Application Note: SA51023

High Common-Mode Rejection Line Receiver

General Description

The SA51023 combines high-performance audio operational amplifier cores with high-precision resistor networks to provide exceptional audio performance. The SA51023 uses an instrumentation amplifier topology with a fixed unity gain to provide high input impedance and a high common-mode rejection ratio (CMRR). Unlike other line receiver products that use a simple four-resistor difference amplifier topology, the SA51023 topology provides excellent CMRR even with mismatched source impedances.

Features

- High Common-mode Rejection: 106dB(Typical)
- High Input Impedance: 1MΩ Differential
- Ultra-low Total Harmonic Distortion + Noise: <0.001%
- Low Quiescent Current: 4.1mA (Typical)
- Short-circuit Protection
- Integrated EMI Filters
- Wide Supply Range: 4.5V to 18V
- Qualified According to AEC-Q100 Grade 1
- -40℃ to 125℃ Ambient Temperature Range
- Available in Small TSSOP-14 Package

Ordering Information

SA51023 □(□□□)

Package Code

Optional Spec Code

Ordering Number	Package type	Note
SA51023HDA	TSSOP14	

Applications

- Differential Audio Interfaces
- Audio Input Circuitry
- Line Drivers
- Audio Power Amplifiers
- Audio Analyzers
- High-End Audio and Video (A/V) Receivers

Typical Application

The SA51023 device is designed to require a minimum number of external components to achieve data sheet level performance in audio line-receiver applications. Figure1 shows the professional audio applications of SA51023. The line receiver recovers a differential audio signal which may have been affected by significant common-mode noise.

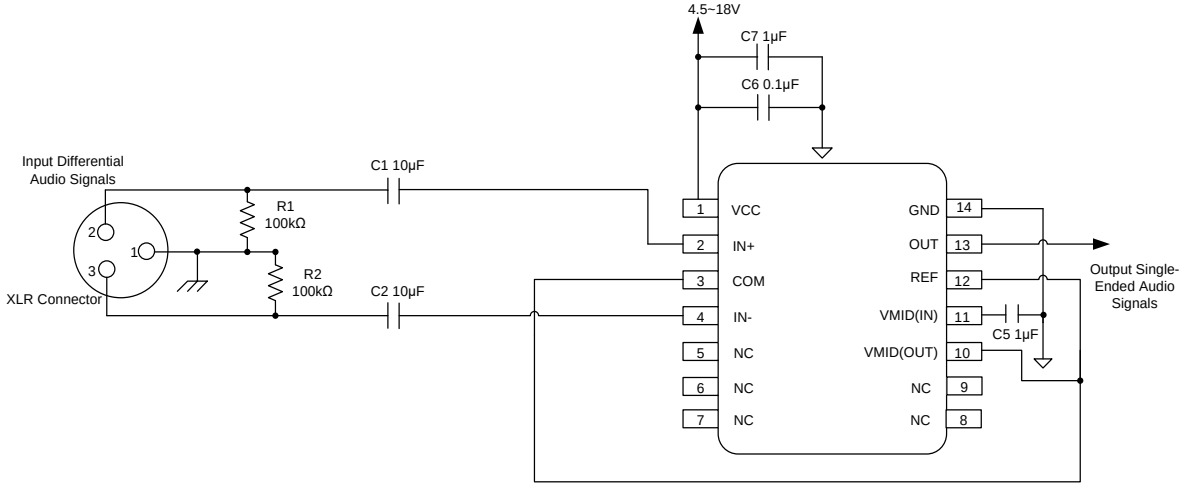
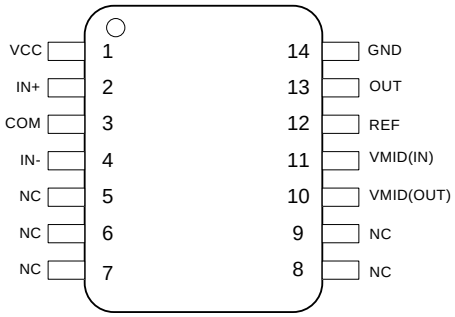


Figure 1. Typical Application

Pinout (top view)



(TSSOP14)

Top Mark: BYY*xyz* **(**device code: BYY, ***x=year code, y=week code, z= lot number code)***

Pin Description

Pin Name	Pin No.	TYPE(1)	Pin Description
VCC	1		Positive (highest) power supply.
IN+	2	I	Non-inverting input.
COM	3	I	Input common.
IN-	4	I	Inverting input.
NC	5,6,7,8,9		No connection.
VMID(OUT)	10	O	Buffered output of internal supply divider.
VMID(IN)	11	I	Input node of internal supply divider. Connect a capacitor to this pin to reduce noise from the supply divider circuit.
REF	12	I	Reference input, This pin must be driven from a low impedance.
OUT	13	O	Output.
GND	14		Ground pin.

Note: (1) TYPE: I = input; O = output.

Block Diagram

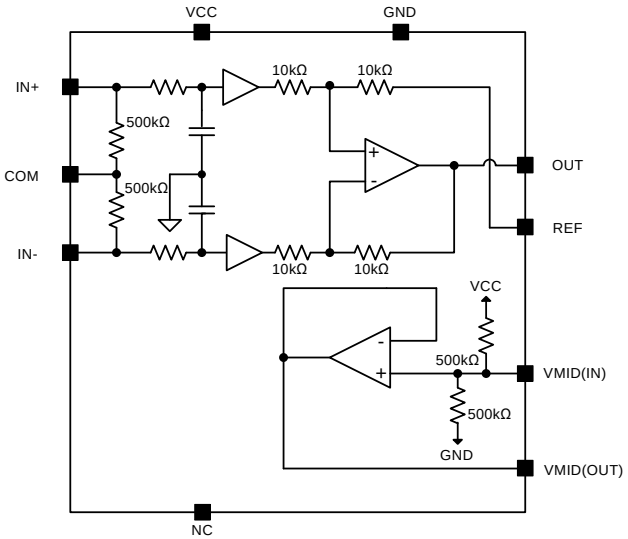


Figure 2. Block Diagram

Absolute Maximum Ratings (Note 1)

V_{CC}, Supply Voltage ---------- -0.3V to 30V
Input Pins Voltage ---------- -0.3V to V_{CC}+0.3V
Input Pins Current ---------- ±10mA
Package Thermal Resistance (Note 2)
θ_{JA} ---------- 95 ℃/W
θ_{JC} (top) ---------- 15 ℃/W
θ_{JB} ---------- 47 ℃/W
ψ_{JT} ---------- 0.84 ℃/W
Operating Temperature Range---------- -55 ℃ to 125 ℃
Junction Temperature Range ---------- 150 ℃
Storage Temperature Range ---------- -65 ℃ to 150 ℃

Recommended Operating Conditions

V_{CC}, Supply Voltage Range---------- 4.5V to 18V
Input Pins Voltage Range----------0V to V_{CC}
Ambient Temperature Range---------- -40 to 125 ℃

Electrical Characteristics

T_A = -40℃ to 125℃, V_{CC} = 4.5V to 18V, V_{CM} = V_{OUT} = midsupply, and R_L = 2kΩ, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Audio Performance (Note 4)						
Total Harmonic Distortion + Noise	THD+N	V_O=3VRMS, f=1kHz, 90kHz measurement bandwidth, V_{CC}=18V		0.0007%		
Intermodulation Distortion	IMD	SMPTE and DIN two-tone, 4:1 (60Hz and 7kHz), V_O =3VRMS, 90kHz measurement bandwidth		0.0011%		
		CCIF twin-tone (19kHz and 20kHz),V_O =3VRMS, 90kHz measurement bandwidth		0.00027%		
AC Performance (Note 4)						
Small Signal Bandwidth	BW	V_{OUT} =0.1V_P		3.5		MHz
Slew Rate	SR			3		V/μs
Full-power Bandwidth (Note 3)		V_{OUT} =1V_P		0.47		MHz
Phase Margin	PM	C_L = 20 pF		80.5		°
		C_L = 200 pF		76.5		°
Settling Time	t_s	To 0.01%, V_{CC}=18V, 10V step		2.2		μs
Overload Recovery Time					330	ns
EMI/RFI Filter Corner Frequency (Note 5)				80		MHz
Noise (Note 4)						
Output Voltage Noise		f = 20Hz to 20kHz, no weighting		6		μVRMS
				–104.7		dBu
Output Voltage Noise Density (Note 5)	e_n	f = 100Hz		90		nV/√Hz
		f = 1kHz		45		
Offset Voltage						
Output Offset Voltage	V_{OS}			±1	±4	mV
Output Offset Voltage Drift (Note 5)	dV_{OS}/dT			3		μV/°C
Power-supply Rejection Ratio (Note 4)	PSRR			2		μV/V
Gain (Note 4)						
Gain				1		V/V
Gain Error				0.08%		
Gain Nonlinearity (Note 5)				1	5	ppm
Input Voltage Range						
Common-mode Voltage Range	V_{CM}		0.25		V_{CC} – 2	V

Common-mode Rejection Ratio	CMRR	$0.25V \le V_{CM} \le V_{CC}$-2V, REF and COM pins connected to $V_{MID(OUT)}$, V_{CC}=18V		90	106		dB
Input Impedance							
Differential				850	1000	1150	kΩ
Common-mode				212.5	250	287.5	kΩ
Input Resistance Mismatch					0.01%	0.25%	
Supply Divider Circuit (Note 4)							
Nominal Output Voltage					V_{CC}/ 2		V
Output Voltage Offset		$V_{MID(IN)} = V_{CC}/2$			1	4	mV
Input Impedance		VMID(IN) pin, f=1kHz			240		kΩ
Output Resistance		VMID(OUT) pin			0.96		Ω
Output Voltage Noise		20Hz to 20kHz, C_{MID}=1μF			2.7		μVRMS
Output Capacitive Load Limit		Phase Margin > 45 °, R_{ISO}=0Ω			150		pF
Output							
Voltage Output Swing from Rail	V_O	Positive rail	R_L = 2kΩ	160	280	400	mV
			R_L = 600Ω	650	850	1200	
		Negative rail	R_L = 2kΩ	100	180	250	
			R_L = 600Ω	330	550	800	
Output Impedance (Note 4)	Z_{OUT}	T_A=25 ℃,f ≤ 100kHz, I_{OUT} = 0A			0.96		Ω
Short-circuit Current	I_{SC}	V_{CC}=18V			±70	±83	mA
Power Supply							
Quiescent Current	I_Q	I_{OUT} = 0 A			4.1	5.1	mA

Note 1: Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. 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 remain possibility to affect device reliability.

Note 2: θ_{JA} is measured in the natural convection at T_A = 25 ℃ on a high effective four layer thermal conductivity test board of JEDEC 51-7 .

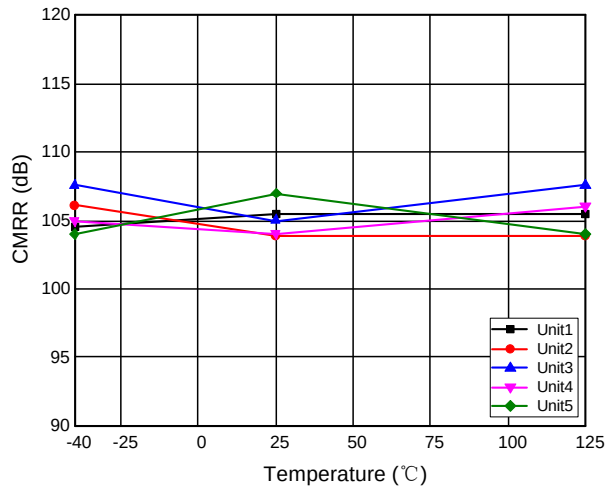
Note 3: Full-power bandwidth = SR / ($2\pi \times V_P$), where SR = slew rate.

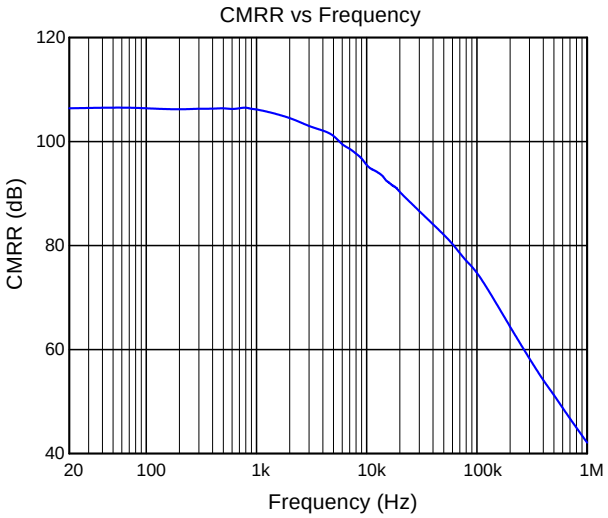
Note 4: Typical value tested on demonstration board is guaranteed by design.

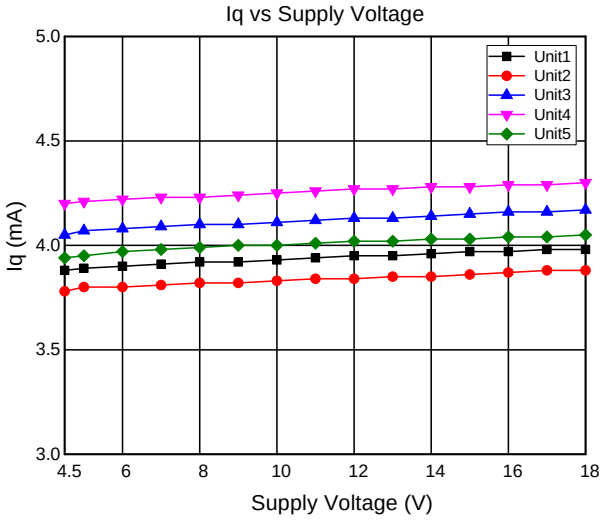
Note 5: Specified by design and characterization.

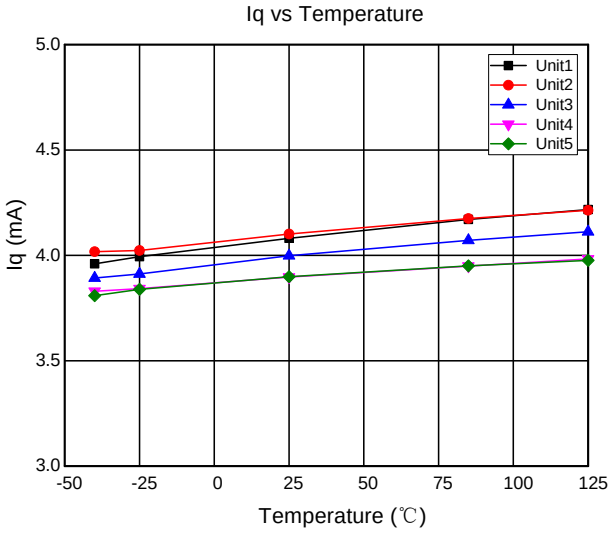
Typical Performance Characteristics

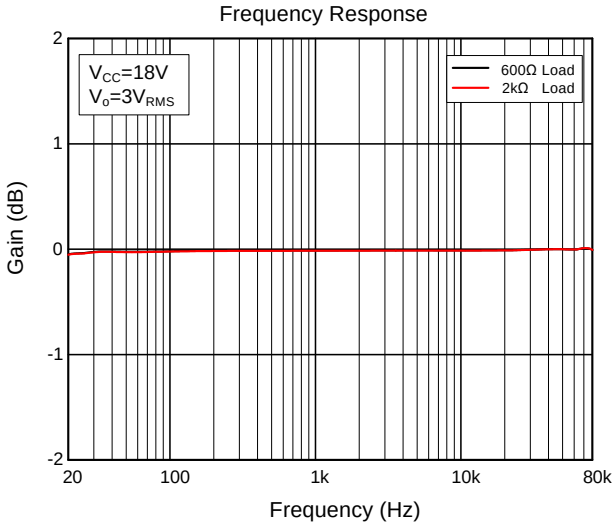
T_A=25℃, V_{CC}=18V， V_{CM} = V_{OUT} = midsupply, and R_L = 2 kΩ (unless otherwise noted)

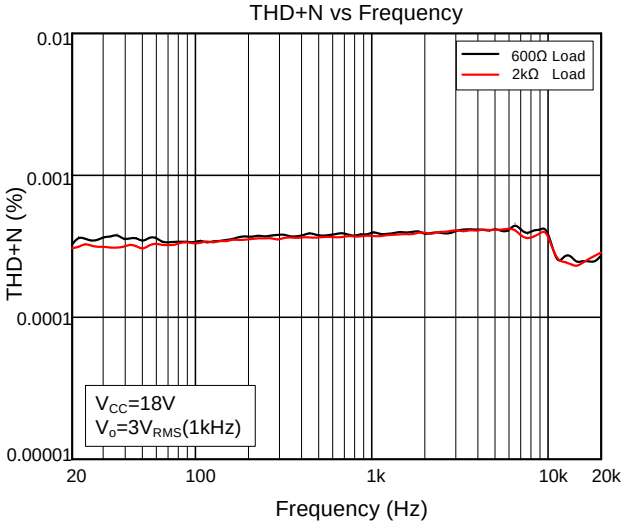


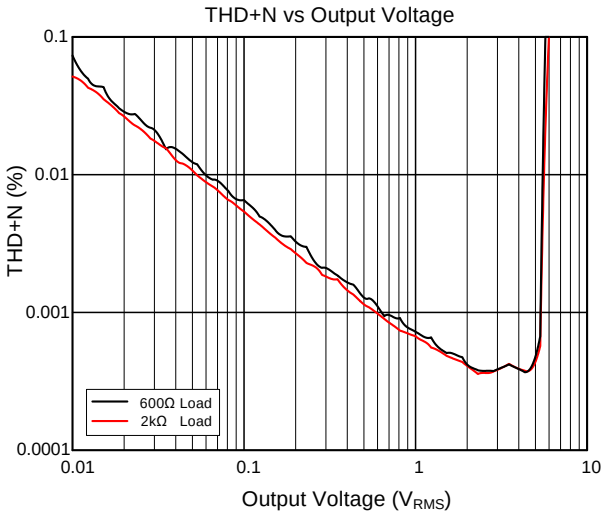


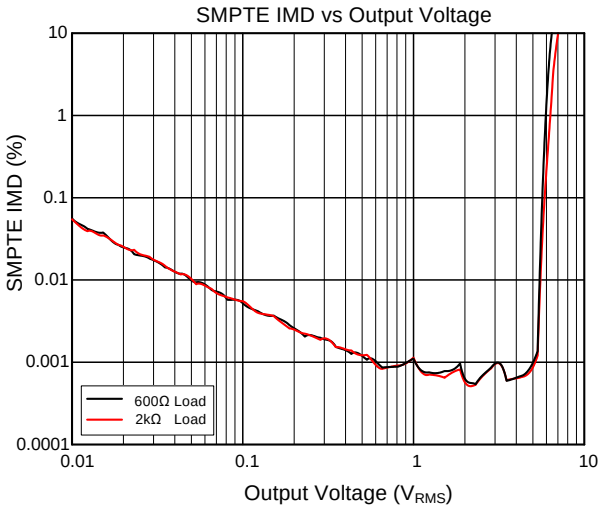


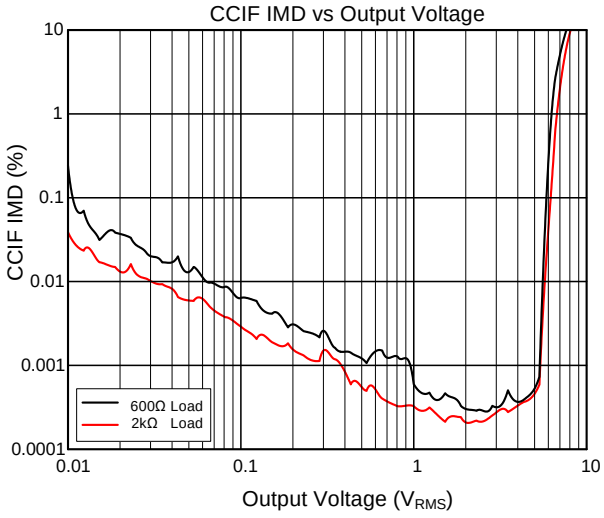












Operation

Audio Signal Path

The basic elements present in audio signal pathway of the SA51023 shows in Figure3. The primary elements include: input biasing resistors, electromagnetic interference (EMI) filtering, input buffers, and a difference amplifier. The primary role of an audio line receiver is to convert a differential input signal into a single-ended output signal while rejecting noise that is common to both inputs (common-mode noise). The difference amplifier (which consists of an op amp and four matched 10kΩ resistors) accomplishes this task. The basic transfer function of the circuit is shown in Equation 1:

$$V_{OUT} = (V_{IN+} - V_{IN-}) + V_{REF} \qquad (1)$$

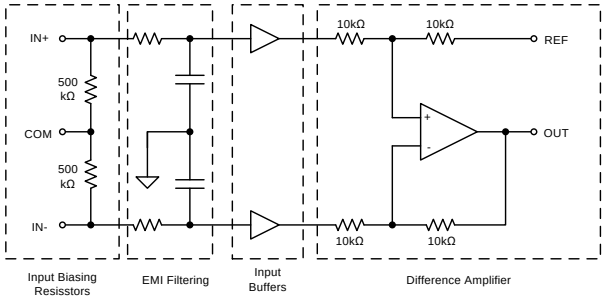


Figure 3. Audio Signal Path

The input buffers prevent external resistances (such as those from the PCB, connectors, or cables) from ruining the precise matching of the internal 10kΩ resistors which would degrade the high common-mode rejection of the difference amplifier. As is typical of many amplifiers, a small bias current flows into or out of the buffer amplifier inputs. This current must flow to a common potential for the buffer to function properly. The input biasing resistors provide an internal pathway for this current to the COM pin. The COM pin connects to the output of the internal supply divider (VMID(OUT)). Finally, EMI filtering is added to the input buffers to prevent high-frequency interference signals from propagating through the audio signal pathway.

Supply Divider

The SA51023 integrates a supply-divider circuit which may bias the input common-mode voltage and output reference voltage to the halfway point between the applied power supply voltages. The nominal output voltage of the supply divider circuit is shown in Equation 2:

$$V_{MID(OUT)} = \frac{V_{CC}}{2} \qquad (2)$$

Figure4 illustrates the internal topology of the supply-divider circuit. The supply divider consists of two 500kΩ resistors connected between the VCC and GND pins of the SA51023. The noninverting input of a buffer amplifier is connected to the midpoint of the voltage divider that is formed by the 500kΩ resistors. The buffer amplifier provides a low-impedance output that is required to bias the REF pins without degrading the CMRR.

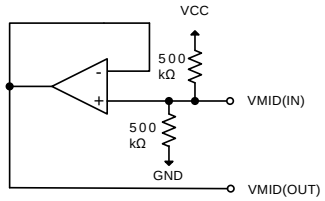


Figure 4. Internal Supply Divider Circuit

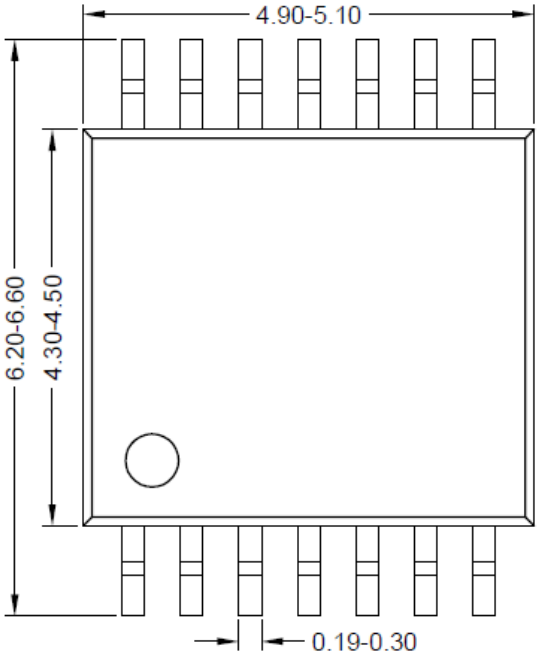
Thermal Shutdown

If the junction temperature of the SA51023 exceeds approximately 170℃, a thermal shutdown circuit will disable the amplifier to protect the device from damage. The amplifier will be automatically re-enabled after the junction temperature falls below the shutdown threshold temperature. If the condition that caused excessive power dissipation is not removed, the amplifier will oscillate between a shutdown and enabled state until the output fault is corrected.

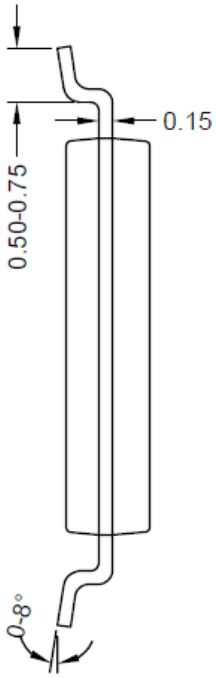
Single-Supply Operation

The SA51023 is used on single power supplies ranging from 4.5V to 18V. Use the COM and REF pins to level shift the internal voltages into a linear operating condition. Ideally, connecting the REF and COM pins to a midsupply potential (such as the $V_{MID(OUT)}$ pin) avoids saturating the output of the internal amplifiers.

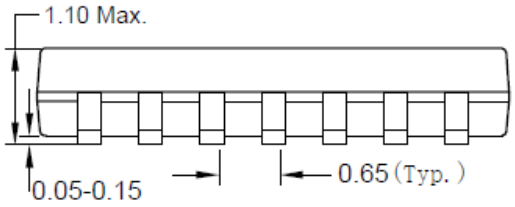
TSSOP14 Package Outline Drawing



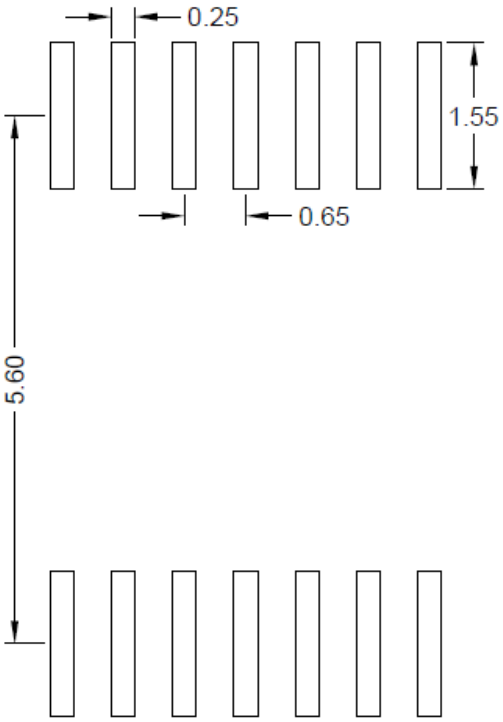
Top view



Side view



Front view



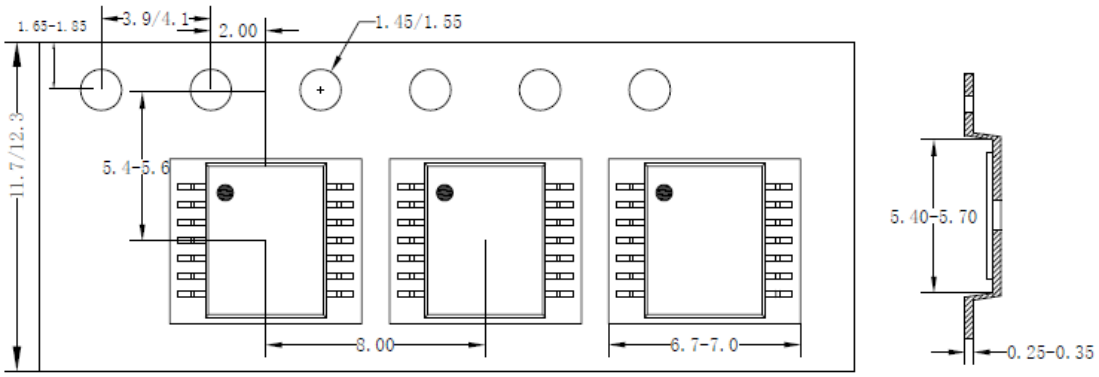
Recommended PCB layout
(Reference only)

Notes: 1, All dimension in millimeter and exclude mold flash & metal burr;

Taping & Reel Specification

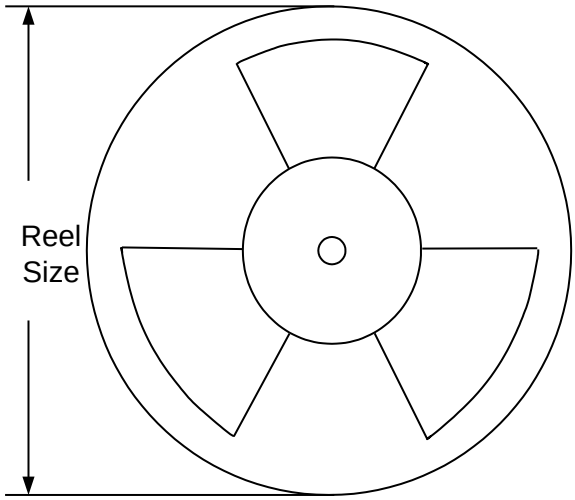
1. Taping Orientation

TSSOP14



Feeding direction →

2. Carrier Tape & Reel Specification for Packages



Package types	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Trailer length(mm)	Leader length (mm)	Qty per reel
TSSOP14E	12	8	13"	400	400	2500

3. Others: NA

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