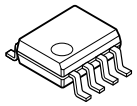
Precision Operational Amplifier

■ GENERAL DESCRIPTION

●Precision	V_{IO}=60μV max.
	V_{IO}=100μV max. (Ta=-40ºC to +85ºC)
●Low Offset Drift	$\Delta V_{IO}/\Delta T$=0.9μV/ºC max. (Ta=-40 to +85ºC)
●Specified for ±15V and ±5V operation	
●CMR	130dB min.
●Low Noise	V_{NI}=80nVrms typ. at f=1 to 100Hz
	en=8nV/√Hz typ. at f=100Hz
●Open Loop Gain	Av=130dB min.
●Guaranteed Temperature	Ta=-40ºC to +85ºC
●Unity Gain Stable	
●Operating Voltage	Vopr=±3V to ±18V
●Unity Gain Frequency	f_T=1.1MHz typ.
●Supply Current	Icc=2mA max.
●Package	EMP8

■ PACKAGE OUTLINE



NJM2729E

■ FEATURES

The NJM2729 is a high performance operational amplifier featured very low offset voltage and drift.

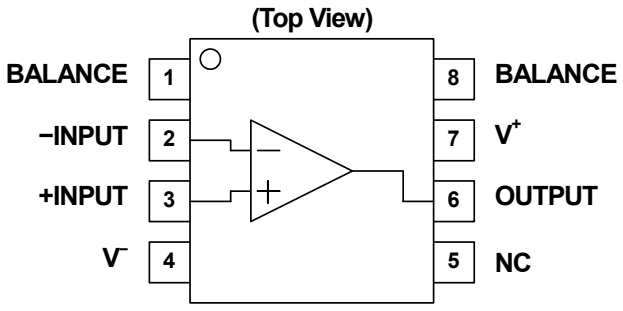
Features are low offset voltage and drift, hi common mode rejection, low noise and open loop gain. DC characteristics are100% tested and specified from −40 to 85ºC.

The NJM2729 is suitable for high gain circuit amplified small signal and sets required stable behavior over a wide temperature range.

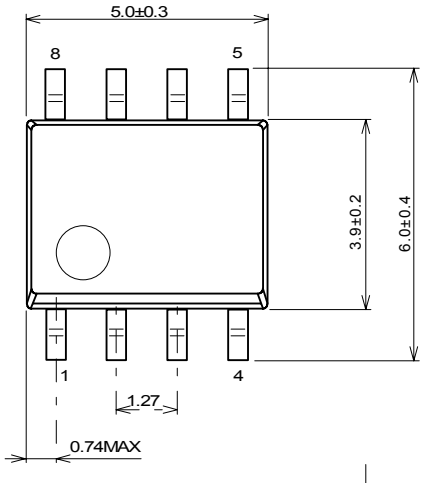
■ APPRICATION

- ●Thermocouple sensor
- ●Bridge Amplifier
- ●Current Sensor
- ●Instrumentation Amplifier
- ●Reference Voltage Circuit

■ PIN CONFIGURATION



■ PACKAGE DESCRIPTION



■ ABSOLUTE MAXIMUM RATING (Ta=25ºC Unless Otherwise Specified)

PARAMETER	SYMBOL	RATING	UNIT
Supply Voltage	V^+/V^-	±20	V
Common Mode Input Voltage (Note1)	V_{ICM}	±20	V
Differential Input Voltage	V_{ID}	±30	V
Power Dissipation (Note 2)	P_D	640	mW
Operating Temperature	Topr	-40 to +85	ºC
Storage Temperature	Tstg	-50 to +125	ºC

(Note1) For supply voltage less than ±20V, the maximum input voltage is equal to the supply voltage.
(Note2) Mounted on the EIA/JEDEC standard board (76.2×114.3×1.6mm, two layer, FR-4).

■ RECOMMENDED OPERATING VOLTAGE

PARAMETER	SYMBOL	RATING	MIN.	TYP.	MAX.	UNIT
Supply Voltage	V^+/V^-		±3	-	±18	V

■ ELECTRONIC CHARACTERISTICS (V^+/V^-=±15V Ta=+25ºC, V_{ICM}=0V unless otherwise specified)

● DC CHARACTERISTICS

PARAMETER	SYMBOL	RATING	MIN.	TYP.	MAX.	UNIT
Input Characteristics						
Input Offset Voltage	$V_{IO}1$		-	20	60	µV
	$V_{IO}2$	Ta=-40 to +85ºC	-	20	100	µV
Input Offset Voltage Drift	ΔVio/T	Ta=-40→+25ºC / Ta=+25ºC→+85ºC	-	0.3	0.9	µV/ºC
Common Mode Input Voltage Range	$V_{ICM}1$		±13	±14	-	V
	$V_{ICM}2$	Ta=-40 to +85ºC	±13	±13.5	-	V
Common Mode Rejection Ratio	CMR1	V_{CM}=0V→-13V / V_{CM}=0V→+13V	130	140	-	dB
	CMR2	Ta=-40 to +85ºC, V_{CM}=0V→-13V / V_{CM}=0V→+13V	120	140	-	dB
Supply Voltage Rejection Ratio	SVR1	V^+/V^-=±3V to ±18V	115	125	-	dB
	SVR2	Ta=-40 to +85ºC,V^+/V^-=±3V to ±18V	110	120	-	dB
Input Bias Current	I_B1		-0.2	1.2	2.8	nA
	I_B2	Ta=-40 to +85ºC	-1.5	1.7	6	nA
Input Bias Current Drift	$\Delta I_B/T$	Ta=-40→+85ºC	-	8	60	pA/ºC
Input Offset Current	$I_{IO}1$		-	0.3	2.8	nA
	$I_{IO}2$	Ta=-40 to +85ºC	-	0.3	4.5	nA
Input Offset Current Drift	$\Delta I_{IO}/T$	Ta=-40→+85ºC	-	1.5	72	pA/ºC
Differential Input Impedance	R_{ID}	Theoretical value by design.	-	90	-	MΩ
Common-Mode Input Impedance	R_{IC}	Theoretical value by design.	-	800	-	GΩ
Input Offset Voltage Trim	Viotri	Rp=20kΩ	-	±3	-	mV
Voltage Gain	Av1	R_L=2kΩ, Vo= -10V→0V / 0V→+10V / -10V→+10V	130	142	-	dB
	Av2	Ta=-40 to +85ºC, R_L=2kΩ, Vo= -10V→0V / 0V→+10V / -10V→+10V	126	136	-	dB

● DC CHARACTERISTICS

PARAMETER	SYMBOL	RATING	MIN.	TYP.	MAX.	UNIT
Output Characteristics						
Maximum Output Voltage	$V_{OM}1$	R_L=10kΩ	±13.5	±14.0	-	V
	$V_{OM}2$	Ta=-40 to +85ºC, R_L=10kΩ	±13.0	±14.0	-	V
	$V_{OM}3$	R_L=2kΩ	±12.5	±13.0	-	V
	$V_{OM}4$	Ta=-40 to +85ºC, R_L=2kΩ	±12.0	±13.0	-	V
	$V_{OM}5$	R_L=1kΩ	±12.0	±12.5	-	V
Output Impedance	R_O	Open-Loop	-	60	-	Ω
Supply Characteristics						
Supply Current	$I_{CC}1$	A_V=+1, R_L=∞	-	1.6	2	mA
	$I_{CC}2$	Ta=-40 to +85ºC, A_V=+1, R_L=∞	-	1.7	2.5	mA
	$I_{CC}3$	V^+/V^-=±3V, A_V=+1, R_L=∞	-	0.58	0.75	mA
Power Dissipation	P_D1	A_V=+1, R_L=∞	-	50	60	mW
	P_D1	V^+/V^-=±3V, A_V=+1, R_L=∞	-	4.2	5.4	mW

● AC CHARACTERISTICS

PARAMETER	SYMBOL	RATING	MIN.	TYP.	MAX.	UNIT
Frequency Characteristics						
Unity Gain Frequency	f_T	A_V=+100, R_L=2kΩ, CL=10pF	-	1.1	-	MHz
Slew Rate	+SR	RISE, A_V=+1, V_{IN}=1Vpp, R_L=2kΩ, C_L=10pF	0.1	0.3	-	V/μs
	-SR	FALL, A_V=+1, V_{IN}=1Vpp, R_L=2kΩ, C_L=10pF	0.1	0.3	-	V/μs
Noise Characteristics						
Equivalent Input Noise Voltage	V_{NI}	fo=1Hz to 100Hz	-	80	-	nVrms
Equivalent Input Noise Current	I_{NI}	fo=1Hz to 100Hz	-	3	-	pArms

■ **ELECTRONIC CHARACTERISTICS (V^+/V^-=±5V Ta=+25ºC, V_{ICM}=0V unless otherwise specified)**

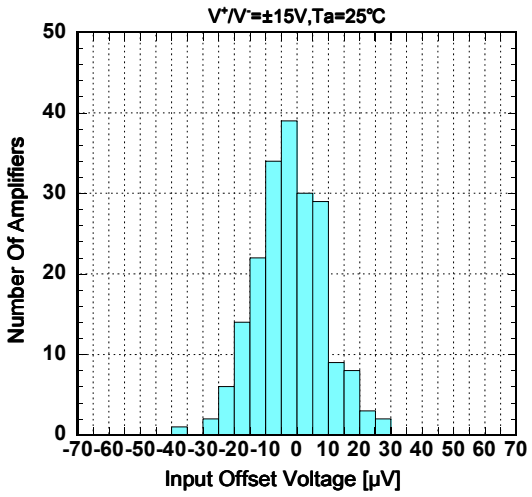
PARAMETER	SYMBOL	RATING	MIN.	TYP.	MAX.	UNIT
Input Characteristics						
Input Offset Voltage	$V_{IO}1$		-	30	70	µV
	$V_{IO}2$	Ta=-40 to +85ºC	-	35	110	µV
Common Mode Input Voltage Range	$V_{ICM}1$		±3	±3.9	-	V
	$V_{ICM}2$	Ta=-40 to +85ºC	±3	±3.5	-	V
Common Mode Rejection Ratio	CMR1	V_{CM}=0V→-3V / V_{CM}=0V→+3V	115	130	-	dB
	CMR2	Ta=-40 to +85ºC, V_{CM}=0V→-3V / V_{CM}=0V→+3V	105	125	-	dB
Input Bias Current	I_B1		-0.2	0.7	2	nA
	I_B2	Ta=-40 to +85ºC	-0.2	1	6	nA
Input Offset Current	$I_{IO}1$		-	0.3	2.8	nA
	$I_{IO}2$	Ta=-40 to +85ºC	-	0.3	4.5	nA
Voltage Gain	Av1	Open-Loop, R_L=2kΩ, Vo= -3V→0V / 0V→+3V / -3V→+3V	115	130	-	dB
	Av2	Ta=-40 to +85ºC, Open-Loop, R_L=2kΩ, Vo= -3V→0V / 0V→+3V / -3V→+3V	110	125	-	dB
Output Characteristics						
Maximum Output Voltage	$V_{OM}1$	R_L=10kΩ	±3.5	±4.0	-	V
	$V_{OM}2$	Ta=-40 to +85ºC, R_L=10kΩ	±3.5	±4.0	-	V
	$V_{OM}3$	R_L=2kΩ	±3.5	±4.0	-	V
	$V_{OM}4$	Ta=-40 to +85ºC, R_L=2kΩ	±3.5	±4.0	-	V
Supply Characteristics						
Supply Current	$I_{CC}1$	A_V=+1, R_L=∞	-	0.85	1.1	mA
	$I_{CC}2$	Ta=-40 to +85ºC, A_V=+1, R_L=∞	-	0.9	1.25	mA

● EXPLANATION OF MEASUREMENT CONDITION

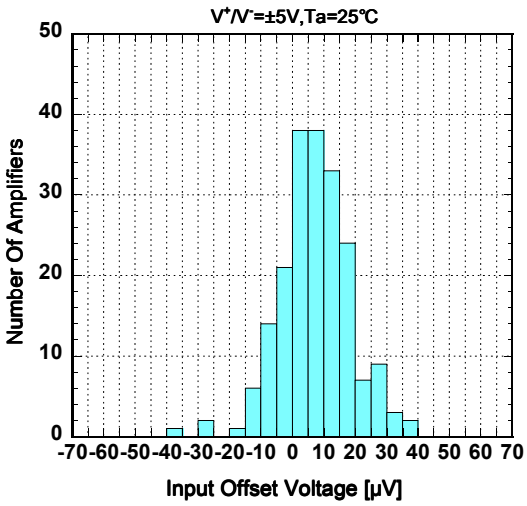
PARAMETER	Explanation
Input Offset Voltage Drift	Input Offset Voltage Drift = $\Delta V_{IO} / \Delta t$ Δt : Amount of Temperature change. ΔV_{IO} : Amount of Input Offset Voltage.
Common Mode Input Voltage range	A range of input voltage at which the operational amplifier can function.
Common Mode Rejection Ratio	$CMR = 20\log \lvert (\Delta V_{IN} / \Delta V_{IO}) \rvert$ ΔV_{IN} : Amount of Input Voltage. ΔV_{IO} : Amount of Input Offset Voltage.
Supply Voltage Rejection Ratio	$SVR = 20\log \lvert (\Delta V_S / \Delta V_{IO}) \rvert$ ΔV_S : Amount of supply Voltage. ΔV_{IO} : Amount of Input Offset Voltage.
Common Mode Input Impedance	$R_{INCM} = \Delta V_{IN} / \Delta I_B$ ΔV_{IN} : Amount of Input Voltage. ΔI_B : Amount of Input bias current.
Voltage Gain	$AV = 20\log \lvert (\Delta V_{IN} / \Delta V_O) \rvert$ ΔV_O : Amount of output Voltage. ΔV_{IN} : Amount of Input Voltage.

■ TYPICAL CHARACTERISTICS

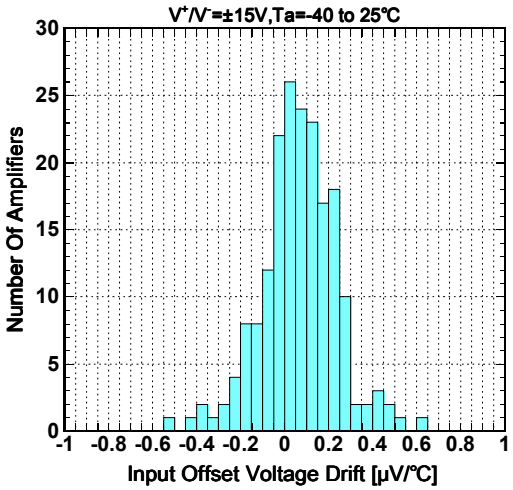
Input Offset Voltage Distribution



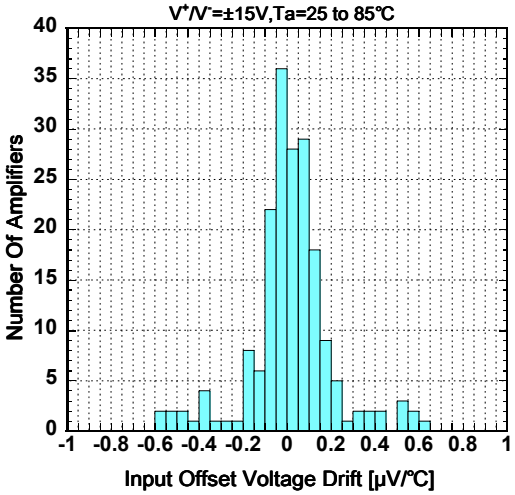
Input Offset Voltage Distribution



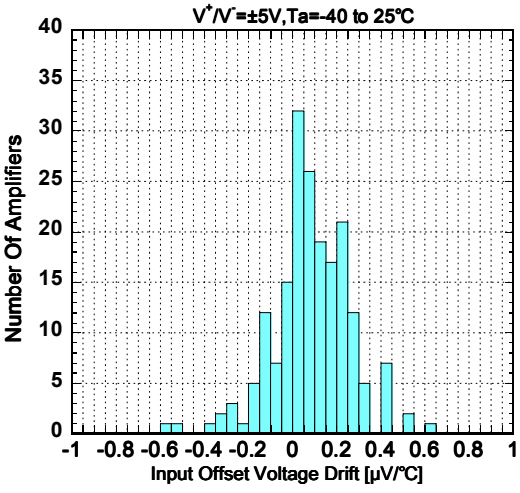
Input Offset Voltage Drift Distribution



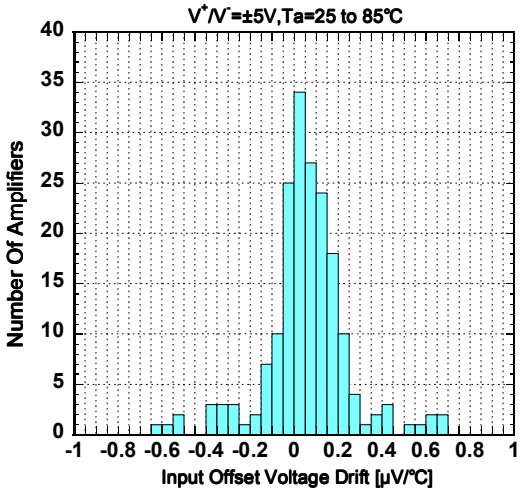
Input Offset Voltage Drift Distribution



Input Offset Voltage Drift Distribution



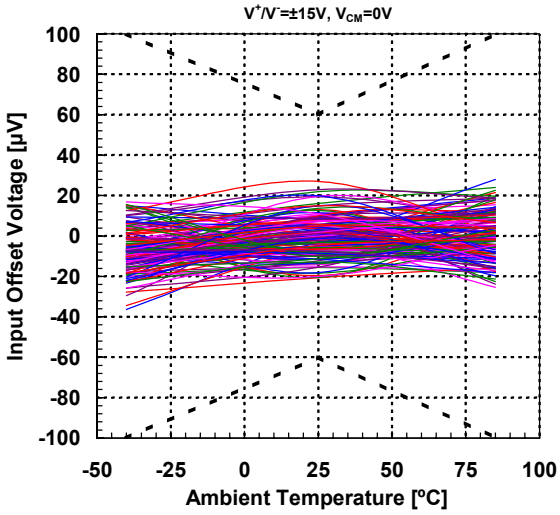
Input Offset Volotage Drift Distribution



■ TYPICAL CHARACTERISTICS

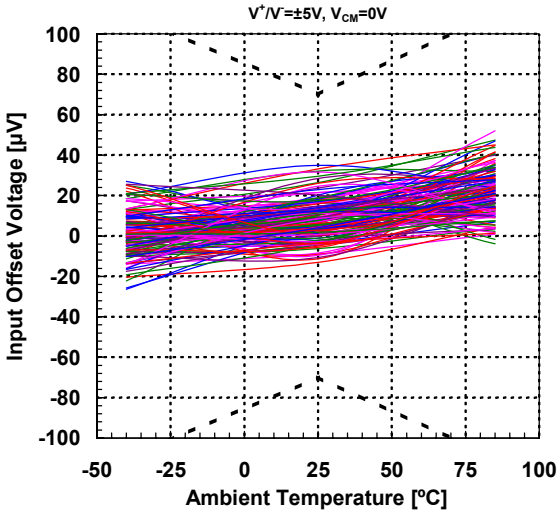
Input Offset Voltage vs. Temperature

V^+/V^-=±15V, V_{CM}=0V



Input Offset Voltage vs. Temperature

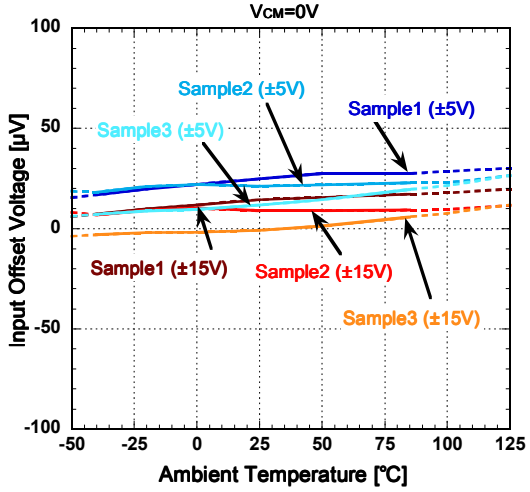
V^+/V^-=±5V, V_{CM}=0V



Input Offset Voltage vs. Temperature

(Supply Voltage)

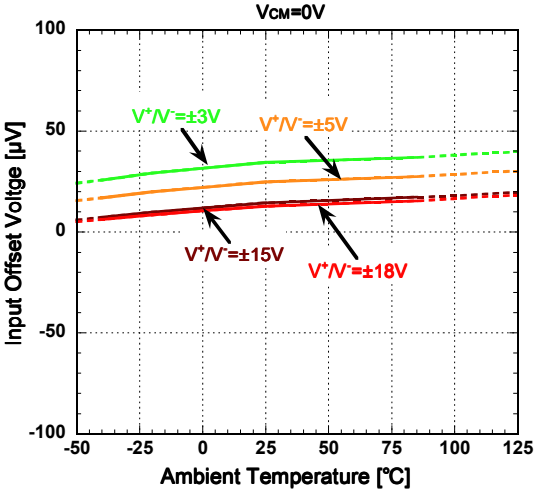
V_{CM}=0V



Input Offset Voltage vs. Temperature

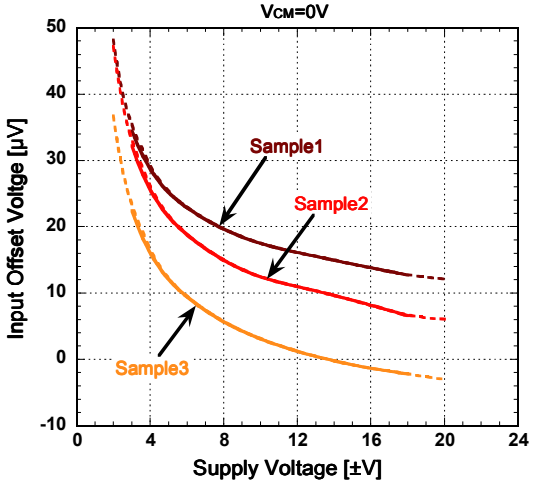
(Supply Voltage)

V_{CM}=0V



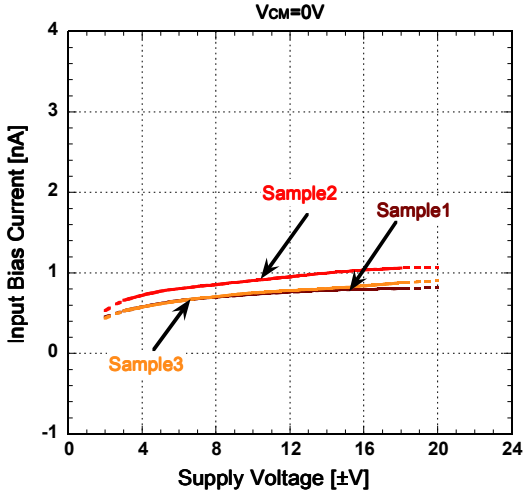
Input Offset Voltage vs. Supply Voltage

V_{CM}=0V



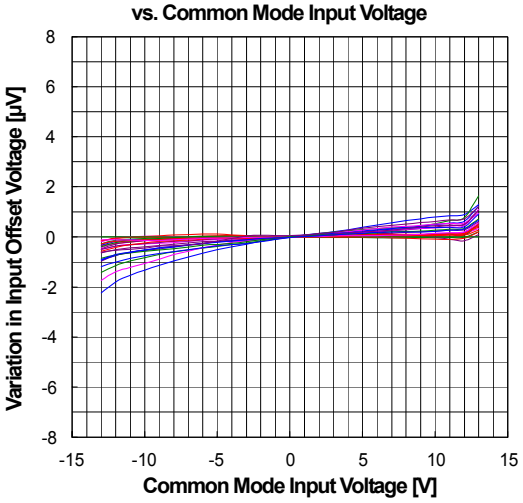
Input Bias Curent vs. Supply Voltage

V_{CM}=0V

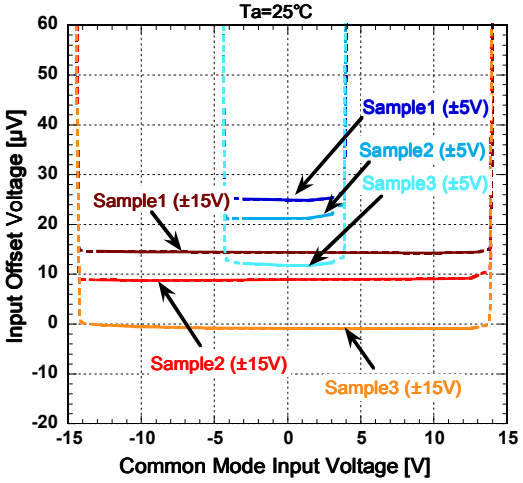


■ TYPICAL CHARACTERISTICS

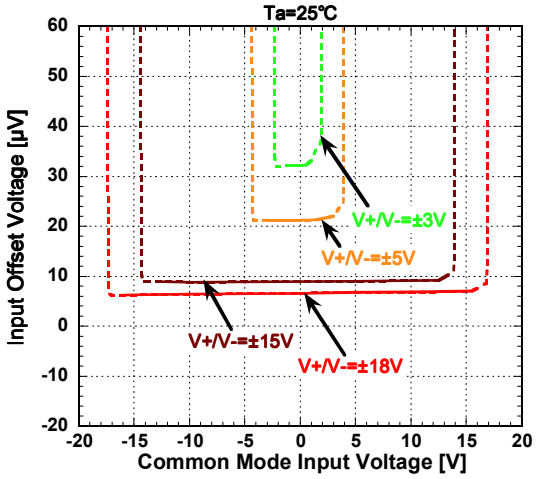
Variation in Input Offset Voltage
vs. Common Mode Input Voltage



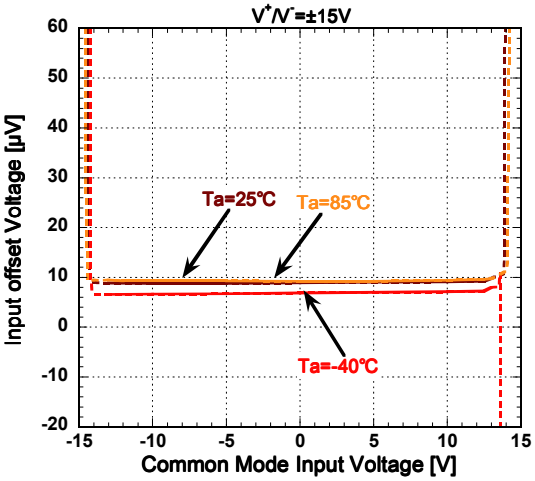
Input Offset Voltage
vs. Common Mode Input Voltage
(Supply Voltage)
Ta=25℃



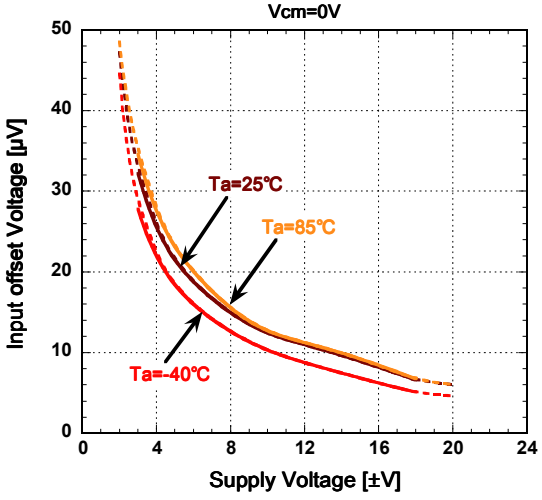
Input Offset Voltage vs. Common Mode Input Voltage
(Supply Voltage)
Ta=25℃



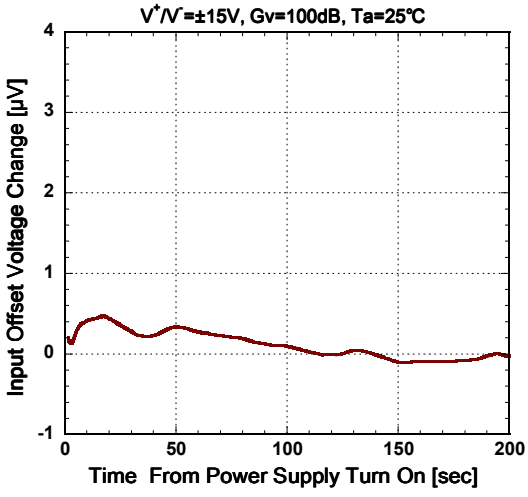
Input Offset Voltage vs. Common Mode Input Voltage
(Temperature)
V^+/V^-=±15V



Input Offset Voltage vs. Supply Voltage
(Temperature)
Vcm=0V

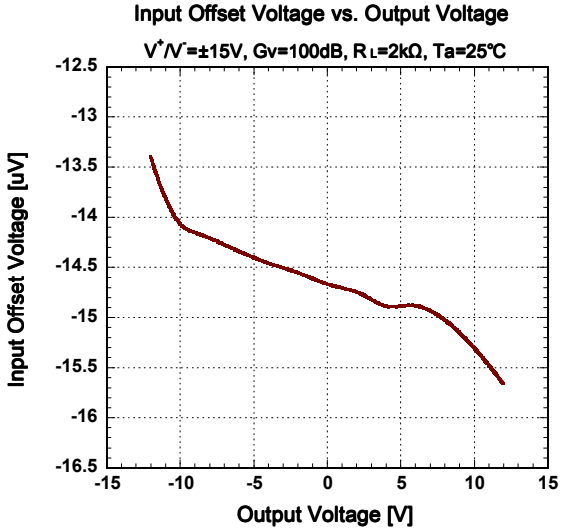


Warm Up Input Offset Voltage Drift
V^+/V^-=±15V, Gv=100dB, Ta=25℃

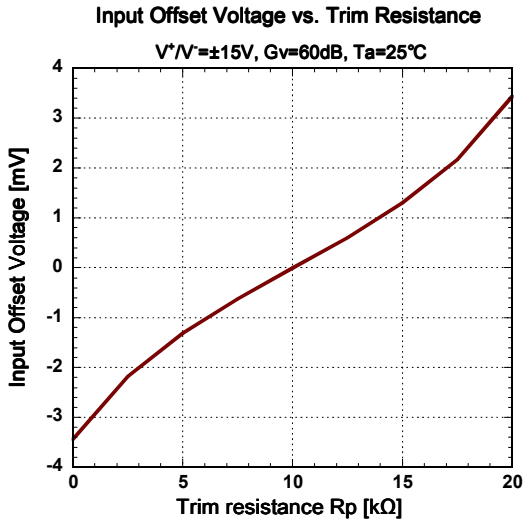


■ TYPICAL CHARACTERISTICS

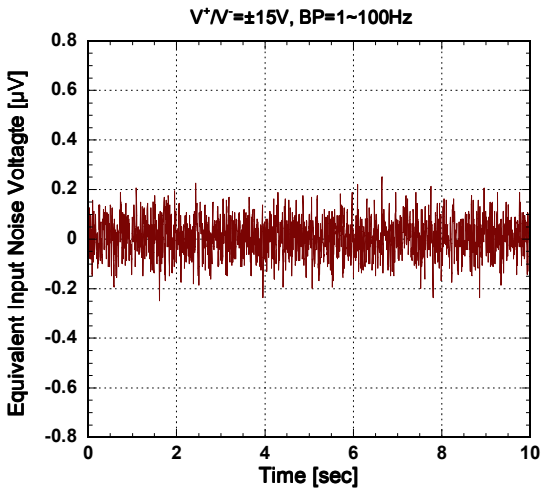
Input Offset Voltage vs. Output Voltage



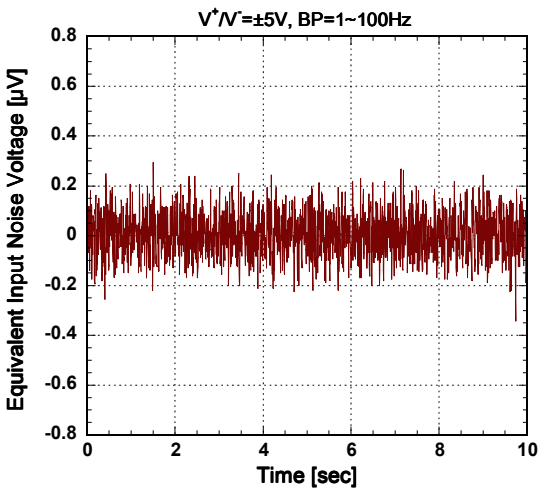
Input Offset Voltage vs. Trim Resistance



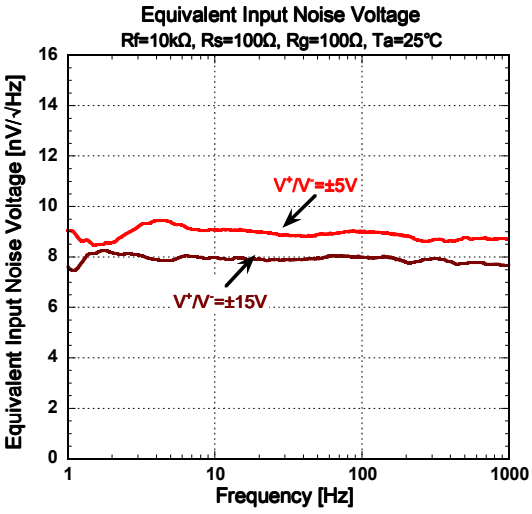
Equivalent Input Noise Voltage



Equivalent Input Noise Voltage

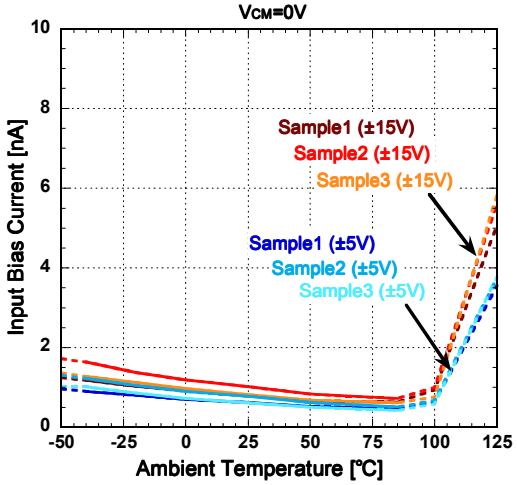


Equivalent Input Noise Voltage

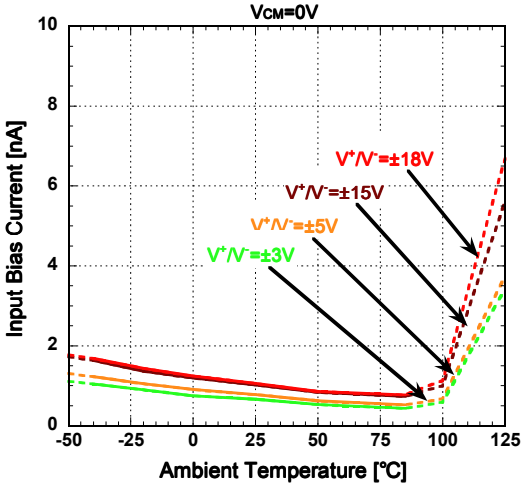


■ TYPICAL CHARACTERISTICS

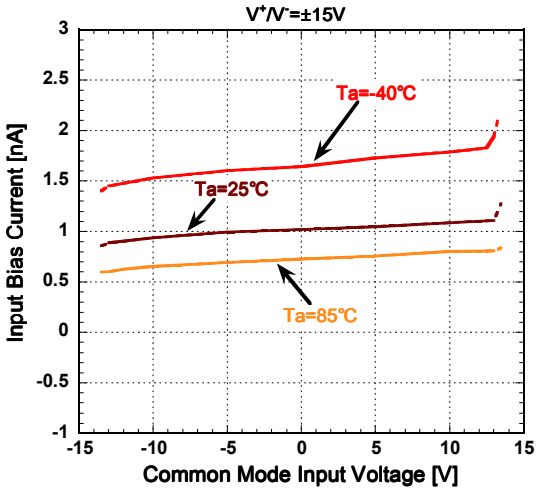
Input Bias Current vs. Temperature
(Supply Voltage)
VCM=0V



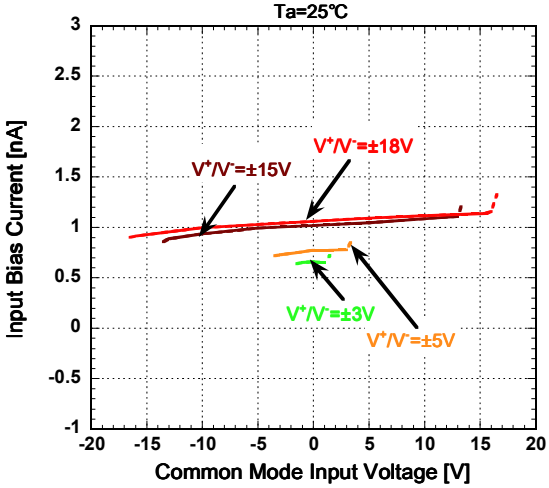
Input Bias Current vs. Temperature
(Supply Voltage)
VCM=0V



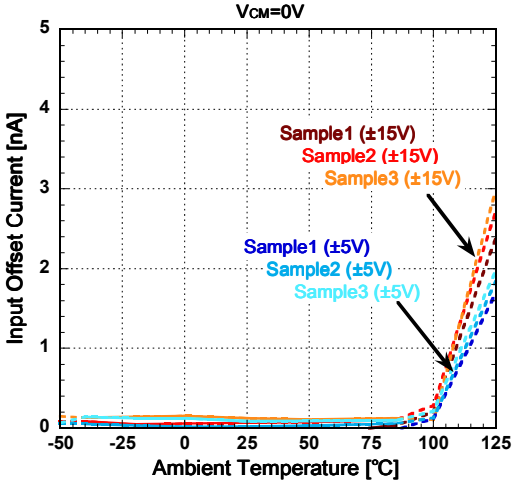
Input Bias Current vs. Common Mode Input Voltage
(Temperature)
V+/V-=±15V



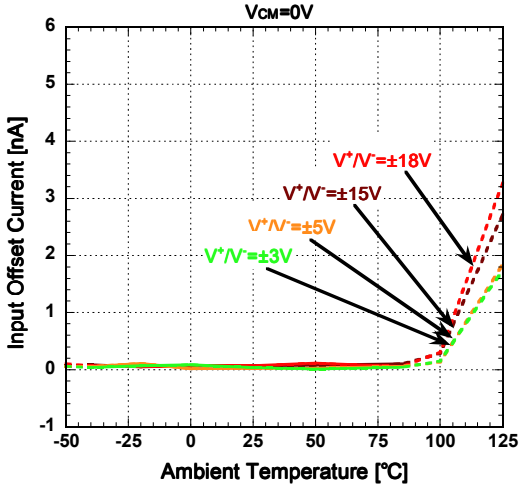
Input Bias Current vs. Common Mode Input Voltage
(Supply Voltage)
Ta=25℃



Input Offset Current vs. Temperature
(Supply Voltage)
VCM=0V

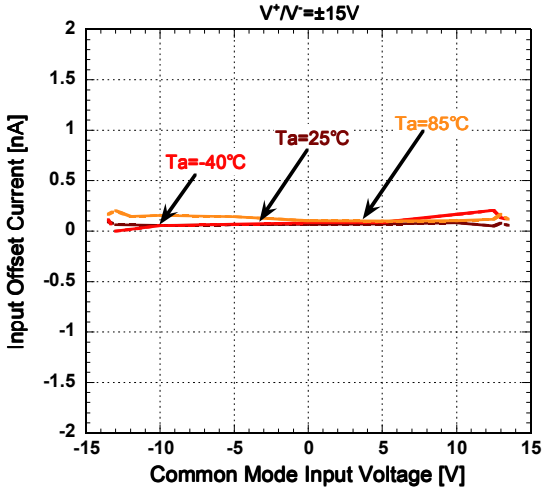


Input Offset Current vs. Temperature
(Supply Voltage)
VCM=0V

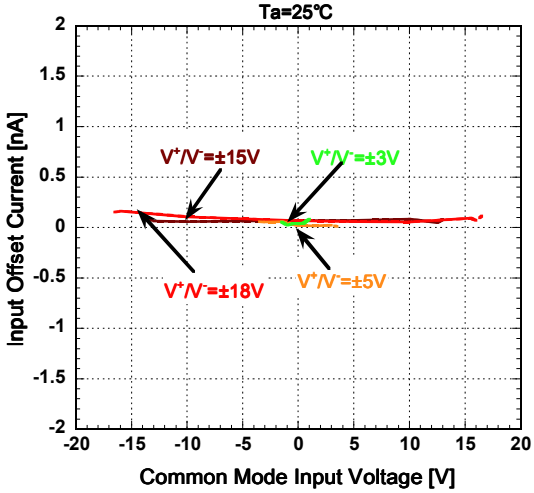


■ TYPICAL CHARACTERISTICS

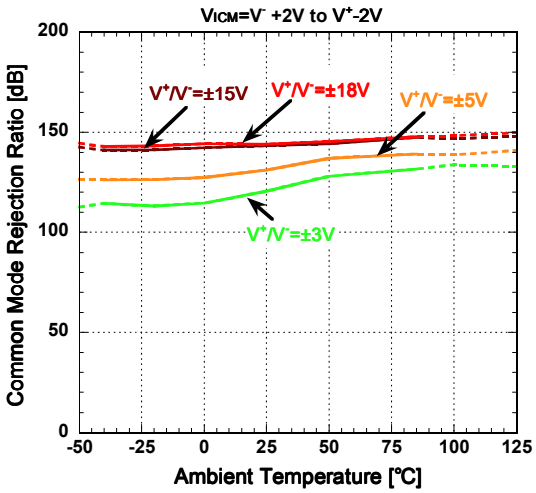
Input Offset Current vs. Common Mode Input Voltage
(Temperature)



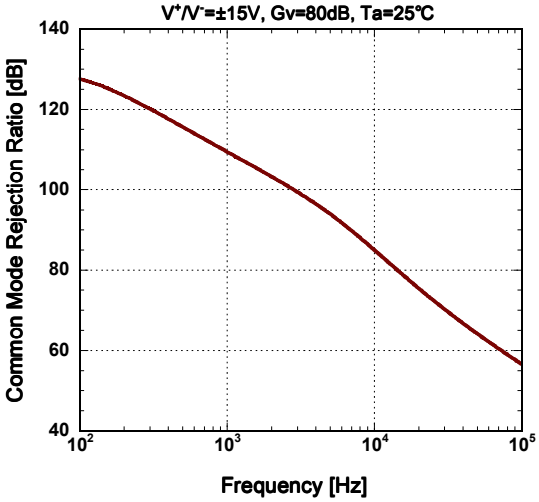
Input Offset Current vs. Common Mode Input Voltage
(Supply Voltage)
Ta=25℃



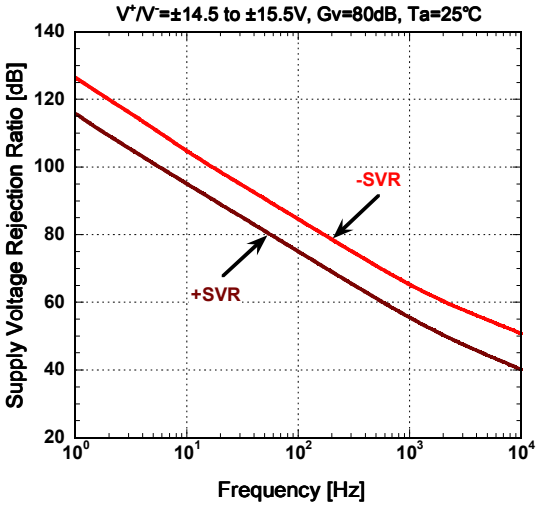
Common Mode Rejection Ratio vs. Temperature
(Supply Voltage)
VICM=V- +2V to V+-2V



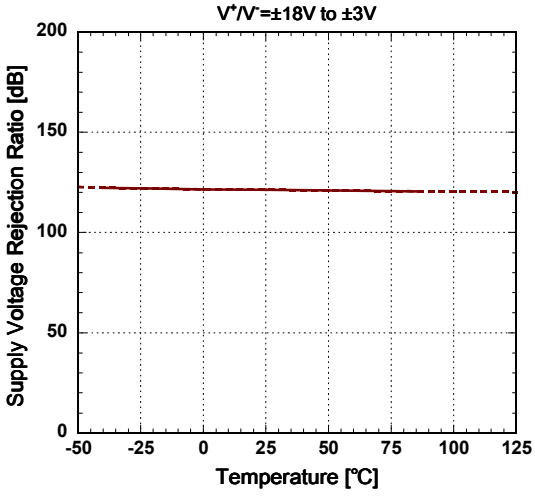
Common Mode Rejection Ratio vs. Frequency
V+/V-=±15V, Gv=80dB, Ta=25℃



Supply Voltage Rejection Ratio vs. Frequency
V+/V-=±14.5 to ±15.5V, Gv=80dB, Ta=25℃

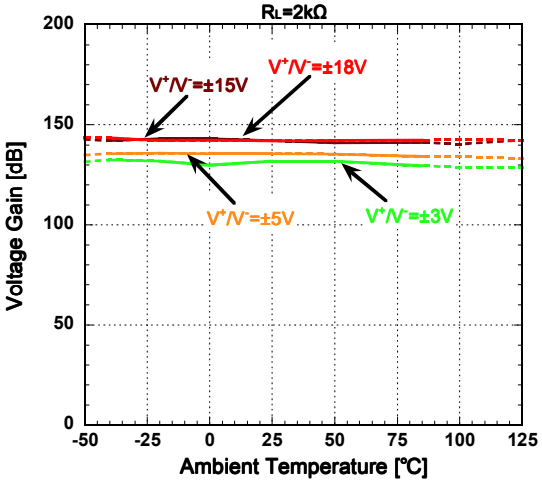


Supply Voltage Rejection Ratio vs. Temperature
V+/V-=±18V to ±3V

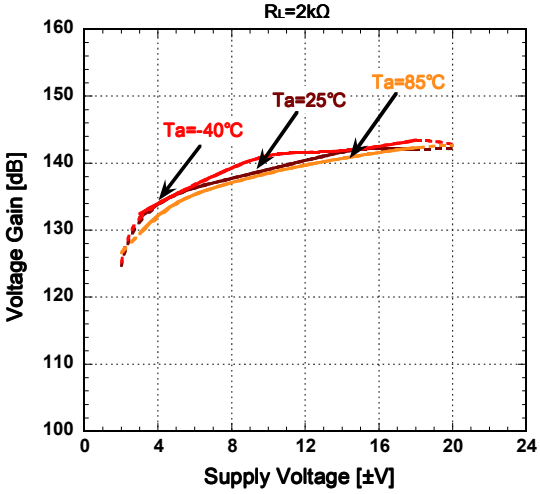


■ TYPICAL CHARACTERISTICS

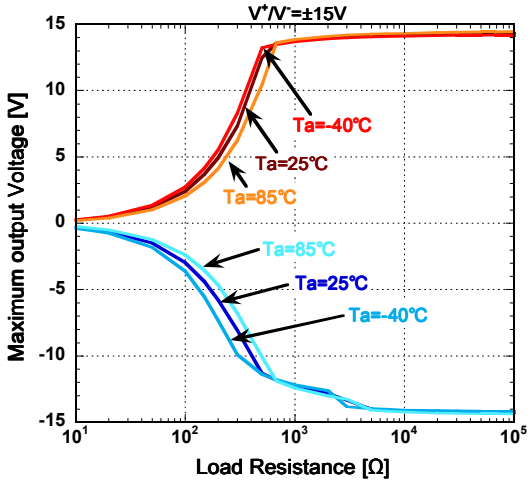
Voltage Gain vs. Temperature
(Supply Voltage)
RL=2kΩ



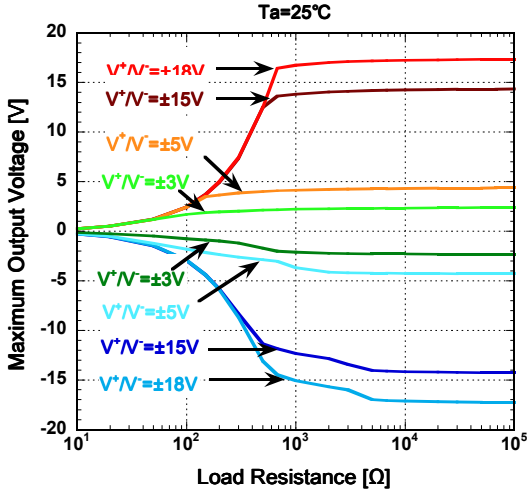
Voltage Gain vs. Supply Voltage
(Temperature)
RL=2kΩ



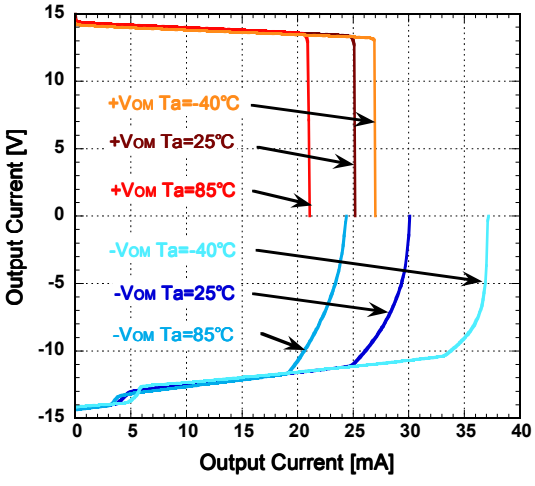
Maximum Output Voltage vs. Load Resistance
(Temperature)
V+/V-=±15V



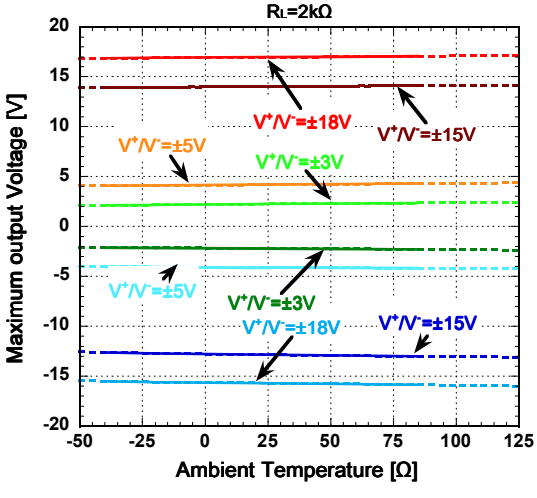
Maximum Output Voltage vs. Load Resistance
(Supply Voltage)
Ta=25℃



Output Voltage vs. Output Current
V+/V-=±15V



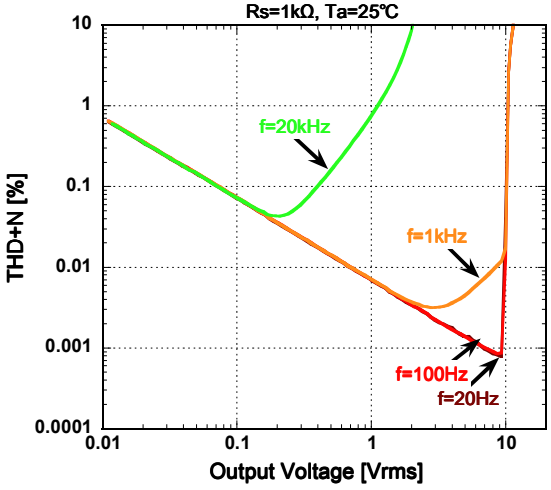
Maximum output Voltage vs. Temperature
(Supply Voltage)
RL=2kΩ



■ TYPICAL CHARACTERISTICS

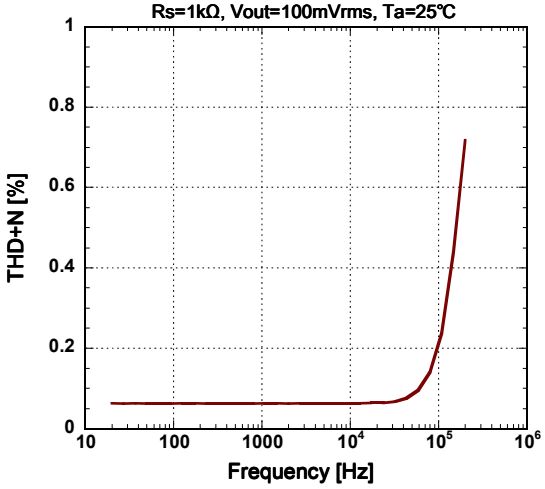
THD+N vs. Output Voltage

V+/V-=±15V, Gv=20dB, RF=10kΩ, Rs=1kΩ, Ta=25℃



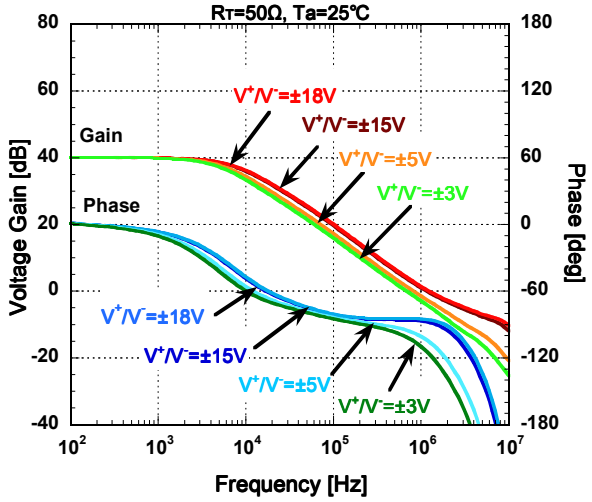
THD+N vs. Frequency

V+/V-=±15V, Gv=20dB, RF=10kΩ, Rs=1kΩ, Vout=100mVrms, Ta=25℃



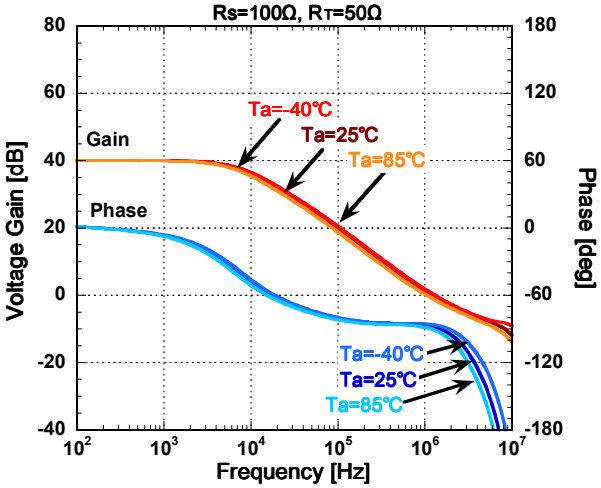
40dB Gain/Phase vs. Frequency (Supply Voltage)

Gv=40dB, RF=10kΩ, Rs=100Ω, RT=50Ω, Ta=25℃



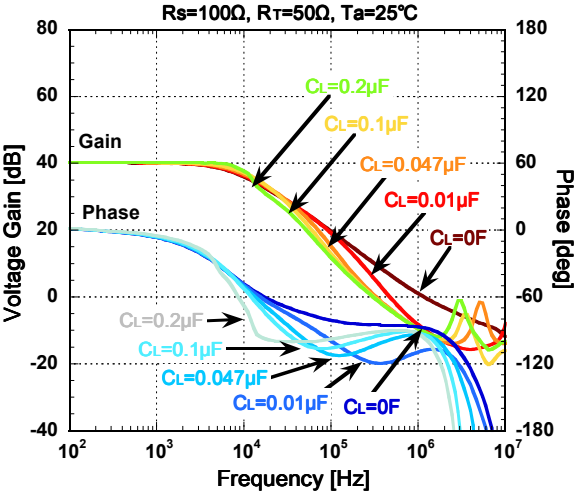
40dB Gain/Phase vs. Frequency (Temperature)

V+/V-=±15V, Gv=40dB, RF=10kΩ, Rs=100Ω, RT=50Ω



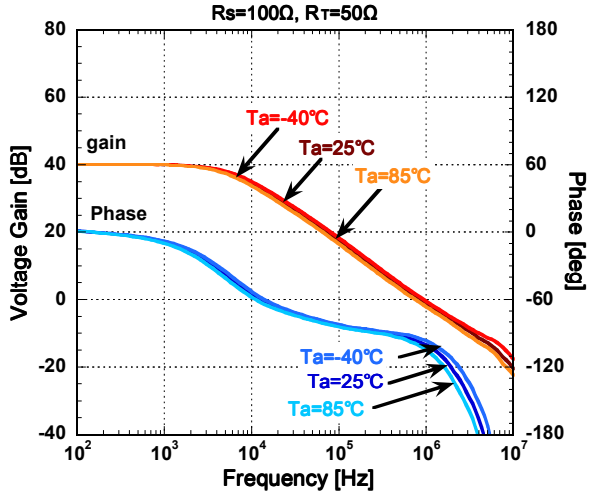
40dB Gain/Phase vs. Frequency (Load Capacitance)

V+/V-=±15V, Gv=40dB, RF=10kΩ, Rs=100Ω, RT=50Ω, Ta=25℃



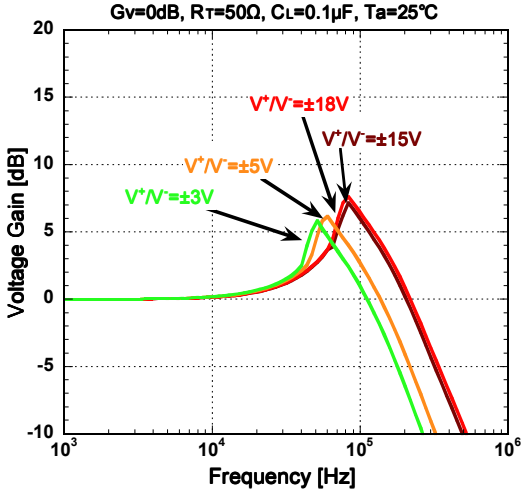
40dB Gain/Phase vs. Frequency (Temperature)

V+/V-=±5V, Gv=40dB, RF=10kΩ, Rs=100Ω, RT=50Ω

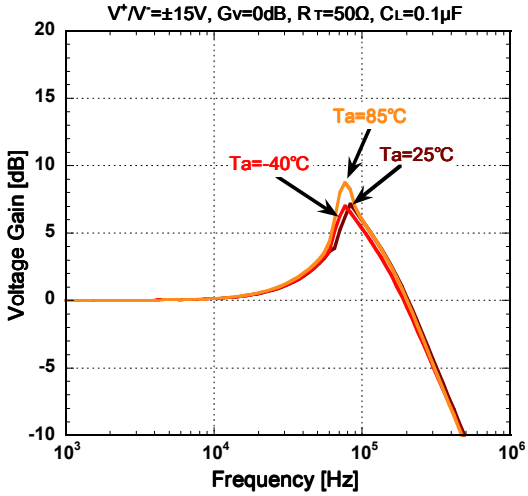


■ TYPICAL CHARACTERISTICS

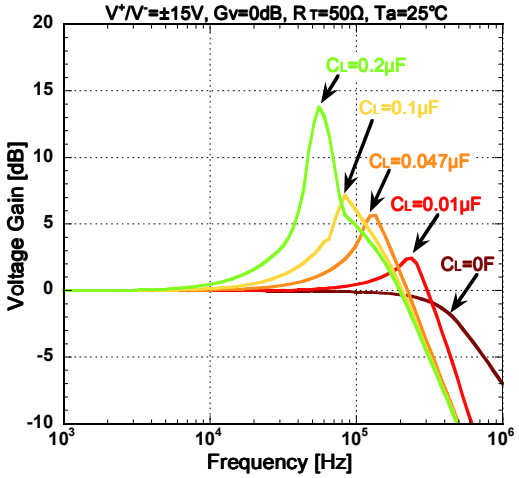
V.F. Peak (Supply Voltage)
Gv=0dB, RT=50Ω, CL=0.1μF, Ta=25℃



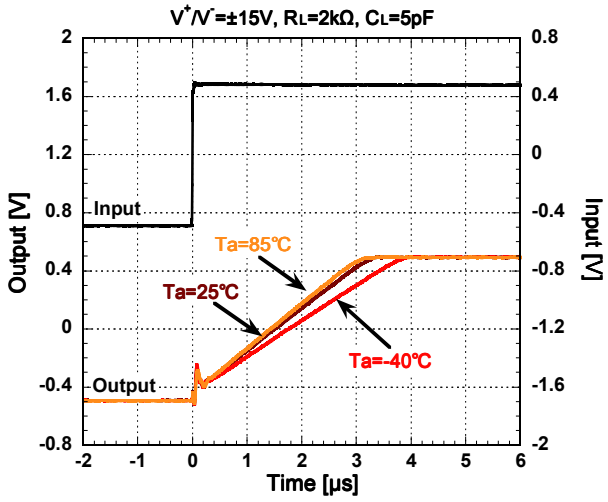
V.F.Peak (Temperature)
V+/V-=±15V, Gv=0dB, RT=50Ω, CL=0.1μF



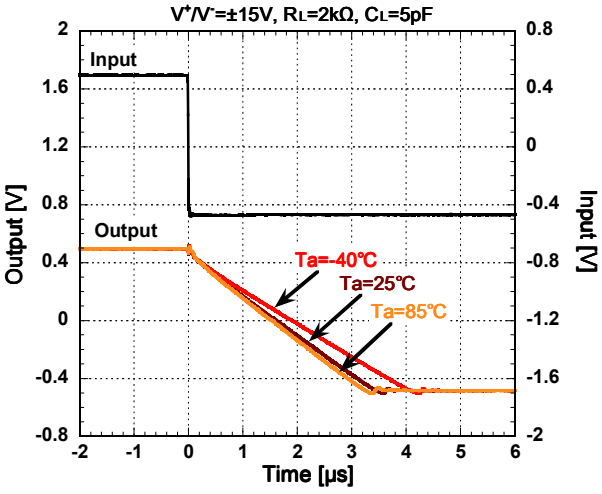
V.F.Peak (Load Capacitance)
V+/V-=±15V, Gv=0dB, RT=50Ω, Ta=25℃



Pulse Response (Temperature)
V+/V-=±15V, RL=2kΩ, CL=5pF



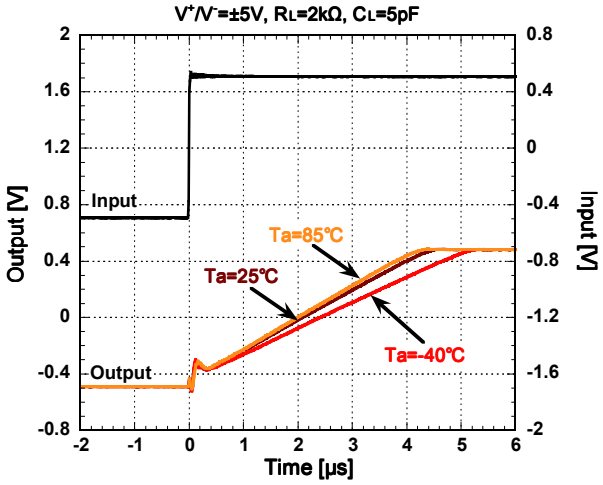
Pulse Response (Temperature)
V+/V-=±15V, RL=2kΩ, CL=5pF



■ TYPICAL CHARACTERISTICS

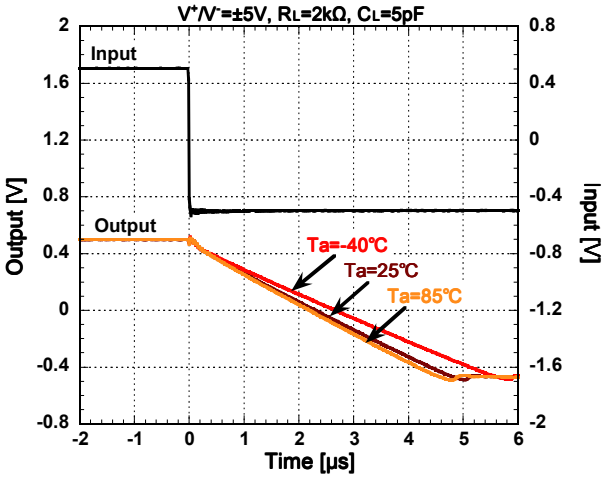
Pulse Response (Temperature)

V⁺/V⁻=±5V, RL=2kΩ, CL=5pF

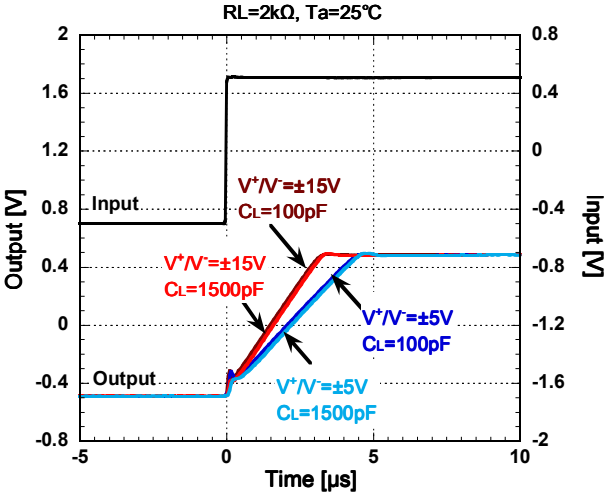


Pulse Response (Temperature)

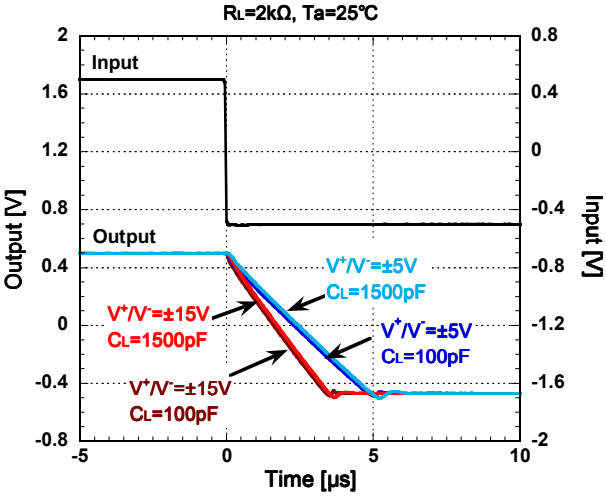
V⁺/V⁻=±5V, RL=2kΩ, CL=5pF



Pulse Response
(Supply Voltage, Load Capacitance)
RL=2kΩ, Ta=25℃

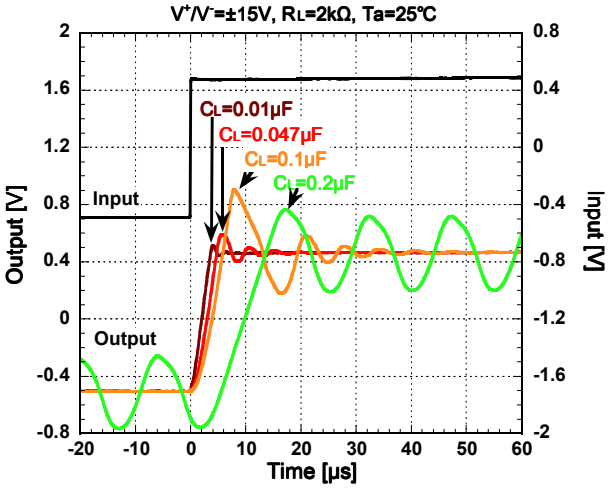


Pulse Response
(Supply Voltage, Load Capacitance)
RL=2kΩ, Ta=25℃



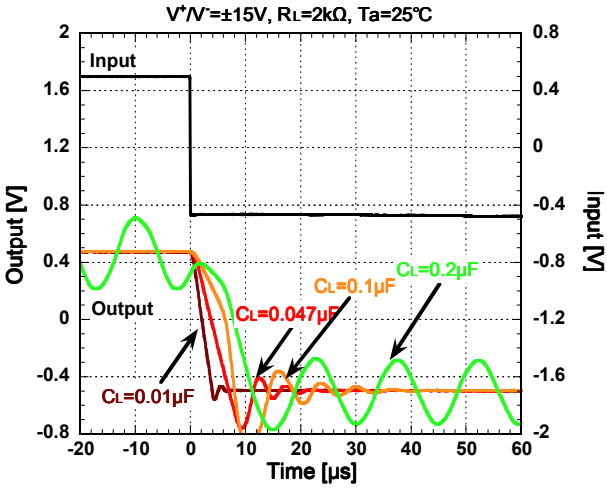
Pulse Response (Load Capacitance)

V⁺/V⁻=±15V, RL=2kΩ, Ta=25℃



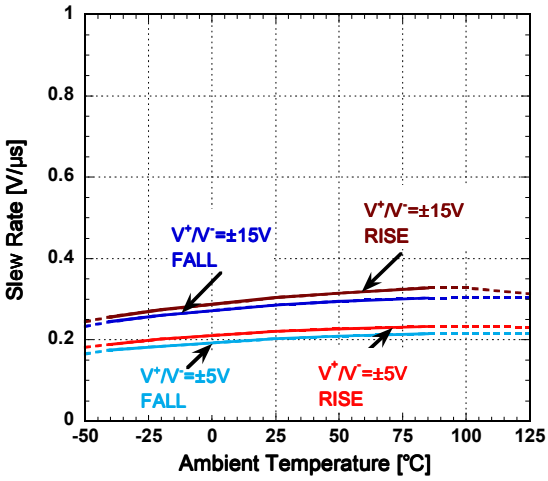
Pulse Response (Load Capacitance)

V⁺/V⁻=±15V, RL=2kΩ, Ta=25℃

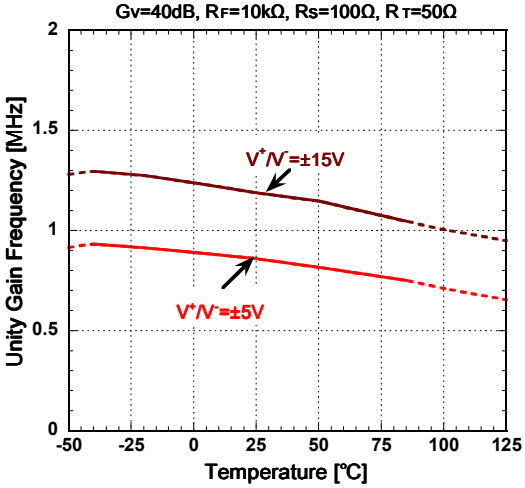


■ TYPICAL CHARACTERISTICS

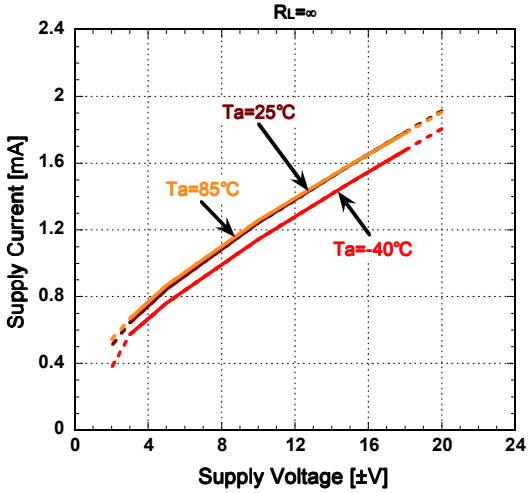
Slew Rate vs. Temperature
R_L=2kΩ



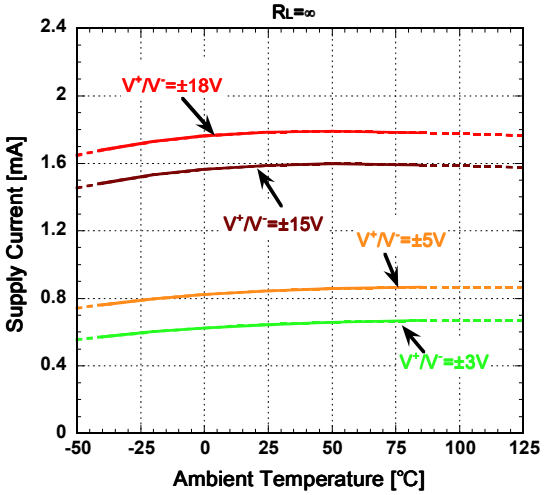
Unity Gain Frequency vs. Temperature
Gv=40dB, R_F=10kΩ, R_S=100Ω, R_T=50Ω



Supply Current vs. Supply Voltage (Temperature)
R_L=∞



Supply Current vs. Temperature
(Supply Voltage)
R_L=∞



■ Application Information

●Power Supply Bypassing

The NJM2729 is a high precision operational amplifier featuring low offset voltage, high voltage gain, high CMR, high SVR and so on. To maximize such a high performance with stable operation, the NJM2729 should be operated by clean and low impedance supply voltage. So, the bypass capacitor should be connected to the NJM2729's both power supply terminals (V+ and V-) as shown in Fig.1. The bypass capacitors should be placed as close as possible to IC package

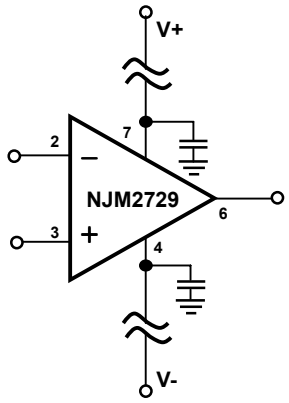


Fig.1 Power Supply Bypassing Circuit

●Thermoelectric Effect

The NJM2729 is a high precision operational amplifier featuring low offset voltage and low offset voltage thermal drift. To achieve such a high performance, take care about thermoelectric effect possibly occurs on each input terminal of the NJM2729. Generally, if there are thermal mismatches at the junction of different types of metals, the thermoelectric voltage (Seebeck effect) occurs at the junction. The thermoelectric voltages possibly occur at the junction of PCB metal patterns and NJM2729's each input terminal metal. If there is thermal mismatch in-between NJM2729's each input terminal metal, the thermoelectric voltages generated on each input terminal possibly have different voltage each. This voltage difference causes offset voltage and offset voltage thermal drift of the NJM2729. To minimize this voltage difference, the thermal mismatch in-between NJM2729's each input terminal and PCB metal should be minimized.

●Offset Voltage Adjustment

The NJM2729 has offset voltage trim terminals (pin1 and pin8) as shown in below Fig.2. By connecting external potentiometer in the range of 20Kohm, the offset voltage trim range is ±3mV. This offset voltage trim is effective only for offset voltage at room temperature, not for offset voltage thermal drift. If offset voltage adjustment is not in use, leave pin1 and pin8 open (un-connected).

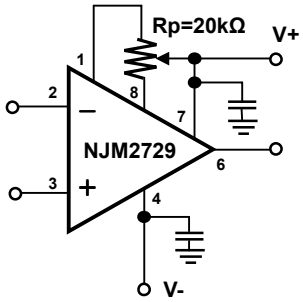


Fig.2 Offset Voltage Trim Circuit

●Differential Amplifier

Differential amplifier (see below Fig.3) is used in high accuracy circuit to improve common mode rejection ratio (CMR).
A matching between the ratio R1/R2 = R3/R4 and R1=R3 makes the high CMR.
For example, acceptable error range to obtain CMR of 130dB or more is about 0.1ppm.

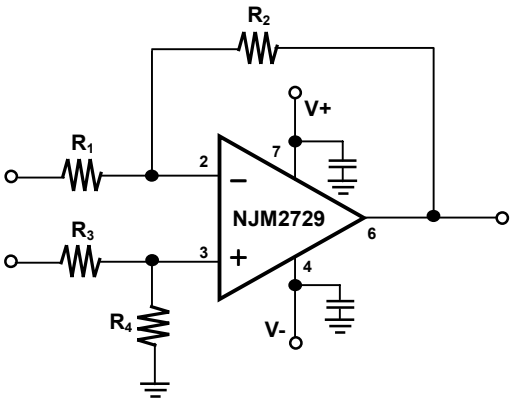


Fig.3 Differential Amplifier

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