AS1702, AS1703, AS1704, AS1705

DataSheet

1.6W Single-Channel Audio Power Amplifiers

1 General Description

The AS1702, AS1703, AS1704, and AS1705 are single-channel differential audio power-amplifiers designed to drive 4 and 8Ω loads. The integrated gain circuitry of these amplifiers and their small size make them ideal for 2.7- to 5V-powered portable audio devices.

The differential input design improves noise rejection and provides common-mode rejection. A bridge-tied load (BTL) design minimizes external component count, while providing Hi-Fi audio power amplification.

The devices deliver 1.6W continuous average power per channel to a 4Ω load with less than 1% total harmonic distortion (plus noise), while operating from a single 2.7 to 5V supply.

In order to facilitate reduced component designs, the devices are available with different gain levels:

- AS1702 – Adjustable Gain (via external components)
- AS1703 – Av = 0dB
- AS1704 – Av = 3dB
- AS1705 – Av = 6dB

Integrated shutdown circuitry disables the bias generator and amplifiers, and reduces quiescent current consumption to less than 100nA. The shutdown input can be set as active-high or active-low. All devices contain comprehensive click-and-pop suppression circuitry that reduces audible clicks and pops during power-up and shutdown.

The AS1702, AS1703, AS1704, and AS1705 are pin compatible with the LM4895 and the MAX9718A/B/C/D.

The devices are available in a 10-pin MSOP package.

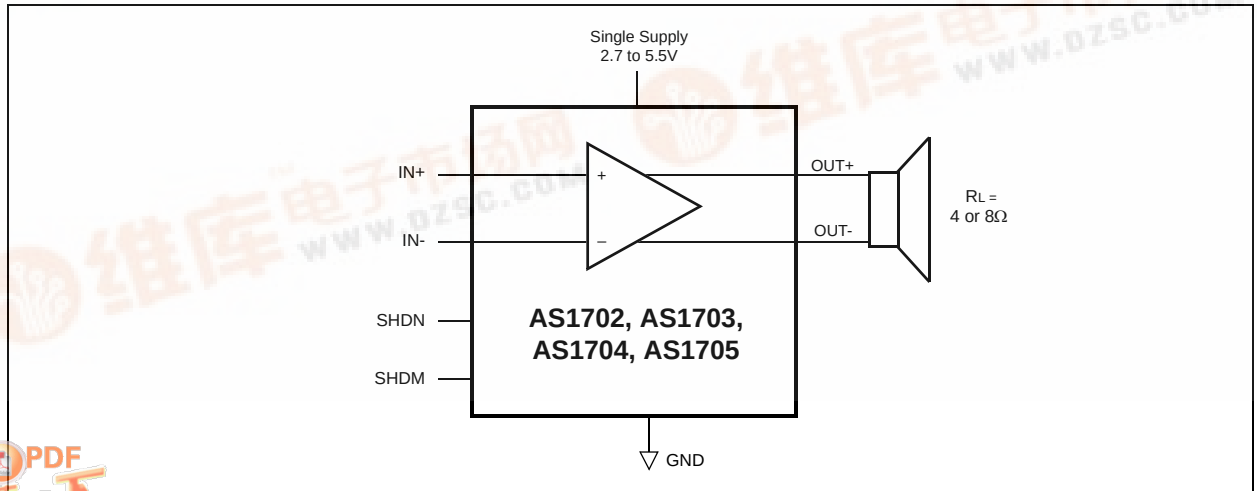
2 Key Features

- 2.7 to 5.5V (Vcc) Single-Supply Operation
- THD+N: 1.6W into 4Ω at 1% (per Channel)
- Differential Input
- Adjustable Gain Option (AS1702)
- Internal Fixed Gain to Reduce External Component Count (AS1703, AS1704, AS1705)
- <100nA Low-Power Shutdown Mode
- Click and Pop Suppression
- Pin-Compatible National Semiconductor LM4895 (AS1705) and Maxim MAX9718A/B/C/D
- Operating Temperature Range: -40 to +85°C
- Low-Cost MSOP-10 Package

3 Applications

The devices are ideal as audio front-ends for battery powered audio devices such as MP3 and CD players, mobile phones, PDAs, portable DVD players, and any other hand-held battery-powered device.

Figure 1. Simplified Block Diagram



4 Absolute Maximum Ratings

Stresses beyond those listed in Table 1 may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in Section 5 Electrical Characteristics on page 3 is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Table 1. Absolute Maximum Ratings

Parameter	Min	Max	Unit	Comments
Supply Voltage (V_{CC} to GND)	-0.3	+7	V	
Any Other Pin to GND	-0.3	V_{CC} + 0.3	V	
Input Current (Latchup Immunity)	-100	100	mA	*JEDEC 17*
Continuous Power Dissipation (T_{AMB} = +70°C)		TBD	mW	MSOP-10 (Derate 10.3mW/°C above +70°C)
Electro-Static Discharge (ESD)		1	kV	*Human Body Model* and *MIL-Std883E 3015.7*methods
Operating Temperature Range (T_{AMB})	-40	+85	°C	
Storage Temperature Range	-65	+150	°C	
Package Body Temperature		260	°C	

5 Electrical Characteristics

5.1 5V Operation

V_{CC} = 5V, GND = 0V, SHDN = V_{CC}, SHDM = GND, R_{IN} = R_F = 10kΩ (AS1702), T_{AMB} = +25°C, C_{BIAS} = 0.1µF, no load. Typical values are at T_{AMB} = +25°C (unless otherwise specified). All specifications are 100% tested at T_{AMB} = +25°C (unless otherwise specified). Specifications over temperature (T_{AMB} = T_{MIN} to T_{MAX}) are guaranteed by design, not production tested.

Table 2. Electrical Characteristics – 5V Supply

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
V_{CC}	Supply Voltage			2.7		5.5	V
I_{CC}	Supply Current [1]	V_{IN-} = V_{IN+} = V_{BIAS}; T_{AMB} = -40 to +85°C, per amplifier			8	10.4	mA
I_{SHDN}	Shutdown Supply	SHDN = SHDM = GND per amplifier			0.05	1	µA
V_{IH}	SHDN, SHDM Threshold			0.7 x V_{CC}			V
V_{IL}						0.3 x V_{CC}	
V_{BIAS}	Common-Mode Bias Voltage [2]			V_{CC}/2 - 5%	V_{CC}/2	V_{CC}/2 + 5%	V
V_{OS}	Output Offset Voltage	V_{IN-} = V_{IN+} = V_{BIAS}	A_V = 0dB (AS1703)		±1	±10	mV
			A_V = 3dB (AS1704)		±1	±15	
			A_V = 6dB (AS1705)		±1	±20	
V_{IC}	Common-Mode Input Voltage	Inferred from CMRR Test	A_V = 0dB (AS1703)	0.5		V_{CC} - 0.5	V
			A_V = 3dB (AS1704)	0.5		V_{CC} - 0.6	
			A_V = 6dB (AS1705)	0.5		V_{CC} - 0.8	
		External Gain AS1702		0.5		V_{CC} - 1.2	
R_{IN}	Input Impedance	AS1703, AS1704, AS1705		10	15	20	kΩ
CMRR	Common-Mode Rejection Ration			-50	-60		dB
		f_N = 1kHz			-64		
PSRR	Power Supply Rejection Ratio	V_{IN-} = V_{IN+} = V_{BIAS}; V_{RIPPLE} = 200mVp-p; R_L = 8Ω; C_{BIAS} = 1µF	f = 217Hz		-79		dB
			f = 1kHz		-73		
P_{OUT}	Output Power [3]	THD+N = 1%; f_{IN} = 1kHz	R_L = 8Ω	0.8	1.2		W
			R_L = 4Ω		1.6		
THD+N	Total Harmonic Distortion plus Noise [4]	R_L = 4Ω, f_{IN} = 1kHz, P_{OUT} = 1.28W, V_{CC} = 5V, A_V = 6dB			0.06		%
		R_L = 8Ω, f_{IN} = 1kHz, P_{OUT} = 0.9W, V_{CC} = 5V, A_V = 6dB			0.03		
	Gain Accuracy	AS1703, AS1704, AS1705			±1	±2	%
	Thermal Shutdown Threshold				+145		°C
	Thermal Shutdown Hysteresis				9		°C
C_{LOAD}	Maximum Capacitive Drive	Bridge-tied capacitance			500		pF
t_{PU}	Power-up/Enable from Shutdown Time				125		ms
t_{SHDN}	Shutdown Time				3.5		µs
V_{POP}	Turn-Off Transient [5]				50		mV

1. Quiescent power supply current is specified and tested with no load. Quiescent power supply current depends on the offset voltage when a practical load is connected to the amplifier. Guaranteed by design.
2. Common-mode bias voltage is the voltage on BIAS and is nominally V_{CC}/2.
3. Output power is specified by a combination of a functional output current test and characterization analysis.
4. Measurement bandwidth for THD+N is 22Hz to 22kHz.
5. Peak voltage measured at power-on, power-off, into or out of SHDN. Bandwidth defined by A-weighted filters, inputs at AC GND. V_{CC} rise and fall times ≥ 1ms.

5.2 3V Operation

V_{CC} = 3V, GND = 0V, SHDN = V_{CC}, SHDM = GND, R_{IN} = R_F = 10kΩ (AS1702), T_{AMB} = +25°C, C_{BIAS} = 0.1µF, no load. Typical values are at T_{AMB} = +25°C (unless otherwise specified.) All specifications are 100% tested at T_{AMB} = +25°C. Specifications over temperature (T_{AMB} = T_{MIN} to T_{MAX}) are guaranteed by design, not production tested.

Table 3. Electrical Characteristics – 3V Supply

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
I_{CC}	Supply Current [1]	V_{IN-} = V_{IN+} = V_{BIAS}; T_{AMB} = -40 to +85°C, per amplifier			7.5		mA
I_{SHDN}	Shutdown Supply	SHDN = SHDM = GND per amplifier			0.05	1	µA
V_{IH}	SHDN, SHDM Threshold			0.7 x V_{CC}			V
V_{IL}						0.3 x V_{CC}	
V_{BIAS}	Common-Mode Bias Voltage [2]			V_{CC}/2 - 5%	V_{CC}/2	V_{CC}/2 + 5%	V
V_{OS}	Output Offset Voltage	V_{IN-} = V_{IN+} = V_{BIAS}	A_V = 0dB (AS1703)		±1	±10	mV
			A_V = 3dB (AS1704)		±1	±15	
			A_V = 6dB (AS1705)		±1	±20	
V_{IC}	Common-Mode Input Voltage	Inferred from CMRR Test	A_V = 0dB (AS1703)	0.5		V_{CC} - 0.7	mV
			A_V = 3dB (AS1704)	0.5		V_{CC} - 0.8	
			A_V = 6dB (AS1705)	0.5		V_{CC} - 1.0	
		External gain AS1702		0.5		V_{CC} - 1.2	
R_{IN}	Input Impedance	AS1703, AS1704, AS1705		10	15	20	kΩ
CMRR	Common-Mode Rejection Ration			-50	-60		dB
		f_N = 1kHz			-64		
PSRR	Power Supply Rejection Ratio	V_{IN-} = V_{IN+} = V_{BIAS}; V_{RIPPLE} = 200mVp-p; R_L = 8Ω; C_{BIAS} = 1µF	f = 217Hz		-79		dB
			f = 1kHz		-73		
P_{OUT}	Output Power [3]	R_L = 4Ω, THD+N = 1%; f_{IN} = 1kHz			590		mW
		R_L = 8Ω, THD+N = 1%; f_{IN} = 1kHz			430		
THD+N	Total Harmonic Distortion plus Noise [4]	R_L = 4Ω, f_{IN} = 1kHz, P_{OUT} = 460mW, A_V = 6dB			0.06		%
		R_L = 8Ω, f_{IN} = 1kHz, P_{OUT} = 330mW, A_V = 6dB			0.04		
	Gain Accuracy	AS1703, AS1704, AS1705			±1	±2	%
	Thermal Shutdown Threshold				+145		°C
	Thermal Shutdown Hysteresis				9		°C
C_{LOAD}	Maximum Capacitive Drive	Bridge-tied capacitance			500		pF
t_{PU}	Power-up/Enable from Shutdown Time				125		ms
t_{SHDN}	Shutdown Time				3.5		µs
V_{POP}	Turn-Off Transient [5]				50		mV

1. Quiescent power supply current is specified and tested with no load. Quiescent power supply current depends on the offset voltage when a practical load is connected to the amplifier. Guaranteed by design.
2. Common-mode bias voltage is the voltage on BIAS and is nominally V_{CC}/2.
3. Output power is specified by a combination of a functional output current test and characterization analysis.
4. Measurement bandwidth for THD+N is 22Hz to 22kHz.
5. Peak voltage measured at power-on, power-off, into or out of SHDN. Bandwidth defined by A-weighted filters, inputs at AC GND. V_{CC} rise and fall times ≥ 1ms.

6 Detailed Description

The AS1702, AS1703, AS1704, and AS1705 are 1.6W high output-current audio amplifiers (configured as BTL amplifiers), and contain integrated low-power shutdown and click- and pop-suppression circuitry. Two inputs (SHDM and SHDN) allow shutdown mode to be configured as active-high or active-low (see Section 6.2 Shutdown Mode on page 5).

Each device has either adjustable or fixed gains (0dB, 3dB, 6dB) (see Section 9 Ordering Information on page 12).

6.1 Bias

The devices operate from a single 2.7 to 5.5V supply and contain an internally generated, common-mode bias voltage of:

$$V_{CC}/2 \quad \text{(EQ 1)}$$

referenced to ground. Bias provides click-and-pop suppression and sets the DC bias level for the audio outputs. Select the value of the bias bypass capacitor as described in Section 7.4.3 BIAS Capacitor on page 9.

Note: Do not connect external loads to BIAS as this can adversely affect overall device performance.

6.2 Shutdown Mode

All devices implement a 100nA, low-power shutdown circuit which reduces quiescent current consumption. As shutdown mode commences, the bias circuitry is automatically disabled, the device outputs go high impedance, and bias is driven to GND.

The SHDM input controls the polarity of SHDN:

- Drive SHDM high for an active-low SHDN input.
- Drive SHDM low for an active-high SHDN input.

Table 4. Shutdown Mode Selection Configurations

SHDM	SHDN	Mode
0	0	Shutdown Mode Enabled
0	1	Normal Operation Enabled
1	0	Normal Operation Enabled
1	1	Shutdown Mode Enabled

6.3 Click-and-Pop Suppression

During power-up, the device common-mode bias voltage (V_{BIAS} (page 3)) ramps to the DC bias point. When entering shutdown, the device outputs are driven high impedance to 100kΩ between both outputs minimizing the energy present in the audio band, thus preventing clicks and pops.

7 Application Information

Figure 2. AS1702 Typical Application Diagram

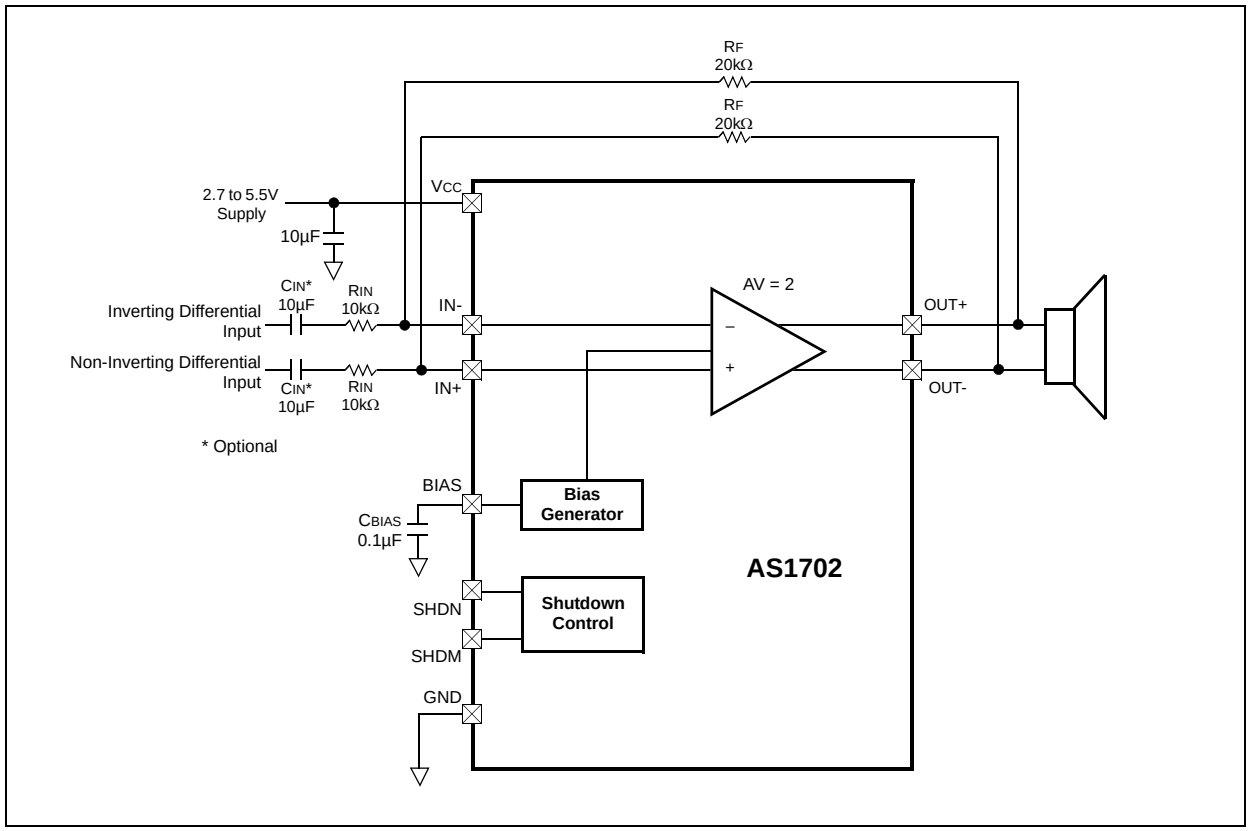
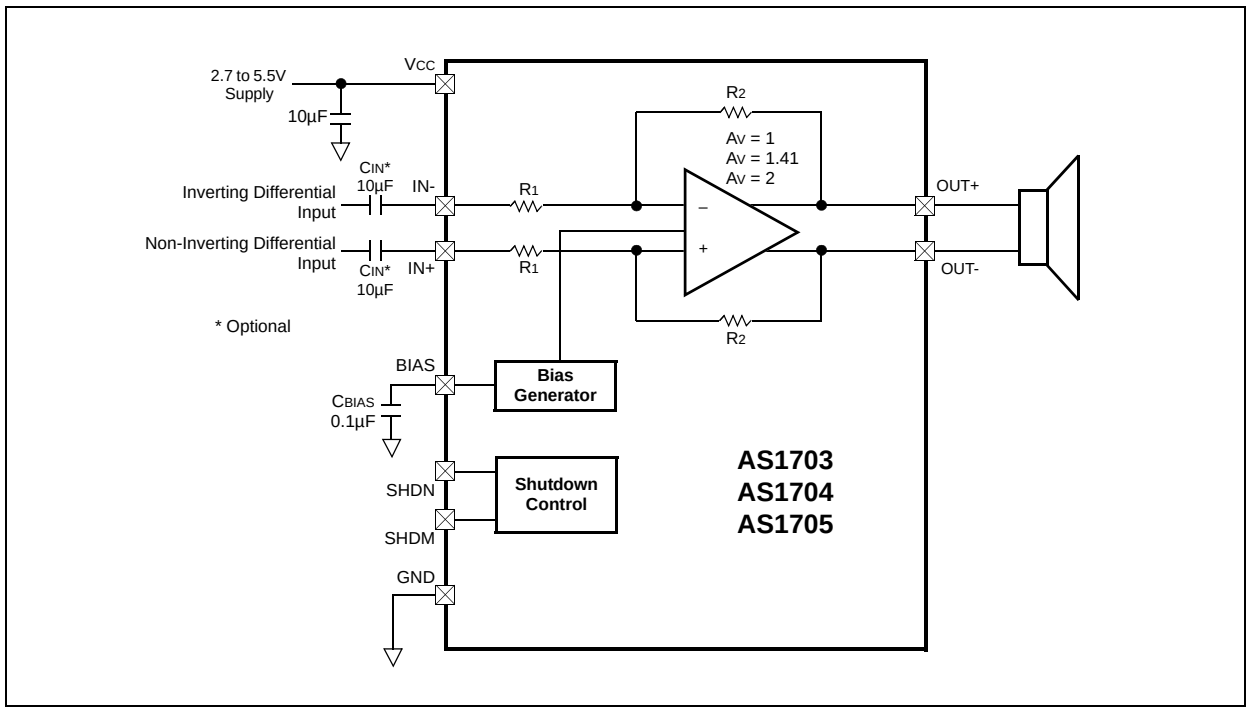


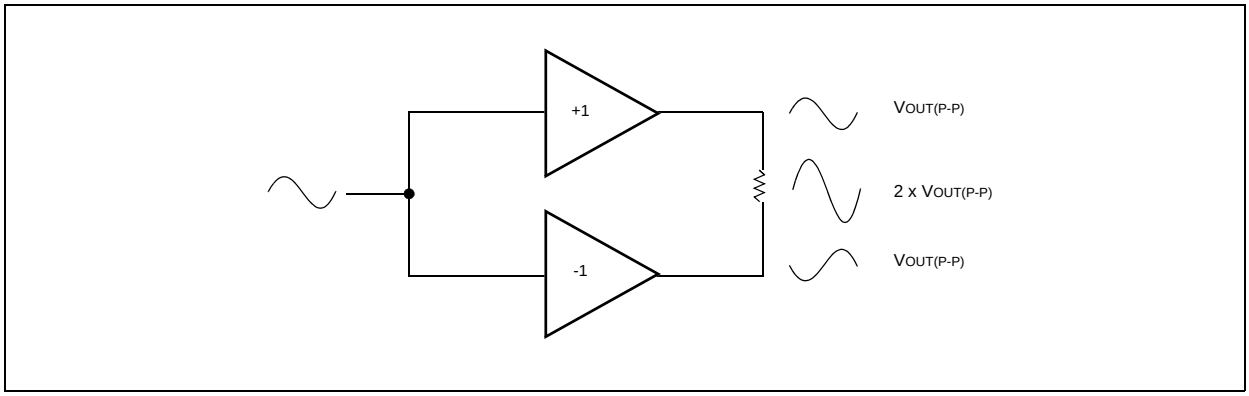
Figure 3. AS1703, AS1704, AS1705 Typical Application Diagram



7.1 BTL Amplifier

All devices are designed to drive loads differentially in a bridge-tied load (BTL) configuration.

Figure 4. Bridge Tied Load Configuration



The BTL configuration doubles the output voltage (illustrated in Figure 4) compared to a single-ended amplifier under similar conditions. Thus, the differential gain of the device (A_{VD}) is twice the closed-loop gain of the input amplifier. The effective gain is given by:

$$A_{VD} = 2 \times \frac{R_F}{R_{IN}} \quad \text{(EQ 2)}$$

Substituting 2 x $V_{OUT(P-P)}$ for $V_{OUT(P-P)}$ into (EQ 3) and (EQ 4) yields four times the output power due to doubling of the output voltage:

$$V_{RMS} = \frac{V_{OUT(P-P)}}{2\sqrt{2}} \quad \text{(EQ 3)}$$

$$P_{OUT} = \frac{V_{RMS}^2}{R_L} \quad \text{(EQ 4)}$$

Since the BTL outputs are biased at mid-supply, there is no net DC voltage across the load. This eliminates the need for the large, expensive, performance degrading DC-blocking capacitors required by single-ended amplifiers.

7.2 Power Dissipation and Heat Sinking

Normally, the devices dissipate a significant amount of power. The maximum power dissipation is given in Table 1 as Continuous Power Dissipation, or it can be calculated by:

$$P_{DISSPKF(MAX)} = \frac{T_{J(MAX)} - T_A}{\Theta_{JA}} \quad \text{(EQ 5)}$$

where $T_{J(MAX)}$ is +150°C, T_{AMB} (see Table 1) is the ambient temperature, and Θ_{JA} is the reciprocal of the derating factor in °C/W as specified in Table 1. For example, Θ_{JA} of the TQFN package is +59.2°C/W.

The increased power delivered by a BTL configuration results in an increase in internal power dissipation versus a single-ended configuration. The maximum internal power dissipation for a given V_{CC} and load is given by:

$$P_{DISSPKF(MAX)} = \frac{2V_{CC}^2}{\pi^2 R_L} \quad \text{(EQ 6)}$$

If the internal power dissipation exceeds the maximum allowed for a given package, power dissipation should be reduced by increasing the ground plane heat-sinking capabilities and increasing the size of the device traces (see Section 7.5 Layout and Grounding Considerations on page 9). Additionally, reducing V_{CC}, increasing load impedance, and decreasing ambient temperature can reduce device power dissipation.

The integrated thermal-overload protection circuitry limits the total device power dissipation. Note that if the junction temperature is ≥ +145°C, the integrated thermal-overload protection circuitry will disable the amplifier output stage. If the junction temperature is reduced by 9°, the amplifiers will be re-enabled.

Note: A pulsing output under continuous thermal overload results as the device heats and cools.

7.3 Fixed Differential Gain (AS1703, AS1704, and AS1705)

The AS1703, AS1704, and AS1705 contain different internally-fixed gains (see Ordering Information on page 12). A fixed gain facilitates simplified designs, decreased footprint size, and elimination of external gain-setting resistors.

The fixed gain values are achieved using resistors R_1 and R_2 (see Figure 3 on page 6).

7.4 Adjustable Differential Gain (AS1702)

7.4.1 Gain-Setting Resistors

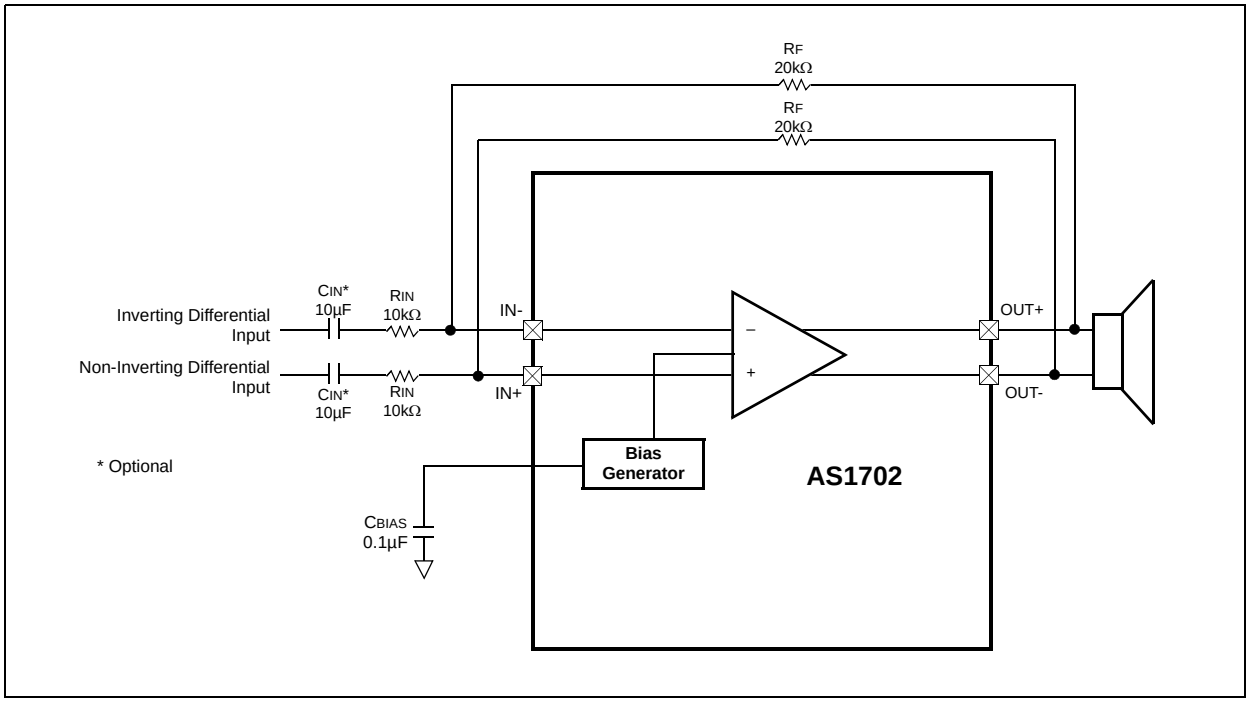
The AS1702 uses external feedback resistors, R_F and R_{IN} (Figure 5), to set the gain of the device as:

$$A_V = \frac{R_F}{R_{IN}} \qquad \textit{(EQ 7)}$$

where A_V is the desired voltage gain. For example, R_{IN} = 10kΩ, R_F = 20kΩ yields a gain of 2V/V, or 6dB.

Note: R_F can be either fixed or variable, allowing the gain to be controlled by software (using a AS150x digital potentiometer. For more information on the AS1500 family of digital potentiometers, refer to the latest version of the AS150x data sheet, available from the austriamicrosystems website http://www.austriamicrosystems.com.)

Figure 5. Setting the AS1702 Gain



7.4.2 Input Filter

The BTL inputs can be biased at voltages other than mid-supply. However, the integrated common-mode feedback circuit adjusts for input bias, ensuring the outputs are still biased at mid-supply. Input capacitors are not required if the common-mode input voltage (V_{IC}) is within the range specified in Table 2 and Table 3.

Input capacitor C_{IN} (if used), in conjunction with R_{IN}, forms a high-pass filter that removes the DC bias from an incoming signal. The AC coupling capacitor allows the amplifier to bias the signal to an optimum DC level. Assuming zero-source impedance, the -3dB point of the high-pass filter is given by:

$$f_{-3dB} = \frac{1}{2\pi R_{IN} C_{IN}} \quad \text{(EQ 8)}$$

Setting f_{-3dB} too high affects the low-frequency response of the amplifier. Capacitors with dielectrics that have low-voltage coefficients such as tantalum or aluminum electrolytic should be used, since capacitors with high-voltage coefficients, such as ceramics, can increase distortion at low frequencies.

7.4.3 BIAS Capacitor

BIAS is the output of the internally generated $V_{CC}/2$ bias voltage. The BIAS bypass capacitor, C_{BIAS}, improves PSRR and THD+N by reducing power supply noise and other noise sources at the common-mode bias node, and also generates the click- and pop-less DC bias waveform for the amplifiers. Bypass BIAS with a 0.1µF capacitor to GND. Larger values of C_{BIAS} (up to 1µF) improve PSRR, but increase t_{ON}/t_{OFF} times. For example, a 1µF C_{BIAS} capacitor increases t_{ON}/t_{OFF} by 10 and improves PSRR by 20dB (at 1kHz).

Note: Do not connect external loads to BIAS.

7.4.4 Supply Bypassing

Proper power supply bypassing – connect a 10µF ceramic capacitor (C_{BIAS}) from V_{CC} to GND – will ensure low-noise, low-distortion performance of the device. Additional bulk capacitance can be added as required.

Note: Place C_{BIAS} as close to the device as possible.

7.5 Layout and Grounding Considerations

Well designed PC board layout is essential for optimizing device performance. Use large traces for the power supply inputs and amplifier outputs to minimize losses due to parasitic trace resistance and route heat away from the device.

Good grounding improves audio performance and prevents digital switching noise from coupling onto the audio signal.

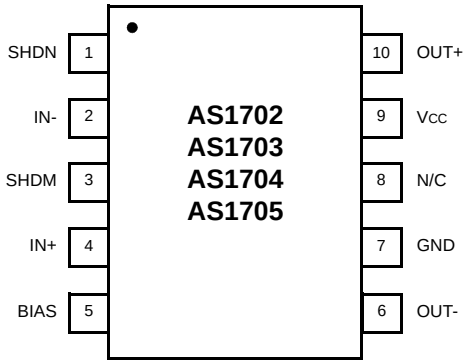
8 Pinout and Packaging

8.1 Pin Descriptions and Assignments

Table 5. Pin Descriptions – MSOP-10 Package

Pin	Name	Description
1	SHDN	Shutdown Input – The polarity of this pin is dependent on the state of pin SHDM.
2	IN-	Inverting Input.
3	SHDM	Shutdown-Mode Polarity Input – Controls the polarity of SHDN. Connect this pin high for an active-high SHDN input. Connect this pin low for an active-low SHDN input (see Table 4 on page 5).
4	IN+	Non-Inverting Input
5	BIAS	DC Bias Bypass
6	OUT-	Bridge Amplifier Negative Output
7	GND	Ground
8	N/C	Not connected. No internal connection.
9	VCC	Power Supply
10	OUT+	Bridge Amplifier Positive Output

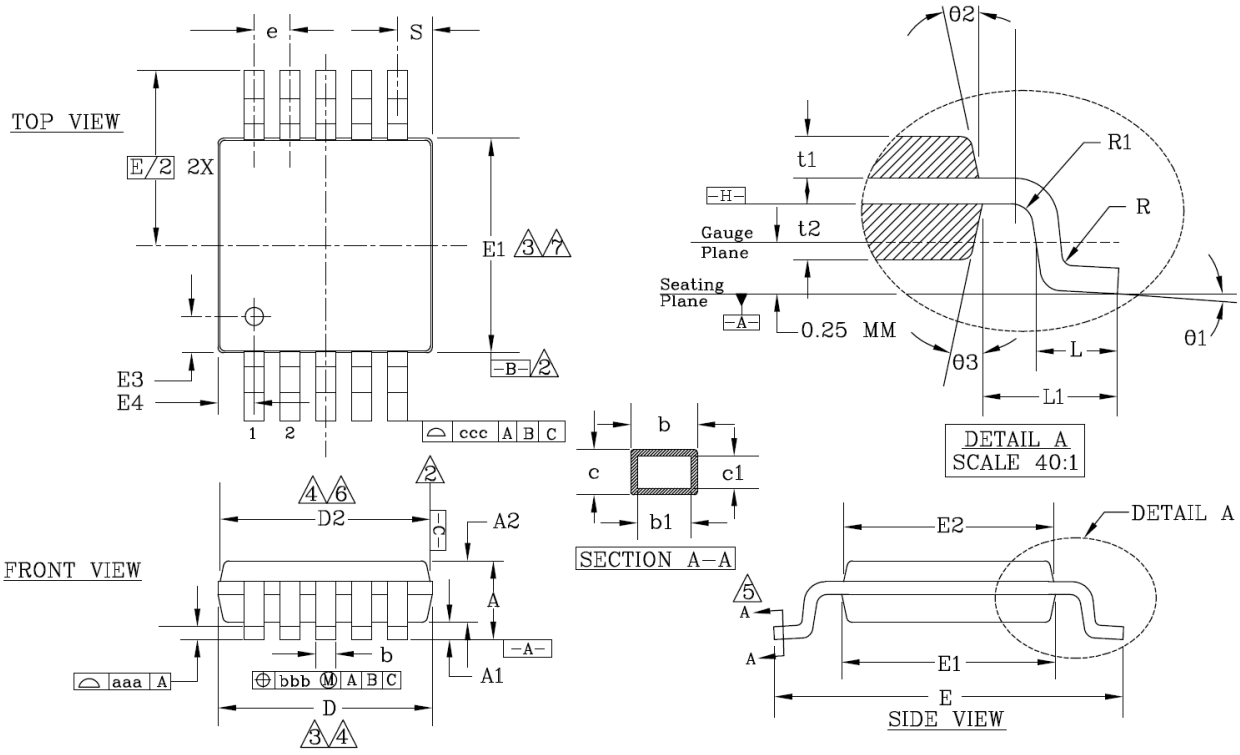
Figure 6. Pin Assignment (Top View)



MSOP-10 Package
(3mmx3mmx0.8mm)

8.2 Package Drawings and Markings

Figure 7. MSOP-10 Package



Notes:

1. All dimensions are in millimeters (angle in degrees), unless otherwise specified.
2. Datums B and C to be determined at datum plane H.
3. Dimensions D and E1 are to be determined at datum plane H.
4. Dimensions D2 and E2 are for top package and D and E1 are for bottom package.
5. Cross section A-A to be determined at 0.12 to 0.25mm from the lead tip.
6. Dimensions D and D2 do not include mold flash, protrusion, or gate burrs.
7. Dimension E1 and E2 do not include interlead flash or protrusion.

SYMBOL	MINI SOIC 10LD PACKAGE OUTLINE (MILLIMETER)	±TOL
A	1.10	MAX
A1	0.10	±0.05
A2	0.86	±0.08
D	3.00	±0.10
D2	2.95	±0.10
E	4.90	±0.15
E1	3.00	±0.10
E2	2.95	±0.10
E3	0.51	±0.13
E4	0.51	±0.13
R	0.15	$^{+0.15}_{-0.08}$
R1	0.15	$^{+0.15}_{-0.08}$
t1	0.31	±0.08
t2	0.41	±0.08
b	0.23	$^{+0.07}_{-0.08}$
b1	0.20	±0.05
c	0.18	±0.05
c1	0.15	$^{+0.03}_{-0.02}$
θ1	3.0°	±3.0°
θ2	12.0°	±3.0°
θ3	12.0°	±3.0°
L	0.55	±0.15
L1	0.95 BSC	———
aaa	0.10	———
bbb	0.08	———
ccc	0.25	———
e	0.50 BSC	———
S	0.50 BSC	———

9 Ordering Information

The AS1702, AS1703, AS1704, and AS1705 are available with adjustable or preset amplifier gain.

Part Number	Package Type	Delivery Form	Gain	Description
AS1702-T	MSOP-10	Tape and Reel	Adjustable	Package Size = 3x3x0.8mm
AS1703-T			Av = 0dB	
AS1704-T			Av = 3dB	
AS1705-T			Av = 6dB	

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