Techcode®

DATASHEET

Stereo, Differential Input Cap-Free Line Driver TD9722

General Description

The TD9722 is a stereo, differential input, single supply,and cap-free line driver, which is available in SOP-14 and TSSOP-14 packages.

The TD9722 is ground-reference output, and doesn't need the output capacitors for DC blocking. The advantages of eliminating the output capacitor are saving the cost, eliminating component height, and improving the low frequency response.

The external gain setting is recommended using from ±1V/V to ±10V/V. High PSRR provides increased immunity to noise and RF rectification. TD9722 has shutdown and under-voltage detector function for Depop solution.

The TD9722 is capable of driving 2.1V_{rms} at 3.3V into 2.5kΩ load, and provides short-circuit and thermal rotection.

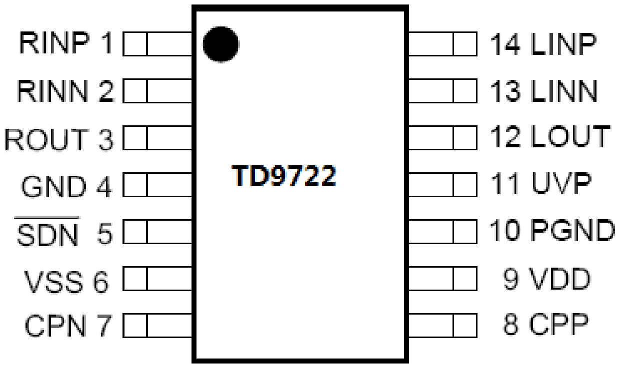
Features

- Operating Voltage: 2.3V~5.5V
- Differential Input
- Ground Reference Output
  - No Output Capacitor Required (for DC Blocking)
  - Save the PCB Space
  - Reduce the BOM Costs
  - Improve the Low Frequency Response
- Low Noise and THD+N
  - SNR > 108dB
  - Noise < 8uV$_{rms}$
  - THD+N < 0.02% at 20Hz~20kHz
- Output Voltage Swing Can Reach 2.1Vrms/Ch into2.5kΩ at V_{DD}=3.3V
- High PSRR: 80dB at 217Hz
- Fast Start-up Time: 500us
- Integrate the De-Pop Circuitry
- Thermal and Short-Circuit Protection
- Surface-Mount Packaging
  - SOP-14
  - TSSOP-14
- Lead Free and Green Devices Available(RoHS Compliant)

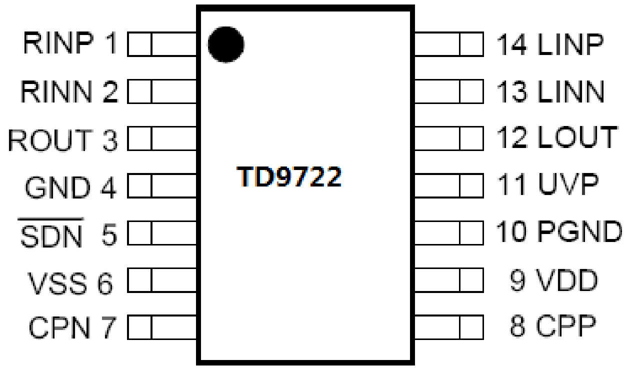
Applications

- Set-Top Boxes
- CD/DVD Players
- LCD TVs
- HTIBs (Home Theater in Box)

Pin Configurations



TSSOP-14
(Top View)

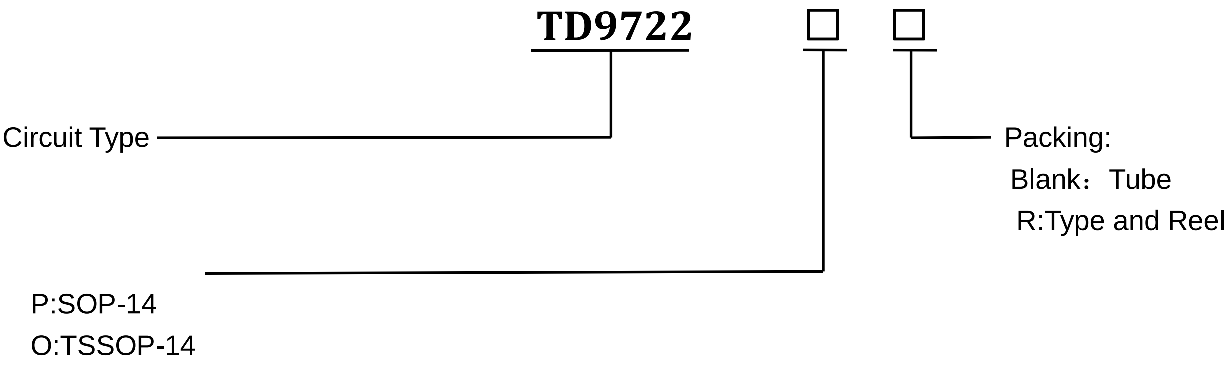


SOP-14
(Top View)

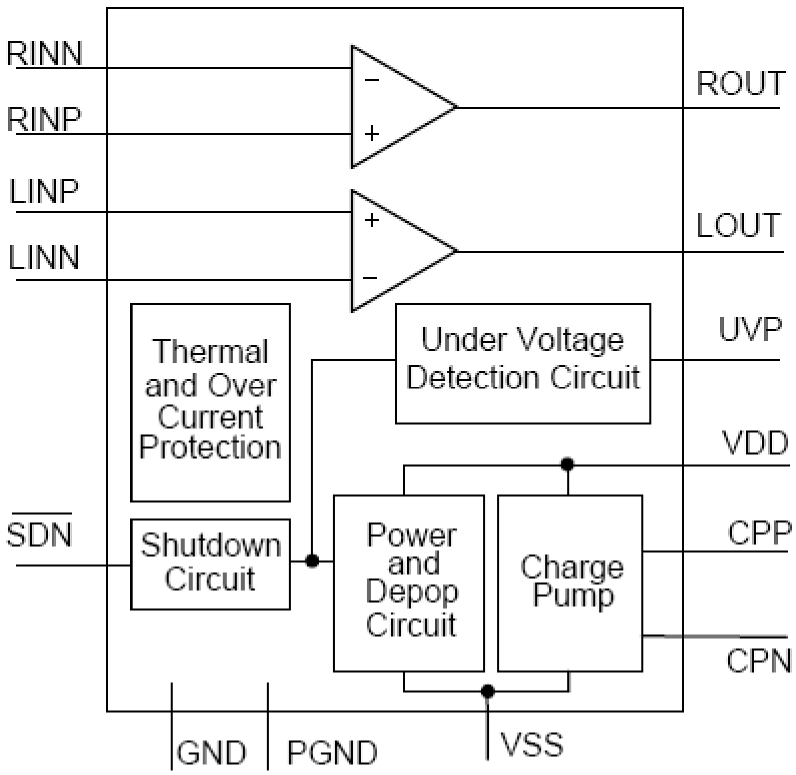
Pin Description

NO.	NAME	I/O/P	FUNCTION
1	RINP	I	Right channel non-inverting input.
2	RINN	I	Right channel inverting input.
3	ROUT	O	Right channel output.
4	GND	P	Signal ground.
5	SDN	I	Shutdown mod control input signal, pull low for shutdown headphone driver. This pin should be connect a 100Ω Protection Resistor.
6	VSS	P	Headphone driver negative power supply.
7	CPN	I/O	Charge pump flying capacitor negative connection.
8	CPP	I/O	Charge pump flying capacitor positive connection.
9	VDD	P	Supply voltage input.
10	PGND	P	Power ground.
11	UVP	I	Under voltage protection input. Floating or Pull “H” to disable this function.
12	LOUT	O	Left channel output.
13	LINN	I	Left channel inverting input.
14	LINP	I	Left channel non-inverting input.

Ordering Information



Functional Block Diagram



Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
V_{PGND_GND}	PGND to GND Voltage	-0.3 to 0.3	V
V_{DD}	Supply Voltage (VDD to GND and PGND)	-0.3 to 6.0	
$V_{\overline{SDN}}$	Input Voltage ($\overline{SDN}$ to GND)	V_{GND}-0.3 to V_{DD}+0.3	
V_{SS}	VSS to GND and PGND Voltage	-6.0 to 0.3	
V_{OUT}	ROUT and LOUT to GND Voltage	V_{SS}-0.3 to V_{DD}+0.3	
V_{CPP}	CPP to PGND Voltage	V_{PGND}-0.3 to V_{DD}+0.3	
V_{CPN}	CPN to PGND Voltage	V_{SS}-0.3 to V_{PGND}+0.3	
T_J	Maximum Junction Temperature	150	°C
T_{STG}	Storage Temperature Range	-65 to +150	
T_{SDR}	Maximum Soldering Temperature Range, 10 Seconds	260	
P_D	Power Dissipation	Internally Limited	W

Note1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Recommended Operating Conditions

Symbol	Parameter		Range		Unit
			Min.	Max.	
V_{DD}	Supply Voltage		2.3	5.5	V
V_{IH}	High Level Threshold Voltage	$\overline{SDN}$	1.0	-	
V_{IL}	Low Level Threshold Voltage	$\overline{SDN}$	-	0.35	
T_A	Operating Ambient Temperature Range		-40	85	°C
T_J	Operating Junction Temperature Range		-40	125	°C
R_L	Load Resistance		600	100k	Ω

Thermal Characteristics

Symbol	Parameter	Typical Value	Unit
θ_{JA}	Thermal Resistance - Junction to Ambient (Note 2) TSSOP-14 SOP-14	 120 120	°C/W

Note 2: Please refer to "Thermal Pad Consideration". 2 layered 5 in2 printed circuit boards with 2oz trace and copper through several thermal vias. The thermal pad is soldered on the PCB.

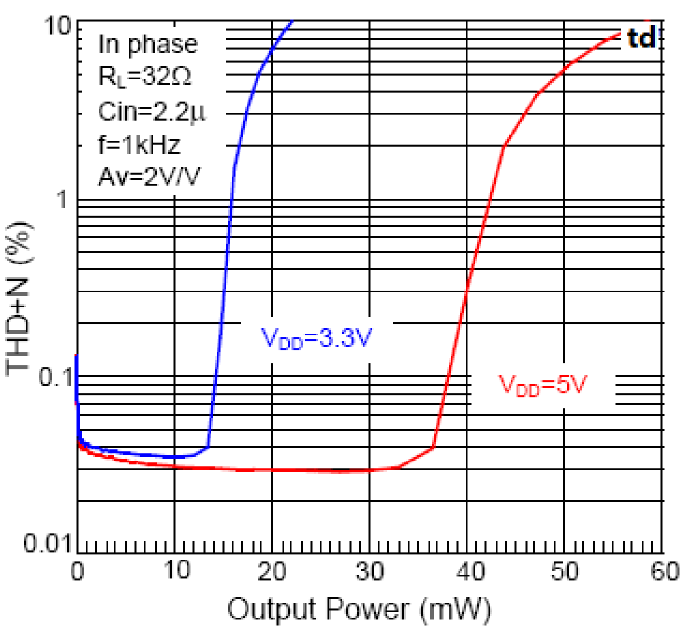
Electrical Characteristics

V_{DD}=3.3V, V_{GND}=V_{PGND}=0V, V_{SDN}=V_{DD}, C_{CPF}=C_{CPO}=1μF, C_i=1μF, R_L=2.5kΩ, T_A=25°C, R_i=10kΩ, R_f=20kΩ (unless otherwise noted)

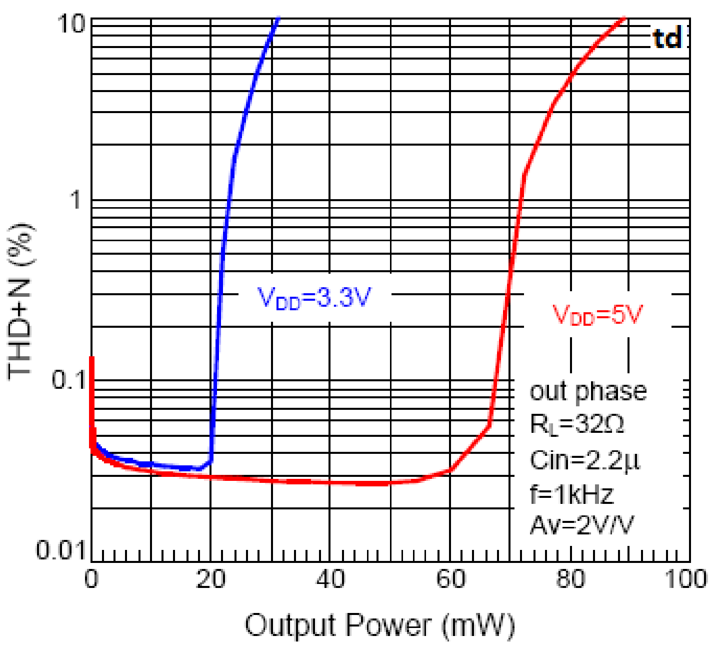
Symbol	Parameter	Test Conditions	APA2172			Unit
			Min.	Typ.	Max.	
I_{DD}	V_{DD} Supply Current		-	10	15	mA
I_{SD}	V_{DD} Shutdown Current	$V_{\overline{SDN}}$=0V	-	1	5	μA
I_I	Input Current	$\overline{SDN}$	-	0.1	-	μA
CHARGE PUMP						
f_{OSC}	Switching Frequency		400	500	600	kHz
R_{eq}	Equivalent Resistance		-	21	25	Ω
DRIVERS						
A_{VO}	Open Loop Voltage Gain		80	100	-	dB
GW	Unity Gain Bandwidth		8	10	-	MHz
V_{SR}	Slew Rate		-	4.5	-	V/μs
V_{OS}	Output Offset Voltage	V_{DD}=2.3V to 5.5V, R_L = 2.5kΩ	-5	-	5	mV
V_N	Output Noise	R_i=10kΩ, R_f=10kΩ	-	8	15	μV_{rms}
$T_{start-up}$	Start-up Time		-	500	-	μs
PSRR	Power Supply Rejection Ratio	V_{DD}=2.3V to 5.5V, V_{rr}=200mV_{rms} f_{in}= 217Hz f_{in}= 1kHz f_{in}= 20kHz	-	-80 -80 -50	-60 -60 -45	dB
C_L	Maximum Capacitive Load		-	220	-	pF
V_{ESD}	ESD Protection	OUTR, OUTL	-	8	-	kV
V_O	Output Voltage (Stereo, In Phase)	THD+N=1%, f_{in}=1kHz R_L=2.5kΩ R_L=100kΩ	2.0 -	2.1 2.3	-	V
P_O	Output Power (Stereo, In Phase)	THD+N=1%, f_{in}=1kHz R_L=32Ω	-	15	-	mW
		VDD=5V THD+N=1%, f_{in}=1kHz R_L=32Ω	-	40	-	
THD+N	Total Harmonic Distortion Plus Noise	V_O=2V_{rms}, R_L=2.5kΩ f_{in}=20Hz f_{in}=1kHz f_{in}=20kHz	-	0.02 0.001 0.02	- 0.002 -	%
		Po=10mW, RL=32Ω,f_{in}=1kHz	-	0.03	-	
		VDD=5V, Po=30mW, RL=32Ω, f_{in}=1kHz	-	0.03	-	
Crosstalk	Channel Separation	V_O=2V_{rms}, R_L=2.5kΩ f_{in}=20Hz f_{in}=1kHz f_{in}=20kHz	-	100 100 90	-	dB
S/N	Signal to Noise Ratio	V_O=2Vrms, R_L=2.5kΩ, R_i=10kΩ, R_f=10kΩ, With A-weighting Filter	-	108	102	dB
T_{SD}	Thermal Shutdown Protection Temperature		-	150	-	°C
UVP FUNCTION						
V_{UVP}	External Under Voltage Detection		-	1.25	-	V
I_{HYS}	External Under Voltage Detection Hysteresis Current		-	5.0	-	μA

Typical Operating Characteristics

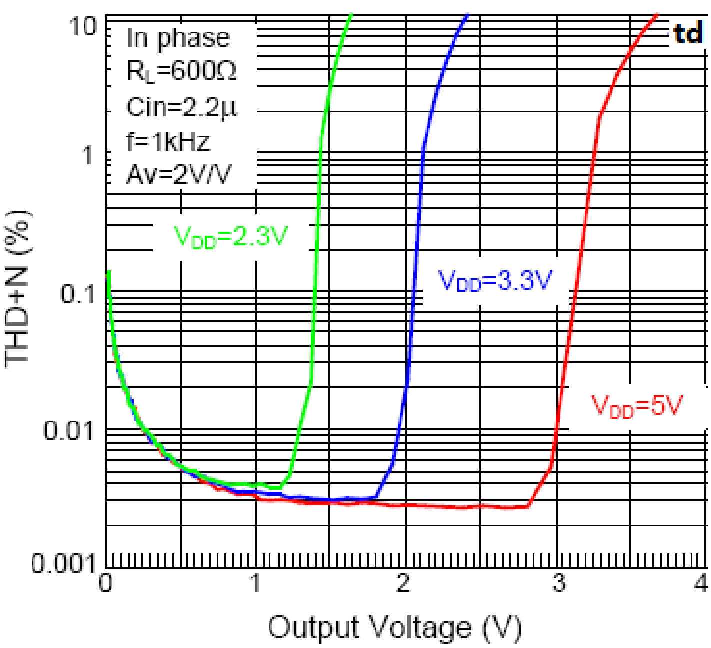
THD+N vs. Output Power



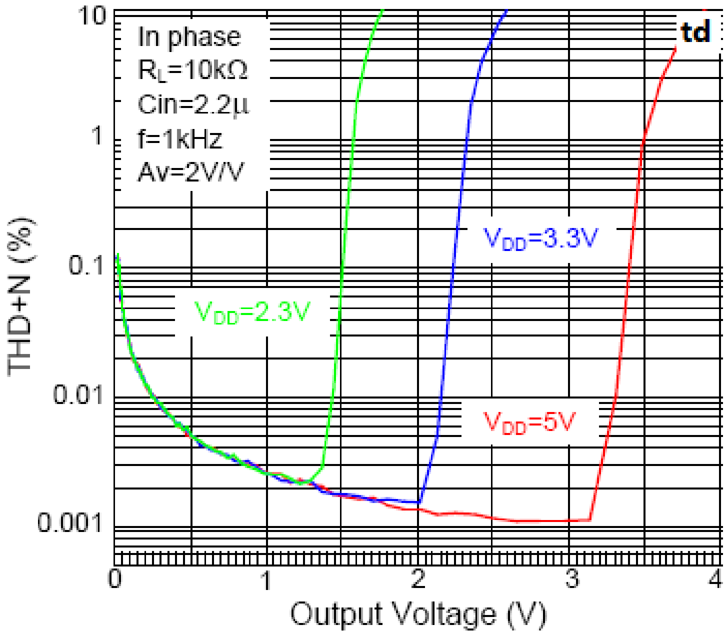
THD+N vs. Output Power



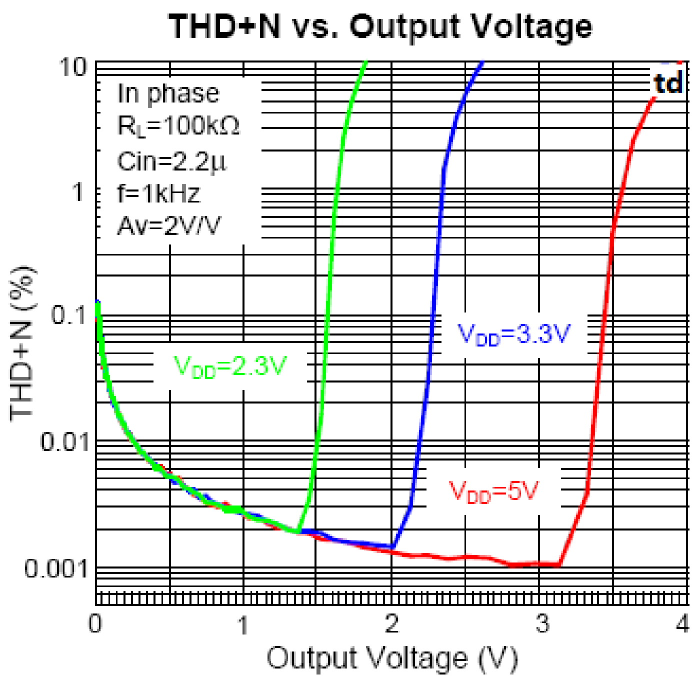
THD+N vs. Output Voltage

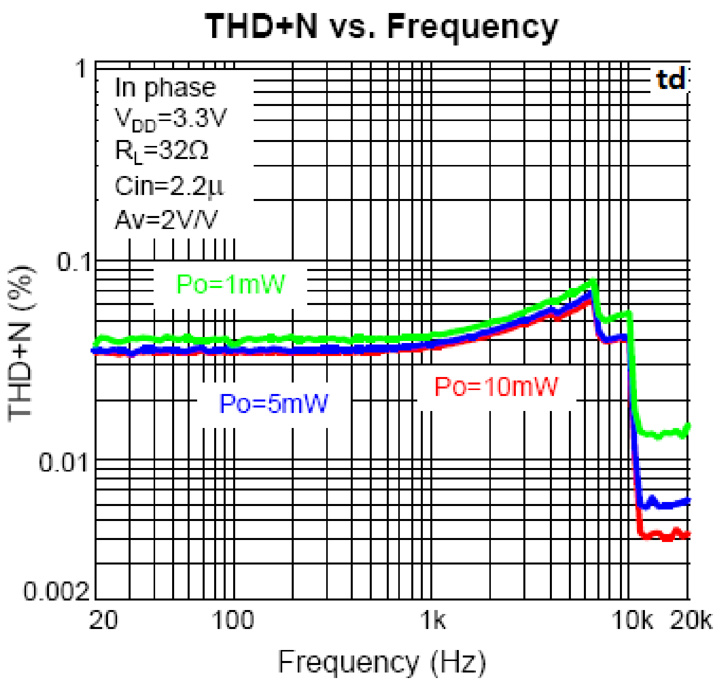


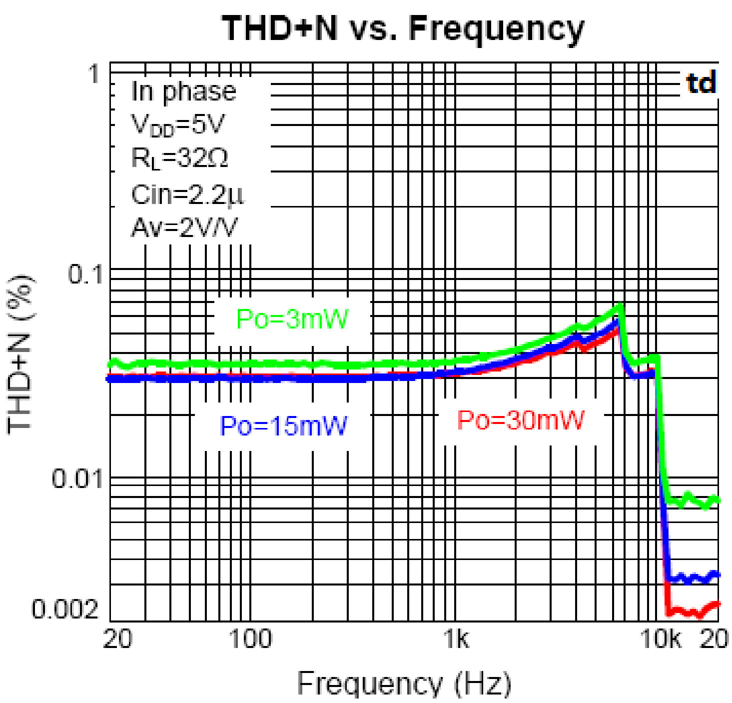
THD+N vs. Output Voltage

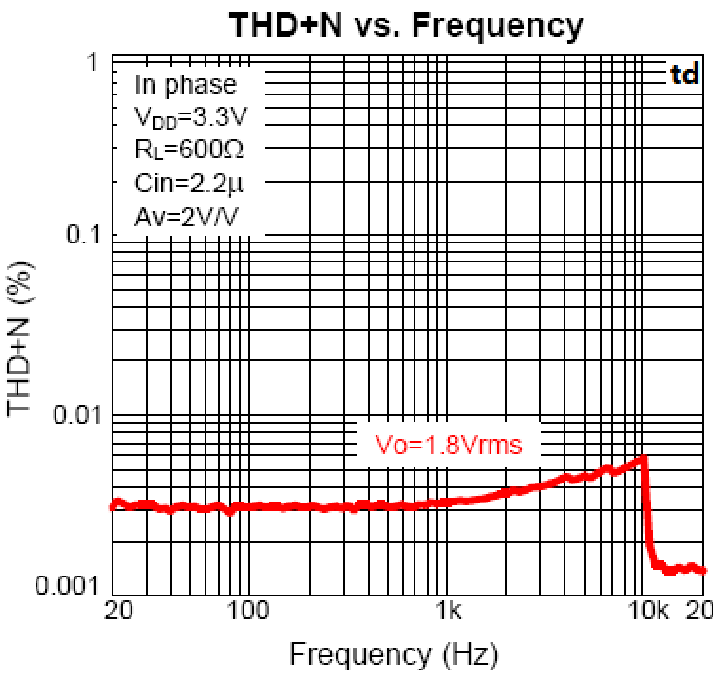


Typical Operating Characteristics(Cont.)

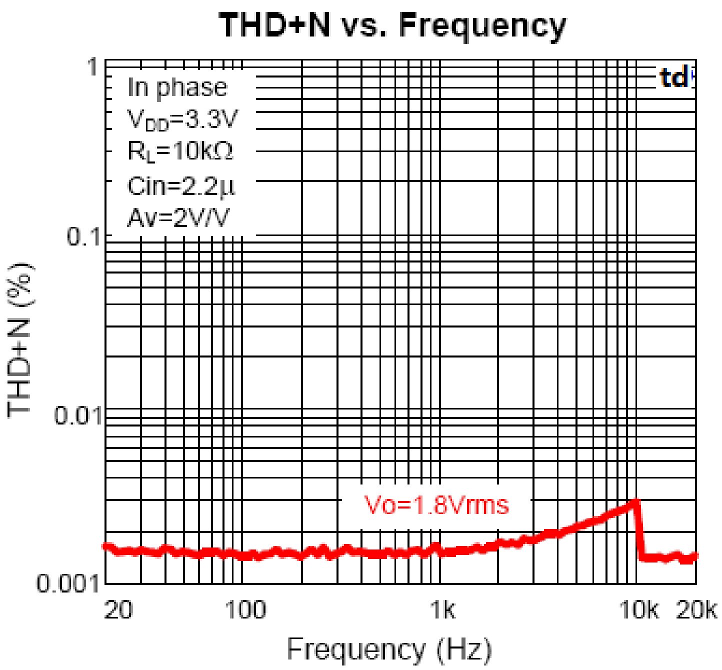


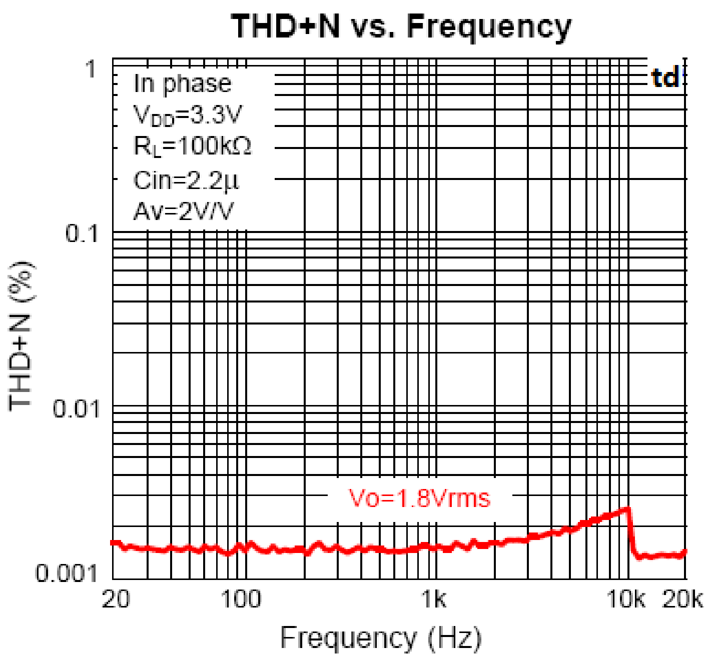


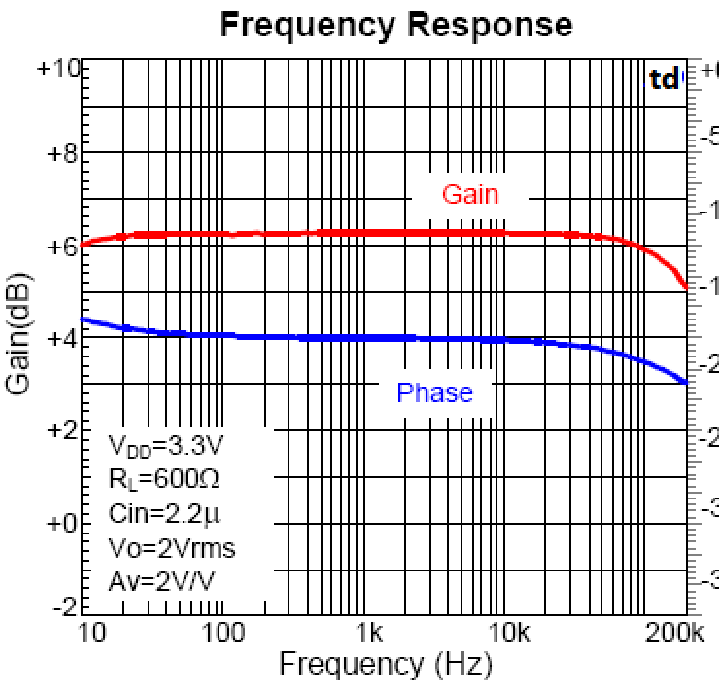


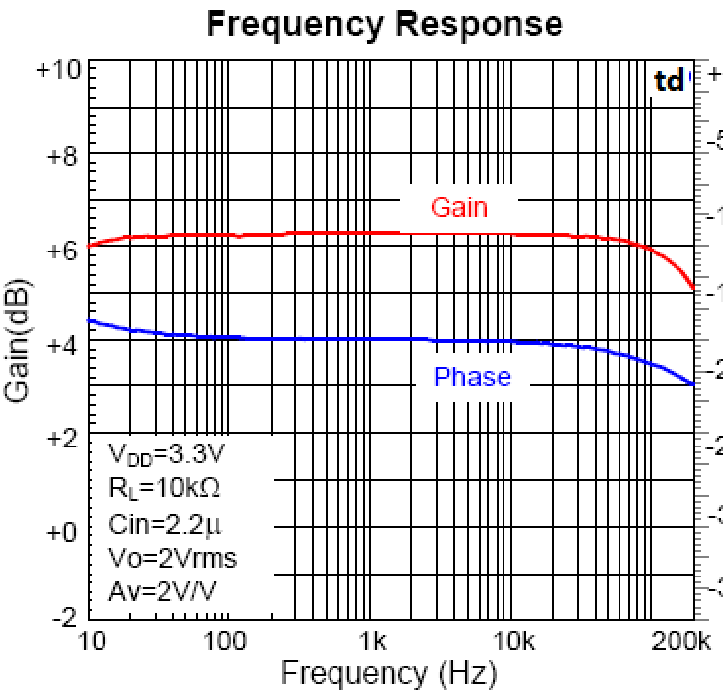


Typical Operating Characteristics(Cont.)



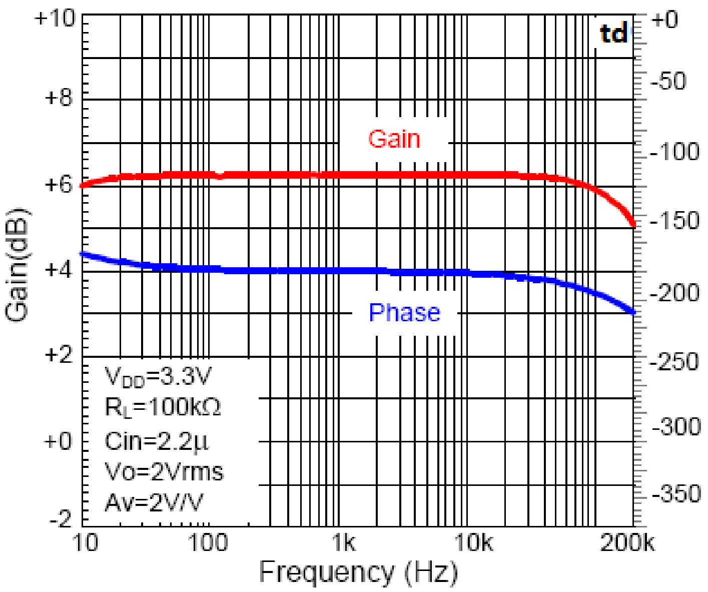




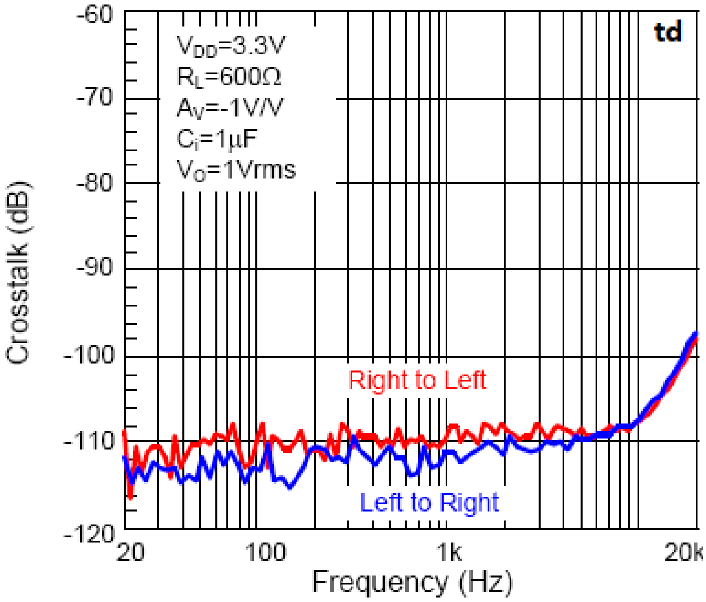


Typical Operating Characteristics(Cont.)

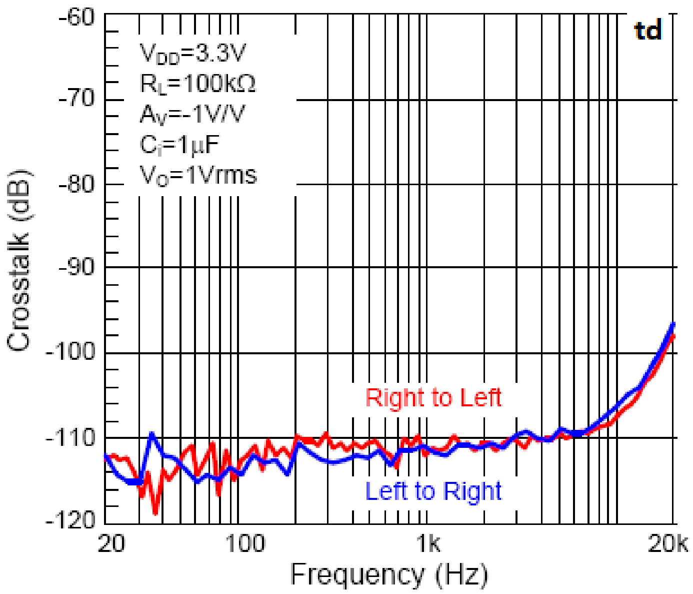
Frequency Response



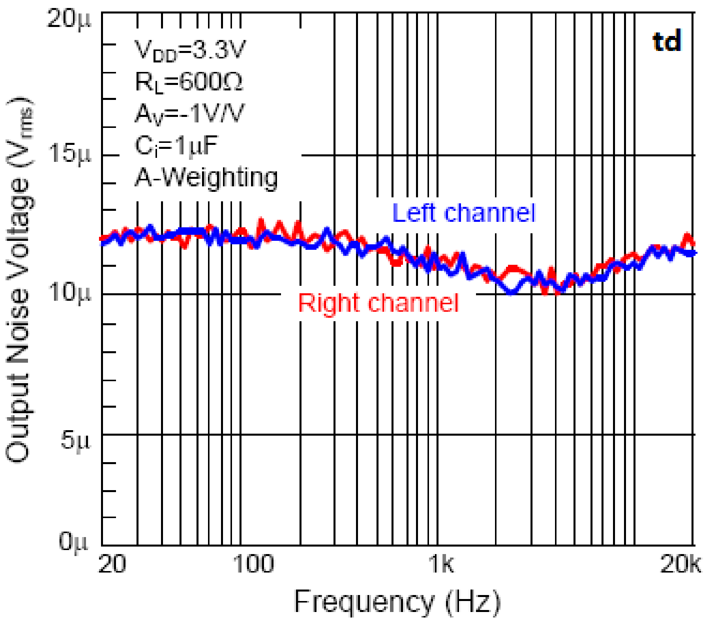
Crosstalk vs. Frequency



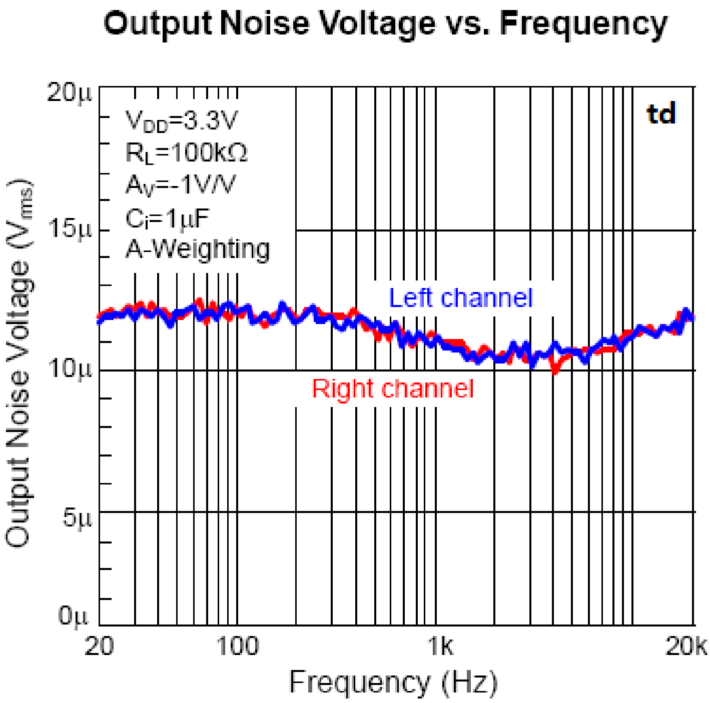
Crosstalk vs. Frequency

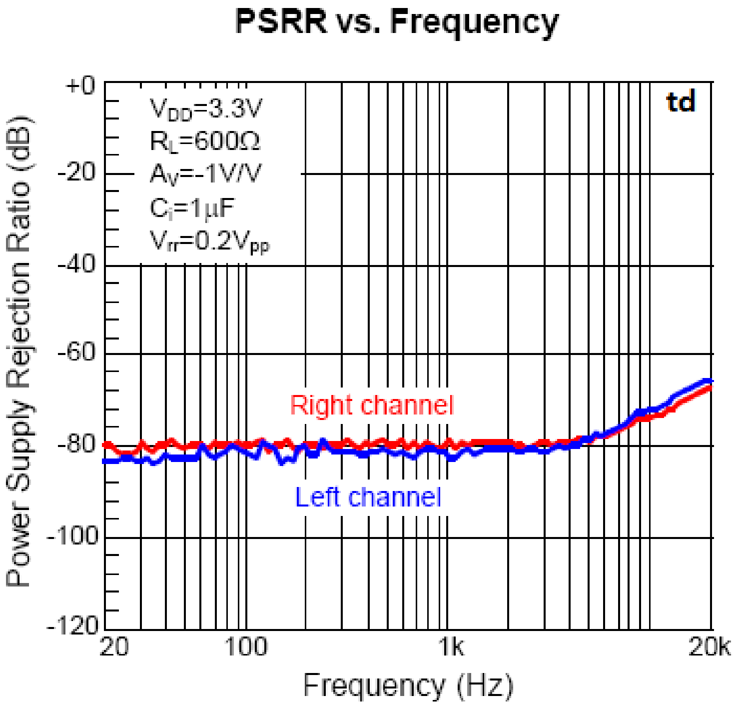


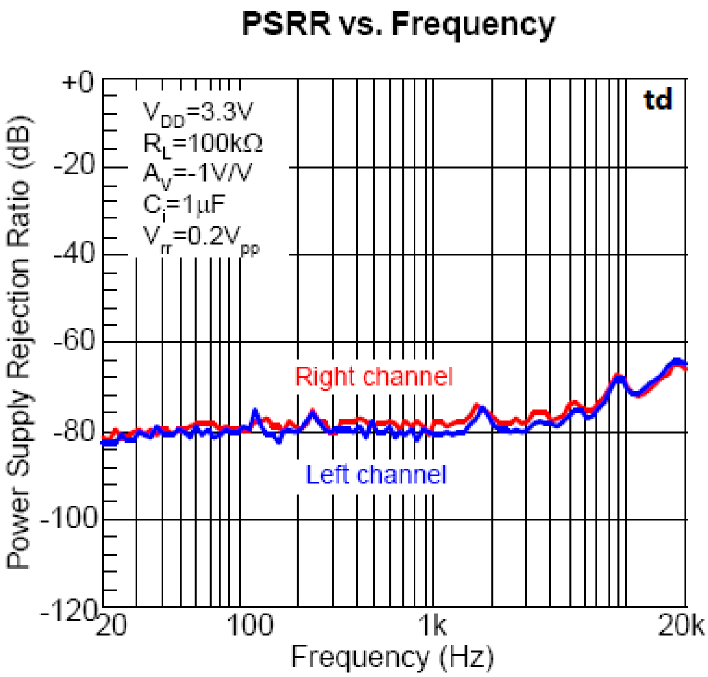
Output Noise Voltage vs. Frequency

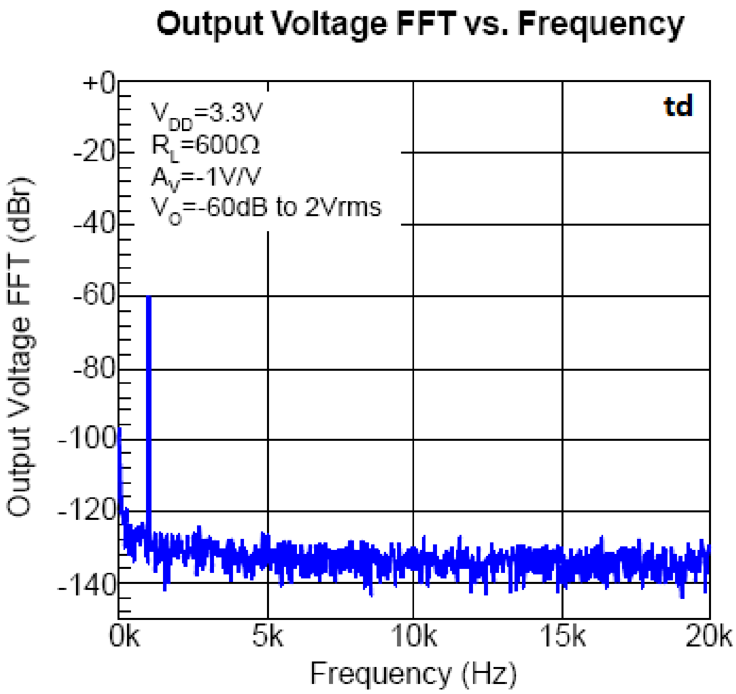


Typical Operating Characteristics(Cont.)

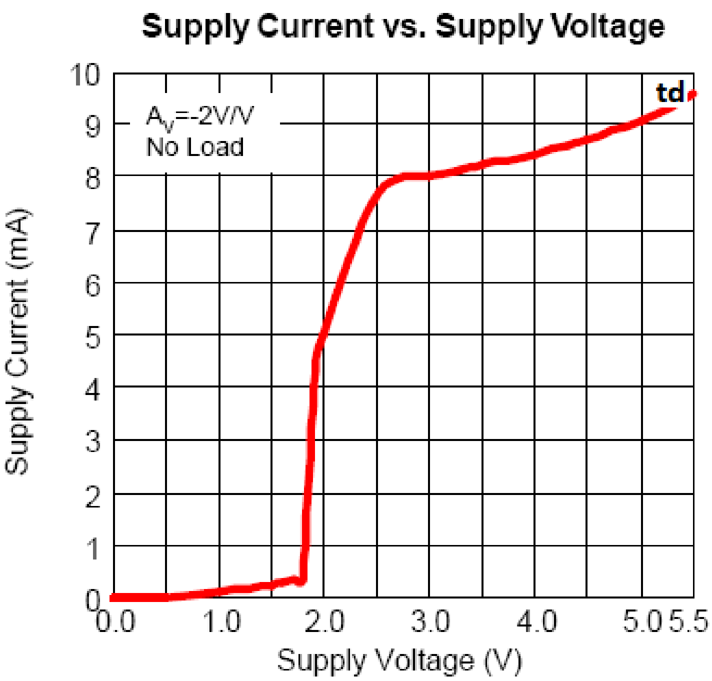


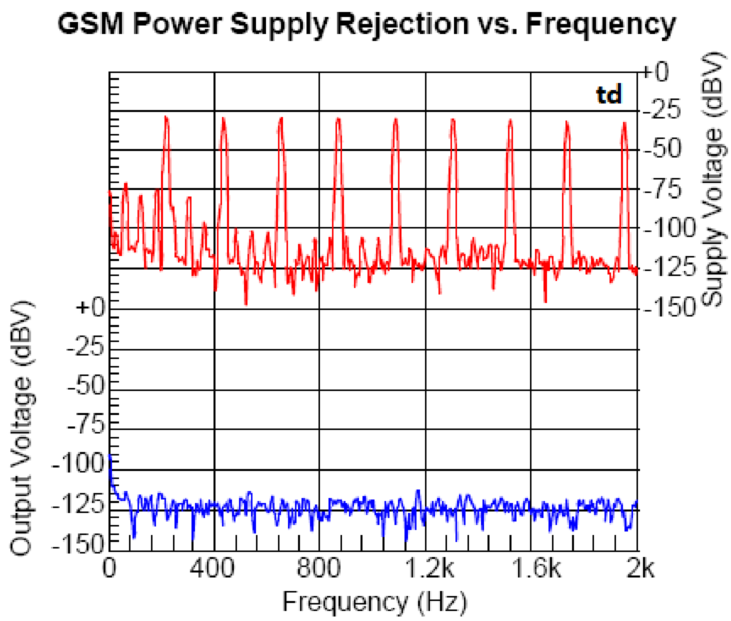






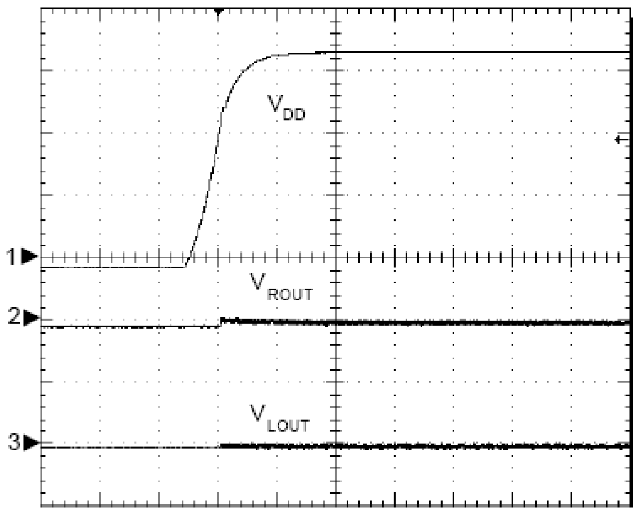
Typical Operating Characteristics(Cont.)





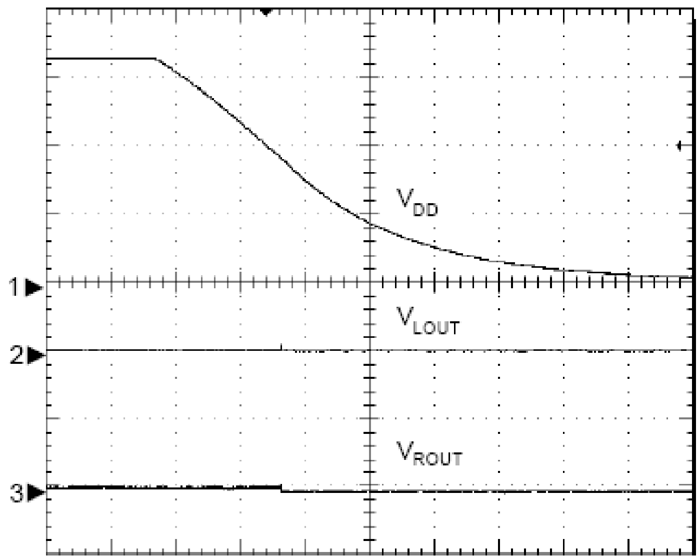
Operating Waveforms

Output Transient at Power On



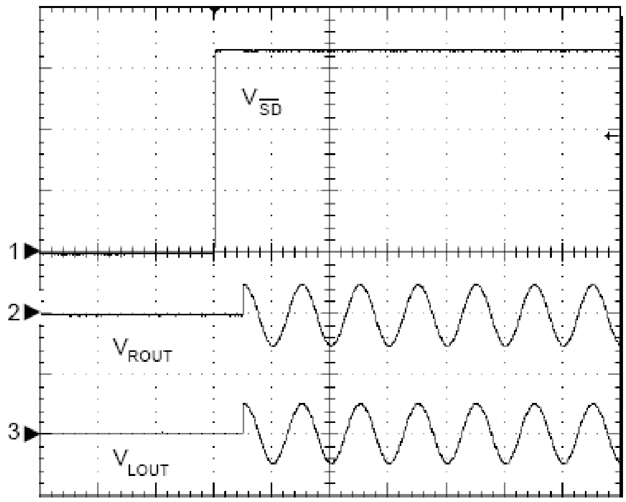
CH1: V_{DD}, 1V/Div, DC
CH2: V_{LOUT}, 20mV/Div, DC
CH3: V_{ROUT}, 20mV/Div, DC
TIME:10ms/Div

Output Transient at Power Off



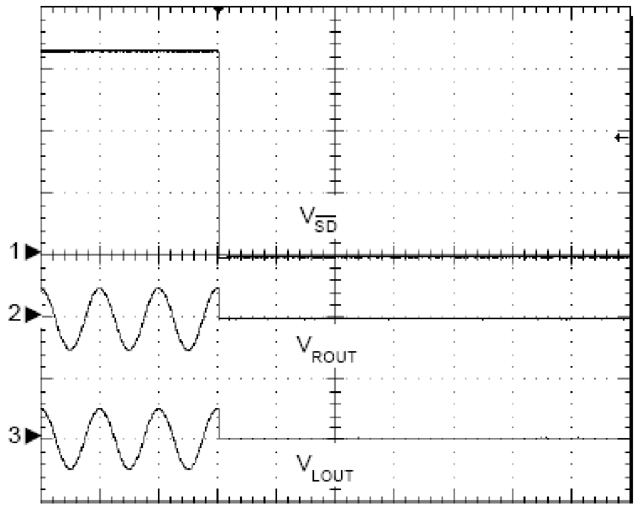
CH1: V_{DD}, 1V/Div, DC
CH2: V_{LOUT}, 20mV/Div, DC
CH3: V_{ROUT}, 20mV/Div, DC
TIME:2ms/Div

Shutdown Release



CH1: $V_{\overline{SD}}$, 1V/Div, DC
CH2: V_{LOUT}, 1V/Div, DC
CH3: V_{ROUT}, 1V/Div, DC
TIME:1ms/Div

Shutdown

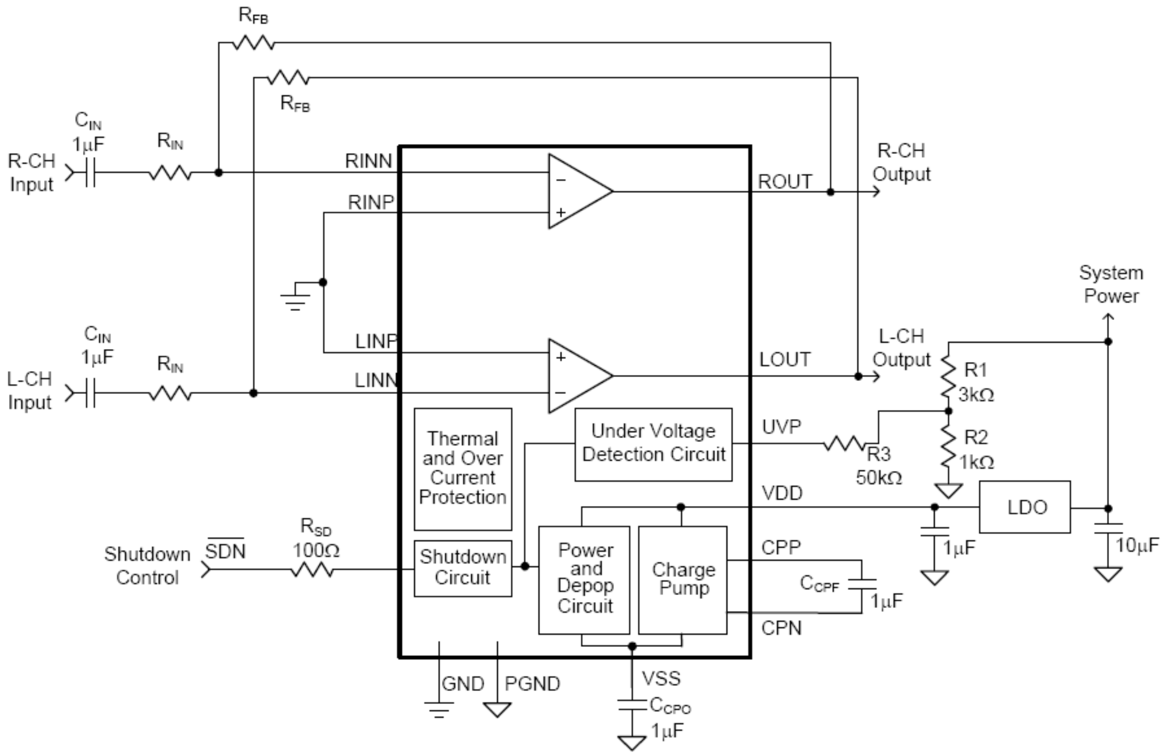


CH1: $V_{\overline{SD}}$, 1V/Div, DC
CH2: V_{LOUT}, 1V/Div, DC
CH3: V_{ROUT}, 1V/Div, DC
TIME:1ms/Div

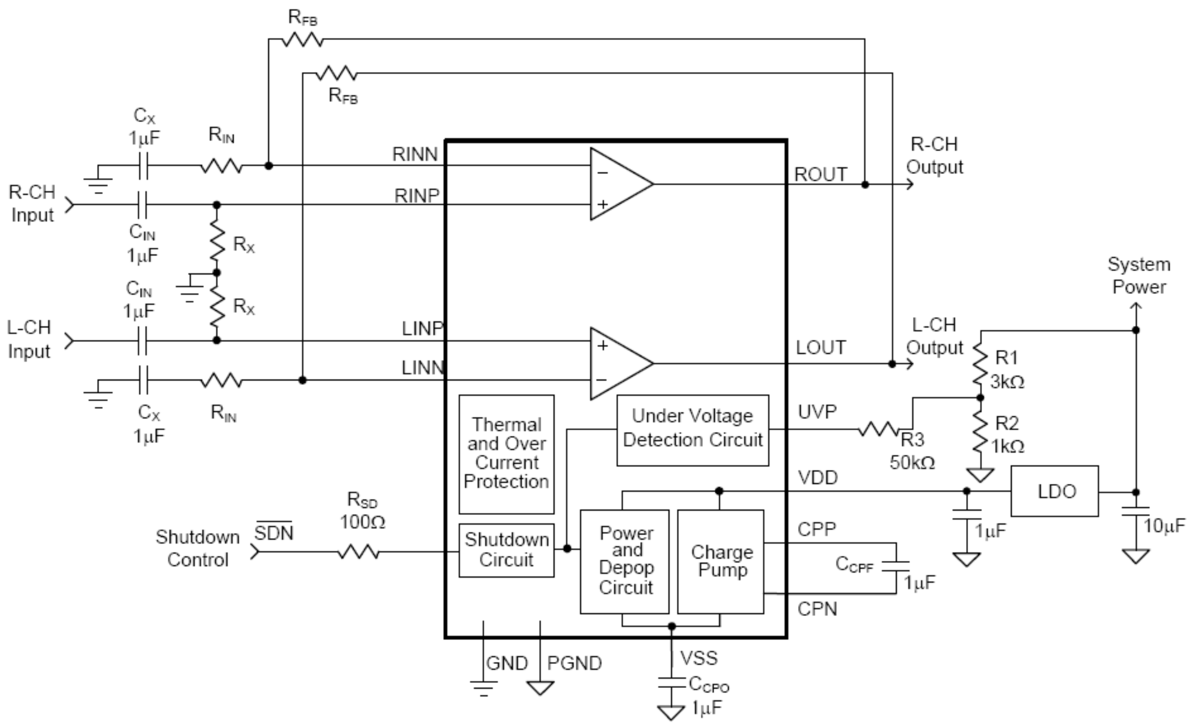
Type Application Circuit

Line Driver Amplifier

1. Inverting



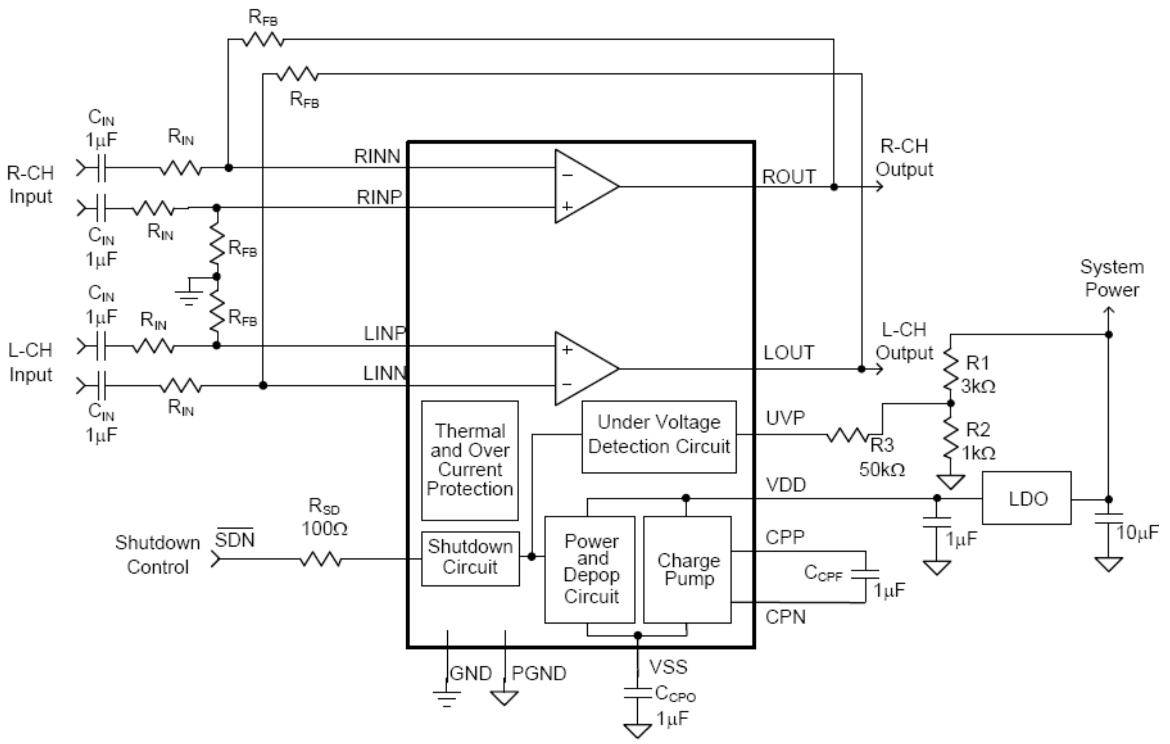
2. Non-Inverting



Type Application Circuit(Cont.)

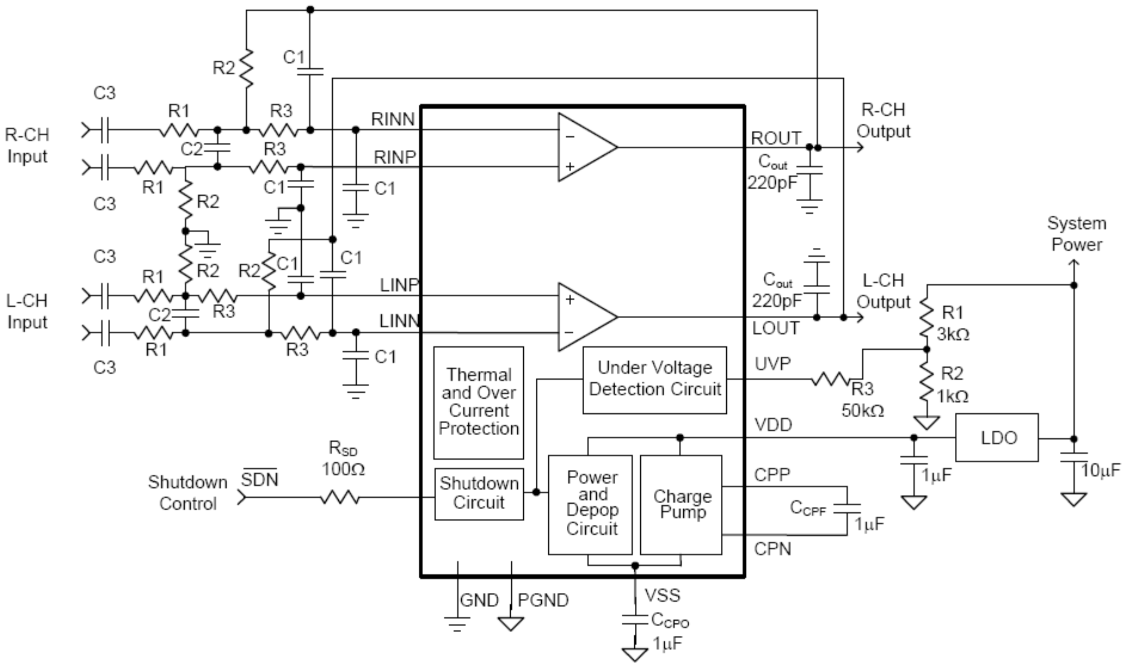
Line Driver Amplifier (Cont.)

3. Differential



Second-Order Active Low-Pass Filter

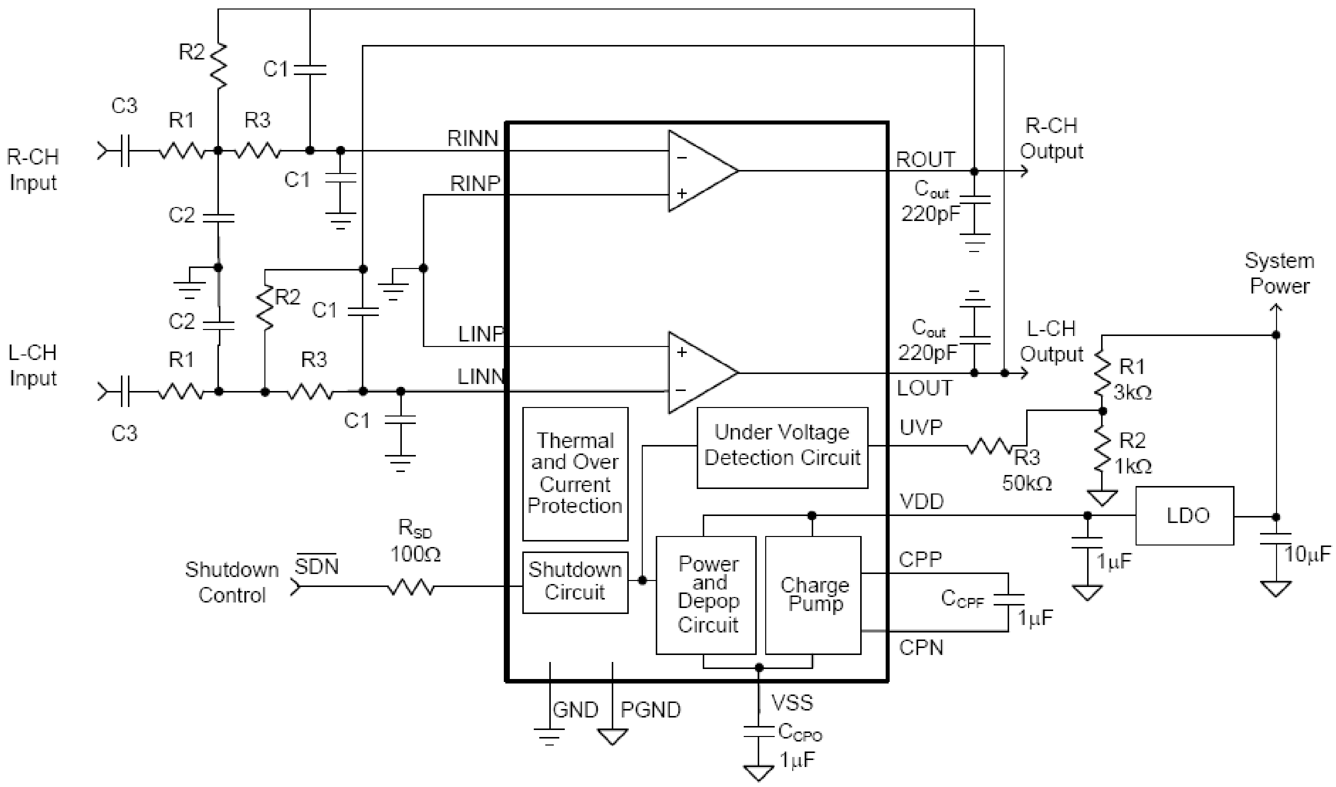
1. Differential



Type Application Circuit(Cont.)

Second-Order Active Low-Pass Filter

2. Inverting



Function Description

Line Driver Operation

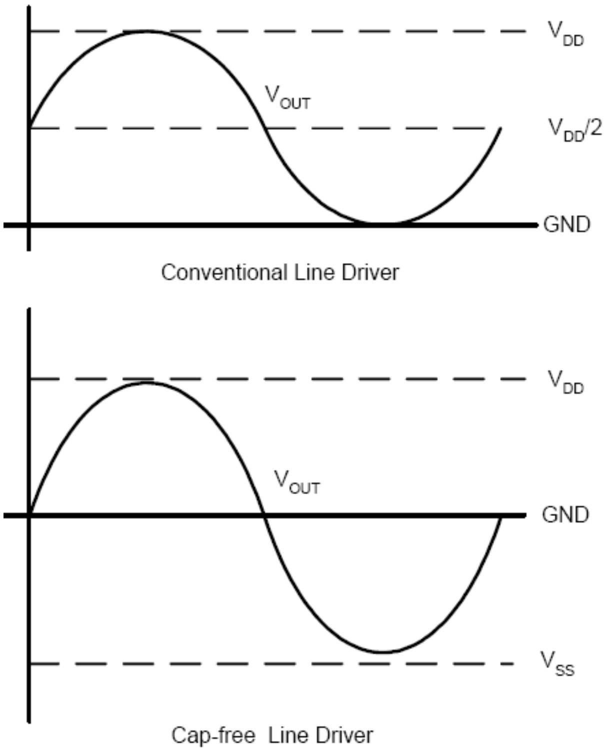


Figure 1. Cap-free Operation

The TD9722's line drivers use a charge pump to invert the positive power supply (V_{DD}) to negative power supply (V_{SS}), see figure1. The headphone drivers operate at this bipolar power supply (V_{DD} and V_{SS}) and the outputs reference refers to the ground. This feature eliminates the output capacitor that is using in conventional single-ended headphone drive amplifier. Compare with the single power supply amplifier, the power supply range has almost doubled.

Thermal Protection

The thermal protection circuit limits the junction temperature of the TD9722. When the junction temperature exceeds T_J=+150°C, a thermal sensor turns off the driver, allowing the devices to cool. The thermal sensor allows the driver to start-up after the junction temperature down about 125°C. The thermal protection is designed with a 25°C hysteresis to lower the average T_J during continuous thermal overload conditions, increasing lifetime of the ICs.

Shutdown Function

In order to reduce power consumption while not in use, the TD9722 contains shutdown controllers to externally turn off the amplifier bias circuitry. This shutdown feature turns the amplifier off when logic low is placed on the SDN pins for the TD9722. The trigger point between a logic high is 1.0V and logic low level is 0.35V. It is recommended to switch between ground and the supply voltage V_{DD} to provide maximum device performance. By switching the SDN pins to a low level, the amplifier enters a low-consumption current circumstance, charge pump is disabled, and I_{DD} for the TD9722 is in shutdown mode. In normal operating, the TD9722's SDN pins should be pulled to a high level to keep the IC out of the shutdown mode. The SDN pins should be tied to a definite voltage to avoid unwanted circumstance changes.

Under-Voltage Protection

External under voltage detection can be used to shutdown the TD9722 before an input device can generate a pop. The shutdown threshold at the UVP pin is 1.25V. The user selects a resistor divider to obtain the shutdown threshold and hysteresis for the specific application. The thresholds can be determined as below:

VUVP = (1.25-6μAxR3) x (R1+R2)/R2

Hysteresis = 5μA x R3 x (R1+R2)/R2

With the condition: R3>>R1//R2

For example, to obtain V_{UVP}=3.8V and 1V hysteresis, R1=3kΩ, R2=1kΩ and R3=50kΩ.

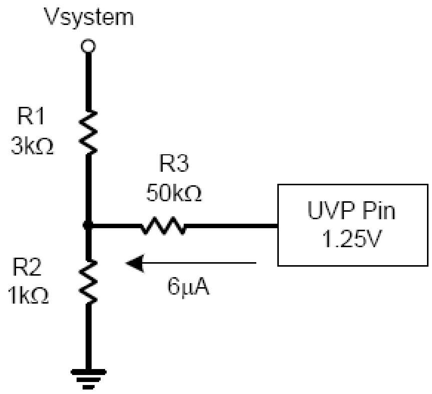


Figure 2. Under-Voltage Protection

Application Information

Using The TD9722 As A Second-Order Filter

Several audio DACs used today require an external lowpass filter to remove out-of-band noise. This is possible with the TD9722, as it can be used like a standard Operational Amplifier. Several filter topologies can be implemented, both single-ended and differential. In Figure3, a multi-feedback (MFB) with differential input and single-ended input is shown.

An ac-coupling capacitor to remove dc content from the source is shown; it serves to block any dc content from the source and lowers the dc-gain to 1, helping reducing the output dc-offset to minimum.

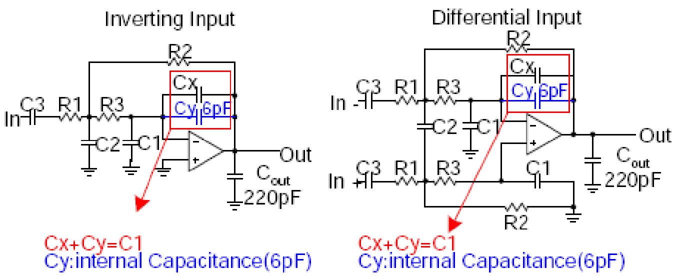


Figure 3. Second-Order Active Low-Pass Filter

Gain (V/V)	High Pass (Hz)	Low Pass (kHz)	C1 (pF)	C2 (pF)	C3 (μF)	R1 (kΩ)	R2 (kΩ)	R3 (kΩ)
-1	1.6	40	100	680	10	10	10	24
-1.5	1.3	40	68	680	15	8.2	12	30
-2	1.6	60	33	150	6.8	15	30	47
-2	1.6	30	47	470	6.8	15	30	43
-3.33	1.2	30	33	470	10	13	43	43
-10	1.5	30	22	1000	22	4.7	47	27

For Inverting Input, The overall gain is:

$$A_V = -\frac{R2}{R1}$$

The high pass filter's cutoff frequency is:

$$f_{c(highpass)} = \frac{1}{2\pi R1C3}$$

The low pass filter's cutoff frequency is:

$$f_{c(lowpass)} = \frac{1}{2\pi\sqrt{R2R3C1C2}}$$

Input Capacitor, C_i

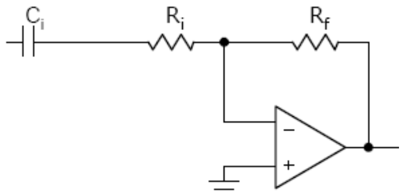


Figure 4. Typical Application Circuit

In the typical application, an input capacitor, C_i, is required to allow the amplifier to bias the input signal to the proper DC level for optimum operation. In this case, C_i and the minimum input impedance R_i from a high-pass filter with the corner frequency are determined in the following equation:

$$f_{c(highpass)} = \frac{1}{2\pi R_i C_i}$$

The value of C_i must be considered carefully because it directly affects the low frequency performance of the circuit. R_i is the external input resistance that typical value is 10kΩ and the specification calls for a flat bass response down to 20Hz. Equation is reconfigured as below:

$$C_i = \frac{1}{2\pi R_i f_{c(highpass)}}$$

When the input resistance variation is considered, the C_i is 0.8μF, so a value in the range of 1μF to 2.2μF would be chosen. A further consideration for this capacitor is the leakage path from the input source through the input network (R_i + R_f, C_i) to the load.

This leakage current creates a DC offset voltage at the input to the amplifier that reduces useful headroom, especially in high gain applications. For this reason, a low leakage tantalum or ceramic capacitor is the best choice. When polarized capacitors are used, the negative side of the capacitor should face the amplifiers' input in most applications because the DC level of the amplifiers' input is held at GND. Please note that it is important to confirm the capacitor polarity in the application.

Input Resistor, R_i

The gain of the TD9722 is be set by the external input resistor (R_i) and external feedback resistor (R_f). Please see the figure 4.

Application Information(Cont.)

Input Resistor, R_i (Cont.)

$$\text{Gain}(A_V) = \frac{R_f}{R_i}$$

The external gain setting is recommended using from -1V/V to -10V/V, and the R_i is in the range from 1kΩ to 47kΩ. It's recommended to use 1% tolerance resistor or better. Keep the input trace as short as possible to limit the noise injection. The gain is recommended to set -1V/V, and R_i is 10kΩ, and R_f is 10kΩ.

Feedback Resistor, R_f

Refer the figure 4, the external gain is setting by R_i and R_f; and the gain setting is recommended using from -1V/V to -10V/V. The R_f is in the range from 4.7kΩ to 100kΩ. It's recommended to use 1% tolerance resistor or better.

Power Supply Decoupling, C_s

The TD9722 is a high-performance CMOS audio amplifier that requires adequate power supply decoupling to ensure the output total harmonic distortion (THD+N) is as low as possible. Power supply decoupling also prevents the oscillations being caused by long lead length between the amplifier and the speaker.

The optimum decoupling is achieved by using two different types of capacitors that target on different types of noise on the power supply leads. For higher frequency transients, spikes, or digital hash on the line, a good low equivalent-series-resistance (ESR) ceramic capacitor, typically 0.1μF, is placed as close as possible to the device VDD and PVDD lead for the best performance. For filtering lower frequency noise signals, a large aluminum electrolytic capacitor of 10μF or greater placed near the audio power amplifier is recommended.

Charge Pump Flying Capacitor, C_{CPF}

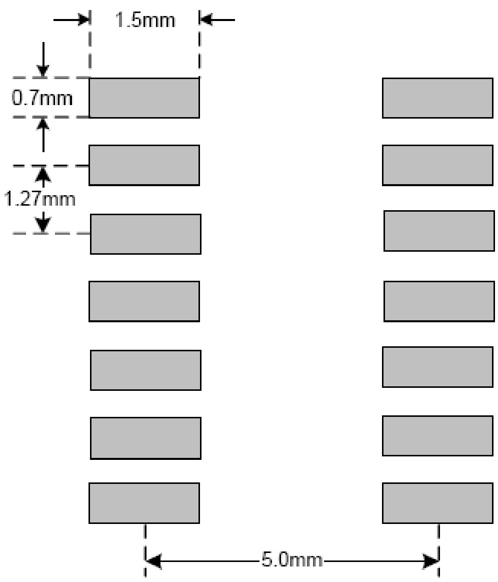
The flying capacitor affects the load transient of the charge pump. If the capacitor's value is too small, then that will degrade the charge pump's current driver capability and the performance of line drive amplifier.

Increasing the flying capacitor's value will improve the load transient of charge pump. It is recommended using the low ESR ceramic capacitors (X7R type is recommended) above 1μF.

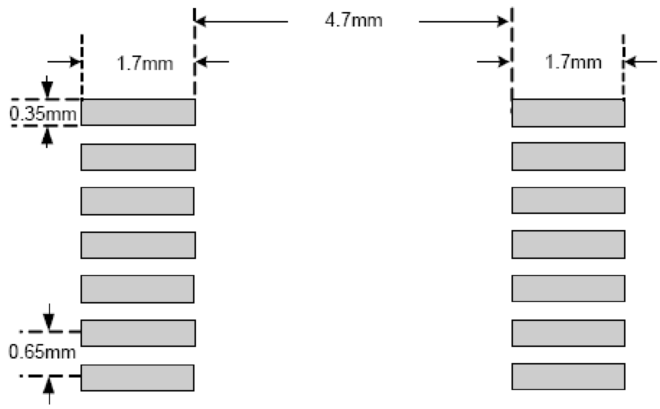
Charge Pump Output Capacitor, C_{CPO}

The output capacitor's value affects the power ripple directly at CV_{SS} (V_{SS}). Increasing the value of output capacitor reduces the power ripple. The ESR of output capacitor affects the load transient of CV_{SS} (V_{SS}). Lower ESR and greater than 1μF ceramic capacitor is a recommendation.

Layout Recommendation



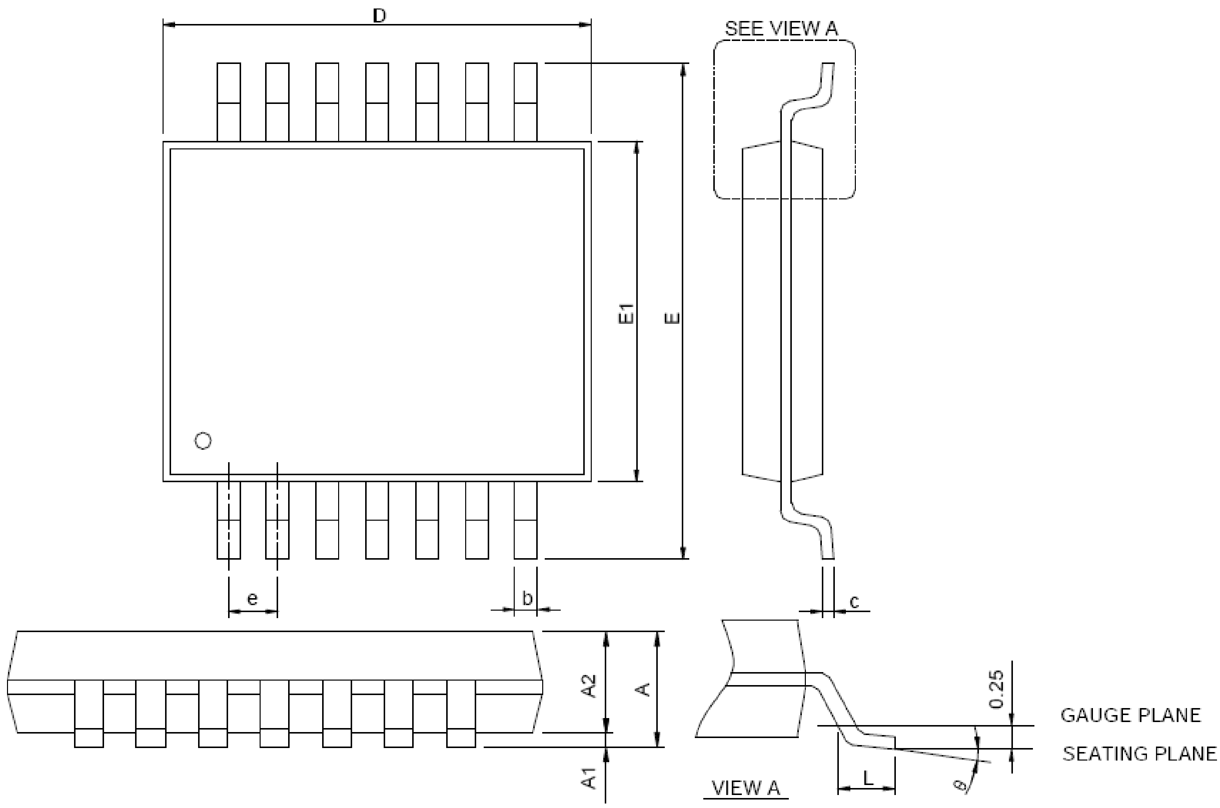
SOP-14 Land Pattern Recommendation



TSSOP-14 Land Pattern Recommendation

Package Information

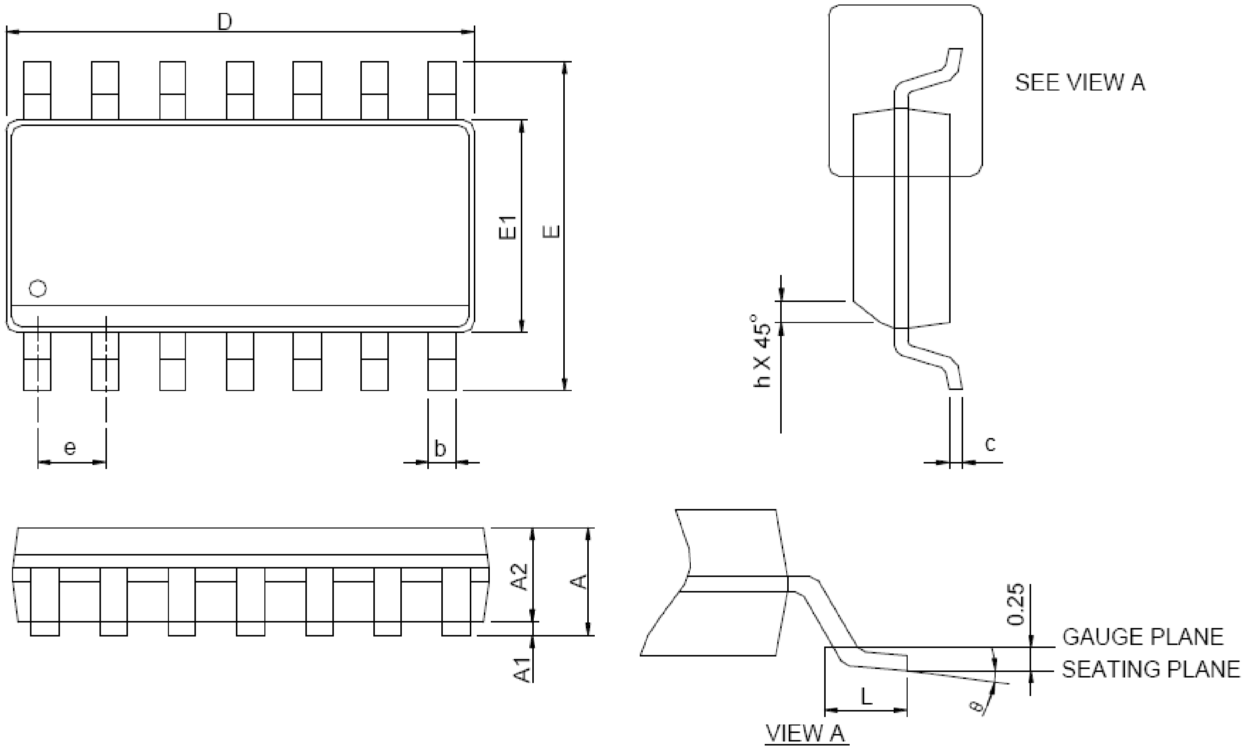
TSSOP-14



SYMBOL	TSSOP-14			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		1.20		0.047
A1	0.05	0.15	0.002	0.006
A2	0.80	1.05	0.031	0.041
b	0.19	0.30	0.007	0.012
c	0.09	0.20	0.004	0.008
D	4.90	5.10	0.193	0.201
E	6.20	6.60	0.244	0.260
E1	4.30	4.50	0.169	0.177
e	0.65 BSC		0.026 BSC	
L	0.45	0.75	0.018	0.030
θ	0°	8°	0°	8°

Package Information(Cont.)

SOP-14



SYMBOL	SOP-14			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		1.75		0.069
A1	0.10	0.25	0.004	0.010
A2	1.25		0.049	
b	0.31	0.51	0.012	0.020
c	0.17	0.25	0.007	0.010
D	8.55	8.75	0.337	0.344
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
h	0.25	0.50	0.010	0.020
L	0.40	1.27	0.016	0.050
θ	0°	8°	0°	8°

Design Notes