

Operational Amplifiers

# Low Noise Operational Amplifier



## LM4565F

● **General Description**

BA4565 is dual operational amplifier with high gain and wide bandwidth. It has good performance of input referred noise voltage( $5\text{ nV}/\sqrt{\text{Hz}}$ ) and total harmonic distortion(0.002%). These are suitable for Audio applications.

● **Features**

- Wide Operating Voltage
- High Voltage Gain
- Low distortion
- Wide Bandwidth
- High Slew Rate
- Low Noise Voltage
- Internal ESD protection

● **Application**

- Audio application
- General Purpose

● **Block Diagram**

● **Key Specifications**

- Wide Operating Voltage:  $\pm 4\text{V to } \pm 18\text{V}$
- Wide Temperature Range:  $-40^\circ\text{C to } +85^\circ\text{C}$
- High voltage gain ( $R_L=2\text{k}\Omega$ ):  $100\text{dB(Typ.)}$
- High Slew Rate:  $5.0\text{V}/\mu\text{s (Typ.)}$
- Wide Unity Gain Bandwidth:  $10\text{MHz (Typ.)}$
- Low Input Noise Voltage:  $0.6\mu\text{Vrms (Typ.)}$

● **Package**

SOP8

W(Typ.) xD(Typ.) xH(Max.)  
5.00mm x 6.20mm x 1.71mm

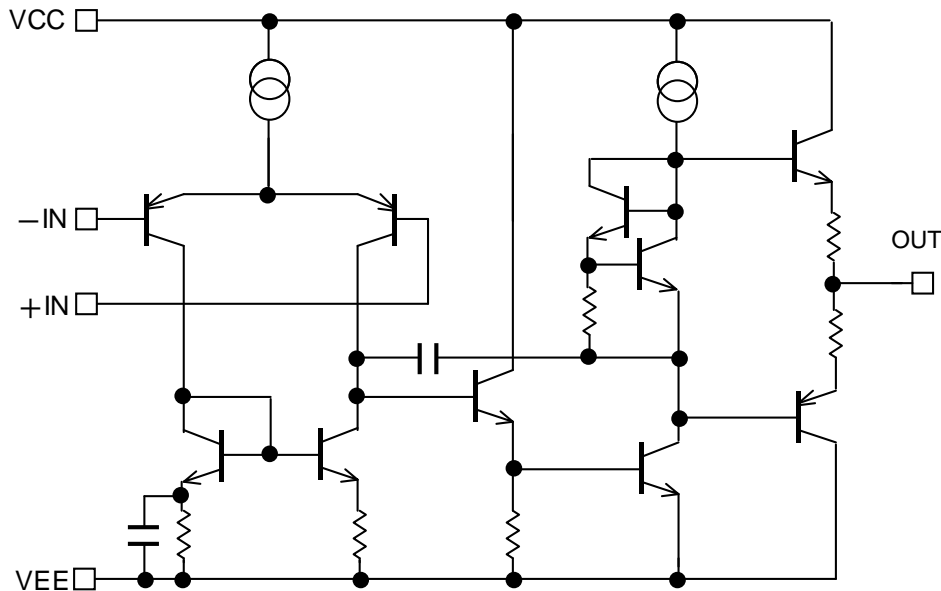
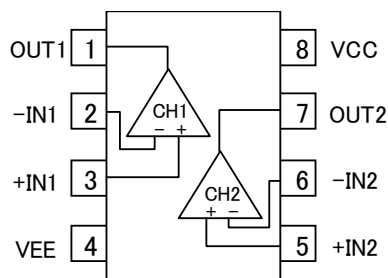


Figure1. Simplified Schematic (1 channel only)

○Product structure : Silicon monolithic integrated circuit ○This product is not designed to be protected against radioactive rays.

●Pin Configuration

SOP8



Pin No.	Symbol
1	OUT1
2	-IN1
3	+IN1
4	VEE
5	+IN2
6	-IN2
7	OUT2
8	VCC

●Ordering Information

L M 4 5 6 5 F	-	E2
Part Number LM4565F	Package F:SOP8	Packaging and forming specification E2: Embossed tape and reel (SOP8)

●Line-up

Topr	Package		Operable Part Number
-40°C to +85°C	SOP8	Reel of 2500	LM4565F-E2

●Absolute Maximum Ratings(Ta=25°C)

Parameter	Symbol	Ratings	Unit
Supply Voltage	VCC - VEE	+36	V
Power Dissipation	Pd	690 <sup>*1*2</sup>	mW
Differential Input Voltage <sup>*3</sup>	Vid	+36	V
Input Common-mode Voltage Range	Vicm	(VEE - 0.3) to (VEE + 36)	V
Operating Voltage	Vopr	±4 to ±18	V
Operating Temperature	Topr	- 40 to +85	°C
Storage Temperature	Tstg	- 55 to +150	°C
Maximum Junction Temperature	Tjmax	+150	°C

Note: Absolute maximum rating of each item indicates the condition which must not be exceeded. Application of voltage in excess of absolute maximum rating or usage out of absolute maximum rated temperature environment may cause deterioration of characteristics.

\*1 When used at temperature above Ta=25°C, reduce by 5.52mW/°C.

\*2 Mounted on a FR4 glass epoxy PCB(70mm×70mm×1.6mm).

\*3 The differential input voltage is the voltage difference between inverting input and non-inverting input. Input terminal voltage is set to more than VEE.

## ●Electrical Characteristics:

OLM4565F (Unless otherwise specified VCC = +15V, VEE = -15V)

Parameter	Symbol	Temperature Range	Limits			Unit	Condition
			Min.	Typ.	Max.		
Input Offset Voltage <sup>*4*5</sup>	Vio	25°C	-	0.5	1.5	mV	RS ≤10kΩ
Input Offset Current <sup>*4</sup>	Iio	25°C	-	2	50	nA	-
Input Bias Current <sup>*4</sup>	Ib	25°C	-	70	250	nA	-
Supply Current <sup>*5</sup>	ICC	25°C	-	4.5	7	mA	RL=∞, All Op-Amps, VIN+=0V
		Full range	-	-	8.5		
Large Signal Voltage Gain	Av	25°C	86	100	-	dB	RL ≥2kΩ, OUT =±10V
Maximum Output Voltage	VOM	25°C	±12	±14	-	V	RL ≥2kΩ
		25°C	±11	±12.5	-	V	Io≥25mA
Input Common-mode Voltage Range	Vicm	25°C	±12	±14	-	V	-
Output Source Current <sup>*6</sup>	IOH	25°C	-	130	-	mA	VIN+=1V, VIN-=0V OUT=-15V, 1CH is short circuit
Output Sink Current <sup>*6</sup>	IOL	25°C	-	160	-	mA	VIN+=0V, VIN-=1V OUT=+15V, 1CH is short circuit
Common-mode Rejection Ratio	CMRR	25°C	80	100	-	dB	RL ≤10kΩ
Power Supply Rejection Ratio	PSRR	25°C	82	100	-	dB	RL ≤10kΩ
Slew Rate	SR	25°C	-	5	-	V/μs	RL=2kΩ, CL=100pF
Unity Gain Frequency	f <sub>r</sub>	25°C	-	4	-	MHz	RL=2kΩ
Gain Band Width	GBW	25°C	-	10	-	MHz	RL=2kΩ, f=100kHz
Phase Margin	θ	25°C	-	40	-	deg	RL=2kΩ
Equivalent Input Noise Voltage	Vn	25°C	-	0.6	-	μVrms	RIAA, RS=100Ω DIN-AUDIO
			-	5	-	nV/√Hz	Vicm=0V, f=1kHz
Total Harmonic Distortion+ Noise	THD+N	25°C	-	0.002	-	%	Av=20dB, OUT=0.1Vrms, f=1kHz
Channel Separation	CS	25°C	-	110	-	dB	Av=40dB, RS=1kΩ f=1kHz

\*4 Absolute value.

\*5 Full range: Ta=-40°C to +85°C

\*6 Please consider the power dissipation when selecting the output current.

When the output terminal is continuously shorted the output current reduces the internal temperature by flushing.

### Description of electrical characteristics

Described here are the terms of electric characteristics used in this datasheet. Items and symbols used are also shown. Note that item name, symbol and their meaning may differ from those on other manufacturer's document or general documents.

#### 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.

##### 1.1 Supply voltage (VCC - VEE)

Indicates the maximum voltage that can be applied between the positive power supply terminal and negative power supply terminal without deterioration or destruction of characteristics of internal circuit.

##### 1.2 Differential input voltage (Vid)

Indicates the maximum voltage that can be applied between non-inverting terminal and inverting terminal without deterioration and destruction of characteristics of IC.

##### 1.3 Input common-mode voltage range (Vicm)

Indicates the maximum voltage that can be applied to the non-inverting terminal and inverting terminal without deterioration or destruction of characteristics. Input common-mode voltage range of the maximum ratings not assures normal operation of IC. When normal Operation of IC is desired, the input common-mode voltage of characteristics item must be followed.

##### 1.4 Power dissipation (Pd)

Indicates the power that can be consumed by the IC when mounted on a specific board at ambient temperature 25°C(normal temperature). As for packaged product, Pd 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 item

##### 2.1 Input offset voltage (Vio)

Indicates the voltage difference between non-inverting terminal and inverting terminal. It can be translated into the input voltage difference required for setting the output voltage to 0 V.

##### 2.2 Input offset current (Iio)

Indicates the difference of input bias current between non-inverting terminal and inverting terminal.

##### 2.3 Input bias current (Ib)

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.

##### 2.4 Supply current (ICC)

Indicates the current that flows within the IC under specified no-load conditions.

##### 2.5 Large signal voltage gain (Av)

Indicates the amplification rate (gain) of output voltage against the voltage difference between non-inverting terminal and inverting terminal. It is normally the amplification rate (gain) with reference to DC voltage.

$$A_v = (\text{Output voltage fluctuation}) / (\text{Input offset fluctuation})$$

##### 2.6 Output saturation voltage (VOM)

Signifies the voltage range that can be output under specific output conditions.

##### 2.7 Input common-mode voltage range (Vicm)

Indicates the input voltage range where IC operates normally.

##### 2.8 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.

$$CMRR = (\text{Change of Input common-mode voltage}) / (\text{Input offset fluctuation})$$

##### 2.9 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)

##### 2.10 Slew rate (SR)

Indicates the ratio of the change in output voltage with time when a step input signal is applied.

##### 2.11 Unity Gain Frequency (f<sub>T</sub>)

Indicates a frequency where the voltage gain of Op-Amp is 1.

##### 2.12 Gain Bandwidth (GBW)

The product of the open-loop voltage gain and the frequency at which the voltage gain decreases 6dB/octave.

##### 2.13 Phase Margin (θ)

Indicates the margin of phase from 180 degree phase lag at unity gain frequency.

##### 2.14 Equivalent input noise voltage (Vn)

Indicates a noise voltage generated inside the operational amplifier reflected back to an ideal voltage source connected in series with input terminal.

**2.15 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.

**2.16 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.

● Typical Performance Curves  
 OLM4565F

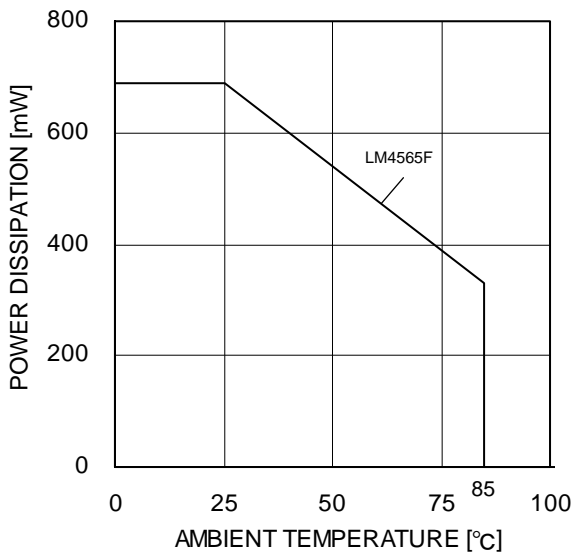


Figure 2.  
 Derating curve

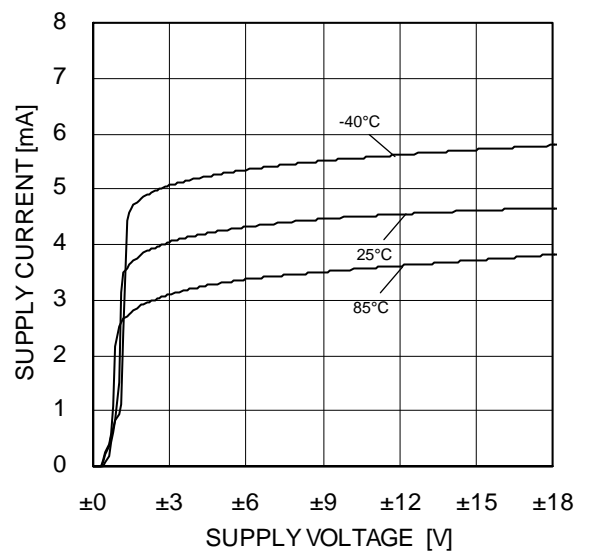


Figure 3.  
 Supply Current – Supply Voltage

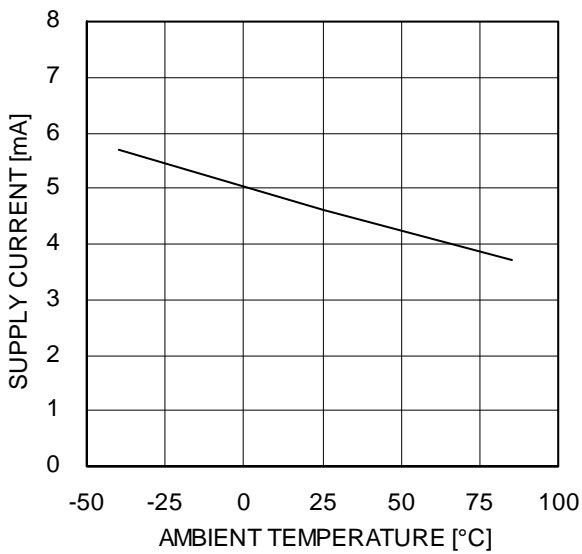


Figure 4.  
 Supply Current – Ambient Temperature  
 (VCC/VEE = ±15V)

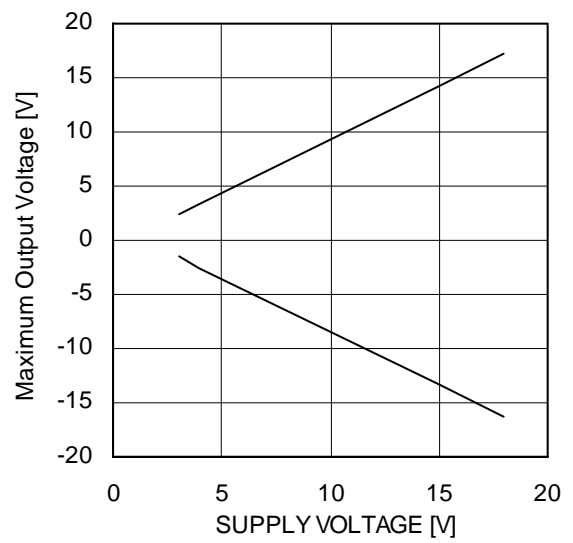


Figure 5.  
 Maximum Output Voltage – Supply Voltage  
 (RL=2kΩ, Ta=25°C)

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

● Typical Performance Curves (Reference data) – Continued  
**OLM4565F**

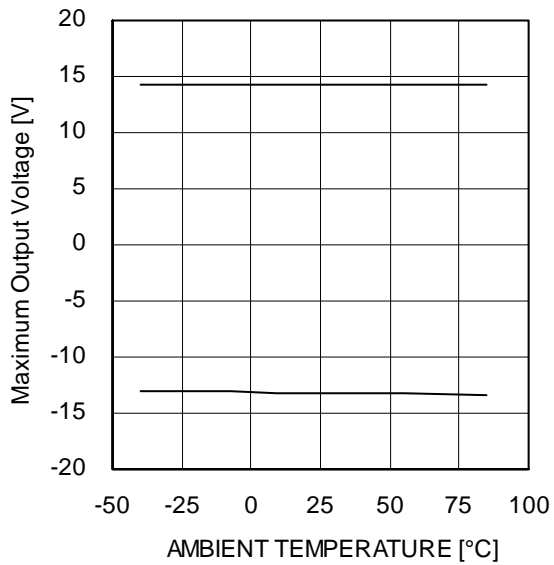


Figure 6.  
 Maximum Output Voltage – Ambient Temperature  
 (VCC/VEE = ±15V, RL=2KΩ)

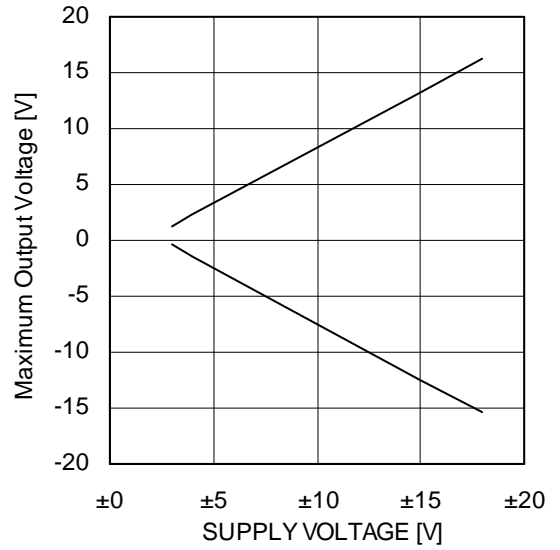


Figure 7.  
 Maximum Output Voltage – Supply Voltage  
 (Io=25mA, Ta=25°C)

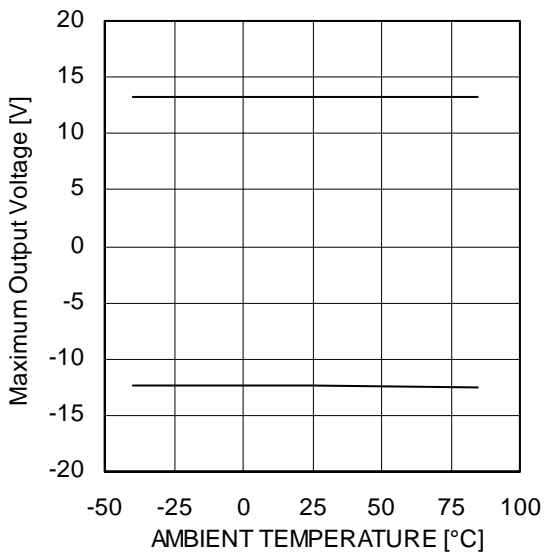


Figure 8.  
 Maximum Output Voltage – Ambient Temperature  
 (VCC/VEE = ±15V, Io=25mA)

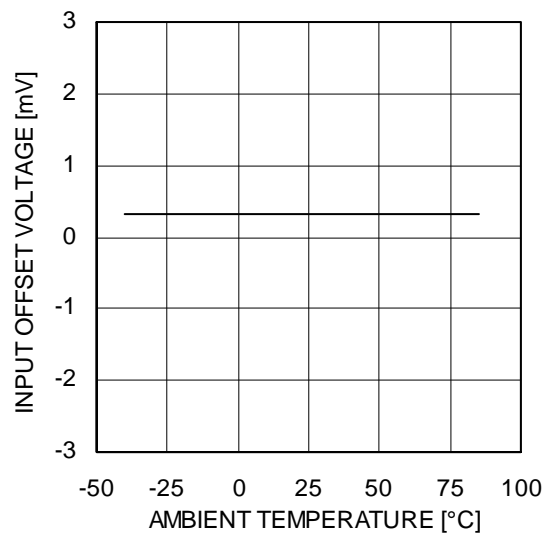


Figure 9.  
 Input Offset Voltage – Ambient Temperature  
 (VCC/VEE = ±15V)

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

● Typical Performance Curves (Reference data) – Continued  
**OLM4565F**

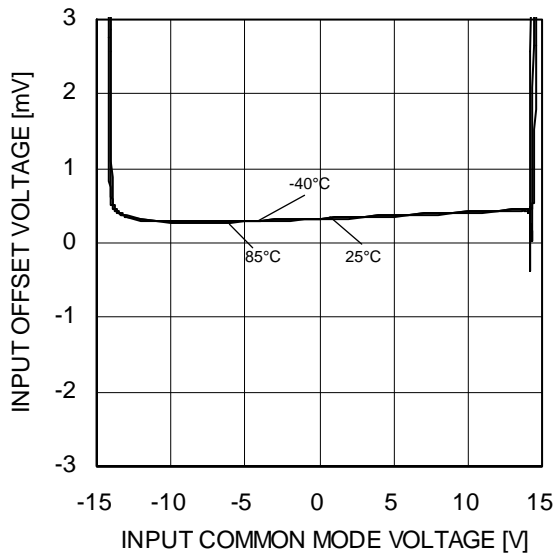


Figure 10.  
 Input Offset Voltage – Input Common mode Voltage  
 (VCC/VEE = ±15V)

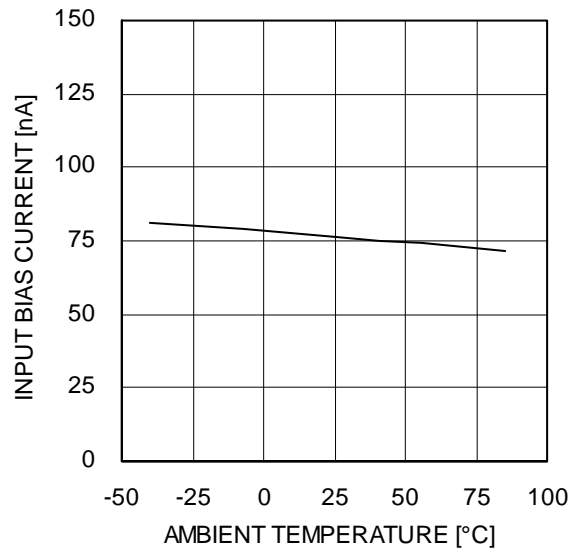


Figure 11.  
 Input Bias Current – Ambient Temperature  
 (VCC/VEE = ±15V)

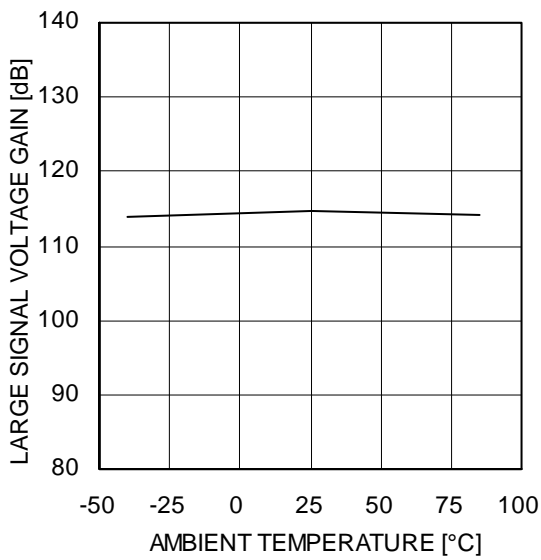


Figure 12.  
 Large Signal Voltage Gain – Ambient Temperature  
 (VCC/VEE = ±15V, RL=2kΩ)

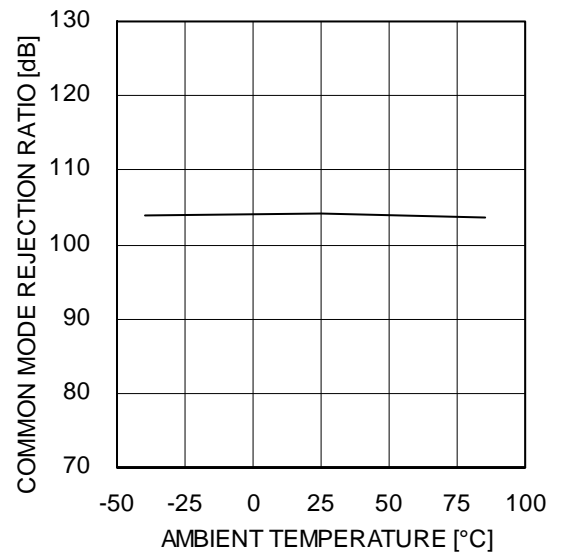


Figure 13.  
 Common Mode Rejection Ratio – Ambient Temperature  
 (VCC/VEE = ±15V)

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



● Typical Performance Curves (Reference data) - Continued  
 ○ LM4565F

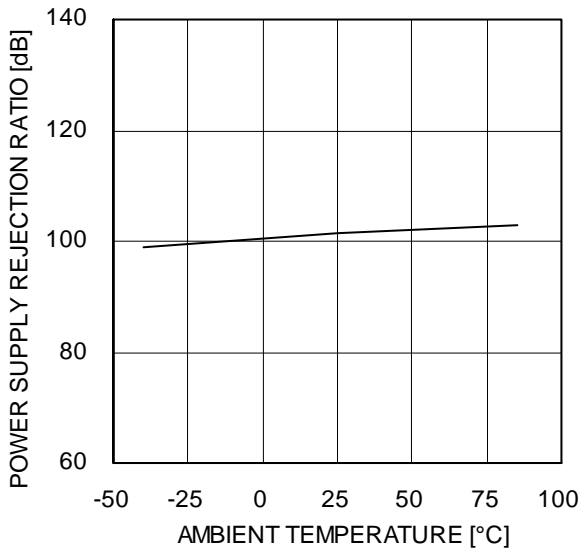


Figure 14.  
 Power Supply Rejection Ratio – Ambient Temperature

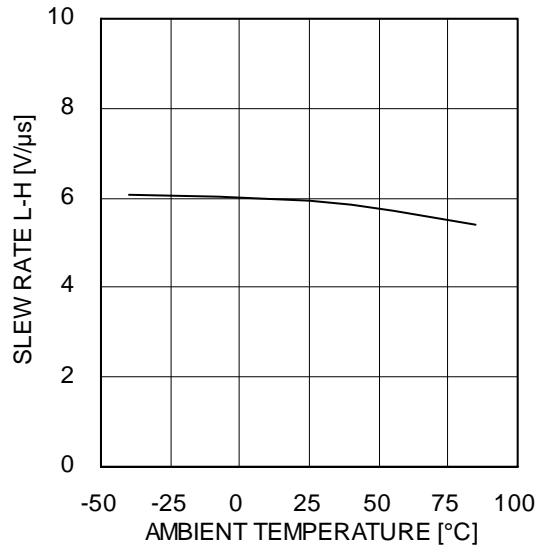


Figure 15.  
 Slew Rate L-H – Ambient Temperature  
 (VCC/VEE = ±15V, RL=2kΩ, CL=100pF)

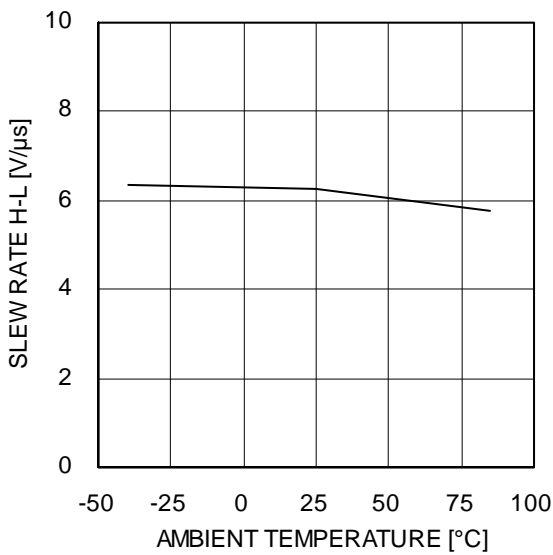


Figure 16.  
 Slew Rate H-L – Ambient Temperature  
 (VCC/VEE = ±15V, RL=2kΩ, CL=100pF)

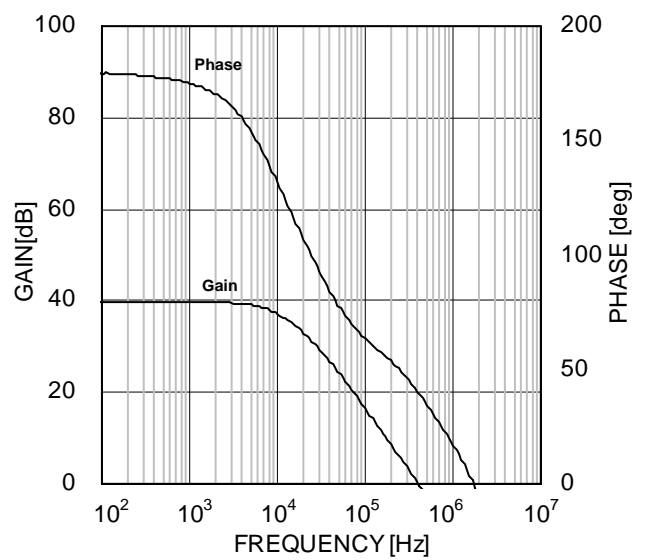


Figure 17.  
 Voltage Gain • Phase – Frequency  
 (VCC/VEE = ±15V, RL=2kΩ)

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

● Typical Performance Curves (Reference data) - Continued  
 ○ LM4565F

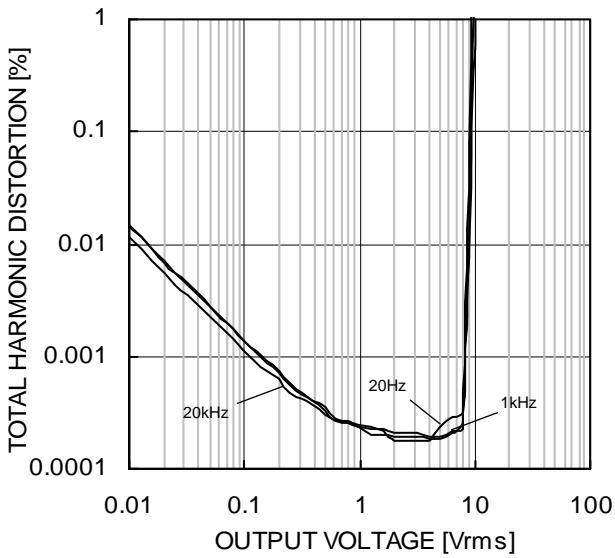


Figure 18.  
 Total Harmonic Distortion – Output Voltage  
 (VCC/VEE = ±15V, RL = 2kΩ, f = 1kHz)

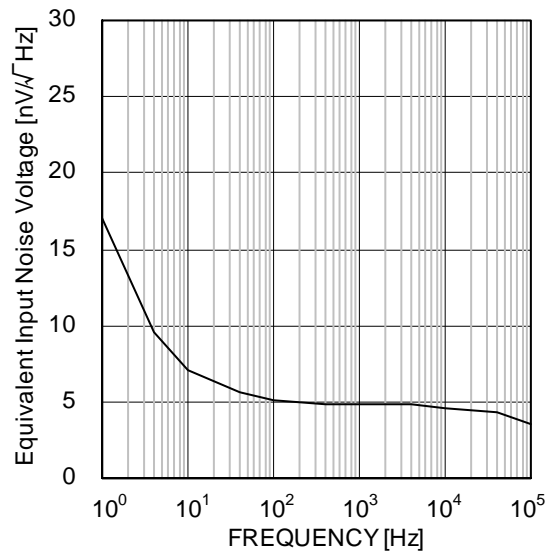


Figure 19.  
 Equivalent Input Noise Voltage – Frequency  
 (VCC/VEE=±15V, Ta = 25°C, Av = 40dB)

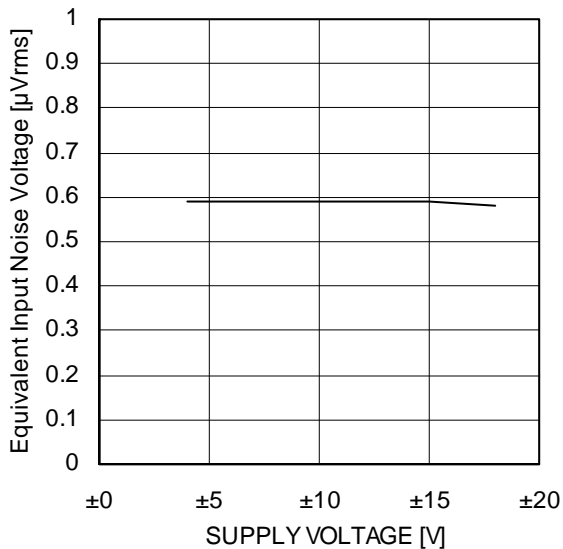


Figure 20.  
 Equivalent Input Noise Voltage – Supply Voltage  
 (Ta = 25°C, DIN-AUDIO)

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

●Application Information  
 NULL method condition for Test Circuit 1

VCC, VEE, EK, Vicm Unit:V

Parameter	VF	S1	S2	S3	VCC	VEE	EK	Vicm	Calculation
Input Offset Voltage	VF1	ON	ON	OFF	15	-15	0	0	1
Large Signal Voltage Gain	VF2	ON	ON	ON	15	-15	-10	0	2
	VF3						10		
Common-mode Rejection Ratio (Input Common-mode Voltage Range)	VF4	ON	ON	OFF	15	-15	0	-10	3
	VF5						10		
Power Supply Rejection Ratio	VF6	ON	ON	OFF	4	-4	0	0	4
	VF7				18	-18			

— Calculation—

1. Input Offset Voltage (Vio) 
$$V_{io} = \frac{|VF1|}{1+RF/RS} [V]$$

2. Large Signal Voltage Gain (Av) 
$$A_v = 20\text{Log} \frac{\Delta EK \times (1+RF/RS)}{|VF2-VF3|} [dB]$$

3. Common-mode Rejection Ratio (CMRR) 
$$\text{CMRR} = 20\text{Log} \frac{\Delta Vicm \times (1+RF/RS)}{|VF4 - VF5|} [dB]$$

4. Power Supply Rejection Ratio (PSRR) 
$$\text{PSRR} = 20\text{Log} \frac{\Delta V_{cc} \times (1+RF/RS)}{|VF6 - VF7|} [dB]$$

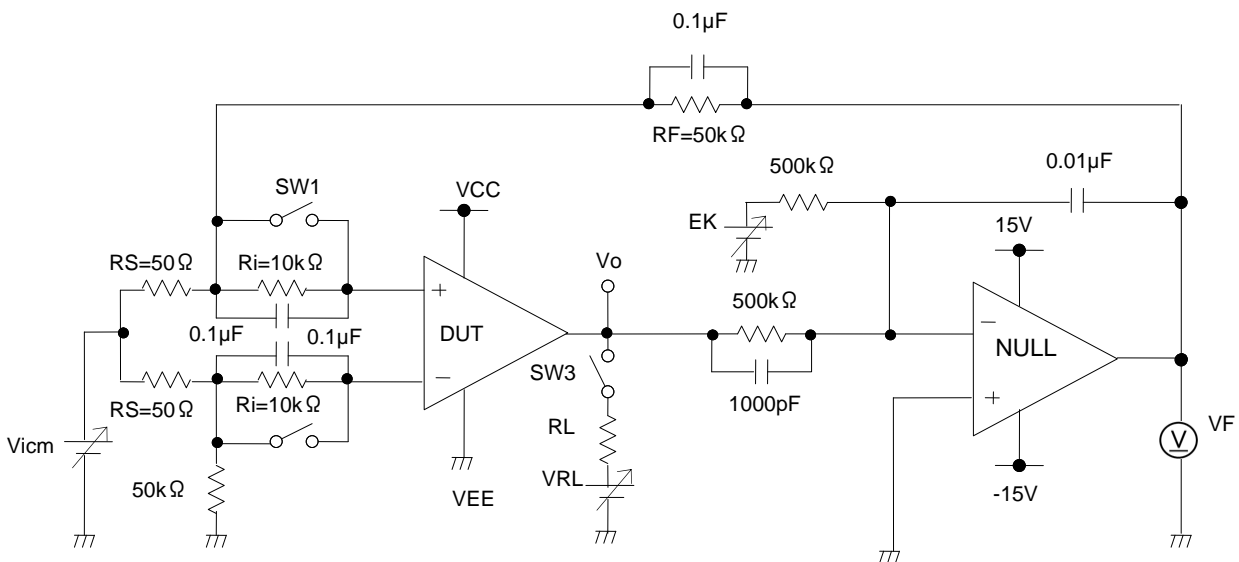


Figure21. Test circuit 1

Switch Condition for Test Circuit 2

SW No.	SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8	SW9	SW10	SW11	SW12
Supply Current	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF
Maximum Output Voltage RL=2kΩ	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	OFF
Slew Rate	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	ON
Maximum Frequency	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	ON

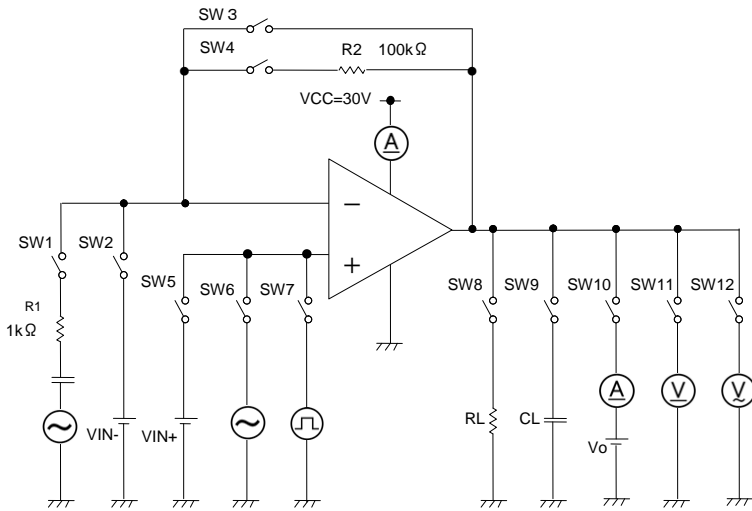


Figure 22. Test circuit2

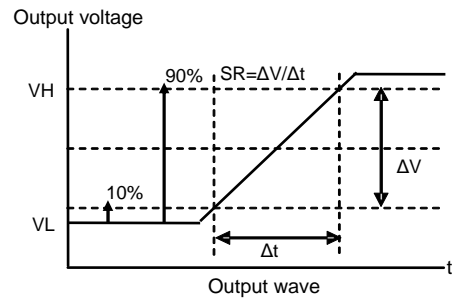
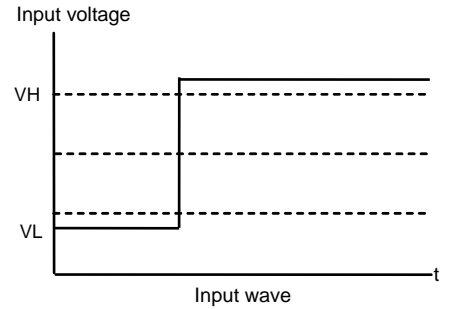


Figure 23 Slew rate input output wave

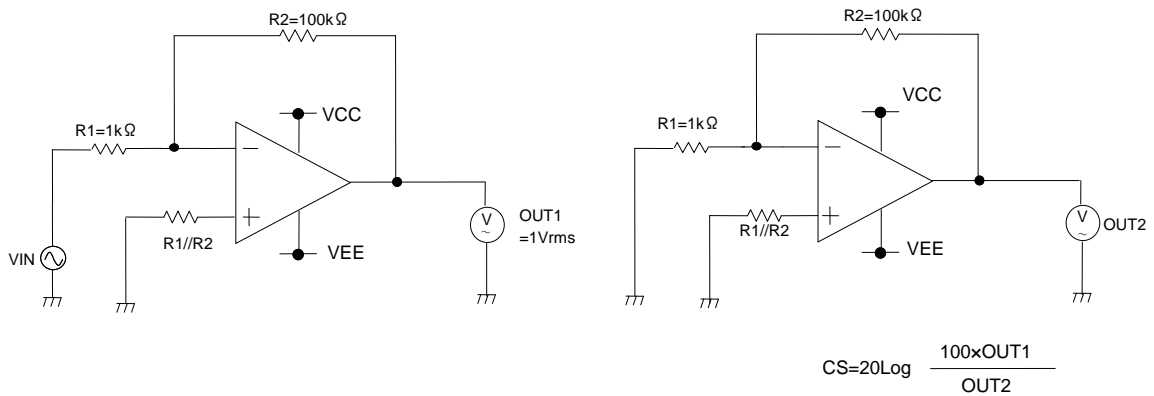


Figure 24. Test circuit 3 (Channel Separation)

## Application example

## ○Voltage follower

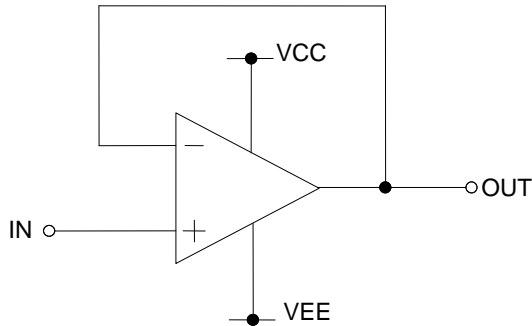


Figure 25. Voltage follower

Voltage gain is 0dB.

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

$$OUT=IN$$

## ○Inverting amplifier

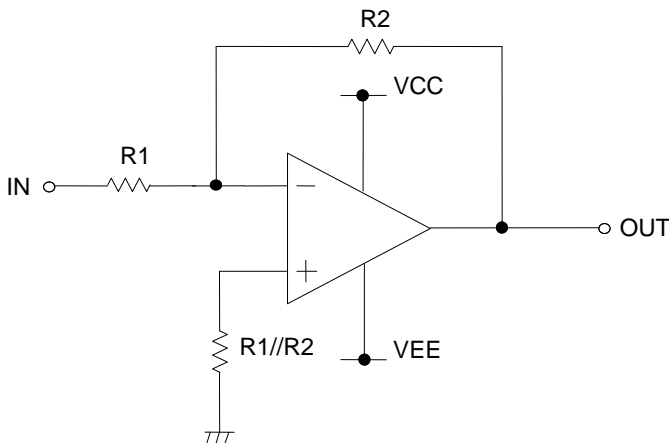


Figure 26. Inverting amplifier circuit

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

$$OUT=-\left(\frac{R2}{R1}\right) \cdot IN$$

This circuit has input impedance equal to R1.

## ○Non-inverting amplifier

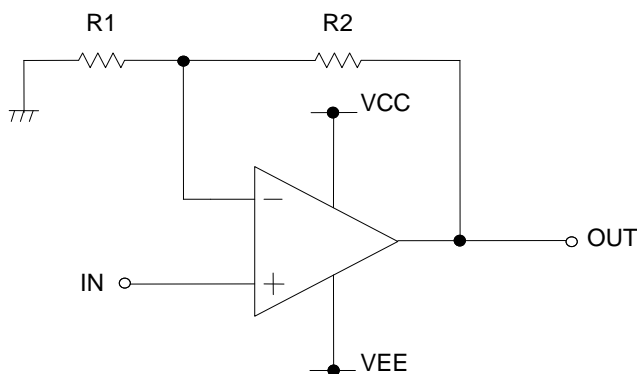


Figure 27. Non-inverting amplifier circuit

For non-inverting amplifier, IN is amplified by a voltage gain decided by the ratio of R1 and R2. OUT is in-phase with Vin and is shown in the next expression.

$$OUT=\left(1+\frac{R2}{R1}\right) \cdot IN$$

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 Ta=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  $\theta_{ja}$ °C/W, indicates this heat dissipation capability. Similarly, the temperature of an IC inside its package can be estimated by thermal resistance.

Figure 28(a) shows the model of the thermal resistance of the package. The equation below shows how to compute for the Thermal resistance ( $\theta_{ja}$ ), given the ambient temperature (Ta), maximum junction temperature (Tjmax), and power dissipation (Pd).

$$\theta_{ja} = (T_{jmax} - T_a) / P_d \quad \text{°C/W} \quad \dots \dots \dots (I)$$

The Derating curve in Figure 28(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 ( $\theta_{ja}$ ), 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 29(c) shows an example of the derating curve for LM4565.

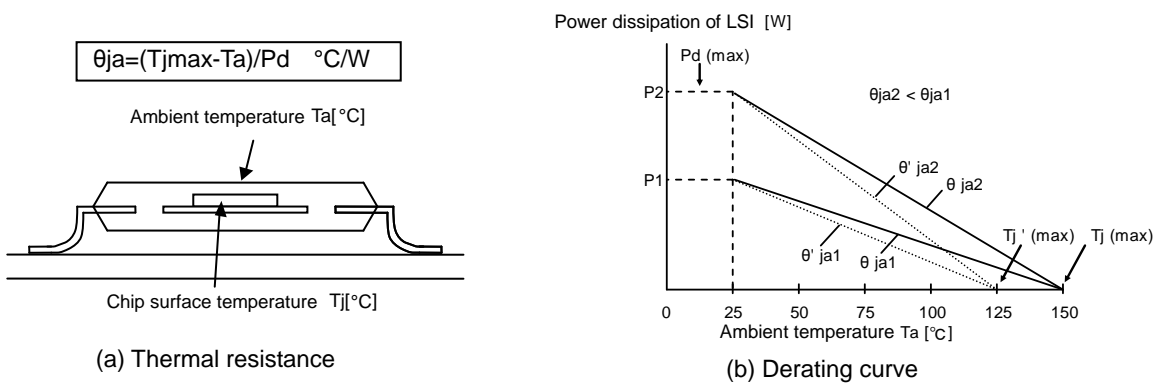
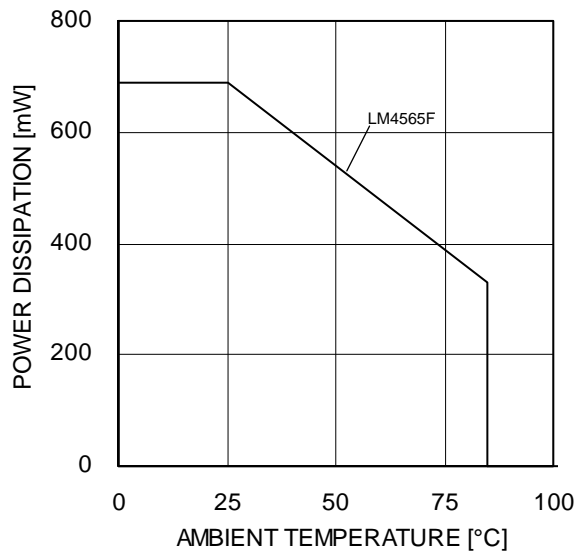


Figure 28. Thermal resistance and derating



(c) LM4565

5.52	mW/°C
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When using the unit above Ta=25°C, subtract the value above per °C. Permissible dissipation is the value when FR4 glass epoxy board 70mm×70mm×1.6mm (cooper foil area below 3%) is mounted

Figure 29. Derating curve

### ●Operational Notes

- 1) Processing of unused circuit  
It is recommended to apply the connection (see the Figure 30.) and set the non-inverting input terminal at a potential within the input common-mode voltage range ( $V_{icm}$ ) for any unused circuit.
- 2) Applied voltage to the input terminal  
For normal circuit operation of voltage comparator, please input a voltage for its input terminal within input common mode voltage. Then, regardless of power supply voltage,  $(V_{EE}) - 0.3V$  can be applied to input terminals without deterioration or destruction of its characteristics.
- 3) Operating power supply (split power supply/single power supply)  
The voltage comparator operates if a certain level of voltage is applied between VCC and VEE. Therefore, the operational amplifier can be operated under single power supply or split power supply.
- 4) Power dissipation ( $P_d$ )  
If the IC is used under excessive power dissipation, an increase in the chip temperature will cause deterioration of the electrical characteristics of the IC. As an example, reduction of current capability may happen. Take consideration of the effective power dissipation and thermal design with a sufficient margin.  $P_d$  is reference to the provided power dissipation curve.
- 5) Short circuits between pins and incorrect mounting  
When mounting the IC on a printed circuit board, take notice of the direction and position of the IC. If IC is mounted erroneously, it may be damaged. Also, when a foreign object is inserted between outputs, between output and VCC terminal, or between output and VEE terminal, it causes short circuit which may damage the IC.
- 6) Usage under strong electromagnetic field  
Be careful when using the IC under strong electromagnetic field because it may malfunction.
- 7) Usage of IC  
When pressure is applied to the IC through warp on the printed circuit board, the characteristics may fluctuate due to piezo effect. Be careful with the warp on the printed circuit board.
- 8) Testing IC on the application board  
When testing IC on the application board, in cases where the capacitor is connected to low impedance, make sure to discharge per process because there is a possibility that the IC may be damaged due to stress. When removing IC from the application board, it is essential to cut supply voltage. As a countermeasure against the static electricity, observe proper grounding during fabrication process and take due care when carrying and storing it.
- 9) The IC destruction caused by capacitive load  
The IC may be damaged when VCC terminal and VEE terminal is shorted with the charged output terminal capacitor. When IC is used as an operational amplifier or as an application circuit where oscillation is not activated by an output capacitor, output capacitor must be kept below  $0.1\mu F$  in order to prevent the damage mentioned above.
- 10) Decoupling capacitor  
Insert the decoupling capacitor between VCC and VEE for stable operation of operational amplifier.

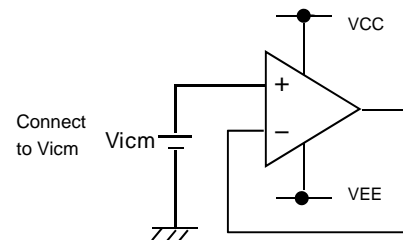


Figure 30. The example of application circuit for unused op-amp

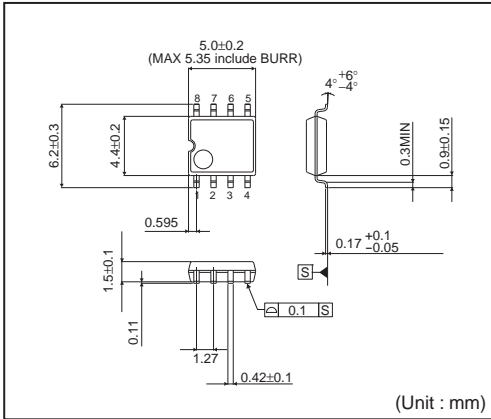
#### Status of this document

The Japanese version of this document is the formal specification. A customer may use this translation version only for reference to help reading the formal version.

If there are any differences in the translated version of this document, the formal version takes priority.

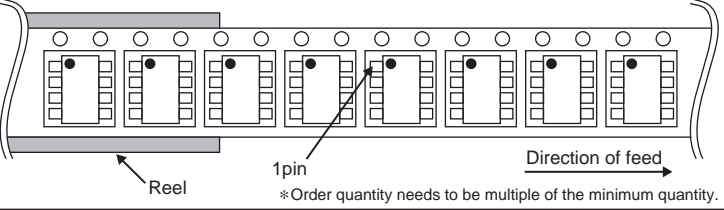
●Physical Dimensions Tape and Reel Information

SOP8

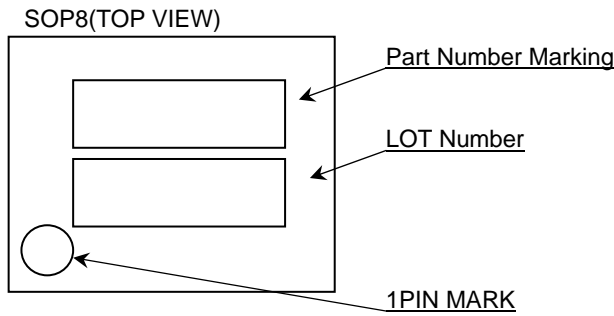


<Tape and Reel information>

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 )



●Marking Diagram

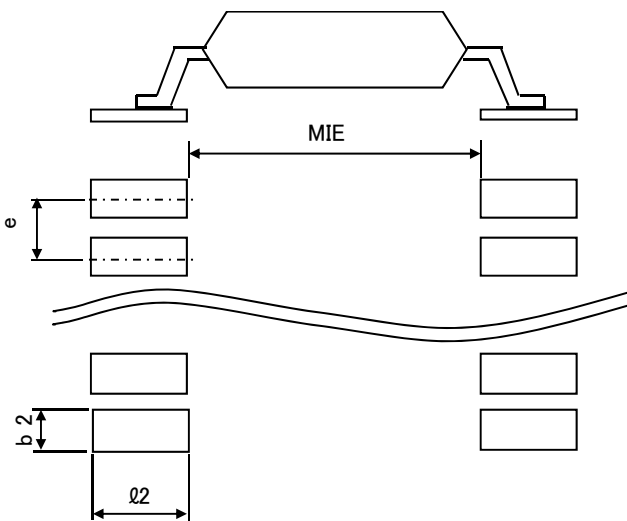


Product Name		Package Type	Marking
LM4565	F	SOP8	4565

●Land pattern data

all dimensions in mm

PKG	Land pitch e	Land space MIE	Land length $\geq l2$	Land width b2
SOP8	1.27	4.60	1.10	0.76





●Revision History

Date	Revision	Changes
30.NOV.2012	001	New Release

# Notice

## ●General Precaution

- 1) Before you use our Products, you are requested to carefully read this document and fully understand its contents. ROHM shall not be in any way responsible or liable for failure, malfunction or accident arising from the use of any ROHM's Products against warning, caution or note contained in this document.
- 2) All information contained in this document is current as of the issuing date and subject to change without any prior notice. Before purchasing or using ROHM's Products, please confirm the latest information with a ROHM sales representative.

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- 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, 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.
- 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<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - [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; if flow soldering method is preferred, 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 Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - [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 our Products might fall under controlled goods prescribed by the applicable foreign exchange and foreign trade act, please consult with ROHM representative in case of export.

**●Precaution Regarding Intellectual Property Rights**

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●Other Precaution

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