Low Supply Current Output Full Swing CMOS Operational Amplifiers

LMR341G LMR342xxx LMR344xxx

General Description

The LMR341G, LMR342xxx and LMR344xxx are input ground sense, output full swing operational amplifiers. They have the features of low operating supply voltage, low supply current and low input bias current. These are suitable for sensor amplifier, battery-powered electronic equipment, battery monitoring and audio pre-amps for voice. Shutdown function is applied to LMR341G.

Key Specifications

- Operating Supply Voltage (Single Supply): +2.7V to +5.5V
- Supply Current (VDD=2.7V, T_A=25°C):
  - LMR341G(Single) 80µA(Typ)
  - LMR342xxx(Dual) 200µA(Typ)
  - LMR344xxx(Quad) 400µA(Typ)
- Voltage Gain (R_L=2kΩ): 103dB(Typ)
- Temperature Range: -40°C to +85°C
- Input Offset Voltage (T_A=25°C): 4mV(Max)
- Input Bias Current (T_A=25°C): 1pA(Typ)
- Turn on time from shutdown: 2µS(Typ)

Features

- Low Operating Supply Voltage
- Low Input Bias Current
- Low Supply Current
- Low Input Offset Voltage

Applications

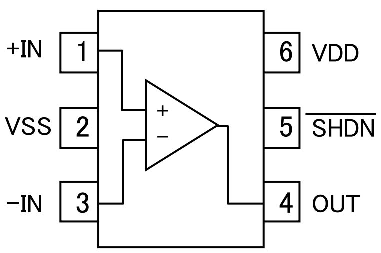
- Sensor Amplifier
- Battery Monitoring
- Battery-Powered Electronic Equipment
- Audio Pre-Amps for Voice
- Active Filter
- Buffer
- Consumer Electronics

Package s

Package	W(Typ) xD(Typ) xH(Max)
SSOP6	2.90mm x 2.80mm x 1.25mm
SOP8	5.00mm x 6.20mm x 1.71mm
SOP-J8	4.90mm x 6.00mm x 1.65mm
SSOP-B8	3.00mm x 6.40mm x 1.35mm
TSSOP-B8	3.00mm x 6.40mm x 1.20mm
MSOP8	2.90mm x 4.00mm x 0.90mm
TSSOP-B8J	3.00mm x 4.90mm x 1.10mm
SOP14	8.70mm x 6.20mm x 1.71mm
SOP-J14	8.65mm x 6.00mm x 1.65mm
TSSOP-B14J	5.00mm x 6.40mm x 1.20mm

Pin Configuration

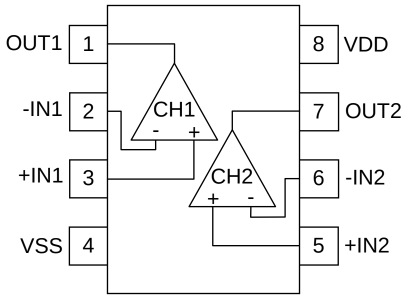
LMR341G : SSOP6



Pin No.	Pin Name
1	+IN
2	VSS
3	-IN
4	OUT
5	$\overline{\text{SHDN}}$
6	VDD

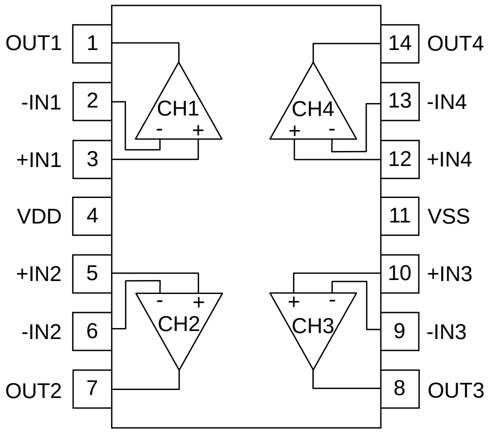
○Product structure : Silicon monolithic integrated circuit ○This product has no designed protection against radioactive rays.

LMR342F : SOP8
LMR342FJ : SOP-J8
LMR342FV : SSOP-B8
LMR342FVT : TSSOP-B8
LMR342FVM : MSOP8
LMR342FVJ : TSSOP-B8J



Pin No.	Pin Name
1	OUT1
2	-IN1
3	+IN1
4	VSS
5	+IN2
6	-IN2
7	OUT2
8	VDD

LMR344F : SOP14
LMR344FJ : SOP-J14
LMR344FVJ : TSSOP-B14J



Pin No.	Pin Name
1	OUT1
2	-IN1
3	+IN1
4	VDD
5	+IN2
6	-IN2
7	OUT2
8	OUT3
9	-IN3
10	+IN3
11	VSS
12	+IN4
13	-IN4
14	OUT4

Package				
SSOP6	SOP8	SOP-J8	SSOP-B8	TSSOP-B8
LMR341G	LMR342F	LMR342FJ	LMR342FV	LMR342FVT
Package				
MSOP8	TSSOP-B8J	SOP14	SOP-J14	TSSOP-B14J
LMR342FVM	LMR342FVJ	LMR344F	LMR344FJ	LMR344FVJ

Ordering Information

L M R 3 4 x x x x - x x

Part Number
LMR341G
LMR342xxx
LMR344xxx

Package
G : SSOP6
F : SOP8
: SOP14
FJ : SOP-J8
: SOP-J14
FV : SSOP-B8
FVT : TSSOP-B8
FVM : MSOP8
FVJ : TSSOP-B8J
: TSSOP-B14J

Packaging and forming specification
E2: Embossed tape and reel
(SOP8/SOP-J8/SSOP-B8/TSSOP-B8/TSSOP-B8J/SOP14)
TR: Embossed tape and reel
(SSOP6/MSOP8)

Line-up

Operation Temperature Range	Channels	Package		Orderable Part Number
-40°C to +85°C	1ch	SSOP6	Reel of 3000	LMR341G-TR
	2ch	SOP8	Reel of 2500	LMR342F-E2
		SOP-J8	Reel of 2500	LMR342FJ-E2
		SSOP-B8	Reel of 2500	LMR342FV-E2
		TSSOP-B8	Reel of 3000	LMR342FVT-E2
		MSOP8	Reel of 3000	LMR342FVM-TR
		TSSOP-B8J	Reel of 2500	LMR342FVJ-E2
	4ch	SOP14	Reel of 2500	LMR344F-E2
		SOP-J14	Reel of 2500	LMR344FJ-E2
		TSSOP-B14J	Reel of 2500	LMR344FVJ-E2

Absolute Maximum Ratings (T_A=25°C)

Parameter	Symbol		Ratings			Unit
			LMR341G	LMR342xxx	LMR344xxx	
Supply Voltage	VDD - VSS		+7.0			V
Power Dissipation	P_D	SSOP6	0.67 (Note 1,9)	-	-	W
		SOP8	-	0.68 (Note 2,9)	-	
		SOP-J8	-	0.67 (Note 3,9)	-	
		SSOP-B8	-	0.62 (Note 4,9)	-	
		TSSOP-B8	-	0.62 (Note 4,9)	-	
		TSSOP-B8J	-	0.58 (Note 5,9)	-	
		MSOP8	-	0.58 (Note 5,9)	-	
		SOP14	-	-	0.56 (Note 6,9)	
		SOP-J14	-	-	1.02 (Note 7,9)	
		TSSOP-B14J	-	-	0.84 (Note 8,9)	
Differential Input Voltage (Note 8)	V_{ID}		VDD - VSS			V
Input Common-Mode Voltage Range	V_{ICM}		(VSS-0.3) to (VDD+0.3)			V
Input Current (Note 9)	I_I		±10			mA
Operating Supply Voltage	V_{opr}		+2.7 to +5.5			V
Operating Temperature	T_{opr}		- 40 to +85			°C
Storage Temperature	T_{stg}		- 55 to +150			°C
Maximum Junction Temperature	T_{Jmax}		+150			°C

(Note 1) To use at temperature above T_A=25°C reduce 5.4mW/°C.
(Note 2) To use at temperature above T_A=25°C reduce 5.5mW/°C.
(Note 3) To use at temperature above T_A=25°C reduce 5.4mW/°C.
(Note 4) To use at temperature above T_A=25°C reduce 5.0mW/°C.
(Note 5) To use at temperature above T_A=25°C reduce 4.7mW/°C.
(Note 6) To use at temperature above T_A=25°C reduce 4.5mW/°C.
(Note 7) To use at temperature above T_A=25°C reduce 8.2mW/°C.
(Note 8) To use at temperature above T_A=25°C reduce 6.8mW/°C.
(Note 9) Mounted on 1-layer glass epoxy PCB 70mm×70mm×1.6mm (Copper foil area less than 3%).
(Note 10) The voltage difference between inverting input and non-inverting input is the differential input voltage. The input pin voltage is set to more than VSS.
(Note 11) An excessive input current will flow when input voltages of more than VDD+0.6V or less than VSS-0.6V are applied. The input current can be set to less than the rated current by adding a limiting resistor.
Caution: Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.

Electrical Characteristics:

○LMR341G (Unless otherwise specified VDD=+2.7V, VSS=0V, $\overline{SHDN}$=VDD)

Parameter	Symbol	Temperature Range	Limits Min	Limits Typ	Limits Max	Unit	Condition
Input Offset Voltage (Note 12,13)	V_{IO}	25°C	-	0.25	4	mV	-
		Full Range	-	-	4.5		
Input Offset Voltage Drift (Note 12,13)	$\Delta V_{IO}/\Delta T$	Full Range	-	1.7	-	μV/°C	-
Input Offset Current (Note 12)	I_{IO}	25°C	-	1	-	pA	-
Input Bias Current (Note 12)	I_B	25°C	-	1	200	pA	-
Supply Current(Note 13)	I_{DD}	25°C	-	80	170	μA	R_L=∞, A_V=0dB, +IN=VDD/2
		Full Range	-	-	230		
Shutdown Current	IDD_SD	25°C	-	0.2	1000	nA	$\overline{SHDN}$=GND
Maximum Output Voltage(High)	V_{OH}	25°C	VDD-0.06	VDD-0.03	-	V	R_L=2kΩ to VDD/2
			VDD-0.03	VDD-0.01	-		R_L=10kΩ to VDD/2
Maximum Output Voltage(Low)	V_{OL}	25°C	-	0.03	0.06	V	R_L=2kΩ to VDD/2
			-	0.01	0.03		R_L=10kΩ to VDD/2
Large Signal Voltage Gain	A_V	25°C	78	113	-	dB	R_L=10kΩ to VDD/2
			72	103	-		R_L=2kΩ to VDD/2
Input Common-Mode Voltage Range	V_{ICM}	25°C	0	-	1.7	V	-
Common-Mode Rejection Ratio	CMRR	25°C	56	80	-	dB	V_{ICM}=VDD/2
Power Supply Rejection Ratio	PSRR	25°C	65	82	-	dB	VDD=2.7V to 5.0V V_{ICM}=0.5V
Output Source Current (Note 14)	I_{SOURCE}	25°C	20	32	-	mA	OUT=0V, short current
Output Sink Current (Note 14)	I_{SINK}	25°C	30	45	-	mA	OUT=2.7V short current
Slew Rate	SR	25°C	-	1.0	-	V/μs	R_L=10kΩ, +IN=1.2V_{P-P}
Gain Bandwidth	GBW	25°C	-	2.0	-	MHz	C_L=200pF, R_L=100kΩ A_V=40dB, f=100kHz
Unit Gain Frequency	f_T	25°C	-	1.2	-	MHz	C_L=200pF, R_L=100kΩ A_V =40dB, gain=0dB
Phase Margin	θ_M	25°C	-	50	-	deg	C_L=20pF, R_L=100kΩ A_V=40dB
Gain Margin	G_M	25°C	-	4.5	-	dB	C_L=20pF, R_L=100kΩ A_V=40dB
Input Referred Noise Voltage	V_N	25°C	-	40	-	$nV/\sqrt{Hz}$	f=1kHz, A_V=40dB
			-	3	-	μVrms	A_V=40dB, DIN-AUDIO
Total Harmonic Distortion + Noise	THD+N	25°C	-	0.017	-	%	R_L=600Ω, A_V=0dB OUT=1V_{P-P}, f=1kHz DIN-AUDIO
Turn On Time From Shutdown	TON	25°C	-	2	-	μs	-
Turn On Voltage High	VSHDN_H	25°C	-	1.8	-	V	-
Turn On Voltage Low	VSHDN_L	25°C	-	1.1	-	V	-

(Note 12) Absolute value.
(Note 13) Full Range: T_A=-40°C to +85°C
(Note 14) Under the high temperature environment, consider the power dissipation of IC when selecting the output current.
When the terminal short circuits are continuously output, the output current is reduced to climb to the temperature inside IC.

Electrical Characteristics - continued

○LMR341G (Unless otherwise specified VDD=+5.0V, VSS=0V, $\overline{SHDN}$=VDD)

Parameter	Symbol	Temperature Range	Limits			Unit	Condition
			Min	Typ	Max		
Input Offset Voltage (Note 15,16)	V_{IO}	25°C	-	0.25	4	mV	-
		Full Range	-	-	4.5		
Input Offset Voltage Drift (Note 15,16)	$\Delta V_{IO}/\Delta T$	Full Range	-	1.9	-	μV/°C	-
Input Offset Current (Note 15)	I_{IO}	25°C	-	1	-	pA	-
Input Bias Current (Note 15)	I_B	25°C	-	1	-	pA	-
Supply Current (Note 16)	I_{DD}	25°C	-	80	200	μA	R_L=∞, A_V=0dB, +IN=VDD/2
		Full Range	-	-	260		
Shutdown Current	IDD_SD	25°C	-	0.5	1000	nA	$\overline{SHDN}$=GND
Maximum Output Voltage(High)	V_{OH}	25°C	VDD-0.06	VDD-0.04	-	V	R_L=2kΩ to VDD/2
			VDD-0.03	VDD-0.01	-		R_L=10kΩ to VDD/2
Maximum Output Voltage(Low)	V_{OL}	25°C	-	0.04	0.06	V	R_L=2kΩ to VDD/2
			-	0.01	0.03		R_L=10kΩ to VDD/2
Large Signal Voltage Gain	A_V	25°C	78	116	-	dB	R_L=10kΩ to VDD/2
			72	107	-		R_L=2kΩ to VDD/2
Input Common-Mode Voltage Range	V_{ICM}	25°C	0	-	4	V	-
Common-Mode Rejection Ratio	CMRR	25°C	56	86	-	dB	V_{ICM}= VDD/2
Power Supply Rejection Ratio	PSRR	25°C	65	82	-	dB	VDD=2.7V to 5.0V V_{ICM}=0.5V
Output Source Current (Note 17)	I_{SOURCE}	25°C	85	113	-	mA	OUT=0V, short current
Output Sink Current (Note 17)	I_{SINK}	25°C	80	115	-	mA	OUT=5V, short current
Slew Rate	SR	25°C	-	1.0	-	V/μs	R_L=10kΩ, +IN=2V_{P-P}
Gain Bandwidth	GBW	25°C	-	2.0	-	MHz	C_L=200pF, R_L=10kΩ A_V=40dB, f=100kHz
Unit Gain Frequency	f_T	25°C	-	1.2	-	MHz	C_L=200pF, R_L=10kΩ A_V=40dB, gain=0dB
Phase Margin	θ_M	25°C	-	50	-	deg	C_L=20pF, R_L=100kΩ A_V=40dB
Gain Margin	G_M	25°C	-	4.5	-	dB	C_L=20pF, R_L=100kΩ A_V=40dB
Input Referred Noise Voltage	V_N	25°C	-	40	-	$nV/\sqrt{Hz}$	f=1kHz, A_V=40dB
			-	3	-	μVrms	A_V=40dB, DIN-AUDIO
Total Harmonic Distortion + Noise	THD+N	25°C	-	0.012	-	%	R_L=600Ω, A_V=0dB OUT=1V_{P-P}, f=1kHz DIN-AUDIO
Turn On Time From Shutdown	TON	25°C	-	2	-	μs	-
Turn On Voltage High	VSHDN_H	25°C	-	3.0	-	V	-
Turn On Voltage Low	VSHDN_L	25°C	-	2.0	-	V	-

(Note 15) Absolute value
(Note 16) Full Range: T_A=-40°C to +85°C
(Note 17) Under the high temperature environment, consider the power dissipation of IC when selecting the output current.
When the terminal short circuits are continuously output, the output current is reduced to climb to the temperature inside IC.

Electrical Characteristics - continued

○LMR342xxx (Unless otherwise specified VDD=+2.7V, VSS=0V, T_A=25°C)

Parameter	Symbol	Temperature Range	Limit			Unit	Condition
			Min	Typ	Max		
Input Offset Voltage (Note 18,19)	V_{IO}	25°C	-	0.25	4	mV	-
		Full Range	-	-	4.5		
Input Offset Voltage Drift (Note 18,19)	$\Delta V_{IO}/\Delta T$	Full Range	-	1.7	-	μV/°C	-
Input Offset Current (Note 18)	I_{IO}	25°C	-	1	-	pA	-
Input Bias Current (Note 18)	I_B	25°C	-	1	200	pA	-
Supply Current (Note 19)	I_{DD}	25°C	-	200	340	μA	R_L=∞, All Op-Amps A_V=0dB, +IN=VDD/2
		Full Range	-	-	460		
Maximum Output Voltage (High)	V_{OH}	25°C	VDD-0.06	VDD-0.03	-	V	R_L=2kΩ, V_{RL}=VDD/2
			VDD-0.03	VDD-0.01	-		R_L=10kΩ, V_{RL}=VDD/2
Maximum Output Voltage (Low)	V_{OL}	25°C	-	0.03	0.06	V	R_L=2kΩ, V_{RL}=VDD/2
			-	0.01	0.03		R_L=10kΩ, V_{RL}=VDD/2
Large Single Voltage Gain	A_V	25°C	78	113	-	dB	R_L=10kΩ, V_{RL}=VDD/2
			72	103	-		R_L=2kΩ, V_{RL}=VDD/2
Input Common-Mode Voltage Range	V_{ICM}	25°C	0	-	1.7	V	-
Common-Mode Rejection Ratio	CMRR	25°C	56	80	-	dB	V_{ICM}=VDD/2
Power Supply Rejection Ratio	PSRR	25°C	65	82	-	dB	VDD=2.7V to 5.0V V_{ICM}=VDD/2
Output Source Current (Note 20)	I_{SOURCE}	25°C	20	32	-	mA	OUT=0V Short Circuit Current
Output Sink Current (Note 20)	I_{SINK}	25°C	15	24	-	mA	OUT=2.7V Short Circuit Current
Slew Rate	SR	25°C	-	1.0	-	V/μs	R_L=10kΩ, +IN=1.2V_{P-P}
Gain Bandwidth	GBW	25°C	-	2	-	MHz	C_L=200pF, R_L=100kΩ A_V=40dB, f=100kHz
Unity Gain Frequency	f_T	25°C	-	1.2	-	MHz	C_L=200pF, R_L=100kΩ A_V=40dB
Phase Margin	θ_M	25°C	-	50	-	deg	C_L=20pF, R_L=100kΩ A_V=40dB
Gain Margin	G_M	25°C	-	4.5	-	dB	C_L=20pF, R_L=100kΩ A_V=40dB
Input Referred Noise Voltage	V_N	25°C	-	40	-	$nV/\sqrt{Hz}$	f=1kHz, Av=40dB
			-	3	-	μVrms	A_V=40dB, DIN-AUDIO
Total Harmonic Distortion + Noise	THD+N	25°C	-	0.017	-	%	R_L=600Ω, A_V=0dB OUT=1V_{P-P}, f=1kHz DIN-AUDIO
Channel Separation	CS	25°C	-	100	-	dB	A_V=40dB, f=1kHz OUT=0.8Vrms

(Note 18) Absolute value.
(Note 19) Full Range: T_A=-40°C to +85°C
(Note 20) Consider the power dissipation of the IC under high temperature environment when selecting the output current value.
There may be a case where the output current value is reduced due to the rise in IC temperature caused by the heat generated inside the IC.

Electrical Characteristics - continued

○LMR342xxx (Unless otherwise specified VDD=+5.0V, VSS=0V, T_A=25°C)

Parameter	Symbol	Temperature Range	Limit			Unit	Condition
			Min	Typ	Max		
Input Offset Voltage (Note 21,22)	V_{IO}	25°C	-	0.25	4	mV	-
		Full Range	-	-	4.5		
Input Offset Voltage Drift (Note 21,22)	$\Delta V_{IO}/\Delta T$	Full Range	-	1.9	-	μV/°C	-
Input Offset Current (Note 21)	I_{IO}	25°C	-	1	-	pA	-
Input Bias Current (Note 21)	I_B	25°C	-	1	200	pA	-
Supply Current (Note 22)	I_{DD}	25°C	-	214	400	μA	R_L=∞, All Op-Amps A_V=0dB, +IN=VDD/2
		Full Range	-	-	520		
Maximum Output Voltage (High)	V_{OH}	25°C	VDD-0.06	VDD-0.04	-	V	R_L=2kΩ, V_{RL}=VDD/2
			VDD-0.03	VDD-0.01	-		R_L=10kΩ, V_{RL}=VDD/2
Maximum Output Voltage (Low)	V_{OL}	25°C	-	0.04	0.06	V	R_L=2kΩ, V_{RL}=VDD/2
			-	0.01	0.03		R_L=10kΩ, V_{RL}=VDD/2
Large Single Voltage Gain	A_V	25°C	78	116	-	dB	R_L=10kΩ, V_{RL}=VDD/2
			72	107	-		R_L=2kΩ, V_{RL}=VDD/2
Input Common-Mode Voltage Range	V_{ICM}	25°C	0	-	4.0	V	-
Common-Mode Rejection Ratio	CMRR	25°C	56	86	-	dB	V_{ICM}=VDD/2
Power Supply Rejection Ratio	PSRR	25°C	65	85	-	dB	VDD=2.7V to 5.0V V_{ICM}=VDD/2
Output Source Current (Note 23)	I_{SOURCE}	25°C	85	113	-	mA	OUT=0V Short Circuit Current
Output Sink Current (Note 23)	I_{SINK}	25°C	50	75	-	mA	OUT=5.0V Short Circuit Current
Slew Rate	SR	25°C	-	1.0	-	V/μs	R_L=10kΩ, +IN=2.0V_{P-P}
Gain Bandwidth	GBW	25°C	-	2	-	MHz	C_L=200pF, R_L=100kΩ A_V=40dB, f=100kHz
Unity Gain Frequency	f_T	25°C	-	1.2	-	MHz	C_L=200pF, R_L=100kΩ A_V=40dB
Phase Margin	θ_M	25°C	-	50	-	deg	C_L=20pF, R_L=100kΩ A_V=40dB
Gain Margin	G_M	25°C	-	4.5	-	dB	C_L=20pF, R_L=100kΩ A_V=40dB
Input Referred Noise Voltage	V_N	25°C	-	39	-	$nV/\sqrt{Hz}$	f=1kHz, Av=40dB
			-	3	-	μVrms	A_V=40dB, DIN-AUDIO
Total Harmonic Distortion + Noise	THD+N	25°C	-	0.012	-	%	R_L=600Ω, A_V=0dB OUT=1V_{P-P}, f=1kHz DIN-AUDIO
Channel Separation	CS	25°C	-	100	-	dB	A_V=40dB, f=1kHz OUT=0.8Vrms

(Note 21) Absolute value.
(Note 22) Full Range: T_A=-40°C to +85°C
(Note 23) Consider the power dissipation of the IC under high temperature environment when selecting the output current value.
There may be a case where the output current value is reduced due to the rise in IC temperature caused by the heat generated inside the IC.

Electrical Characteristics - continued

○LMR344xxx (Unless otherwise specified VDD=+2.7V, VSS=0V, T_A=25°C)

Parameter	Symbol	Temperature Range	Limit Min	Limit Typ	Limit Max	Unit	Condition
Input Offset Voltage (Note 24,25)	V_{IO}	25°C	-	0.25	4	mV	-
		Full Range	-	-	4.5		
Input Offset Voltage Drift (Note 24,25)	$\Delta V_{IO}/\Delta T$	Full Range	-	1.7	-	μV/°C	-
Input Offset Current (Note 24)	I_{IO}	25°C	-	1	-	pA	-
Input Bias Current (Note 24)	I_B	25°C	-	1	200	pA	-
Supply Current (Note 25)	I_{DD}	25°C	-	400	680	μA	R_L=∞, All Op-Amps A_V=0dB, +IN=VDD/2
		Full Range	-	-	920		
Maximum Output Voltage (High)	V_{OH}	25°C	VDD-0.06	VDD-0.03	-	V	R_L=2kΩ, V_{RL}=VDD/2
			VDD-0.03	VDD-0.01	-		R_L=10kΩ, V_{RL}=VDD/2
Maximum Output Voltage (Low)	V_{OL}	25°C	-	0.03	0.06	V	R_L=2kΩ, V_{RL}=VDD/2
			-	0.01	0.03		R_L=10kΩ, V_{RL}=VDD/2
Large Single Voltage Gain	A_V	25°C	78	113	-	dB	R_L=10kΩ, V_{RL}=VDD/2
			72	103	-		R_L=2kΩ, V_{RL}=VDD/2
Input Common-Mode Voltage Range	V_{ICM}	25°C	0	-	1.7	V	-
Common-Mode Rejection Ratio	CMRR	25°C	56	80	-	dB	V_{ICM}=VDD/2
Power Supply Rejection Ratio	PSRR	25°C	65	82	-	dB	VDD=2.7V to 5.0V V_{ICM}=VDD/2
Output Source Current (Note 26)	I_{SOURCE}	25°C	20	32	-	mA	OUT=0V Short Circuit Current
Output Sink Current (Note 26)	I_{SINK}	25°C	15	24	-	mA	OUT=2.7V Short Circuit Current
Slew Rate	SR	25°C	-	1.0	-	V/μs	R_L=10kΩ, +IN=1.2 V_{P-P}
Gain Bandwidth	GBW	25°C	-	2	-	MHz	C_L=200pF, R_L=100kΩ A_V=40dB, f=100kHz
Unity Gain Frequency	f_T	25°C	-	1.2	-	MHz	C_L=200pF, R_L=100kΩ A_V=40dB
Phase Margin	θ_M	25°C	-	50	-	deg	C_L=20pF, R_L=100kΩ A_V=40dB
Gain Margin	G_M	25°C	-	4.5	-	dB	C_L=20pF, R_L=100kΩ A_V=40dB
Input Referred Noise Voltage	V_N	25°C	-	40	-	$nV/\sqrt{Hz}$	f=1kHz, Av=40dB
			-	3	-	μVrms	A_V=40dB, DIN-AUDIO
Total Harmonic Distortion + Noise	THD+N	25°C	-	0.017	-	%	R_L=600Ω, A_V=0dB OUT=1V_{P-P}, f=1kHz DIN-AUDIO
Channel Separation	CS	25°C	-	100	-	dB	A_V=40dB, f=1kHz OUT=0.8Vrms

(Note 24) Absolute value.
(Note 25) Full Range: T_A=-40°C to +85°C
(Note 26) Consider the power dissipation of the IC under high temperature environment when selecting the output current value. There may be a case where the output current value is reduced due to the rise in IC temperature caused by the heat generated inside the IC.

Electrical Characteristics - continued

○LMR344xxx (Unless otherwise specified VDD=+5.0V, VSS=0V, T_A=25°C)

Parameter	Symbol	Temperature Range	Limit			Unit	Condition
			Min	Typ	Max		
Input Offset Voltage (Note 27,28)	V_{IO}	25°C	-	0.25	4	mV	-
		Full Range	-	-	4.5		
Input Offset Voltage Drift (Note 27,28)	$\Delta V_{IO}/\Delta T$	Full Range	-	1.9	-	μV/°C	-
Input Offset Current (Note 27)	I_{IO}	25°C	-	1	-	pA	-
Input Bias Current (Note 27)	I_B	25°C	-	1	200	pA	-
Supply Current (Note 28)	I_{DD}	25°C	-	428	800	μA	R_L=∞, All Op-Amps A_V=0dB, +IN=VDD/2
		Full Range	-	-	1040		
Maximum Output Voltage (High)	V_{OH}	25°C	VDD-0.06	VDD-0.04	-	V	R_L=2kΩ, V_{RL}=VDD/2
			VDD-0.03	VDD-0.01	-		R_L=10kΩ, V_{RL}=VDD/2
Maximum Output Voltage (Low)	V_{OL}	25°C	-	0.04	0.06	V	R_L=2kΩ, V_{RL}=VDD/2
			-	0.01	0.03		R_L=10kΩ, V_{RL}=VDD/2
Large Single Voltage Gain	A_V	25°C	78	116	-	dB	R_L=10kΩ, V_{RL}=VDD/2
			72	107	-		R_L=2kΩ, V_{RL}=VDD/2
Input Common-Mode Voltage Range	V_{ICM}	25°C	0	-	4.0	V	-
Common-Mode Rejection Ratio	CMRR	25°C	56	86	-	dB	V_{ICM}=VDD/2
Power Supply Rejection Ratio	PSRR	25°C	65	85	-	dB	VDD=2.7V to 5.0V V_{ICM}=VDD/2
Output Source Current (Note 29)	I_{SOURCE}	25°C	85	113	-	mA	OUT=0V Short Circuit Current
Output Sink Current (Note 29)	I_{SINK}	25°C	50	75	-	mA	OUT=5V Short Circuit Current
Slew Rate	SR	25°C	-	1.0	-	V/μs	R_L=10kΩ, +IN=2.0V_{P-P}
Gain Bandwidth	GBW	25°C	-	2	-	MHz	C_L=200pF, R_L=100kΩ A_V=40dB, f=100kHz
Unity Gain Frequency	f_T	25°C	-	1.2	-	MHz	C_L=200pF, R_L=100kΩ A_V=40dB
Phase Margin	θ_M	25°C	-	50	-	deg	C_L=20pF, R_L=100kΩ A_V=40dB
Gain Margin	G_M	25°C	-	4.5	-	dB	C_L=20pF, R_L=100kΩ A_V=40dB
Input Referred Noise Voltage	V_N	25°C	-	39	-	$nV/\sqrt{Hz}$	f=1kHz, Av=40dB
			-	3	-	μVrms	A_V=40dB, DIN-AUDIO
Total Harmonic Distortion + Noise	THD+N	25°C	-	0.012	-	%	R_L=600Ω, A_V=0dB OUT=1V_{P-P}, f=1kHz DIN-AUDIO
Channel Separation	CS	25°C	-	100	-	dB	A_V=40dB, f=1kHz OUT=0.8Vrms

(Note 27) Absolute value.
(Note 28) Full Range: T_A=-40°C to +85°C
(Note 29) Consider the power dissipation of the IC under high temperature environment when selecting the output current value.
There may be a case where the output current value is reduced due to the rise in IC temperature caused by the heat generated inside the IC.

Description of Electrical Characteristics

Described below are descriptions of the relevant electrical terms used in this datasheet. Items and symbols used are also shown. Note that item name and symbol and their meaning may differ from those on another manufacturer's document or general document.

1. Absolute maximum ratings

Absolute maximum rating items indicate the condition which must not be exceeded. Application of voltage in excess of absolute maximum rating or use out of absolute maximum rated temperature environment may cause deterioration of characteristics.

(1) Supply Voltage (VDD/VSS)
Indicates the maximum voltage that can be applied between the VDD terminal and VSS terminal without deterioration or destruction of characteristics of internal circuit.

(2) Differential Input Voltage (V_{ID})
Indicates the maximum voltage that can be applied between non-inverting and inverting terminals without damaging the IC.

(3) Input Common-Mode Voltage Range (V_{ICM})
Indicates the maximum voltage that can be applied to the non-inverting and inverting terminals without deterioration or destruction of electrical characteristics. Input common-mode voltage range of the maximum ratings does not assure normal operation of IC. For normal operation, use the IC within the input common-mode voltage range characteristics.

(4) Power Dissipation (P_D)
Indicates the power that can be consumed by the IC when mounted on a specific board at the ambient temperature 25°C (normal temperature). As for package product, P_D is determined by the temperature that can be permitted by the IC in the package (maximum junction temperature) and the thermal resistance of the package.

2. Electrical characteristics

(1) Input Offset Voltage (V_{IO})
Indicates the voltage difference between non-inverting terminal and inverting terminals. It can be translated into the input voltage difference required for setting the output voltage at 0 V.

(2) Input Offset Voltage drift ($\Delta V_{IO}/\Delta T$)
Denotes the ratio of the input offset voltage fluctuation to the ambient temperature fluctuation.

(3) Input Offset Current (I_{IO})
Indicates the difference of input bias current between the non-inverting and inverting terminals.

(4) Input Bias Current (I_B)
Indicates the current that flows into or out of the input terminal. It is defined by the average of input bias currents at the non-inverting and inverting terminals.

(5) Supply Current (I_{DD})
Indicates the current that flows within the IC under specified no-load conditions.

(6) Shutdown current (IDD_SD)
Indicates the current when the circuit is shutdown.

(7) Maximum Output Voltage(High) / Maximum Output Voltage(Low) (V_{OH}/V_{OL})
Indicates the voltage range of the output under specified load condition. It is typically divided into maximum output voltage high and low. Maximum output voltage high indicates the upper limit of output voltage. Maximum output voltage low indicates the lower limit.

(8) Large Signal Voltage Gain (A_V)
Indicates the amplifying rate (gain) of output voltage against the voltage difference between non-inverting terminal and inverting terminal. It is normally the amplifying rate (gain) with reference to DC voltage.
A_V = (Output voltage) / (Differential Input voltage)

(9) Input Common-Mode Voltage Range (V_{ICM})
Indicates the input voltage range where IC normally operates.

(10) Common-Mode Rejection Ratio (CMRR)
Indicates the ratio of fluctuation of input offset voltage when the input common mode voltage is changed. It is normally the fluctuation of DC.
CMRR = (Change of Input common-mode voltage)/(Input offset fluctuation)

(11) Power Supply Rejection Ratio (PSRR)
Indicates the ratio of fluctuation of input offset voltage when supply voltage is changed.
It is normally the fluctuation of DC.
PSRR = (Change of power supply voltage)/(Input offset fluctuation)

(12) Output Source Current/ Output Sink Current (I_{SOURCE} / I_{SINK})
The maximum current that can be output from the IC under specific output conditions. The output source current indicates the current flowing out from the IC, and the output sink current indicates the current flowing into the IC.

(13) Slew Rate (SR)
Indicates the ratio of the change in output voltage with time when a step input signal is applied.

(14) Unity Gain Frequency (f_T)
Indicates a frequency where the voltage gain of operational amplifier is 1.

(15) Gain Bandwidth (GBW)
The product of the open-loop voltage gain and the frequency at which the voltage gain decreases 6dB/octave.

(16) Phase Margin (θ) (θ_M)
Indicates the margin of phase from 180 degree phase lag at unity gain frequency.

(17) Gain Margin (GM)
Indicates the difference between 0dB and the gain where operational amplifier has 180 degree phase delay.

(18) Input Referred Noise Voltage (V_N)
Indicates a noise voltage generated inside the operational amplifier equivalent by ideal voltage source connected in series with input terminal.

(19) Total Harmonic Distortion + Noise (THD+N)
Indicates the fluctuation of input offset voltage or that of output voltage with reference to the change of output voltage of driven channel.

(20) Channel Separation (CS)
Indicates the fluctuation in the output voltage of the driven channel with reference to the change of output voltage of the channel which is not driven.

(21) Turn On Time From Shutdown (Ton)
Indicates the time from applying the voltage to shutdown terminal until the IC is active.

(22) Turn On Voltage / Turn Off Voltage (VSHDN_H/ VSHDN_L)
The IC is active if the shutdown terminal is applied more than Turn On Voltage (VSHDN_H).
The IC is shutdown if the shutdown terminal is applied less than Turn Off Voltage (VSHDN_L).

Typical Performance Curves

○LMR341G

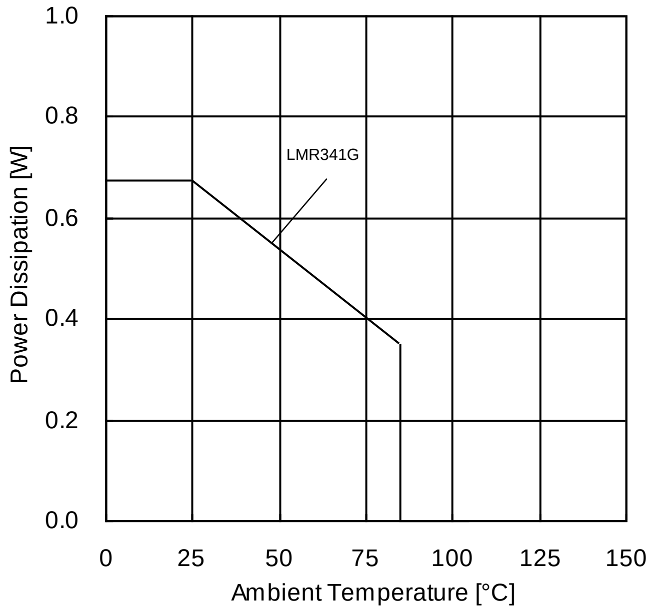


Figure 1. Power Dissipation vs Ambient Temperature (Derating Curve)

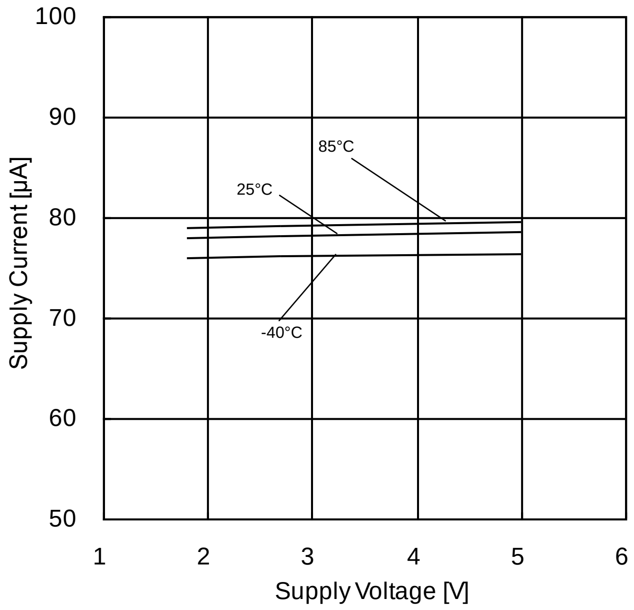


Figure 2. Supply Current vs Supply Voltage

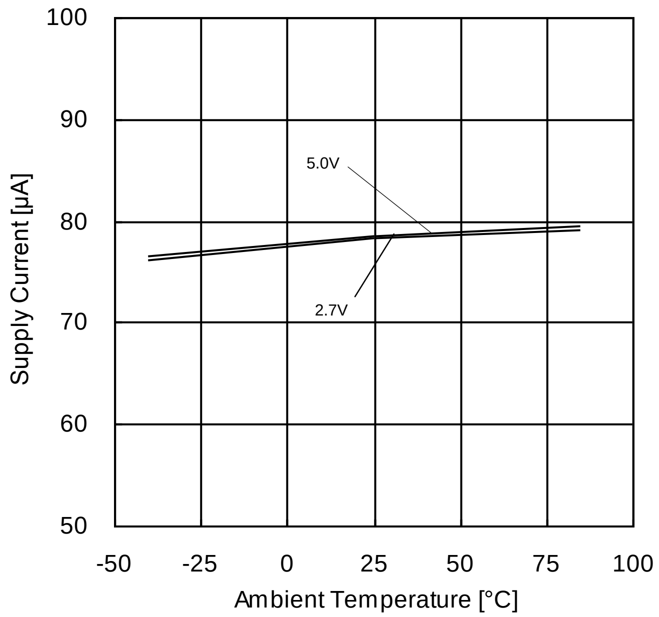


Figure 3. Supply Current vs Ambient Temperature

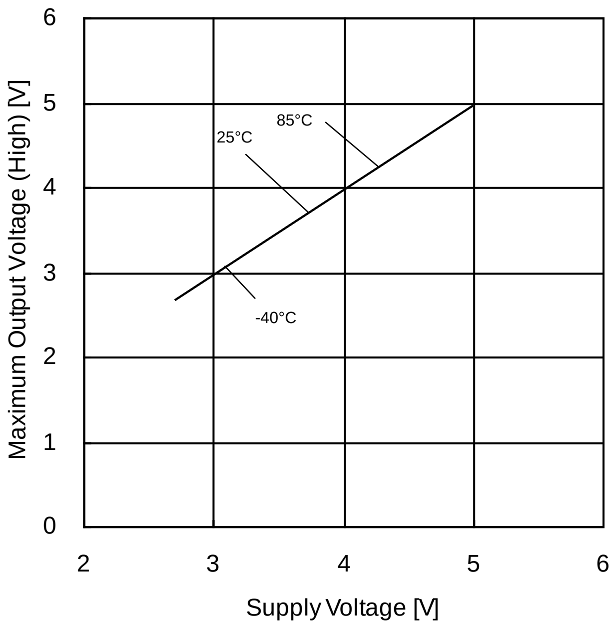


Figure 4. Maximum Output Voltage High vs Supply Voltage (R_L=2kΩ)

(*)The data above is measurement value of typical sample, it is not guaranteed.

Typical Performance Curves – continued

○LMR341G

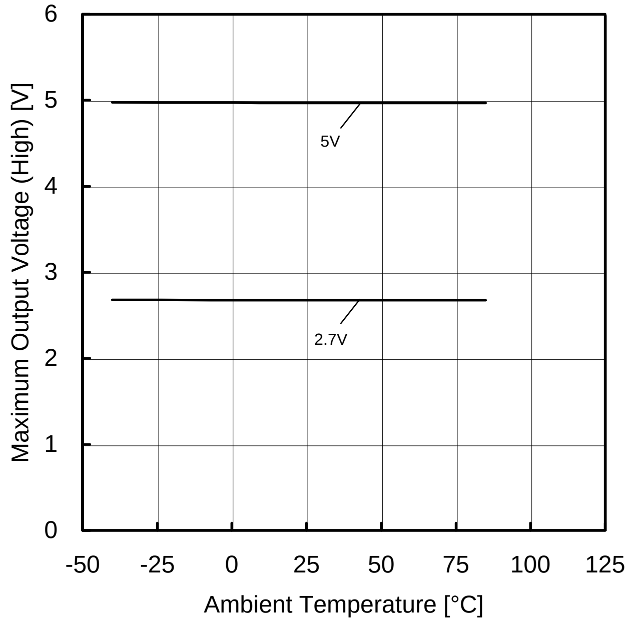


Figure 5. Maximum Output Voltage (High) vs Ambient Temperature (R_L=2kΩ)

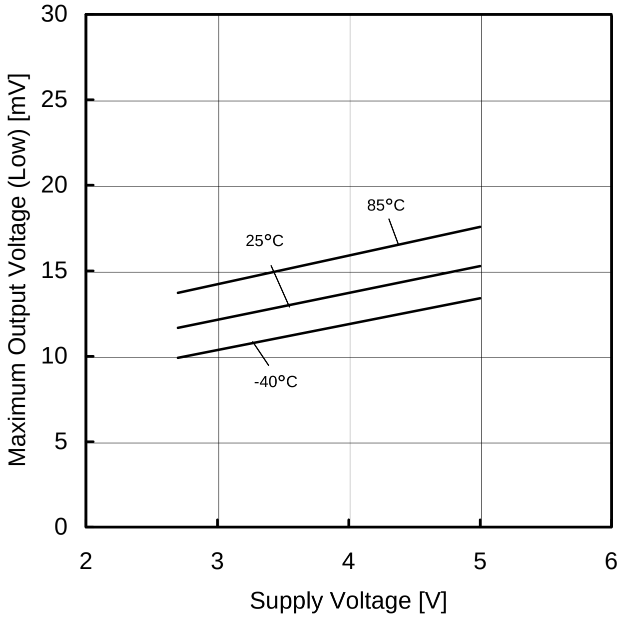


Figure 6. Maximum Output Voltage (Low) vs Supply Voltage (R_L=2kΩ)

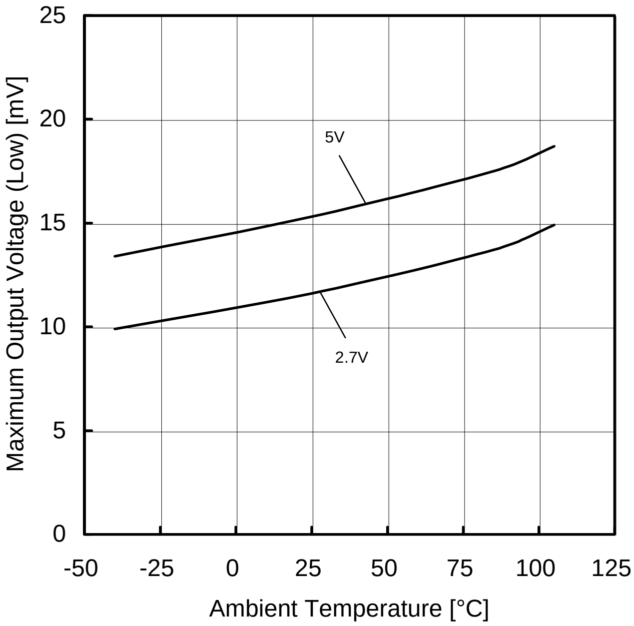


Figure 7. Maximum Output Voltage (Low) vs Ambient Temperature (R_L=2kΩ)

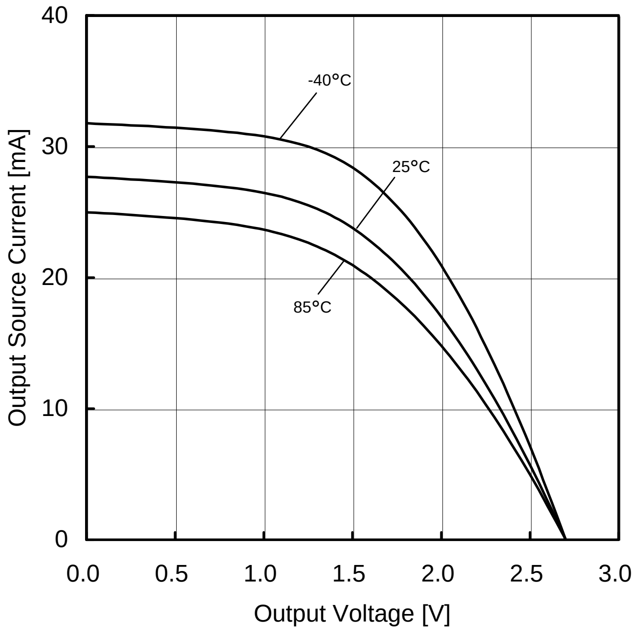


Figure 8. Output Source Current vs Output Voltage (VDD=2.7V)

(*)The data above is measurement value of typical sample, it is not guaranteed.

Typical Performance Curves – continued

○LMR341G

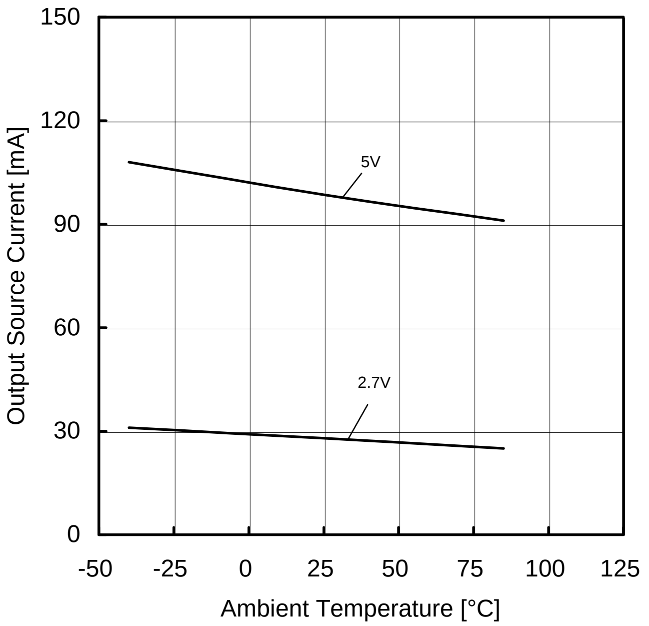


Figure 9. Output Source Current
vs Ambient Temperature
(OUT=0V)

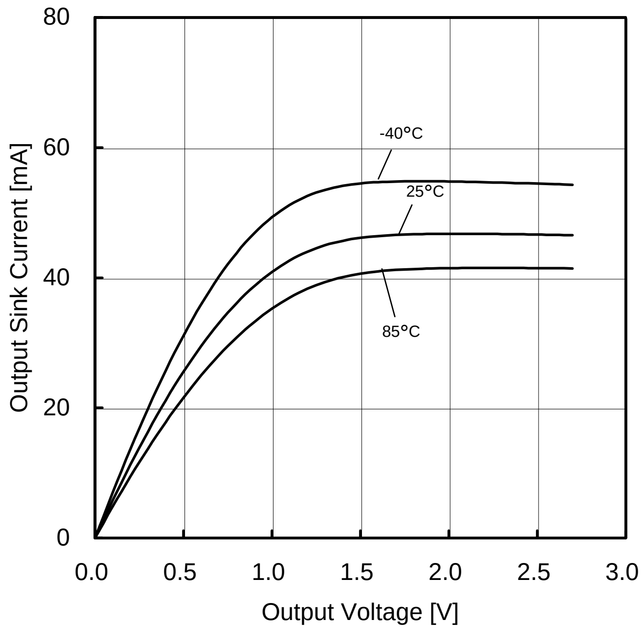


Figure 10. Output Sink Current vs Output Voltage
(VDD=2.7V)

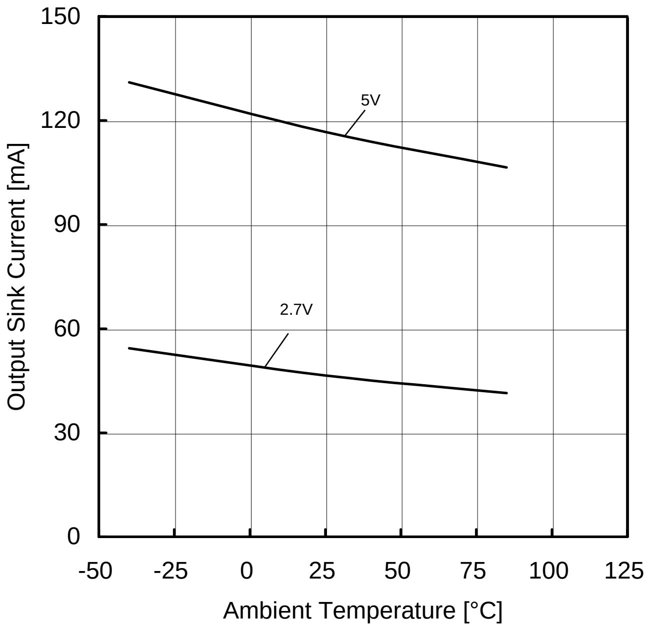


Figure 11. Output Sink Current
vs Ambient Temperature
(OUT=VDD)

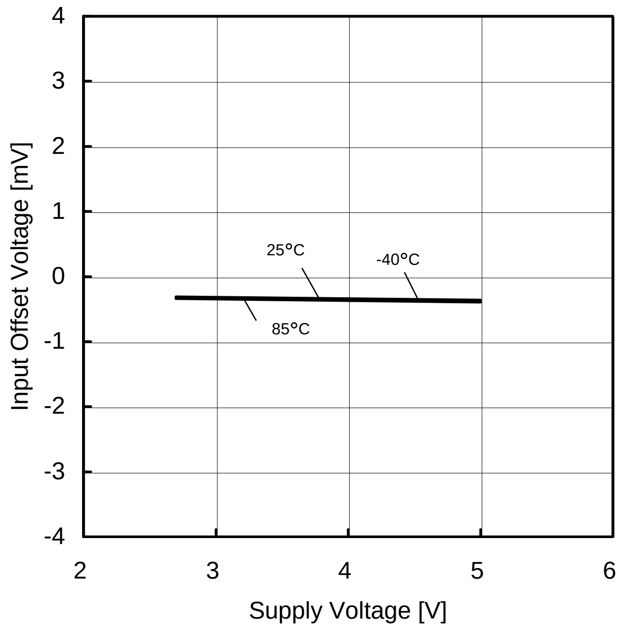


Figure 12. Input Offset Voltage vs Supply Voltage
(V_{ICM}=VDD/2, E_K=-VDD/2)

(*)The data above is measurement value of typical sample, it is not guaranteed.

Typical Performance Curves – continued

○LMR341G

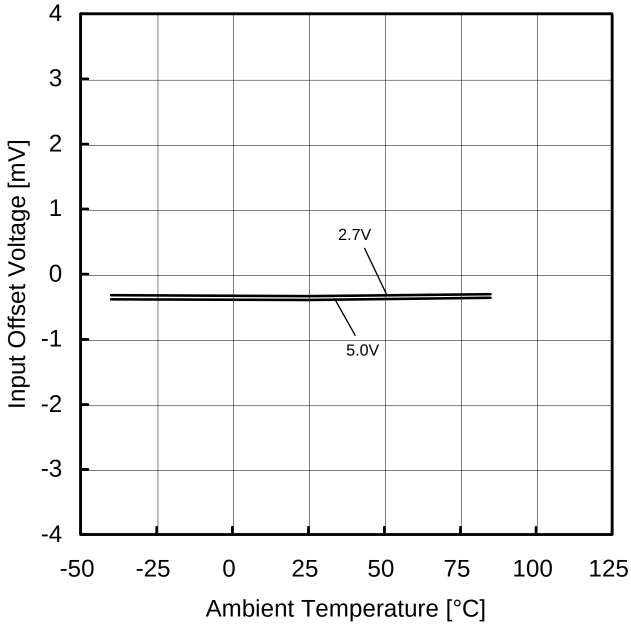


Figure 13. Input Offset Voltage vs Ambient Temperature (V_{ICM}=VDD/2, E_K=-VDD/2)

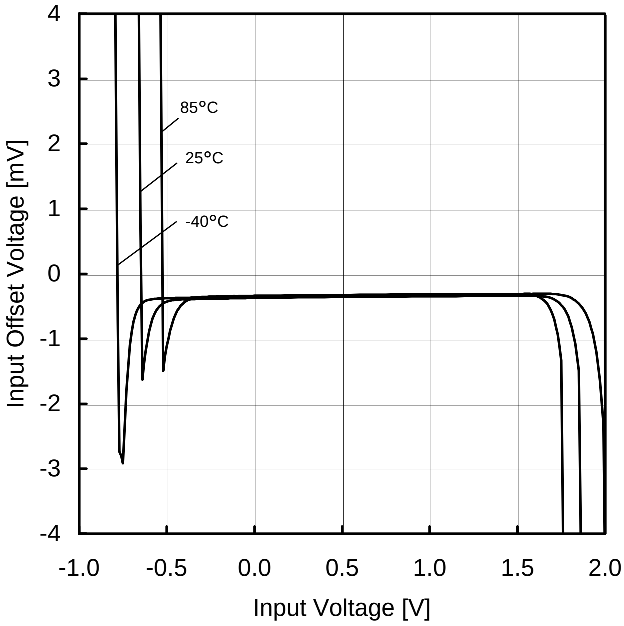


Figure 14. Input Offset Voltage vs Input Voltage (VDD=2.7V, E_K=-VDD/2)

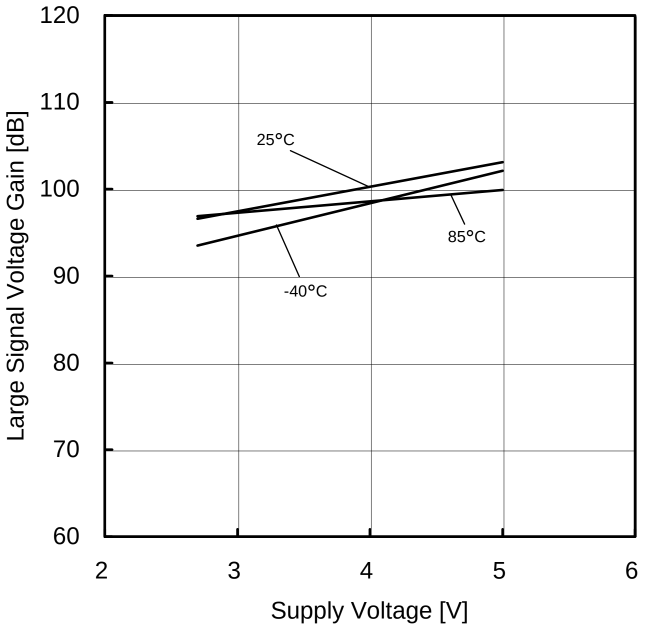


Figure 15. Large Signal Voltage Gain vs Supply Voltage

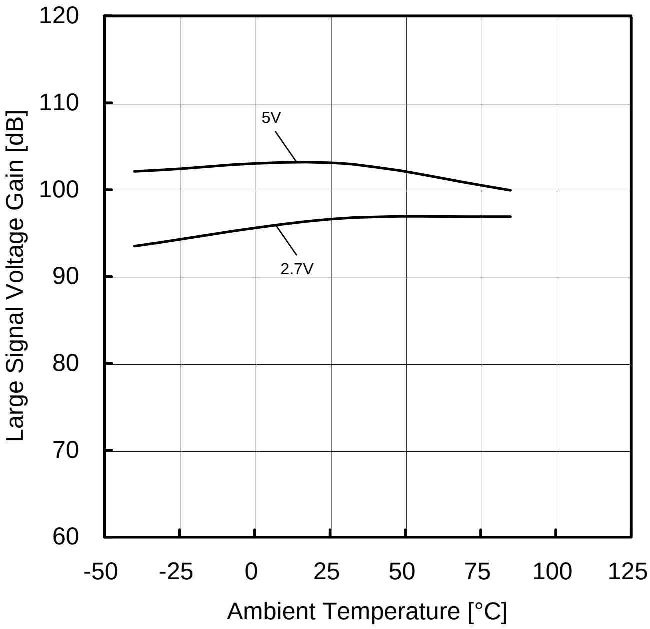


Figure 16. Large Signal Voltage Gain vs Ambient Temperature

(*)The data above is measurement value of typical sample, it is not guaranteed.

Typical Performance Curves – continued

○LMR341G

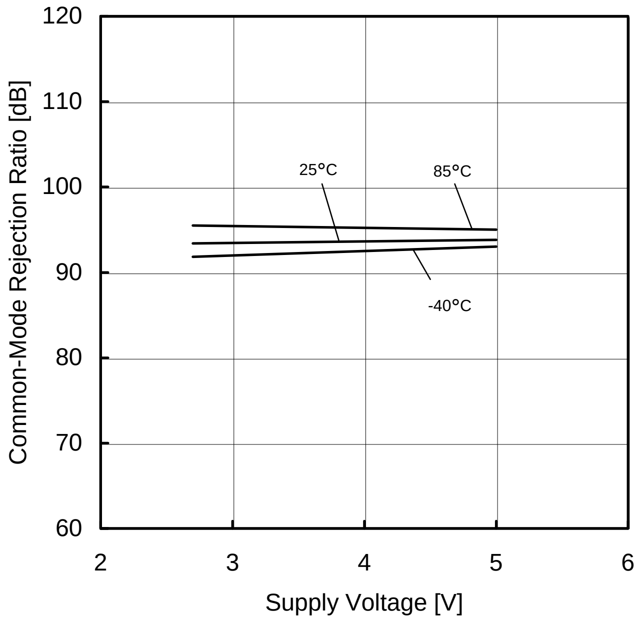


Figure 17. Common-Mode Rejection Ratio
vs Supply Voltage
(VDD=2.7V)

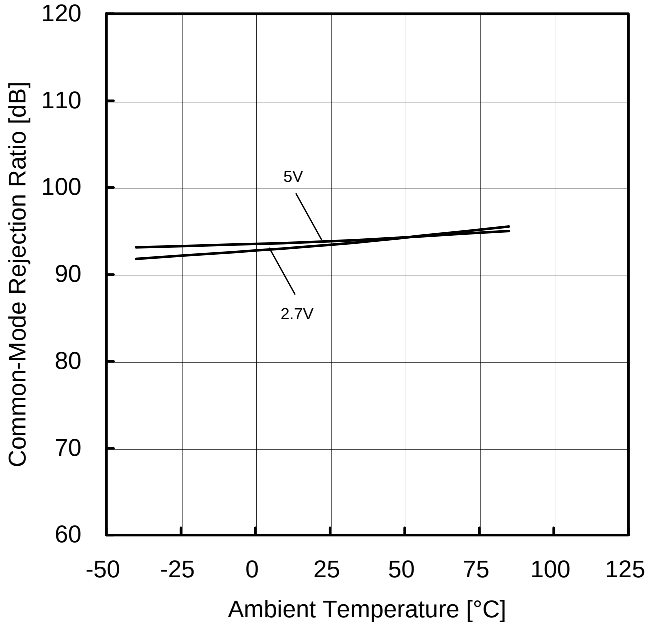


Figure 18. Common-Mode Rejection Ratio
vs Ambient Temperature

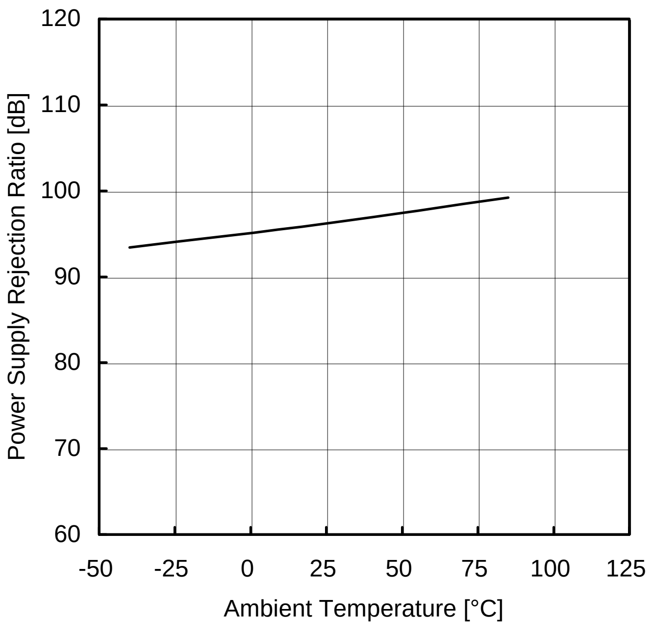


Figure 19. Power Supply Rejection Ratio
vs Ambient Temperature
(VDD=2.7V to 5.0V)

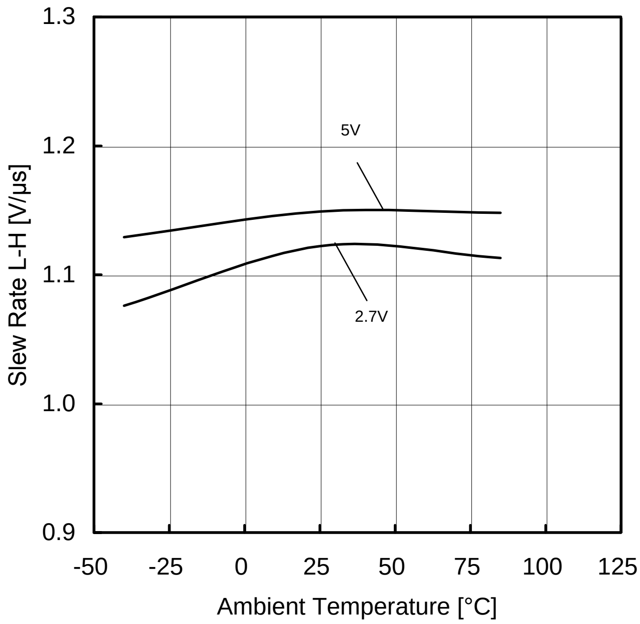


Figure 20. Slew Rate L-H vs Ambient Temperature
(R_L=10kΩ)

(*)The data above is measurement value of typical sample, it is not guaranteed.

Typical Performance Curves – continued

○LMR341G

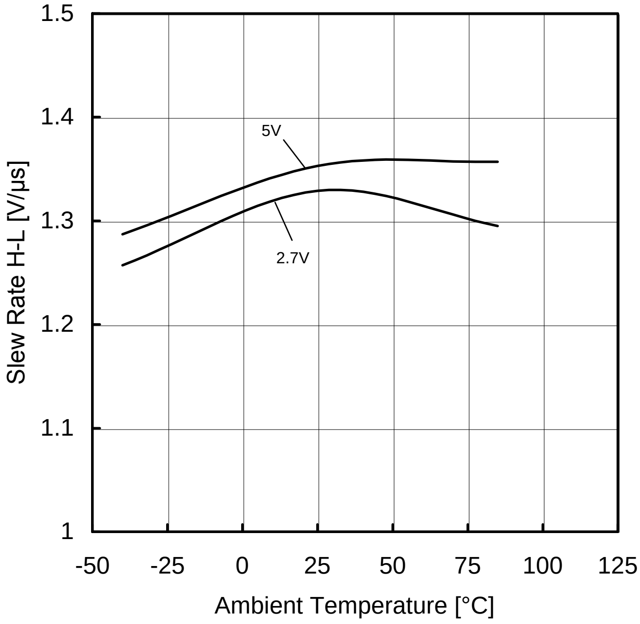


Figure 21. Slew Rate H-L vs Ambient Temperature (R_L=10kΩ)

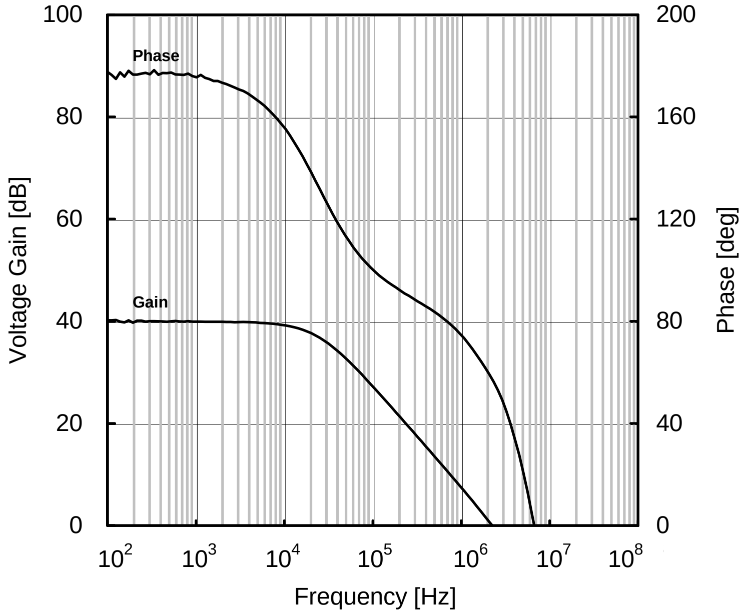


Figure 22. Voltage Gain・Phase vs Frequency (C=20pF)

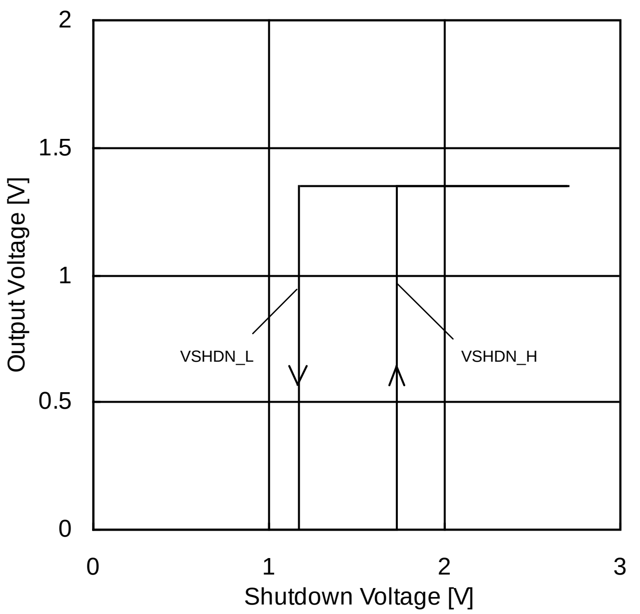


Figure 23. Shutdown Voltage vs Output Voltage (VDD=2.7V, Av=0dB, VIN=1.35V)

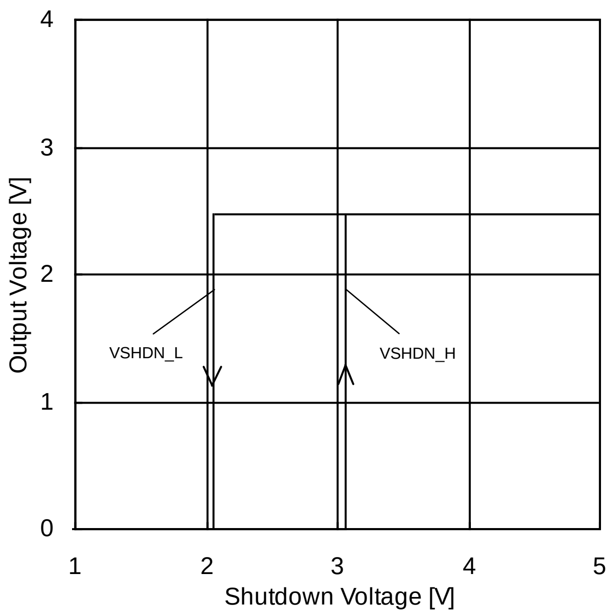


Figure 24. Shutdown Voltage vs Output Voltage (VDD=5V, Av=0dB, VIN=2.5V)

(*)The data above is measurement value of typical sample, it is not guaranteed.

Typical Performance Curves – continued

○LMR342xxx

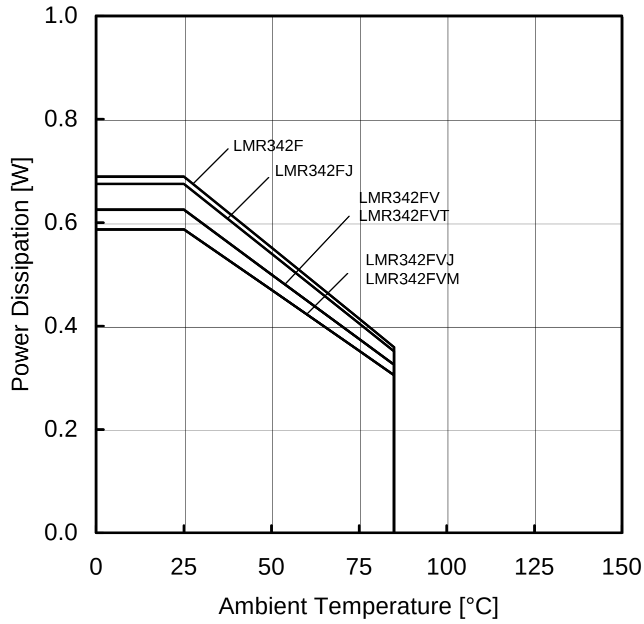


Figure 25. Power Dissipation vs Ambient Temperature (Derating Curve)

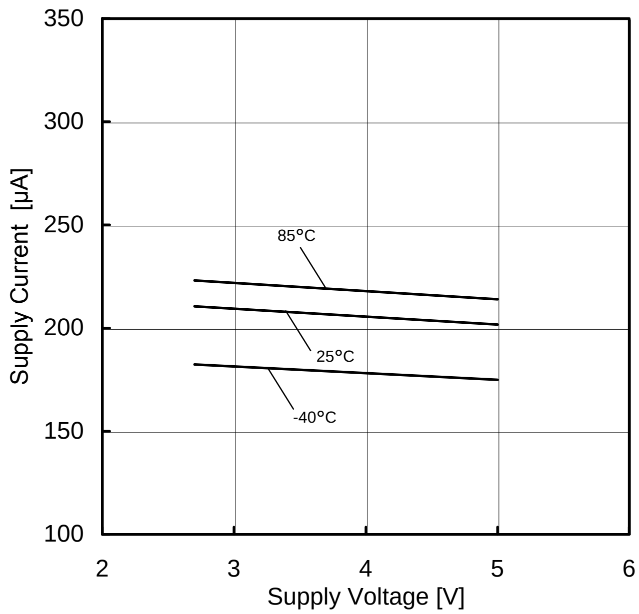


Figure 26. Supply Current vs Supply Voltage

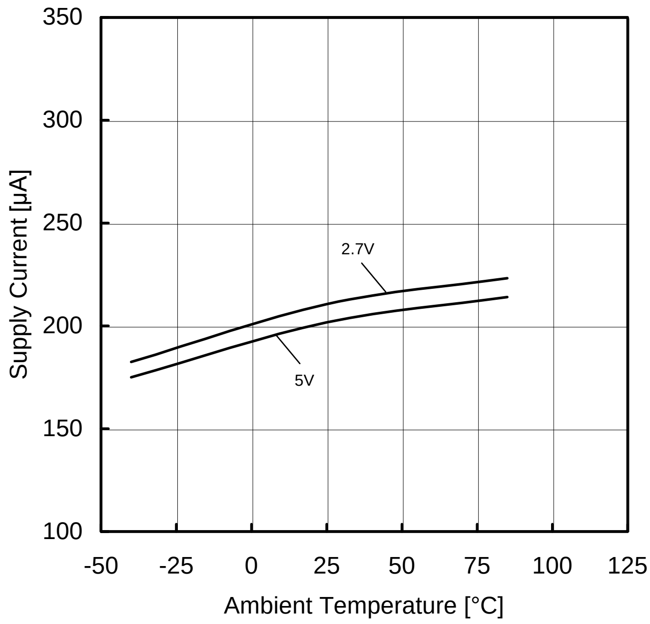


Figure 27. Supply Current vs Ambient Temperature

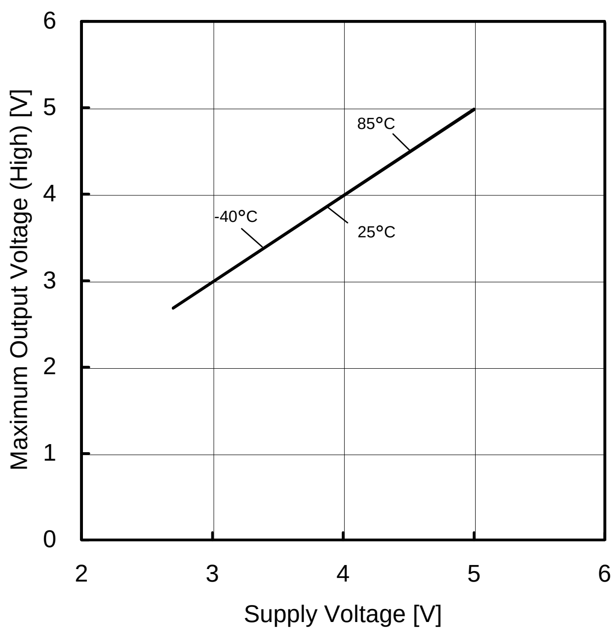


Figure 28. Maximum Output Voltage (High) vs Supply Voltage (R_L=2kΩ)

(*)The data above is measurement value of typical sample, it is not guaranteed.

Typical Performance Curves – continued

○LMR342xxx

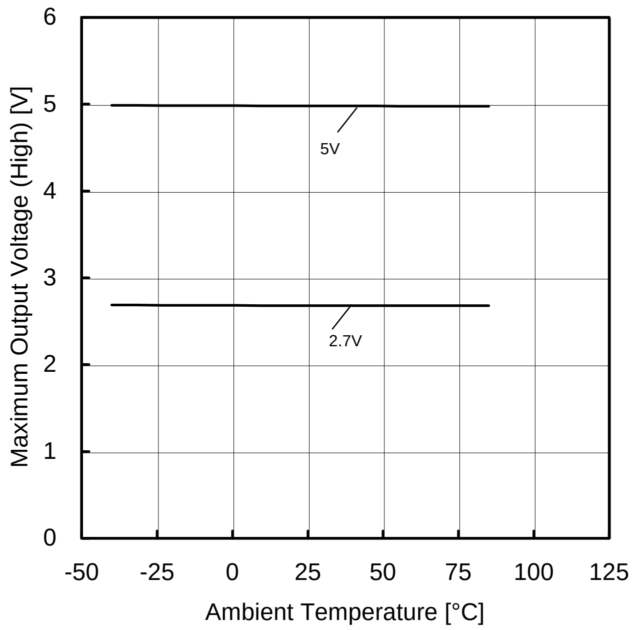


Figure 29. Maximum Output Voltage (High)
vs Ambient Temperature
(R_L=2kΩ)

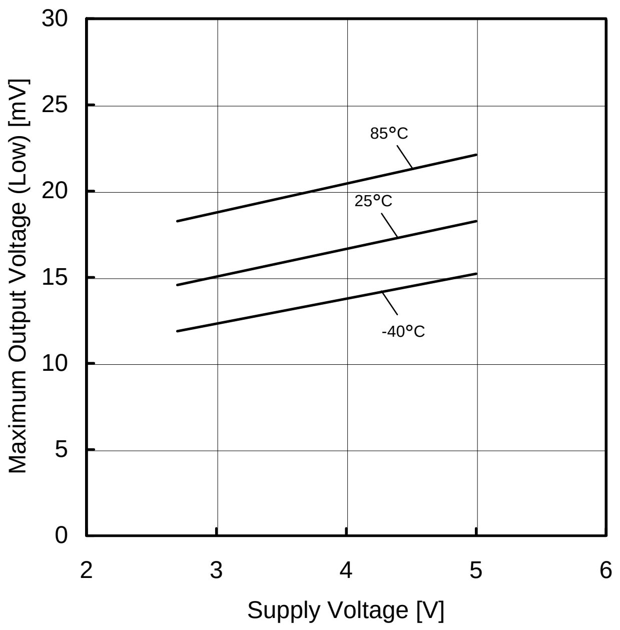


Figure 30. Maximum Output Voltage (Low)
vs Supply Voltage
(R_L=2kΩ)

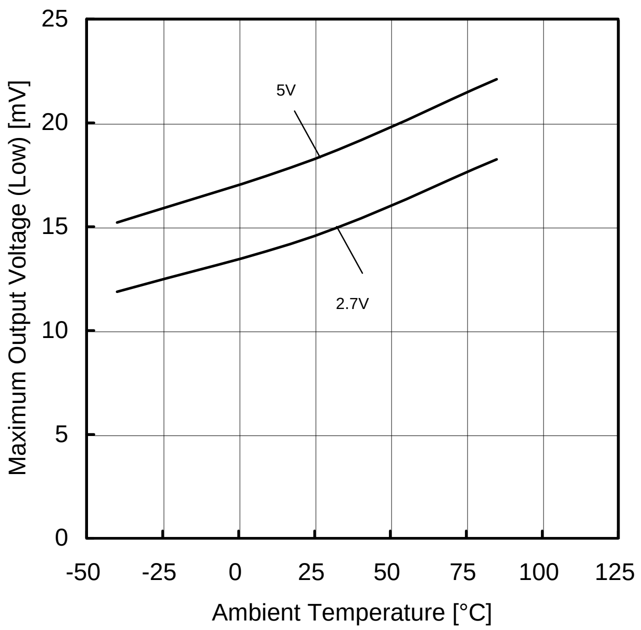


Figure 31. Maximum Output Voltage (Low)
vs Ambient Temperature
(R_L=2kΩ)

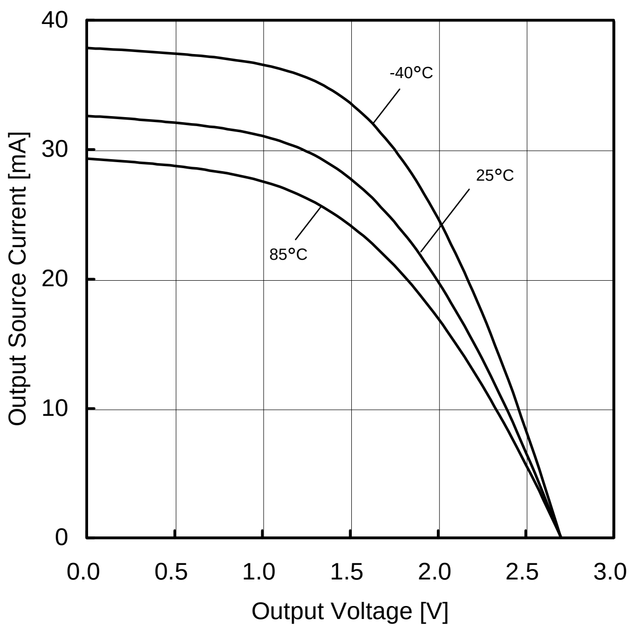


Figure 32. Output Source Current vs Output Voltage
(VDD=2.7V)

(*)The data above is measurement value of typical sample, it is not guaranteed.

Typical Performance Curves – continued

○LMR342xxx

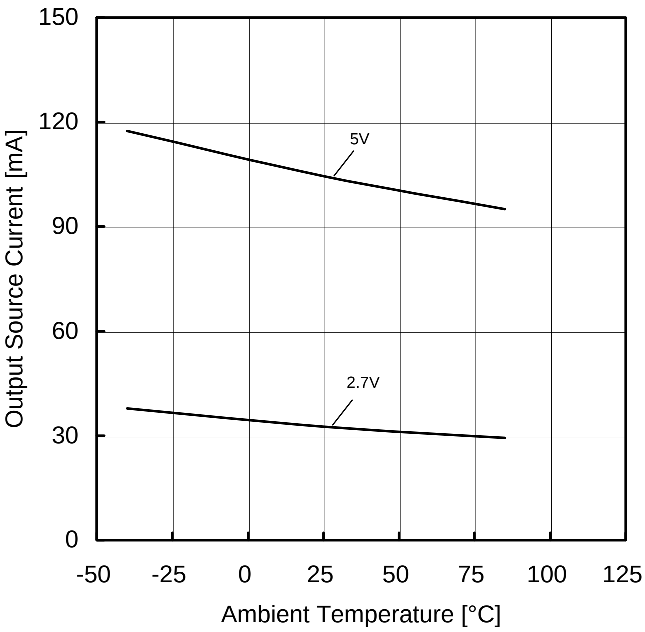


Figure 33. Output Source Current
vs Ambient Temperature
(OUT=0V)

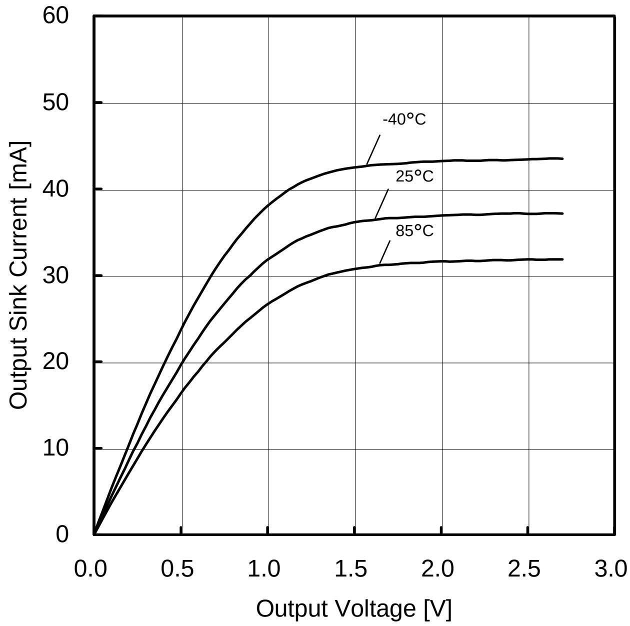


Figure 34. Output Sink Current
vs Output Voltage
(VDD=2.7V)

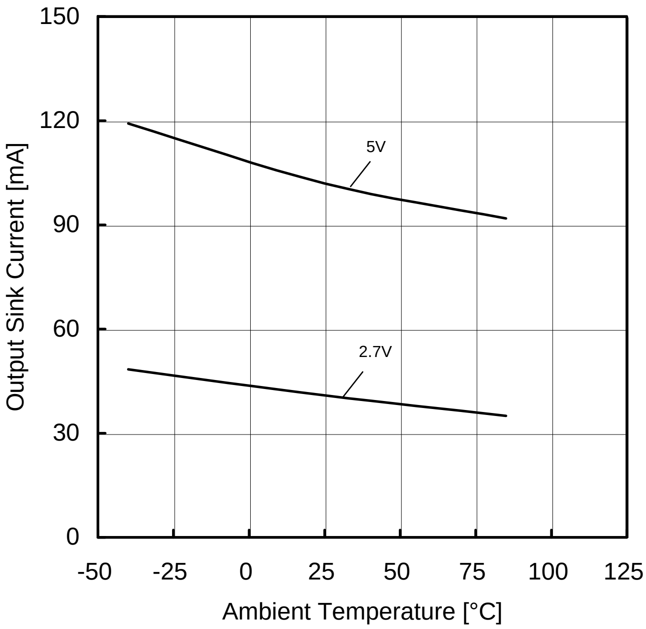


Figure 35. Output Sink Current
vs Ambient Temperature
(OUT=2.7V)

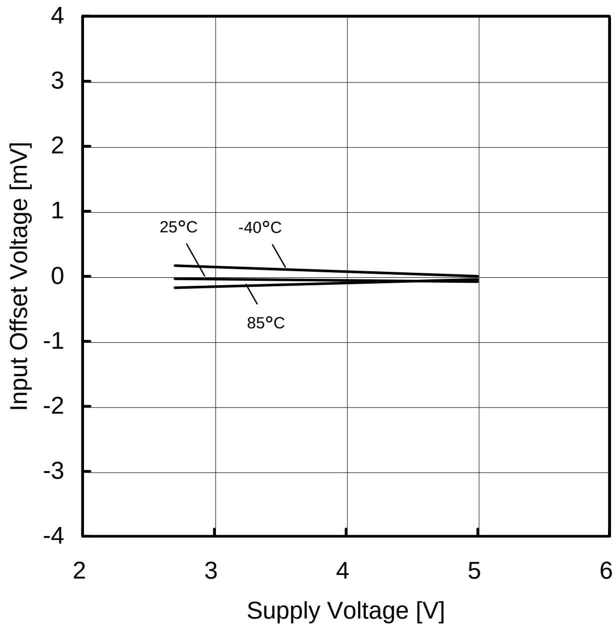


Figure 36. Input Offset Voltage vs Supply Voltage
(V_{ICM}=VDD/2, E_K=-VDD/2)

(*)The data above is measurement value of typical sample, it is not guaranteed.

Typical Performance Curves – continued

○LMR342xxx

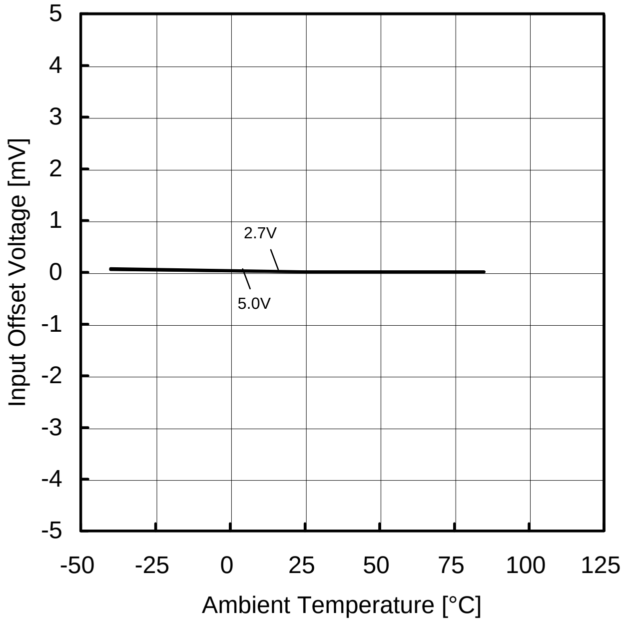


Figure 37. Input Offset Voltage
vs Ambient Temperature
(V_{ICM}=VDD/2, E_K=-VDD/2)

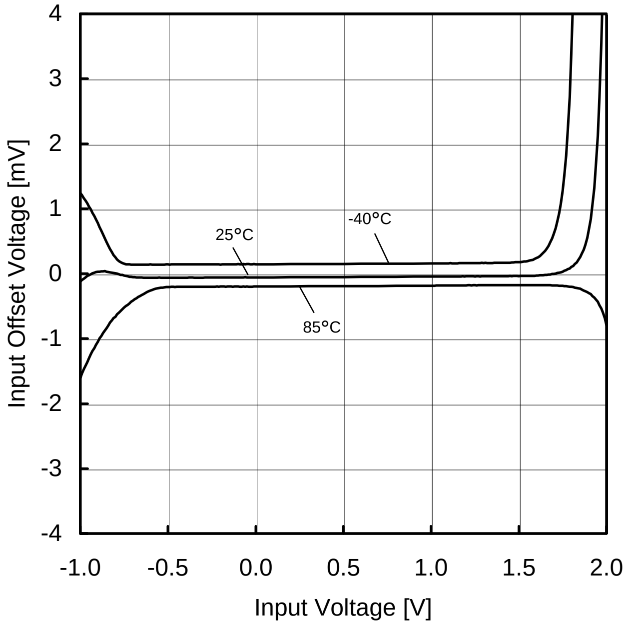


Figure 38. Input Offset Voltage
vs Input Voltage
(VDD=2.7V, E_K=-VDD/2)

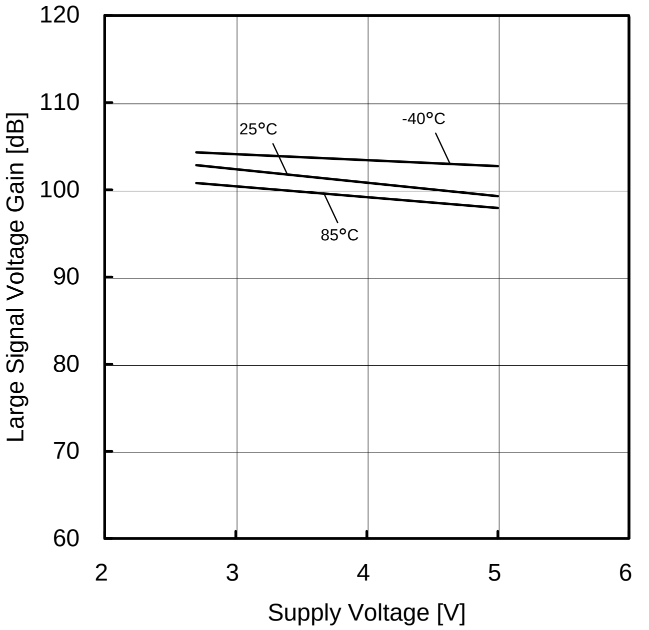


Figure 39. Large Signal Voltage Gain
vs Supply Voltage

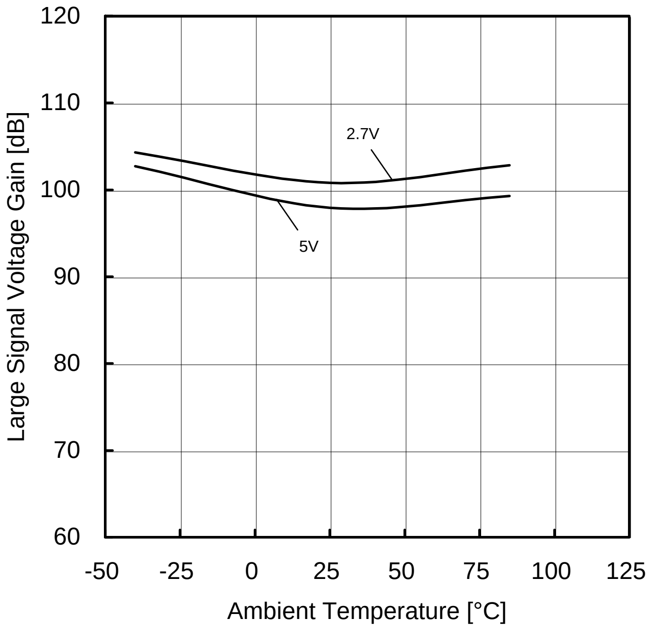


Figure 40. Large Signal Voltage Gain
vs Ambient Temperature

(*)The data above is measurement value of typical sample, it is not guaranteed.

Typical Performance Curves – continued

○LMR342xxx

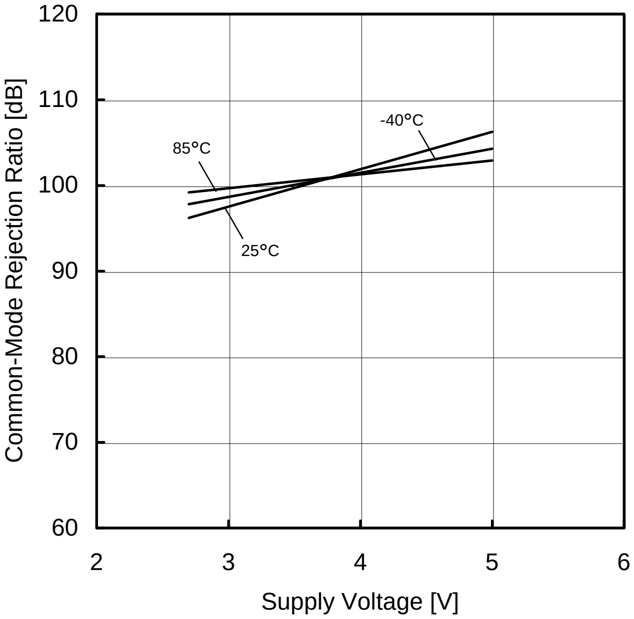


Figure 41. Common-Mode Rejection Ratio vs Supply Voltage (VDD=2.7V)

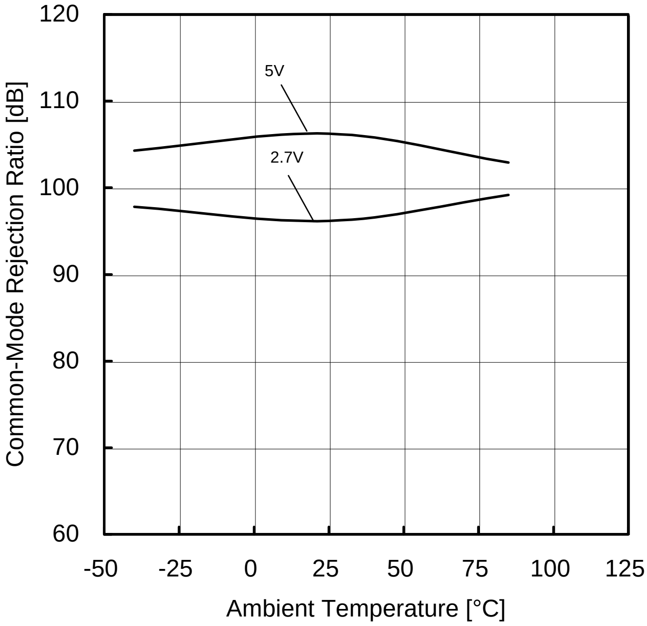


Figure 42. Common-Mode Rejection Ratio vs Ambient Temperature

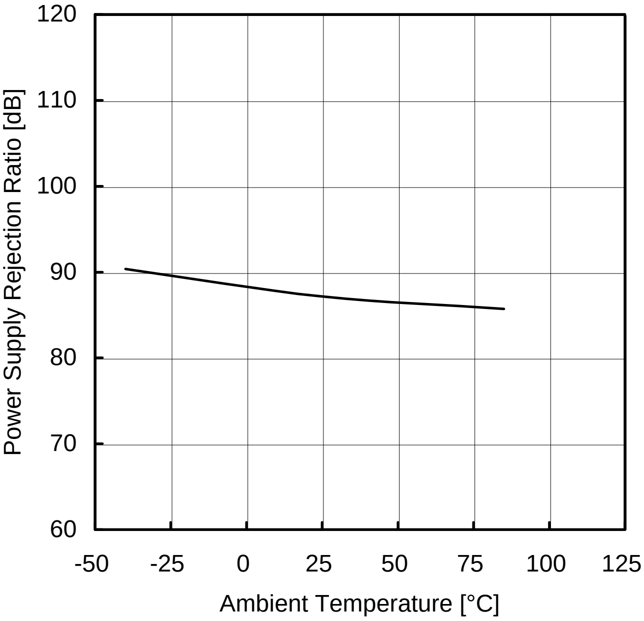


Figure 43. Power Supply Rejection Ratio vs Ambient Temperature (VDD=2.7V to 5.0V)

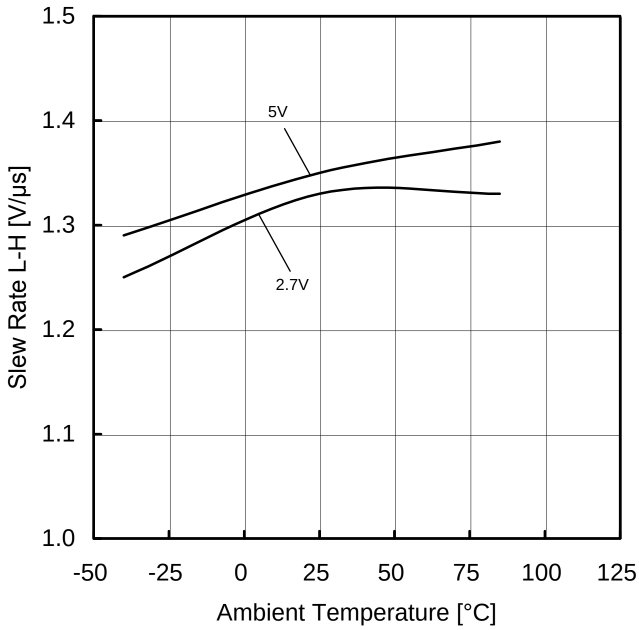


Figure 44. Slew Rate L-H vs Ambient Temperature (R_L=10kΩ)

(*)The data above is measurement value of typical sample, it is not guaranteed.

Typical Performance Curves – continued

○LMR342xxx

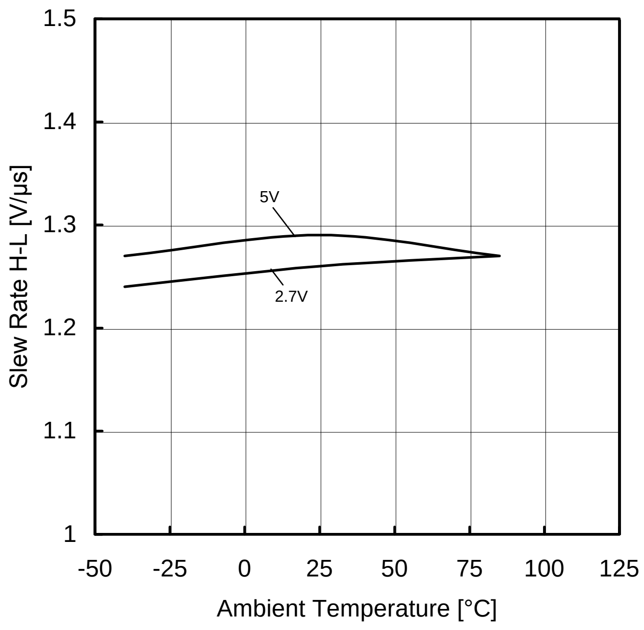


Figure 45. Slew Rate H-L vs Ambient Temperature (R_L=10kΩ)

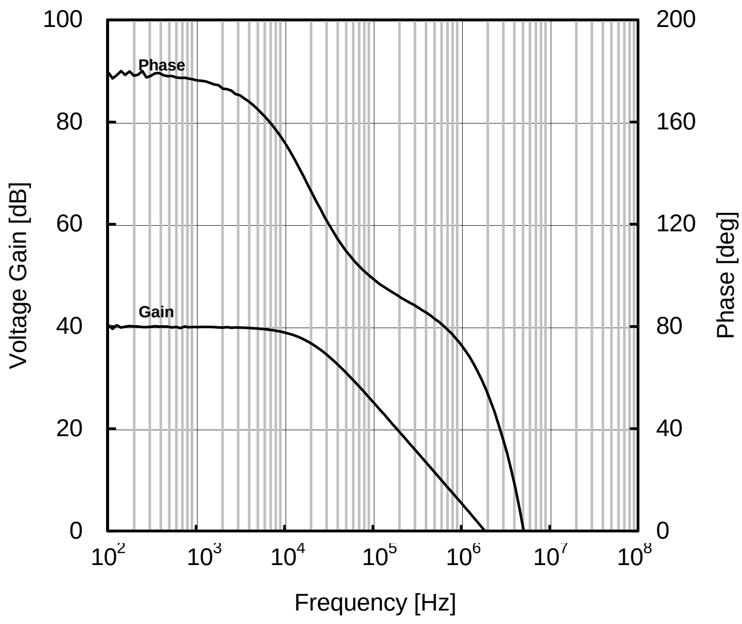


Figure 46. Voltage Gain・Phase vs Frequency (C=20pF)

(*)The data above is measurement value of typical sample, it is not guaranteed.

Typical Performance Curves – continued

○LMR344xxx

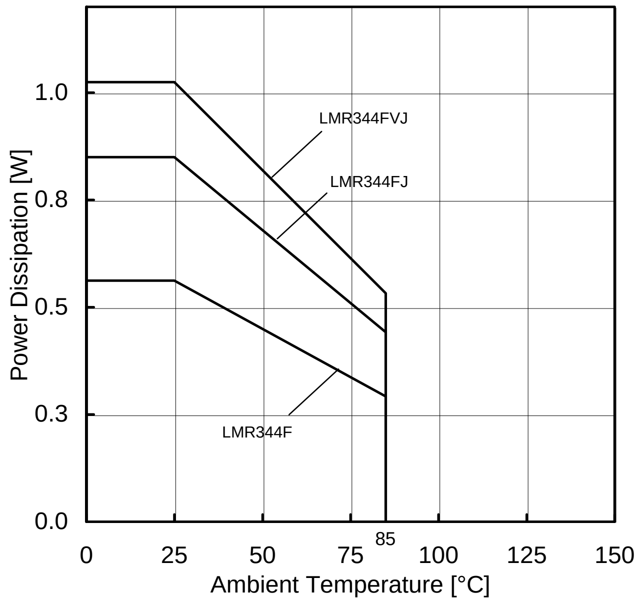


Figure 47. Power Dissipation vs Ambient Temperature (Derating Curve)

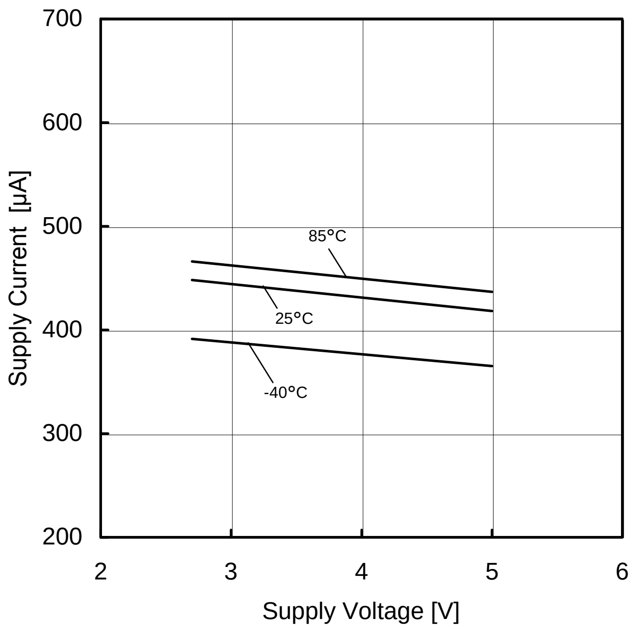


Figure 48. Supply Current vs Supply Voltage

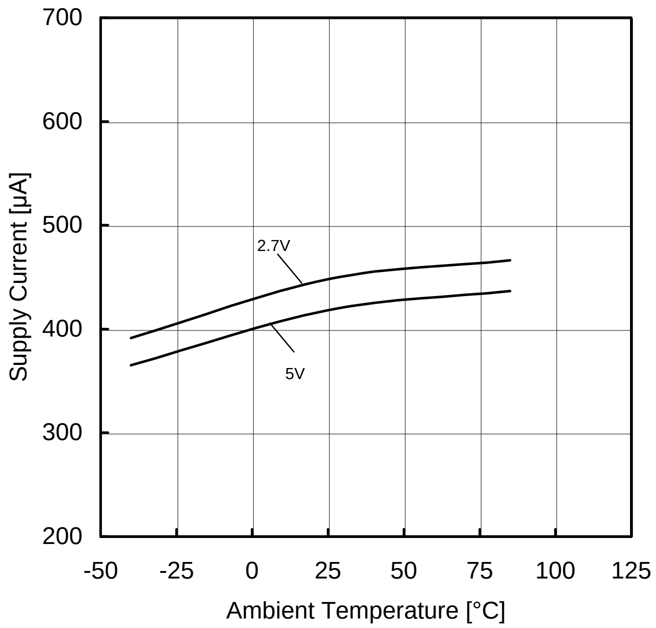


Figure 49. Supply Current vs Ambient Temperature

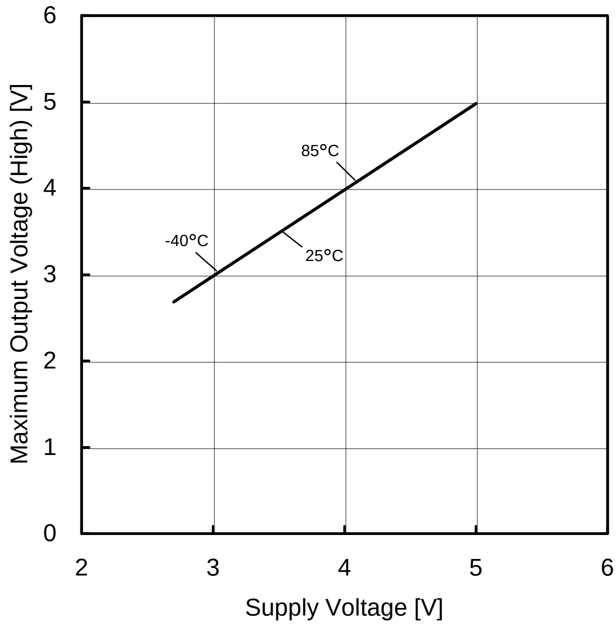


Figure 50. Maximum Output Voltage (High) vs Supply Voltage (R_L=2kΩ)

(*)The data above is measurement value of typical sample, it is not guaranteed.

Typical Performance Curves – continued

○LMR344xxx

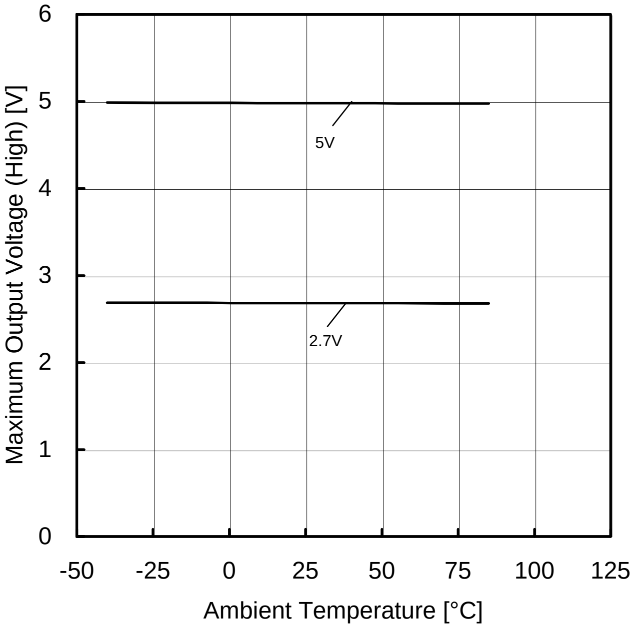


Figure 51. Maximum Output Voltage (High) vs Ambient Temperature (R_L=2kΩ)

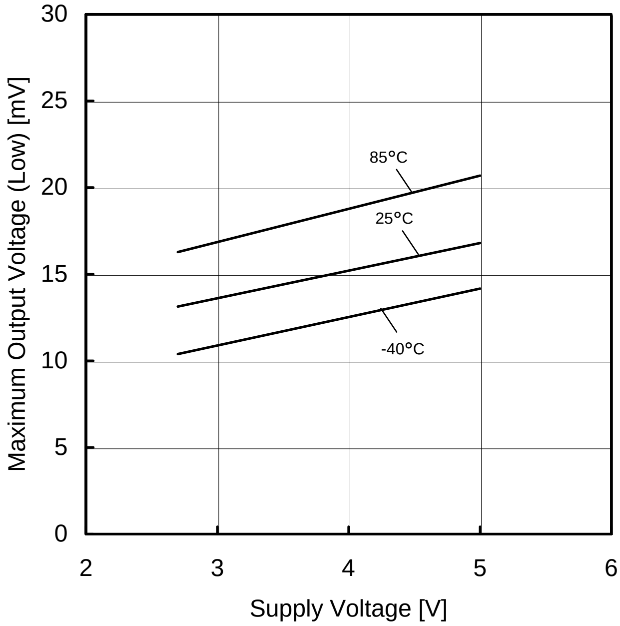


Figure 52. Maximum Output Voltage (Low) vs Supply Voltage (R_L=2kΩ)

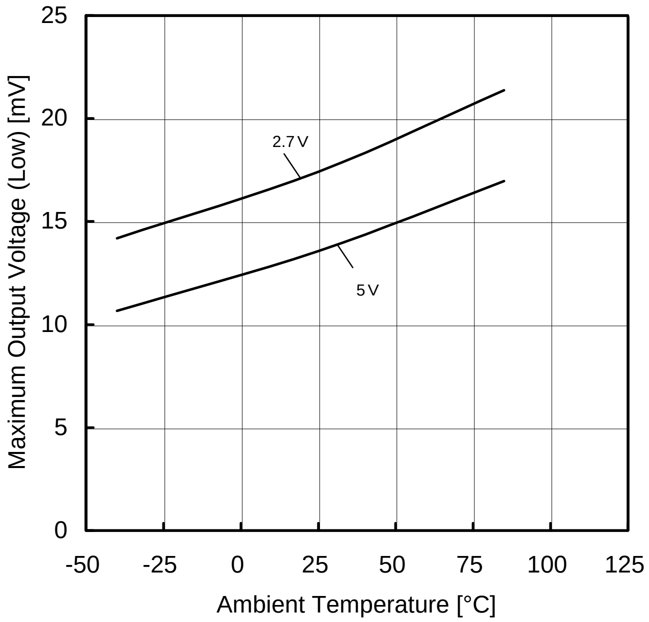


Figure 53. Maximum Output Voltage (Low) vs Ambient Temperature (R_L=2kΩ)

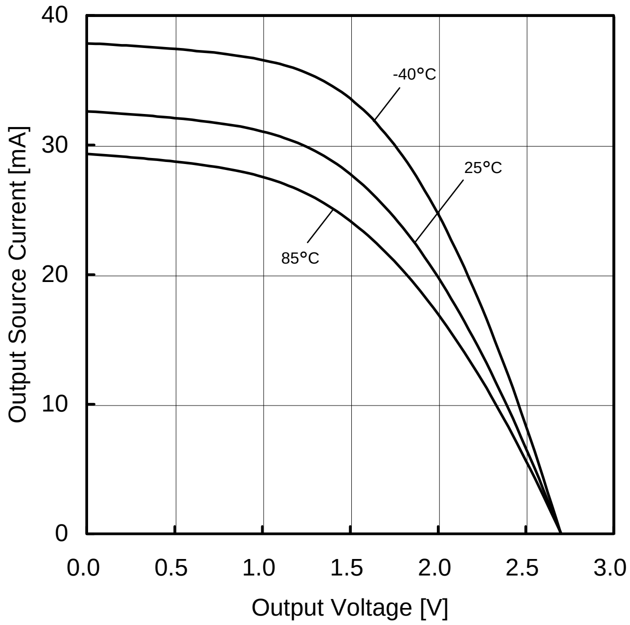


Figure 54. Output Source Current vs Output Voltage (VDD=2.7V)

(*)The data above is measurement value of typical sample, it is not guaranteed.

Typical Performance Curves – continued

○LMR344xxx

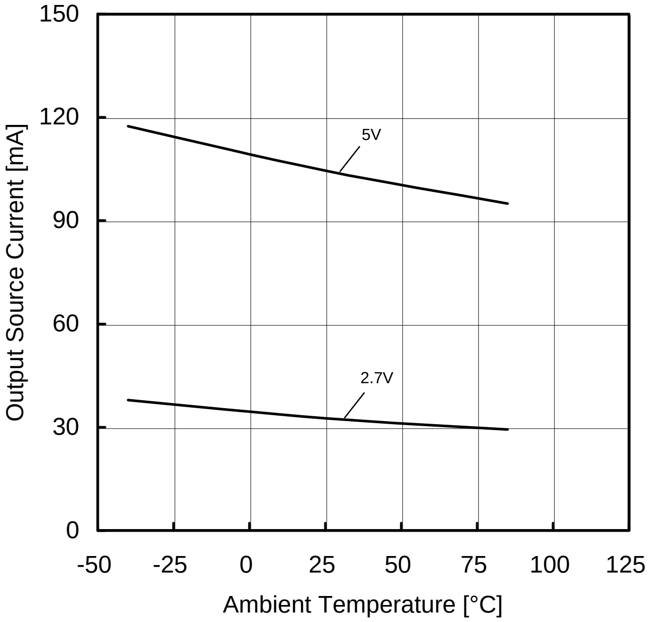


Figure 55. Output Source Current
vs Ambient Temperature
(OUT=0V)

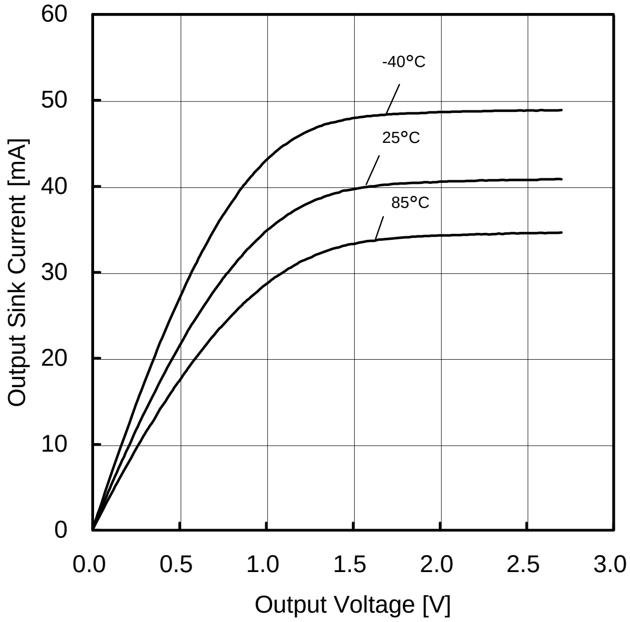


Figure 56. Output Sink Current
vs Output Voltage
(VDD=2.7V)

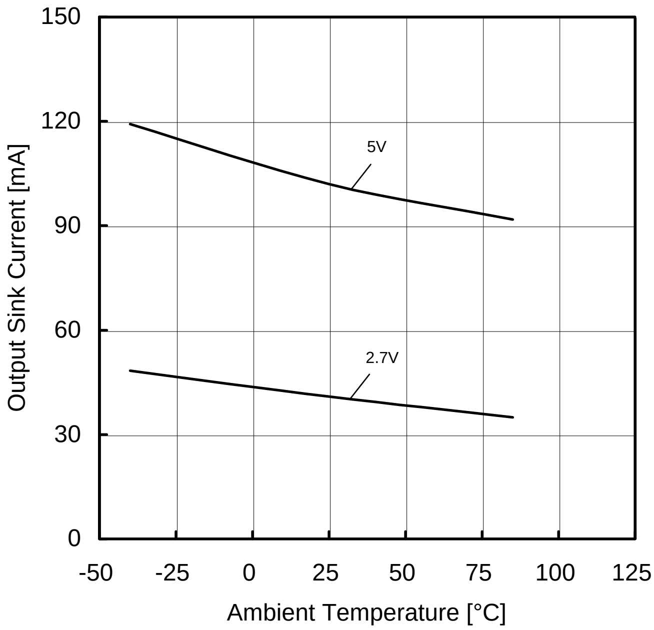


Figure 57. Output Sink Current
vs Ambient Temperature
(OUT=2.7V)

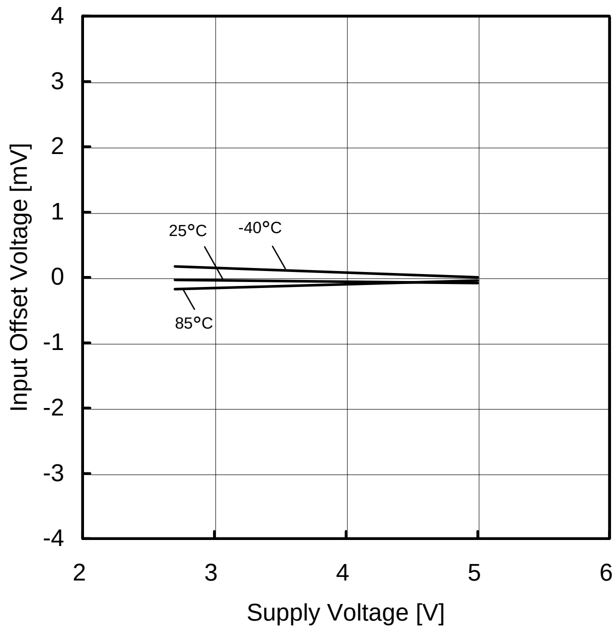


Figure 58. Input Offset Voltage
vs Supply Voltage
(V_{ICM}=VDD/2, E_K=-VDD/2)

(*)The data above is measurement value of typical sample, it is not guaranteed.

Typical Performance Curves – continued

○LMR344xxx

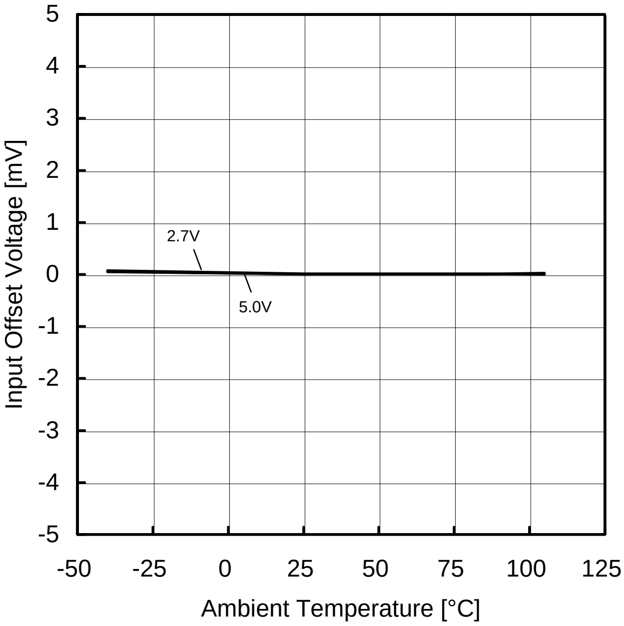


Figure 59. Input Offset Voltage
vs Ambient Temperature
(V_{ICM}=VDD/2, E_K=-VDD/2)

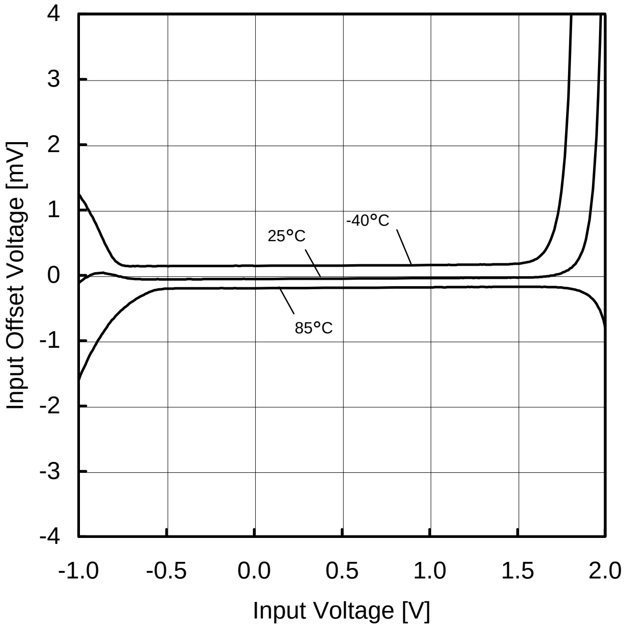


Figure 60. Input Offset Voltage vs Input Voltage
(VDD=2.7V, E_K=-VDD/2)

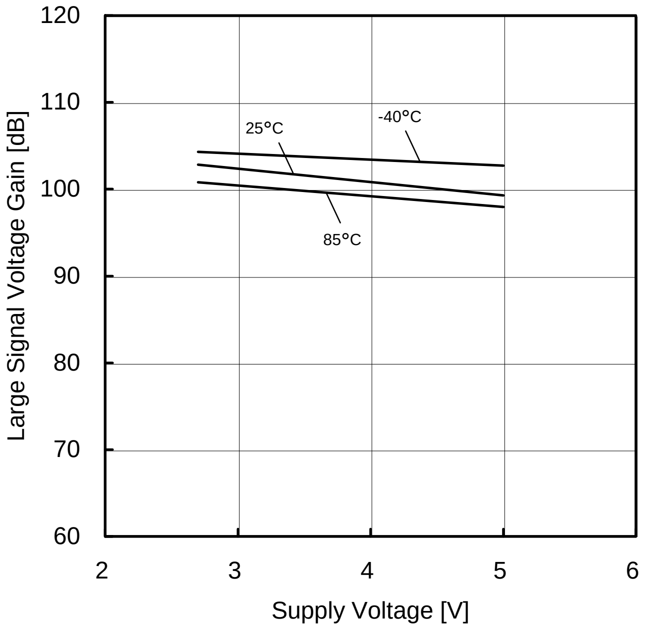


Figure 61. Large Signal Voltage Gain
vs Supply Voltage

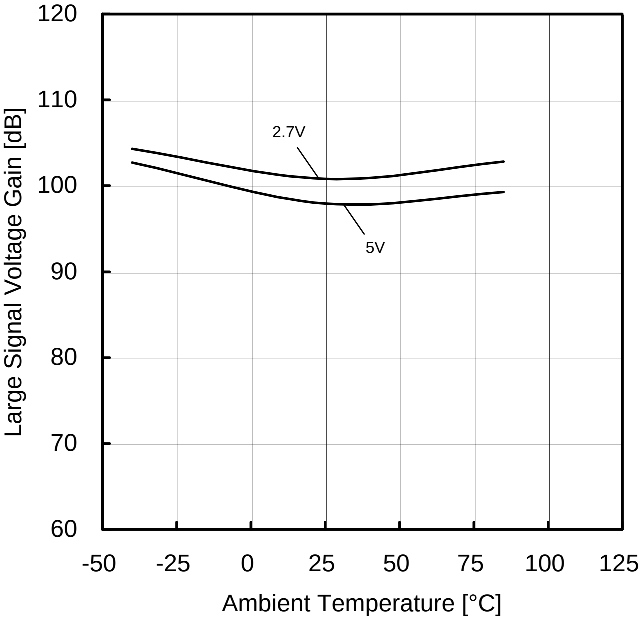


Figure 62. Large Signal Voltage Gain
vs Ambient Temperature

(*)The data above is measurement value of typical sample, it is not guaranteed.

Typical Performance Curves – continued

○LMR344xxx

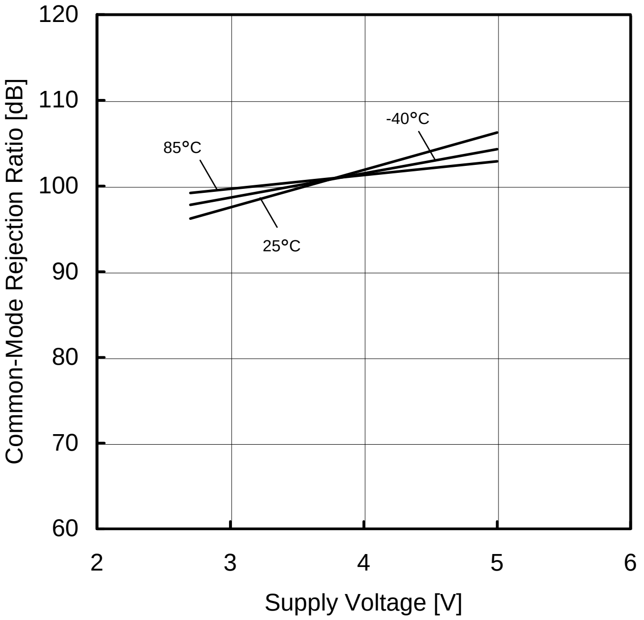


Figure 63. Common-Mode Rejection Ratio
vs Supply Voltage
(VDD=2.7V)

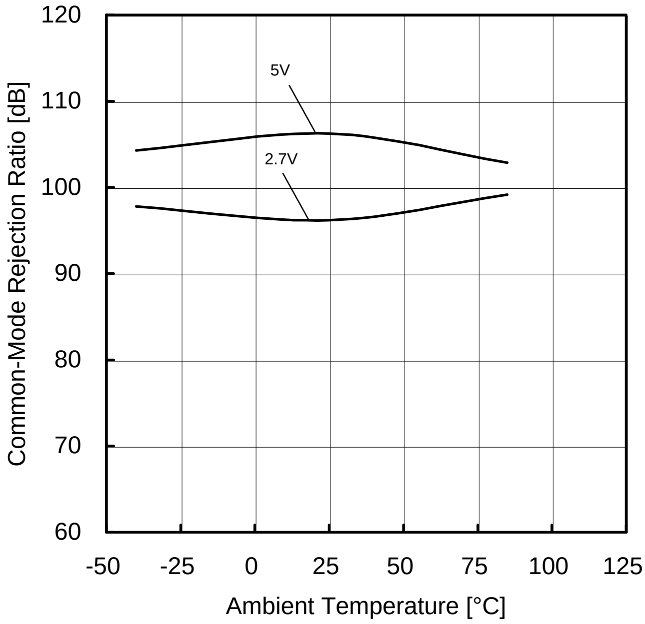


Figure 64. Common-Mode Rejection Ratio
vs Ambient Temperature

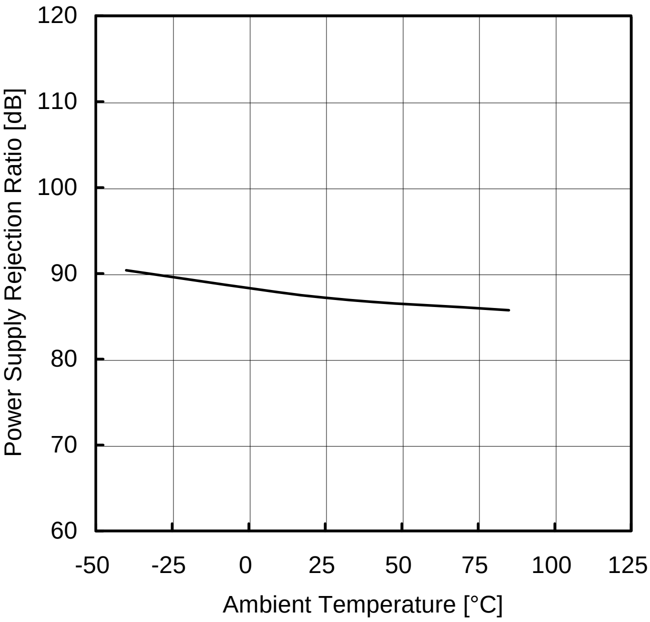


Figure 65. Power Supply Rejection Ratio
vs Ambient Temperature
(VDD=2.7V to 5.0V)

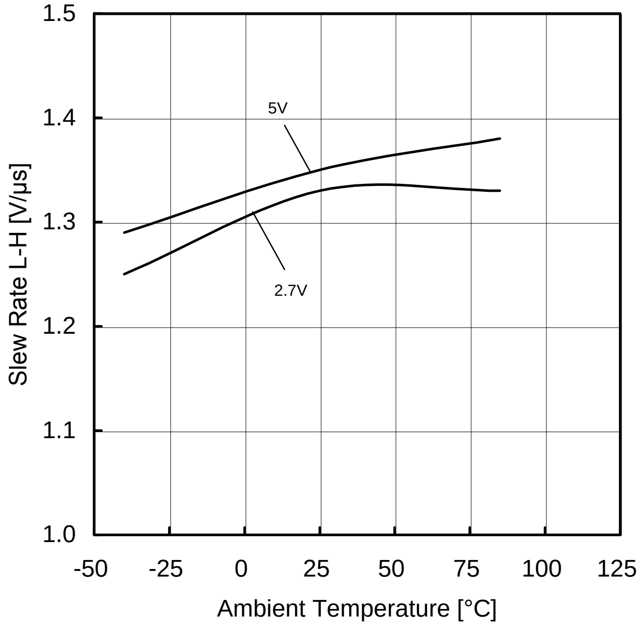


Figure 66. Slew Rate L-H vs Ambient Temperature
(R_L=10kΩ)

(*)The data above is measurement value of typical sample, it is not guaranteed.

Typical Performance Curves – continued

○LMR344xxx

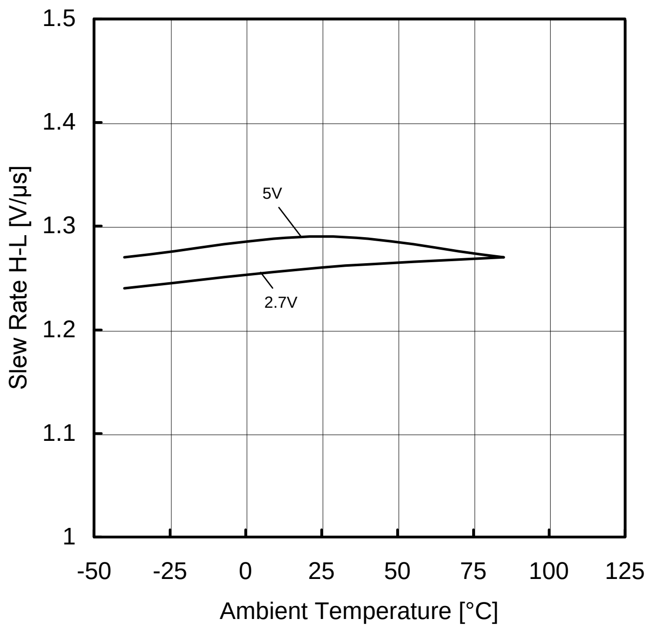


Figure 67. Slew Rate H-L vs Ambient Temperature (R_L=10kΩ)

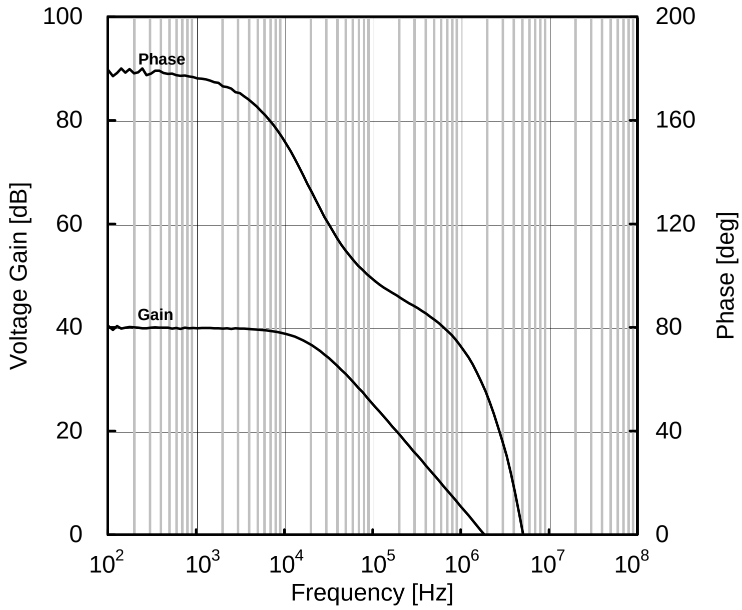


Figure 68. Voltage Gain・Phase vs Frequency (C=20pF)

(*)The data above is measurement value of typical sample, it is not guaranteed.

Application Information

NULL method condition for Test Circuit 1

VDD, VSS, E_K, V_{ICM} Unit: V

Parameter	V_F	SW1	SW2	SW3	VDD	VSS	E_K	V_{ICM}	Calculation
Input Offset Voltage	V_{F1}	ON	ON	OFF	5	0	-2.5	2.5	1
Large Signal Voltage Gain	V_{F2}	ON	ON	ON	5	0	-0.5	1.5	2
	V_{F3}						-2.5		
Common-Mode Rejection Ratio (Input Common-Mode Voltage Range)	V_{F4}	ON	ON	OFF	5	0	-1.5	0	3
	V_{F5}							3	
Power Supply Rejection Ratio	V_{F6}	ON	ON	OFF	2.7	0	-1.2	0	4
	V_{F7}				5				

\- Calculation -

1. Input Offset Voltage (V_{IO})

$$V_{IO} = \frac{|V_{F1}|}{1 + R_F/R_S} \quad [V]$$

2. Large Signal Voltage Gain (A_V)

$$Av = 20Log \frac{\Delta E_K \times (1+R_F/R_S)}{|V_{F3} - V_{F2}|} \quad [dB]$$

3. Common-Mode Rejection Ration (CMRR)

$$CMRR = 20Log \frac{\Delta V_{ICM} \times (1+R_F/R_S)}{|V_{F5} - V_{F4}|} \quad [dB]$$

4. Power Supply Rejection Ratio (PSRR)

$$PSRR = 20Log \frac{\Delta VDD \times (1+ R_F/R_S)}{|V_{F7} - V_{F6}|} \quad [dB]$$

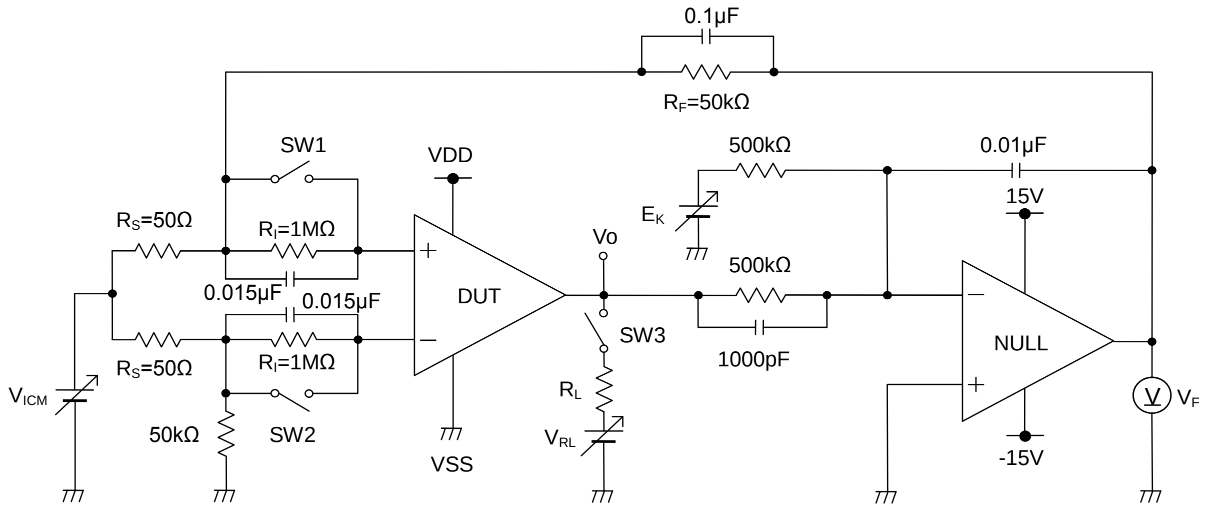


Figure 69. Test Circuit 1 (one channel only)

Application Information – continued

Switch Condition for Test Circuit 2

SW No.	SW 1	SW 2	SW 3	SW 4	SW 5	SW 6	SW 7	SW 8	SW 9	SW 10	SW 11
Supply Current	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF
Maximum Output Voltage (R_L=10kΩ)	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	OFF	ON	OFF
Output Current	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF
Slew Rate	OFF	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	OFF	ON
Unity Gain Frequency	ON	OFF	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	ON

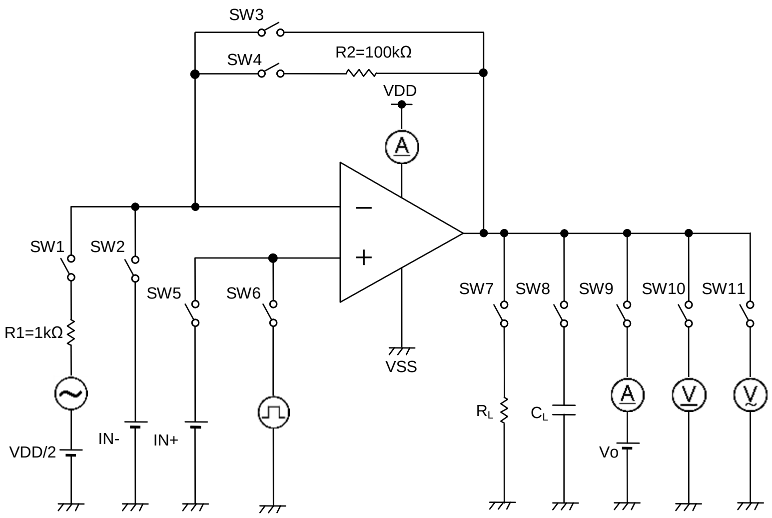


Figure 70. Test Circuit 2 (each channel)

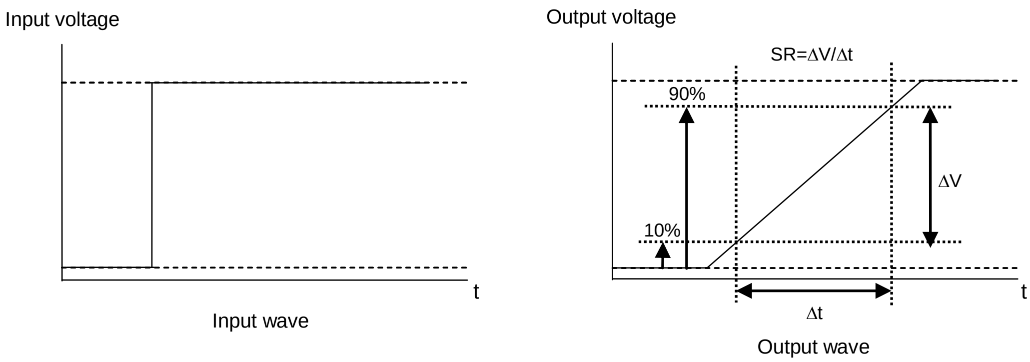


Figure 71. Slew Rate Input and Output Wave

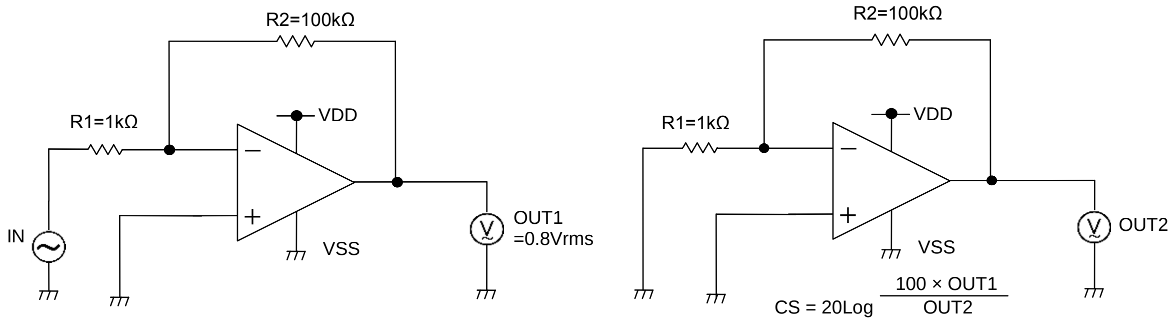


Figure 72. Test Circuit 3 (Channel Separation)

Examples of Circuit

○Voltage Follower

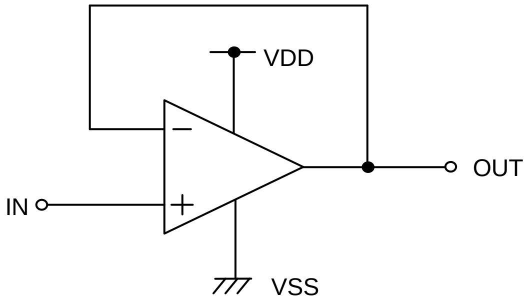


Figure 73. Voltage Follower Circuit

Voltage gain is 0dB.

Using this circuit, the output voltage (OUT) is configured to be equal to the input voltage (IN). This circuit also stabilizes the output voltage (OUT) due to high input impedance and low output impedance. Computation for output voltage (OUT) is shown below.

OUT=IN

○Inverting Amplifier

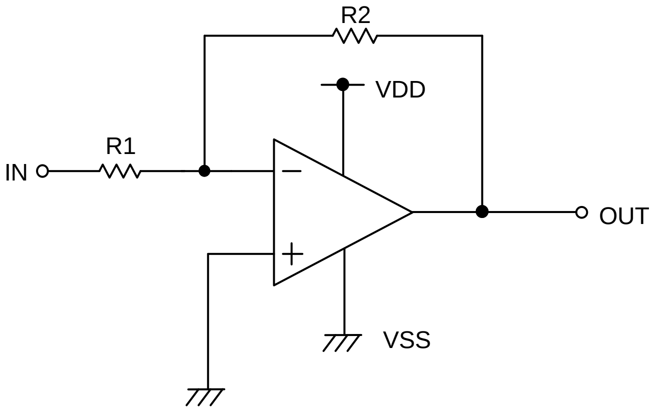


Figure 74. Inverting Amplifier Circuit

For inverting amplifier, input voltage (IN) is amplified by a voltage gain and depends on the ratio of R1 and R2. The out-of-phase output voltage is shown in the next expression

OUT=-(R2/R1)・IN

This circuit has input impedance equal to R1.

○Non-inverting Amplifier

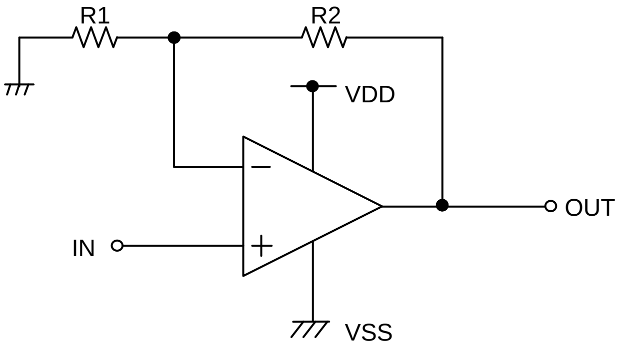


Figure 75. Non-inverting Amplifier Circuit

For non-inverting amplifier, input voltage (IN) is amplified by a voltage gain, which depends on the ratio of R1 and R2. The output voltage (OUT) is in-phase with the input voltage (IN) and is shown in the next expression.

OUT=(1 + R2/R1)・IN

Effectively, this circuit has high input impedance since its input side is the same as that of the operational amplifier.

Power Dissipation

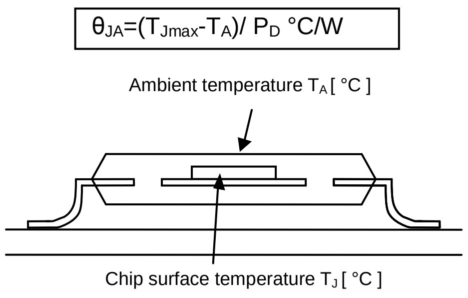
Power dissipation (total loss) indicates the power that the IC can consume at T_A=25°C (normal temperature). As the IC consumes power, it heats up, causing its temperature to be higher than the ambient temperature. The allowable temperature that the IC can accept is limited. This depends on the circuit configuration, manufacturing process, and consumable power.

Power dissipation is determined by the allowable temperature within the IC (maximum junction temperature) and the thermal resistance of the package used (heat dissipation capability). Maximum junction temperature is typically equal to the maximum storage temperature. The heat generated through the consumption of power by the IC radiates from the mold resin or lead frame of the package. Thermal resistance, represented by the symbol θ_{JA}°C/W, indicates this heat dissipation capability. Similarly, the temperature of an IC inside its package can be estimated by thermal resistance.

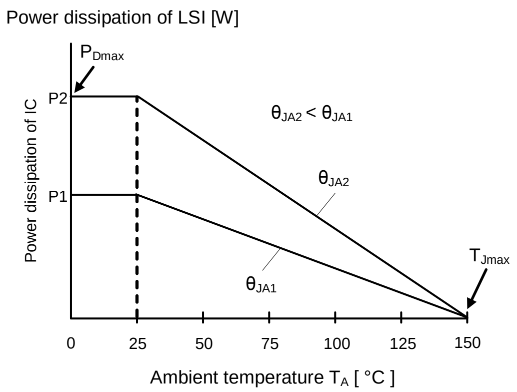
Figure 76(a) shows the model of the thermal resistance of a package. The equation below shows how to compute for the Thermal resistance (θ_{JA}), given the ambient temperature (T_A), maximum junction temperature (T_{Jmax}), and power dissipation (P_D).

$$\theta_{JA} = (T_{Jmax} - T_A) / P_D \quad °C/W$$

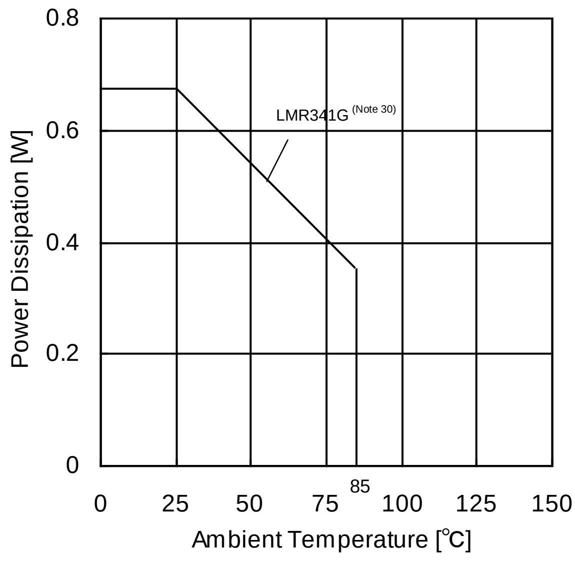
The derating curve in Figure 76(b) indicates the power that the IC can consume with reference to ambient temperature. Power consumption of the IC begins to attenuate at certain temperatures. This gradient is determined by Thermal resistance (θ_{JA}), which depends on the chip size, power consumption, package, ambient temperature, package condition, wind velocity, etc. This may also vary even when the same of package is used. Thermal reduction curve indicates a reference value measured at a specified condition. Figure 76(c), (d), (e) shows an example of the derating curve for LMR341G, LMR342xxx, and LMR344xxx.



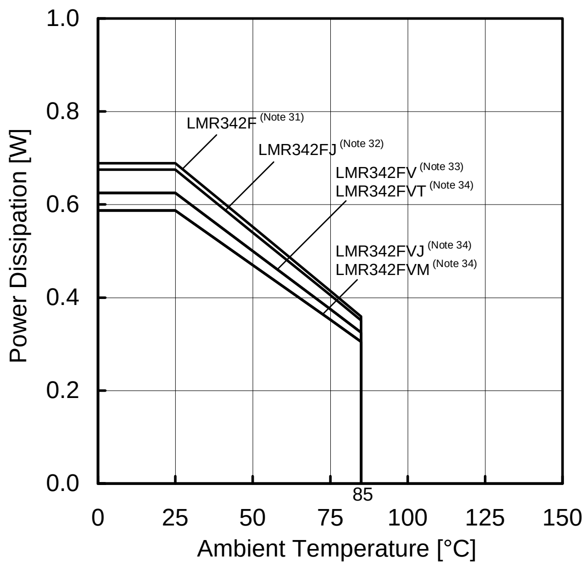
(a) Thermal Resistance



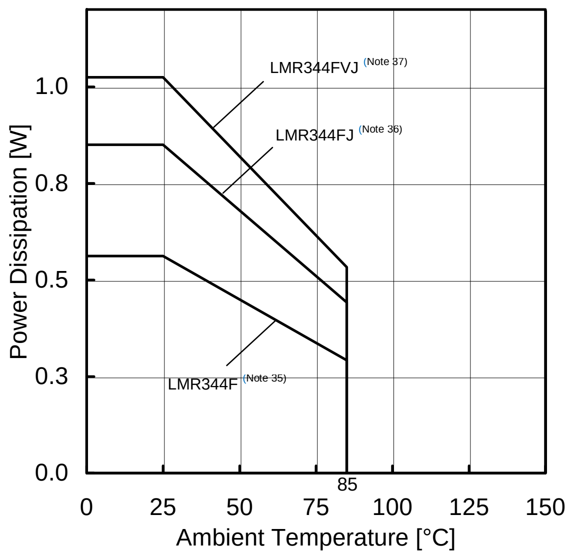
(b) Derating Curve



(c) LMR341G



(d) LMR342xxx



(e) LMR344xxx

Figure 76. Thermal Resistance and Derating Curve

(Note 30)	(Note 31)	(Note 32)	(Note 33)	(Note 34)	(Note 35)	(Note 36)	(Note 37)	Unit
5.4	5.5	5.4	5.0	4.7	4.5	8.2	6.8	mW/°C

When using the unit above T_A =25°C, subtract the value above per Celsius degree.
Power dissipation is the value when FR4 glass epoxy board 70mm × 70mm × 1.6mm (copper foil area less than 3%) is mounted.

Operational Notes

1. **Reverse Connection of Power Supply**
Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC's power supply pins.

2. **Power Supply Lines**
Design the PCB layout pattern to provide low impedance supply lines. Separate the ground and supply lines of the digital and analog blocks to prevent noise in the ground and supply lines of the digital block from affecting the analog block. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

3. **Ground Voltage**
Ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition.

4. **Ground Wiring Pattern**
When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

5. **Thermal Consideration**
Should by any chance the power dissipation rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. The absolute maximum rating of the P_D stated in this specification is when the IC is mounted on a 70mm x 70mm x 1.6mm glass epoxy board. In case of exceeding this absolute maximum rating, increase the board size and copper area to prevent exceeding the P_D rating.

6. **Recommended Operating Conditions**
These conditions represent a range within which the expected characteristics of the IC can be approximately obtained. The electrical characteristics are guaranteed under the conditions of each parameter.

7. **Inrush Current**
When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

8. **Operation Under Strong Electromagnetic Field**
Operating the IC in the presence of a strong electromagnetic field may cause the IC to malfunction.

9. **Testing on Application Boards**
When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

10. **Inter-pin Short and Mounting Errors**
Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.

11. **Unused Input Pins**
Input pins of an IC are often connected to the gate of a MOS transistor. The gate has extremely high impedance and extremely low capacitance. If left unconnected, the electric field from the outside can easily charge it. The small charge acquired in this way is enough to produce a significant effect on the conduction through the transistor and cause unexpected operation of the IC. So unless otherwise specified, unused input pins should be connected to the power supply or ground line.

Operational Notes – continued

12. Regarding the Input Pin of the IC
In the construction of this IC, P-N junctions are inevitably formed creating parasitic diodes or transistors. The operation of these parasitic elements can result in mutual interference among circuits, operational faults, or physical damage. Therefore, conditions which cause these parasitic elements to operate, such as applying a voltage to an input pin lower than the ground voltage should be avoided. Furthermore, do not apply a voltage to the input pins when no power supply voltage is applied to the IC. Even if the power supply voltage is applied, make sure that the input pins have voltages within the values specified in the electrical characteristics of this IC.

13. Unused Circuits
When there are unused op-amps, it is recommended that they are connected as in Figure 77, setting the non-inverting input terminal to a potential within the input common-mode voltage range (V_{ICM}).

14. Input Voltage
Applying VDD+0.3V to the input terminal is possible without causing deterioration of the electrical characteristics or destruction. However, this does not ensure normal circuit operation. Please note that the circuit operates normally only when the input voltage is within the common mode input voltage range of the electric characteristics.

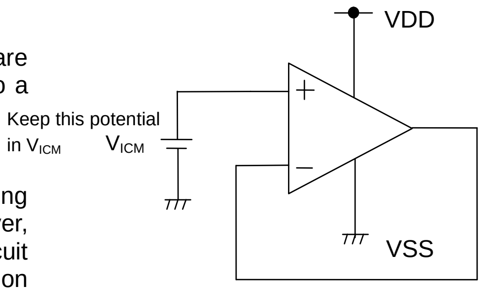


Figure 77. Example of Application Circuit for Unused Op-amp

15. Power Supply(single/dual)
The operational amplifiers operate when the voltage supplied is between VDD and VSS. Therefore, the single supply operational amplifiers can be used as dual supply operational amplifiers as well.

16. Output Capacitor
If a large capacitor is connected between the output pin and VSS pin, current from the charged capacitor will flow into the output pin and may destroy the IC when the VDD pin is shorted to ground or pulled down to 0V. Use a capacitor smaller than 0.1µF between output pin and VSS pin.

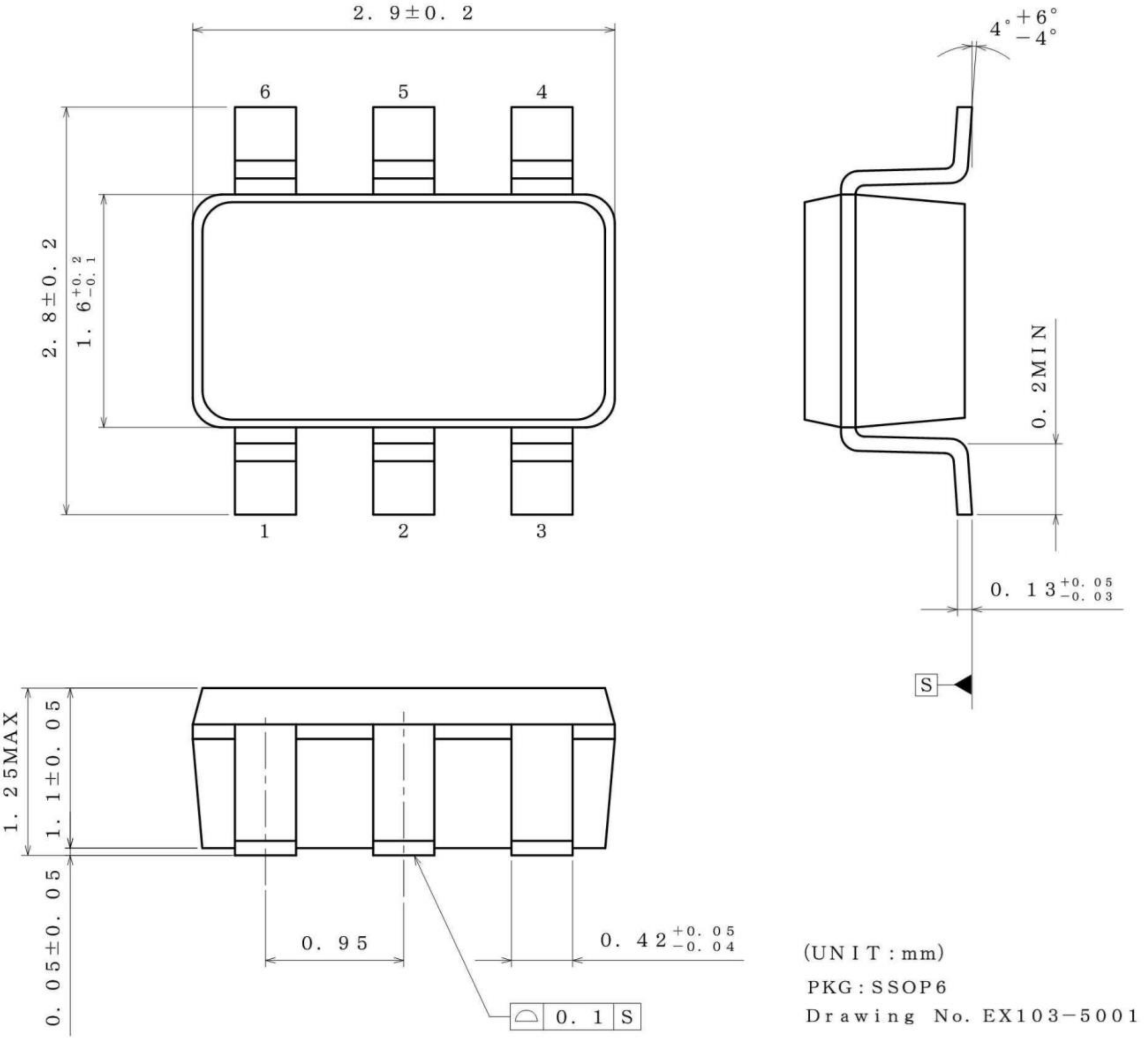
17. Oscillation by Output Capacitor
Please pay attention to the oscillation by output capacitor and in designing an application of negative feedback loop circuit with these ICs.

18. Latch Up
Be careful of input voltage that exceed the VDD and VSS. When CMOS device have sometimes occur latch up and protect the IC from abnormaly noise.

19. Shutdown Terminal
The shutdown terminal can’t be left unconnected. In case shutdown operation is not needed, the shutdown pin should be connected to VDD when the IC is used. Leaving the shutdown pin floating will result in an undefined operation mode, either shutdown or active, or even oscillating between the two modes.

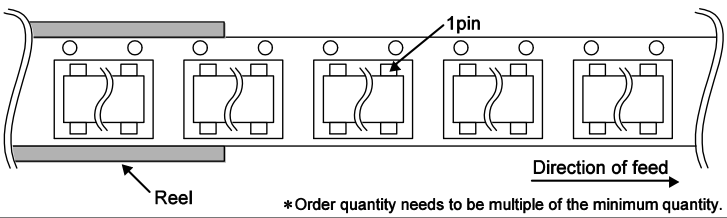
Physical Dimension, Tape and Reel Information

Package Name	SSOP6



<Tape and Reel information>

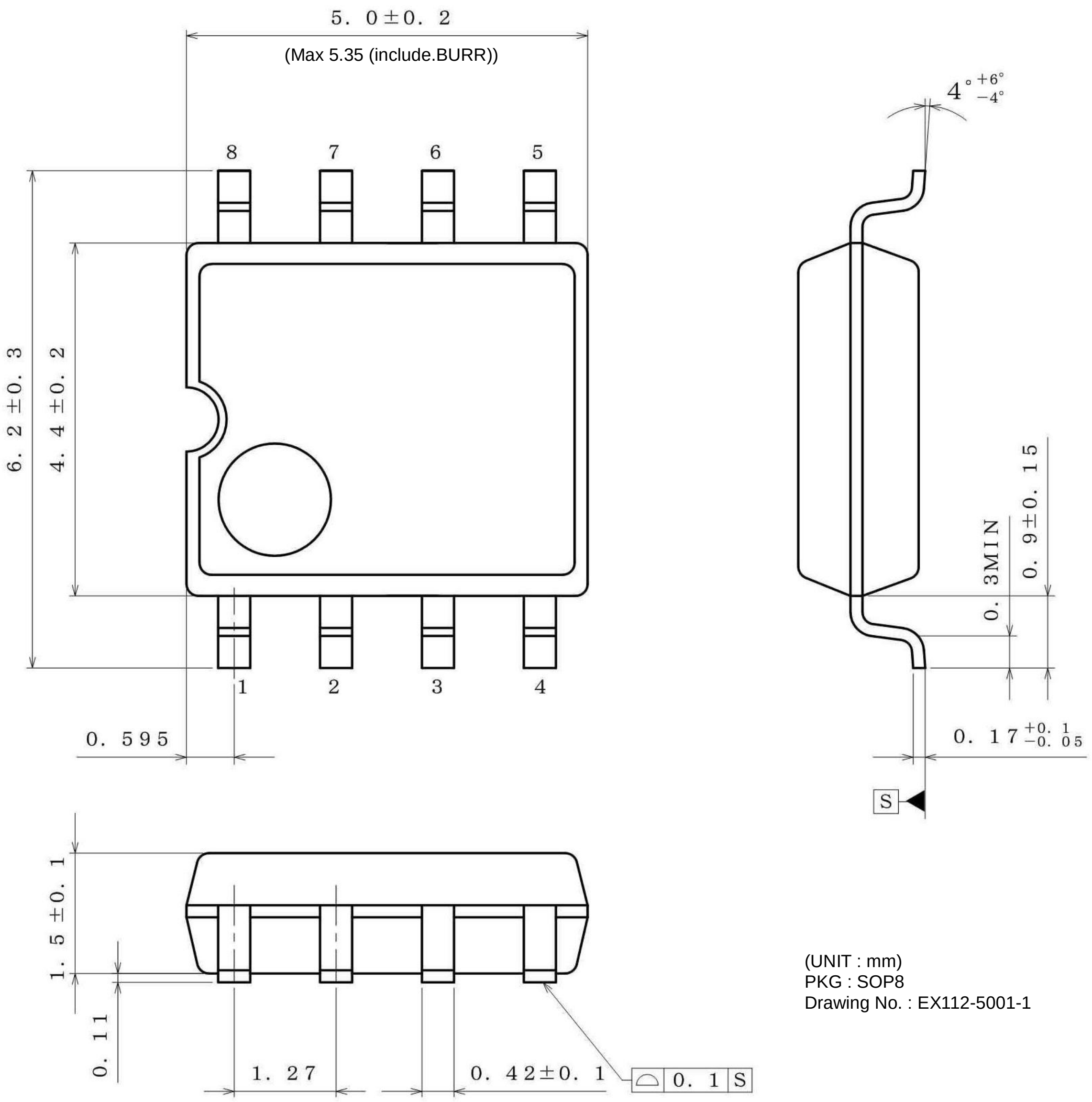
Tape	Embossed carrier tape
Quantity	3000pcs
Direction of feed	TR (The direction is the 1pin of product is at the upper right when you hold reel on the left hand and you pull out the tape on the right hand)



∗Order quantity needs to be multiple of the minimum quantity.

Physical Dimension, Tape and Reel Information - continued.

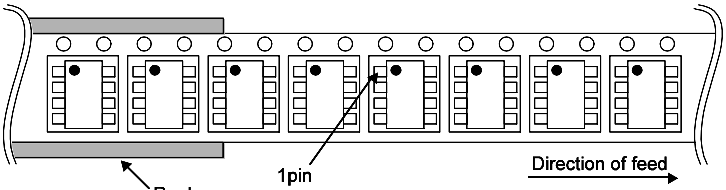
Package Name	SOP8



(UNIT : mm)
PKG : SOP8
Drawing No. : EX112-5001-1

<Tape and Reel information>

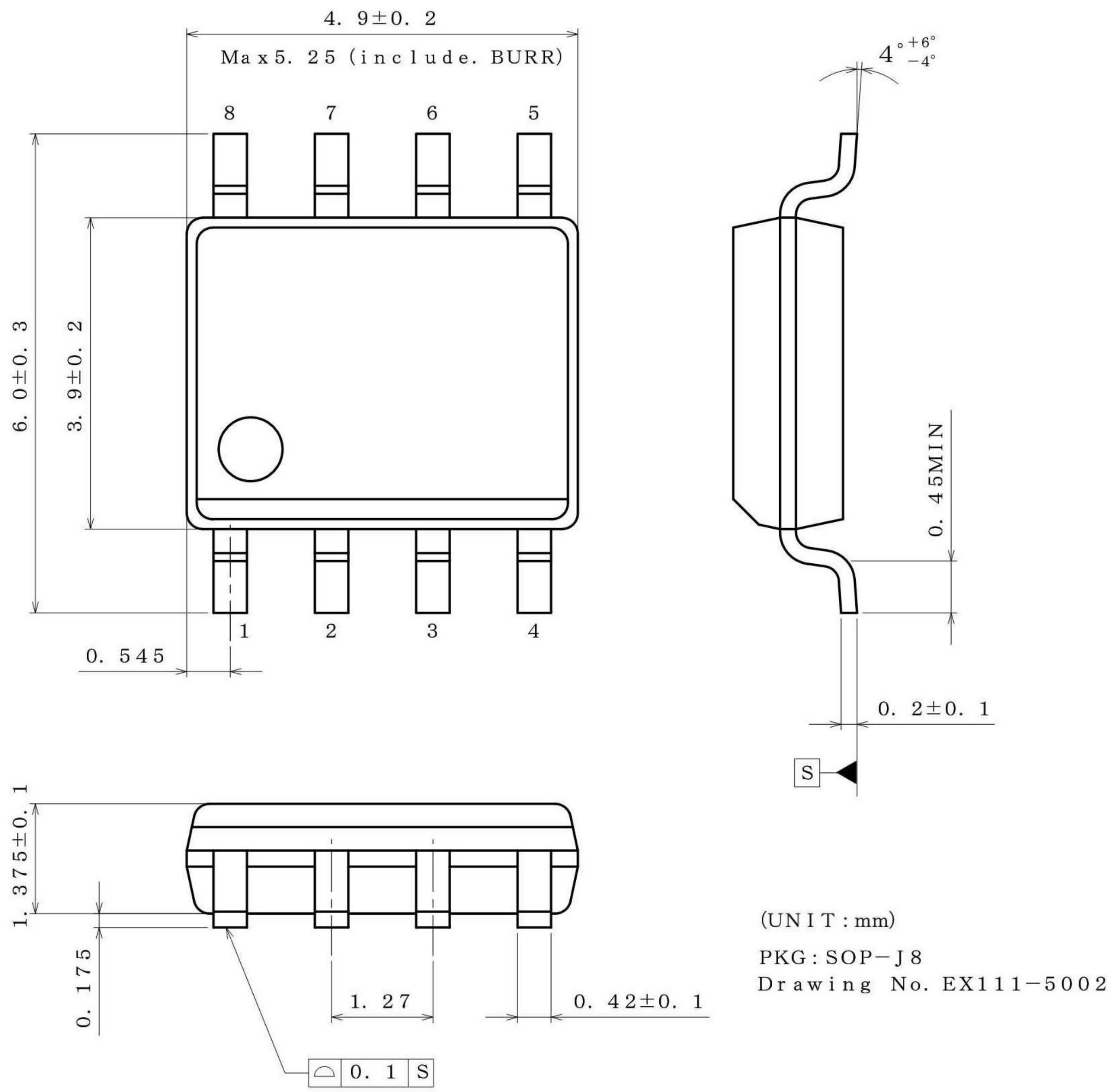
Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



∗Order quantity needs to be multiple of the minimum quantity.

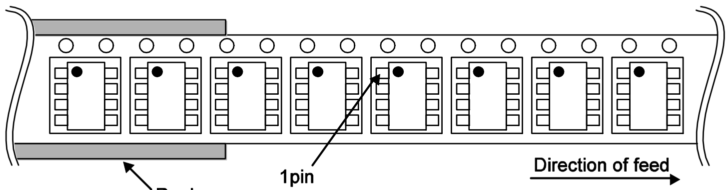
Physical Dimension, Tape and Reel Information – continued

Package Name	SOP-J8



<Tape and Reel information>

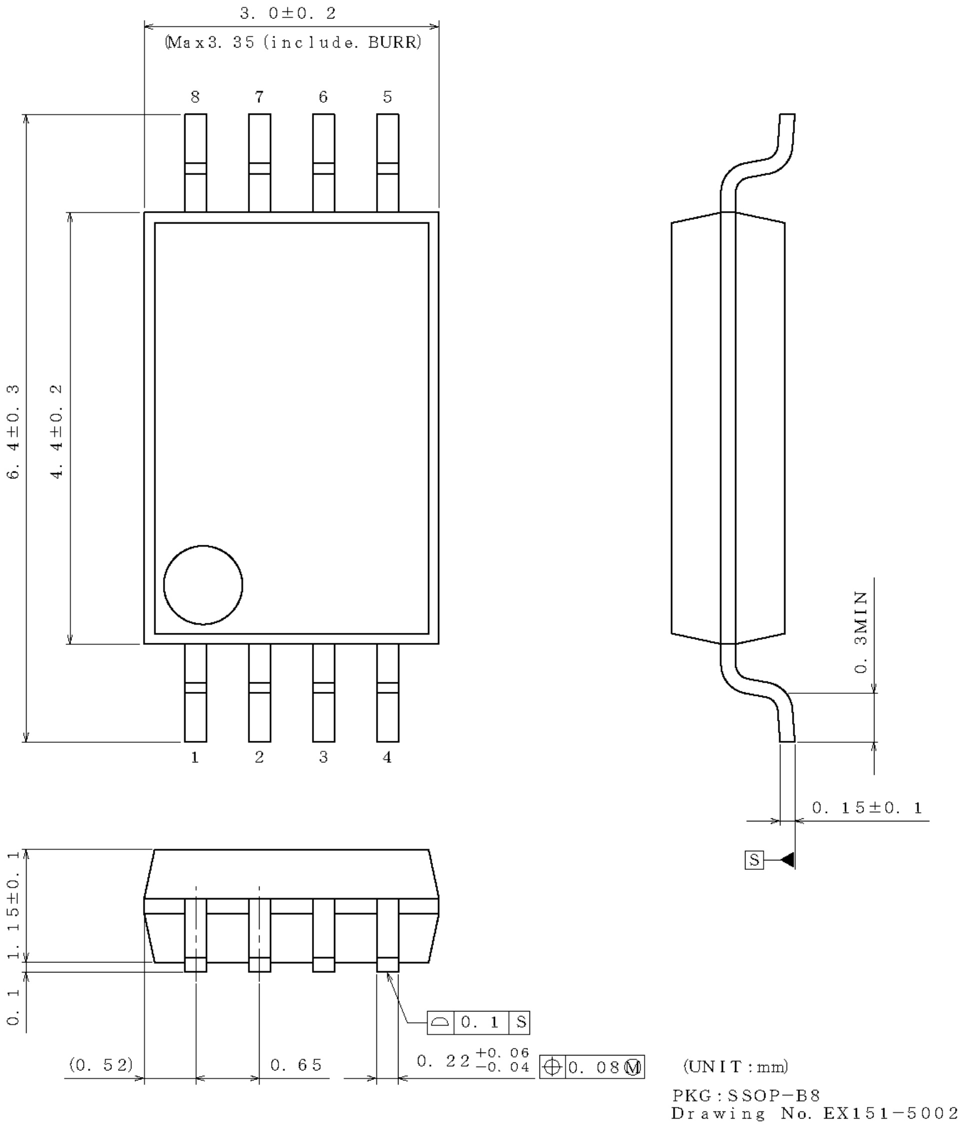
Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



∗Order quantity needs to be multiple of the minimum quantity.

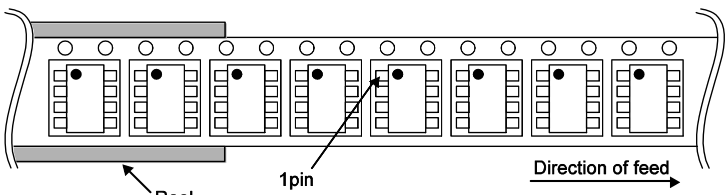
Physical Dimension, Tape and Reel Information – continued

Package Name	SSOP-B8



<Tape and Reel information>

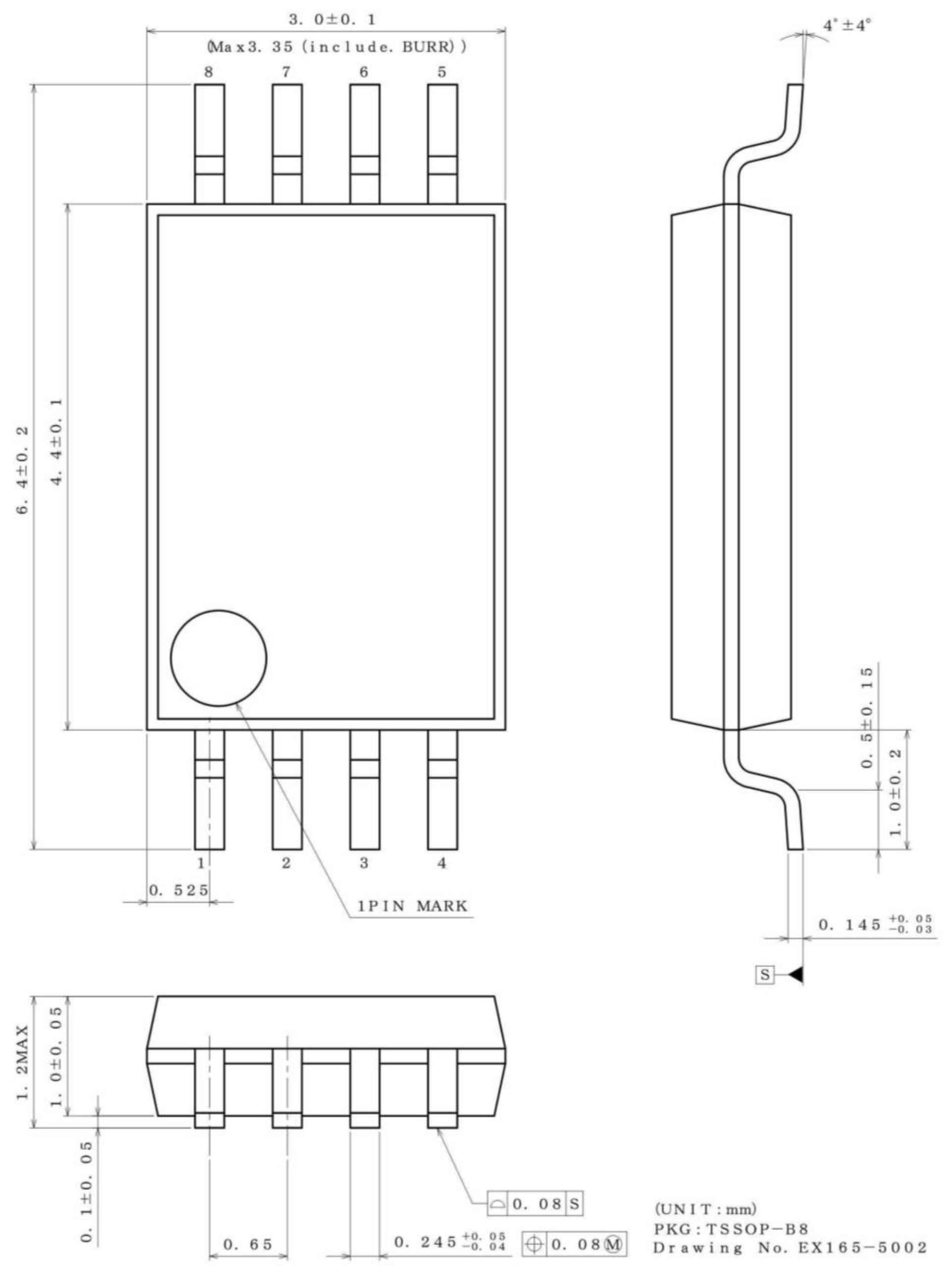
Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



∗Order quantity needs to be multiple of the minimum quantity.

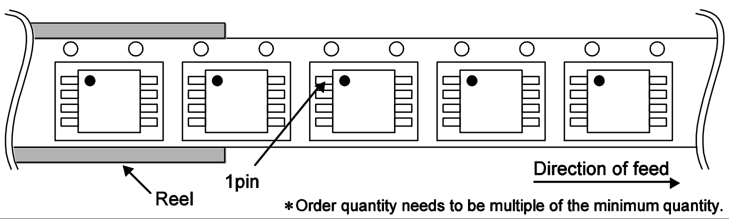
Physical Dimension, Tape and Reel Information – continued

Package Name	TSSOP-B8



<Tape and Reel information>

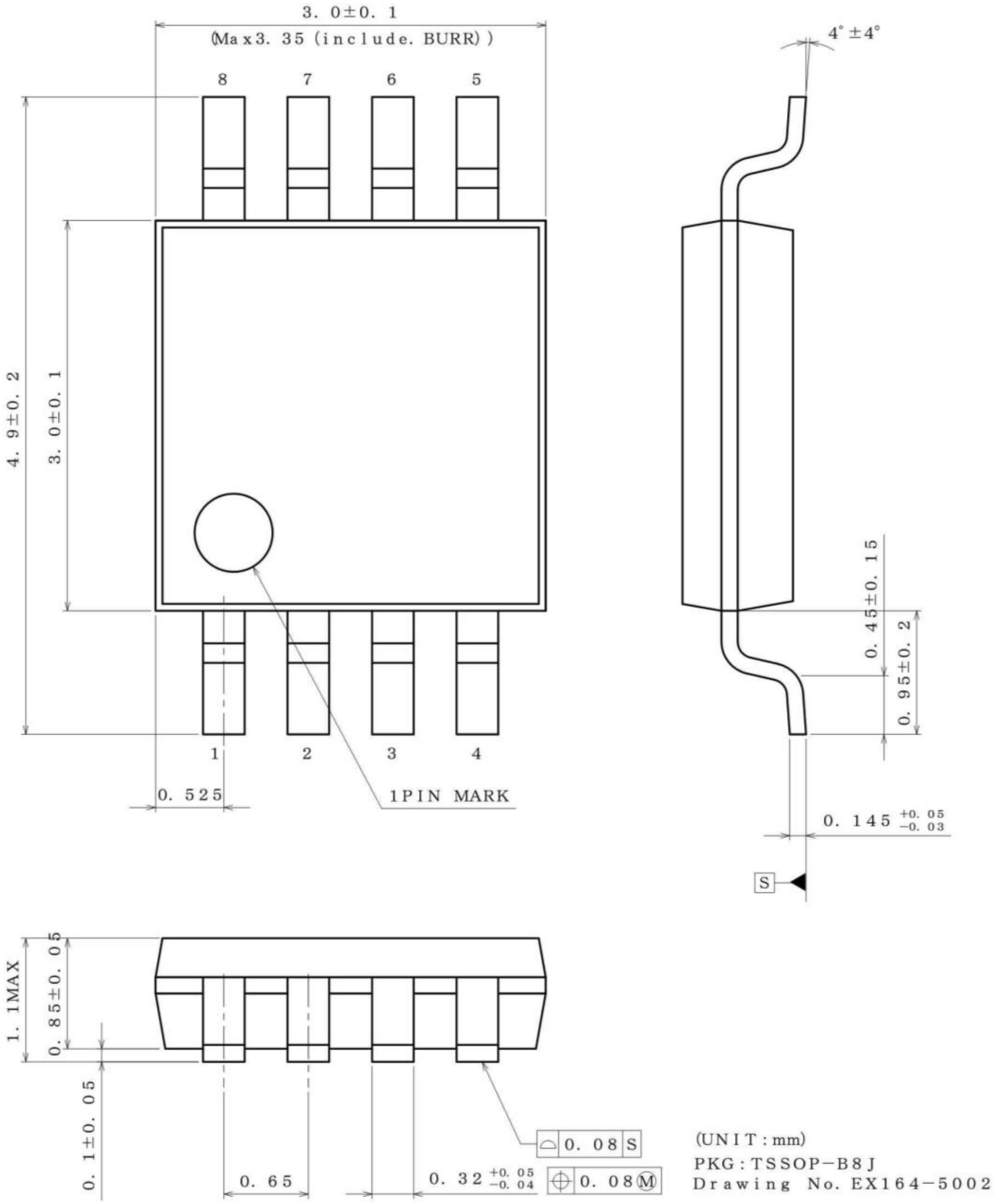
Tape	Embossed carrier tape
Quantity	3000pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



∗Order quantity needs to be multiple of the minimum quantity.

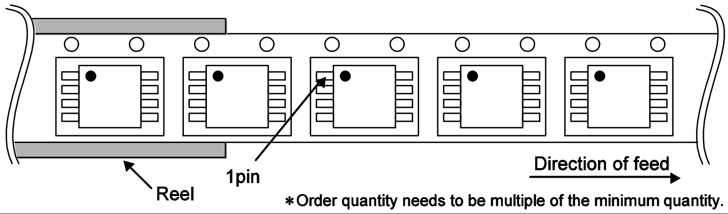
Physical Dimension, Tape and Reel Information – continued

Package Name	TSSOP-B8J



<Tape and Reel information>

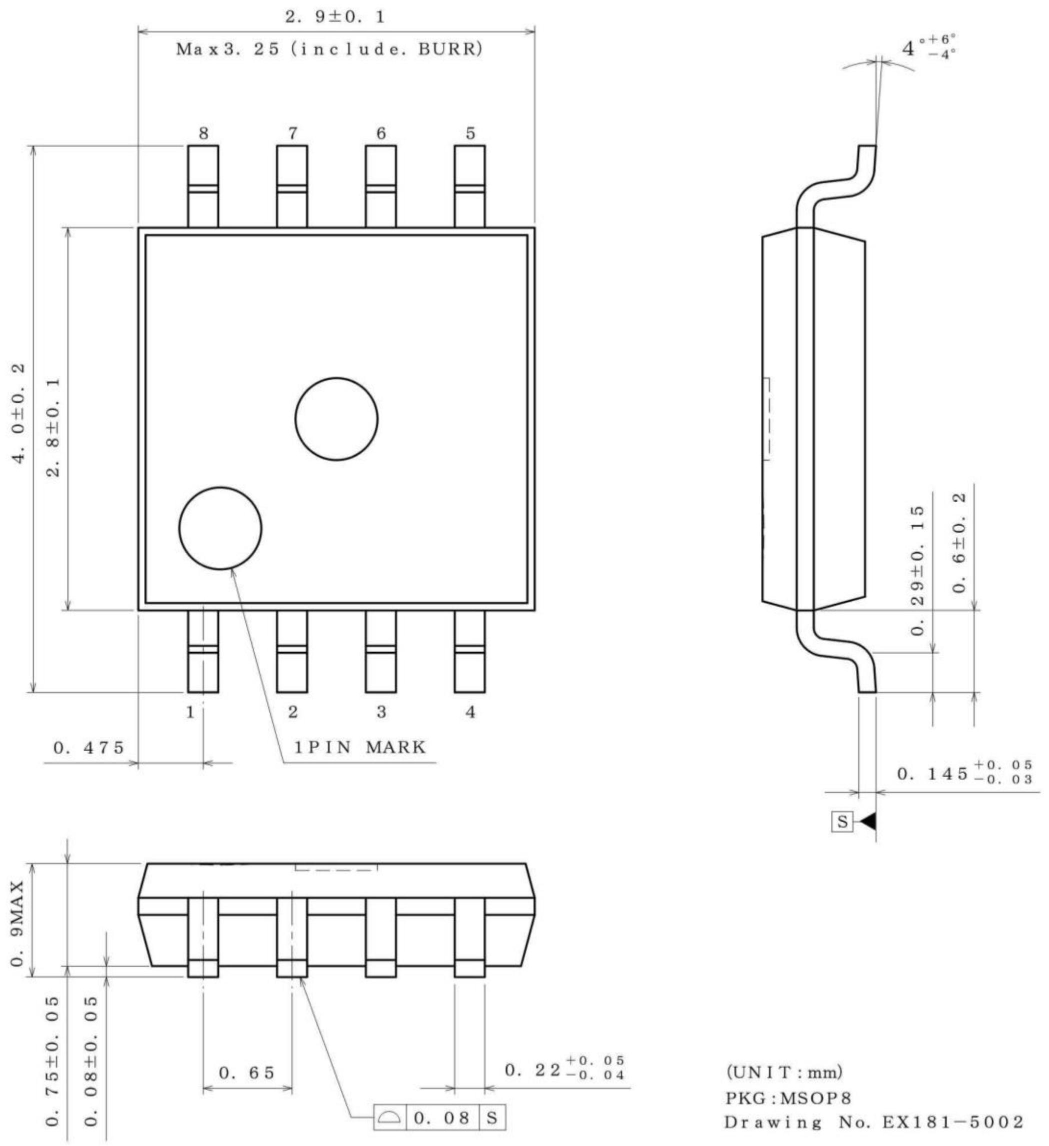
Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



∗Order quantity needs to be multiple of the minimum quantity.

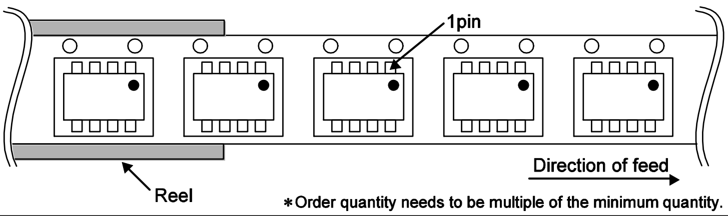
Physical Dimension, Tape and Reel Information – continued

Package Name	MSOP8



<Tape and Reel information>

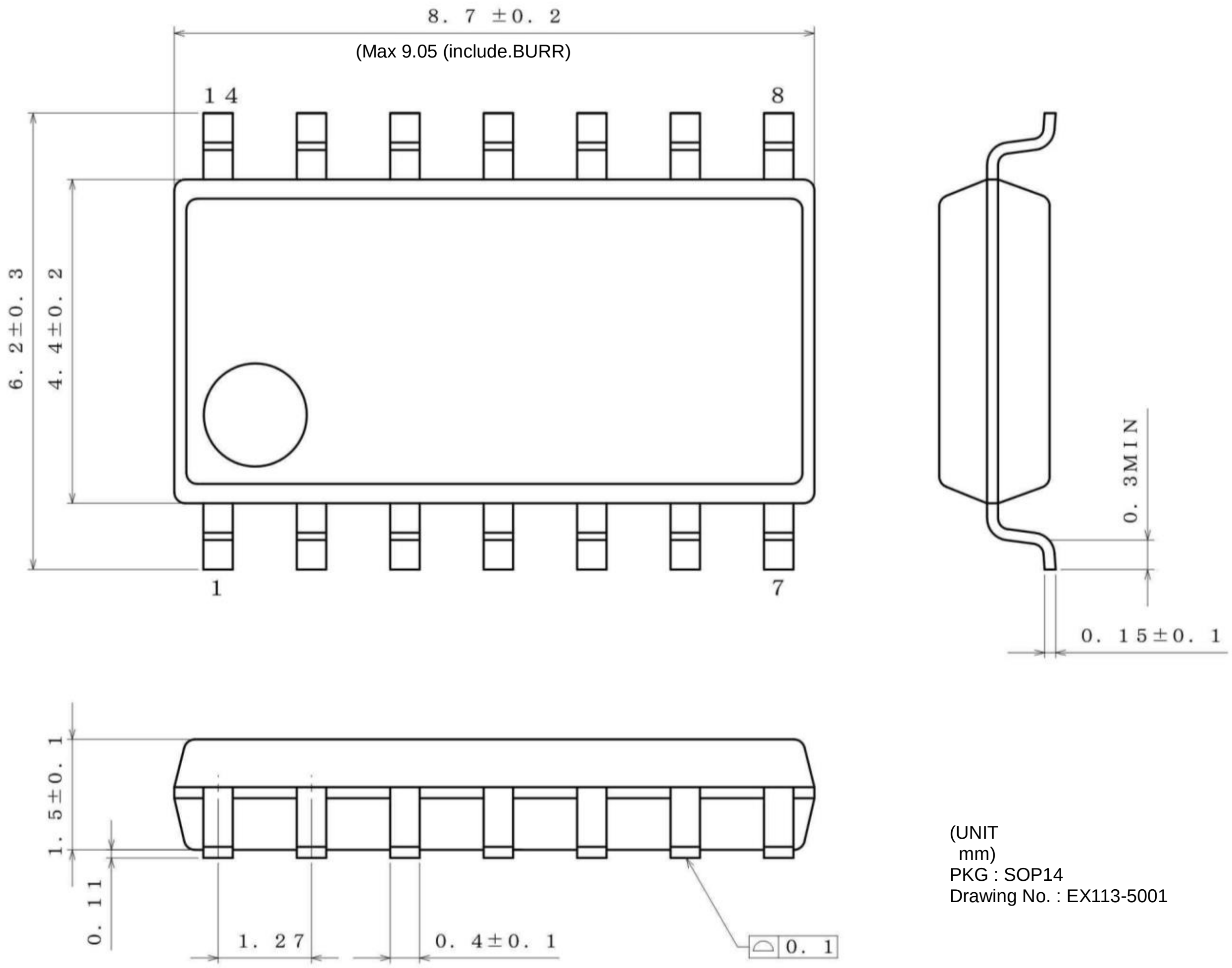
Tape	Embossed carrier tape
Quantity	3000pcs
Direction of feed	TR (The direction is the 1pin of product is at the upper right when you hold reel on the left hand and you pull out the tape on the right hand)



∗Order quantity needs to be multiple of the minimum quantity.

Physical Dimensions Tape and Reel Information – continued

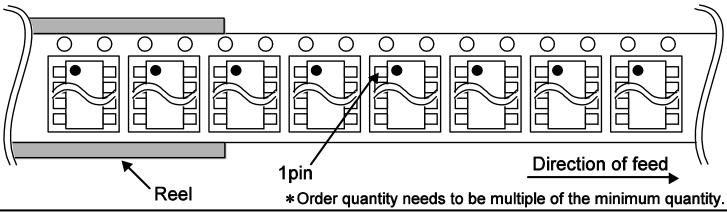
Package Name	SOP14



(UNIT
mm)
PKG : SOP14
Drawing No. : EX113-5001

<Tape and Reel information>

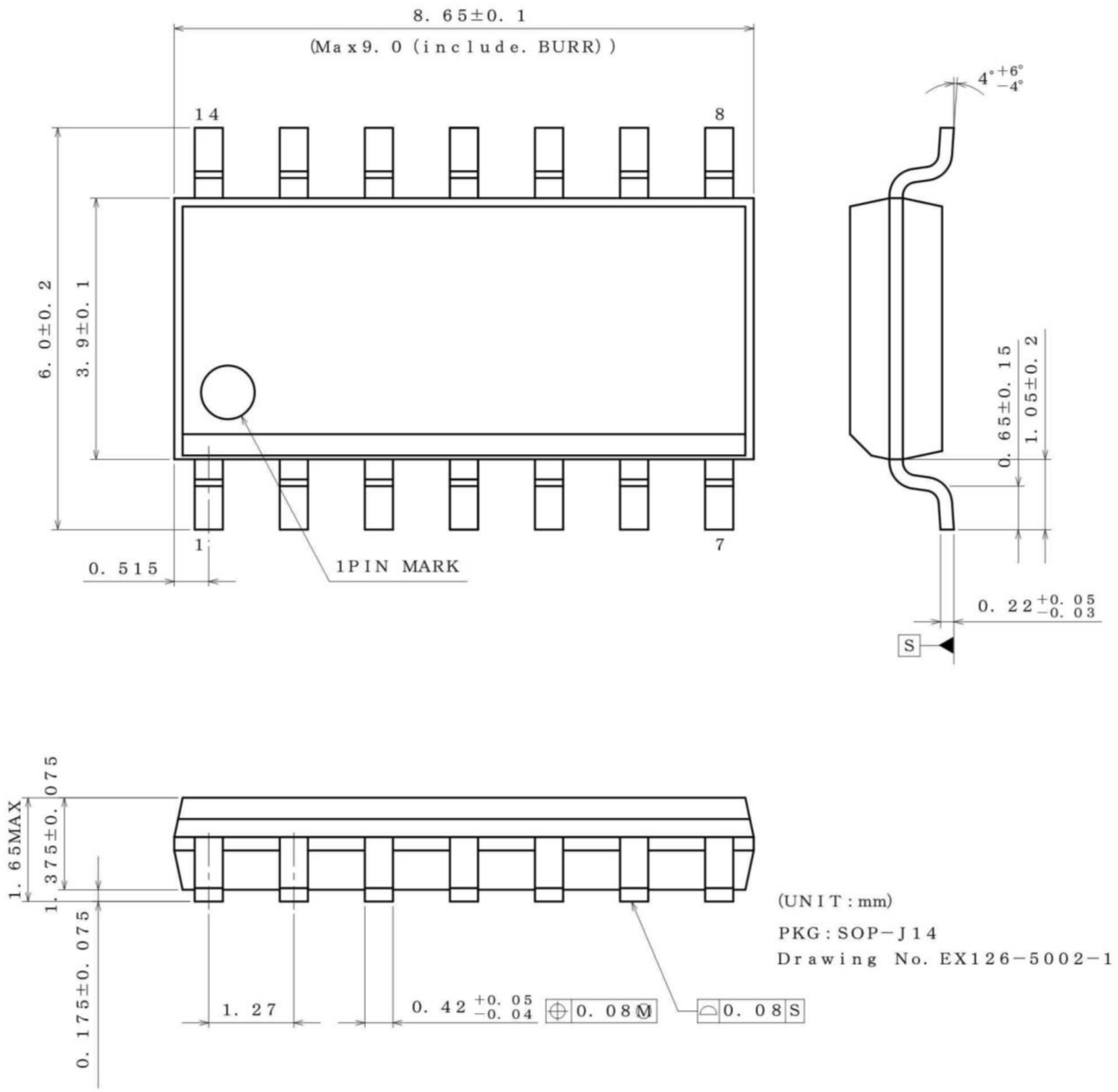
Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



∗Order quantity needs to be multiple of the minimum quantity.

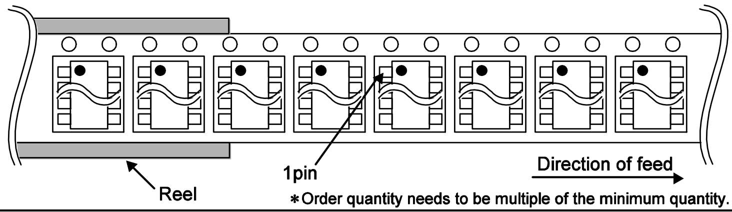
Physical Dimension, Tape and Reel Information – continued

Package Name	SOP-J14



<Tape and Reel information>

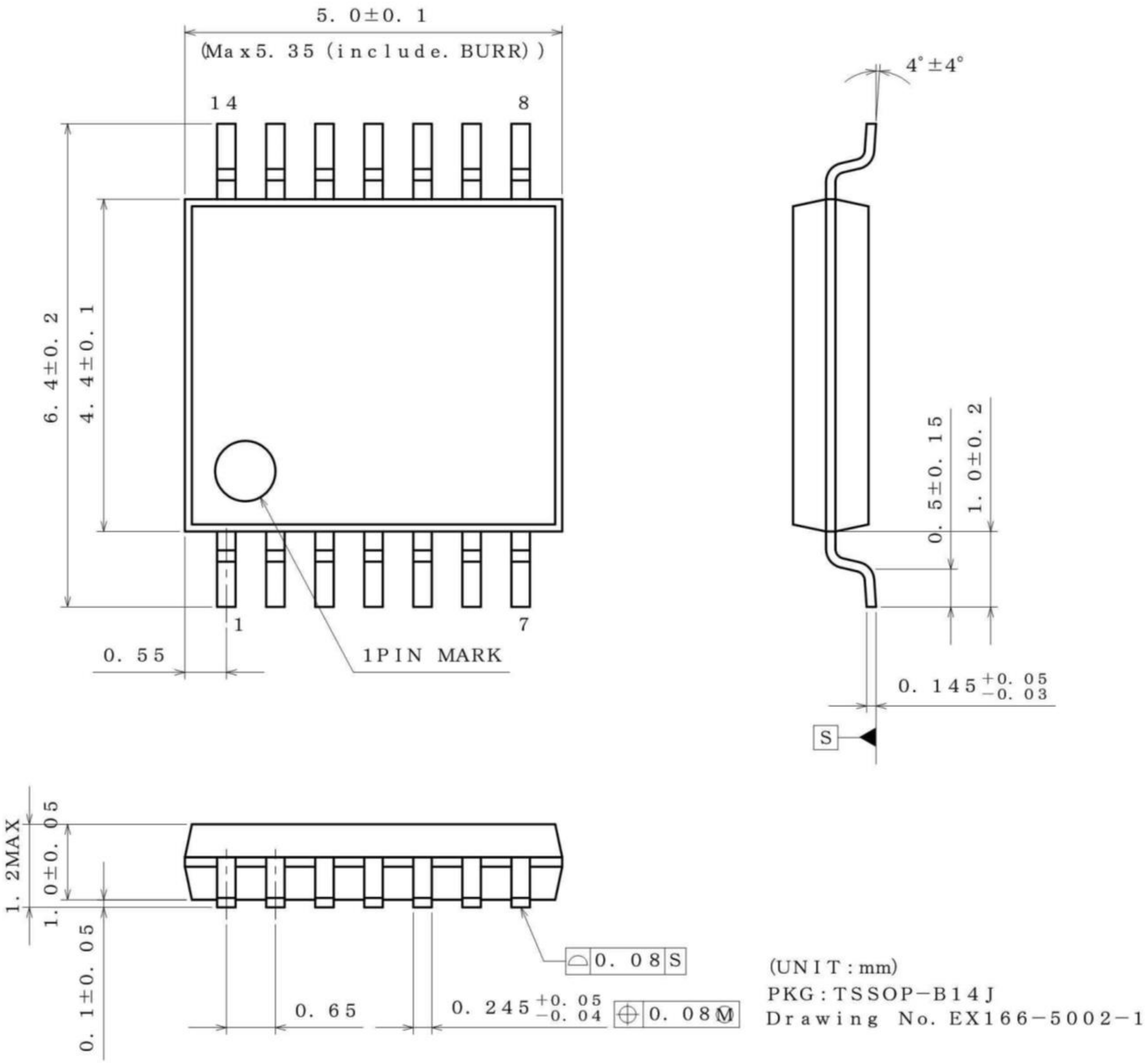
Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



∗Order quantity needs to be multiple of the minimum quantity.

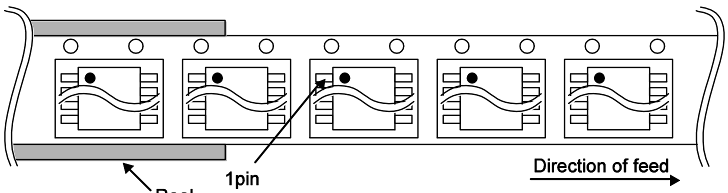
Physical Dimension, Tape and Reel Information – continued

Package Name	TSSOP-B14J



<Tape and Reel information>

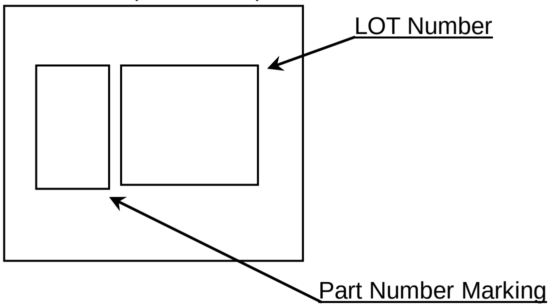
Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



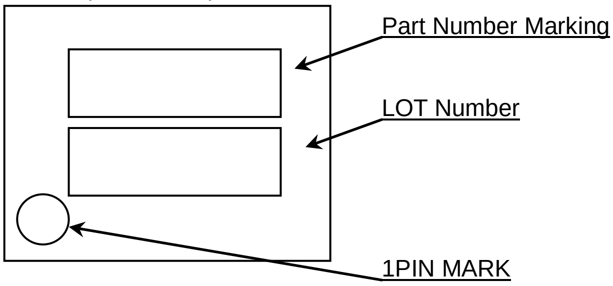
∗Order quantity needs to be multiple of the minimum quantity.

Marking Diagram

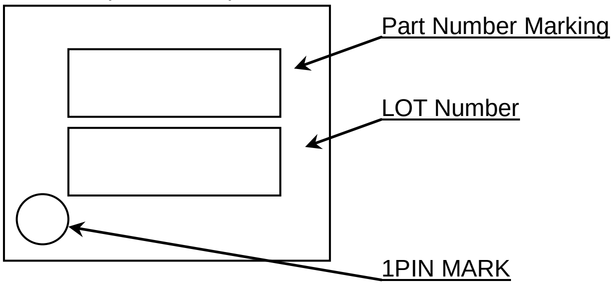
SSOP6 (TOP VIEW)



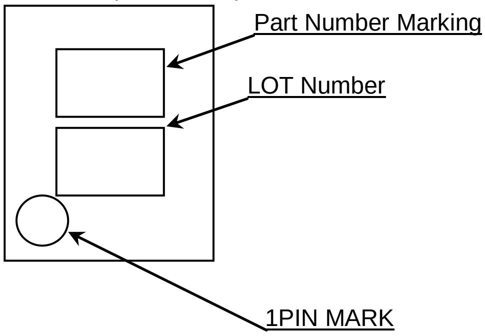
SOP8(TOP VIEW)



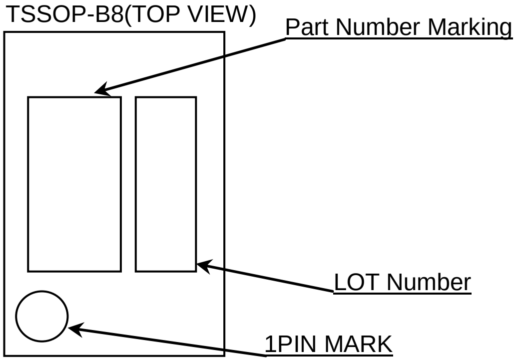
SOP-J8(TOP VIEW)



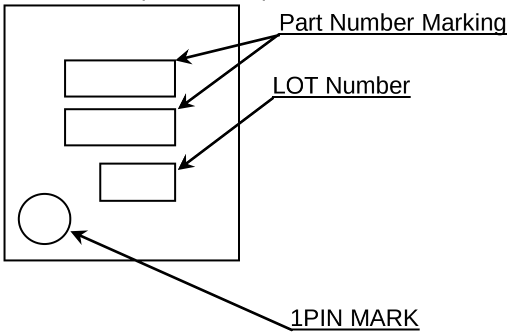
SSOP-B8(TOP VIEW)



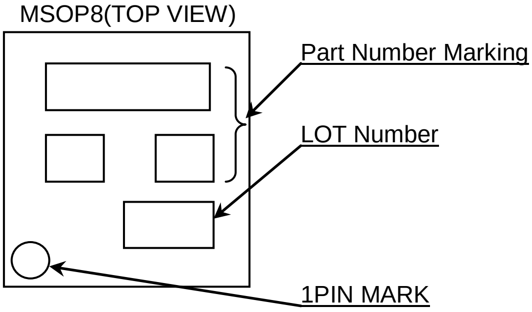
TSSOP-B8(TOP VIEW)



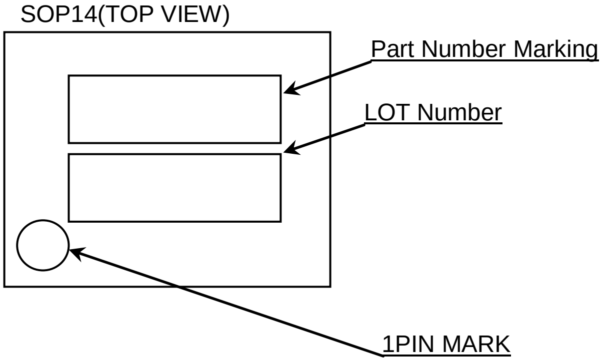
TSSOP-B8J(TOP VIEW)



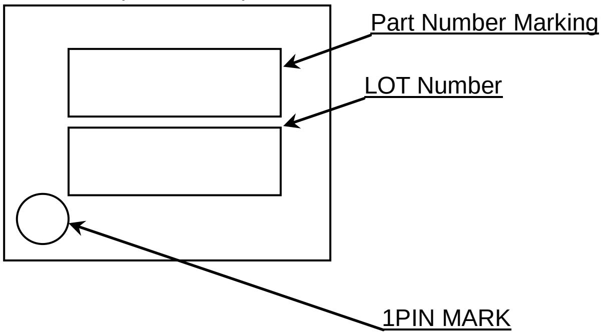
MSOP8(TOP VIEW)



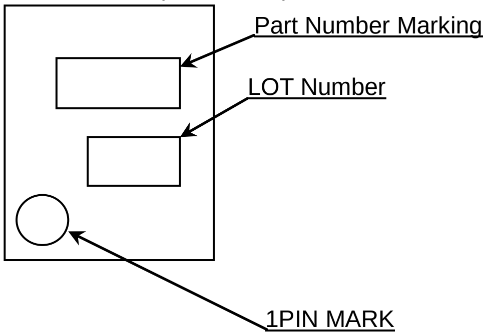
SOP14(TOP VIEW)



SOP-J14(TOP VIEW)



TSSOP-B14J (TOP VIEW)



Marking Diagram - Continued

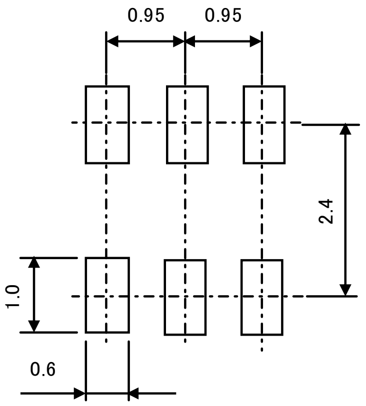
Product Name		Package Type	Marking
LMR341	G	SSOP6	BD
LMR342	F	SOP8	R342
	FJ	SOP-J8	R342
	FV	SSOP-B8	R342
	FVT	TSSOP-B8	R342
	FVJ	TSSOP-B8J	R342
	FVM	MSOP8	R342
LMR344	F	SOP14	R344
	FJ	SOP-J14	LMR344FJ
	FVJ	TSSOP-B14J	R344

Land Pattern Data

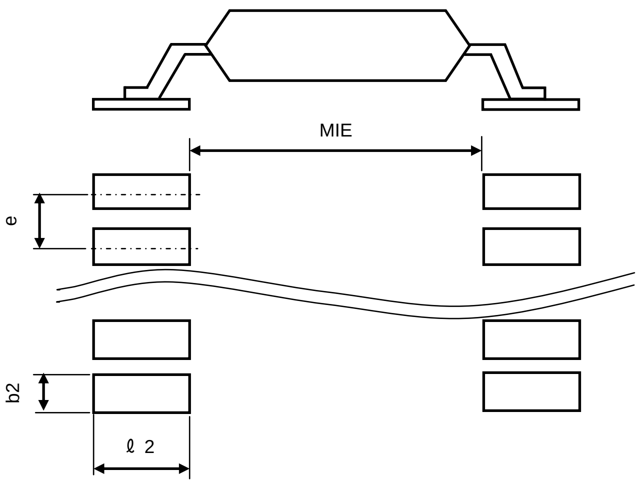
All dimensions in mm

Package	Land pitch e	Land space MIE	Land length ≧ℓ 2	Land width b2
SSOP6	0.95	2.4	1.0	0.6
SOP8 SOP14	1.27	4.60	1.10	0.76
SOP-J8 SOP-J14	1.27	3.9	1.35	0.76
SSOP-B8	0.65	4.60	1.20	0.35
TSSOP-B8 TSSOP-B14J	0.65	4.60	1.20	0.35
MSOP8	0.65	2.62	0.99	0.35
TSSOP-B8J	0.65	3.20	1.15	0.35

SSOP6



SOP8, SOP-J8, SSOP-B8, MSOP8, TSSOP-B8, TSSOP-B8J,
SOP14, SOP-J14, TSSOP-B14J



Revision History

Date	Revision	Changes
03.Jul.2013	001	New Release
09.Oct.2013	002	LMR344F Added
7.Jan.2014	003	LMR341G Added
11.Jun.2014	004	Added LMR342F, LMR342FJ, LMR342FV, LMR342FVT, LMR342FVM
08.Jul.2014	005	Correction of Marking. (LMR341G : AX to BD) Correction of Figure 76. ([mW] to [W]) Correction of Operating Supply Voltage to +5.5V from +5.0V.(Page 1,4)
16.Jan.2015	006	Added LMR344FJ, LMR344FVJ
16.Jun.2015	007	Correction of Product Name.(LMR344F-G to LMR344F)

Notice

Precaution on using ROHM Products

1. Our Products are designed and manufactured for application in ordinary electronic equipments (such as AV equipment, OA equipment, telecommunication equipment, home electronic appliances, amusement equipment, etc.). If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment (Note 1), transport equipment, traffic equipment, aircraft/spacecraft, nuclear power controllers, fuel controllers, car equipment including car accessories, safety devices, etc.) and whose malfunction or failure may cause loss of human life, bodily injury or serious damage to property ("Specific Applications"), please consult with the ROHM sales representative in advance. Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of any ROHM's Products for Specific Applications.

(Note1) Medical Equipment Classification of the Specific Applications

JAPAN	USA	EU	CHINA
CLASSⅢ	CLASSⅢ	CLASSⅡb	CLASSⅢ
CLASSⅣ		CLASSⅢ	

2. ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
   [a] Installation of protection circuits or other protective devices to improve system safety
   [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

3. Our Products are designed and manufactured for use under standard conditions and not under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc, prior to use, must be necessary:
   [a] Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
   [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
   [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2
   [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
   [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
   [f] Sealing or coating our Products with resin or other coating materials
   [g] Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
   [h] Use of the Products in places subject to dew condensation

4. The Products are not subject to radiation-proof design.

5. Please verify and confirm characteristics of the final or mounted products in using the Products.

6. In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse. is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.

7. De-rate Power Dissipation (Pd) depending on Ambient temperature (Ta). When used in sealed area, confirm the actual ambient temperature.

8. Confirm that operation temperature is within the specified range described in the product specification.

9. ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

Precaution for Mounting / Circuit board design

1. When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.

2. In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.

2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

Precaution for Electrostatic

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of Ionizer, friction prevention and temperature / humidity control).

Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
   [a] the Products are exposed to sea winds or corrosive gases, including Cl2, H2S, NH3, SO2, and NO2
   [b] the temperature or humidity exceeds those recommended by ROHM
   [c] the Products are exposed to direct sunshine or condensation
   [d] the Products are exposed to high Electrostatic

2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.

3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.

4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

Precaution for Product Label

QR code printed on ROHM Products label is for ROHM's internal use only.

Precaution for Disposition

When disposing Products please dispose them properly using an authorized industry waste company.

Precaution for Foreign Exchange and Foreign Trade act

Since concerned goods might be fallen under listed items of export control prescribed by Foreign exchange and Foreign trade act, please consult with ROHM in case of export.

Precaution Regarding Intellectual Property Rights

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2. ROHM shall not have any obligations where the claims, actions or demands arising from the combination of the Products with other articles such as components, circuits, systems or external equipment (including software).

3. No license, expressly or implied, is granted hereby under any intellectual property rights or other rights of ROHM or any third parties with respect to the Products or the information contained in this document. Provided, however, that ROHM will not assert its intellectual property rights or other rights against you or your customers to the extent necessary to manufacture or sell products containing the Products, subject to the terms and conditions herein.

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