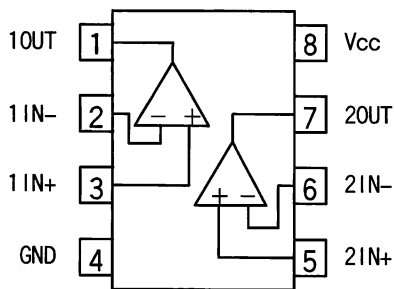


STRUCTURE SILICON MONOLITHIC INTEGRATED CIRCUIT
 FUNCTION TROPHY SERIES GROUND SENSE DUAL OPERATIONAL AMPLIFIERS
 PRODUCT SERIES **LM2904DR LM2904DGKR LM2904VQPWR**
LM2904PWR LM2904VQDR

- FEATURES
- Operating temperature range $-40[^\circ\text{C}]$ to $+125[^\circ\text{C}]$ (Extended Industrial Grade)
 - Wide supply voltage range
 Single supply $+3[\text{V}]$ to $+26[\text{V}]$
 ($+3[\text{V}]$ to $+32[\text{V}]$ for LM2904VQPWR, LM2904VQDR)
 Dual supply $\pm 1.5[\text{V}]$ to $\pm 13[\text{V}]$
 ($\pm 1.5[\text{V}]$ to $\pm 16[\text{V}]$ for LM2904VQPWR, LM2904VQDR)
 - Low supply current drain $0.7[\text{mA}]$ Typ
 - Common-mode input voltage range includes ground, Allowing direct sensing near ground
 - Low Input offset and bias parameters:
 Input offset voltage $3[\text{mV}]$ Typ
 Input offset current $2[\text{nA}]$ Typ
 Input bias current $20[\text{nA}]$ Typ
 - Differential input voltage range equal to maximum rated supply voltage $26[\text{V}]$
 ($32[\text{V}]$ for LM2904VQPWR, LM2904VQDR)
 - Large signal voltage gain $100[\text{V/mV}]$ Typ
 - Internal frequency compensation

LM2904 family (TROPHY SERIES)

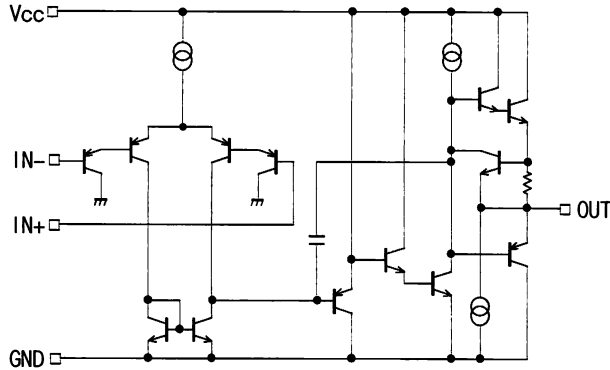
○BLOCK DIAGRAM



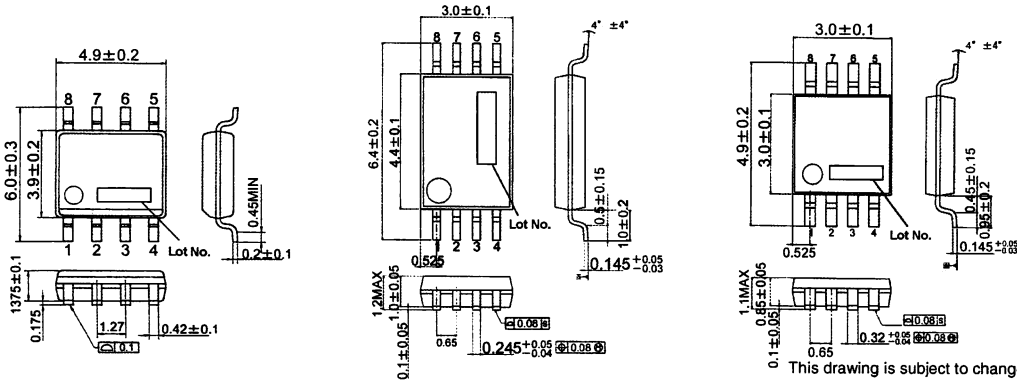
○PIN No. - PIN NAME

PIN No.	PIN NAME
1	1OUT
2	1IN-
3	1IN+
4	GND
5	2IN+
6	2IN-
7	2OUT
8	Vcc

○SCHEMATIC DIAGRAM(Each Operational Amplifier)



○PHYSICAL DIMENSIONS



LM2904DR/VQDR (SOIC8) (Unit : [mm]) LM2904PWR/VQPWR(TSSOP8) (Unit : [mm]) LM2904DGKR(MSOP8/VSSOP8)(Unit : [mm])

○ABSOLUTE MAXIMUM RATINGS (Ta=25[°C])

Parameter	Symbol	Rating	Unit
Supply Voltage	Vcc – GND	LM2904DR/LM2904PWR	V
		LM2904DGKR	
		LM2904VQDR/LM2904VQPWR	
Power Dissipation	Pd	LM2904DR/LM2904VQDR	mW
		LM2904PWR/LM2904VQPWR	mW
		LM2904DGKR	mW
Differential Input Voltage (*5)	Vid	LM2904DR/LM2904PWR	V
		LM2904DGKR	
		LM2904VQDR/LM2904VQPWR	
Input Common-mode Voltage Range	Vicm	LM2904DR/LM2904PWR	V
		LM2904DGKR	
		LM2904VQDR/LM2904VQPWR	
Operating Temperature	Topr	-40 to +125	°C
Storage Temperature Range	Tstg	-65 to +150	°C
Maximum junction Temperature	Tjmax	+150	°C

- (*1) To use at temperature above Ta=25[°C] reduce 3.60[mW]/[°C].
- (*2) To use at temperature above Ta=25[°C] reduce 4.00[mW]/[°C].
- (*3) To use at temperature above Ta=25[°C] reduce 3.76[mW]/[°C].
- (*4) Mounted on a glass epoxy PCB(70[mm]×70[mm]×1.6[mm]).
- (*5) The voltage difference between inverting input and non-inverting input is the differential input voltage. Then input terminal voltage is set to more than GND terminal.

○OPERATING CONDITION (Ta=-40[°C] to +125[°C])

Parameter	Symbol	Rating	Unit
Supply Voltage	Vcc	LM2904DR/LM2904PWR	V
		LM2904DGKR	
		LM2904VQDR/LM2904VQPWR	
		+3.0 to +26.0 (Single Supply)	
		± 1.5 to ± 13.0 (Dual Supply)	
		+3.0 to +32.0 (Single Supply)	
		± 1.5 to ± 16.0 (Dual Supply)	

○ELECTRICAL CHARACTERISTICS (Unless otherwise specified Vcc=+5[V])

Parameter	Symbol	Temperature Range	Guaranteed Limit			Unit	Condition	
			Min.	Typ.	Max.			
Input Offset Voltage (*6)	VIO	25°C	-	3	7	mV	VO=1.4[V],VIC=VICR(min) Vcc=5[V] to MAX(*8)	
		Full range	-	-	10			
Average Temperature Coefficient of Input Offset Voltage	αVIO	-	-	7	-	μV/°C	-	
Input Offset Current (*6)	LM2904*(8)	IIO	25°C	-	2	50	nA	VO=1.4[V]
			Full range	-	-	300		
	LM2904V*(8)	25°C	-	2	50			
		Full range	-	-	150			
Average Temperature Coefficient of Input Offset Current	αIIO	-	-	10	-	pA/°C	-	
Input Bias Current (*6)	IIB	25°C	-	20	250	nA	VO=1.4[V]	
		Full range	-	-	500			
Common-mode input Voltage Range	VICR	25°C	-	-	Vcc-1.5	V	Vcc=5[V] to MAX(*8)ss	
		Full range	-	-	Vcc-2.0			
High-Level Output Voltage	LM2904*(8)	VOH	25°C	Vcc-1.5	-	-	V	RL ≥ 10[kΩ]
			Full range	23	24	-		Vcc=MAX(*8),RL ≥ 10[kΩ]
			LM2904V*(8)	Full range	27	28		-
Low Level Output Voltage	VOL	Full range	-	5	20	mV	RL ≤ 10[kΩ]	
Large Signal Differential Voltage Amplification	AVD	25°C	25	100	-	V/mV	Vcc=15[V],VO=1[V] to 11[V] RL ≥ 2[kΩ]	
Common-mode Rejection Ratio	LM2904*(8)	CMRR	25°C	50	80	-	dB	Vcc=5[V] to MAX(*8),VIC=VICR(min)
	LM2904V*(8)		25°C	65	80	-		
Supply Voltage Rejection Ratio	KSVR	25°C	65	100	-	dB	Vcc=5[V] to MAX(*8)	
Crosstalk Attenuation	VO1/VO2	25°C	-	120	-	dB	f=1[kHz] to 20[kHz]	
Output Current(*7)	Source	25°C	20	30	-	mA	Vcc=15[V],VO=0[V],VID=1[V]	
		Full range	10	-	-			
	Sink	25°C	10	20	-	mA	Vcc=15[V],VO=0[V],VID=-1[V]	
		Full range	2	-	-			
	LM2904*(8)	Io	25°C	-	30	-	μA	VO=200[mV],VID=-1[V]
			LM2904V*(8)	25°C	12	40		
Supply Current (Two amplifiers)	ICC	Full range	-	0.7	1.2	mA	VO=2.5[V],No Load	
		Full range	-	1	2		Vcc=MAX(*8),VO=0.5[V],No Load	
Slew Rate at Unity Gain	SR	25°C	-	0.3	-	V/μs	RL=1[MΩ],CL=30[pF],VI=±10[V] Vcc=15[V],GND=-15[V] (see Fig.1)	
Unity-Gain Bandwidth	B1	25°C	-	0.7	-	MHz	RL=1[MΩ],CL=20[pF] Vcc=15[V],GND=-15[V] (see Fig.1)	
Equivalent Input Noise Voltage	Vn	25°C	-	40	-	nV/√Hz	Vcc=15[V],GND=-15[V],RS=100[Ω], VI=0[V],f=1[kHz],(see Fig.2)	

(*6) Absolute value.

(*7) Under the high temperature environment, consider the power dissipation of IC when select the output current.

When output terminal short-circuits continuously, the output current reduce to climb temperature inside IC by flash.

(*8) Maximum supply voltage is 26[V] for LM2904D, LM2904DR, LM2904PW, LM2904PWR, and LM2904DQKR

Maximum supply voltage is 32[V] for LM2904VQDR, LM2904VQPWR

○APPLICATION EXAMPLE

(1) Absolute maximum ratings

Absolute maximum ratings are the values which indicate the limits, within which the given voltage range can be safely charged to the terminal. However, it does not guarantee the circuit operation.

(2) The example of disabled circuit application

When there is a circuit not in use, it is recommended to make the non-inverting input terminal be the potential in the common-mode input voltage range like in Fig.3.

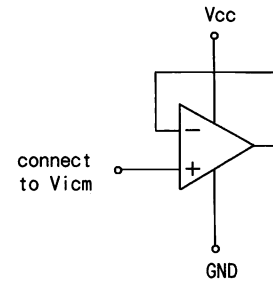


Fig.1 The example of disable circuit

(3) Applied voltage to the input terminal

Regardless of power supply voltage, $GND + 26[V]$ (LM2904VQDR, LM2904VQPWR) $GND + 32[V]$ can be applied to input terminals without deterioration or destruction of its characteristics. However, this does not guarantee a circuit operation. Note that circuits do not operate normally with input voltage not within input common mode voltage in terms of the electrical characteristics.

(4) Operating power supply (single power supply/dual power supply)

The OP-Amp operates if a given level of voltage is applied between Vcc and GND. Therefore, the OP-Amp can be operated under single power supply or dual power supply.

(5) Power dissipation(Pd)

If the IC is used under excessive power dissipation. An increase in the chip temperature will cause deterioration of the radical characteristics of IC. For example, reduction of current capability. Take consideration of the effective power dissipation and thermal design with a sufficient margin. Pd is reference to the provided power dissipation curve.

(6) Short circuits between pins and incorrect mounting

Short circuits between pins and incorrect mounting when mounting the IC on a printed circuits board, take notice of the direction and positioning of the IC. If IC is mounted erroneously, It may be damaged. Also, when a foreign object is inserted between output, between output and Vcc terminal or GND terminal which causes short circuit, the IC may be damaged.

(7) Using under strong electromagnetic field

Be careful when using the IC under strong electromagnetic field because it may malfunction.

(8) Usage of IC

When stress is applied to the IC through warp of the printed circuit board, The characteristics may fluctuate due to the piezo effect. Be careful of the warp of the printed circuit board.

(9) Output operation

This IC is configured with a push-pull circuit and Class C output stage. Therefore, when load resistance is connected to the middle point potential of Vcc and GND, this configuration generates crossover distortion when switching between source and sink current. To suppress crossover distortion, connect a resistor between the output terminal and GND then increase the bias current to enable Class A operation.

(10) Testing IC on the set board

When testing IC on the set board, in cases where the capacitor is connected to the low impedance, make sure to discharge per fabrication because there is a possibility that IC may be damaged by stress. When removing IC from the set 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 storage it.

(11) Output terminal capacitor

Transistor in circuits may be damaged when Vcc terminal and GND terminal is shorted with the charged output terminal capacitor. When IC is used as a comparator or as an application circuit, where oscillation is not activated by an output capacitor, the output capacitor must be kept below $0.1[\mu F]$ in order to prevent the damage mentioned above. Be careful when IC is used as voltage follower application with output capacitance. If capacitance connect output terminal then evaluate for output terminal oscillation.

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