1.2MHz, Rail to Rail I/O CMOS Operational Amplifier

FEATURES

- **Gain-Bandwidth Product: 1.2MHz**
- **Unity Gain Stable**
- **Rail to Rail Input and Output**
- **Low Offset Voltage: ±0.5mV(Typ.)**
- **Very Low Input Bias Current: 0.5pA**
- **Supply Voltage Range: 2.1V to 5.5V**
- **Input Voltage Range:**
  -0.1V to +5.6V with V_S=5.5V
- **Low Supply Current: 60μA/Amplifier**
- **Small Packaging**
  YX1321 Available in SOIC-8 and SOT23-5
  YX1358 Available in SOIC-8, MSOP-8 and TSSOP8
  YX1324 Available in SOIC-14 and TSSOP-14

DESCRIPTION

The YX1321 (single), YX1358 (dual) and YX1324 (quad) are low cost, rail to rail input and output voltage feedback amplifiers. They have a wide input common-mode voltage range and output voltage swing, and take the minimum operating supply voltage down to 2.1V. The maximum recommended supply voltage is 5.5V. All are specified over the extended -40℃ to +125℃ temperature range.

The YX1321/1358/1324 provide 1.2MHz bandwidth at a low current consumption of 60μA per amplifier. Very low input bias current of 0.5pA enable YX1321/1358/1324 to be used for integrators, photodiode amplifiers, and piezoelectric sensors. Rail to rail input and output are useful to designers for buffering ASIC in single-supply systems.

Applications for these amplifiers include safety monitoring, portable equipment, battery and power supply control, and signal conditioning and interfacing for transducers in very low power systems.

The YX1321 single is available in the Green SOT23-5 and SOIC-8 packages. The YX1358 dual comes in the Green SOIC-8, MSOP-8 and TSSOP-8 packages. The quad YX1324 is offered in Green TSSOP-14 and SOIC-14 packages.

APPLICATIONS

- **ASIC Input or Output Amplifier**
- **Sensor Interface**
- **Piezoelectric Transducer Amplifier**
- **Medical Instrumentation**
- **Mobile Communication**
- **Audio Output**
- **Portable Systems**
- **Smoke Detectors**
- **Notebook PC**
- **Battery-Powered Equipment**

TYPICAL APPLICATIONS

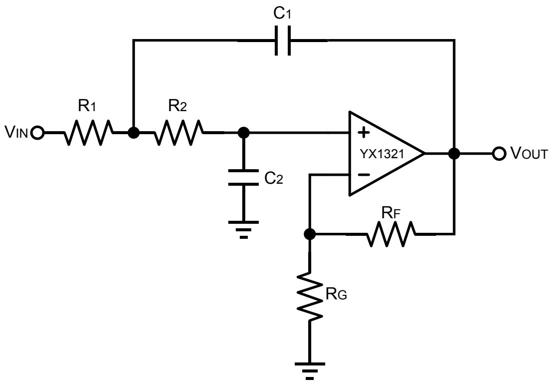


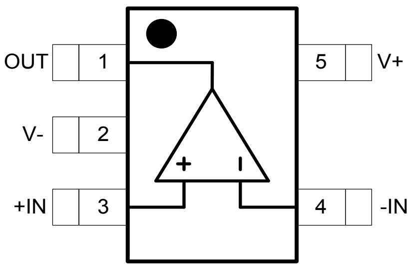
Figure 1. Typical Application Circuit

ORDERING INFORMATION

DEVICE	ORDER NUMBER	PACKAGE DESCRIPTION	AMBIENT TEMPERATURE	PACKAGE MARKING	PACKAGE OPTION	Package Qty.
YX1321	YX1321AEER	SOT23-5	-40℃ to +85℃		Tape and Reel	3000
	YX1321APGR	SOIC-8	-40℃ to +85℃	YX1321	Tape and Reel	3000
YX1358	YX1358APGR	SOIC-8	-40℃ to +85℃	YX1358	Tape and Reel	3000
	YX1358ANGR	MSOP-8	-40℃ to +85℃	YX1358	Tape and Reel	3000
	YX1358ASGR	TSSOP-8	-40℃ to +85℃	YX1358	Tape and Reel	3000
YX1324	YX1324APKR	SOIC-14	-40℃ to +85℃	YX1324	Tape and Reel	3000
	YX1324ASKR	TSSOP-14	-40℃ to +85℃	YX1324	Tape and Reel	3000

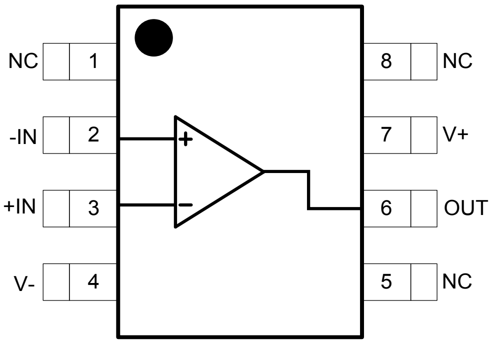
PIN CONFIGURATION

YX1321



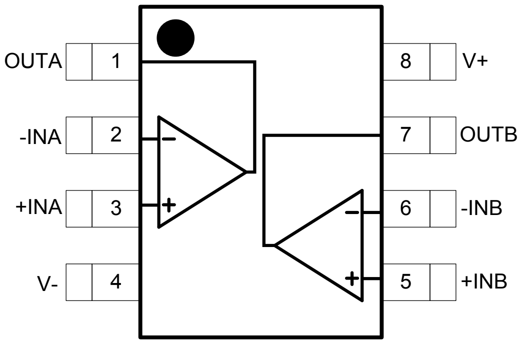
SOT23-5

YX1321



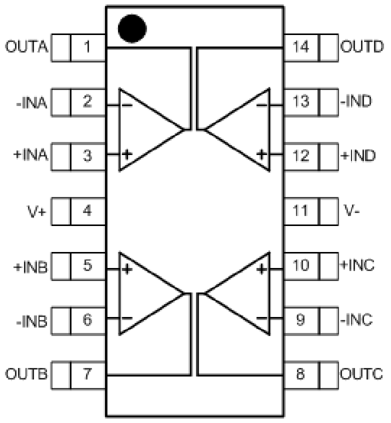
SOIC-8

YX1358



SOIC-8/MSOP-8/TSSOP-8

YX1324



SOIC-14/TSSOP-14

ABSOLUTE MAXIMUM RATINGS

Description		Ratings / Value / Range	Units
Supply Input Voltage (V+ to V-)		-0.3 ~ 6	V
Input Common Mode Voltage		(V-) - 0.3 ~ (V+) + 0.3	V
Storage Temperature Range		-65 ~ +150	°C
Junction Temperature		150	°C
Lead Temperature		260	°C
ESD Rating	HBM (Human Body Mode)	4000	V
	CDM (Charge Device Mode)	1000	V

THERMAL INFORMATION

Description		Ratings / Value / Range	Units
Package Thermal Resistance (θ_{JA})	SOT23-5	190	°C/W
	SOIC-8	125	°C/W
	MSOP-8	215	°C/W
	TSSOP-8	175	°C/W
Power Dissipation, P_D@T_A=25°C	SOT23-5	0.65	W
	SOIC-8	1.00	W
	MSOP-8	0.58	W
	TSSOP-8	0.70	W

RECOMMENDED OPERATION CONDITIONS

Description	Ratings / Value / Range	Units
Operating Junction Temperature	-40 ~ 125	°C
Operating Ambient Temperature	-40 ~ 85	°C
Supply Input Voltage	+2.1 ~ +5.5	V

Note 1. Stresses beyond those listed as the above *ABSOLUTED MAXIMUM RATINGS* may cause permanent damage to the device. These are for stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the *RECOMMENDED OPERATION CONDITIONS* section of the specifications are not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

Note 2. Devices are ESD sensitive. Handling precaution recommended.

Note 3. θ_{JA} is measured in the natural convection at T_A=25°C on a low effective thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

Note 4. The device is not guaranteed to function outside its operating conditions.

Important information and disclaimer:

ELECTRICAL CHARACTERISTICS

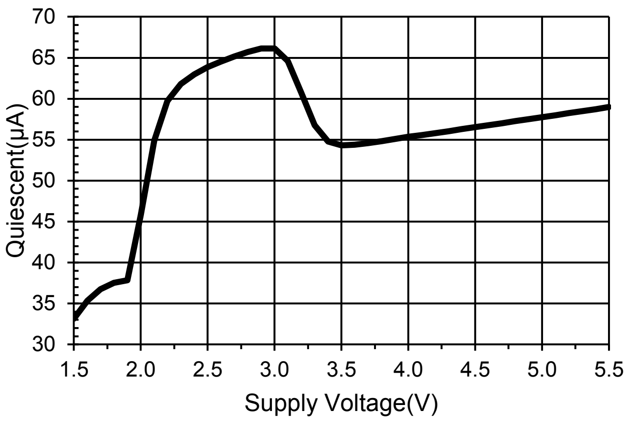
(V_{IN} = 5.0V, T_A = 25°C, unless otherwise specified.)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Input Offset Voltage	V_{OS}	$V_{CM} = V_S/2$		0.5	3.0	mV
		$V_{CM} = V_S/2$, T_A = - 40℃ to 125℃				mV
Drift	dV_{OS}/dT			2.7		μV/℃
Input Bias Current	I_B			0.5		pA
Input Offset Current	I_{OS}			0.5		pA
Input Common Mode Voltage Range	V_{CM}	V_S = 5.5V	-0.1		5.6	V
Common Mode Rejection Ratio	CMRR	V_S = 5.5V,V_{CM} = - 0.1V to + 4.0V	60	80		dB
		V_S = 5.5V,V_{CM} = - 0.1V to + 5.6V	70	90		dB
Differential Input Impedance	Z_{ID}			TBD		Ω||pF
Common Mode Input Impedance	Z_{IC}			TBD		Ω||pF
Input Voltage Noise, f = 0.1Hz to 10Hz		VS = 5 V, f = 0.1 Hz to 10 Hz		TBD		μV
Input Voltage Noise Density, f = 10kHz	e_n	VS = 5 V, f = 1 kHz		TBD		nV/√Hz
Input Current Noise Density, f = 10kHz	i_n	f = 1 kHz		TBD		fA/√Hz
Open-Loop Voltage Gain	A_{OL}	R_L = 5kΩ,V_O = + 0.1V to + 4.9V	80	105		dB
		R_L = 100kΩ,V_O = + 0.035V to + 4.965V	85	115		dB
		R_L = 5kΩ,V_O = + 0.1V to + 4.9V, T_A = - 40℃ to 125℃	73			dB
		R_L =100kΩ,V_O=+0.035V to +4.965V, T_A= -40℃ to 125℃	75			dB
Voltage Output Swing from Rail	V_{OH}	R_L = 100kΩ	4.980	4.997		V
	V_{OL}	R_L = 100kΩ	20	5		mV
	V_{OH}	R_L = 10kΩ		4.992		V
	V_{OL}	R_L = 10kΩ		8		mV
Short-Circuit Current	I_{Source}	R_L = 10Ω to $V_S/2$		TBD		mA
	I_{Sink}			TBD		mA
Open-Loop Output Impedance	Z_O			950		Ω
Gain-Bandwidth Product	GBP			1.2		MHz
Slew Rate	SR	G = + 1,2V Output Step		0.65		V/μs
Settling Time, 0.1%	t_s	G = + 1,2V Output Step		5		μs
Overload Recovery Time		V_{IN}·Gain = V_S		1		μs
Power Supply Rejection Ratio	PSRR	V_S = 2.5V to 5.5V,V_{CM} = 0.5V	70	90		dB
Operating Voltage Range	V_S		2.1	5	5.5	V
Quiescent Current/Amplifier	I_Q	VS = 5 V, IO = 0 mA	40	60	80	μA
		VS = 5 V, IO = 0 mA, TA= –40°C to 125°C			90	μA

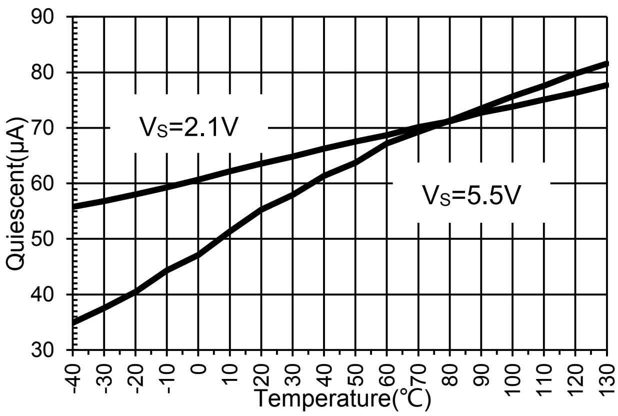
TYPICAL CHARACTERISTICS

T_A = 25°C, V_S=5V, and R_L=100kΩ connected to V_S/2, unless otherwise specified.

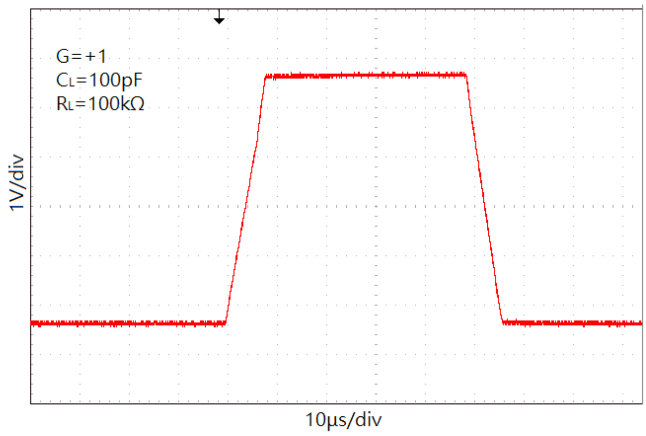
Quiescent Current vs Supply Voltage



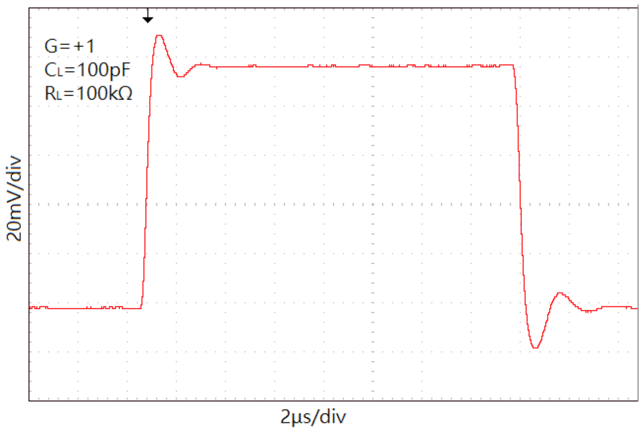
Quiescent Current vs Temperature



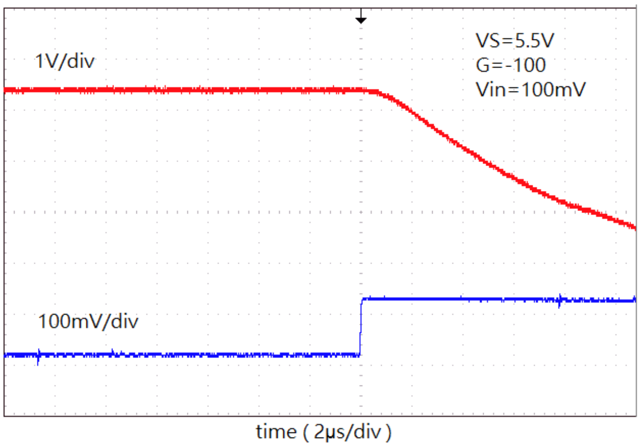
Large-Signal Step Response



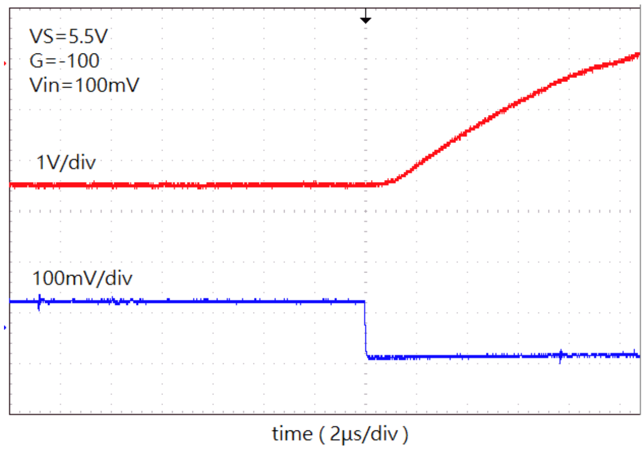
Small-Signal Step Response



Positive Overload Recovery



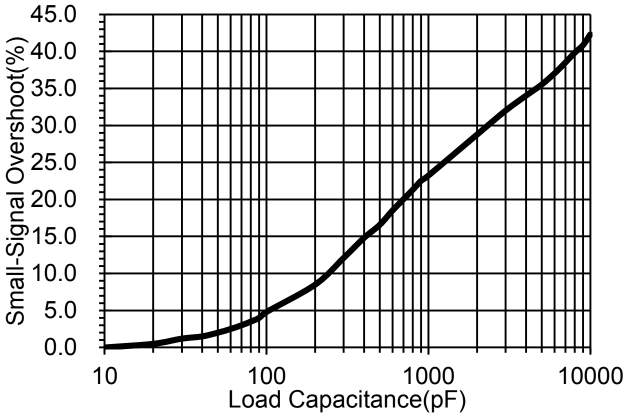
Negative Overload Recovery



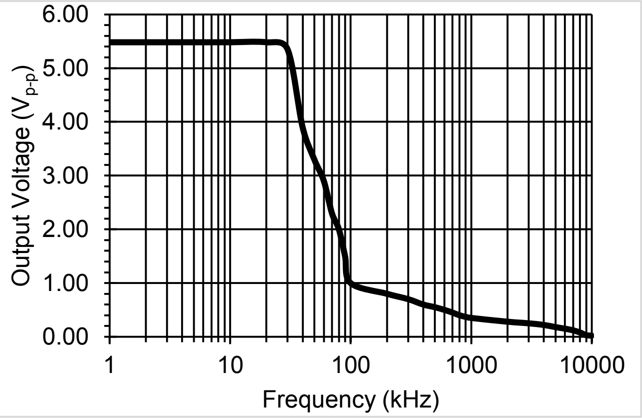
TYPICAL CHARACTERISTICS

T_A = 25°C, V_S=5V, and R_L=100kΩ connected to V_S/2, unless otherwise specified.

Small-Signal Overshoot vs Load Capacitance



Maximum Output Voltage vs Frequency



FUNCTION DESCRIPTION

Driving Capacitive Loads

The YX1321/1358/1324 can directly drive 250pF in unity-gain without oscillation. The unity-gain follower (buffer) is the most sensitive configuration to capacitive loading. Direct capacitive loading reduces the phase margin of amplifiers and this results in ringing or even oscillation. Applications that require greater capacitive driving capability should use an isolation resistor between the output and the capacitive load like the circuit in Figure 2. The isolation resistor R_{ISO} and the load capacitor C_L form a zero to increase stability. The bigger the R_{ISO} resistor value, the more stable V_{OUT} will be. Note that this method results in a loss of gain accuracy because R_{ISO} forms a voltage divider with the R_{LOAD}.

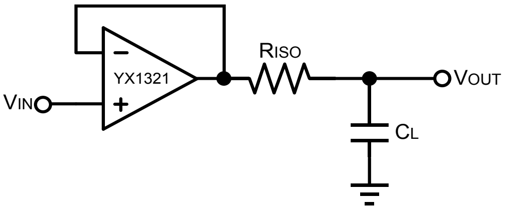


Figure 2. Indirectly Driving Heavy Capacitive Load

An improved circuit is shown in Figure 3. It provides DC accuracy as well as AC stability. R_F provides the DC accuracy by connecting the inverting signal with the output. C_F and R_{ISO} serve to counteract the loss of phase margin by feeding the high frequency component of the output signal back to the amplifier's inverting input, thereby preserving phase margin in the overall feedback loop.

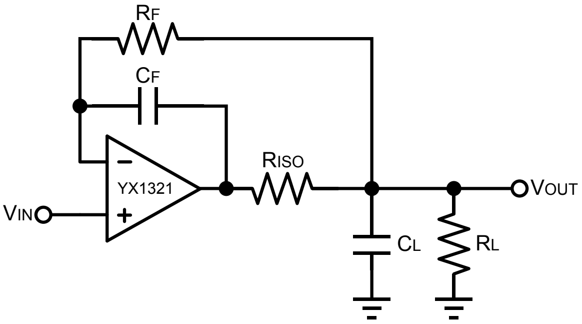


Figure 3. Indirectly Driving Heavy Capacitive Load with DC Accuracy

For non-buffer configuration, there are two other ways to increase the phase margin: (a) by increasing the amplifier's gain or (b) by placing a capacitor in parallel with the feedback resistor to counteract the parasitic capacitance associated with inverting node.

Power-Supply Bypassing and Layout

The YX1321/1358/1324 family operates from either a single +2.1V to +5.5V supply or dual ±1.05V to ±2.75V supplies. For single-supply operation, bypass the power supply V+ with a 0.1μF ceramic capacitor which should be placed close to the V+ pin. For dual-supply operation, both the V+ and V- supplies should be bypass to ground with separate 0.1μF ceramic capacitors. 2.2μF tantalum capacitor can be added for better performance.

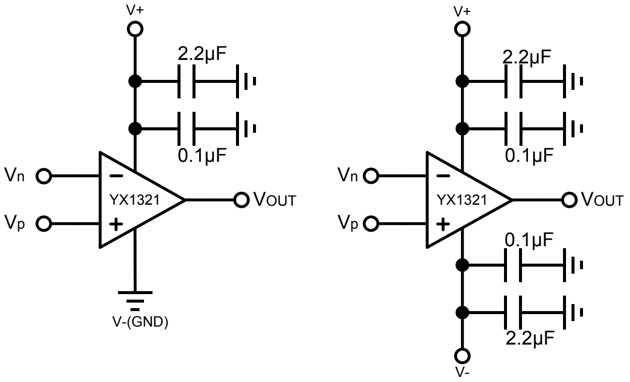


Figure 4. Amplifier with Bypass Capacitors

Power Dissipation

The device's junction temperature depends on several factors such as ambient temperature, PCB layout, the load and package type. Equations that can be used to calculate power dissipation and junction temperature are found below:

$P_D=R_{DS(ON)}\times I_{OUT}^2$

To relate this P_D to junction temperature, the following equation can be used:

$T_J=P_D\times\theta_{JA} + T_A$

Where:

T_J is junction temperature,

T_A is ambient temperature,

θ_{JA} is the thermal resistance of the package type.

TYPICAL APPLICATION

Differential Amplifier

The circuit shown in Figure 5 performs the difference function. If the resistor ratios are equal to $R_4/R_3=R_2/R_1$, then $V_{OUT} = (V_P-V_N) \times R_2/R_1 + V_{REF}$.

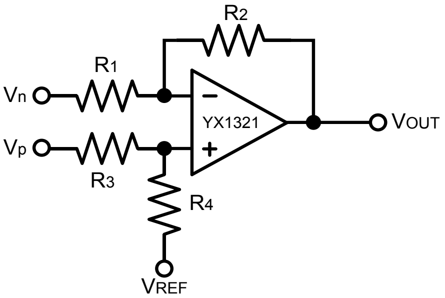


Figure 5. Differential Amplifier

Instrumentation Amplifier

The circuit in Figure 6 that the YX1324 (quad) was used performs the same function as that in Figure 5 but with high input impedance.

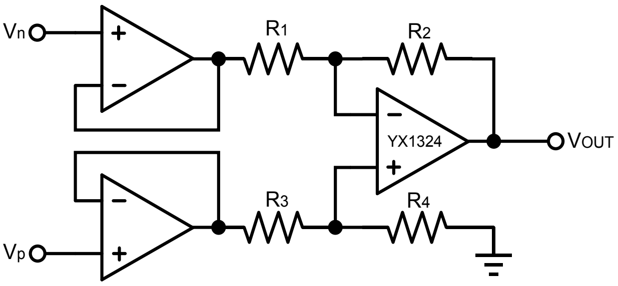


Figure 6. Instrumentation Amplifier

Low Pass Active Filter

The low pass filter shown in Figure 7 has a DC gain of $-R_2/R_1$ and the -3dB corner frequency is $1/2\pi R_2C$. Make sure the filter bandwidth is within the bandwidth of the amplifier. The large values of feedback resistors can couple with parasitic capacitance and cause undesired effects such as ringing or oscillation in high-speed amplifiers. Keep resistor values as low as possible and consistent with output loading consideration.

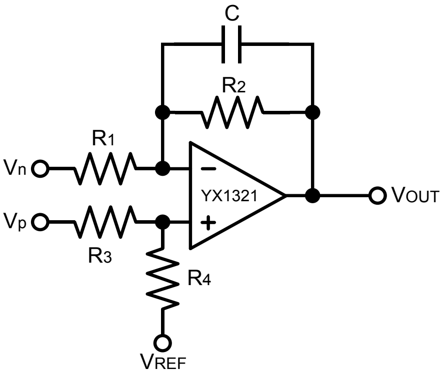
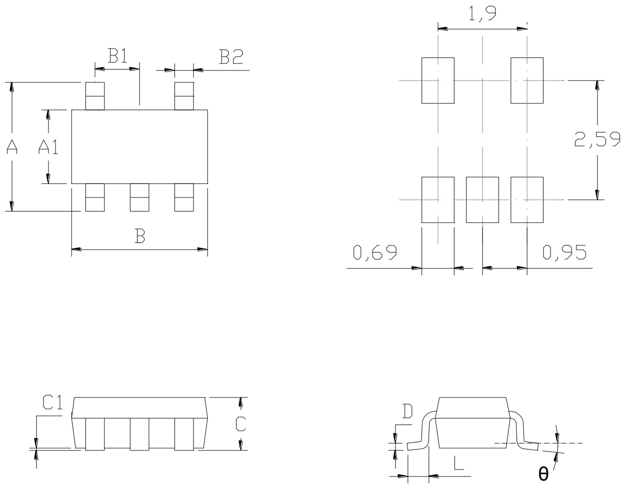


Figure 7. Low Pass Active Filter

PACKAGE DESCRIPTION

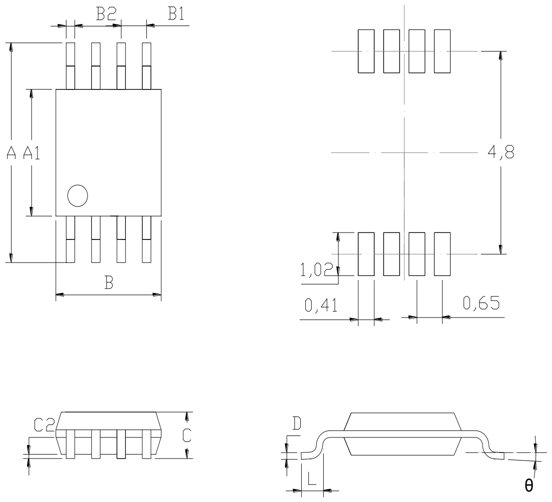
SOT23-5 package mechanical drawing



SOT23-5 package mechanical data

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	2.6	3	0.1024	0.1181
A1	1.45	1.75	0.0571	0.0689
B	2.75	3.05	0.1083	0.1201
B1	0.95		0.0374	
B2	0.3	0.5	0.0118	0.0197
C		1.45MAX		0.0571MAX
C1	0	0.15	0.0000	0.0059
L	0.3	0.5	0.0118	0.0197
D	0.08	0.22	0.0031	0.0087
θ	0º	8º	0º	8º

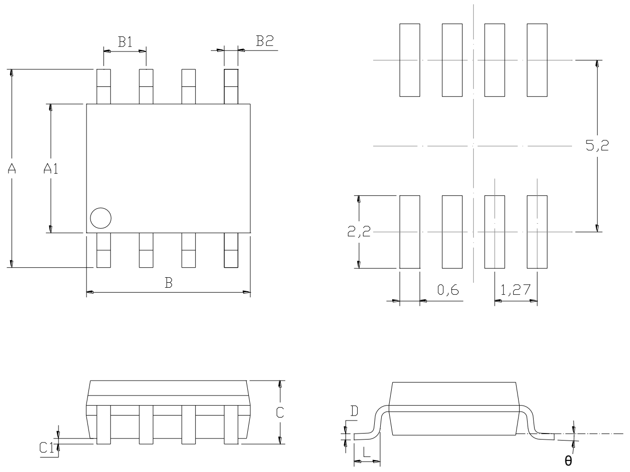
MSOP-8 package mechanical drawing



MSOP-8 package mechanical data

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	4.75	5.05	0.1870	0.1988
A1	2.9	3.1	0.1142	0.1220
B	2.9	3.1	0.1142	0.1220
B1	0.65		0.0197	
B2	0.17	0.3	0.0067	0.0106
C		1.10MAX		0.0433
C1	0.05	0.15	0.0020	0.0059
L	0.4	0.7	0.0157	0.0276
D	0.13	0.23	0.0051	0.0091
θ	0°	8°	0°	8°

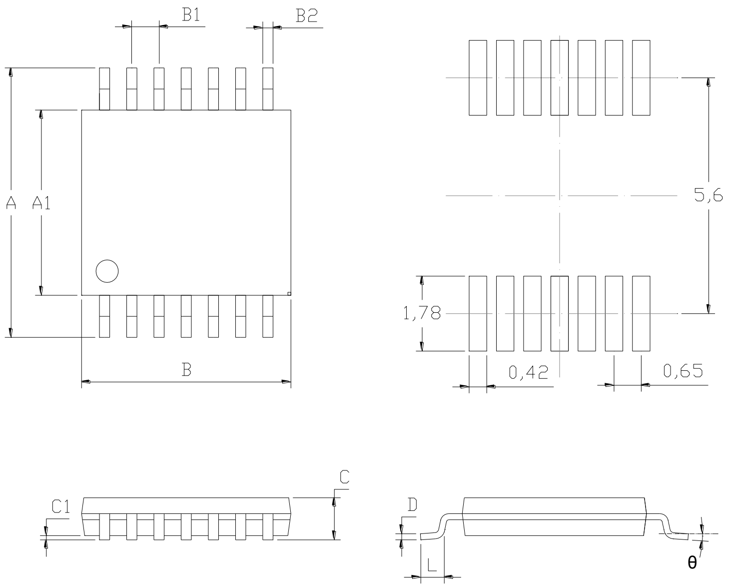
SOIC-8 package mechanical drawing



SOIC-8 package mechanical data

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	5.8	6.2	0.2283	0.2441
A1	3.8	4	0.1496	0.1575
B	4.8	5	0.1890	0.1969
B1	1.27		0.0500	
B2	0.31	0.51	0.0122	0.0201
C		1.75MAX		0.0689MAX
C1	0.1	0.25	0.0039	0.0098
L	0.4	1.27	0.0157	0.0500
D	0.13	0.25	0.0051	0.0098
θ	0°	8°	0°	8°

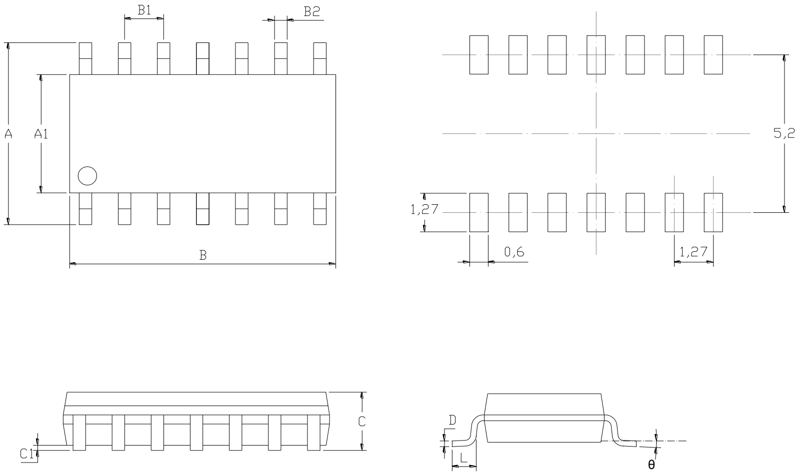
TSSOP-14 package mechanical drawing



TSSOP-14 package mechanical data

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	6.2	6.6	0.2441	0.2598
A1	4.3	4.5	0.1693	0.1772
B	4.9	5.1	0.1929	0.2008
B1	0.65		0.0256	
B2	0.19	0.3	0.0075	0.0118
C		1.20MAX		0.0472MAX
C1	0.05	0.15	0.0020	0.0059
L	0.5	0.75	0.0197	0.0295
D	0.1	0.2	0.0039	0.0079
θ	0º	8º	0º	8º

SOIC-14 package mechanical drawing



SOIC-14 package mechanical data

symbol	dimensions			
	millimeters		inches	
	min	max	min	max
A	6.2	5.8	0.2441	0.2283
A1	3.8	4	0.1496	0.1575
B	8.55	8.75	0.3366	0.3445
B1	1.27		0.0500	
B2	0.31	0.51	0.0122	0.0201
C		1.75MAX		0.0689
C1	0.1	0.25	0.0039	0.0098
L	0.4	1.27	0.0157	0.0500
D	0.13	0.25	0.0051	0.0098
θ	0°	8°	0°	8°