NuMicro® Family

Operational Amplifiers (OP Amps)

NOP912/NOP914 Series Datasheet

For additional information or questions, please contact: Nuvoton Technology Corporation.

www.nuvoton.com

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1 GENERAL DESCRIPTION

The NOP912/NOP914 series operational (OP) amplifier is a 2.7~5.5V single-powered OP amplifier with low offset voltage and wide gain bandwidth devices. It is suitable for precision small signal and high speed signal conditioning, such as voltage or current sampling and sensor interfacing in industrial control.

The NOP912/NOP914 series is a chopper-stabilized amplifier which can minimize the offset voltage to 50 µV and temperature drift to 0.05 µV/°C. The NOP912/NOP914 series also provides wide gain bandwidth to 8 MHz, rail-to-rail input/output, and high slew rate to help users improve the precision of measurement.

The NOP912 series (Dual version) is offered in the SOIC8 package. The NOP914 series (Quad version) is offered in the TSSOP14 package. All versions are specified over the industrial temperature range of -40°C to +105°C.

The above features make the NOP912/NOP914 series suitable for applications such as photodiode amplification, sensor interface, signal conditioning, and battery powered instrumentation.

2 FEATURES

- Low offset voltage: 50µV
- Offset Voltage Temperature Drift: 0.05 µV/℃
- Low noise: 140 nV/$\sqrt{Hz}$
- High Slew Rate: 6V/us
- Wide Gain-bandwidth: 8 MHz
- Low Supply Current
  - NOP912(dual): 2.5 mA
  - NOP914(quad): 4 mA
- Operation power supply: 2.7 V to 5.5 V
- Rail-to-rail settle time: 1µs
- Temperature range: -40°C to 105°C
- Package Types: SOIC8, TSSOP14
- ESD internal protection: ±4KV,Latch-up ±100mA
- EFT ±4.4KV

3 APPLICATIONS

- Photodiode amplification
- Sensor interface
- Battery powered instrumentation
- Portable devices
- Signal conditioning
- Active filtering
- Health care application

4 PARTS INFORMATION

Package is Halogen-free, RoHS-compliant and TSCA-compliant.

4.1 Package Type

Part No.	Package	Body Size
NOP912	SOIC8	3.91 mm x 4.90 mm
NOP914	TSSOP14	4.40 mm x 5.00 mm

5 PIN CONFIGURATION

5.1 NOP912 Series SOIC 8-Pin Diagram

Part Number: NOP912

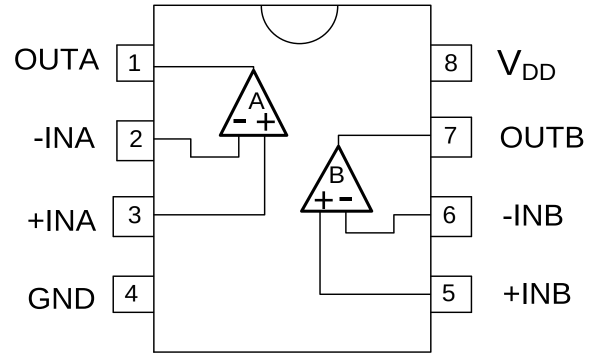


Figure 5-1 NOP912 Series SOIC 8-Pin Diagram

5.2 NOP914 Series TSSOP 14-Pin Diagram

Part Number: NOP914

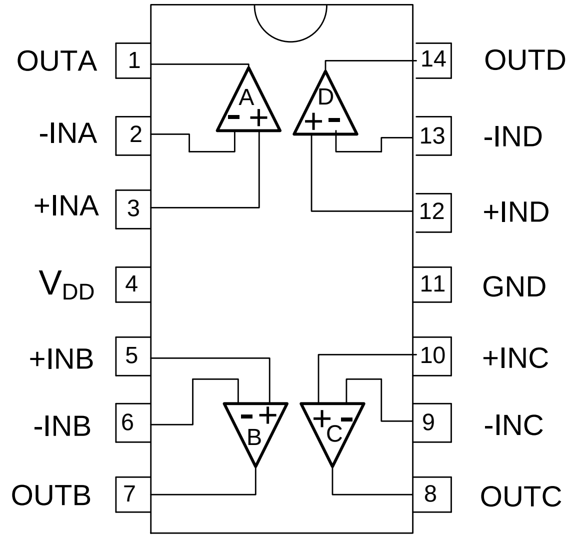


Figure 5-2 NOP914 Series TSSOP 14-Pin Diagram

5.3 Pin Functional Description

Pin Number		Pin Name	Type	Description
NOP914 (TSSOP14)	NOP912 (SOIC8)			
1	1	OUTA	O	Output, channel A
2	2	-INA	I	Inverting input, channel A
3	3	+INA	I	Noninverting input, channel A
4	8	V_{DD}	P	Power supply
5	5	+INB	I	Noninverting input, channel B
6	6	-INB	I	Inverting input, channel B
7	7	OUTB	O	Output, channel B
8	-	OUTC	O	Output, channel C
9	-	-INC	I	Inverting input, channel C
10	-	+INC	I	Noninverting input, channel C
11	4	GND	G	GND
12	-	+IND	I	Noninverting input, channel D
13	-	-IND	I	Inverting input, channel D
14	-	OUTD	O	Output, channel D

Table 5.3-1 Pin Functional Description Table

6 FEATURE DESCRIPTION

6.1 Overview

The NOP912/NOP914 series is engineered with the unique combination of a proprietary precision auto-calibration technique, and offers low input offset voltage and drift and achieve excellent input and output dynamic linearity. The NOP912/NOP914 series also includes 8 MHz gain bandwidth, 140-nV/$\sqrt{Hz}$ noise and spectral density, making the NOP912/NOP914 suitable for high-accuracy and wide-bandwidth signal conditioning.

6.2 Operating Voltage

The NOP912/NOP914 series operates in only single power voltage range from 2.7V to 5.5V. In addition, all temperature specifications apply from -40°C to +105°C. Most behavior remains unchanged throughout the full operating voltage range. Key parameters that vary over the supply voltage or temperature range are shown in chapter 9錯誤! 找不到參照來源。.

6.3 Rail-to-Rail Input and Output

The NOP912/NOP914 series features rail-to-rail input/output (RRIO) with a supply voltage from 2.7V to 5.5V. This allows the amplifier inputs to have a wide common mode range. This is achieved by using complementary input stage. For normal operation, inputs should be limited to this range.

7 APPLICATION AND IMPLEMENTATION

The NOP912/NOP914 series has low offset, high gain bandwidth and high open-loop gain. It is suitable for high precision voltage/current measurement and sensor interfacing application.

7.1 Precision Current Shunt Sensor

A precision current shunt sensor benefits from the unique attributes of auto-zero amplifiers when used in a differential configuration, as shown in Figure 7-1. The current shunt sensors are used in precision current sources for feedback control systems. The current shunt sensors are also used in a variety of other applications, including motor control, battery monitor and precision power metering.

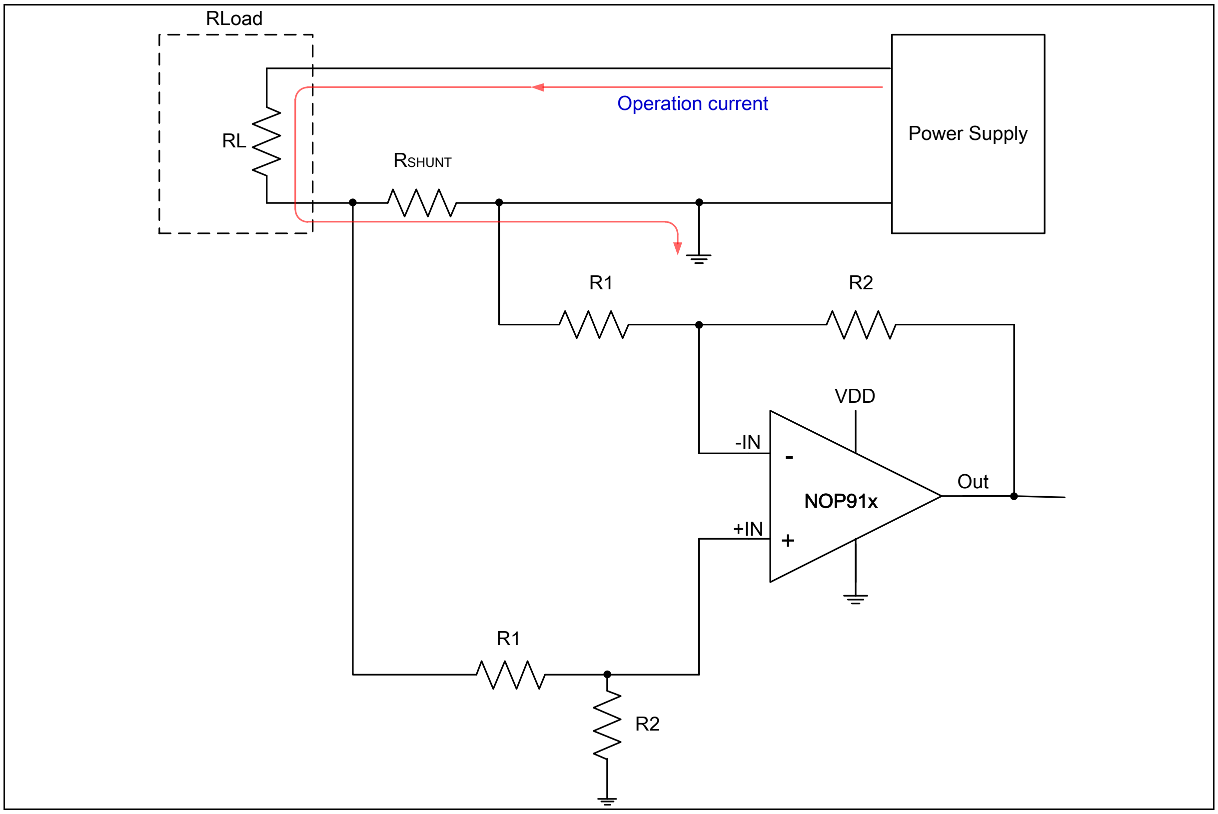


Figure 7-1 Precision Current Shunt Sensor Amplifier Circuit

$V_{OUT} = (I_{OP} * R_{SHOUNT}) * (R2/R1) = (V1 - V2) * (R2/R1)$

In such applications, a low resistance shunt sensor minimizes the series voltage drop. A typical shunt might be around 0.1Ω or lower. For measuring around 1A current, the output signal between the shunt is around hundreds of millivolts, this minimizes wasted power and allows the measurement of high currents while saving power.

7.2 Photodiode Trans-Impedance Amplification

The NOP912/NOP914 series, with high bandwidth and slew rate, is well suited for photodiode signal conditioning in a Trans-impedance amplifier circuit. This application is useful in high performance UV sensors, smoke detectors or particle sensors.

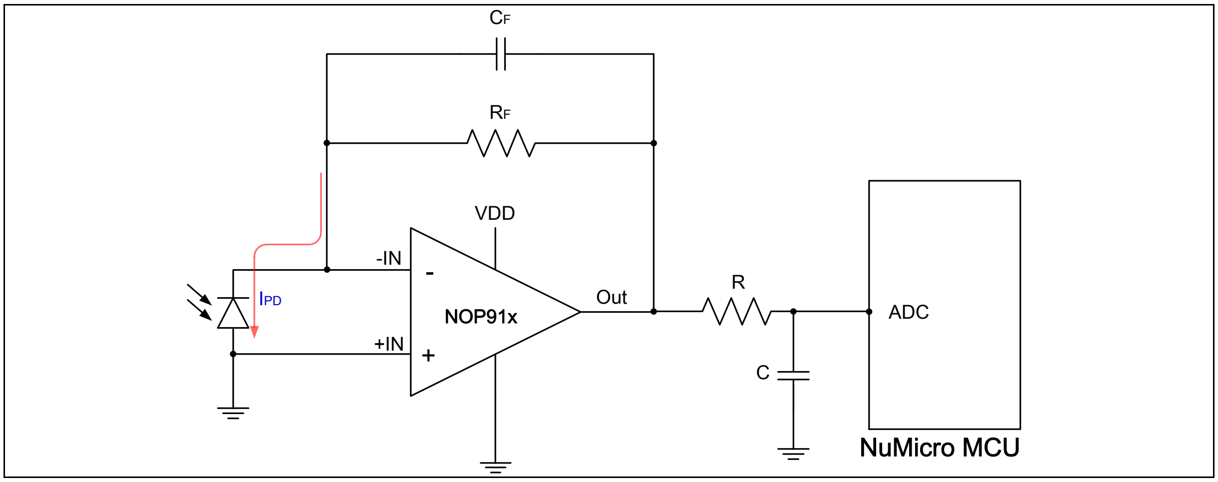


Figure 7-2 Photodiode Trans-Impedance Amplifier Circuit

The trans-impedance amplifier circuit converts the small photodiode output current in the nA range into a voltage signal readable by an ADC. The feedback resistance is usually in the MΩ range, in order to get a large enough voltage output range. However, together with the diode parasitic capacitance, the op amp input capacitances and the PCB stray capacitance, this feedback network creates a pole that makes the circuit oscillate. Using a small (pF) capacitor in parallel with the feedback resistor is mandatory to stabilize the circuit.

To avoid OP output voltage staying close to 0V which OP operates in nearly low saturation state, a small bias voltage may be applied to non-inverting end.

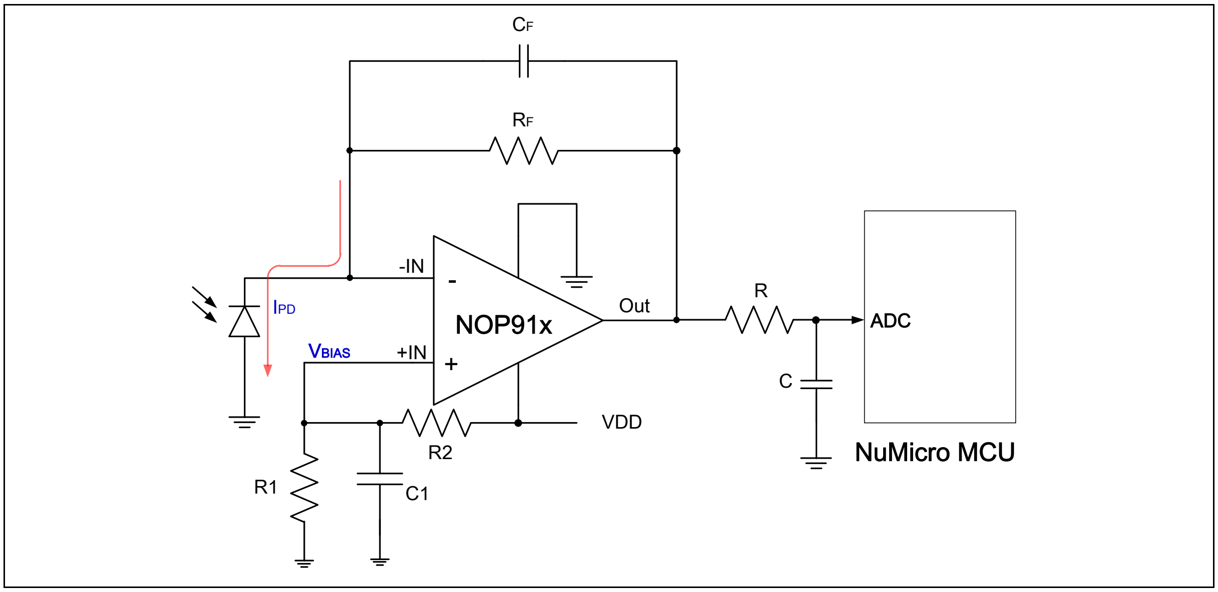


Figure 7-3 Photodiode Trans-Impedance Amplifier Circuit with Bias Voltage

8 ELECTRICAL CHARACTERISTICS

8.1 Absolute Maximum Ratings

Stresses above the absolute maximum ratings may cause permanent damage to the device. The limiting values are stress ratings only and cannot be used to functional operation of the device. Exposure to the absolute maximum ratings may affect device reliability and proper operation is not guaranteed.

8.2 Voltage Characteristics

Symbol	Description	Min	Max	Unit
V_{DD}	DC power supply	-0.3	6	V
V_{IN}	Input voltage on any other pin	-0.3	V_{DD}+0.3	V

Note:

1. V_{DD} and GND pins must be connected to the external power supply.

Table 8.2-1 Voltage Characteristics

8.3 General Operating Conditions

V_{DD} = 2.7 to 5.5V, T_A = 25°C unless otherwise specified.

Symbol	Parameter	Min	Typ	Max	Unit	Test Conditions
T_A	Temperature	-40	-	105	°C	
V_{DD}	Operation voltage	2.7	-	5.5	V	

Table 8.3-1 General Operating Conditions

8.4 Thermal Characteristics

The average junction temperature can be calculated by using the following equation:

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

- T_A = ambient temperature (°C)
- θ_{JA} = thermal resistance junction-ambient (°C/Watt)
- P_D = sum of internal and I/O power dissipation

Symbol	Description	Min	Typ	Max	Unit
T_A	Operating ambient temperature	-40	-	105	°C
T_J	Operating junction temperature	-40	-	125	°C
T_{ST}	Storage temperature	-65	-	150	°C
θ_{JA}[*1]	Thermal resistance junction-ambient SOIC8	-	120	-	°C/Watt
	Thermal resistance junction-ambient TSSOP14	-	100	-	°C/Watt
Note: Determined according to JESD51-2 Integrated Circuits Thermal Test Method Environment Conditions.					

Table 8.4-1 Thermal Characteristics

8.5 EMC Characteristics

8.5.1 Electrostatic discharge (ESD)

For Nuvoton products, there are ESD protection circuits built into chips to avoid any damage that can be caused by typical levels of ESD.

8.5.2 Static Latchup

Two complementary static tests are required on six parts to assess the latchup performance:

- A supply overvoltage is applied to each power supply pin
- A current injection is applied to each input and output.

8.5.3 Electrical Fast Transients (EFT)

In some application circuit compoment will produce fast and narrow high-frequency trasnients bursts of narrow high-frequency transients on the power distribution system.

- Inductive loads:
  - Relays, switch contactors
  - Heavy-duty motors when de-energized etc.

The fast transient immunity requirements for electronic products are defined in IEC 61000-4-4 by International Electrotechnical Commission (IEC).

Symbol	Description	Min	Typ	Max	Unit
V_{HBM}[*1]	Electrostatic discharge,human body mode	-4000	-	+4000	V
V_{CDM}[*2]	Electrostatic discharge,charge device model	-500	-	500	
LU[*3]	Pin current for latch-up[*3]	-100	-	100	mA
V_{EFT}[*4] [*5]	Fast transient voltage burst	-4.4	-	+4.4	kV

Notes:

1. Determined according to ANSI/ESDA/JEDEC JS-001 Standard for Electrostatic Discharge(ESD) Sensitivity Testing – Human Body Model (HBM) – Component Level
2. Determined according to ANSI/ESDA/JEDEC JS-002 Standard for Electrostatic Discharge(ESD) Sensitivity Testing – Charged Device Model (CDM) – Component Level.
3. Determined according to JEDEC EIA/JESD78 Standard.
4. Determinded according to IEC 61000-4-4 Electrical fast transient/burst(EFT) immunity test.
5. The performace cretia class is 4A.

Table 8.5-1 EMC Characteristics

8.6 DC Electrical Characteristics

(V_{DD} = 2.7V ~ 5.5V, T_A = 25 °C, V_{CM} = V_{DD}/2, R_L = 10KΩ connected to V_{DD}/2, unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit	Test Condition
V_{DD}	Analog supply voltage	2.7	5	5.5	V	
I_{DD}	Current Consumption of NOP912		2.5	4	mA	
	Current Consumption of NOP914		4	6	mA	
T_A	Temperature	-40	25	105	℃	
V_{CM}[*1]	Common mode input range	0	-	V_{DD}	V	
V_{DD} - V_{OH}	High level output Voltage		50	100	mV	R_L=10 KΩ, connect to V_{DD}/2
V_{OL}	Low level output Voltage		50	100	mV	R_L=10 KΩ, connect to V_{DD}/2
I_{SC}	Short Circuit Current		40	72	mA	V_{DD} = 5V
R_{LOAD}[*1]	External resistive load at output	10	-	-	kΩ	
C_{LOAD}[*1]	External capacitive load at output	-	-	50	pF	
R_D[*1]	Open-loop Output Impedance		125		Ω	I_O=0 mA, f=1 MHz
V_{OS}	Input offset voltage	-	50	100	µV	V_{CM}=0~V_{DD}
ΔVio/ΔT[*2]	Input offset voltage Temperature Drift		0.05	0.15	µV/℃	V_{CM} =0~V_{DD}; T_A=-40~105℃
I_B	Input Bias Current		±200[*2]		pA	V_{DD} =5V, V_{CM}= V_{DD} /2
I_{OS}	Input Offset Current		±400[*2]		pA	V_{DD} =5V, V_{CM}= V_{DD} /2
CMRR[*2]	Common Mode Rejection Ratio	-	87	-	dB	V_{DD} =5V, V_{CM}= V_{DD} /2
PSRR[*1]	Power Supply Rejection Ratio	-	100	-	dB	V_{DD} =5V, V_{CM}= V_{DD} /2
GBW[*2]	Unity-gain bandwidth	6	8	12	MHz	V_{DD} =5V, V_{CM}= V_{DD} /2
SR	Slew rate	-	6	-	V/µS	R_{LOAD} = 10 KΩ, C_{LOAD} = 50pF From 10% to 90% output voltage
ts[*1]	Settling Time		1		µS	V_{DD} =5V, C_L=50pF,settle to 0.1%
A_O[*2]	Open loop gain	70	100	-	dB	
PM[*2]	Phase Margin	45	-	-	degree	V_{DD} =5V, V_{CM}= V_{DD} /2
GM[*1]	Gain Margin	-	16	-	dB	R_{LOAD} = 10 KΩ, C_{LOAD} = 50pF
C_{ID}[*1]	Input Capacitance Differential –mode		4		pF	
C_{IC}[*1]	Input Capacitance Common-mode		2.5		pF	
E_N[*1]	Input Voltage Noise		5		µVPP	
e_N[*1]	Input Voltage Noise Density		140		nV/$\sqrt{Hz}$	f =1kHz
			50		nV/$\sqrt{Hz}$	f=10kHz
i_N[*1]	Input Current Noise Density		23		fA/$\sqrt{Hz}$	f=1kHz

Note:

1. Guaranteed by design, not tested in production

2.	Guaranteed by characteristic, not tested in production.

Table 8.6-1 DC Electrical Characteristics

9 TYPICAL CHARACTERISTICS

At TA = 25°C, V_{DD} = 5V, V_{CM} = V_{DD} /2, RL = 10 KΩ connected to GND and CL = 50 Pf (unless otherwise noted)

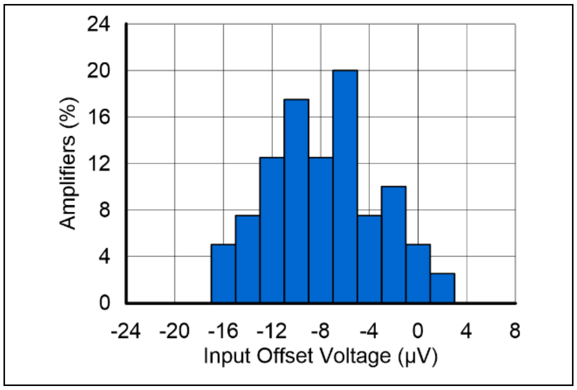


Figure 9-1 Offset Voltage Production Distribution

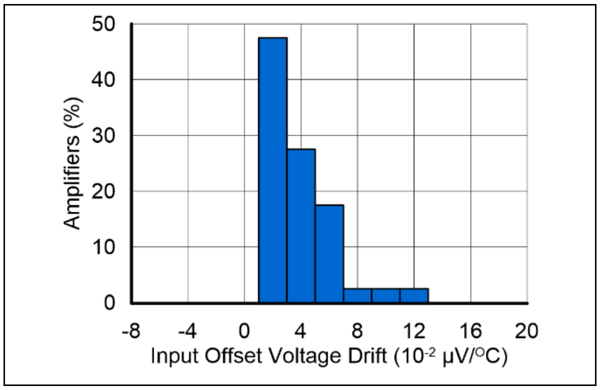


Figure 9-2 Offset Voltage Drift Distribution From 40°C to 125°C

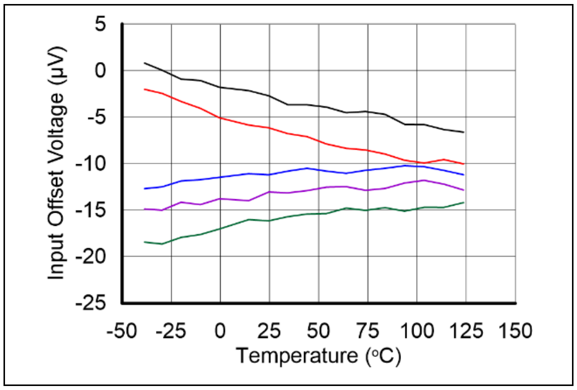


Figure 9-3 Offset Voltage vs Temperature

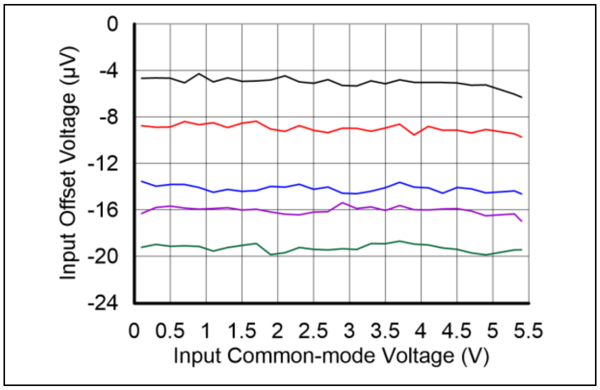


Figure 9-4 Offset Voltage vs Common-Mode Voltage

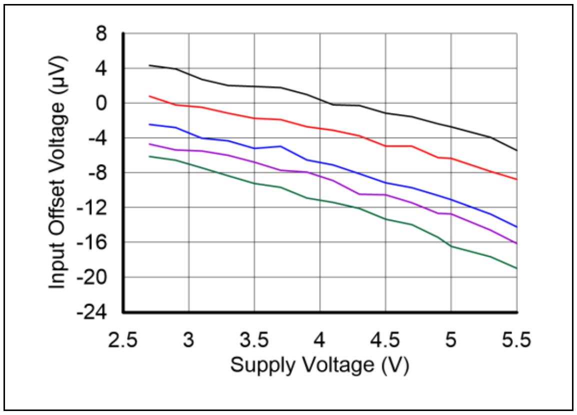


Figure 9-5 Offset Voltage vs Supply Voltage

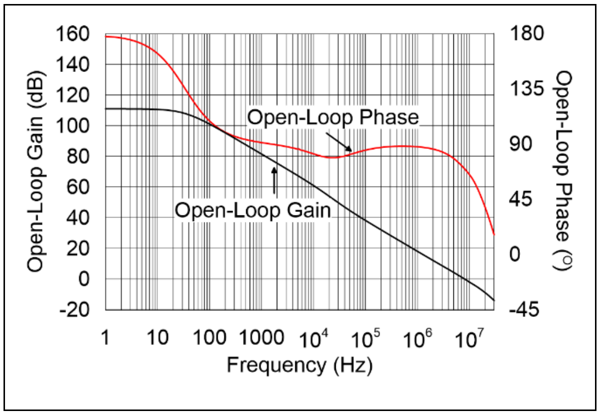


Figure 9-6 Open-Loop Gain and Phase vs Frequency

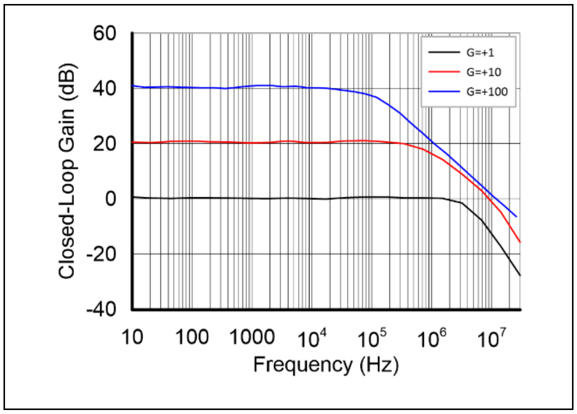


Figure 9-7 Closed-Loop Gain and Phase vs Frequency

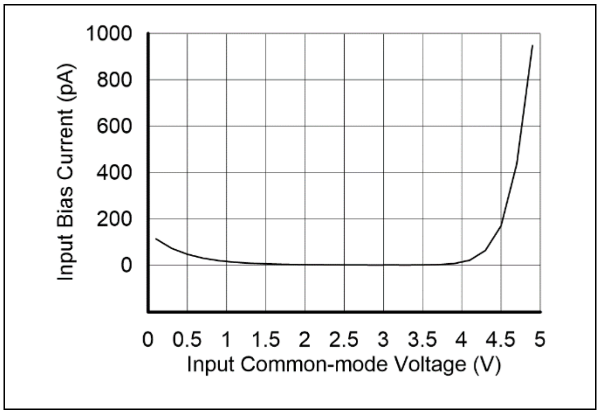


Figure 9-8 Input Bias Current vs Common-Mode Voltage

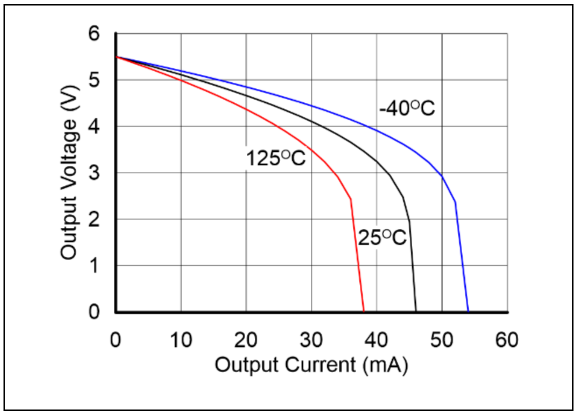


Figure 9-9 Output Voltage Swing vs Output Current (Max. supply)

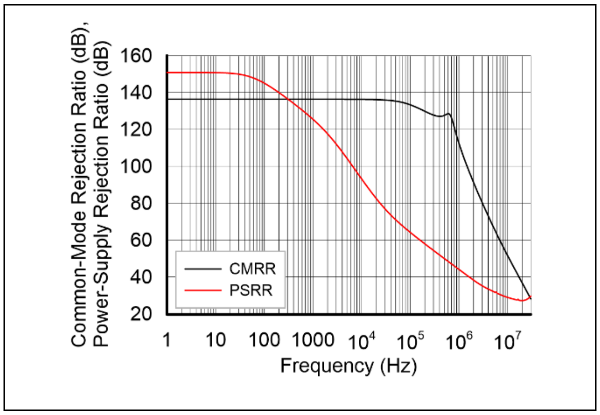


Figure 9-10 CMRR and PSRR vs Frequency

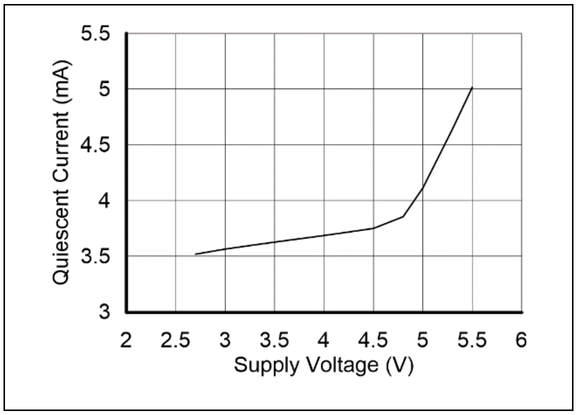


Figure 9-11 Quiescent Current vs Supply Voltage (NOP914)

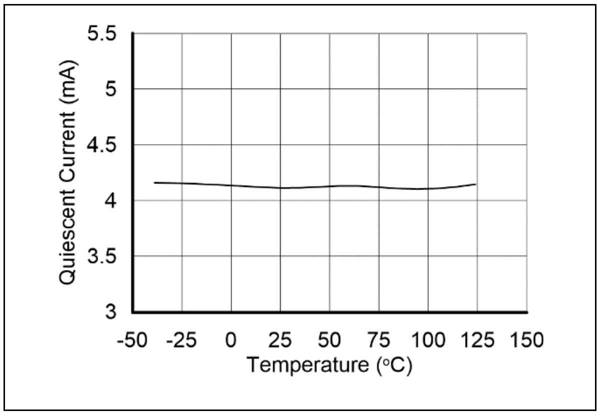


Figure 9-12 Quiescent Current vs Temperature (NOP914)

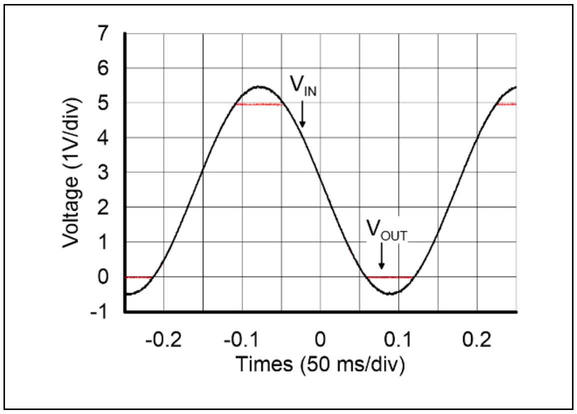


Figure 9-13 No Phase Reversal

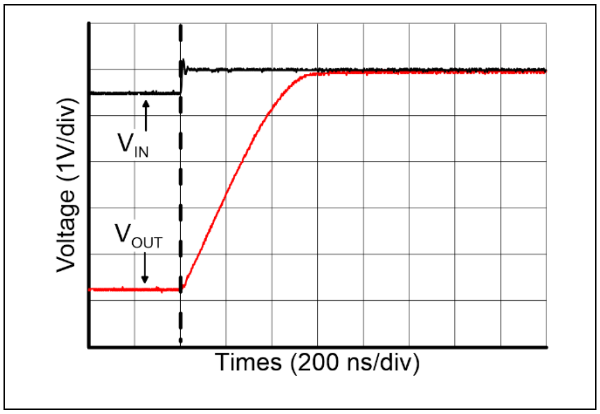


Figure 9-14 Positive Overload Recovery

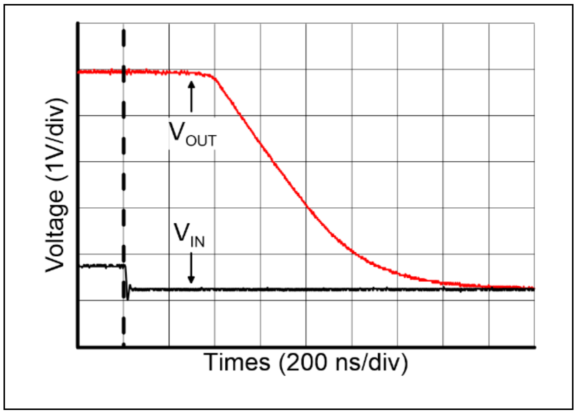


Figure 9-15 Negative Overload Recovery

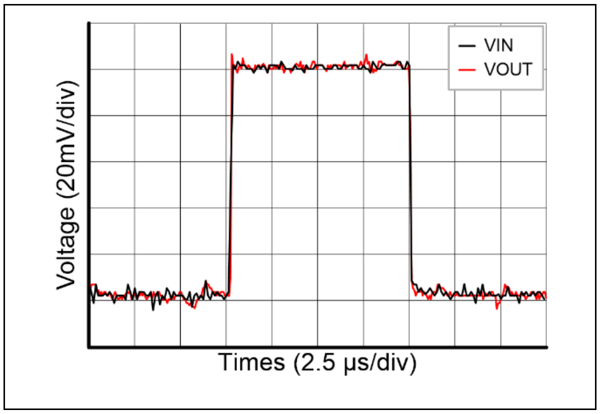


Figure 9-16 Small-Signal Step Response (10-mV Step)

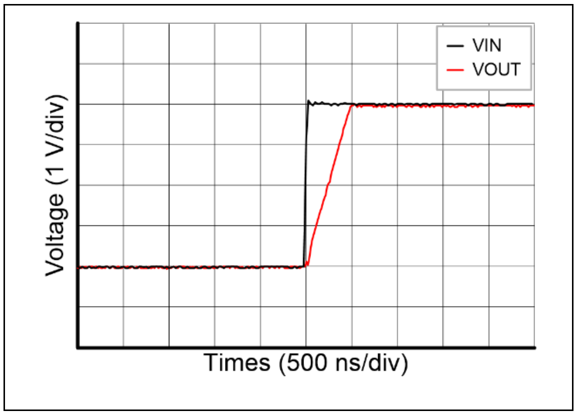


Figure 9-17 Large-Signal Step Response(4-V Step)

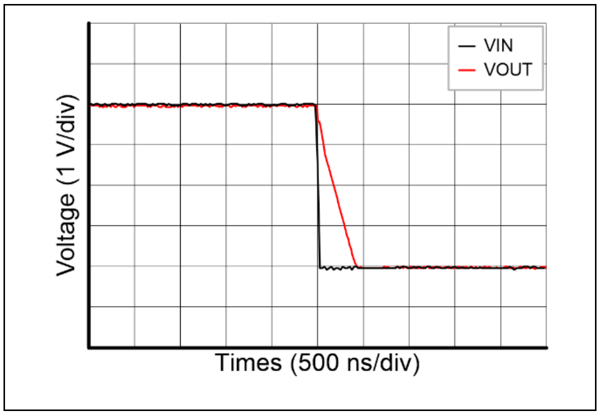


Figure 9-18 Large-Signal Step Response (4-V Step)

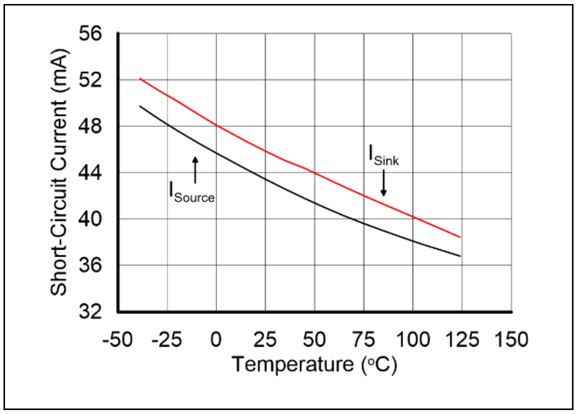


Figure 9-19 Short-Circuit Current vs Temperature

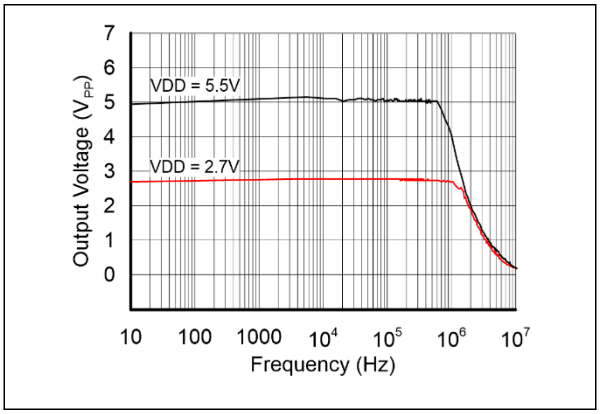


Figure 9-20 Maximum Output Voltage vs Frequency

10 LAYOUT

10.1 Layout Guidelines

The NOP912/NOP914 series operates from a single 2.7V to 5.5V. For best performance, at least 10nF ceramic capacitor should be placed close to the V_{DD} pin in single supply operation. Generally, utilize a good ground plane, keep traces short and place components as close as possible can provide good performance for NOP912/NOP914 operating.

For more techniques to reduce susceptibility to electromagnetic interference and keep OP amp's high accuracy, please refer to below information.

10.1.1 Grounding

Good grounding is a system-level design consideration. The NOP912/NOP914 power and ground traces are critical as they must provide adequate energy and grounding for all circuits. The best practice is to use short and wide PCB traces to minimize voltage drops and parasitic inductance.

10.1.2 Decoupling

Decoupling capacitor in order to ensure op amp full functionality, it is mandatory to place a decoupling capacitor of at least 10 nF as close as possible to NOP912/NOP914 V_{DD} pins. A good decoupling helps to reduce electromagnetic interference impact.

10.2 Layout Example

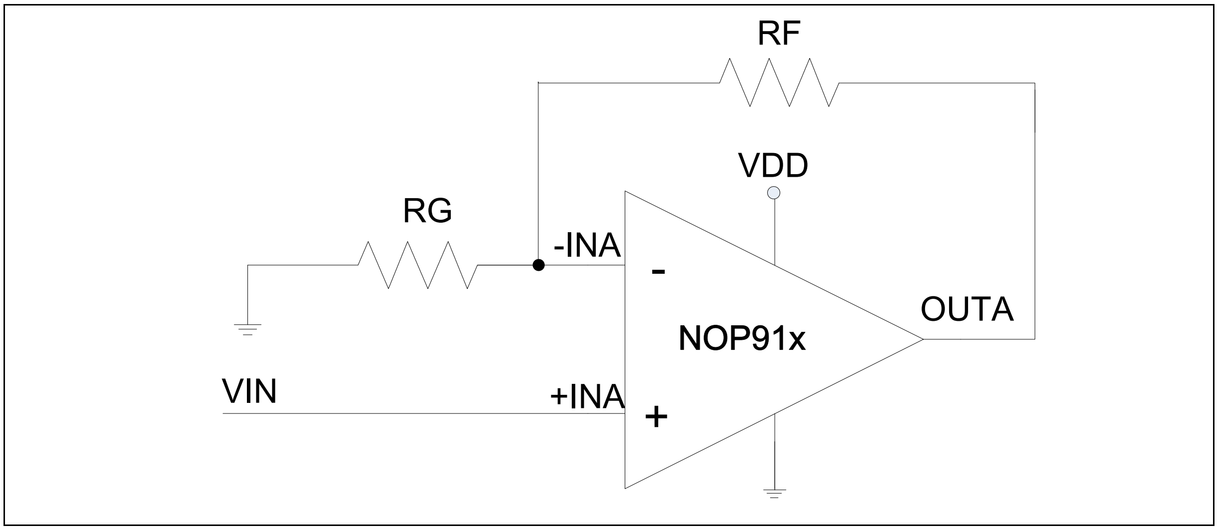


Figure 10-1 NOP912/NOP914 Schematic Representation Layout Example

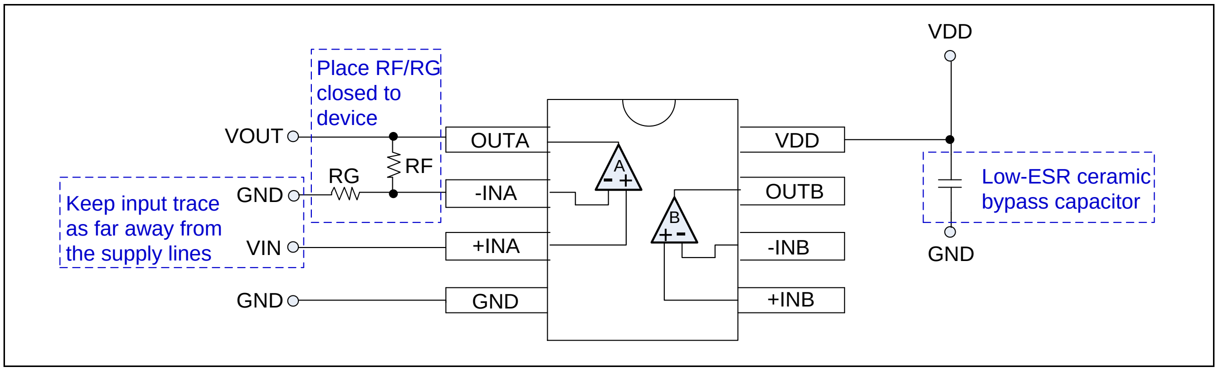


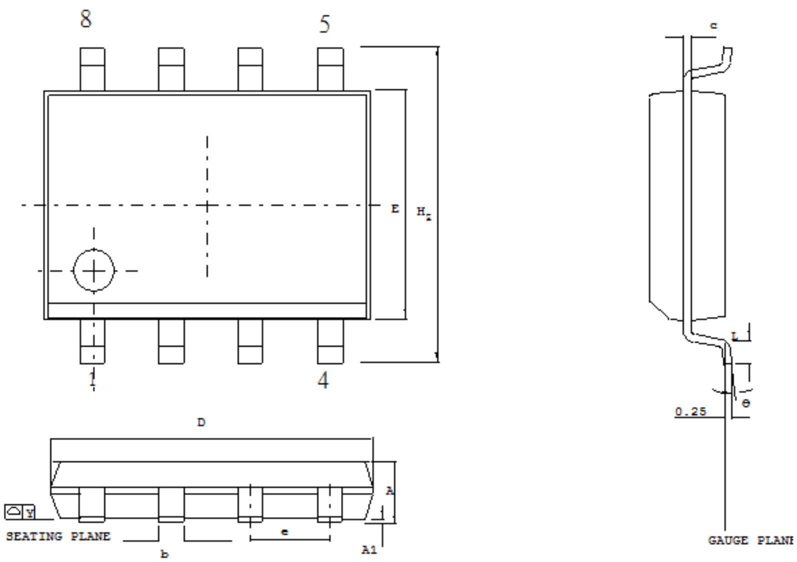
Figure 10-2 NOP912 Layout Example

11 PACKAGE DIMENSIONS

Package is Halogen-free, RoHS-compliant and TSCA-compliant.

11.1 SOIC8 (3.91 mm x 4.90 mm)

SOP8L 150mil, Thickness 1.38mm, Lead_Pitch 1.27mm, Lead_Length 1.05mm



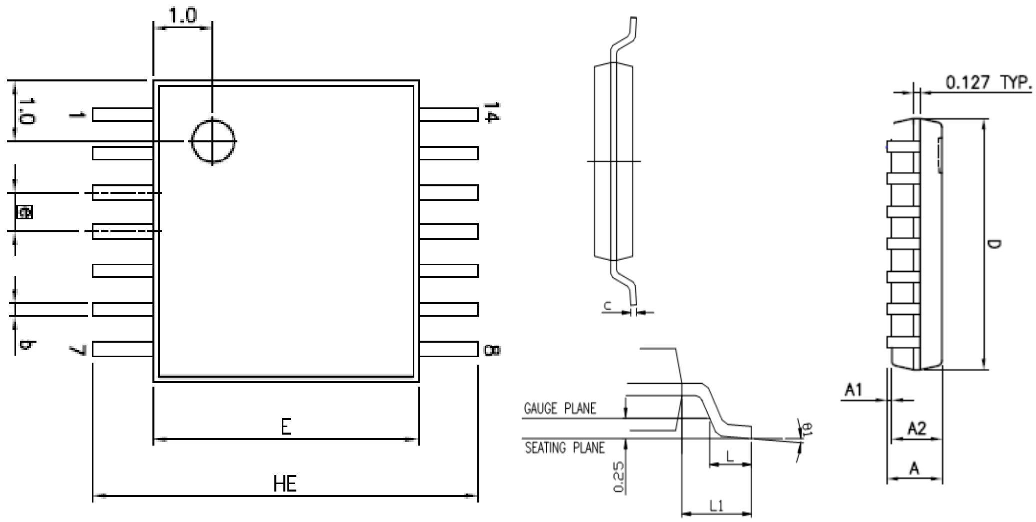
Control demensions are in milmeters .

SYMBOL	DIMENSION IN MM		DIMENSION IN INCH	
	MIN.	MAX.	MIN.	MAX.
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
b	0.33	0.51	0.013	0.020
c	0.19	0.25	0.008	0.010
E	3.80	4.00	0.150	0.157
D	4.80	5.00	0.188	0.196
e	1.27 BSC		0.050 BSC	
H_E	5.80	6.20	0.228	0.244
Y	—	0.10	—	0.004
L	0.40	1.27	0.016	0.050
θ	0	10	0	10

Figure 11-1 SOIC8 Package Dimension

11.2 TSSOP14 (4.4mm x 5.0mm)

TSSOP14L 4.4x5.0 mm^2, Thickness 0.90mm, Lead_Pitch 0.65mm, Lead_Length 1.00mm



CONTROLLING DIMENSION: MILLMETERS						
SYMBOL	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM	MAX.	MIN.	NOM	MAX.
A	---	---	1.20	---	---	0.043
A1	0.05	---	0.15	0.02	---	0.006
A2	0.80	0.90	1.05	0.031	0.035	0.041
L	0.50	0.60	0.75	0.020	0.024	0.030
HE	6.40 BSC.			0.252 BSC.		
E	4.30	4.40	4.50	0.169	0.173	0.177
D	4.90	5.00	5.10	0.193	0.197	0.201
b	0.19	---	0.30	0.007	---	0.012
c	0.09	---	0.20	0.004	---	0.008
L1	1.0 REF.			0.039 REF.		
e	0.65 BSC.			0.026 BSC.		
θ1	0	---	8	0	---	8

Figure 11-2 TSSOP14 Package Dimension

12 REVISION HISTORY

Date	Revision	Description
2022.12.19	1.00	• Initial version.

Important Notice

Nuvoton Products are neither intended nor warranted for usage in systems or equipment, any malfunction or failure of which may cause loss of human life, bodily injury or severe property damage. Such applications are deemed, "Insecure Usage".

Insecure usage includes, but is not limited to: equipment for surgical implementation, atomic energy control instruments, airplane or spaceship instruments, the control or operation of dynamic, brake or safety systems designed for vehicular use, traffic signal instruments, all types of safety devices, and other applications intended to support or sustain life.

All Insecure Usage shall be made at customer's risk, and in the event that third parties lay claims to Nuvoton as a result of customer's Insecure Usage, customer shall indemnify the damages and liabilities thus incurred by Nuvoton.