1. DESCRIPTION

The XL/XD386 series are power amplifiers intended for use in low voltage consumer applications. The gain is set internally to 20 to minimize the number of external components, but can be set to any value between 20 and 200 by adding external resistors and capacitors between pins 1 and 8.

The input is referenced to ground and the output is automatically biased to half the supply voltage. The XL/XD386 series consume only 24mW of quiescent power from a 6V supply, making them ideal for battery operation.

2. FEATURES

- Battery powered
- Extremely low external component count
- Wide supply voltage range: 4V to 12V
- Low quiescent current consumption: 5mA (Typical)
- Voltage gain range: 20 to 200
- Ground-referenced input
- Auto-centered output quiescent voltage
- Low distortion: 0.2% (AV = 20, VS = 6V, RL = 8Ω, PO = 125mW, f = 1kHz)
- Thress kinds of available packages：

  -SOP8 (XL386)

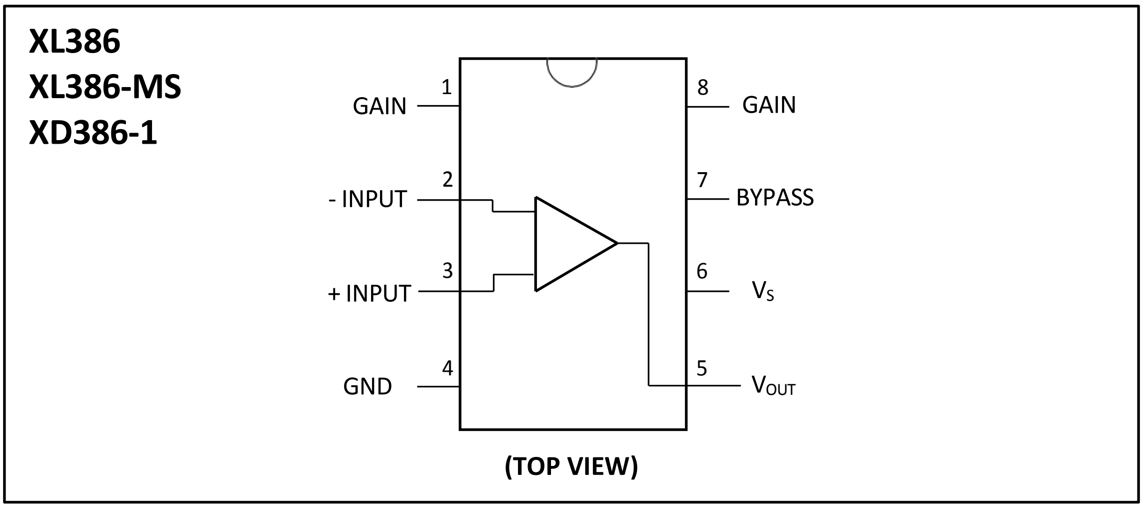
  -DIP8 (XD386-1)

  -MSOP (XL386-MS)

3. APPLICATIONS

- AM-FM radio amplifiers
- Portable Tape Player Amplifiers
- Walkie Talkies
- TV sound systems
- Line drivers
- Ultrasonic Driver
- Small Servo Drivers
- Power converters

4. PIN CONFIGURATIONS AND FUNCTIONS

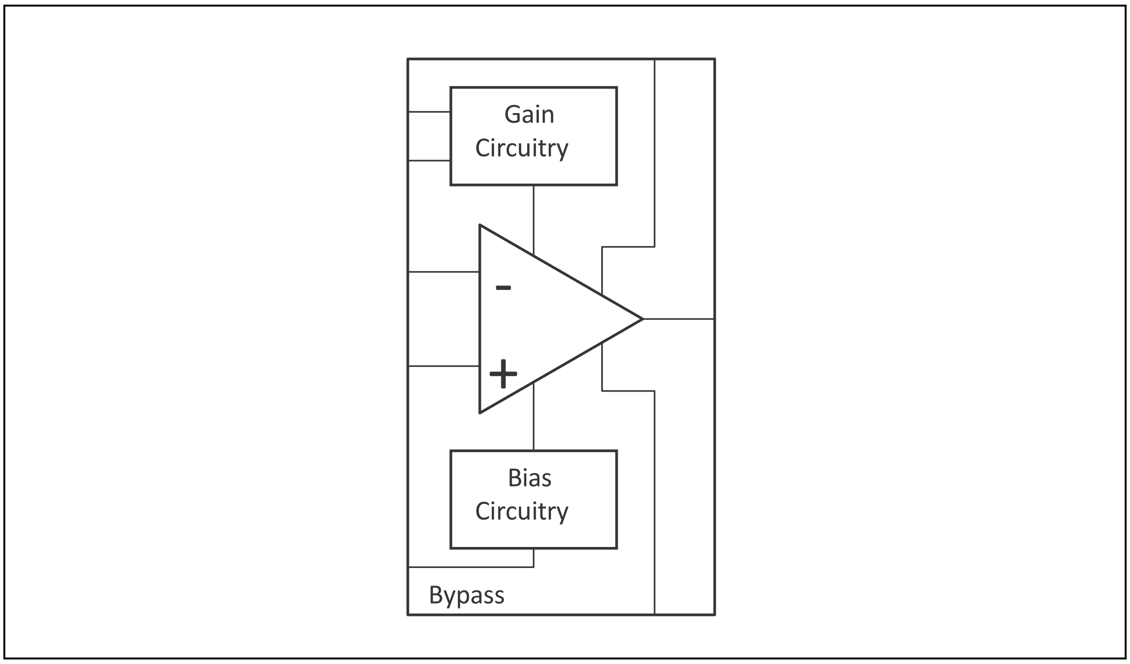


Pin Functions

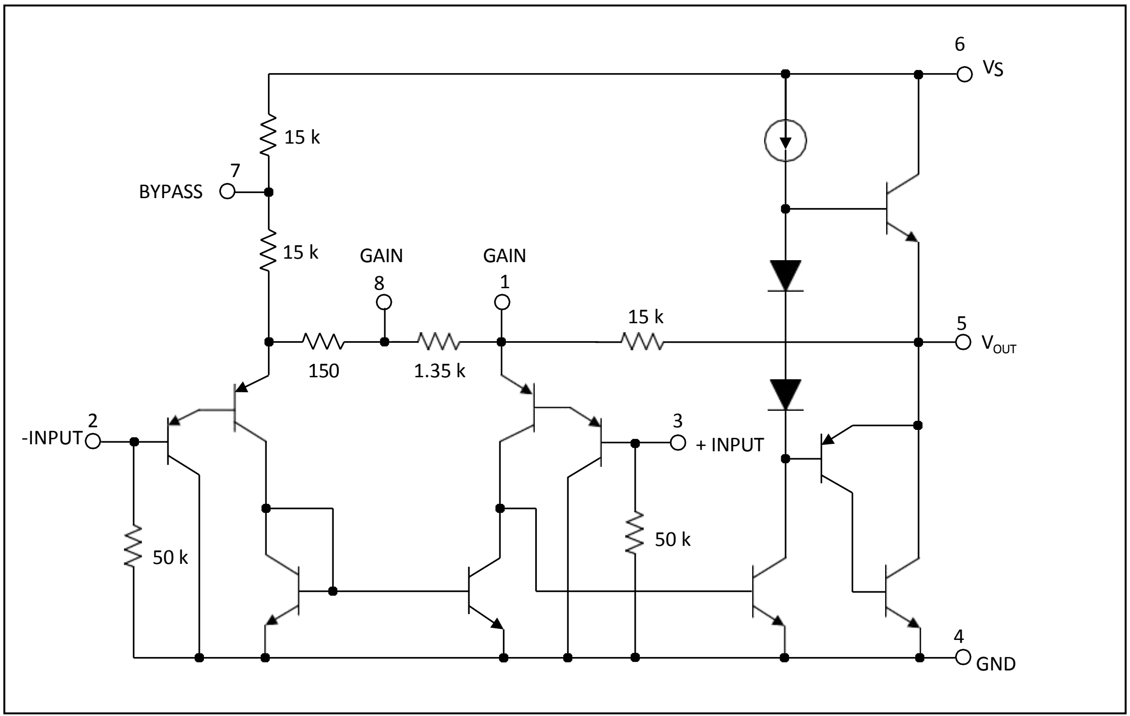
PIN		TYPE[1]	DESCRIPTION
NAME	NO.		
GAIN	1	–	Gain setting pin
− INPUT	2	I	Inverting input
+INPUT	3	I	Noninverting input
GND	4	P	Ground reference
V_{OUT}	5	O	Output
V_S	6	P	Power supply voltage
BYPASS	7	O	Bypass decoupling path
GAIN	8	–	Gain setting pin

[1] I = Input, O = Output, P = Power

5. FUNCTIONAL BLOCK DIAGRAM



Block Diagram



schematic diagram

6. SPECIFICATIONS

6.1. Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)[(1)]

		MIN	MAX	UNIT
Supply Voltage, V_{CC}	XL386, XL386-MS, XD386-1		15	V
Package Dissipation	XL386		1.25	W
	XL386-MS		0.73	
	XD386-1		0.595	
Input Voltage, V_I		－0.4	0.4	V
Storage temperature, T_{stg}		－65	150	℃

[1] Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

6.2. Thermal Resistance Characteristics

THERMAL METRIC[(1)]		XL386 SOP 8	XL386 MSOP 8	XL386 DIP 8	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	115.7	169.3	53.4	℃/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	59.7	73.1	42.1	℃/W
$R_{\theta JB}$	Junction-to-board thermal resistance	56.2	100.2	30.6	℃/W
ψ_{JT}	Junction-to-top characterization parameter	12.4	9.2	19.0	℃/W
ψ_{JB}	Junction-to-board characterization parameter	55.6	99.1	50.5	℃/W

6.3. ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001[(1)]	±1000	V
		Charged-device model (CDM), per JEDEC specification JESD22- C101[(2)]	±1000	

[1] JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

[2] JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.4. Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
V_{CC}	Supply Voltage	4		12	V
	Speaker Impedance	4			Ω
VI	Analog input voltage	－0.4		0.4	V
TA	Operating free-air temperature	0		70	℃

6.5. Electrical Characteristics

over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_S	Operating Supply Voltage	XL386, XL386-MS, XD386-1	4		12	V
I_Q	Quiescent Current	V_S = 6 V, V_{IN} = 0		5	12	mA
P_{OUT}	Output Power	V_S = 6 V, R_L = 8 Ω, THD = 10%	250	325		mW
A_V	Voltage Gain	V_S = 6 V, f = 1 kHz		26		dB
		10 μF from Pin 1 to 8		46		
BW	Bandwidth	V_S = 6 V, Pins 1 and 8 Open		300		kHz
THD	Total Harmonic Distortion	V_S = 6 V, R_L = 8 Ω, POUT = 125 mW f = 1 kHz, Pins 1 and 8 Open		0.2%		
PSRR	Power Supply Rejection Ratio	V_S = 6 V, f = 1 kHz, CBYPASS = 10 μF Pins 1 and 8 Open, Referred to Output		50		dB
R_{IN}	Input Resistance			50		kΩ
I_{BIAS}	Input Bias Current	V_S = 6 V, Pins 2 and 3 Open		250		nA

6.6. Typical Characteristics

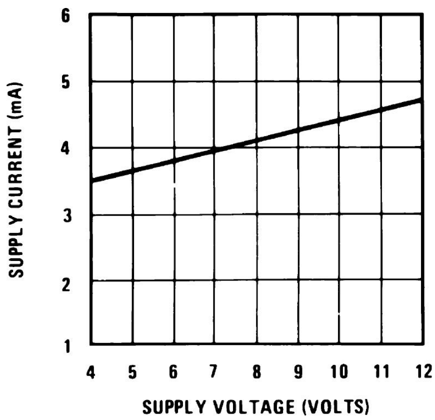


Figure 6-1. Supply Current vs Supply Voltage

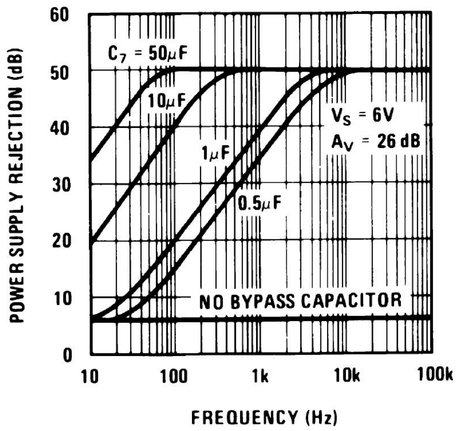


Figure 6-2. Power Supply Rejection vs Frequency

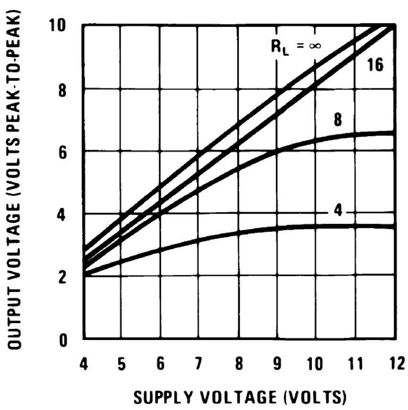


Figure 6-3. Output Voltage vs Supply Voltage

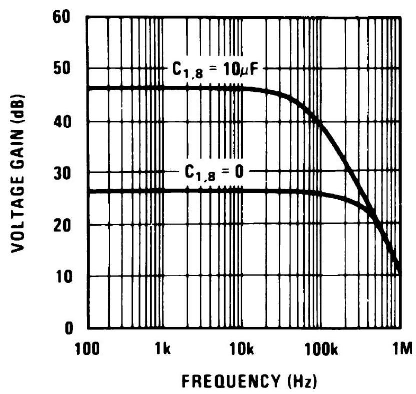


Figure 6-4. Voltage Gain vs Frequency

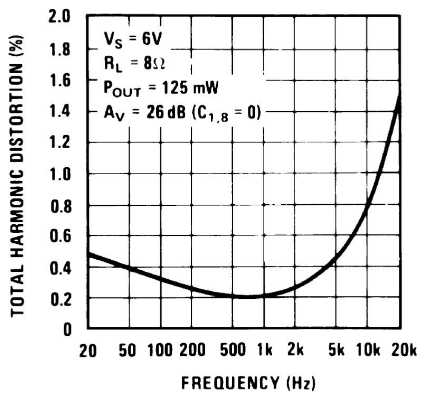


Figure 6-5. Total Harmonic Distortion vs Frequency

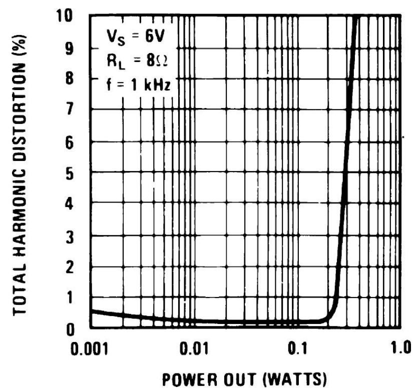


Figure 6-6. Total Harmonic Distortion vs Power Out

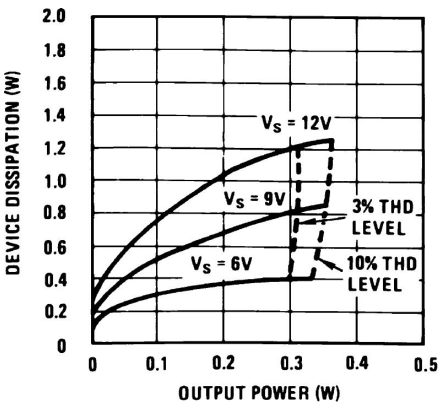


Figure 6-7. Device Dissipation vs Output Power

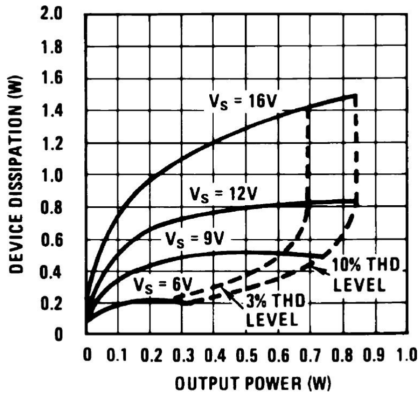


Figure 6-8. Device Dissipation vs Output Power

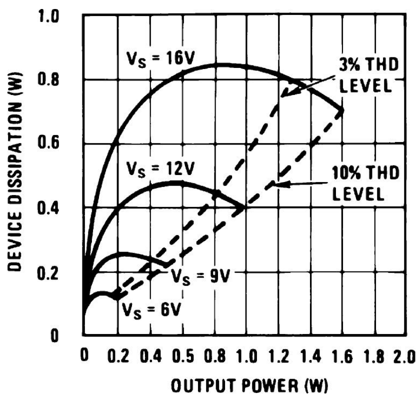


Figure 6-9. Device Dissipation vs Output Power

7. DETAILED DESCRIPTION

7.1. Overview

The XL/XD386 is a mono low voltage amplifier that can be used in a variety of applications. It can drive loads from 4Ω to 32Ω. The gain is internally set to 20 but it can be modified from 20 to 200 by placing a resistor and capacitor between pins 1 and 8. This device comes in three different 8-pin packages as DIP, SOP and MSOP to fit in different applications.

7.2. Feature Description

There is an internal 1.35-KΩ resistor that sets the gain of this device to 20. The gain can be modified from 20 to 200. Detailed information about gain setting can be found in the section 8.2.5.

7.3. Device Functional Modes

As this is an Op Amp it can be used in different configurations to fit in several applications. The internal gain setting resistor allows the XL/XD386 to be used in a very low part count system. In addition a series resistor can be placed between pins 1 and 5 to modify the gain and frequency response for specific applications.

8. Application and Implementation

8.1. Application Information

Below are shown different setups that show how the XL/XD386 can be implemented in a variety of applications.

8.2. Typical Application

8.2.1. XL/XD386 with Gain = 20

Figure 8-1 shows the minimum part count application that can be implemented using XL/XD386. Its gain is internally set to 20.

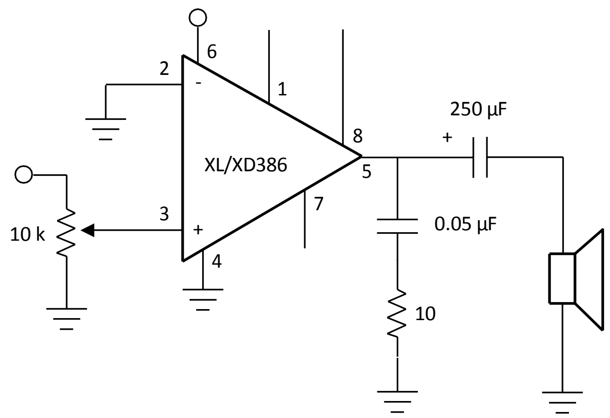


Figure 8-1. XL/XD386 with Gain = 20

8.2.1.1 Design Requirements

Table 8-1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Load Impedance	4 Ω to 32 Ω
Supply Voltage	4 V to 12 V

8.2.2. Detailed Design Procedure

8.2.2.1 Gain Control

To make the XL/XD386 a more versatile amplifier, two pins (1 and 8) are provided for gain control. With pins 1 and 8 open the 1.35-kΩ resistor sets the gain at 20 (26 dB). If a capacitor is put from pin 1 to 8, bypassing the 1.35 kΩ resistor, the gain will go up to 200 (46 dB). If a resistor is placed in series with the capacitor, the gain can be set to any value from 20 to 200. Gain control can also be done by capacitively coupling a resistor (or FET) from pin 1 to ground.

Additional external components can be placed in parallel with the internal feedback resistors to tailor the gain and frequency response for individual applications. For example, we can compensate poor speaker bass response by frequency shaping the feedback path. This is done with a series RC from pin 1 to 5 (paralleling the internal 15-kΩ resistor). For 6 dB effective bass boost: R ~= 15 kΩ, the lowest value for good stable operation is R = 10 kΩ if pin 8 is open. If pins 1 and 8 are bypassed then R as low as 2 kΩ can be used. This restriction is because the amplifier is only compensated for closed-loop gains greater than 9.

8.2.2.2 Input Biasing

The schematic shows that both inputs are biased to ground with a 50 kΩ resistor. The base current of the input transistors is about 250 nA, so the inputs are at about 12.5 mV when left open. If the dc source resistance driving the XL/XD386 is higher than 250 kΩ it will contribute very little additional offset (about 2.5 mV at the input, 50 mV at the output). If the dc source resistance is less than 10 kΩ, then shorting the unused input to ground will keep the offset low (about 2.5 mV at the input, 50 mV at the output). For dc source resistances between these values we can eliminate excess offset by putting a resistor from the unused input to ground, equal in value to the dc source resistance. Of course all offset problems are eliminated if the input is capacitively coupled.

When using the XL/XD386 with higher gains (bypassing the 1.35 kΩ resistor between pins 1 and 8) it is necessary to bypass the unused input, preventing degradation of gain and possible instabilities. This is done with a 0.1 µF capacitor or a short to ground depending on the dc source resistance on the driven input.

8.2.2.3 Application Curve

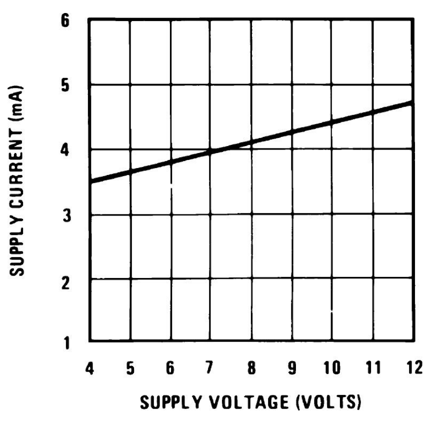


Figure 8-2. Supply Current vs Supply Voltage

8.2.3. XL/XD386 with Gain = 200

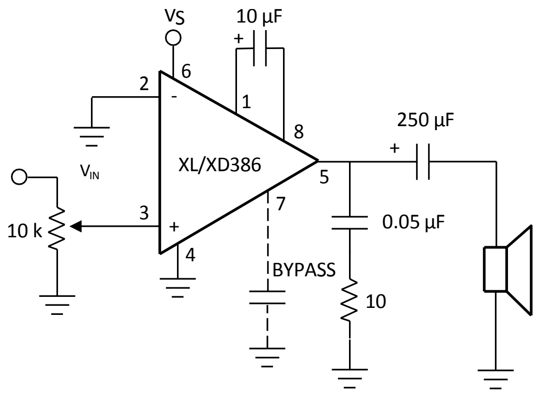


Figure 8-3. XL/XD386 with Gain = 200

8.2.3.1 Design Requirements

Table 8-2. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Load Impedance	4 Ω to 32 Ω
Supply Voltage	4 V to 12 V

8.2.3.2 Detailed Design Procedure

The Detailed Design Procedure can be found in the section 8.2.2.

8.2.3.3 Application Curve

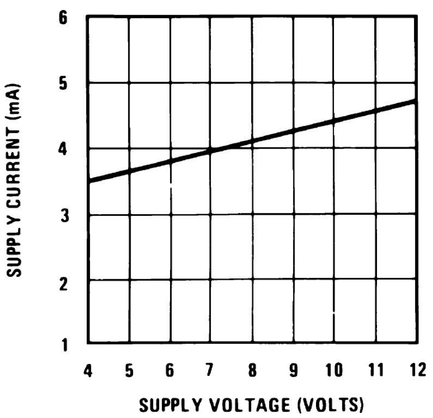


Figure 8-4. Supply Current vs Supply Voltage

8.2.4. XL/XD386 with Gain = 50

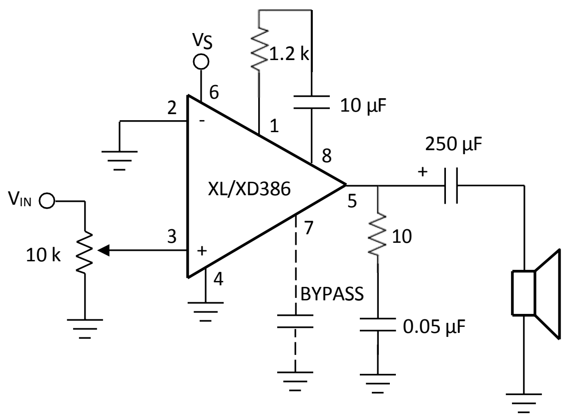


Figure 8-5. XL/XD386 with Gain = 50

8.2.4.1 Design Requirements

Table 8-3. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Load Impedance	4 Ω to 32 Ω
Supply Voltage	4 V to 12 V

8.2.4.2 Detailed Design Procedure

The Detailed Design Procedure can be found in the section 8.2.2.

8.2.4.3 Application Curve

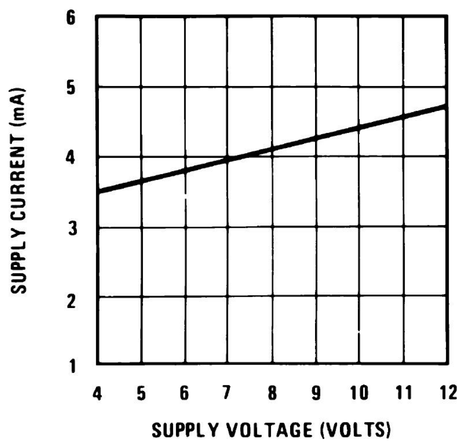


Figure 8-6. Supply Current vs Supply Voltage

8.2.5. Low Distortion Power Wienbridge Oscillator

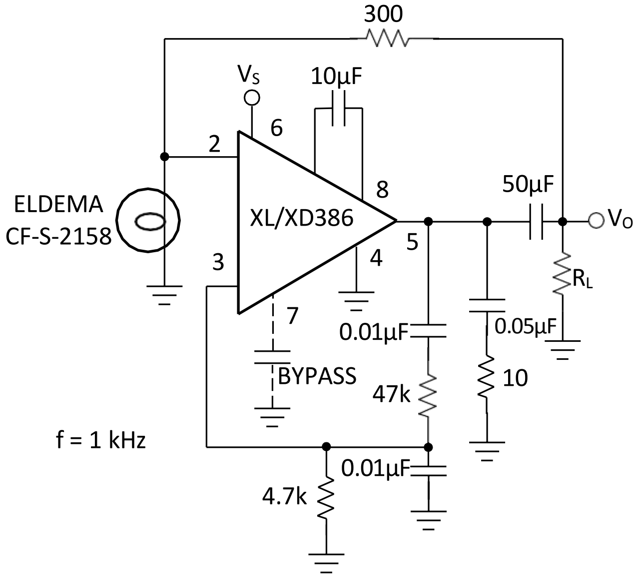


Figure 8-7. Low Distortion Power Wienbridge Oscillator

8.2.5.1 Design Requirements

Table 8-4. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Load Impedance	4 Ω to 32 Ω
Supply Voltage	4 V to 12 V

8.2.5.2 Detailed Design Procedure

The Detailed Design Procedure can be found in the section 8.2.2.

8.2.5.3 Application Curve

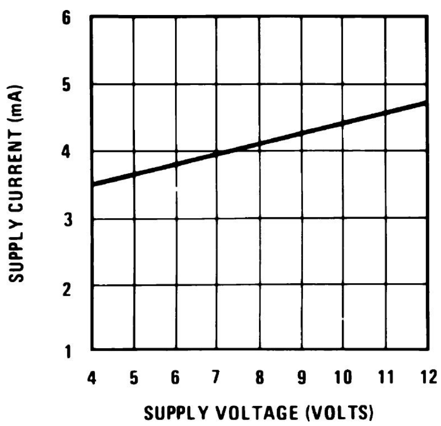


Figure 8-8. Supply Current vs Supply Voltage

8.2.6. XL/XD386 with Bass Boost

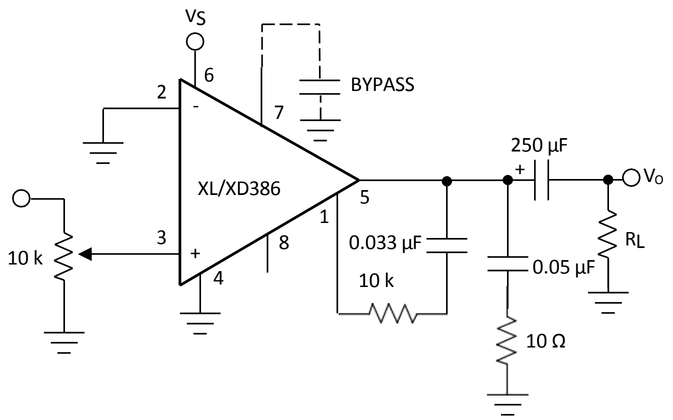


Figure 8-9. XL/XD386 with Bass Boost

8.2.6.1 Design Requirements

Table 8-5. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Load Impedance	4 Ω to 32 Ω
Supply Voltage	4 V to 12 V

8.2.6.2 Detailed Design Procedure

The Detailed Design Procedure can be found in the section 8.2.2.

8.2.6.3 Application Curve

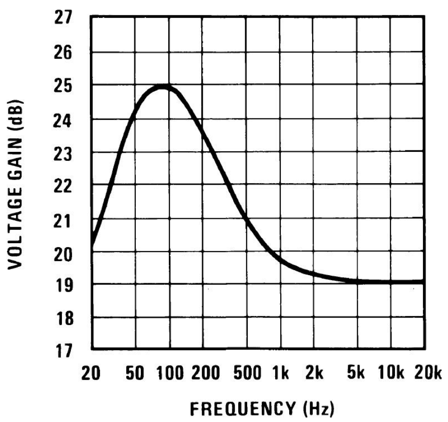
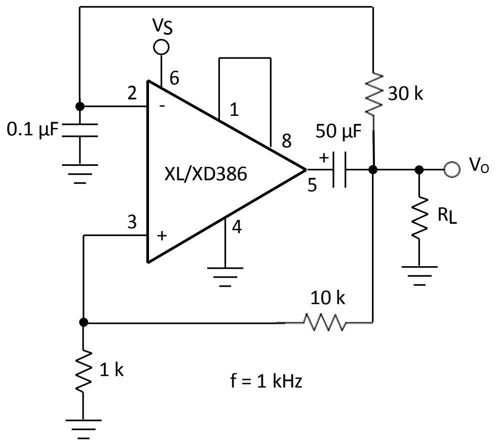


Figure 8-10. Voltage Gain vs Frequency

8.2.7. Square Wave Oscillator



Tigure 8-11. Square Wave Oscillator

Table 8-6. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Load Impedance	4 Ω to 32 Ω
Supply Voltage	4 V to 12 V

8.2.7.1 Detailed Design Procedure

The Detailed Design Procedure can be found in the section 8.2.2.

8.2.7.2 Application Curve

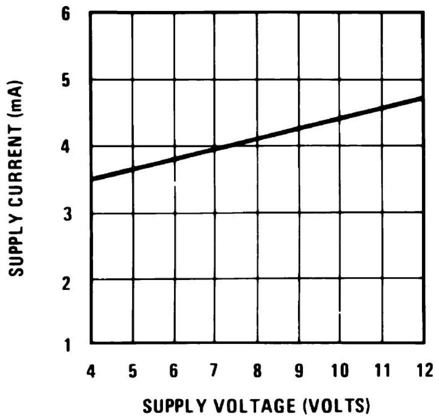


Figure 8-12. Supply Current vs Supply Voltage

8.2.7.3 AM Radio Power Amplifier

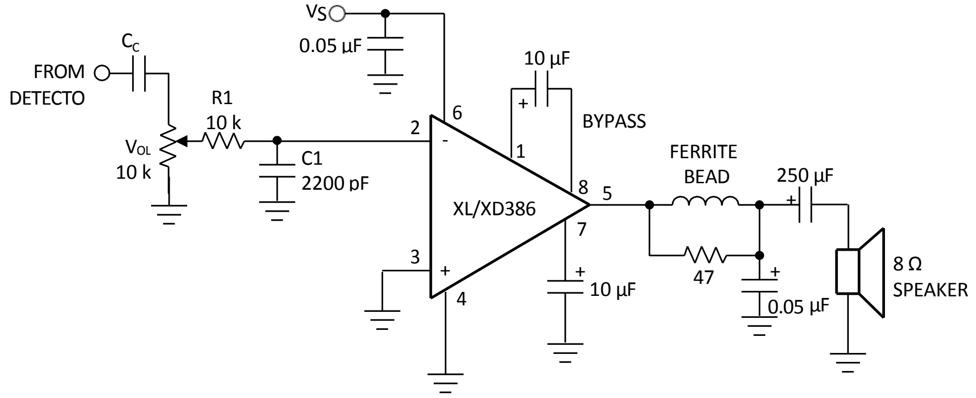


Figure 8-13. AM Radio Power Amplifier

Table 8-7. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Load Impedance	4 Ω to 32 Ω
Supply Voltage	4 V to 12 V

8.2.7.4 Detailed Design Procedure

The Detailed Design Procedure can be found in the section 8.2.2 .

8.2.7.5 Application Curve

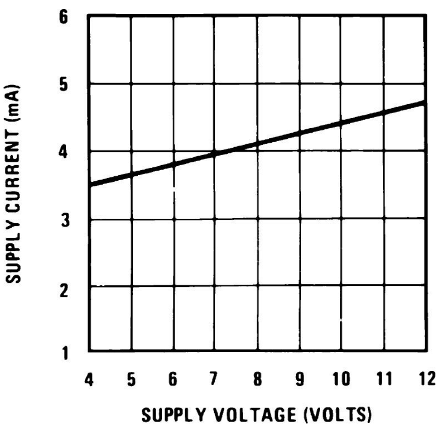


Figure 8-14. Supply Current vs Supply Voltage

9. Power Supply Recommendations

The XL/XD386 is specified for operation up to 12 V. The power supply should be well regulated and the voltage must be within the specified values. It is recommended to place a capacitor to GND close to the XL/XD386 power supply pin.

10. Layout

10.1. Layout Guidelines

Place all required components as close as possible to the device. Use short traces for the output to the speaker connection. Route the analog traces far from the digital signal traces and avoid crossing them.

10.2. Layout Examples

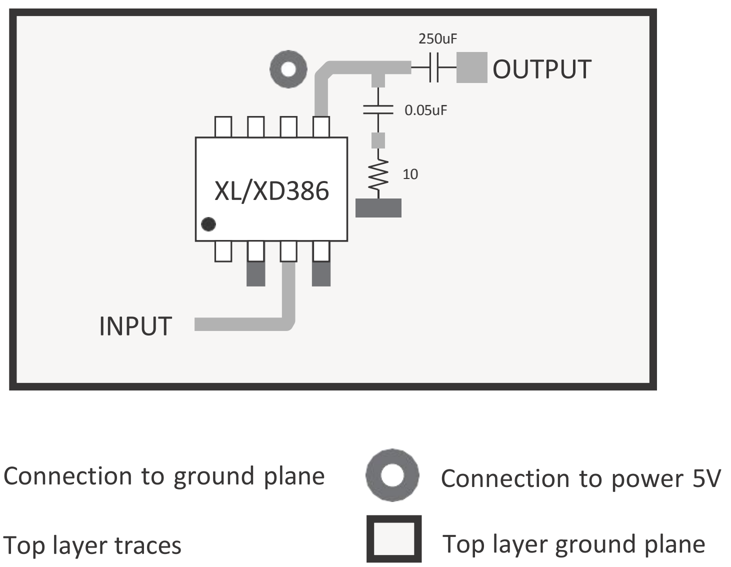


Figure 10-1. Layout Example for Minimum Parts Gain = 20 dB on DIP package

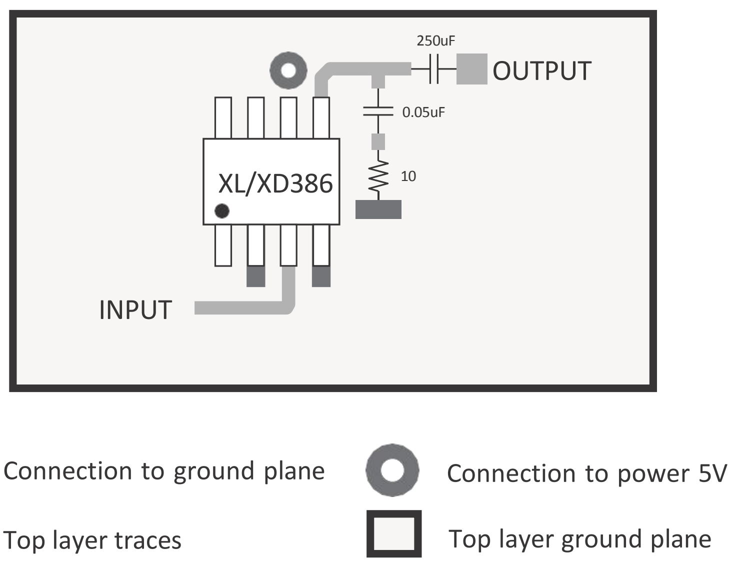


Figure 10-2. Layout Example for Minimum Parts Gain = 20 dB on SOP package

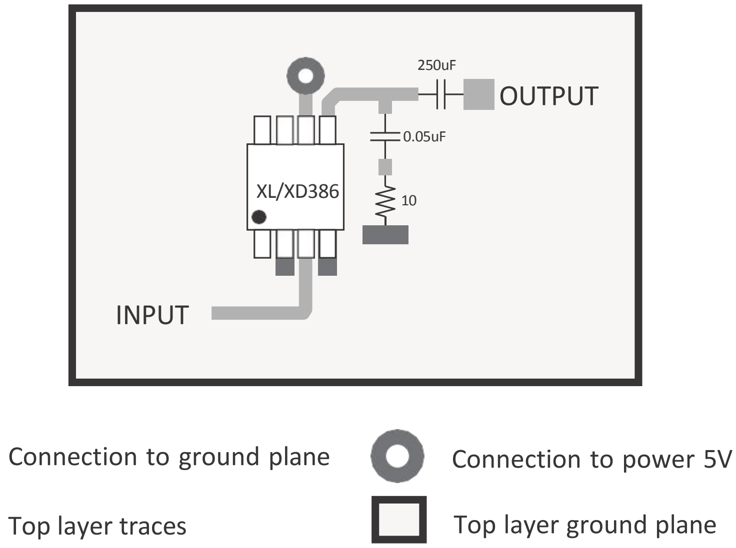


Figure 10-3. Layout Example for Minimum Parts Gain = 20 dB on MSOP package

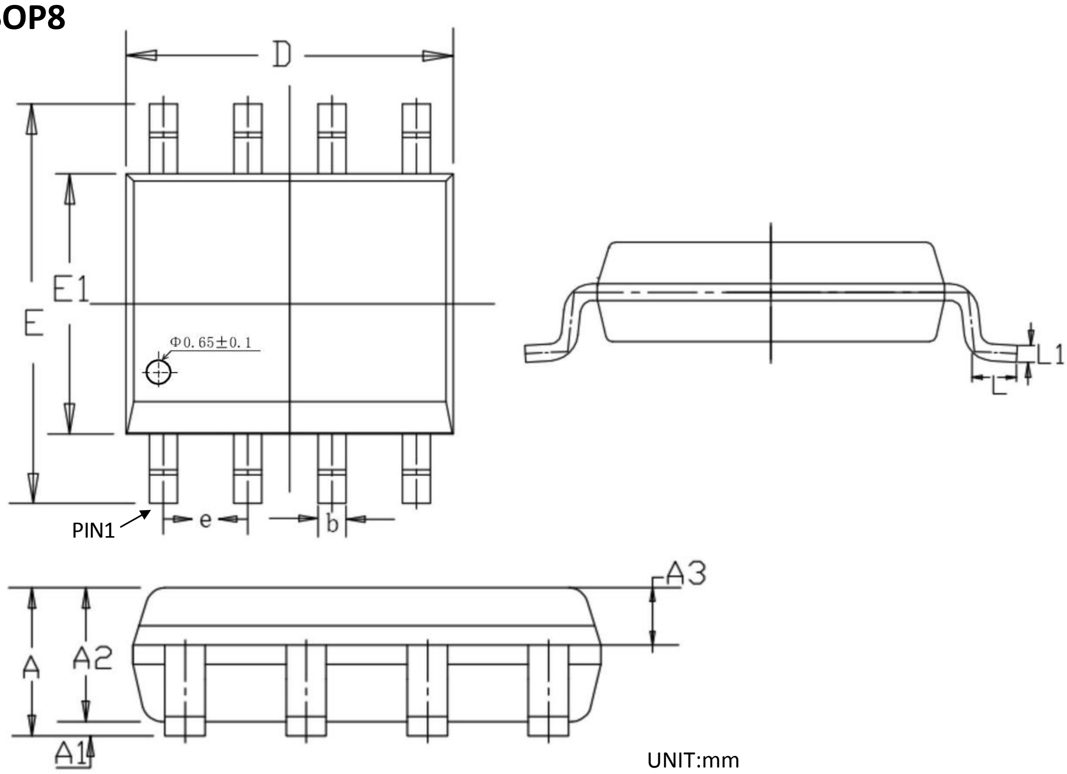
11. ORDERING INFORMATION

Ordering Information

Part Number	Device Marking	Package Type	Body size (mm)	Temperature (°C)	MSL	Transport Media	Package Quantity
XL386	XL386	SOP8	4.90 * 3.90	-40 to +85	MSL3	T&R	2500
XL386-MS	XL386-MS	MSOP8	3.00 * 4.90	-40 to +85	MSL3	T&R	2500
XD386-1	XD386-1	DIP8	9.25 * 6.38	-40 to +85	MSL3	Tube 50	2000

12. DIMENSIONAL DRAWINGS

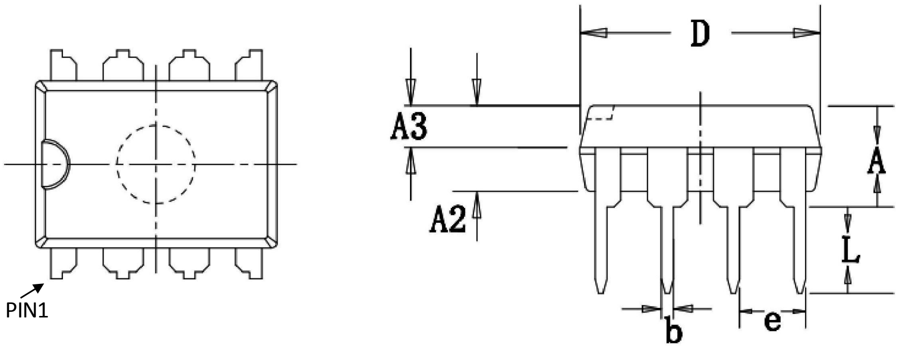
SOP8

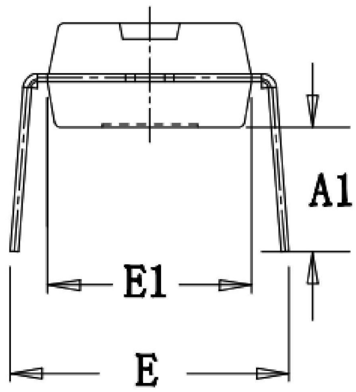


UNIT:mm

	MIN	NOM	MAX
A	1.450	1.550	1.650
A1	0.100	0.150	0.200
A2	1.300	1.400	1.500
A3	0.600	0.650	0.700
b	0.380	–	0.510
e	1.240	1.270	1.300
D	4.800	4.900	5.000
E	5.800	6.000	6.200
E1	3.800	3.900	4.000
L	0.450	0.600	0.750
L1	–	0.25BSC	–

DIP8

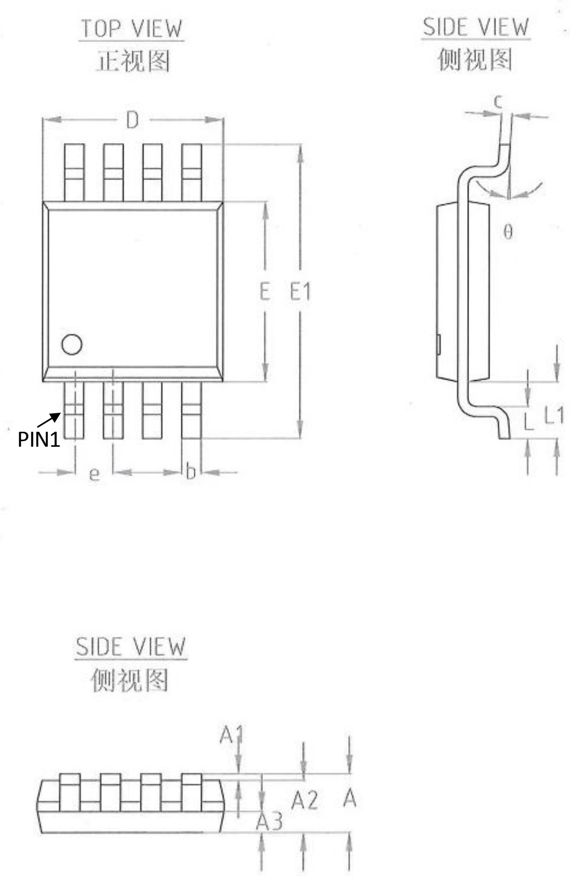




UNIT:mm

	MIN	NOM	MAX
A	3.600	3.800	4.000
A1	3.786	3.886	3.986
A2	3.200	3.300	3.400
A3	1.550	1.600	1.650
b	0.440	–	0.490
e	2.510	2.540	2.570
D	9.150	9.250	9.350
E	7.800	8.500	9.200
E1	6.280	6.380	6.480
L	3.000	–	–

MSOP8



机械尺寸/mm Dimensions			
字符 SYMBOL	最小值 MIN	典型值 NOMINAL	最大值 MAX
A	–	–	1.10
A1	0.05	–	0.15
A2	0.75	0.85	0.95
A3	0.30	0.35	0.40
b	0.28	–	0.36
c	0.15	–	0.19
D	2.90	3.00	3.10
E	2.90	3.00	3.10
E1	4.70	4.90	5.10
e	0.65 BSC		
L1	0.95 REF		
L	0.40	–	0.70
θ	0°	–	8°