MINGDA
MICROELECTRONICS

MD1321/2/4
1MHz, 40μA, Rail-to-Rail I/O CMOS Operational Amplifiers

FEATURES

- Low Cost
- Rail-to-Rail Input and Output
  0.8mV Typical V_{OS}
- Unity Gain Stable
- Gain-Bandwidth Product: 1MHz
- Very Low Input Bias Current: 10pA
- Supply Voltage Range: 2.1V to 5.5V
- Input Voltage Range:
  -0.1V to +5.6V with $(V_{DD} - V_{SS}) = 5.5V$
- Low Supply Current: 40μA/Amplifier
- Small Packaging
  MD1321 Available in SOT-23-5
  MD1322 Available in SOIC-8
  MD1324 Available in SOIC-14

APPLICATIONS

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

PRODUCT DESCRIPTION

The MD1321 (single), MD1322 (dual) and MD1324 (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. It is specified over the extended -40 ℃ to +85 ℃ temperature range.

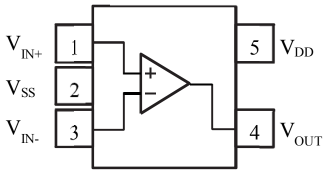
The MD1321/2/4 provides 1MHz bandwidth at a low current consumption of 40μA per amplifier. Very low input bias currents of 10pA enable MD1321/2/4 to be used for integrators, photodiode amplifiers, and piezoelectric sensors. Rail-to-rail input and output are useful to designers for buffering ASIC in single-supply systems.

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

The MD1321 is available in the Green SOT-23-5 Package. The MD1322 comes in the Green SOIC-8 package. The MD1324 comes in the Green SOIC-14 package.

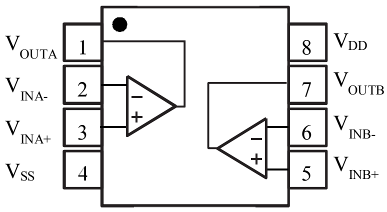
PIN CONFIGURATIONS (TOP VIEW)

MD1321



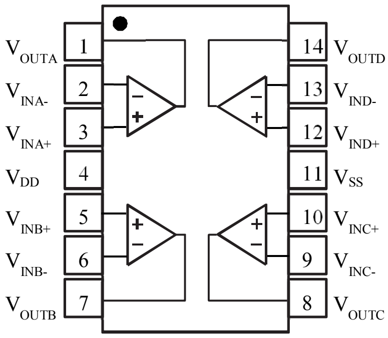
SOT-23-5

MD1322



SOIC-8

MD1324



SOIC-14

ORDER INFORMATION

MODEL	ORDER NUMBER	PACKAGE DESCRIPTION	PACKAGE OPTION	MARKING INFORMATION
MD1321	--	SOT23-5	Tape and Reel, 3000	--
MD1322	--	SOIC-8	Tape and Reel, 4000	--
MD1324	--	SOIC-14	Tape and Reel, 4000	--

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_{DD} to V_{SS}...6V
Common Mode Input Voltage.......................V_{SS} - 0.3V to V_{DD} + 0.3V
Storage Temperature Range.......................................-65℃ to +150℃
Junction Temperature..150℃
Operating Temperature Range.....................................-40℃ to +85℃

Package Thermal Resistance @ T_A = +25℃
SOT23-5, θJA..260℃/W
SOIC-8, θJA..165℃/W
SOIC-14, θJA..125℃/W
Lead Temperature (Soldering 10sec)...............................260℃

NOTE:

Stresses beyond those listed under "Absolute Maximum Ratings" 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 the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ESD, Electrostatic Discharge Protection

Symbol	Parameter	Condition	Minimum Level	Unit
HBM	Human Body Model ESD		4	kV
MM	Machine Model ESD		300	V

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are At T_A=25℃, V_{DD} = +5V, V_{SS} = GND, R_L = 100kΩ connected to V_{DD}/2, and V_{OUT} = V_{DD}/2.

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
INPUT CHARACTERISTICS							
Input Offset Voltage	V_{OS}	V_{CM} = V_{DD}/2			0.8	5	mV
		V_{CM} = V_{DD}/2	●			6.6	
Input Bias Current	I_B				10		pA
Input Offset Current	I_{OS}				10		pA
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta_T$				2		µV/℃
Input Common Mode Voltage Range	V_{CM}	V_{DD} = 5.5V			-0.1-5.6		V
Common Mode Rejection Ratio	CMRR	V_{DD} = 5.5V, V_{CM} = -0.1V to 4V			76		dB
Open-Loop Voltage Gain	A_{OL}	R_L = 100kΩ, V_{OUT} = 2.5V			95		dB
		R_L = 100kΩ, V_{OUT} = +0.2V to +4.8V			93		dB
OUTPUT CHARACTERISTICS							
Output Voltage Swing from Rail	V_{OH}	R_L = 100kΩ		4.980	4.995		V
	V_{OL}	R_L = 100kΩ		25	5		mV
	V_{OH}	R_L = 10kΩ		4.970	4.994		V
	V_{OL}	R_L = 10kΩ		35	6		mV
Output Current	I_{SOURCE}	R_L = 10Ω to V_{DD}/2			40		mA
	I_{SINK}				40		
POWER SUPPLY							
Operating Voltage Range				2.1			V
			●	2.5		5.5	V
Power Supply Rejection Ratio	PSRR	V_{DD} = +2.5V to +5.5V, V_{CM} = +0.5V			85		dB
Quiescent Current/Amplifier	I_Q				40		µA
			●	35		80	
DYNAMIC PERFORMANCE (C_L = 100pF)							
Gain-Bandwidth Product	GBP				1		MHz
Phase Margin	PM	R_L = 100kΩ, C_L = 100pF			45		°
Harmonic Distortion	HD2	f = 10kHz, G = +1, R_L=100k,V_{OUT}=2V_{PP}			>80		dBc
	HD3	f = 10kHz, G = +1, R_L=100k,V_{OUT}=2V_{PP}			>80		
Slew Rate	SR	G = +1, 2V Output Step			0.64		V/µs
Settling Time to 0.1%	t_S	G = +1, 2V Output Step			6		µs
Overload Recovery Time		V_{IN}·G = V_{DD}			2.5		µs
NOISE PERFORMANCE							
Voltage Noise Density	e_n	f = 1kHz			30		nV/√Hz
		f = 10kHz			20		nV/√Hz

TYPICAL PERFORMANCE CHARACTERISTICS

At T_A = +25℃, V_{DD} = +5V, V_{SS} = GND, and R_L = 100kΩ connected to $V_{DD}/2$, unless otherwise specified.

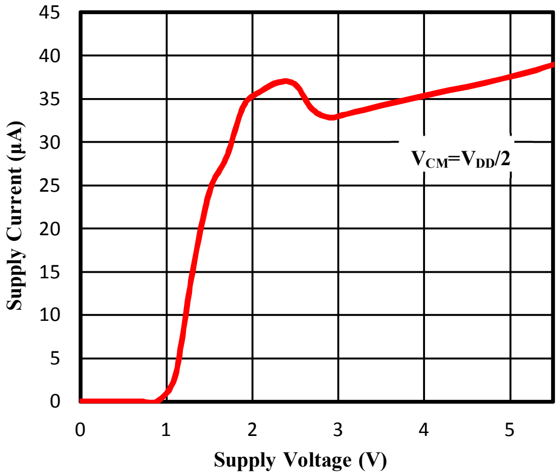


Figure 1. Supply Current vs. Supply Voltage

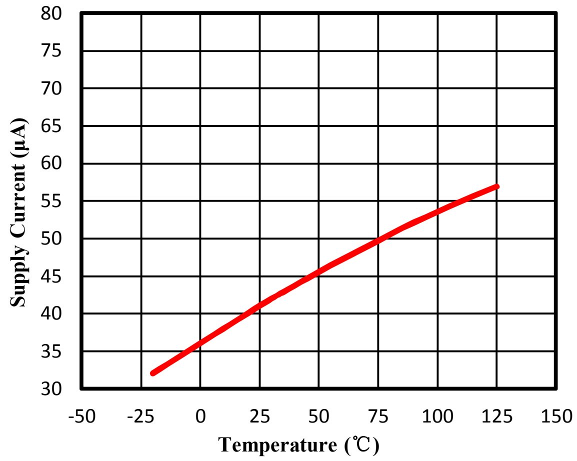


Figure 2. Supply Current vs. Temperature

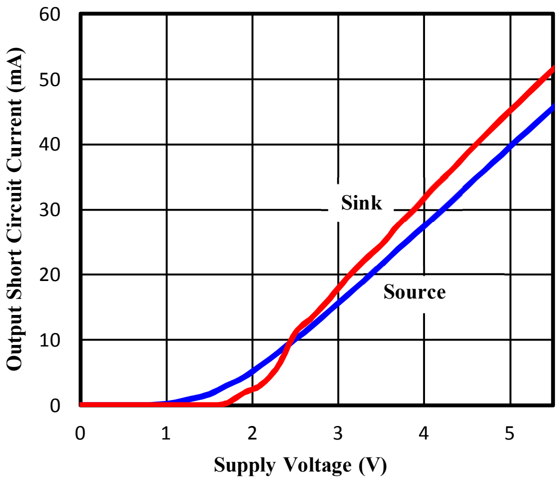


Figure 3. Output Short Circuit Current vs. Supply Voltage

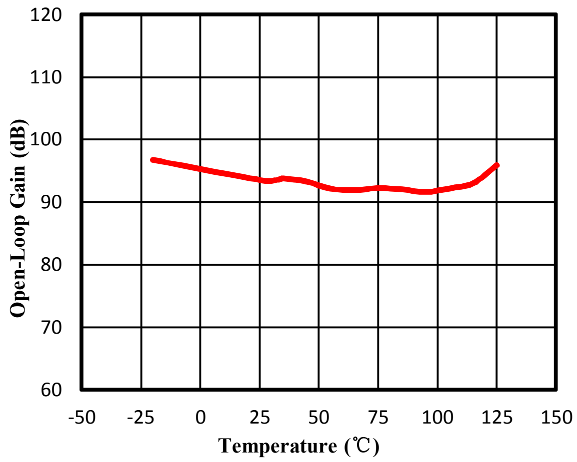


Figure 4. Open-Loop Gain vs. Temperature

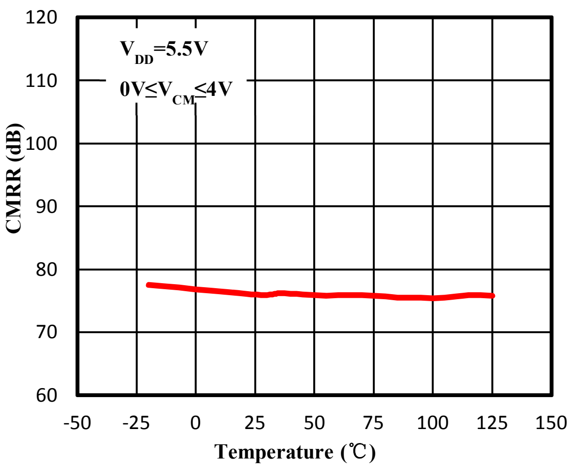


Figure 5. CMRR vs. Temperature

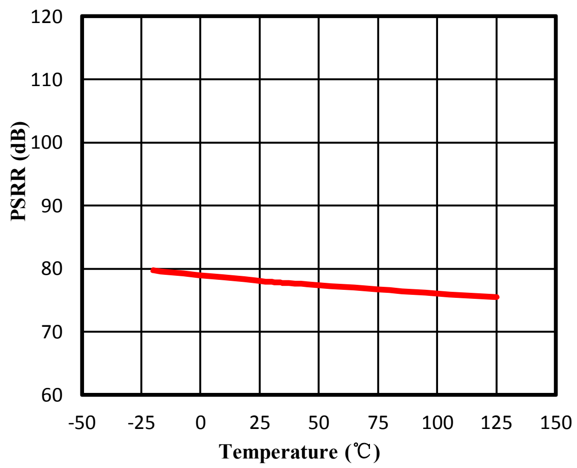


Figure 6. PSRR vs. Temperature

TYPICAL PERFORMANCE CHARACTERISTICS

At T_A = +25℃, V_{DD} = +5V, V_{SS} = GND, and R_L = 100kΩ connected to V_{DD}/2, unless otherwise specified.

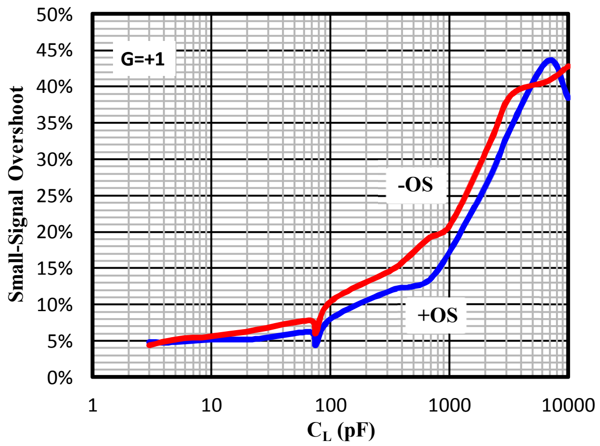


Figure 7. Small-Signal Overshoot vs. Load Capacitance

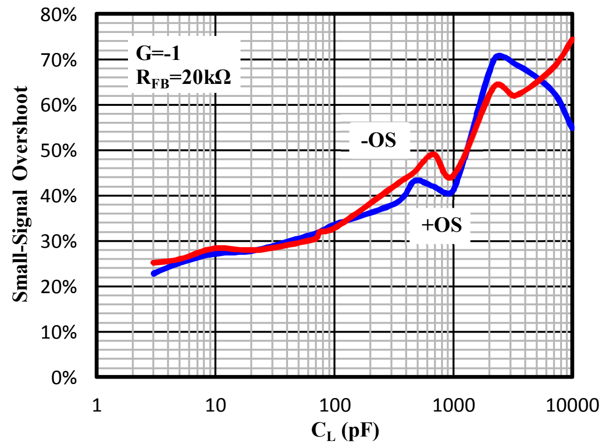


Figure 8. Small-Signal Overshoot vs. Load Capacitance

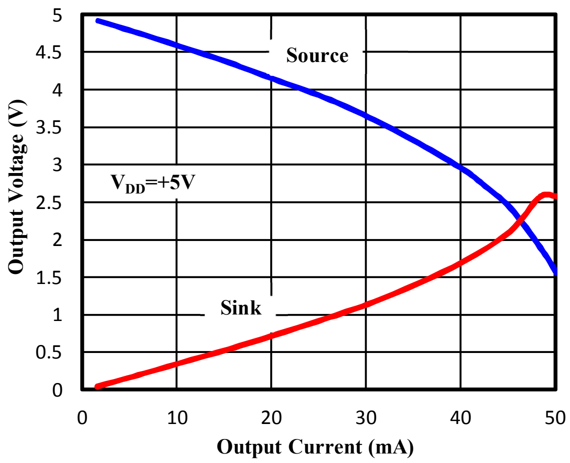


Figure 9. Output Voltage vs. Output Current

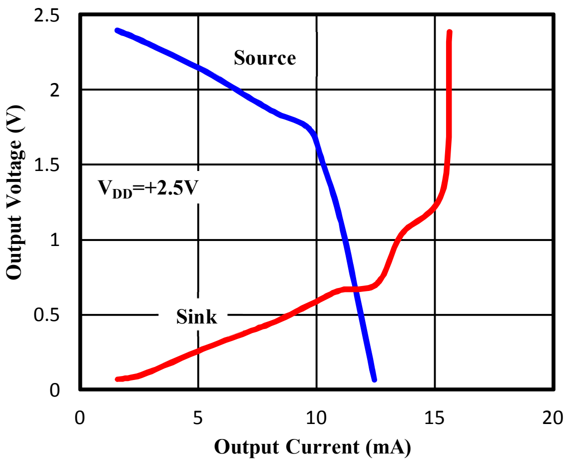


Figure 10. Output Voltage vs. Output Current

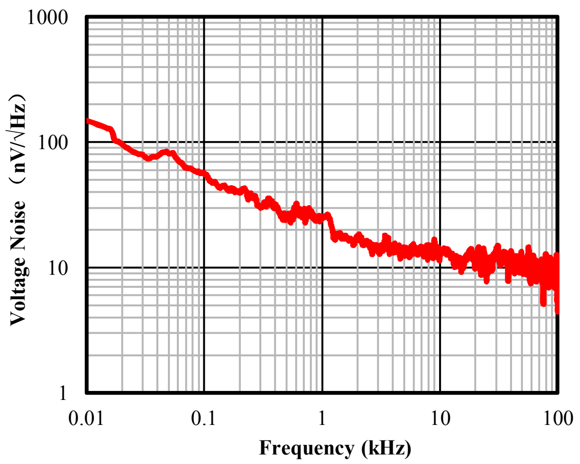


Figure 11. Input Voltage Noise Spectral Density vs. Frequency

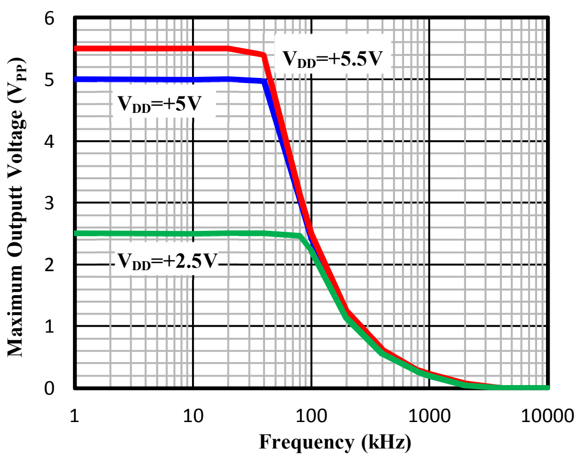


Figure 12. Maximum Output Voltage vs. Frequency

TYPICAL PERFORMANCE CHARACTERISTICS

At T_A = +25℃, V_{DD} = +5V, V_{SS} = GND, and R_L = 100kΩ connected to $V_{DD}/2$, unless otherwise specified

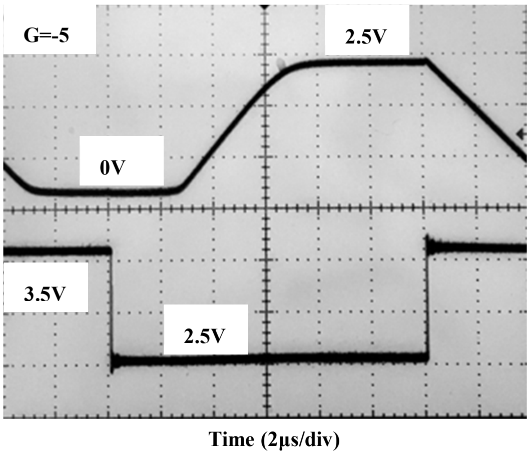


Figure 13. Positive Overload Recovery Time

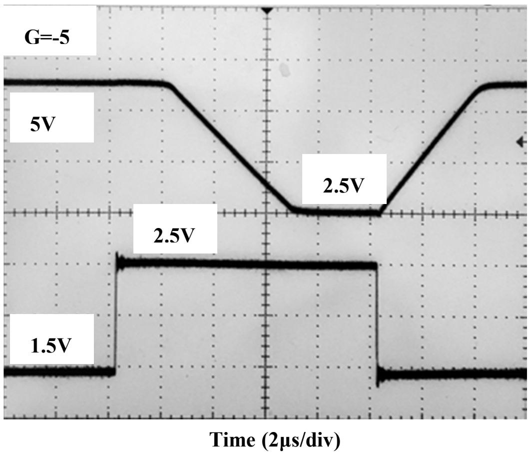


Figure 14. Negative Overload Recovery Time

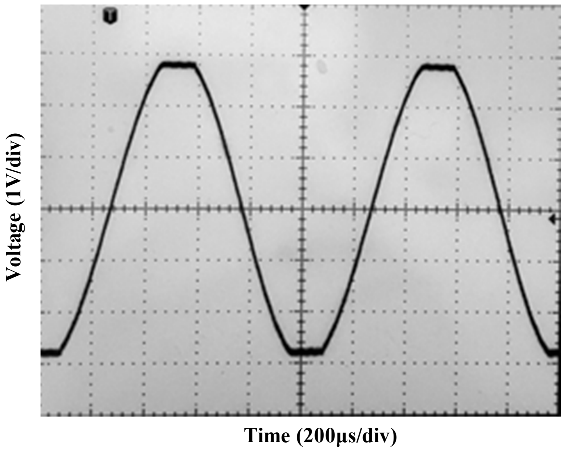


Figure 15. Phase Reversal

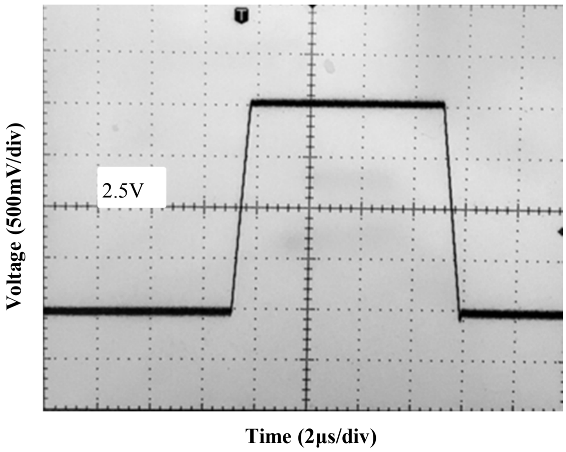


Figure 16. Large-Signal Step Response

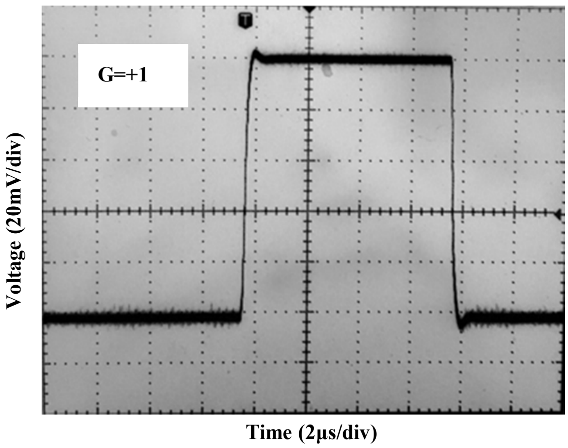


Figure 17. Small-Signal Step Response

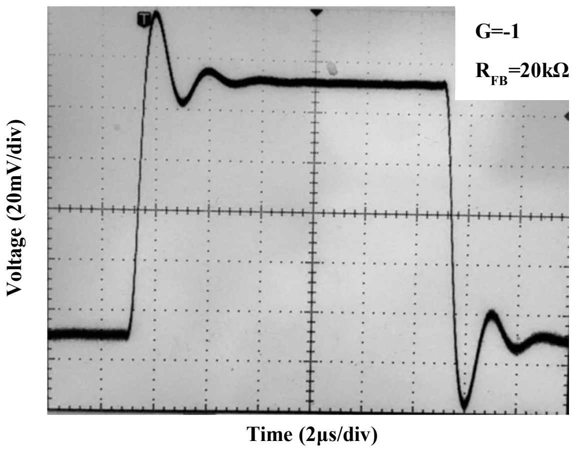


Figure 18. Small-Signal Step Response

TYPICAL PERFORMANCE CHARACTERISTICS

At T_A = +25℃, V_{DD} = +5V, V_{SS} = GND, and R_L = 100kΩ connected to $V_{DD}/2$, unless otherwise specified.

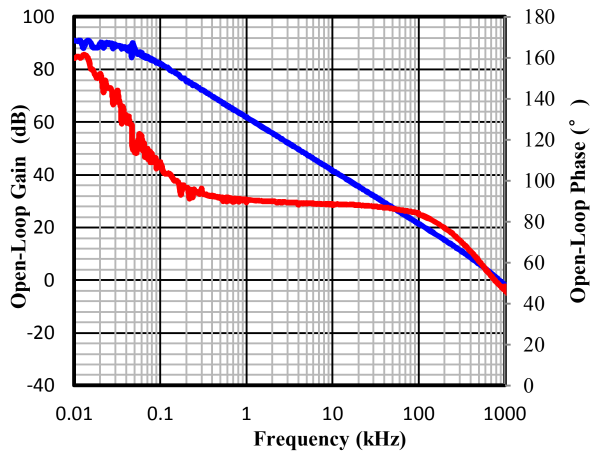


Figure 19. Gain and Phase vs. Frequency

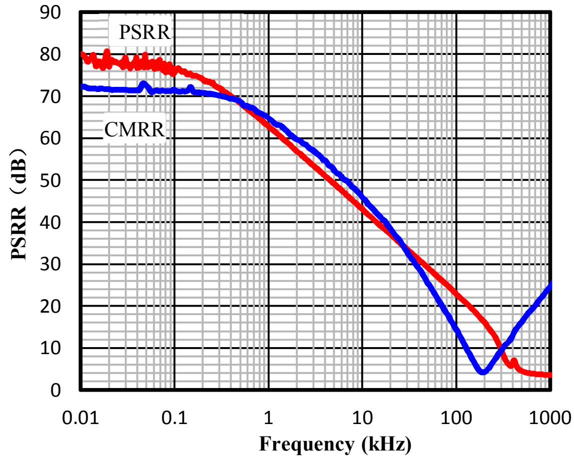


Figure 20. CMRR and PSRR vs. Frequency

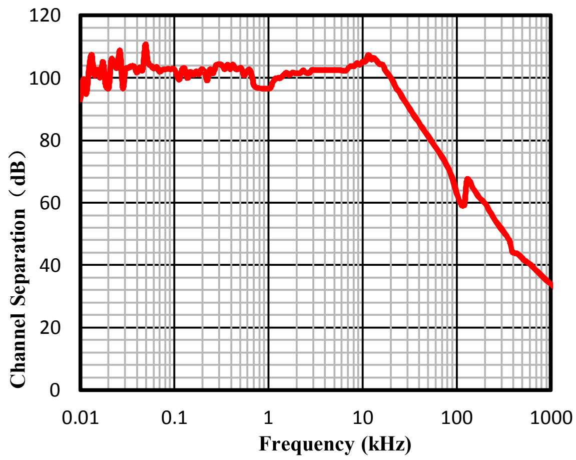


Figure 21. Channel Separation vs. Frequency

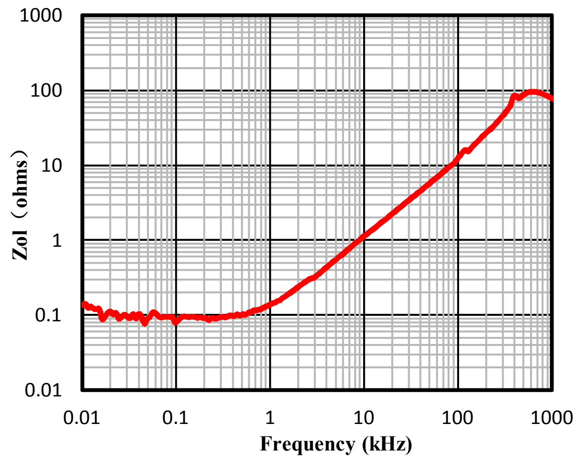


Figure 22. Zol vs. Frequency

APPLICATION INFORMATION

MD1321/2/4 are CMOS, rail-to-rail input and output voltage feedback amplifiers designed for general purpose applications.

Operating Voltage

The MD1321/2/4 are specified over a power-supply range of +2.1V to +5.5V (±1.05V to ±2.75V), Supply voltages higher than 6V (absolute maximum) can permanently damage the amplifier.

Parameters that vary over supply voltage or temperature are shown in the typical characteristics section of this datasheet.

Rail-to-Rail Input

The input stage of the amplifiers is a true rail-to-rail architecture, allowing the input common-mode voltage range of the op amp to extend to both positive and negative supply rails. This maximizes the usable voltage range of the amplifier, an important feature for single-supply and low voltage applications. This rail-to-rail input range is achieved with a complementary input stage—an NMOS input differential pair in parallel with a PMOS differential pair. The NMOS pair is active at the upper end of the common-mode voltage range, typically V_{DD} – 1.2V to 100mV above the positive supply, while the PMOS pair is active for inputs from 100mV below the negative supply to approximately V_{DD} – 1.2V.

Rail-to-Rail Output

A class AB output stage with common-source transistors is used to achieve rail-to-rail output. The maximum output voltage swing is proportional to the output current, and larger currents will limit how close the output voltage can get to the proximity of the output voltage to the supply rail. This is a characteristic of all rail-to-rail output amplifiers. See the typical performance characteristic Figure 9, Output Voltage Swing vs. Output Current.

Capacitive Loads

The MD1321/2/4 op amps can directly drive large capacitive loads. As the load capacitance increases, the feedback loop's phase margin decreases and the closed-loop's bandwidth is reduced. This produces gain peaking in the frequency response, with overshoot and ringing in the step response. While a op amp in unity gain configuration (G = +1 V/V) is most susceptible to the effects of capacitive loading.

When driving large capacitive loads with the MD1321/2/4 amplifiers (e.g., > 100pF when G = +1 V/V), a small series resistor at the output (R_{ISO} in Figure 23) improves the feedback loop's phase margin (stability) by making the output load resistive at higher frequencies.

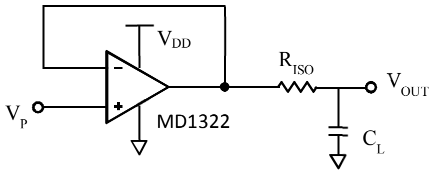


Figure 23. Driving Large Capacitive Loads

PCB Surface Leakage

In Applications where low input bias current is critical, PC board surface leakage effects need to be considered. Surface leakage is caused by humidity, dust or other contamination on the board. Under low humidity conditions, a typical resistance between nearby traces is $10^{12}\Omega$. A 5V difference would cause 5pA of current to flow; which is similar to the MD1321/2/4 op amps' bias current at +25℃ (±10pA, typical).

The best way to reduce surface leakage is to use a guard ring around sensitive pins (or traces). The guard ring is biased at the same voltage as the sensitive pin. An example of this type of layout is shown in Figure 24.

1. Non-inverting Gain and Unity-Gain Buffer:
   a) Connect the non-inverting pin (V_{IN+}) to the input with a wire that does not touch the PCB surface.
   b) Connect the guard ring to the inverting input pin (V_{IN-}). This biases the guard ring to the Common Mode input voltage.
2. Inverting Gain and Transimpedance Gain Amplifiers (convert current to voltage, such as photo detectors):
   a) Connect the guard ring to the non-inverting input pin (V_{IN+}). This biases the guard ring to the same reference voltage as the op amp (e.g., $V_{DD}/2$ or ground).
   b) Connect the inverting pin (V_{IN-}) to the input with a wire that does not touch the PCB surface.

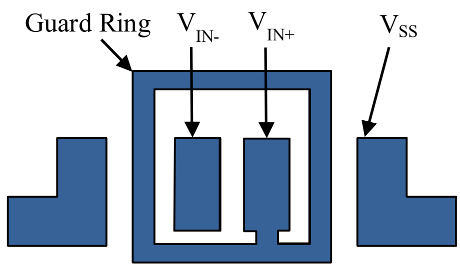


Figure 24. Example Guard Ring Layout for Inverting Gain

TYPICAL APPLICATION

Differential Amplifier

The circuit shown in Figure 25 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) × R_2 / R_1 + V_{REF}.

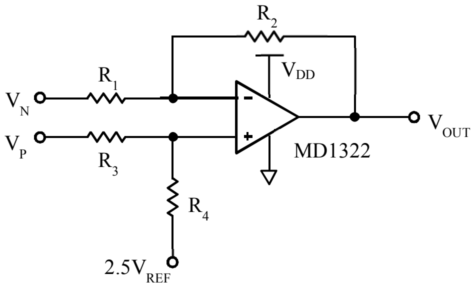


Figure 25. Differential Amplifier

Photodiode Application

The MD1321/2/4 have very high impedance with an input bias current typically around 10 pA. This characteristic allows the MD1321/2/4 op amp to be used in photodiode applications and other applications that require high input impedance. Note that the MD1321/2/4 have significant voltage offset that can be removed by capacitive coupling or software calibration.

Figure 26 illustrates a photodiode or current measurement application. The feedback resistor is limited to 10 MΩ to avoid excessive output offset. In addition, a resistor is not needed on the noninverting input to cancel bias current offset because the bias current-related output offset is not significant when compared to the voltage offset contribution. For best performance, follow the standard high impedance layout techniques, which include the following:

- Shielding the circuit.
- Cleaning the circuit board.
- Putting a trace connected to the noninverting input around the inverting input.
- Using separate analog and digital power supplies.

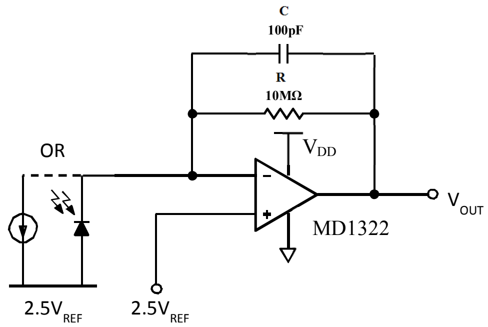
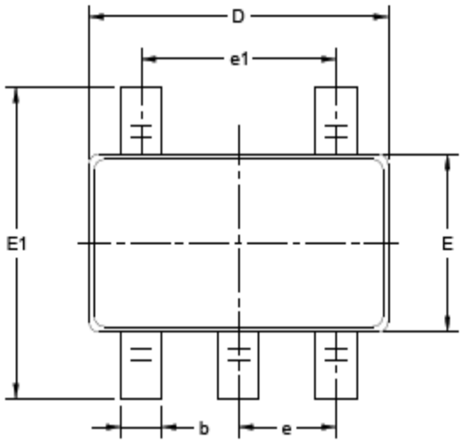
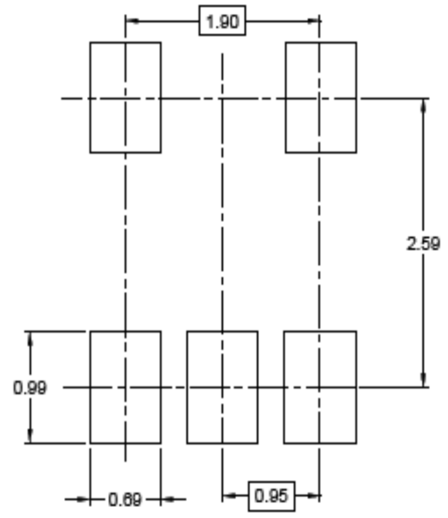


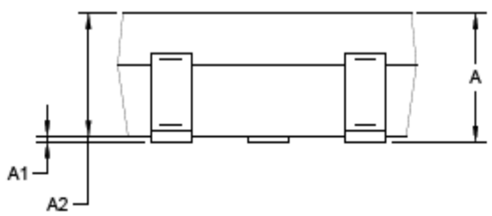
Figure 26. High Input Impedance Application—Photodiode Amplifier

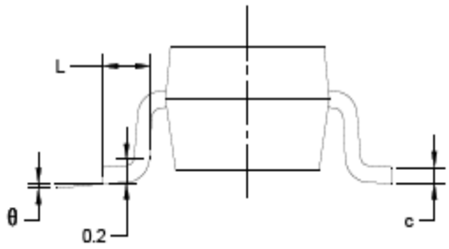
PACKAGE OUTLINE DIMENSIONS(SOT23-5)





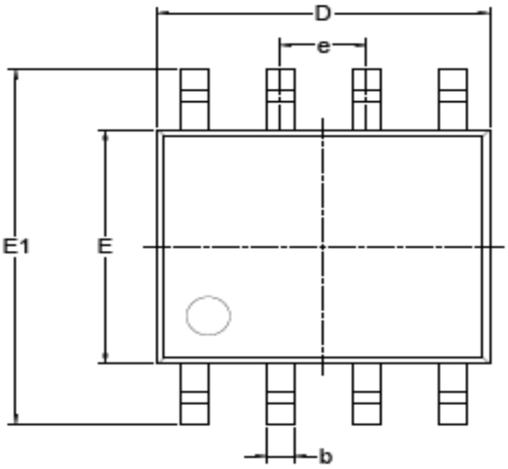
RECOMMENDED LAND PATTERN (Unit: mm)

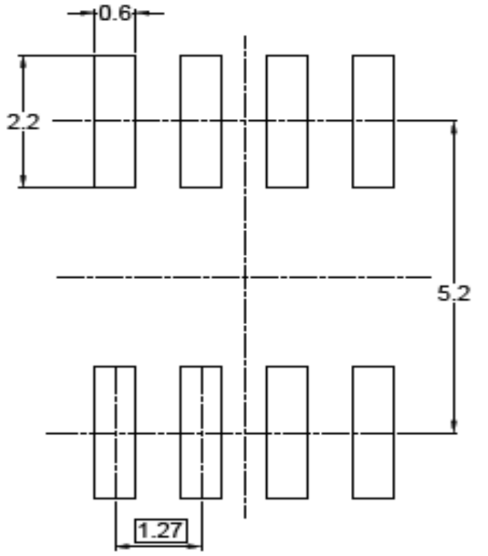




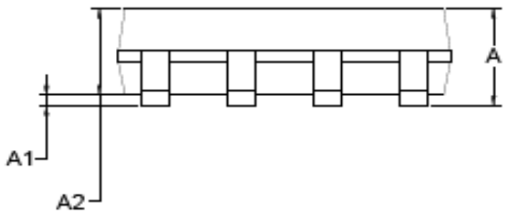
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 BSC	
e1	1.900 BSC		0.075 BSC	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

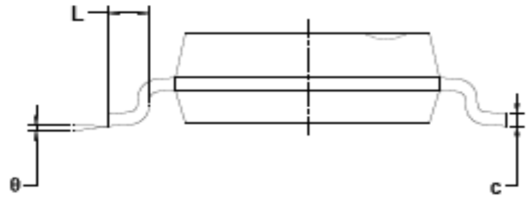
PACKAGE OUTLINE DIMENSIONS(SOIC8)





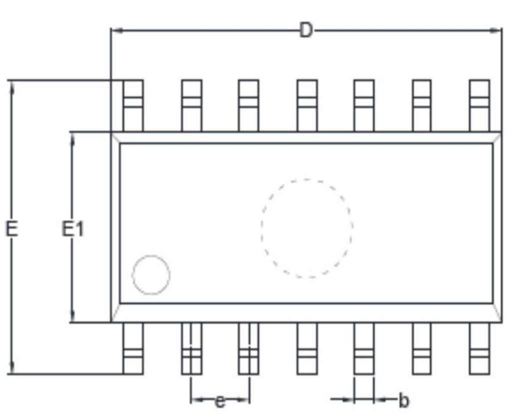
RECOMMENDED LAND PATTERN (Unit: mm)

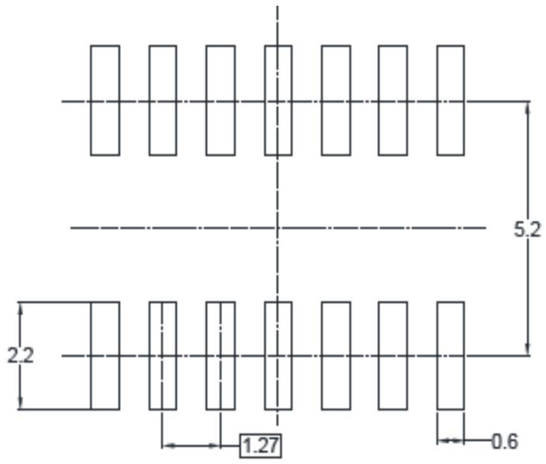




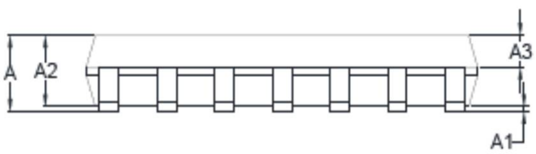
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

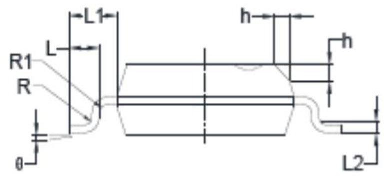
PACKAGE OUTLINE DIMENSIONS(SOIC14)





RECOMMENDED LAND PATTERN (Unit: mm)

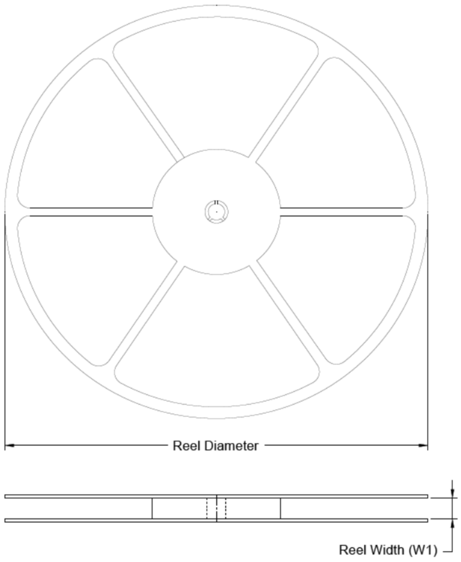




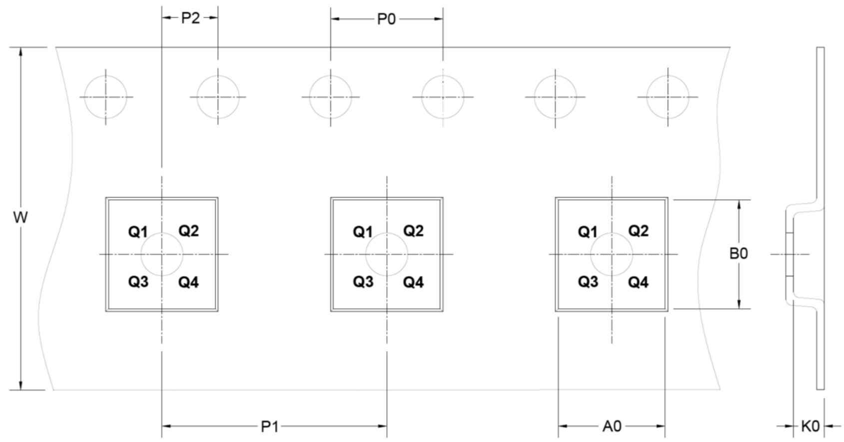
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
A2	1.25	1.65	0.049	0.065
A3	0.55	0.75	0.022	0.030
b	0.36	0.49	0.014	0.019
D	8.53	8.73	0.336	0.344
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
L	0.45	0.80	0.018	0.032
L1	1.04 REF		0.040 REF	
L2	0.25 BSC		0.01 BSC	
R	0.07		0.003	
R1	0.07		0.003	
h	0.30	0.50	0.012	0.020
θ	0°	8°	0°	8°

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



DIRECTION OF FEED

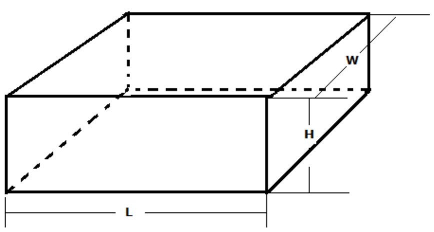
NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOT23-5	7″	9.5	3.20	3.20	1.40	4.0	4.0	2.0	8.0	Q3
SOIC-8	13″	12.4	6.40	5.40	2.10	4.0	8.0	2.0	12.0	Q1
SOIC-14	13″	16.4	6.60	9.30	2.10	4.0	8.0	2.0	16.0	Q1

ARTON BOX DIMENSIONS

Unit: mm



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF CARTON BOX

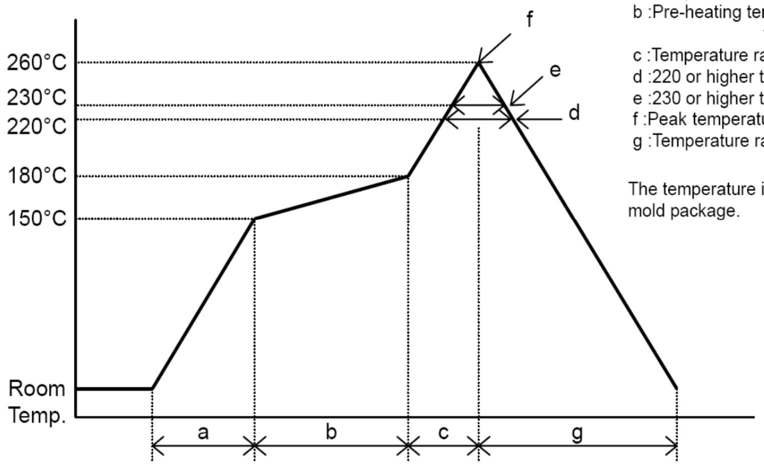
Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
7″	210	210	210	10
13″	455	355	355	8

RECOMMENDED MOUNTING METHOD

Soldering Methods, Recommended Soldering Method for Moisture-Proof Packing and Flux Cleaning are in the following.Mounting was evaluated with the following profiles in our company, so there was no problem. However, confirm mounting by the condition of your company beforehand.

1. Soldering Temperature Profile of Reflow

Recommended reflow soldering temperature profile is in the following.

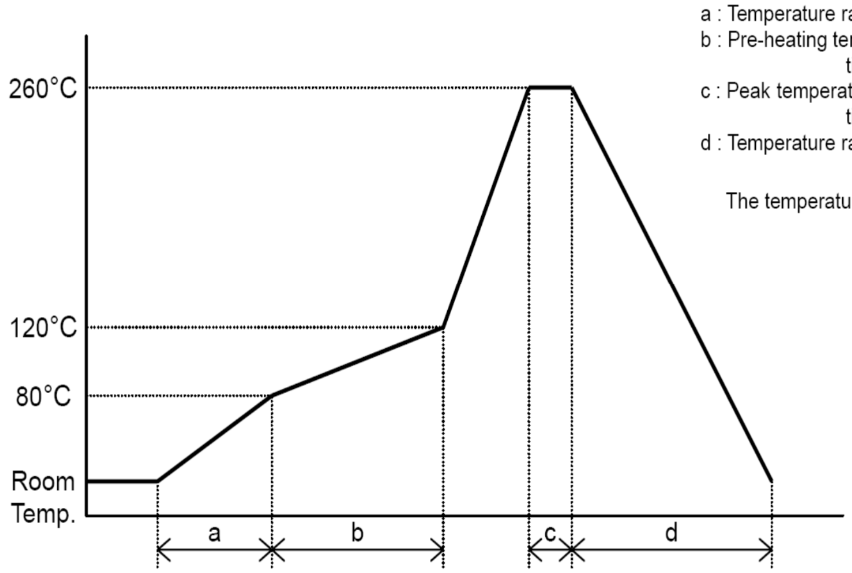


a :Temperature ramping rate : 1 to 4°C /s
b :Pre-heating temperature : 150°C to 180°C
time : 60 to 120s
c :Temperature ramp rate : 1 to 4°C /s
d :220 or higher time : Shorter than 60s
e :230 or higher time : Shorter than 40s
f :Peak temperature : Lower than 260°C
g :Temperature ramping rate : 1 to 6°C /s

The temperature indicates at the surface of mold package.

2. Soldering Temperature Profile of Flow

Recommended flow soldering temperature profile is in the following.



a : Temperature ramping rate : 1 to 7°C /s
b : Pre-heating temperature : 80 to 120°C
time : 60 to 120s
c : Peak temperature : Lower than 260°C
time : Shorter than 10s
d : Temperature ramping rate : 1 to7°C /s

The temperature indicates at solder joint.

3. Soldering Temperature Profile of Iron

Recommended iron soldering temperature profile is in the following.

At 1 lead Temperature : Lower than 350°C

Time : within 3s

4. Note

It is not good for IC's reliability to keep IC high temperature for long time within limit of recommended ranges.Please finish soldering as soon as possible within limit of recommended ranges.