High Output Current, Rail-to-Rail Input / Output Single CMOS Operational Amplifiers

■ FEATURES

- AEC-Q100 Grade 1 Qualified
- High output current ±100mA typ. (200mA$_{PP}$ typ.)
- Operating temperature T_{opr} = −40°C to 125°C
- Rail-to-Rail input / output
- High EMI immunity
- Supply voltage 6.8V to 36V
- Supply current 9.5mA typ.
- Open loop gain 100dB typ.
- Input bias current 1pA typ.
- Slew rate 3.5V/µs typ.
- Unity gain frequency 1.5MHz typ.
- Thermal shutdown
- Current limit
- Package TO-252-5-L3

■ DESCRIPTION

The NJU77903 is a 36V operable Rail-to-Rail input/output CMOS operational amplifier featuring an output current capacity of 200mA$_{PP}$ typ.

It is suitable for high voltage and high output current applications such as drive motors for hybrid and electric vehicles and resolver excitation applications that are angle detection sensors for EPS.

In such applications, high output current was supported by configuring the circuit with multiple parts such as operational amplifiers and transistors, which led to complicated circuit design and larger ECU. By using the NJU77903, it contributes to simplification of design and reduction in size and weight of the mounting board and ECU.

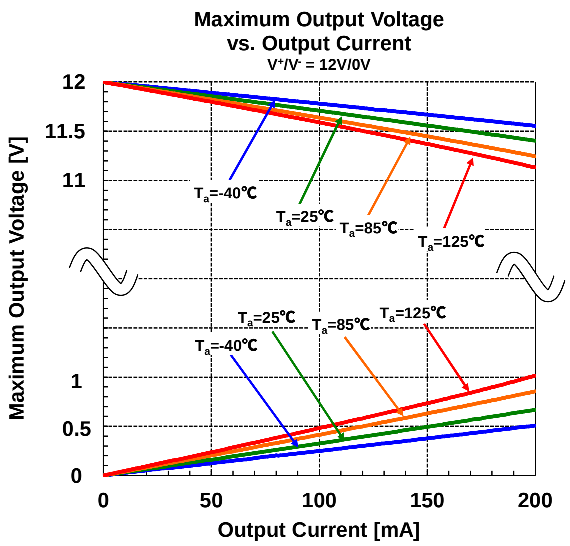
■ RELATED PRODUCTS

PRODUCT NAME	FEATURES
NJU7870-Z2	Resolver excitation amplifier for automotives

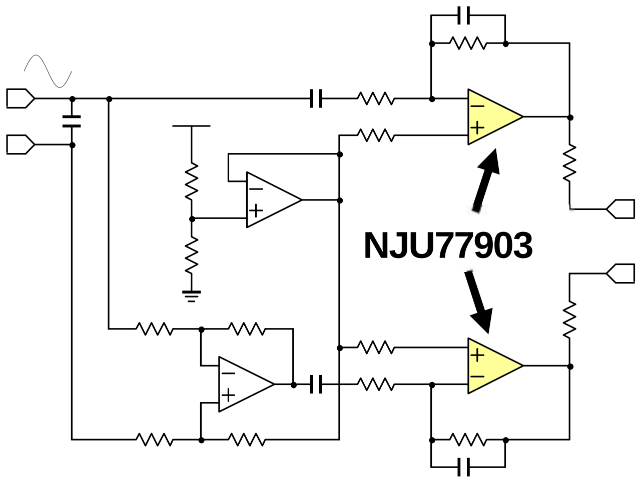
■ APPLICATIONS

- Angle resolver
- Motor driver
- Speaker driver
- 4mA to 20mA Transmitter
- Liner power booster

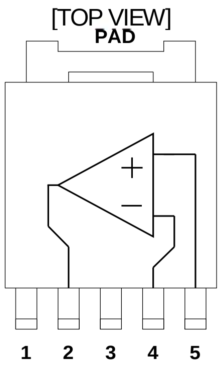
■ TYPICAL CHARACTERISTICS



■ RESOLVER EXCITATION CIRCUIT



■ PIN CONFIGURATION

PRODUCT NAME	NJU77903DL3-H
Package	TO-252-5-L3
Pin Functions	 1 V^+ 2 OUTPUT 3 V^- 4 −INPUT 5 +INPUT

The PAD have to be wired as short as possible to connect with a V^- terminal.

■ PRODUCT NAME INFORMATION

NJU77903 DL3 - H (TE2)

- NJU77903: Part Number
- DL3: Package
- H: Grade (H: Automotive*)
- (TE2): Taping Form

* The detail information of automotive grades and recommended applications are described in NJR Web site.
  (https://www.njr.com/electronic_device/semiconductor/application/automotive.html)

■ ORDERING INFORMATION

PRODUCT NAME	PACKAGE	RoHS	HALOGEN-FREE	TERMINAL FINISH	MARKING	WEIGHT (mg)	MOQ (pcs)
NJU77903DL3-H (TE2)	TO-252-5-L3	Yes	Yes	Sn-2Bi	77903H	301	3000

■ ABSOLUTE MAXIMUM RATINGS

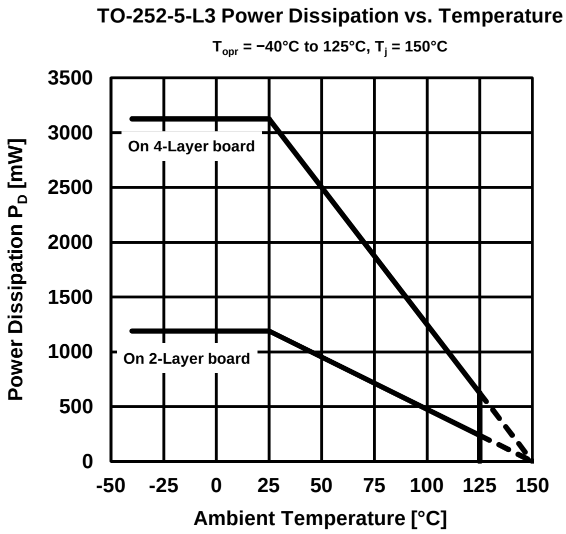
PARAMETER	SYMBOL	RATING	UNIT
Supply Voltage	$V^+ - V^-$	40	V
Differential Input Voltage(1)	V_{ID}	±36	V
Input Voltage(2)	V_{IN}	V^-−0.3 to V^++0.3	V
Input Current	I_{IN}	±10(3)	mA
Output Terminal Input Voltage(4)	V_O	V^-−0.3 to V^++0.3	V
Power Dissipation(7) (T_a = 25°C) TO-252-5-L3	P_D	2-Layer / 4-Layer 1190(5) / 3125(6)	mW
Storage Temperature	T_{stg}	−55 to 150	°C
Junction Temperature	T_j	150	°C

■ THERMAL CHARACTERISTICS

PACKAGE	SYMBOL	VALUE	UNIT
Junction-to-Ambient Thermal Resistance TO-252-5-L3	θ_{ja}	2-Layer / 4-Layer 105(5) / 40(6)	°C/W

(1) Differential voltage is the voltage difference between +INPUT and −INPUT.
(2) Input voltage is the voltage should be allowed to apply to the input terminal independent of the magnitude of V^+. The normal operation will establish when any input is within the Common Mode Input Voltage Range of electrical characteristics.
(3) If the input voltage exceeds the supply voltage, the input current must be limited 10mA or less by using a restriction resistance.
(4) Output voltage is the voltage should be allowed to apply to the output terminal independent of the magnitude of V^+.
(5) 2-Layer: Mounted on glass epoxy board (76.2 mm × 114.3 mm × 1.6 mm: based on EIA/JEDEC standard, 2-layer FR-4), Cu area: 100 mm^2.
(6) 4-Layer: Mounted on glass epoxy board (76.2 mm × 114.3 mm × 1.6 mm: based on EIA/JEDEC standard, 4-layer FR-4).
(For 4-layer: Applying 74.2 mm × 74.2 mm inner Cu area and a thermal via hole to a board based on JEDEC standard JESD51-5.)
(7) Power dissipation is the power that can be consumed by the IC at T_a = 25°C, and is the typical measured value based on JEDEC condition. When using the IC over T_a = 25°C subtract the value [mW/°C] = P_D / (T_{stg}(MAX) − 25) per temperature.
(8) The PAD have to be wired as short as possible to connect with a V^- terminal.

■ POWER DISSIPATION vs. AMBIENT TEMPERATURE



■ RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	VALUE	UNIT
Supply Voltage	$V^+ - V^-$	6.8 to 36	V
Operating Temperature	T_{opr}	−40 to 125	°C

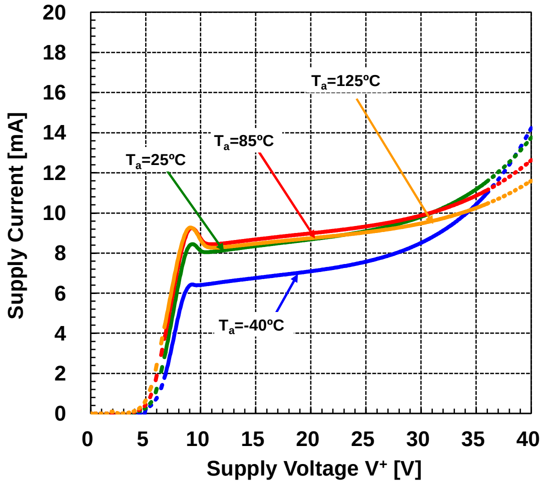
■ **ELECTRICAL CHARACTERISTICS** (V^+ = 12V, V^- = 0V, V_{IC} = 6V, R_L = 10kΩ, T_a = 25°C, unless otherwise noted.)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
INPUT CHARACTERISTICS						
Input Offset Voltage	V_{IO}	R_S = 50Ω	-	1	6	mV
		R_S = 50Ω, T_a = −40°C to 125°C	-	-	15	
Input Offset Voltage Drift	$\Delta V_{IO}/\Delta T$	T_a = −40°C to 125°C	-	20	-	µV/°C
Input Bias Current	I_B		-	1	-	pA
Input Offset Current	I_{IO}		-	1	-	pA
Open Loop Gain	A_V	V_O = 1V to 11V, R_L = 10kΩ to $V^+/2$	80	100	-	dB
		V_O = 1V to 11V, R_L = 10kΩ to $V^+/2$, T_a = −40°C to 125°C	75	-	-	
Common Mode Rejection Ratio	CMR	V_{IC} = 0V to 6V, V_{IC} = 6V to 12V	55	75	-	dB
		V_{IC} = 0V to 6V, V_{IC} = 6V to 12V, T_a = −40°C to 125°C	50	-	-	
Common Mode Input Voltage Range	V_{ICM}	CMR ≥ 55dB	0	-	12	V
		CMR ≥ 50dB, T_a = −40°C to 125°C	0	-	12	
OUTPUT CHARACTERISTICS						
Output Voltage	V_{OH}	R_L = 10kΩ to $V^+/2$	11.97	11.99	-	V
		R_L = 10kΩ to $V^+/2$, T_a = −40°C to 125°C	11.97	-	-	
		I_{SOURCE} = 100mA	11.40	11.65	-	
		I_{SOURCE} = 100mA, T_a = −40°C to 125°C	11.20	-	-	
	V_{OL}	R_L = 10kΩ to $V^+/2$	-	0.01	0.03	V
		R_L = 10kΩ to $V^+/2$, T_a = −40°C to 125°C	-	-	0.03	
		I_{SINK} = 100mA	-	0.35	0.60	
		I_{SINK} = 100mA, T_a = −40°C to 125°C	-	-	0.80	
Output Source Current Limit	$I_{SOURCELIM}$		-	375	700	mA
		T_a = −40°C to 125°C	-	-	700	
Output Sink Current Limit	$I_{SINKLIM}$		-	375	700	mA
		T_a = −40°C to 125°C	-	-	700	
POWER SUPPLY						
Supply Current	I_{DD}	No Signal, R_L = OPEN	-	9.5	12.5	mA
		No Signal, R_L = OPEN, T_a = −40°C to 125°C	-	-	12.5	
Supply Voltage Rejection Ratio	SVR	V^+ = 6.8V to 36V	70	85	-	dB
		V^+ = 6.8V to 36V, T_a = −40°C to 125°C	65	-	-	
DYNAMIC PERFORMANCE						
Unity Gain Frequency	f_T	R_L = 10kΩ to $V^+/2$, C_L = 10pF	-	1.5	-	MHz
Phase Margin	Φ_M	R_L = 10kΩ to $V^+/2$, C_L = 10pF	-	75	-	deg
Slew Rate(9)	SR	G_V = 0dB, R_L = 10kΩ to $V^+/2$, C_L = 10pF, V_{IN} = 4V_{PP} (4V to 8V)	2.5	3.5	-	V/µs
		G_V = 0dB, R_L = 10kΩ to $V^+/2$, C_L = 10pF, V_{IN} = 4V_{PP} (4V to 8V), T_a = −40°C to 125°C	2.0	-	-	
NOISE PERFORMANCE						
Equivalent Input Noise Voltage	e_n	f = 10kHz, R_S = 50Ω	-	50	-	nV/√Hz
Total Harmonic Distortion +Noise	THD+N	G_V = 6dB, R_F = 10kΩ, R_L = 10kΩ, C_L = 10pF, V_O = 2V_{PP}, f = 10kHz	-	0.03	-	%

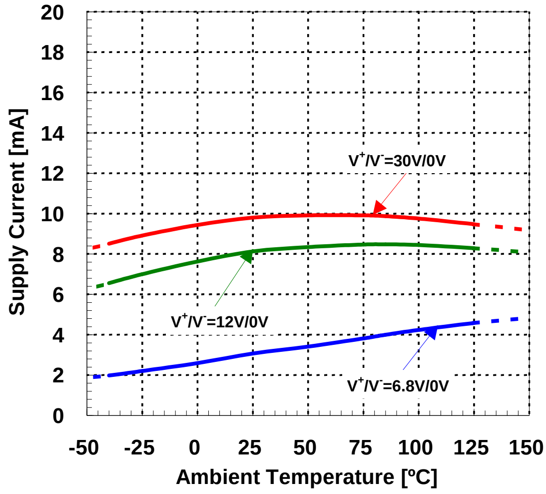
(9) Number specified is the slower of the positive and negative slew rates

■ TYPICAL CHARACTERISTICS

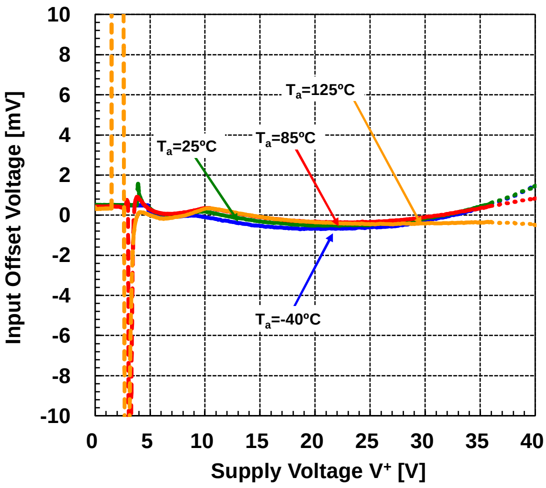
Supply Current vs. Supply Voltage
A_V=0dB, R_L=OPEN, V^-=0V



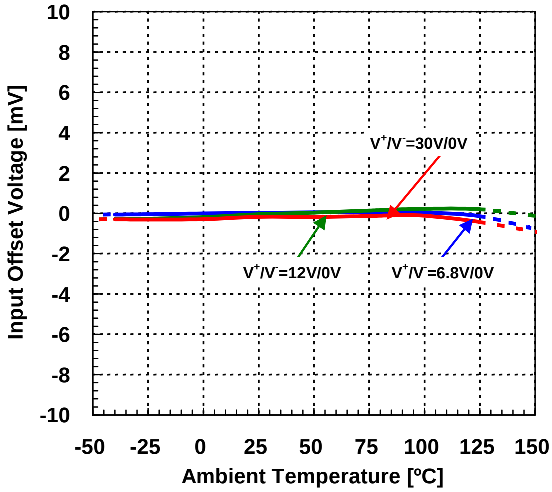
Supply Current vs. Temperature
A_V=0dB, R_L=OPEN



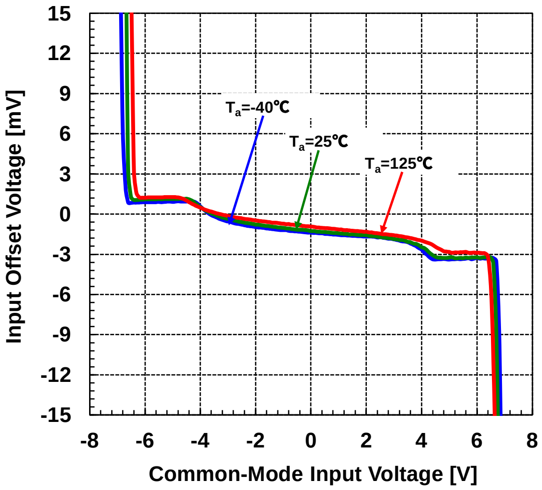
Input Offset Voltage vs. Supply Voltage
A_V=0dB, V^-=0V



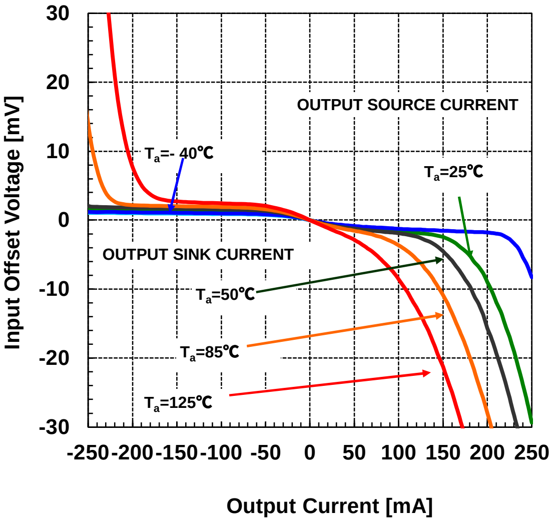
Input Offset Voltage vs. Temperature
A_V=0dB



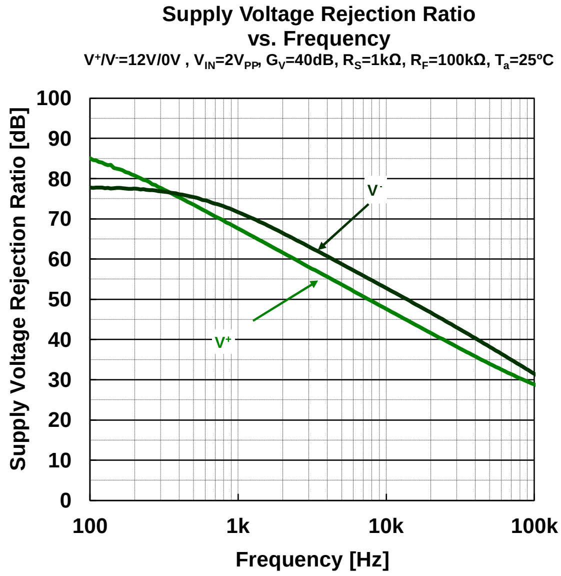
Input Offset Voltage vs. Common-Mode Input Voltage
V^+/V^-=±6V

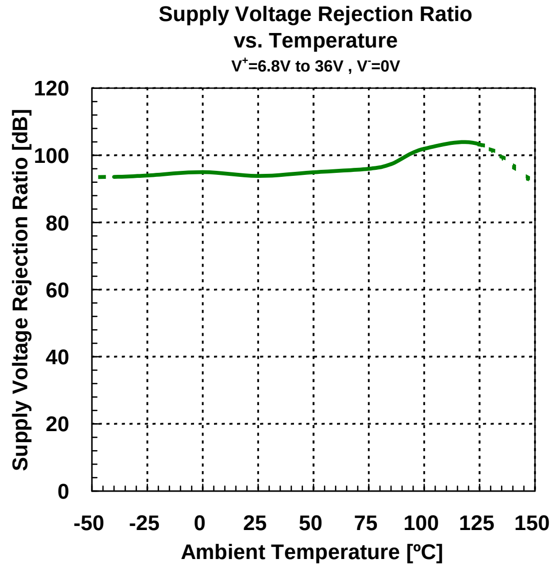


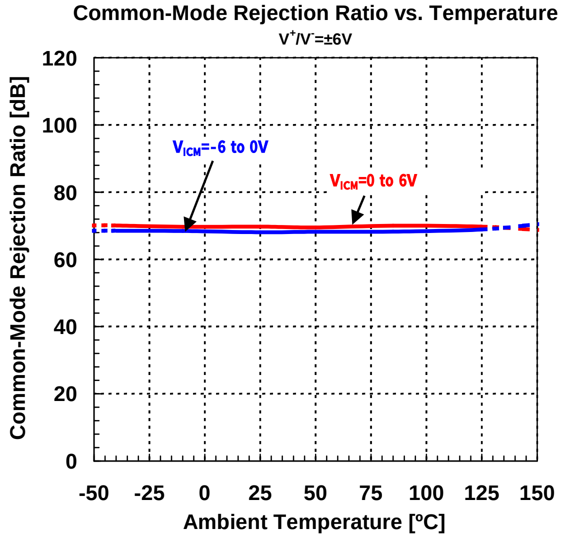
Input Offset Voltage vs. Output Current
V^+/V^-=±6V

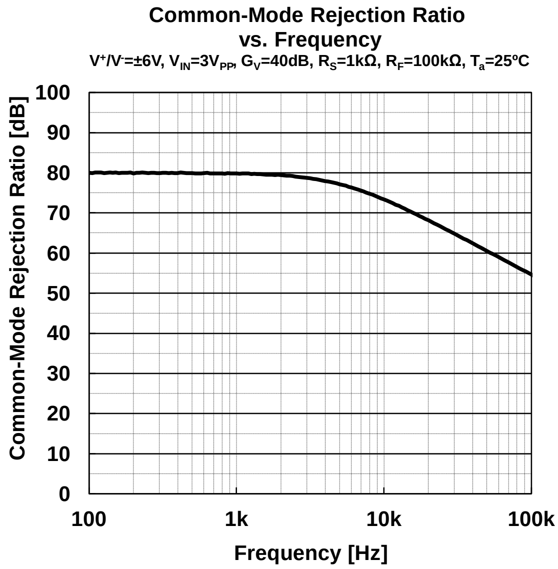


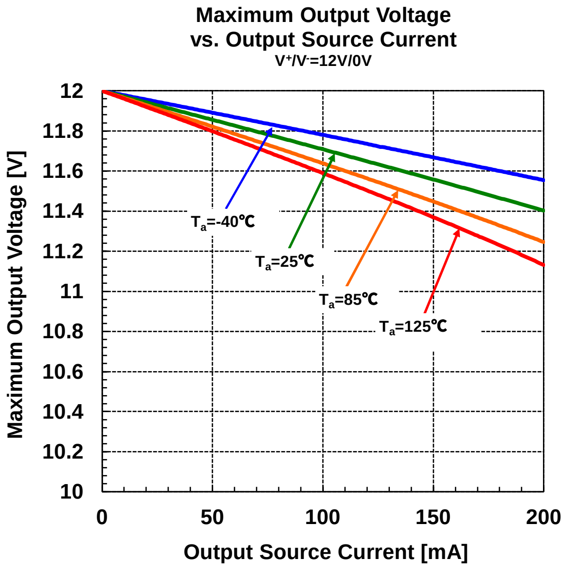
■ TYPICAL CHARACTERISTICS

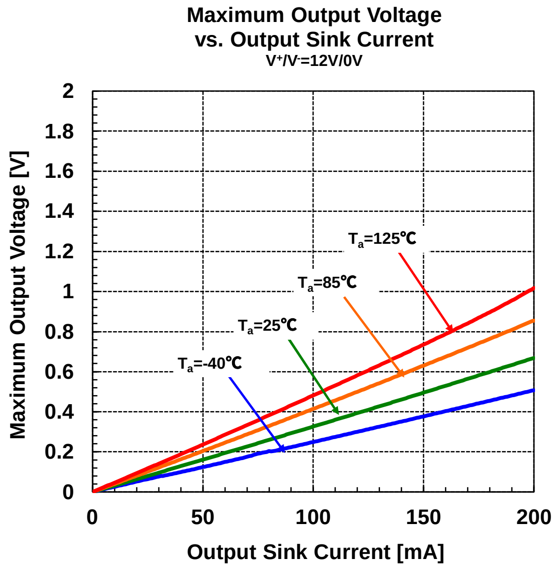






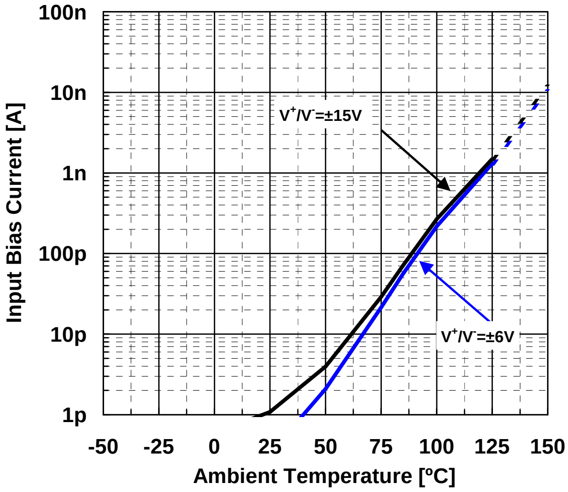




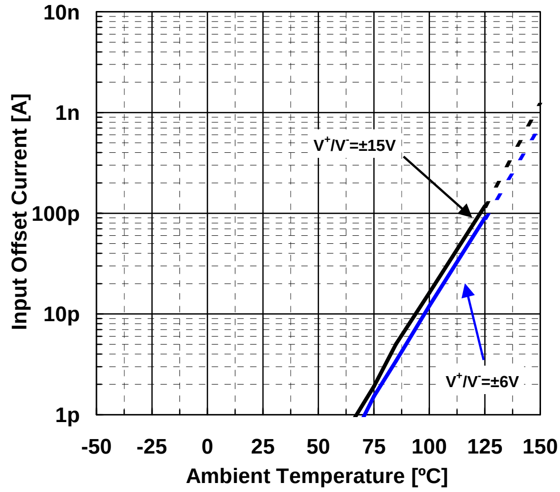


■ TYPICAL CHARACTERISTICS

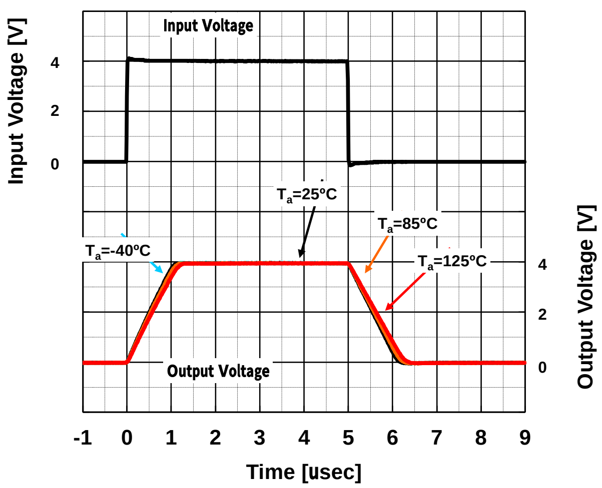
Input Bias Current vs. Temperature
V_{ICM}=0V



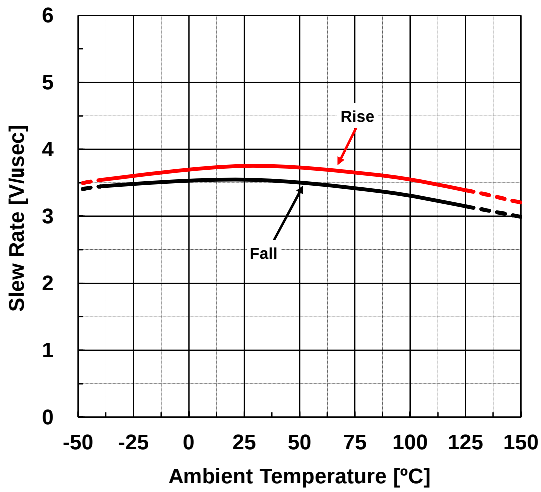
Input Offset Current vs. Temperature
V_{ICM}=0V



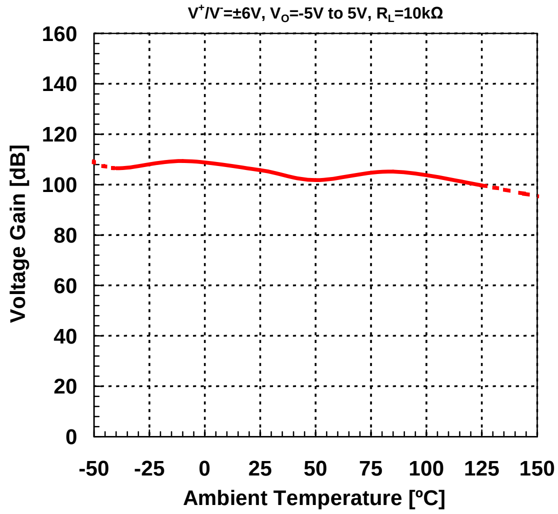
Pulse Response
V^+/V^-=±6V, V_{IN}=4V_{PP}, f=100kHz
PulseEdge=10nsec, Gv=0dB, C_L=10pF, R_L=10kΩ



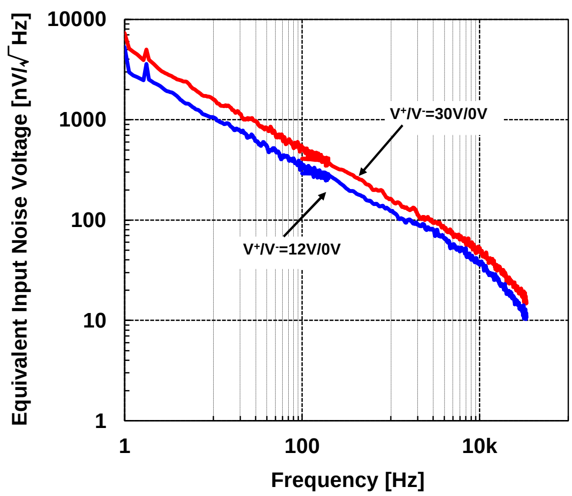
Slew Rate vs. Temperature
V^+/V^-=±6V, V_{IN}=4V_{PP}, f=100kHz
PulseEdge=10nsec, Gv=0dB, C_L=10pF, R_L=10kΩ



Voltage Gain vs. Temperature
V^+/V^-=±6V, V_O=-5V to 5V, R_L=10kΩ



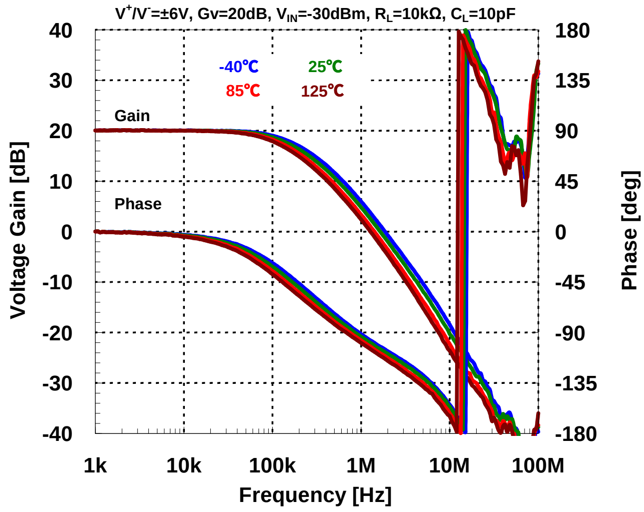
Equivalent Input Noise Voltage vs. Frequency
R_F=2kΩ, R_G=20Ω, T_a=25ºC



■ TYPICAL CHARACTERISTICS

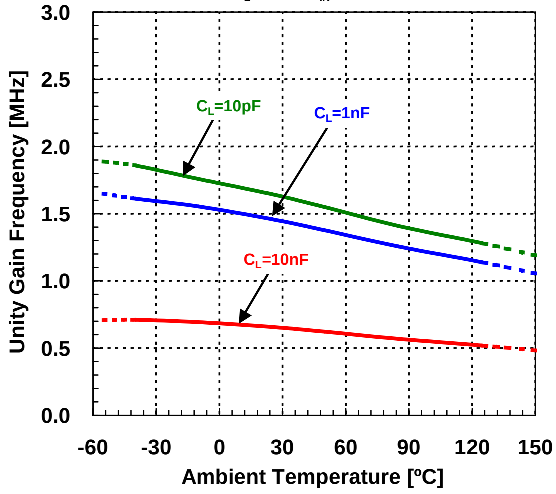
Voltage Gain/Phase vs. Frequency

V^+/V^-=±6V, Gv=20dB, V_{IN}=-30dBm, R_L=10kΩ, C_L=10pF



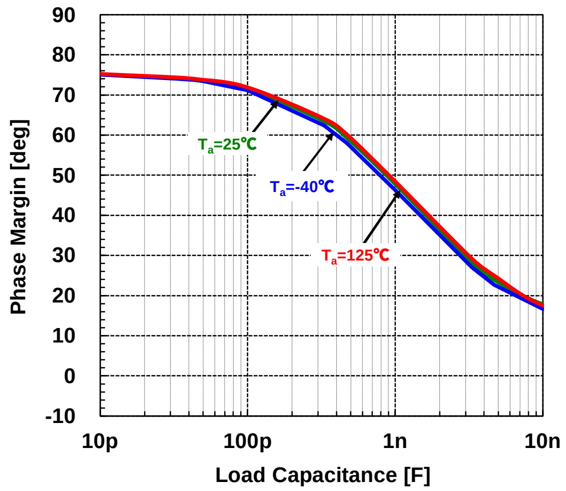
Unity Gain Frequency vs. Load Capacitance

V^+/V^-=±6V, R_L=10kΩ, V_{IN}=-30dBm, Gv=20dB



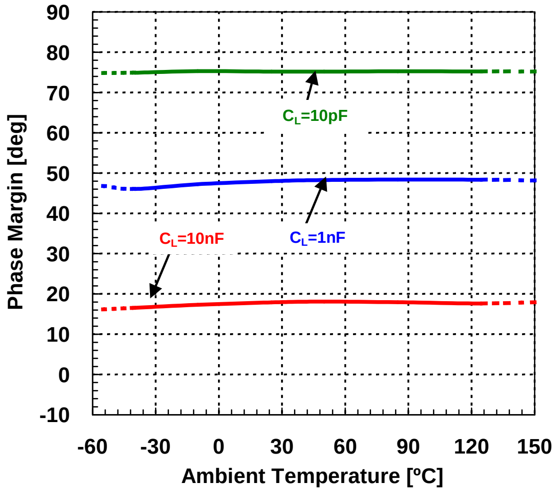
Phase Margin vs. Load Capacitance

V^+/V^-=±6V, R_L=10kΩ, V_{IN}=-30dBm, Gv=20dB



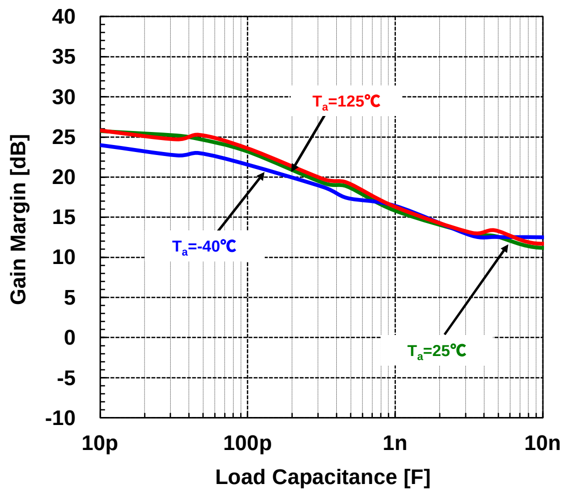
Phase Margin vs. Temperature

V^+/V^-=±6V, R_L=10kΩ, V_{IN}=-30dBm, Gv=20dB



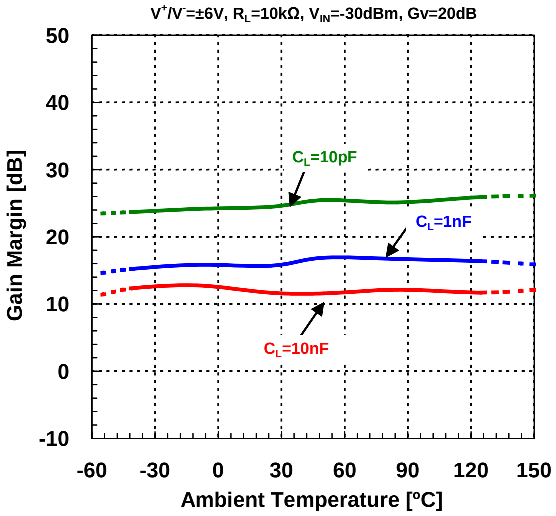
Gain Margin vs. Load Capacitance

V^+/V^-=±6V, R_L=10kΩ, V_{IN}=-30dBm, Gv=20dB,

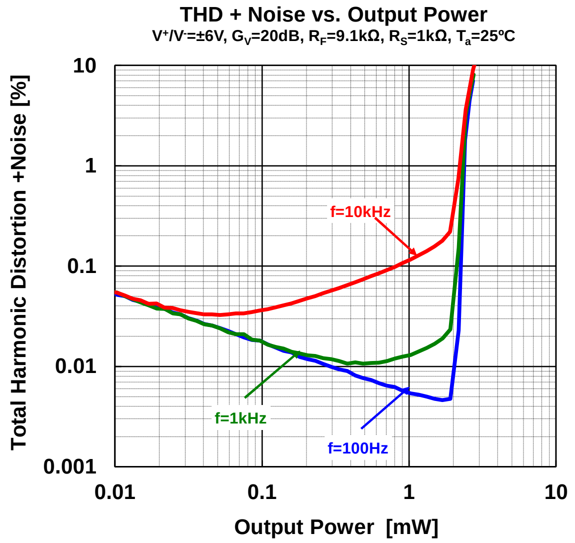


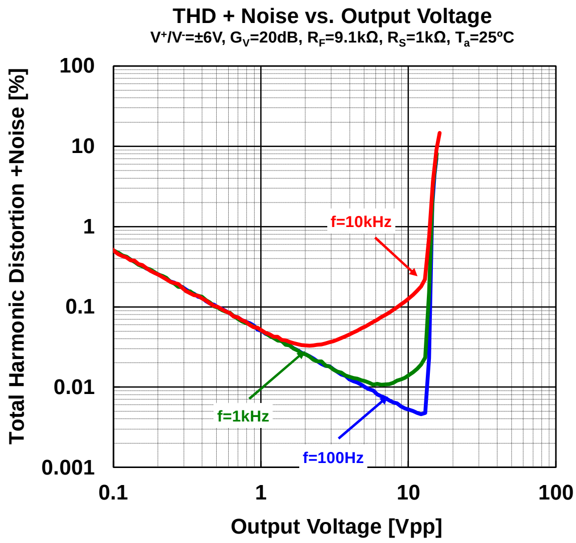
Gain Margin vs.Temperature

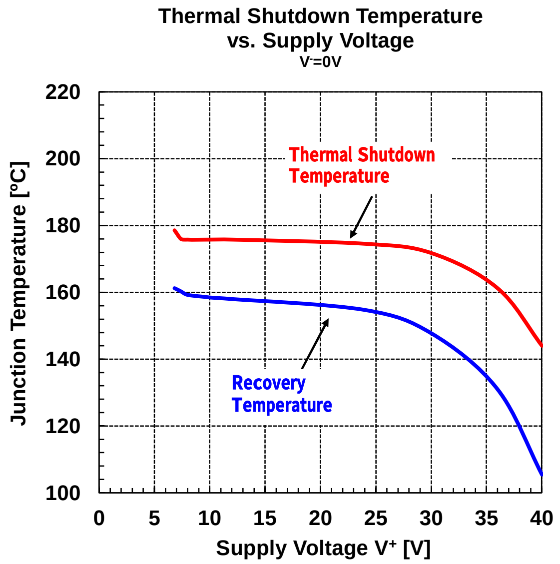
V^+/V^-=±6V, R_L=10kΩ, V_{IN}=-30dBm, Gv=20dB



■ TYPICAL CHARACTERISTICS

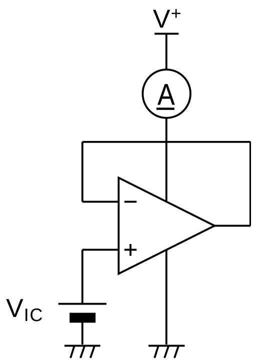






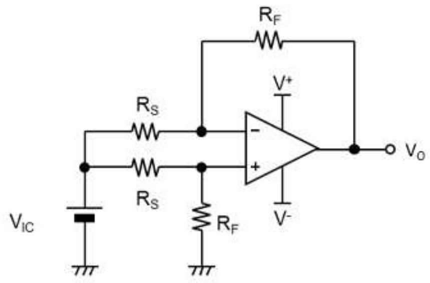
■ TEST CIRCUITS

● I_{DD}



● V_{IO}, CMR, SVR

$R_S = 50\Omega$, $R_F = 50k\Omega$



$$V_{IO} = \frac{R_S}{(R_S+R_F)} \times (V_o - V_{IC})$$

$$CMR = 20\log \frac{\Delta V_{IC}\left(1+\frac{R_F}{R_S}\right)}{\Delta V_O}$$

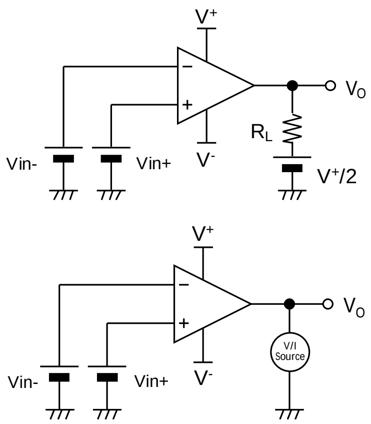
$$SVR = 20\log \frac{\Delta V_S\left(1+\frac{R_F}{R_S}\right)}{\Delta V_O}$$

$$V_S = V^+ - V^-$$

● V_{OH}, V_{OL}

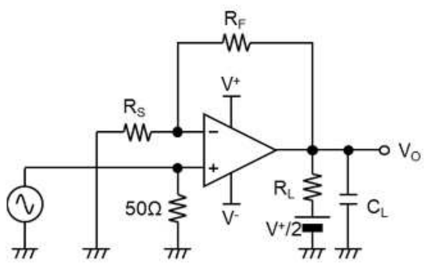
V_{OH}; Vin+ = $V^+/2$ + 1V, Vin− = $V^+/2$

V_{OL}; Vin+ = $V^+/2$, Vin− = $V^+/2$ + 1V



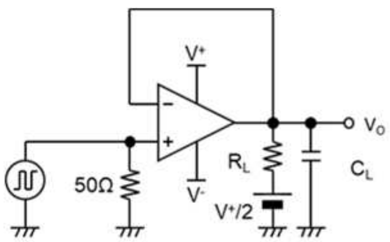
● f_T

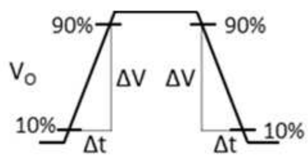
$R_L = 10k\Omega$, $C_L = 10pF$



● SR

$R_L = 10k\Omega$, $C_L = 10pF$





$$SR = \frac{\Delta V}{\Delta t}$$

■ APPLICATION NOTE

The NJU77903 is CMOS operational amplifier that combines rail−to−rail input and output with operating up to 36V. It is able to output high current without the power booster. Therefore, the NJU77903 is suitable for the application requires high operating voltage and high output current.
This application note is one of effectual measures for understanding the dissipation power, thermal shutdown and behavior of current limit, to avoiding unexpected trebles. This application note consists of following matter.

1. Calculation of dissipation power
2. Thermal shutdown
3. Current limit
4. Resolver Excitation Circuit
5. Input Overvoltage Protection

This description does not assure the actual behavior. The performance of the NJU77903 should be conducted trials using actual equipment.

1. Calculation of dissipation power

The dissipation power is determined by the type of loads. It in case of resistance load and inductance load are shown respectively on this note. The symbols of supply voltage are defined as V_{DD} and V_{SS} instead of V^+ and V^-.

1.1 Calculation of dissipation power with resistance load

The dissipation power from the time 0 to π and it from π to 2π are calculated separately.

t = 0 to π

Fig.1.1 shows the internal current from 0 to π, Fig.1.2 shows the output current and the output voltage from 0 to π. Io is the output current and I_A is the current with the exception of the output current. The dissipation power from 0 to π is expressed by the following equation.

$$P_{R1} = (V_{DD} - V_{SS})I_A + \frac{1}{\pi}\int_0^{\pi}(V_{DD} - V_O \sin\theta)I_O \sin\theta d\theta$$

$$= (V_{DD} - V_{SS})I_A + \frac{1}{\pi}\int_0^{\pi}(V_{DD} - V_O \sin\theta)\frac{V_O}{R}\sin\theta d\theta$$

$$= (V_{DD} - V_{SS})I_A + \frac{2V_{DD}V_O}{\pi R} - \frac{V_O{}^2}{2R}$$

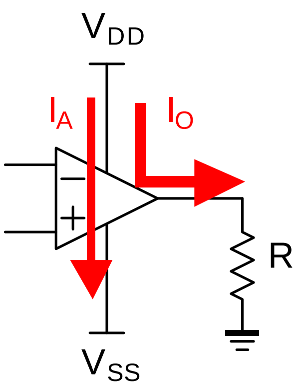


Fig.1.1 The internal current from 0 to π

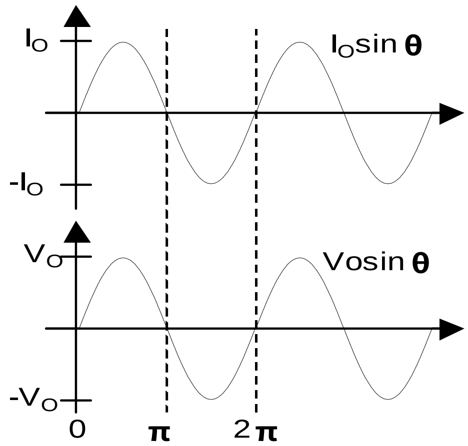


Fig.1.2 The output current and voltage with resistance load

t = π to 2π

Fig.1.3 shows the internal current from π to 2π, the dissipation power from π to 2π is expressed by the following equation.

$$P_{R2} = (V_{DD} - V_{SS})I_A + \frac{1}{\pi}\int_{\pi}^{2\pi}(V_O \sin\theta - V_{SS})I_O \sin\theta d\theta$$

$$= (V_{DD} - V_{SS})I_A + \frac{1}{\pi}\int_{\pi}^{2\pi}(V_O \sin\theta - V_{SS})\frac{V_O}{R}\sin\theta d\theta$$

$$= (V_{DD} - V_{SS})I_A - \frac{2V_{SS}V_O}{\pi R} - \frac{V_O{}^2}{2R}$$

In the case of $V_{DD} = -V_{SS}$, the internal loss P_R is the following result.

$$P_R = (V_{DD} - V_{SS})I_A + \frac{2V_{DD}V_O}{\pi R} - \frac{V_O{}^2}{2R}$$

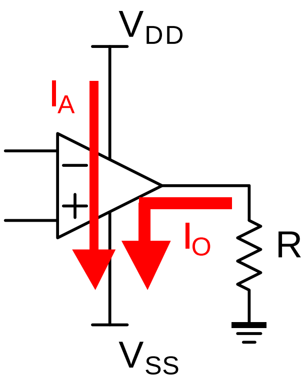


Fig.1.3 The internal current from π to 2π

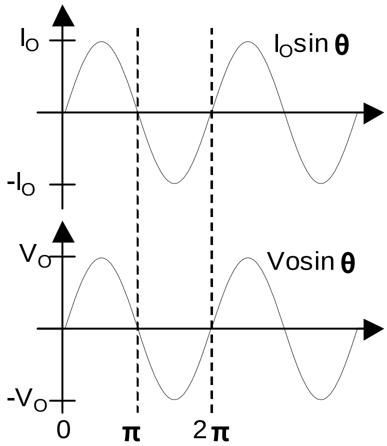


Fig.1.4 The output current and voltage with resistance load

Example for use

The dissipation power is calculated on the following condition.
Condition:
V_{DD}/V_{SS} = 6V/−6V
V_O = $1V_{PK}$
R = 20Ω (I_O = $1V_{PK}$/20Ω = $50mA_{PK}$ = $100mA_{PP}$)
I_A = 1.5mA

$$P_R = (V_{DD} - V_{SS})I_A + \frac{2V_{DD}V_O}{\pi R} - \frac{V_O{}^2}{2R}$$

$$= (6V + 6V) \times 1.5mA + \frac{2 \times 6V \times 1V}{\pi \times 20\Omega} - \frac{(1V)^2}{2 \times 20\Omega} = 184mW$$

On the single power supply operation (V_{DD}/V_{SS} = 12V/0V) with the load resistance (R = 20Ω which is the middle point Voltage), the dissipation power is 184mW. It is same as previous one.

1.2 Calculation of dissipation power with inductance load

The dissipation power from the time 0 to π and it from π to 2π are calculated separately.

t = 0 to π

Fig.1.5 shows the internal current from 0 to π and Fig.1.7 shows the output current and the output Voltage from 0 to π. Since it is an inductance load, the output current and the output voltage make 90-degree phase difference. Io is the output current and I_A is the current with the exception of the output current. The loss by output current from 0 to π is expressed by the following equation.

$$P_{LO1} = (V_{DD} - V_O\cos\theta)I_O\sin\theta = V_{DD}I_O\sin\theta - \frac{1}{2}V_OI_O\sin 2\theta$$

The loss by output current from 0 to π is expressed by the following equation.

$$P_{L1} = (V_{DD} - V_{SS})I_A + \frac{1}{\pi}\int_0^{\pi} V_{DD}I_O\sin\theta d\theta - \frac{1}{\pi}\int_0^{\pi}\frac{1}{2}V_OI_O\sin 2\theta d\theta$$
$$= (V_{DD} - V_{SS})\,I_A + \frac{2V_{DD}I_O}{\pi}$$

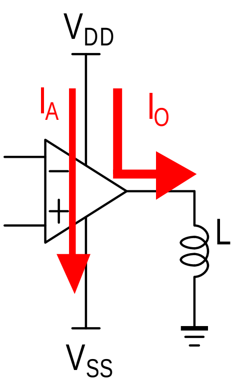


Fig.1.5 The internal current from 0 to π

t = π to 2π

Fig.1.6 shows the internal current from π to 2π.The loss by output current from π to 2π is expressed by the following equation.

$$P_{LO2} = (V_O\cos\theta - V_{SS})I_O\sin\theta = -V_{SS}I_O\sin\theta + \frac{1}{2}V_OI_O\sin 2\theta$$

The Dissipation power from π to 2π is expressed by the following equation.

$$P_{L2} = (V_{DD} - V_{SS})I_A + \frac{1}{\pi}\int_{\pi}^{2\pi} - V_{SS}I_O\sin\theta d\theta + \frac{1}{\pi}\int_{\pi}^{2\pi}\frac{1}{2}V_OI_O\sin 2\theta d\theta = (V_{DD} - V_{SS})I_A - \frac{2V_{SS}I_O}{\pi}$$

In the case of $V_{DD} = -V_{SS}$, the dissipation power is the following result.

$$P_L = (V_{DD} - V_{SS})I_A + \frac{2V_{DD}I_O}{\pi}$$

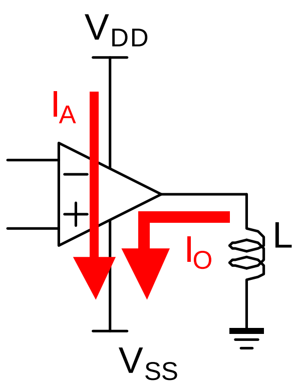


Fig.1.6 The internal current from π to 2π

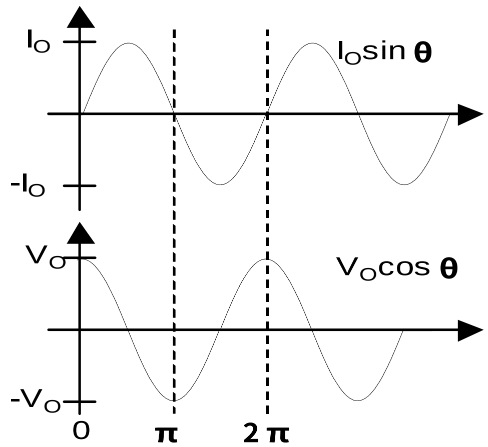


Fig.1.7 The output current and output voltage with inductance load

Example for use
The dissipation power is calculated on the following condition.

Condition:
V_{DD}/V_{SS} = 6V/−6V
I_O = 50mA_{PK} (100mA_{PP})
I_A = 1.5mA

$$P_L = (V_{DD} - V_{SS})I_A + \frac{2V_{DD}I_O}{\pi} = (6V + 6V) \times 1.5mA + \frac{2 \times 6V \times 50mA}{\pi} = 209mW$$

On the Single power supply operation whose equivalent circuit is Fig.1.8, the dissipation power is as follows.

Condition:
V_{DD}/V_{SS} = 12V/0V
I_O = 50mA_{PK} (100mA_{PP})
I_A = 1.5mA

$$P_L = (V_{DD} - V_{SS})I_A + \frac{2V_{DD}I_O}{\pi} = (6V + 6V) \times 1.5mA + \frac{2 \times (12V/2) \times 50mA}{\pi} = 209mW$$

Fig.1.9 is the supply-voltage dependency of the dissipation power on inductance load. The NJU77903 should be operated in lower than package power (P_D).

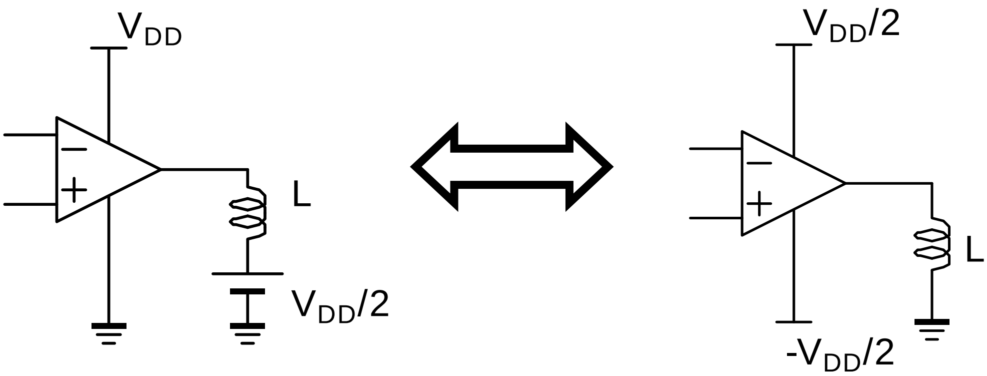


Fig.1.8 Equivalent circuit (Single Supply and Dual Supply)

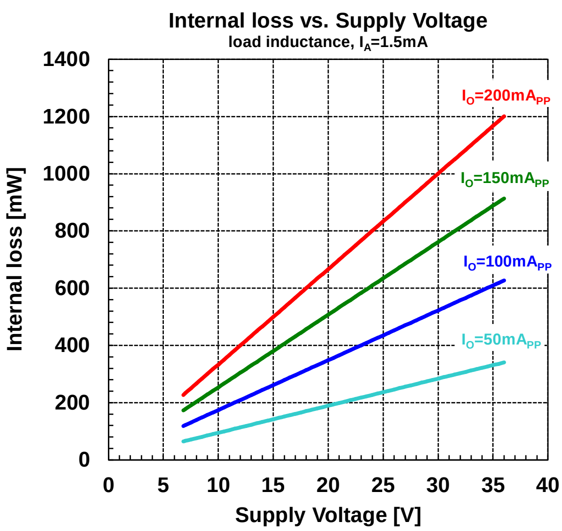


Fig.1.9 The supply voltage dependency of the dissipation power by inductance load. (Single−Supply)

1.3 The current with the exception of the Output current

Fig.1.10 shows the evaluation circuit of the current with the exception of the output current. This result shows Fig1.11 and Fig.1.12.

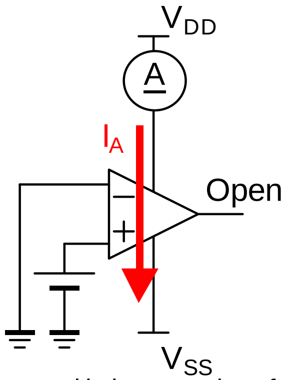


Fig.1.10 The current with the exception of the output current

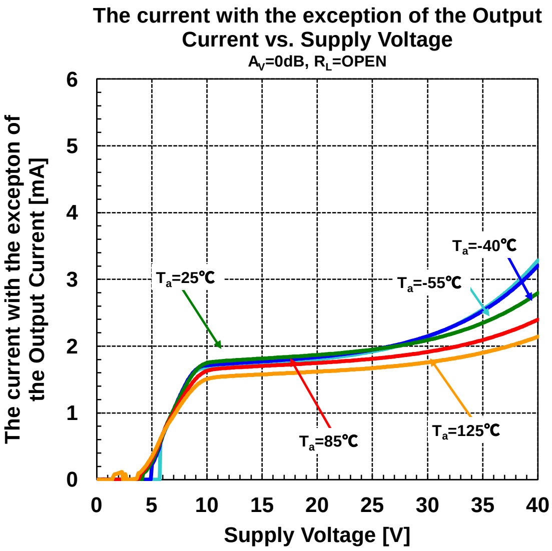


Fig.1.11 The current with the exception of the Output current vs. Supply Voltage

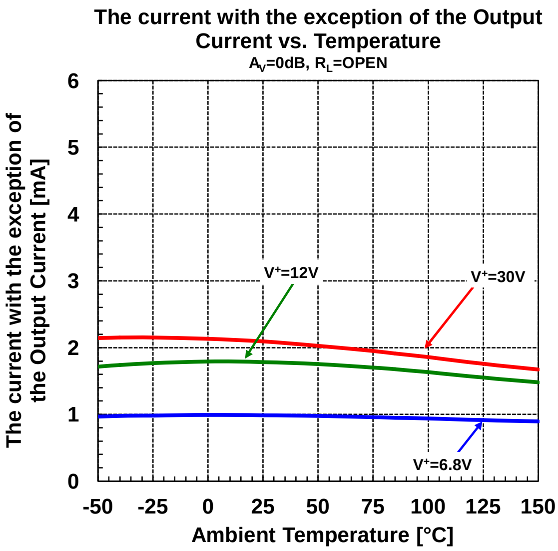


Fig.1.12 The current with the exception of the Output current vs. Temperature

2. Thermal Shutdown

The NJU77903 has thermal shutdown (TSD) function in case that dissipation power exceeds package power P_D. Fig.2.1 shows Thermal Shutdown Temperature vs. Supply Voltage. When the junction temperature exceeds the shutdown temperature approximately 175°C on the supply voltage 12V, the TSD function operates and disables the output current. Under the TSD operation, the output terminal is regarded as high impedance terminal. If the output voltage is necessarily GND Voltage, the output terminal should be connected to GND via resistance.

When the junction temperature cools to recovery temperature approximately 160°C on the supply voltage 12V, the NJU77903 automatically recover from the TSD operation and output current is re-enabled.

The TSD function is not intended to replace proper heat sinking. The NJU77903 should be operated in lower than 150°C the maximum junction temperature.

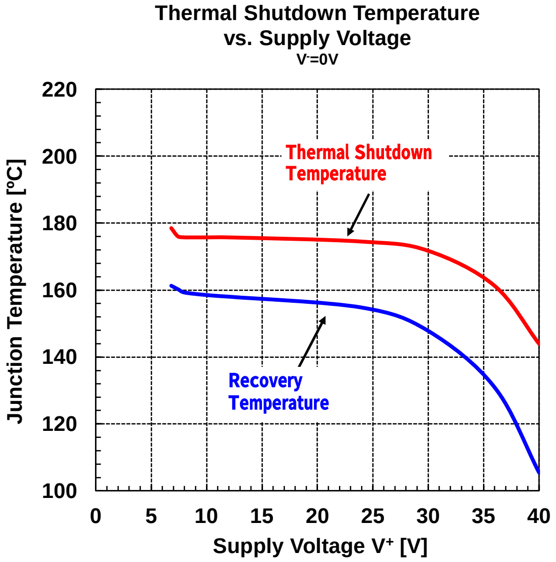


Fig.2.1 Thermal Shutdown Temperature vs. Supply Voltage

3. Current Limit

The NJU77903 is designed with internal current limit in case of overload condition. Fig.3.1 shows the Output Source Current Limit vs. temperature and Fig.3.2 shows the Output Sink Current Limit vs. temperature respectively. With the increasing in temperature, the limits are reduced.

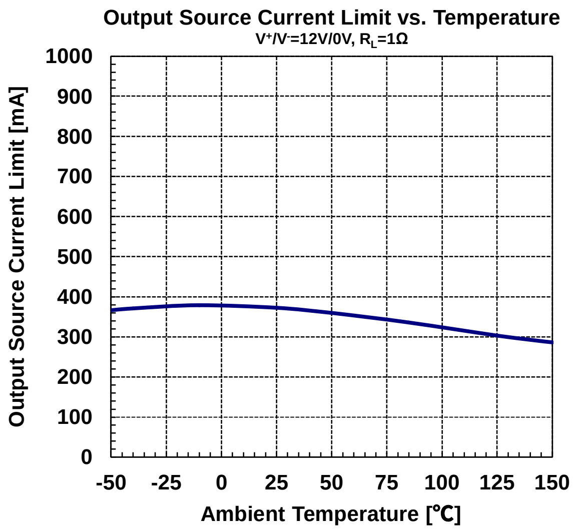


Fig.3.1 Output Source Current Limit vs. Temperature

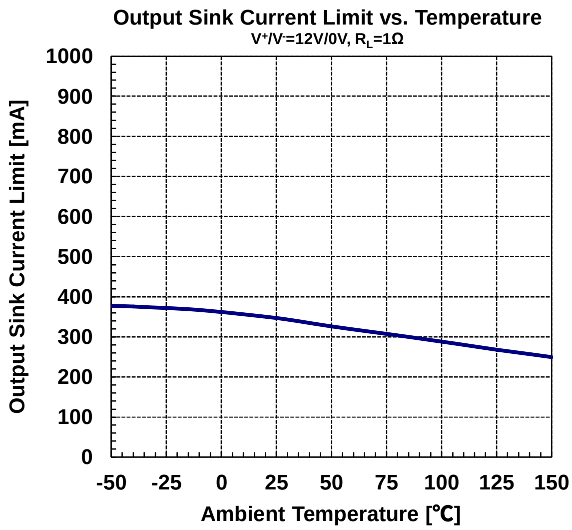


Fig.3.2 Output Sink Current Limit vs. Temperature

Fig.3.3 shows Output Source Current vs. time. Output Source Current Limit decreases gradually since junction temperature rises. The output current is temporarily disabled due to TSD operation in T_a = 150°C line of Fig.3.3 (time = 55msec to 75msec). When the junction temperature falls, the output current is automatically recovered (time = 75msec to 100msec). In order to prevent from damage the NJU77903 should be running under maximum junction temperature.

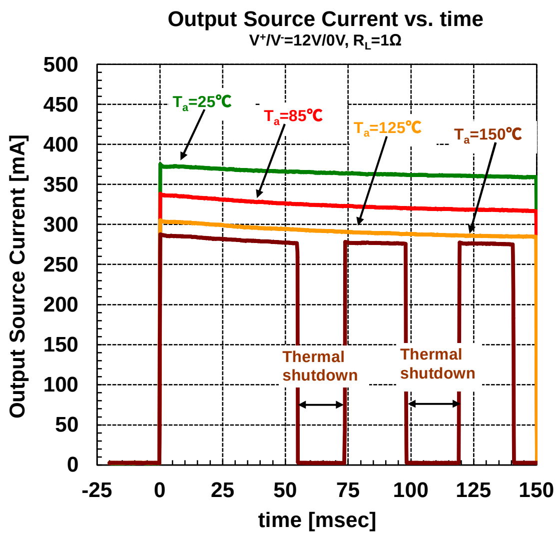


Fig.3.3 Output Source Current Limit vs. Time

4. Resolver Excitation Circuit

Fig.4.1 shows the typical resolver excitation circuit using the NJU77903 and the NJM2904. The NJM2904(A) makes midpoint voltage and the NJM2904(B) makes signal phase inversion. Fig.4.2 is the circuit without NJM2904(A), its dominant voltage is given by resistance voltage divider. Fig.4.3 is the circuit omitted NJM2904(A) and NJM2904(B), it is available under the condition using the input signals which have phase difference one another.

Fig.4.4 shows output voltage and current. The output voltage (Vout) is the voltage drop on the inductance load, the output current (Iout) is defined as positive side according Fig.4.4. The inductance load makes phase difference between Vout and Iout. However, it is not just 90° because of internal resistance on inductance. The performance of resolver excitation should be conducted trials using actual equipment.

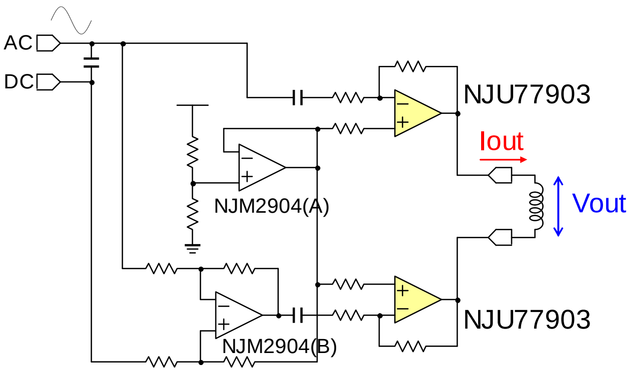


Fig.4.1 Resolver Excitation Circuit

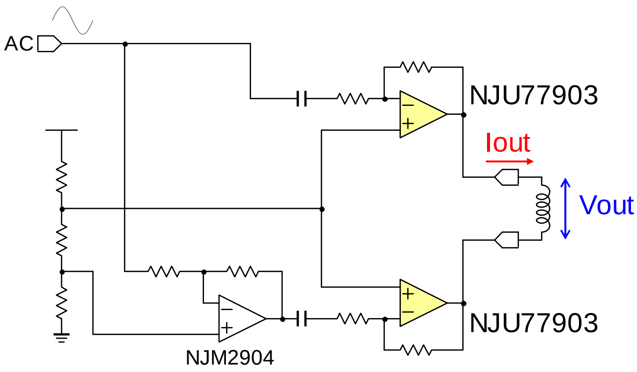


Fig.4.2 Resolver Excitation Circuit
(This version omitted NJM2904(A))

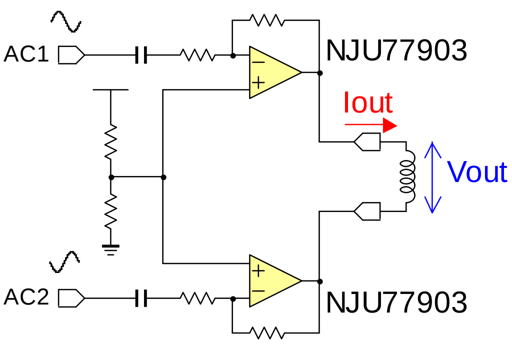


Fig.4.3 Resolver Excitation Circuit
(This version omitted NJM2904)

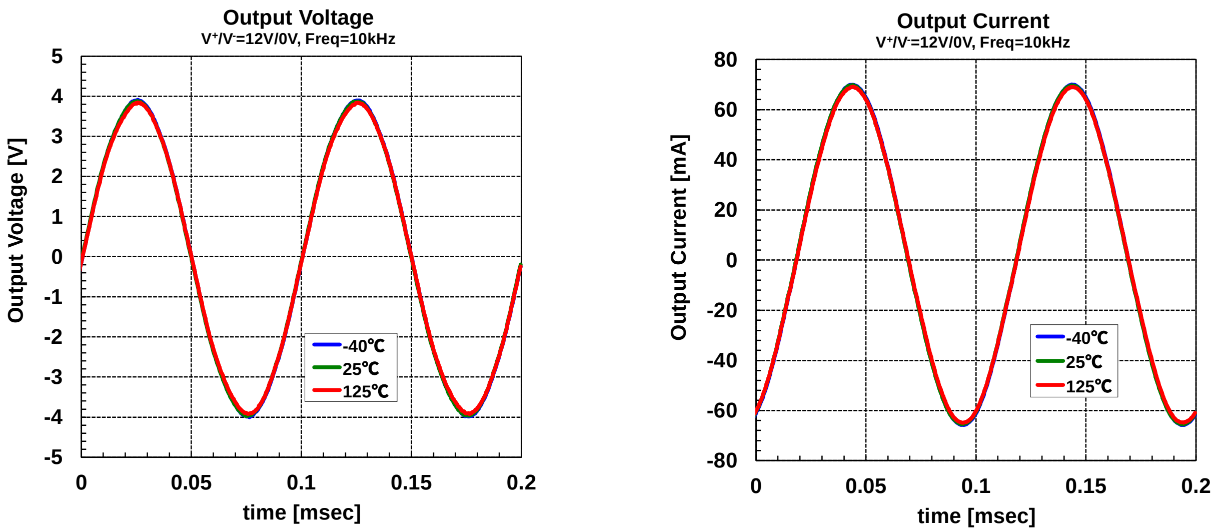
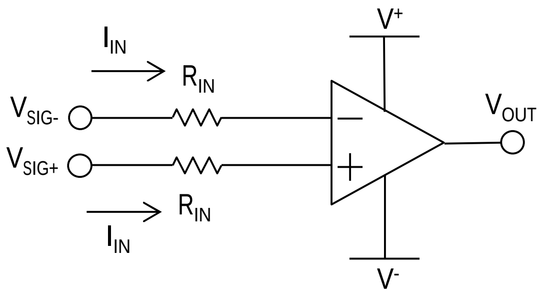


Fig.4.4 Output Voltage and Output Current of Resolver Excitation Circuit

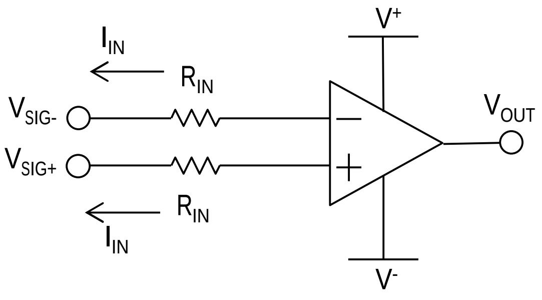
5. Input Overvoltage Protection

If the input voltage exceeds the supply rail, you must use a limiting resistor as shown in Fig.5.1, because you must be limited to less than the input current of absolute maximum ratings. Resistance value of the current limiting and can be calculated by the following equation.



$$I_{IN} = \frac{V_{SIG} - V^+}{R_{IN}} \leq 10mA, \left(V_{SIG} > V^+\right)$$

Fig.5.1a Input Overvoltage ($V_{SIG} > V^+$)



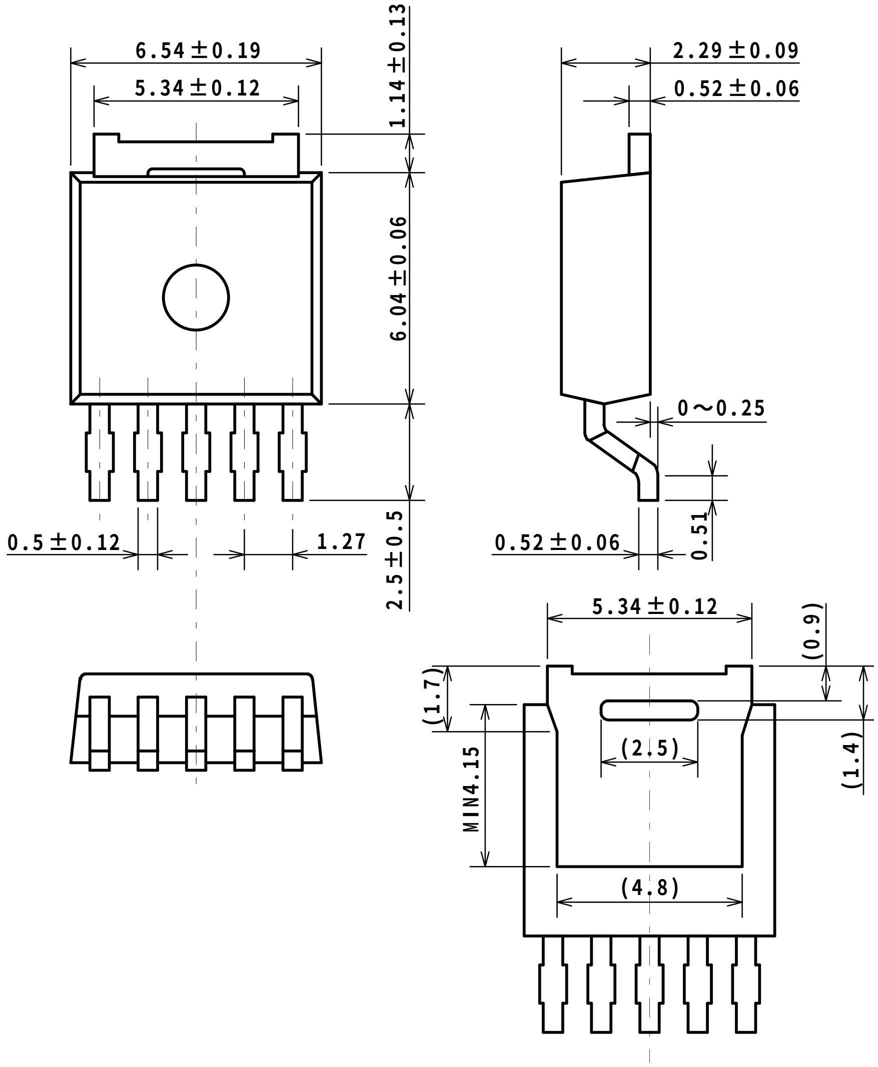
$$I_{IN} = \frac{V^- - V_{SIG}}{R_{IN}} \leq 10mA, (V_{SIG} < V^-)$$

Fig.5.1b Input Overvoltage ($V_{SIG} < V^-$)

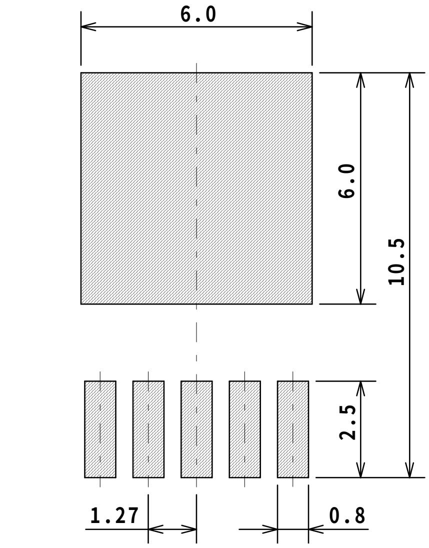
TO-252-5-L3

Unit: mm

■ PACKAGE DIMENSIONS



■ EXAMPLE OF SOLDER PADS DIMENSIONS

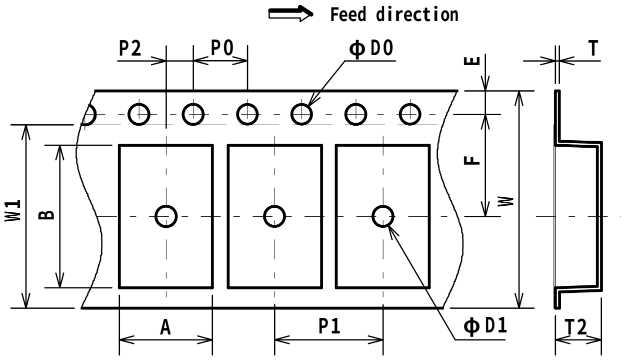


TO-252-5-L3

Unit: mm

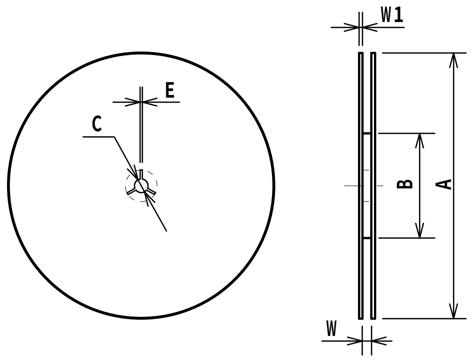
■ PACKING SPEC

TAPING DIMENSIONS



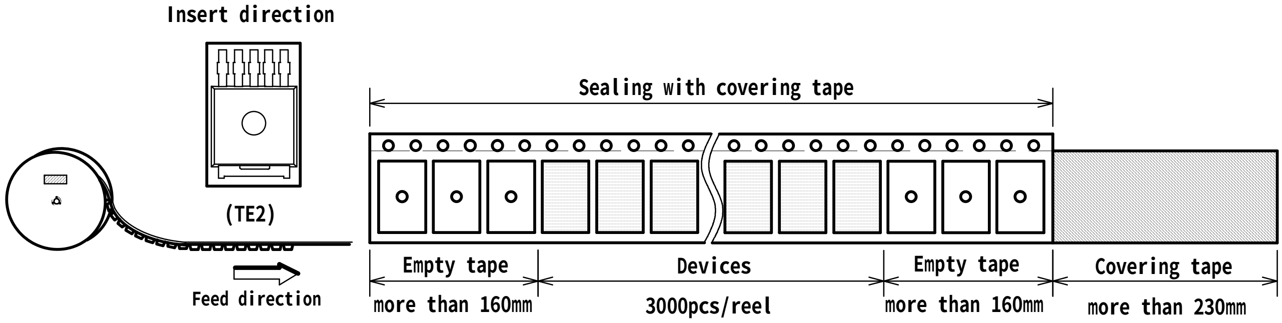
SYMBOL	DIMENSION	REMARKS
A	6.9±0.1	BOTTOM DIMENSION
B	10.5±0.1	BOTTOM DIMENSION
D0	1.5 $^{+0.1}_{0}$	
D1	1.5 $^{+0.1}_{0}$	
E	1.75±0.1	
F	7.5±0.1	
P0	4.0±0.1	
P1	8.0±0.1	
P2	2.0±0.1	
T	0.3±0.1	
T2	3.4 max	
W	16.0±0.3	
W1	13.5	THICKNESS 0.1max

REEL DIMENSIONS

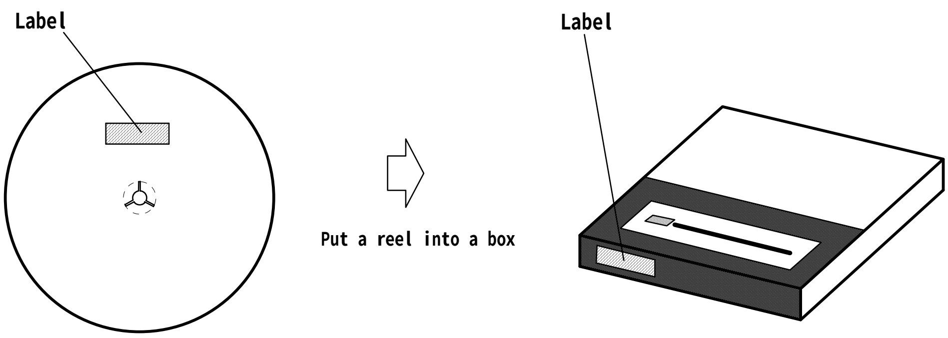


SYMBOL	DIMENSION
A	ϕ330±2
B	ϕ 80±1
C	ϕ 13±0.5
E	2
W	17.5±0.5
W1	2±0.5

TAPING STATE

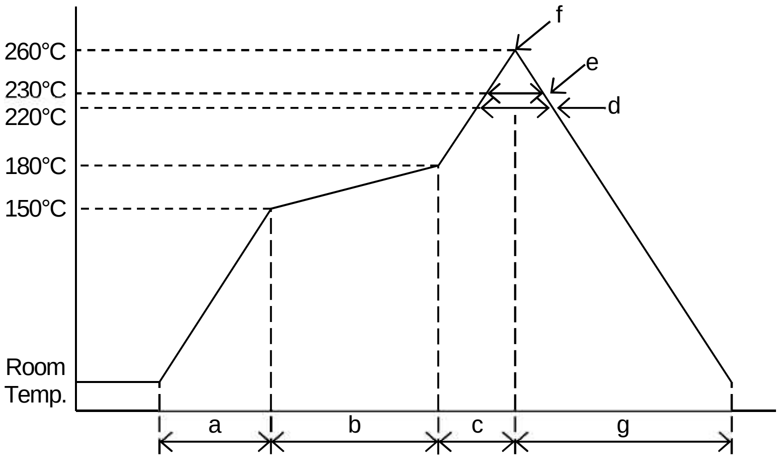


PACKING STATE



■ RECOMMENDED MOUNTING METHOD

INFRARED REFLOW SOLDERING PROFILE



a	Temperature ramping rate	1 to 4°C/s
b	Pre-heating temperature Pre-heating time	150 to 180°C 60 to 120s
c	Temperature ramp rate	1 to 4°C/s
d	220°C or higher time	shorter than 60s
e	230°C 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.

■ REVISION HISTORY

DATE	REVISION	CHANGES
April 19, 2021	Ver.1.0	Initial release

[CAUTION]

1. NJR strives to produce reliable and high quality semiconductors. NJR's semiconductors are intended for specific applications and require proper maintenance and handling. To enhance the performance and service of NJR's semiconductors, the devices, machinery or equipment into which they are integrated should undergo preventative maintenance and inspection at regularly scheduled intervals. Failure to properly maintain equipment and machinery incorporating these products can result in catastrophic system failures

2. The specifications on this datasheet are only given for information without any guarantee as regards either mistakes or omissions. The application circuits in this datasheet are described only to show representative usages of the product and not intended for the guarantee or permission of any right including the industrial property rights.
   All other trademarks mentioned herein are the property of their respective companies.

3. To ensure the highest levels of reliability, NJR products must always be properly handled.
   The introduction of external contaminants (e.g. dust, oil or cosmetics) can result in failures of semiconductor products.

4. NJR offers a variety of semiconductor products intended for particular applications. It is important that you select the proper component for your intended application. You may contact NJR's Sale's Office if you are uncertain about the products listed in this datasheet.

5. Special care is required in designing devices, machinery or equipment which demand high levels of reliability. This is particularly important when designing critical components or systems whose failure can foreseeably result in situations that could adversely affect health or safety. In designing such critical devices, equipment or machinery, careful consideration should be given to amongst other things, their safety design, fail-safe design, back-up and redundancy systems, and diffusion design.

6. The products listed in this datasheet may not be appropriate for use in certain equipment where reliability is critical or where the products may be subjected to extreme conditions. You should consult our sales office before using the products in any of the following types of equipment.

   ・Aerospace Equipment
   ・Equipment Used in the Deep Sea
   ・Power Generator Control Equipment (Nuclear, steam, hydraulic, etc.)
   ・Life Maintenance Medical Equipment
   ・Fire Alarms / Intruder Detectors
   ・Vehicle Control Equipment (Airplane, railroad, ship, etc.)
   ・Various Safety Devices

7. NJR's products have been designed and tested to function within controlled environmental conditions. Do not use products under conditions that deviate from methods or applications specified in this datasheet. Failure to employ the products in the proper applications can lead to deterioration, destruction or failure of the products. NJR shall not be responsible for any bodily injury, fires or accident, property damage or any consequential damages resulting from misuse or misapplication of the products. The products are sold without warranty of any kind, either express or implied, including but not limited to any implied warranty of merchantability or fitness for a particular purpose.

8. Warning for handling Gallium and Arsenic (GaAs) Products (Applying to GaAs MMIC, Photo Reflector). These products use Gallium (Ga) and Arsenic (As) which are specified as poisonous chemicals by law. For the prevention of a hazard, do not burn, destroy, or process chemically to make them as gas or power. When the product is disposed of, please follow the related regulation and do not mix this with general industrial waste or household waste.

9. The product specifications and descriptions listed in this datasheet are subject to change at any time, without notice.