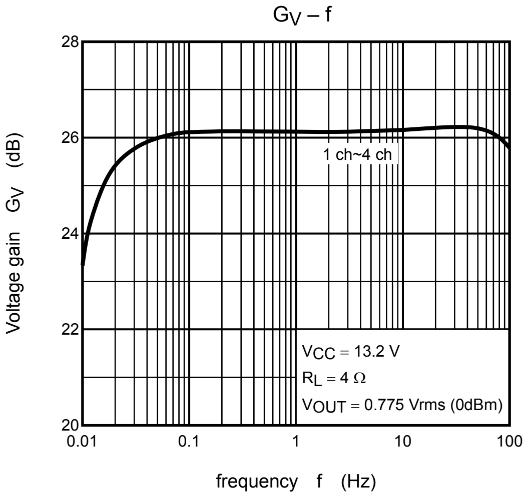


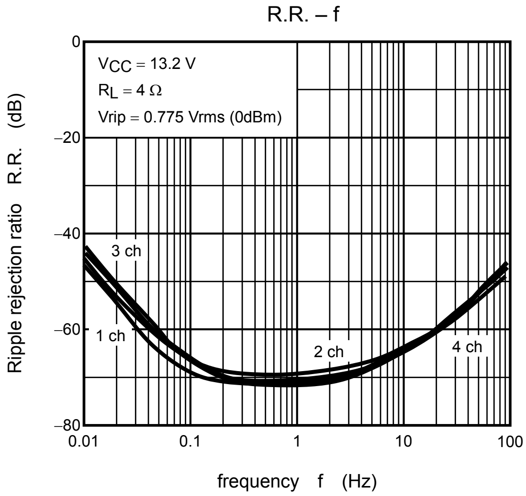
THD – P_{OUT} (ch4)

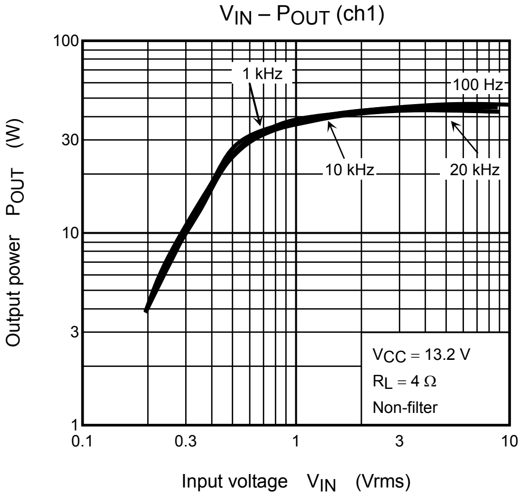


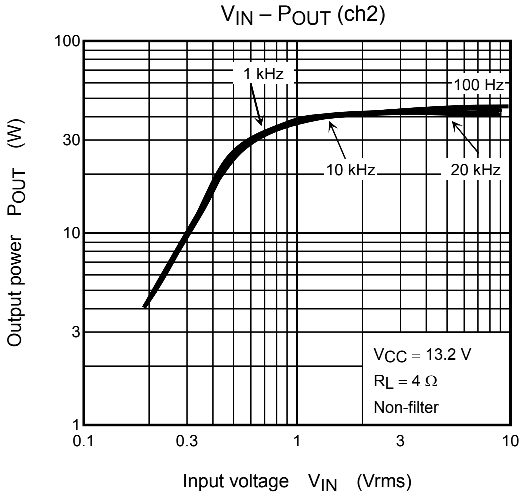

muteATT – f
VCC = 13.2 V
RL = 4 Ω
VOUT = 7.75 Vrms (20dBm)
1 ch~4 ch
Mute attenuation muteATT (dB)
0
−20
−40
−60
−80
−100
−120
10
100
1 k
10 k
100 k
frequency f (Hz)

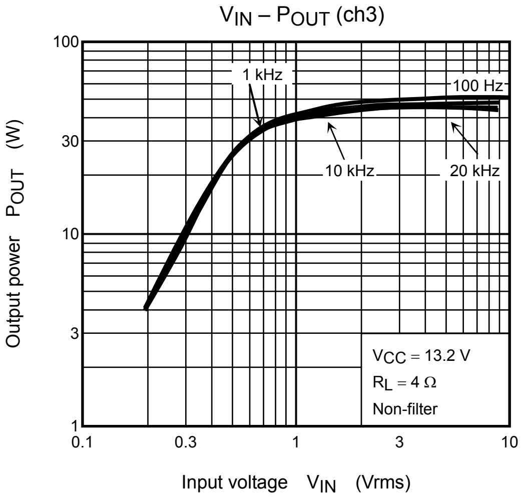

THD – f
VCC = 13.2 V
RL = 4 Ω
POUT = 5 W
1ch input
Non-filter
4 ch
3 ch
2 ch
1 ch
Total harmonic distortion THD (%)
3
1
0.3
0.1
0.03
0.01
0.003
0.001
0.01
0.1
1
10
100
frequency f (Hz)

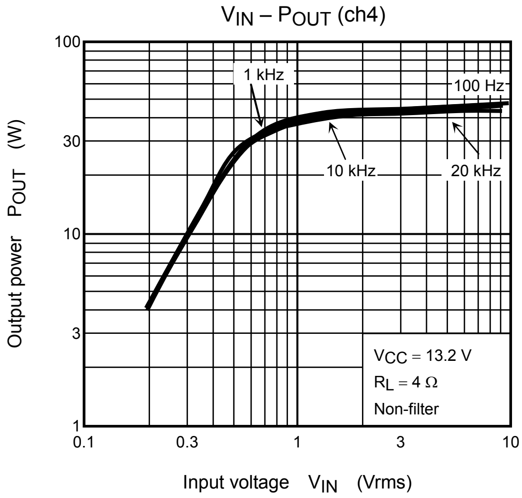

GV – f
1 ch~4 ch
VCC = 13.2 V
RL = 4 Ω
VOUT = 0.775 Vrms (0dBm)
Voltage gain GV (dB)
28
26
24
22
20
0.01
0.1
1
10
100
frequency f (Hz)

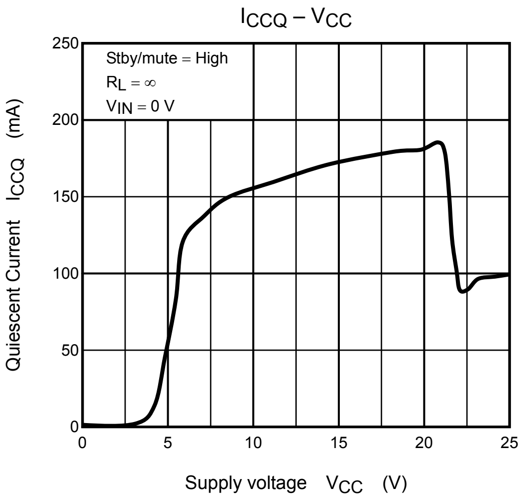

R.R. – f
VCC = 13.2 V
RL = 4 Ω
Vrip = 0.775 Vrms (0dBm)
3 ch
1 ch
2 ch
4 ch
Ripple rejection ratio R.R. (dB)
0
−20
−40
−60
−80
0.01
0.1
1
10
100
frequency f (Hz)

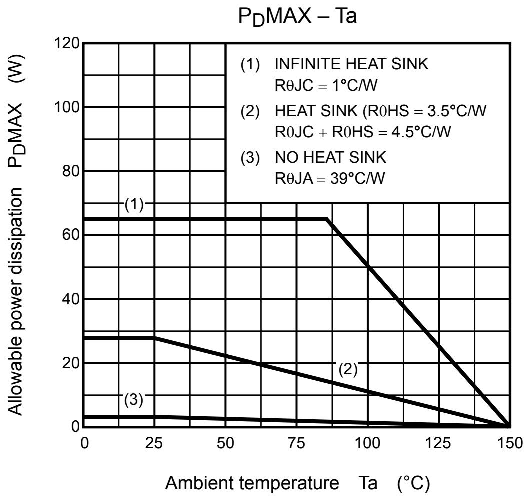

VIN – POUT (ch1)
1 kHz
100 Hz
10 kHz
20 kHz
VCC = 13.2 V
RL = 4 Ω
Non-filter
Output power POUT (W)
Input voltage VIN (Vrms)

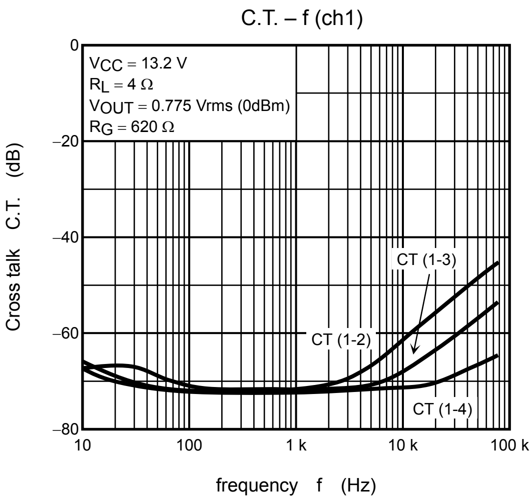

VIN – POUT (ch2)
1 kHz
100 Hz
10 kHz
20 kHz
VCC = 13.2 V
RL = 4 Ω
Non-filter
Output power POUT (W)
Input voltage VIN (Vrms)

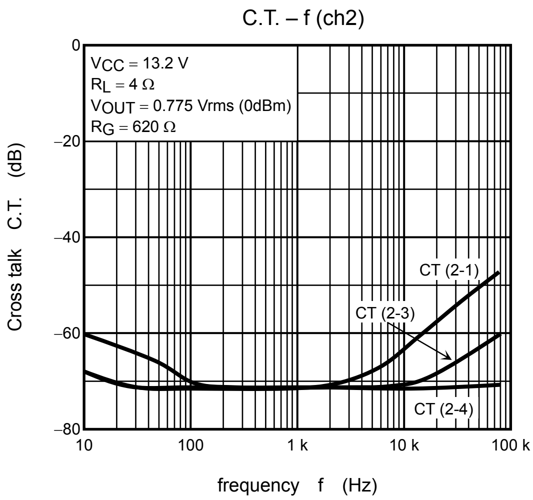

VIN – POUT (ch3)
1 kHz
100 Hz
10 kHz
20 kHz
VCC = 13.2 V
RL = 4 Ω
Non-filter
Output power POUT (W)
Input voltage VIN (Vrms)

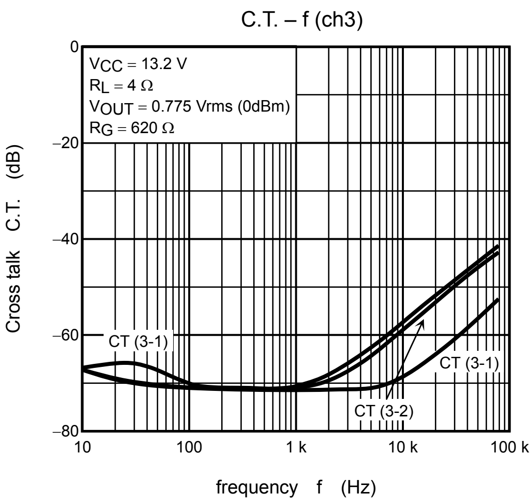

VIN – POUT (ch4)
1 kHz
100 Hz
10 kHz
20 kHz
VCC = 13.2 V
RL = 4 Ω
Non-filter
Output power POUT (W)
Input voltage VIN (Vrms)

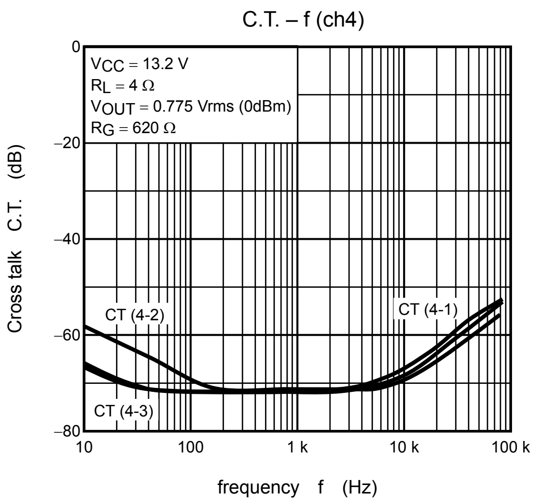

ICCQ – VCC
Stby/mute = High
RL = ∞
VIN = 0 V
Quiescent Current ICCQ (mA)
Supply voltage VCC (V)

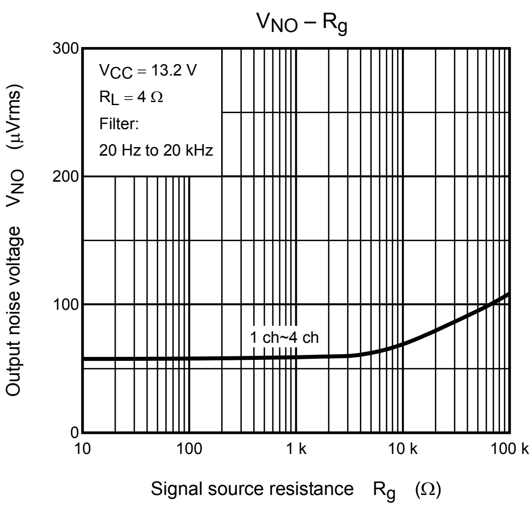

PDMAX – Ta
(1) INFINITE HEAT SINK
RθJC = 1°C/W
(2) HEAT SINK (RθHS = 3.5°C/W
RθJC + RθHS = 4.5°C/W
(3) NO HEAT SINK
RθJA = 39°C/W
(1)
(2)
(3)
Allowable power dissipation PDMAX (W)
Ambient temperature Ta (°C)

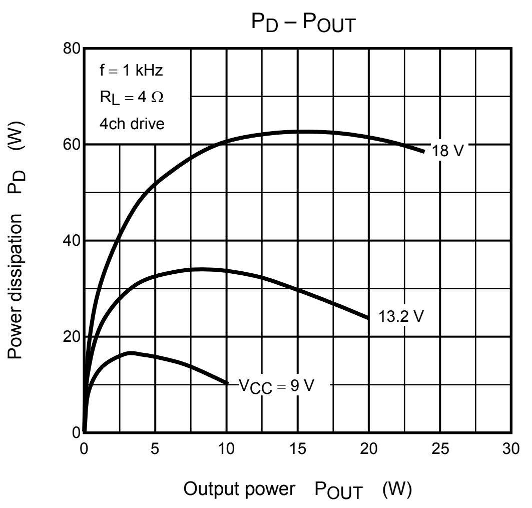

C.T. – f (ch1)
VCC = 13.2 V
RL = 4 Ω
VOUT = 0.775 Vrms (0dBm)
RG = 620 Ω
CT (1-3)
CT (1-2)
CT (1-4)
Cross talk C.T. (dB)
frequency f (Hz)
0
−20
−40
−60
−80
10
100
1 k
10 k
100 k


C.T. – f (ch2)
VCC = 13.2 V
RL = 4 Ω
VOUT = 0.775 Vrms (0dBm)
RG = 620 Ω
CT (2-1)
CT (2-3)
CT (2-4)
Cross talk C.T. (dB)
frequency f (Hz)
0
−20
−40
−60
−80
10
100
1 k
10 k
100 k


C.T. – f (ch3)
VCC = 13.2 V
RL = 4 Ω
VOUT = 0.775 Vrms (0dBm)
RG = 620 Ω
CT (3-1)
CT (3-1)
CT (3-2)
Cross talk C.T. (dB)
frequency f (Hz)
0
−20
−40
−60
−80
10
100
1 k
10 k
100 k

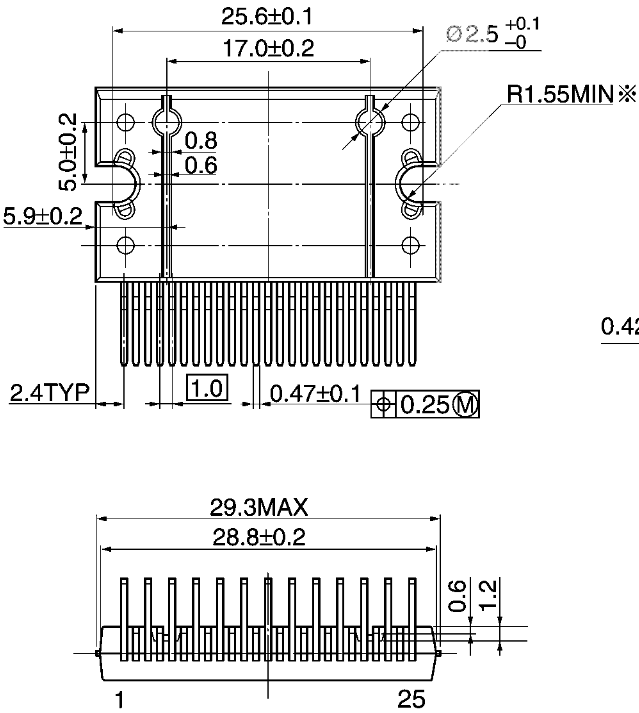

C.T. – f (ch4)
VCC = 13.2 V
RL = 4 Ω
VOUT = 0.775 Vrms (0dBm)
RG = 620 Ω
CT (4-2)
CT (4-1)
CT (4-3)
Cross talk C.T. (dB)
frequency f (Hz)
0
−20
−40
−60
−80
10
100
1 k
10 k
100 k

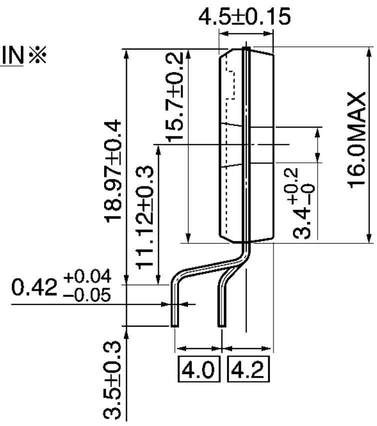

VNO – Rg
VCC = 13.2 V
RL = 4 Ω
Filter:
20 Hz to 20 kHz
1 ch~4 ch
Output noise voltage VNO (μVrms)
Signal source resistance Rg (Ω)
300
200
100
0
10
100
1 k
10 k
100 k


PD – POUT
f = 1 kHz
RL = 4 Ω
4ch drive
18 V
13.2 V
VCC = 9 V
Power dissipation PD (W)
Output power POUT (W)
80
60
40
20
0
0
5
10
15
20
25
30

Package Dimensions

HZIP25-P-1.00F Unit: mm





※ From center to parting line.

Weight: 7.7 g (typ.)

- Use an appropriate power supply fuse to ensure that a large current does not continuously flow in case of over current and/or IC failure. The IC will fully break down when used under conditions that exceed its absolute maximum ratings, when the wiring is routed improperly or when an abnormal pulse noise occurs from the wiring or load, causing a large current to continuously flow and the breakdown can lead smoke or ignition. To minimize the effects of the flow of a large current in case of breakdown, appropriate settings, such as fuse capacity, fusing time and insertion circuit location, are required.
- If your design includes an inductive load such as a motor coil, incorporate a protection circuit into the design to prevent device malfunction or breakdown caused by the current resulting from the inrush current at power ON or the negative current resulting from the back electromotive force at power OFF. For details on how to connect a protection circuit such as a current limiting resistor or back electromotive force adsorption diode, refer to individual IC datasheets or the IC databook. IC breakdown may cause injury, smoke or ignition.
- Use a stable power supply with ICs with built-in protection functions. If the power supply is unstable, the protection function may not operate, causing IC breakdown. IC breakdown may cause injury, smoke or ignition.
- Carefully select external components (such as inputs and negative feedback capacitors) and load components (such as speakers), for example, power amp and regulator. If there is a large amount of leakage current such as input or negative feedback condenser, the IC output DC voltage will increase. If this output voltage is connected to a speaker with low input withstand voltage, overcurrent or IC failure can cause smoke or ignition. (The over current can cause smoke or ignition from the IC itself.) In particular, please pay attention when using a Bridge Tied Load (BTL) connection type IC that inputs output DC voltage to a speaker directly.
- Over current Protection Circuit
  Over current protection circuits (referred to as current limiter circuits) do not necessarily protect ICs under all circumstances. If the Over current protection circuits operate against the over current, clear the over current status immediately. Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the over current protection circuit to not operate properly or IC breakdown before operation. In addition, depending on the method of use and usage conditions, if over current continues to flow for a long time after operation, the IC may generate heat resulting in breakdown.
- Thermal Shutdown Circuit
  Thermal shutdown circuits do not necessarily protect ICs under all circumstances. If the Thermal shutdown circuits operate against the over temperature, clear the heat generation status immediately. Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the thermal shutdown circuit to not operate properly or IC breakdown before operation.
- Heat Radiation Design
  When using an IC with large current flow such as power amp, regulator or driver, please design the device so that heat is appropriately radiated, not to exceed the specified junction temperature (Tj) at any time and condition. These ICs generate heat even during normal use. An inadequate IC heat radiation design can lead to decrease in IC life, deterioration of IC characteristics or IC breakdown. In addition, please design the device taking into considerate the effect of IC heat radiation with peripheral components.
- Installation to Heat Sink
  Please install the power IC to the heat sink not to apply excessive mechanical stress to the IC. Excessive mechanical stress can lead to package cracks, resulting in a reduction in reliability or breakdown of internal IC chip. In addition, depending on the IC, the use of silicon rubber may be prohibited. Check whether the use of silicon rubber is prohibited for the IC you intend to use, or not. For details of power IC heat radiation design and heat sink installation, refer to individual technical datasheets or IC databooks.

About solderability, following conditions were confirmed

- Solderability

  (1) Use of Sn-37Pb solder Bath
  - solder bath temperature = 230°C
  - dipping time = 5 seconds
  - the number of times = once
  - use of R-type flux

  (2) Use of Sn-3.0Ag-0.5Cu solder Bath
  - solder bath temperature = 245°C
  - dipping time = 5 seconds
  - the number of times = once
  - use of R-type flux

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