3-Vrms Cap-Less Line Driver with Adjustable Gain

Features

- Operation Voltage: 3V to 5.5V
- Cap-less Output
  - Eliminates Output Capacitors
  - Improves Low Frequency Response
  - Reduces POP/Clicks
- Low Noise and THD at 2.5k Load
  - SNR > 102dB
  - Typical Vn < 12uVrms
  - THD+N < 0.02%
- Maximum Output Voltage Swing into 2.5k Load
  - 2Vrms at 3.3V Supply Voltage
  - 3Vrms at 5V Supply Voltage
- Single-ended Input Directly
- External Gain Setting from 1V/V to 10V/V
- Fast Start-up Time : 2ms
- Integrated De-Pop Control
- External Under Voltage Protection
- Thermal Protection
- Less External Components Required
- +/-8kV IEC ESD Protection at line outputs

Applications

- LCD / PDP TVs
- CD / DVD players
- Set-Top Boxes
- Home Theater in Box

Description

The AD22654B is a 3-Vrms cap-less stereo line driver. The device is ideal for single supply electronics. Cap-less design can eliminate output dc-blocking capacitors for better low frequency response and save cost.

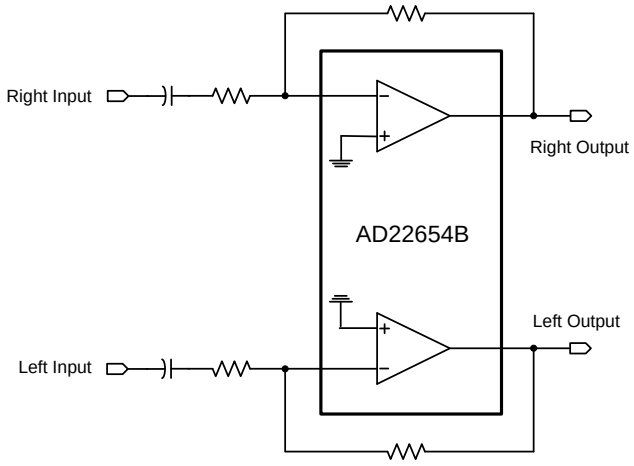
The AD22654B is capable of delivering 3-Vrms output into a 2.5kΩ load with 5V supply. The gain settings can be set by users from 1V/V to 10V/V externally. The AD22654B has internal and external under voltage protection to prevent POP noise. Build-in shutdown control and de-pop control sequence also help AD22654B to be a pop-less device.

The AD22654B is available in a 10-pin E-MSOP package.

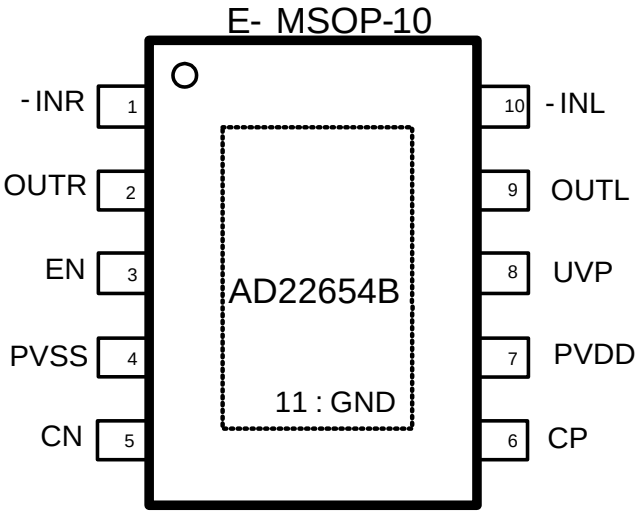
Ordering Information

Product ID	Package	Packing	Comments
AD22654B-MG10NRT	E-MSOP-10	80 Units / Tube 100 Tubes / Small Box	Green (HF)
AD22654B-MG10NRR		3k Units Tape & Reel	

Simplified Application Circuit



Pin Assignments

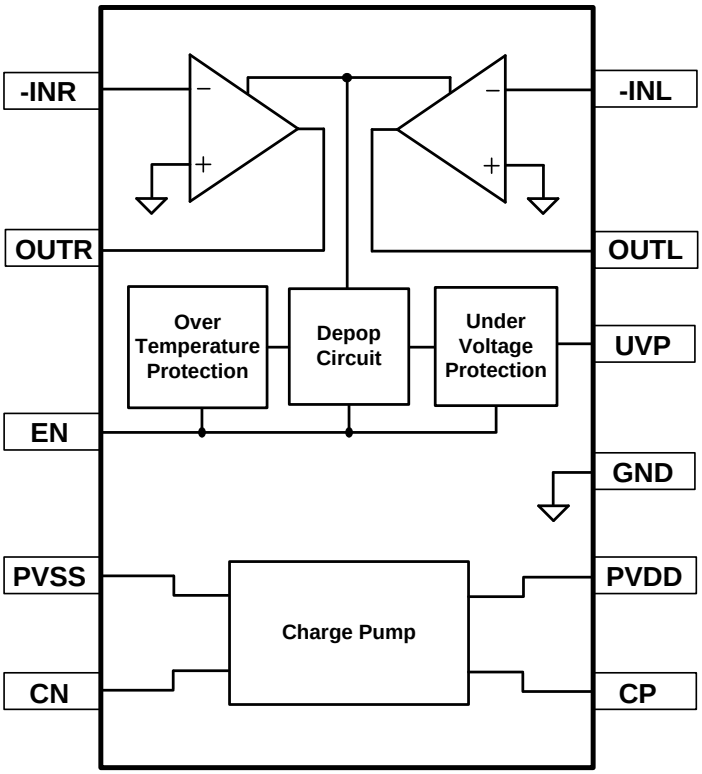


Pin Description

No.	Name	Type (1)	Pin Description
1	-INR	I	Right channel OP negative input
2	OUTR	O	Right channel OP output
3	EN	I	Enable input, active high
4	PVSS	P	Supply voltage
5	CN	I/O	Charge-pump flying capacitor negative terminal
6	CP	I/O	Charge-pump flying capacitor positive terminal
7	PVDD	P	Positive supply
8	UVP	I	Under-voltage protection input, internally pulled high
9	OUTL	O	Left channel OP output
10	-INL	I	Left channel OP negative input
11	GND	P	Ground

(1) I=input, O=output, P=power

Functional Block Diagram



Available Package

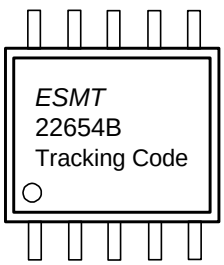
Package Type	Device No.	Θ_{ja} (℃/W)(1)	$\Theta_{jc(top)}$ (℃/W)(2)
MSOP-10	AD22654B	67	54

(1) Θ_{ja} is measured at room temperature (TA=25℃), natural convection environment test board, which is constructed with a thermal efficient, 2-layers PCB. The measurement is tested using the JEDEC51-3 thermal measurement standard.

(2) $\Theta_{jc(top)}$ represents the heat resistance for the heat flow between the chip and package's top surface.

Marking Information

AD22654B
Line 1 : LOGO
Line 2 : Product No.
Line 3 : Tracking Code



Absolute Maximum Ratings(1)

SYMBOL	PARAMETER	VALUE	UNIT
	Supply Voltage, V_{DD} to GND	-0.3 to 6.5	V
V_I	Input Voltage	VSS -0.3 to VDD+0.3	V
R_L	Minimum load impedance	16	Ω
	EN to GND	-0.3 to VDD+0.3	V
T_{stg}	Storage temperature range	-65 to 150	℃
T_J	Maximum operating junction temperature range	-40 to 150	℃

(1) The absolute maximum ratings are limiting values of operation, safety of the device cannot be guaranteed if beyond those values.

Recommended Operating Conditions

SYMBOL	PARAMETER		Min	NOM	Max	UNIT
V_{DD}	Supply Voltage		3.0		5.5	V
V_{IH}	High Level Input Voltage	EN	60			% of V_{DD}
V_{IL}	Low Level Input Voltage	EN			40	% of V_{DD}
T_A	Operating Ambient Temperature Range		-40		85	℃
R_L	Load Resistance		16			Ω

Electrical Characteristics

PVDD=3.3V, T_A=25℃, R_L=2.5kΩ, C_{FLY}=C_{PVSS}=1μF, C_{IN}=1μF, R_I=10kΩ, R_F=20kΩ (unless otherwise noted)

SYMBOL	PARAMETER	TEST CONDITIONS	Min	NOM	Max	UNIT
I_{DD}	V_{DD} Supply Current	EN=V_{DD}		6	15	mA
I_{SD}	V_{DD} Shutdown Current	EN=0V, V_{DD} =5.5V		<1	5	μA
II	Input Current	EN pin			1	μA
V_O	Output Voltage (Outputs In Phase)	THD+N=1%, V_{DD}=3.3V, f_{IN}=1kHz		2.2		Vrms
		THD+N=1%, V_{DD}=5V, f_{IN}=1kHz		3.4		
		THD+N=1%, V_{DD}=5V, f_{IN}=1kHz, RL=100k		3.5		
Po	Output Power (Outputs In Phase)	THD+N=1%, V_{DD}=3.3V, f_{IN}=1kHz, R_L=32Ω		23		mW
		THD+N=1%, V_{DD}=5V, f_{IN}=1kHz, R_L=32Ω		63		
		THD+N=1%, V_{DD}=3.3V, f_{IN}=1kHz, R_L=16Ω		15		
		THD+N=1%, V_{DD}=5V, f_{IN}=1kHz, R_L=16Ω		45		
THD+N	Total Harmonic Distortion Plus Noise	V_O=2Vrms, f_{IN}=1kHz		0.001		%
		Po=10mW, f_{IN}=1kHz, R_L=32Ω		0.02		

Electrical Characteristics (Con't)

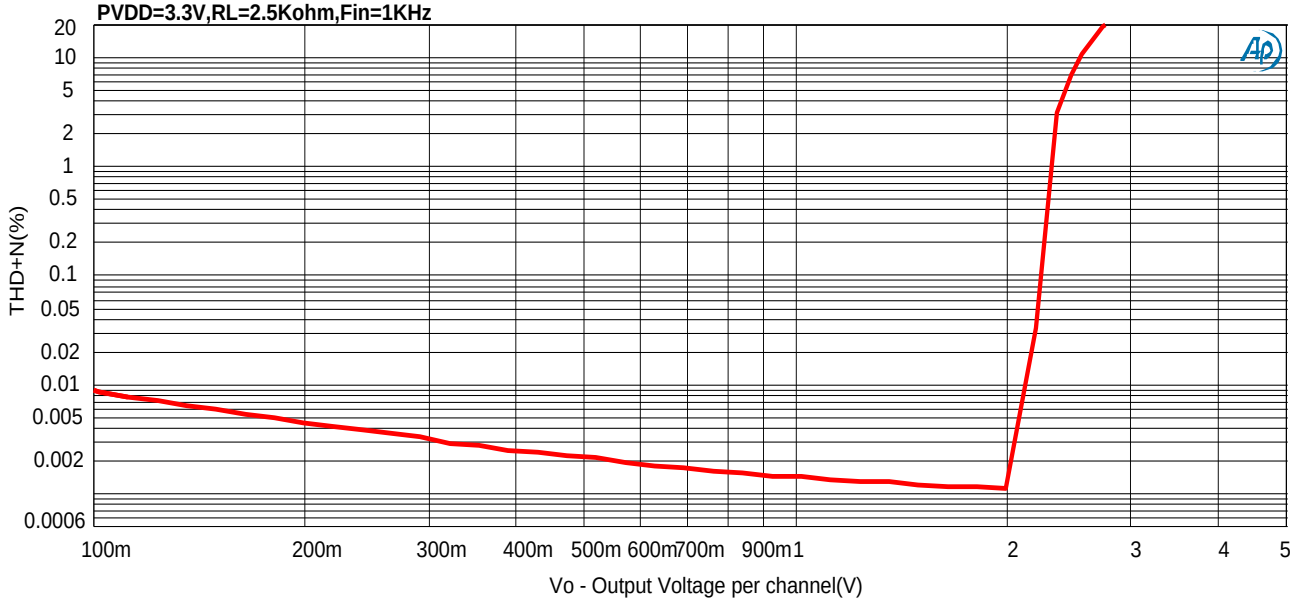
PVDD=3.3V, T_A=25℃, R_L=2.5kΩ, C_{FLY}=C_{PVSS}=1μF, C_{IN}=1μF, R_I=10kΩ, R_F=20kΩ (unless otherwise noted)

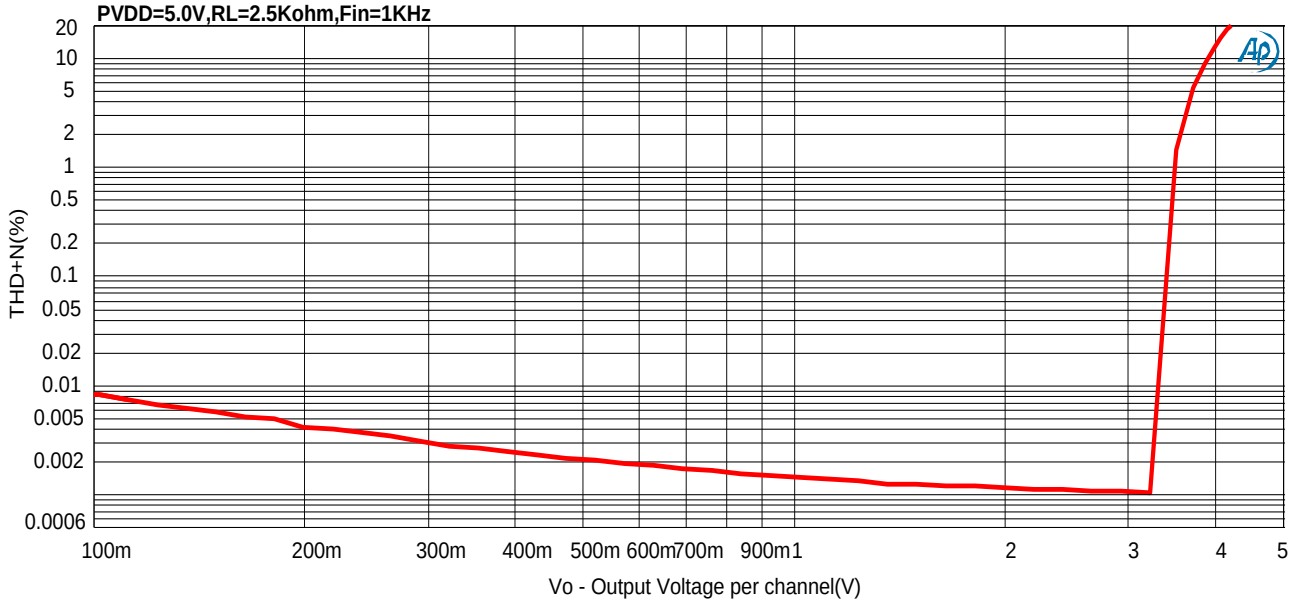
SYMBOL	PARAMETER	TEST CONDITIONS	Min	NOM	Max	UNIT
THD+N	Total Harmonic Distortion Plus Noise	Po=10mW, f_{IN}=1kHz, R_L=16Ω		0.04		%
Crosstalk	Channel Separation	V_O=2Vrms, f_{IN}=1kHz		-120		dB
		Po=20mW, f_{IN}=1kHz, R_L=32Ω		-97		
V_N	Output Noise	R_I=10k, R_F=10k		4	15	μVrms
V_{OS}	Output Offset Voltage	V_{DD}=3V to 5.5V, Input Grounded	-1		1	mV
PSRR	Power Supply Rejection Ratio	V_{DD}=3V to 5.5V, V_{rr}=200mVrms, f_{IN}=1kHz		-80	-60	dB
R_I	Input Resistor Range		1	10	47	kΩ
R_F	Feedback Resistor Range		4.7	20	100	kΩ
f_{CP}	Charge-Pump Frequency		400	500	600	kHz
	Maximum capacitive Load			220		pF
V_{UVP}	External Under Voltage Detection			1.25		V
I_{HYS}	External Under Voltage Detection Hysteresis Current			5		μA
TSD	Over Temperature Protection Level			150		℃
$T_{start-up}$	Start-up Time			2		ms

Typical Characteristics

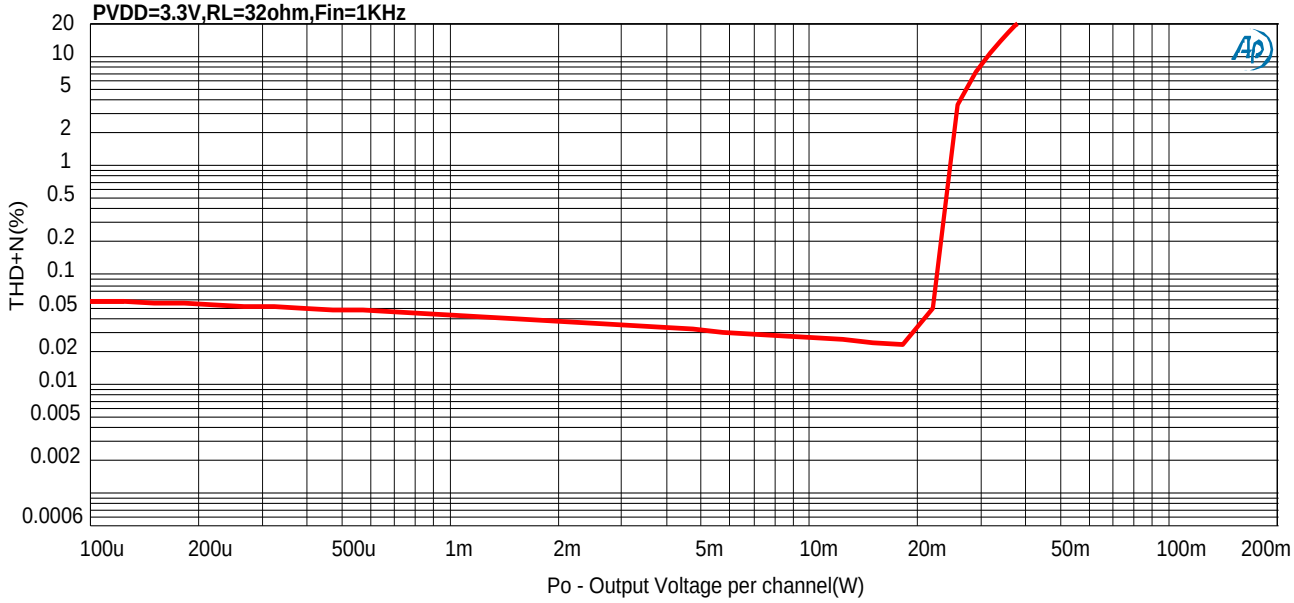
PVDD=3.3V, T_A=25℃, R_L=2.5kΩ, C_{FLY}=C_{PVSS}=1μF, C_{IN}=1μF, R_I=10kΩ, R_F=20kΩ,(unless otherwise noted)

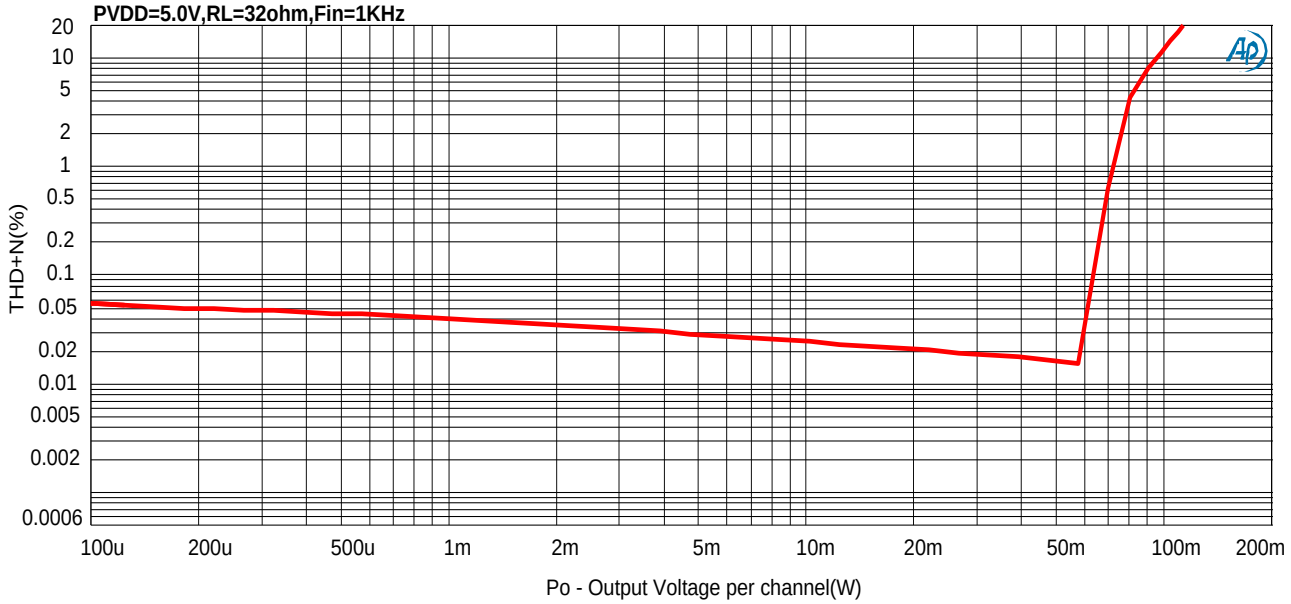
- Total Harmonic Distortion + Noise (THD+N) vs. Output Power (2.5Kohm)



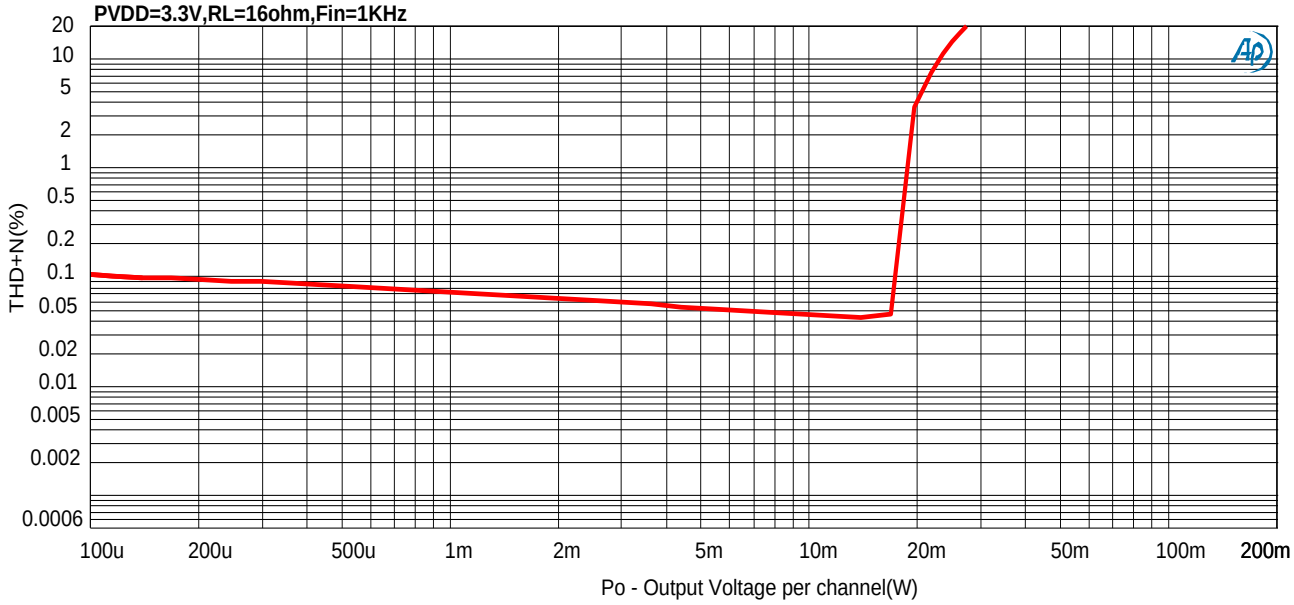


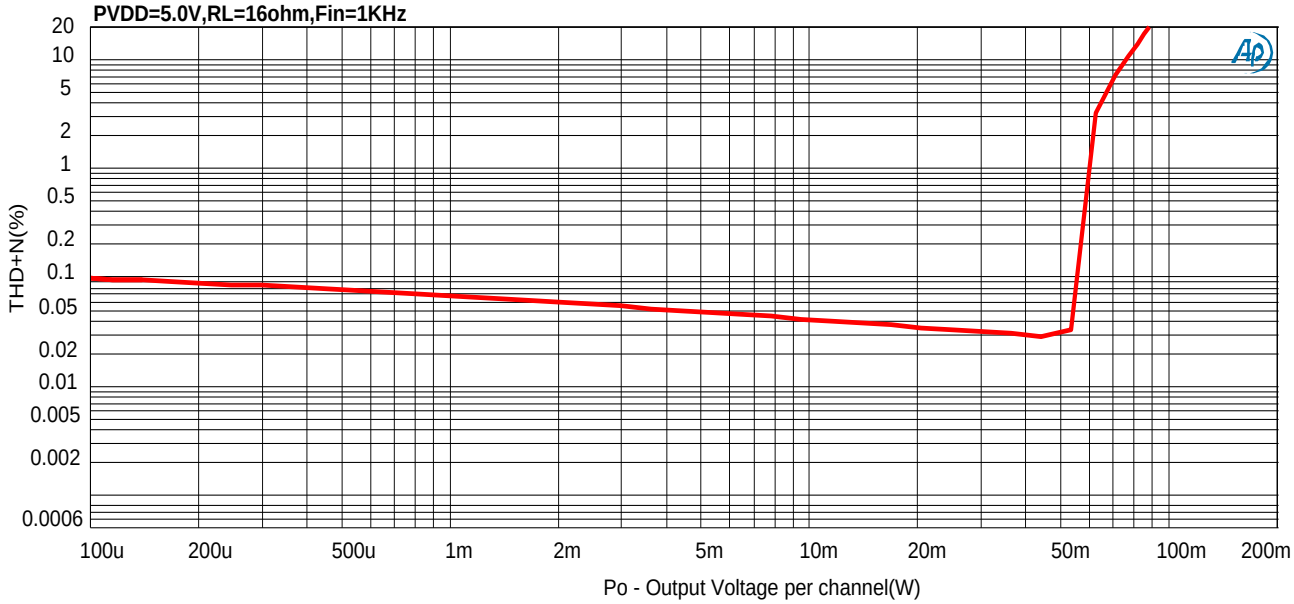
- Total Harmonic Distortion + Noise (THD+N) vs. Output Power (32ohm)



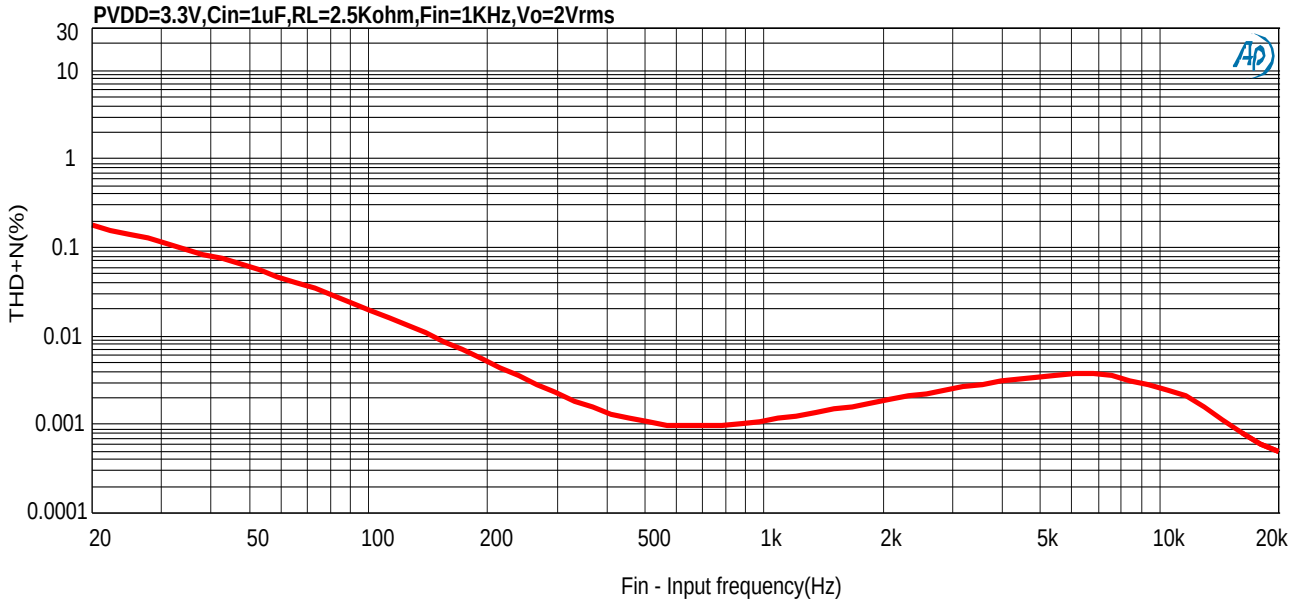


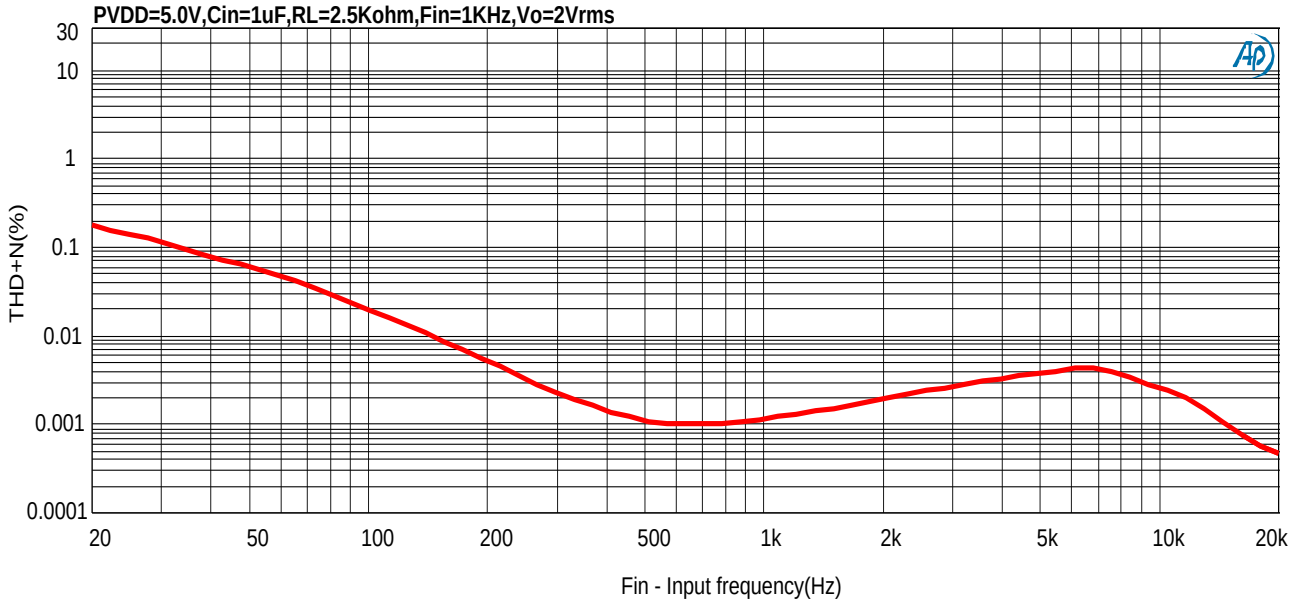
- Total Harmonic Distortion + Noise (THD+N) vs. Output Power (16ohm)



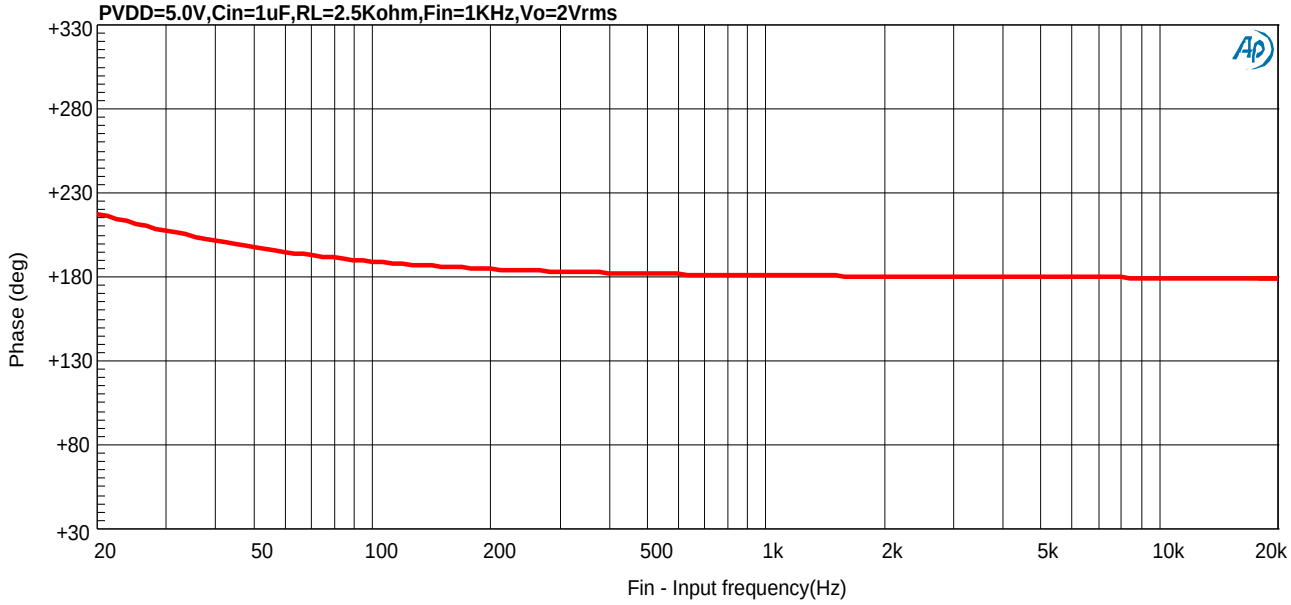


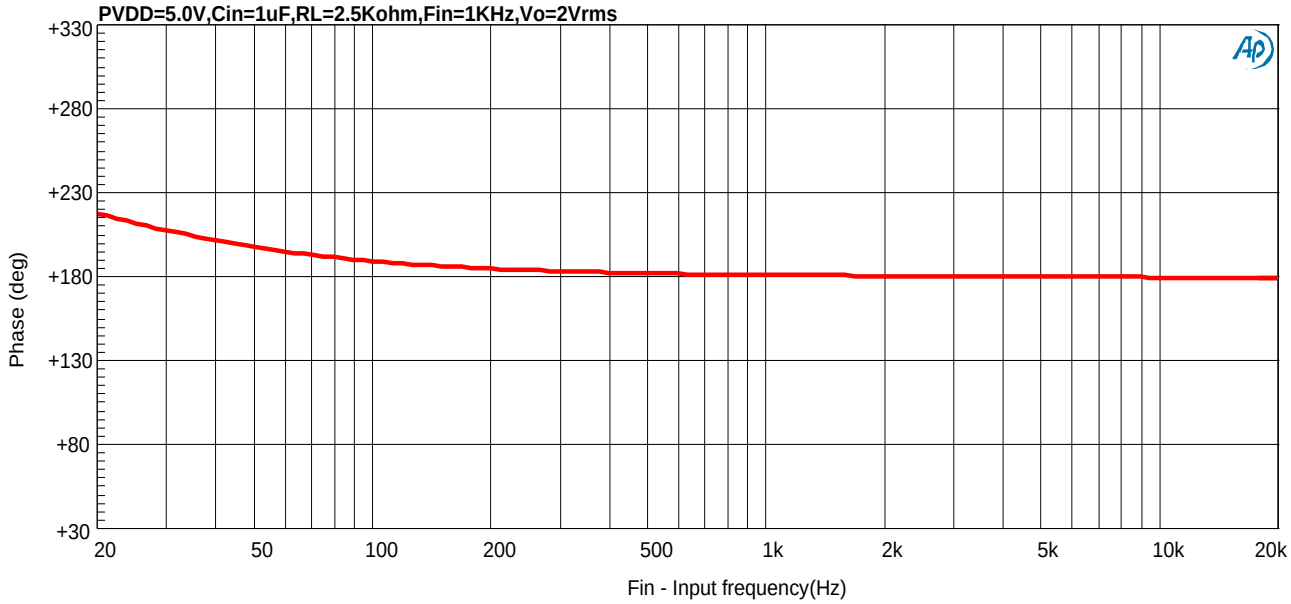
- Total Harmonic Distortion + Noise (THD+N) vs. Signal Frequency



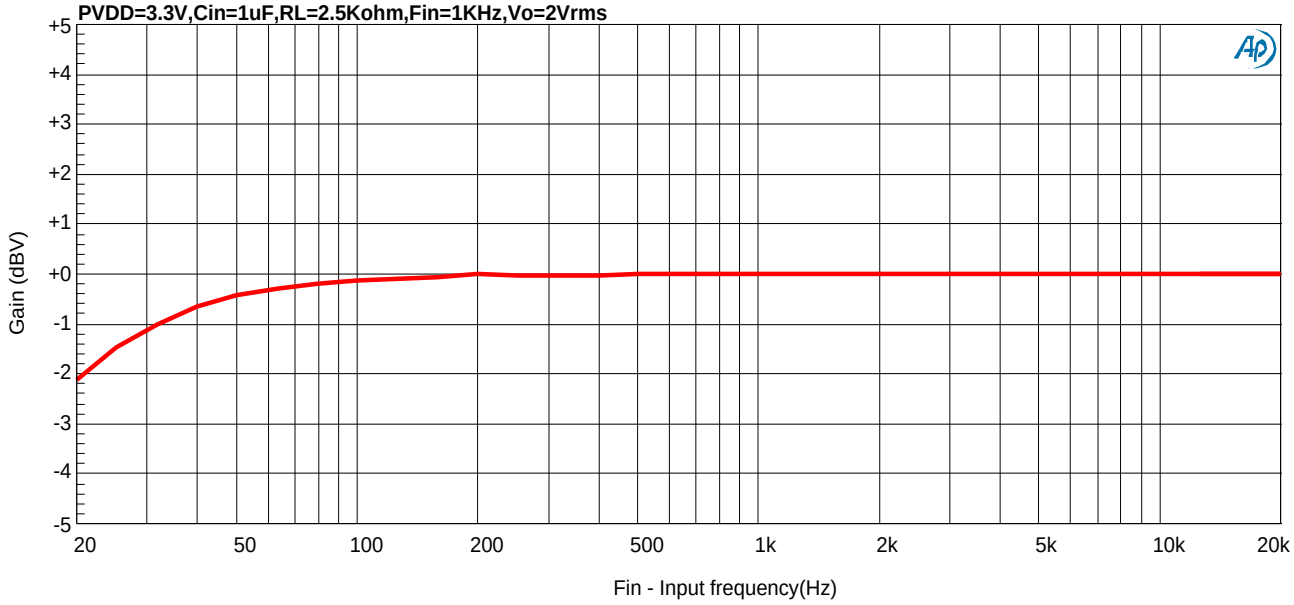


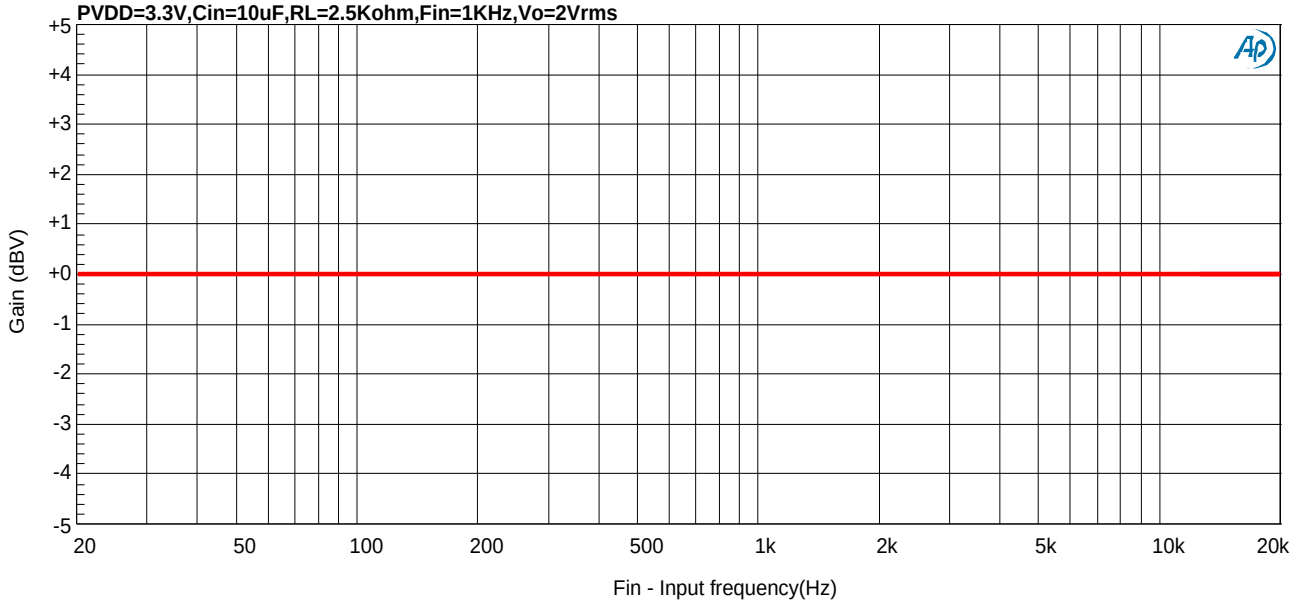
- Phase vs. Signal Frequency





- Gain vs. Signal Frequency





Application Information

■ Line Driver Amplifiers Operation

A conventional inverting line-driver amplifier always requires an output dc-blocking capacitor and a bypass capacitor, see Figure 1. DC blocking capacitors are large in size and cost a lot. It also restricts the output low frequency response. POP will occur if the charge and discharge processes on output capacitors are not carefully take cared. Besides, it needs to wait for a long time to charge V_{OUT} from 0V to PVDD/2.

For a cap-less line driver, see figure 2, a negative supply voltage (PVSS) is produced by the integrated charge-pump, and feeds to line driver's negative supply instead of ground. The positive input can directly connect to ground without a C_{BYPASS}, and V_{OUT} is biased at ground which can eliminate the output dc-blocking capacitors. The output voltage swing is doubled compared to conventional amplifiers.

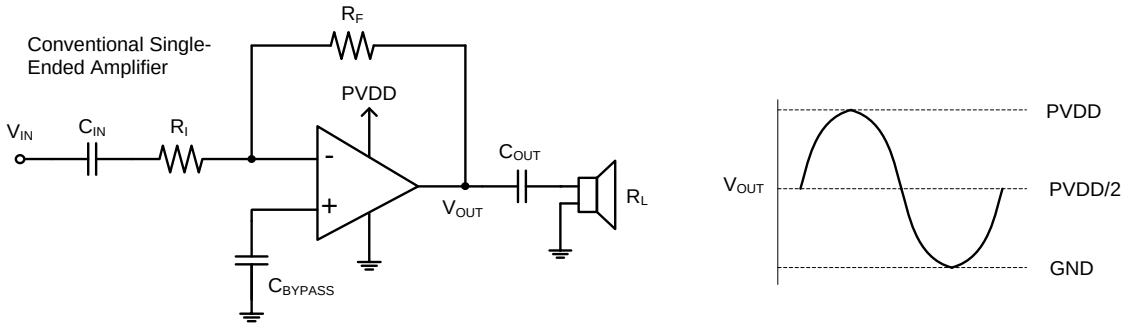


Figure 1. Conventional Line Driver Amplifier

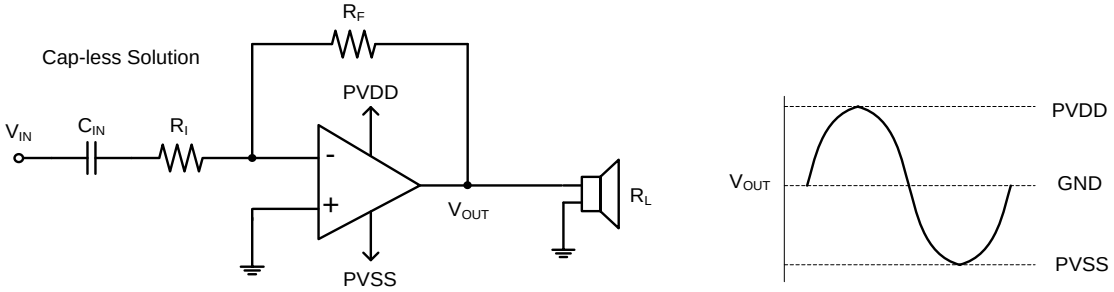


Figure 2. Cap-less Line Driver Amplifier

External Under-Voltage Protection

The external under-voltage protection is used to mute the line-driver before any input voltage change to generate a POP. The threshold of UVP pin is designed to 1.25V. By using a resistor divider, users can decide the UVP level and hysteresis level. The levels can be obtained by following equations:

$$V_{UVP} = (1.25V - 6\mu A \times R13) \times (R11 + R12) / R12$$

$$Hysteresis = 5\mu A \times R13 \times (R11 + R12) / R12$$

With the condition R13 >> (R11 // R12).

For example, to obtain V_{UVP}=2.67V, Hysteresis=0.37V, R11=1.5kΩ, R12=1kΩ, R13=30kΩ.

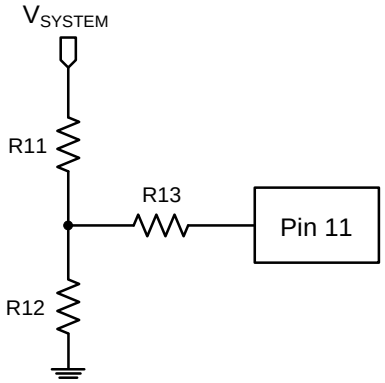
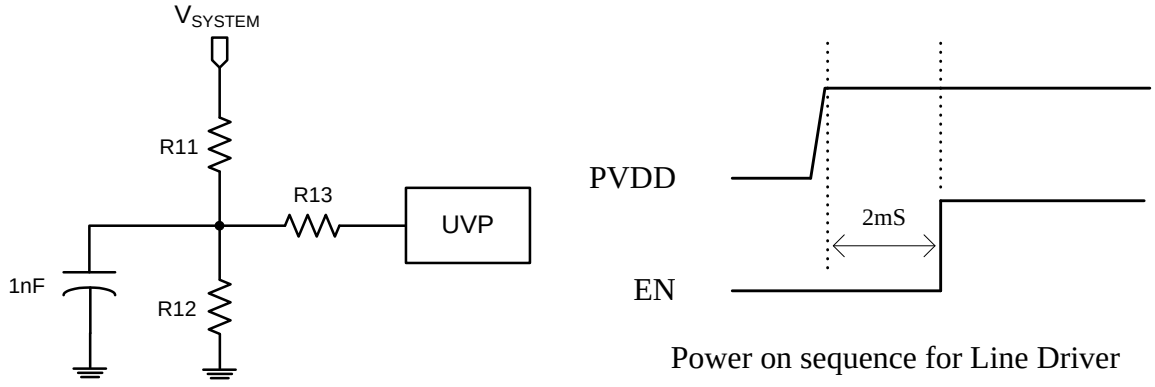


Figure 3. Application Circuit of UVP Pin

The UVP pin voltage ripple needs to take care during power up state within 2mS. The UVP pin ripple lower 1.25V by 2~4 times will trigger test mode in Line Driver. To put a capacitor parallel with UVP pin can improve test mode mis-operating triggered while V_{STSTEM} is not stable during power up initially. That's recommended 2mS timing delay to enable the Line Driver after PVDD power up ready.



Power on sequence for Line Driver

UVP pin is pulled high internally, and therefore it can be floated to disable the external under-voltage protection feature.

Charge-Pump Operation

The charge-pump is used to generate a negative supply voltage to supply to line-driver. It needs two external capacitors, C_{FLY} and C_{PVSS}, for normal operation, see figure 4 (a). The operation can be analyzed with two phase. In phase I, see figure 4 (b), C_{FLY} is charged to PVDD, and in phase II, see figure 4 (c), the charges on C_{FLY} are shared with C_{PVSS}, that makes PVSS a negative voltage. After an adequate clock cycles, PVSS will be equaled to –PVDD. Low ESR capacitors are recommended, and the typical value of C_{FLY} and C_{PVSS} is 1μF. A smaller capacitance can be used, but the maximum output voltage may be reduced.

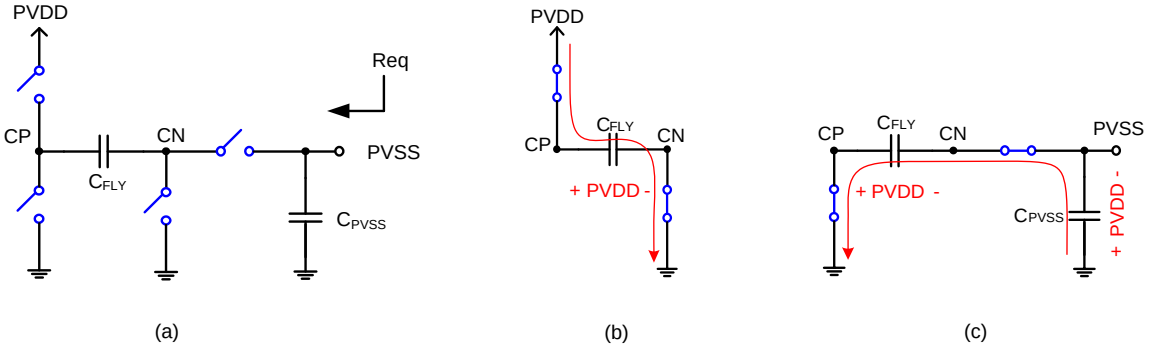


Figure 4. Charge-Pump Operation

Enable Function

The enable function is used to reduce power consumption while the device is not in use. When a logic low is applied to this pin, the overall circuits are turned off. Line driver output and PVSS are pulled to ground. When a logic high is applied to enable pin, the PVSS is started to build-up and line driver output signal is released after about 0.5ms typically.

Decoupling Capacitors

A low ESR power supply decoupling capacitor is required for better performance. The capacitor should place as close to chip as possible, the value is typically 1μF. For filtering low frequency noise signals, a 10μF or greater capacitor placed near the chip is recommended.

Input Blocking Capacitors (C_{IN})

An input blocking capacitor is required to block the dc voltage of the audio source and allows the input to bias at a proper dc level for optimum operation. The input capacitor and input resistor (R_I) form a high-pass filter with the corner frequency determined as following equation:

$$f_C = \frac{1}{2\pi R_I C_{IN}}$$

■ Gain Setting Resistors (R_I and R_F)

The line driver's gain is determined by R_I and R_F. The configuration of the amplifier is inverting type, see figure 5. The gain equation is listed as follows:

Inverting configuration: $A_V = -\frac{R_F}{R_I}$

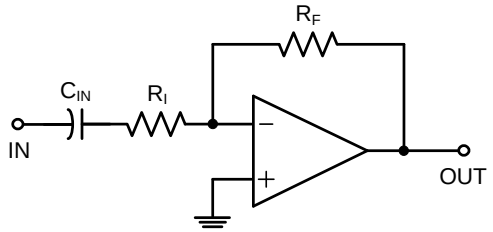


Figure 5. Line Driver Amplifier Configurations

The values of R_I and R_F must be chosen with consideration of stability, frequency response and noise. The recommended value of R_I is in the range from 1kΩ to 47kΩ, and R_F is from 4.7kΩ to 100kΩ for. The gain is in the range from -1V/V to -10V/V for inverting configuration. Table 1 lists the recommended resistor values for different configurations.

R_I (kΩ)	R_F (kΩ)	Inverting Input Gain (V/V)
22	22	-1
15	30	-2
33	68	-2.1
10	100	-10

Table 1. Recommended Resistor Values

■ Second-Order Filter Configuration

AD22654B can be used like a standard OPAMP. Several filter topologies can be implemented by using AD22654B, single-ended input configuration, see figure 6. For inverting input configuration, the overall gain is $-\frac{R2}{R1}$, the high-pass filter's cutoff frequency is $\frac{1}{2\pi R1C3}$, the low-pass filter's cutoff frequency is $\frac{1}{2\pi\sqrt{R2R3C1C2}}$, The detail component values are listed on table 2.

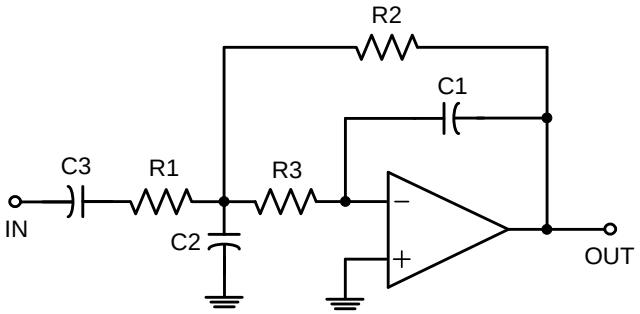


Figure 6. Second-order Active Low-Pass Filter

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

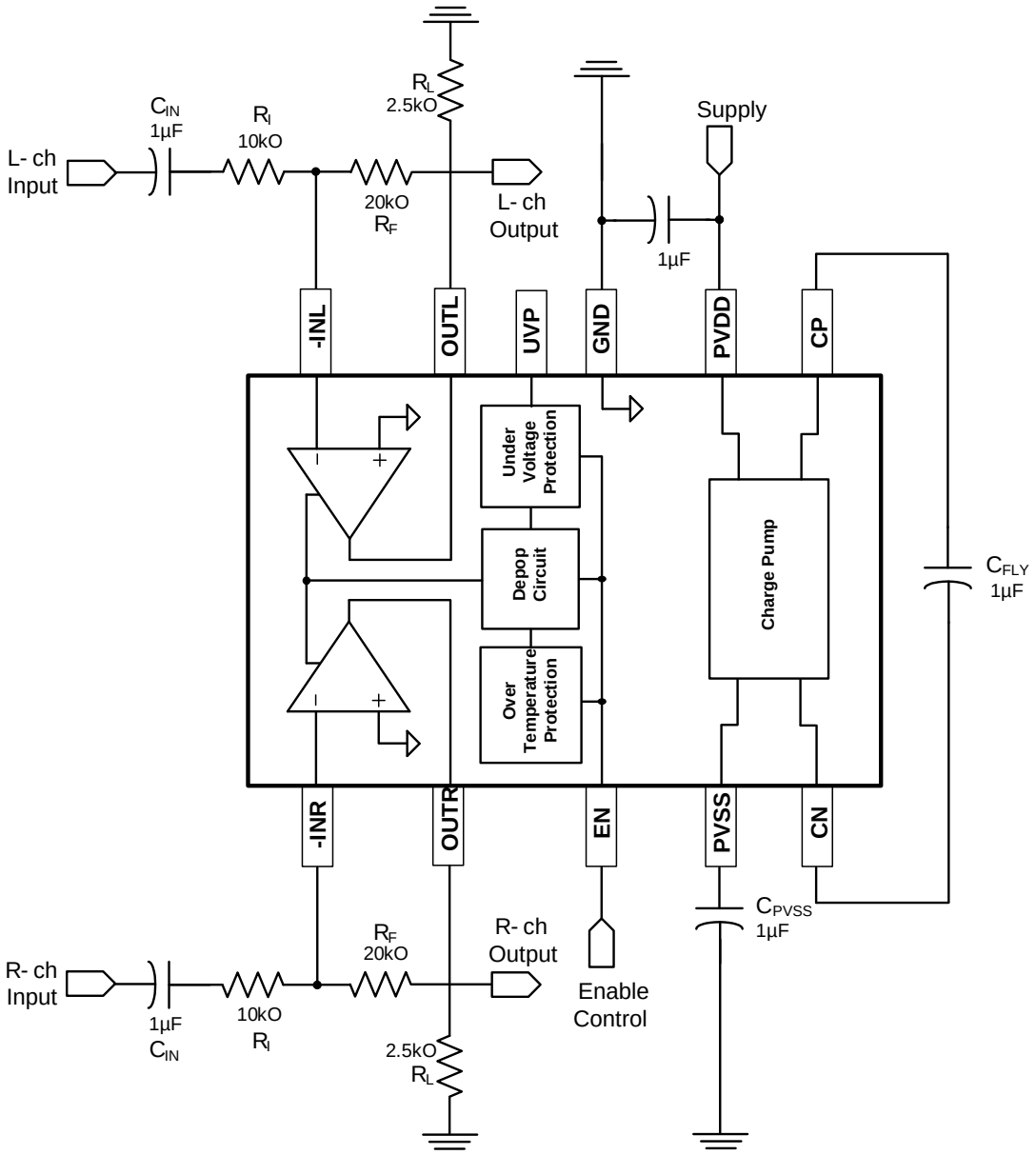
Table 2. Second-order Low-Pass Filter Specifications

■ Over-Temperature Protection

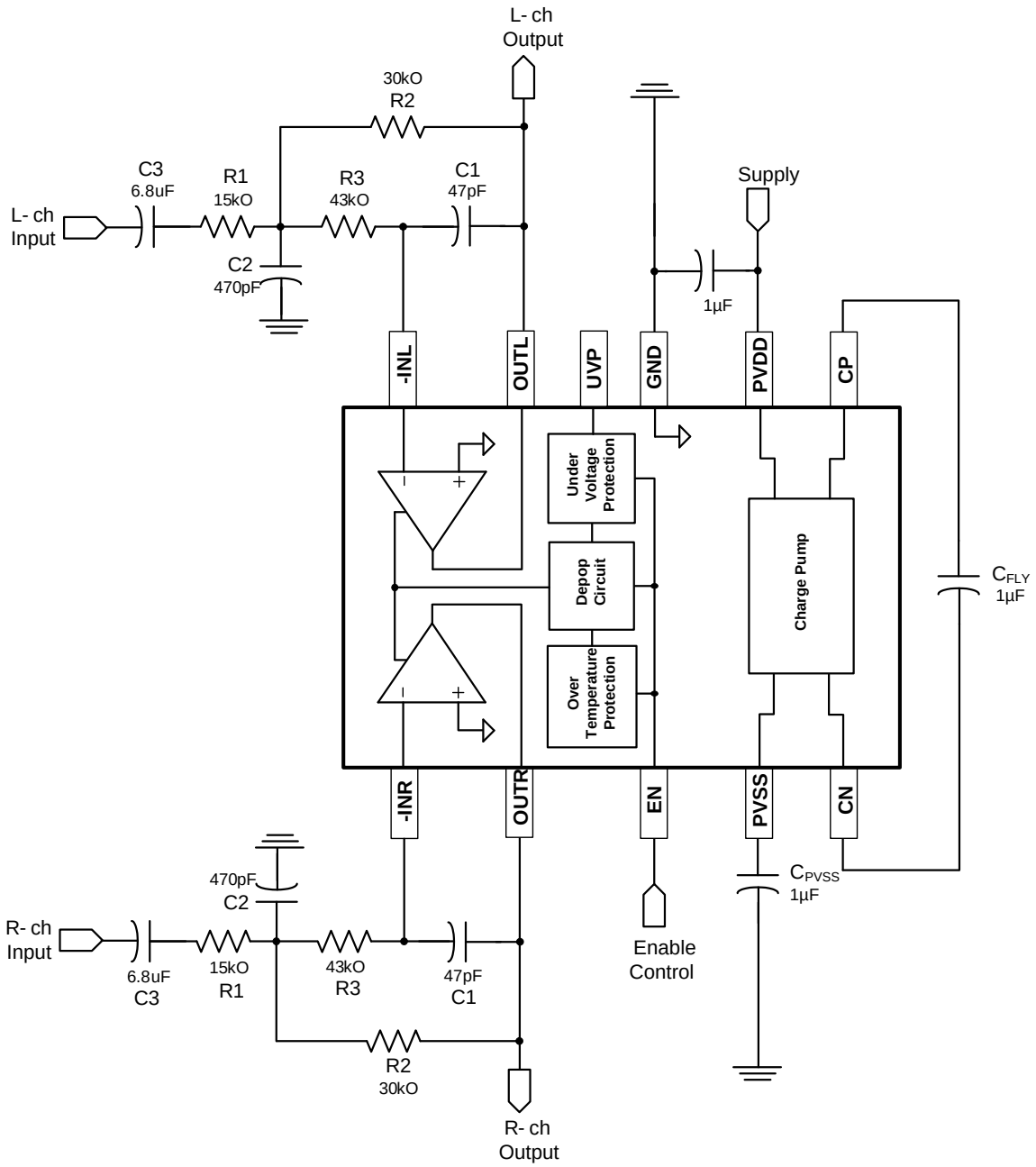
AD22654B provide an over-temperature protection to limit the junction temperature to 150℃. As junction temperature exceeds 150℃, internal thermal sensor will turn off the drivers immediately. The drivers will turn on again if the junction temperature is smaller than 130℃. A 20℃ hysteresis is designed to lower the average junction temperature during continuous thermal overload conditions, increasing lifetime of the chip.

Typical Application Circuit

■ Inverting Input Line Driver Amplifier

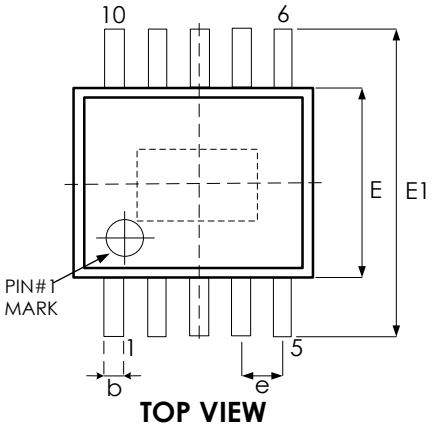


■ Inverting Input Second-Order Active Low-Pass Filter(load support >= 600Ω only)

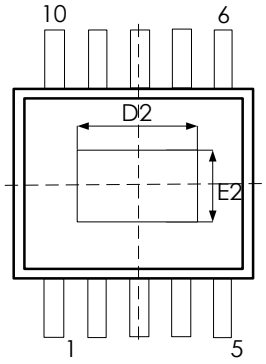


Package Outline Drawing

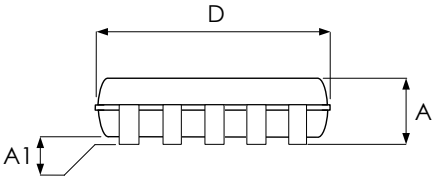
E-MSOP-10L



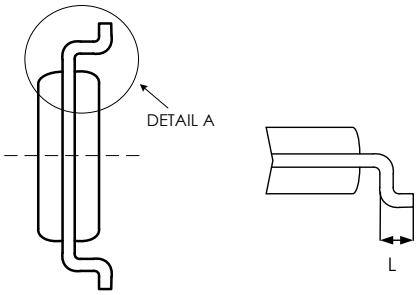
TOP VIEW



BOTTOM VIEW



SIDE VIEW



DETAIL A

Symbol	Dimension in mm	
	Min	Max
A	0.81	1.10
A1	0.00	0.15
b	0.17	0.33
c	0.08	0.23
D	2.90	3.10
E	2.90	3.10
E1	4.80	5.00
e	0.50 BSC	
L	0.40	0.80

Exposed pac

	Dimension in mm	
	Min	Max
D2	1.50	1.78
E2	1.62	1.91

Revision History

Revision	Date	Description
0.1	2018.05.04	Initial version.

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