

WS72144

300nA Nano-Power Rail-to-Rail Input Output Operational Amplifiers

Descriptions

The WS72144 is a quad low-voltage operational amplifier with rail-to-rail input/output swing. Ultra low power makes this amplifier ideal for battery-powered and portable applications. The WS72144 has a gain-bandwidth product of 13kHz (TYP) and is unity gain stable. These specifications make this operational amplifier appropriate for low frequency applications, such as battery current monitoring and sensor conditioning.

WS72144 is available with MSL 3 Level in SOP-14L package and TSSOP-14L package. Standard products are Pb-Free and halogen-Free.

Applications

- Handsets and Mobile Accessories
- Current Sensing
- Wireless Remote Sensors, Active RFID Readers
- Environment/Gas/Oxygen Sensors
- Threshold Detectors/Discriminators
- Low Power Filters
- Battery or Solar Powered Devices
- Sensor Network Powered by Energy Scavenging

Features

Wide Supply Voltage : 1.6~5.5VQuiescent Current per : 300nA Typical

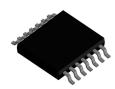
Amplifier

GBWP : 13kHz

- Rail-to-Rail Input/Output Swing
- Unity Gain Stable
- -40°C to 125°C Operation Temperature Range
- Available in Green SOP-14L and TSSOP-14L Packages

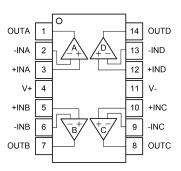
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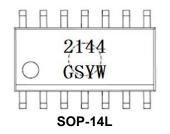


SOP-14L

TSSOP-14L



SOP-14L/TSSOP-14L
Pin configuration (Top view)





Marking

2144 = Device code
GS = Special code
GH = Special code
Y = Year code
W = Week code

Order Information

Device	Package	Shipping
WS72144S-14/TR	SOP-14L	4000/Reel &Tape
WS72144H-14/TR	TSSOP-14L	4000/Reel &Tape



Pin Descriptions

Pin Number	Symbol	Descriptions
1	OUTA	Output
2	-INA	Inverting input
3	+INA	Non-inverting input
4	V+	Positive supply
5	+INB	Non-inverting input
6	-INB	Inverting input
7	OUTB	Output
8	OUTC	Output
9	-INC	Inverting input
10	+INC	Non-inverting input
11	V-	Negative supply
12	+IND	Non-inverting input
13	-IND	Inverting input
14	OUTD	Output

Absolute Maximum Ratings(1)

Parameter	Symbol	Value	Unit		
Supply Voltage, ([V+] - [V-])	Vs ⁽²⁾	6	V		
Input Common Mode Voltage Range	V _{ICR}	(V-)-0.3 to (V+)+0.3	V		
Output Short-Circuit Duration	t _{SO} (3)	Unlimited	/		
Operating Fee-Air Temperature Range	T _A	-40 to 125	°C		
Storage Temperature Range	T _{STG}	-65 to 150	°C		
Junction Temperature Range	TJ	150	°C		
Lead Temperature Range	TL	260	°C		

Note:

- Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the
 device. These are only stress ratings, and functional operation of the device at these or any other
 conditions beyond those indicated under recommended operating conditions are not implied. Exposure
 to absolute-maximum-rated conditions for extended periods may affect device reliability.
- 2. All voltage values, except differential voltage are with respect to network terminal.
- 3. A heat sink may be required to keep the junction temperature below the absolute maximum, depends on the power supply voltage and how many amplifiers are shorted. Thermal resistance varies the amount of PC board metal connected to the package. The specified values are for short traces connected to leads.

ESD, Electrostatic Discharge Protection

Symbol	Parameter	Condition	Minimum level	Unit
HBM	Human Body Model ESD	MIL-STD-883H Method 3015.8	±8000	V
НВМ	Truman body Moder LSD	JEDEC-EIA/JESD22-A114A	±0000	V
CDM	Charged Device Model ESD	JEDEC-EIA/JESD22-C101E	±2000	٧
MM	Machine Model ESD	JEDEC-EIA/JESD22-A115	±400	V

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Electronics Characteristics

The *denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 27°C. V_S = 5V, V_{CM} = V_{OUT} = $V_S/2$, R_{load} = 100k Ω , C_{load} = 60pF.

Voss Input Offset Voltage V _{CM} = Vs/2 and V _{CM} =GND * -3.0 ±0.1 3.0 mV αyos Input Offset Voltage Drift Input Offset Voltage 1.6 μ/V/C lig Input Offset Current - - -1.0 pA los Input Offset Current - <th>Symbol</th> <th>F</th> <th>Parameter</th> <th>Conditions</th> <th></th> <th>Min.</th> <th>Тур.</th> <th>Max.</th> <th>Unit</th>	Symbol	F	Parameter	Conditions		Min.	Тур.	Max.	Unit
Ingut Bias Current	Vos	Input Offset	: Voltage	V _{CM} = V _S /2 and V _{CM} =GND	*	-3.0	±0.1	3.0	mV
Input Offset Current	α _{VOS}	Input Offset	Voltage Drift				1.6		μV/°C
Vn Input Voltage Noise f=0.1Hz to10Hz 8 μV _{P-P} en Input Voltage Noise Density f=1kHz 80 nV/Hz RIN Input Resistance >1 TΩ CMRR Common Mode Rejection Ratio V _{CM} =0.1V to 4.9V * 55 75 dB VCM Common Mode Input Voltage Range * (V-)-0.3 (V+)+0.3 V PSRR Power Supply Rejection Ratio * 65 91 dB Avol. Open Loop Large Signal Gain Vour=2.5V,Rload=100kΩ 1118 dB Avol. Open Loop Large Signal Gain Vour=0.1V to 4.9V, Rload=100kΩ * 85 118 dB Avol. Open Loop Large Signal Gain Rload=100kΩ * 85 118 dB VoLVoH Output Swing from Supply Rail Rload=100kΩ * 85 118 dB VoLVoH Output Swing from Supply Rail Rload=100kΩ * 11 4.3 Ω Rout Closed-Loop Output Impedance G=1,f=1kHz,lour=0 * 1.6 5.5 V Is	I _{IB}	Input Bias (Current				<10		pА
en Input Voltage Noise Density f=1kHz 80 nV/NHz R _{IN} Input Resistance >1 TΩ CMRR Common Mode Rejection Ratio V _{CM} =0.1V to 4.9V * 55 75 dB V _{CM} Common Mode Input Voltage Range * (V-)-0.3 (V+)+0.3 V PSRR Power Supply Rejection Ratio * 65 91 dB A _{VOL} Open Loop Large Signal Gain Vour=2.5V,R _{Issad} =100kΩ 1118 dB A _{VOL} Open Loop Large Signal Gain Vour=0.1V to 4.9V, R _{Issad} =100kΩ * 85 118 dB VoLVOH Output Swing from Supply Rail R _{Issad} =100kΩ 5 mV ROUT Closed-Loop Output Impedance G=1,f=1kHz,I _{OUT} =0 4.3 Ω Ω Isc Output Short-Circuit Current Sink or Source Current 10 15 mA VpD Supply Voltage 1.6 5.5 V Iq Quiescent Current per Amplifier * 300 450 nA PM Phase Margin	los	Input Offset	Current				<10		pА
Rin	Vn	Input Voltag	ge Noise	f=0.1Hz to10Hz			8		μV _{P-P}
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	en	Input Voltag	ge Noise Density	f=1kHz			80		nV/√Hz
V _{CM} Common Mode Input Voltage Range * (V-)-0.3 (V+)+0.3 V (V+)+0.3 M (BB) Volution Signal Gain Nout of 4.9V, Rload=100kΩ Set Instance To Sink or Source Current 10 15 m M Volution Supply Sail Relation Supply Sail Relation Supply Sail Relation Sail Sail N M Volution Supply Sail Relation Sail Sail Sail Sail Sail Sail Sail Sail	R _{IN}	Input Resis	tance				>1		ΤΩ
Note	CMRR	Common M	lode Rejection Ratio	V _{CM} =0.1V to 4.9V	*	55	75		dB
$A_{VOL} = \begin{array}{c ccccccccccccccccccccccccccccccccccc$	V _{CM}		lode Input Voltage		*	(V-)-0.3		(V+)+0.3	٧
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	PSRR	Power Supp	oly Rejection Ratio		*	65	91		dB
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$				V_{OUT} =2.5 V , R_{load} =100 $k\Omega$			118		dB
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	A _{VOL}	Open Loop	Large Signal Gain	·	*	85	118		dB
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	V _{OL} ,V _{OH}	Output Swing from Supply Rail		R_{load} =100k Ω			5		mV
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Rout	Closed-Loop Output Impedance		G=1,f=1kHz,l _{OUT} =0			4.3		Ω
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	I _{SC}	Output Short-Circuit Current		Sink or Source Current		10	15		mA
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	V _{DD}	Supply Volt	age			1.6		5.5	V
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	IQ	Quiescent (Current per Amplifier		*		300	450	nA
GBWP Gain-Bandwidth Product f=1kHz 13 kHz t_s Settling Time 1.5 to 3.5V, Unity Gain 0.1% 0.4 0.4 0.4 SR Slew Rate 0.1% 0.04 0.04 0.04 SR Slew Rate Av=1, Vout=1.5V to 3.5V, Rload=100kΩ, Cload=60pF 5 mV/μs	PM	Phase Març	gin	R_{load} =100kΩ, C_{load} =60pF			80		degrees
ts Settling Time 1.5 to 3.5V, Unity Gain 0.1% 0.4 ms SR Slew Rate Av=1, Vout=1.5V to 3.5V, Rload=60pF 5 mV/μs	GM	Gain Margi	n	R_{load} =100kΩ, C_{load} =60pF			18		dB
ts Settling Time Gain 2.45 to 2.55V, Unity Gain 0.1% 0.04 ms SR Slew Rate A _V =1, V _{OUT} =1.5V to 3.5V, R _{load} =100kΩ, C _{load} =60pF 5 mV/μs	GBWP	Gain-Band	width Product	f=1kHz			13		kHz
Time 2.45 to 2.55V,	Se	Settling		0.1%			0.4		mo
SR Slew Rate $R_{load}=100k\Omega$, $C_{load}=60pF$ 5 $mV/\mu s$	ıs	Time		0.1%			0.04		IIIS
FPBW Full Power Bandwidth ^{Note1} 2V _{P-P} 300 Hz	SR	Slew Rate					5		mV/μs
	FPBW	Full Power	Bandwidth ^{Note1}	2V _{P-P}			300		Hz

Note:

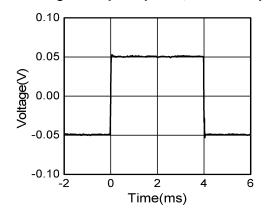
1. Full power bandwidth is calculated from the slew rate FPBW = $SR/(\pi \cdot V_{P-P})$.

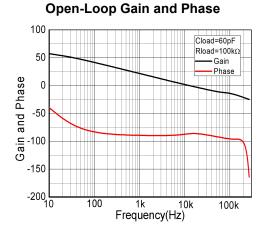


Typical Characteristics

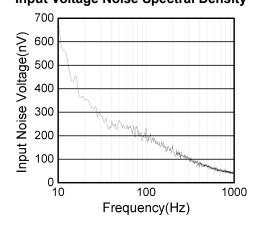
T_A=25°C, V_S=5V, V_{CM}=V_S/2, unless otherwise noted

Small-Siganl Step Response, 100mV Step

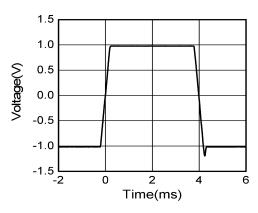




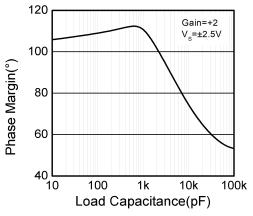
Input Voltage Noise Spectral Density



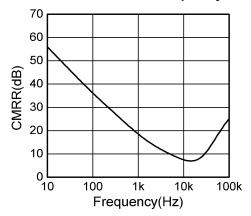
Large-Siganl Step Response, 2V Step



Phase Margin vs. C_{load} (Stable for Any C_{load})



CMRR vs. Frequency

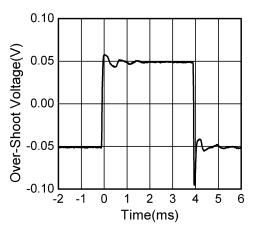




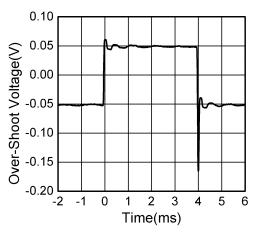
Typical Characteristics (continued)

T_A=25°C, V_S=5V, V_{CM}=V_S/2, unless otherwise noted

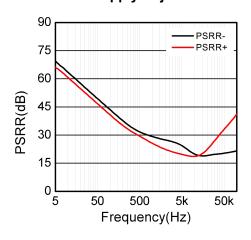
Over-Shoot Voltage
Gain=-1,C_{LOAD} = 40nF, V_S=±2.5V



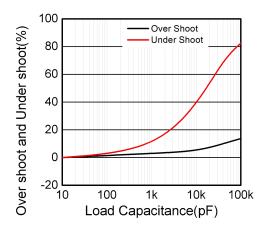
Over-Shoot Voltage
Gain=+1,C_{LOAD} = 40nF, V_S=±2.5V



Power-Supply Rejection Ratio

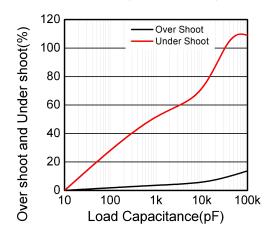


Over-Shoot % vs. C_{load}
Gain=-1,C_{LOAD} = 40nF, V_S=±2.5V

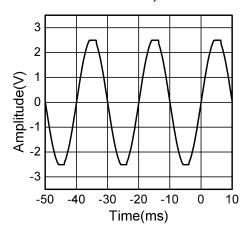


Over-Shoot % vs. C_{load}

Gain =+1, C_{LOAD} = 40nF, V_S=±2.5V



VIN = -0.2V to 5.7V, No Phase Reversal

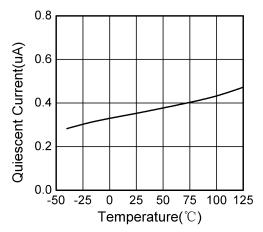




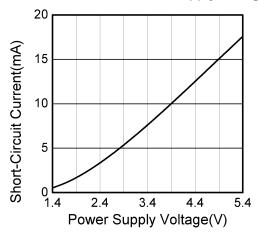
Typical Characteristics (continued)

T_A=25°C, V_S=5V, V_{CM}=V_S/2, unless otherwise noted

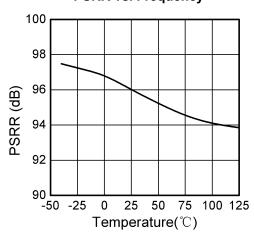
Quiescent Supply Current vs. Temperature



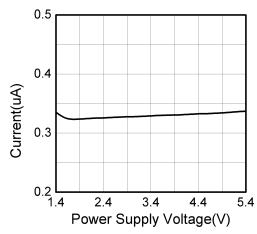
Short-Circuit Current vs. Supply Voltage



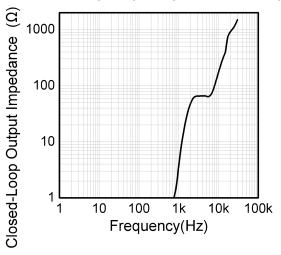
PSRR vs. Frequency



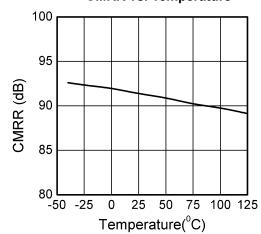
Quiescent Supply Current vs. Supply Voltage



Closed-Loop Output Impedance vs. Frequency



CMRR vs. Temperature

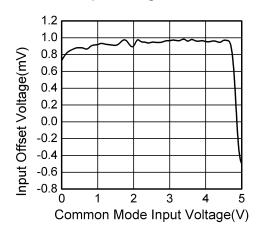




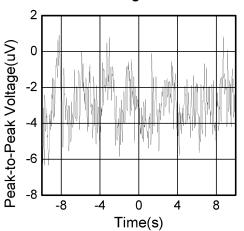
Typical Characteristics (continued)

T_A=25°C, V_S=5V, V_{CM}=V_S/2, unless otherwise noted

Input Offset Voltage vs. Common Mode Input Voltage



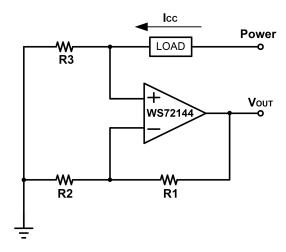
0.1Hz to 10Hz Time Domain Output Voltage Noise





Application Circuit

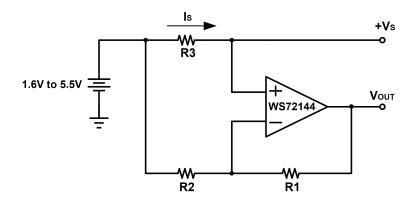
(1) WS72144 in Low Side Battery Current Sensor



Application Circuit for Low Side Battery Current Sensor

$$V_{OUT} = I_{CC} \times R_3 \times (\frac{R_1}{R_2} + 1)$$

(2) WS72144 in High Side Battery Current Sensor



Application Circuit for High Side Battery Current Sensor

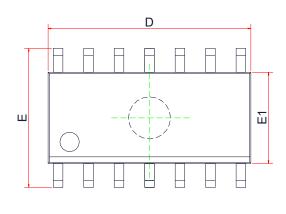
$$I_S = \frac{+V_S - V_{OUT}}{R_1 \times R_3 \div R_2}$$

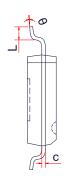
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PACKAGE OUTLINE DIMENSIONS

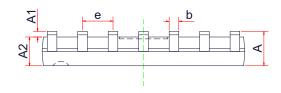
SOP-14L





TOP VIEW

SIDE VIEW



SIDE VIEW

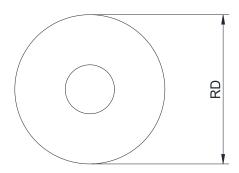
Symbol	Dimensions In Millimeters (mm)					
	Min.	Тур.	Max.			
А	-	-	1.75			
A1	0.10	1	0.25			
A2	1.25	-	-			
b	0.31	0.41	0.51			
С	0.10	1	0.25			
D	8.45	8.65	8.85			
Е	5.80	6.00	6.20			
E1	3.80	3.90	4.00			
е		1.27 BSC				
L	0.40	-	1.27			
θ	0°	-	8°			



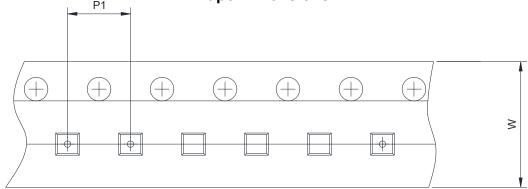
TAPE AND REEL INFORMATION

SOP-14L

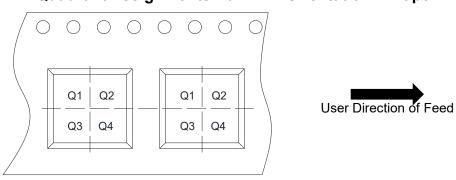
Reel Dimensions



Tape Dimensions



Quadrant Assignments For PIN1 Orientation In Tape

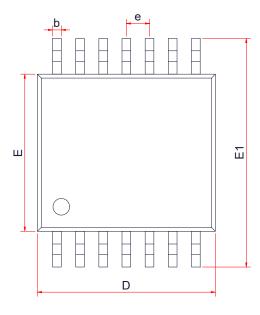


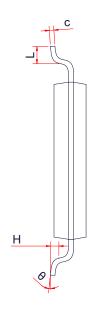
RD	Reel Dimension	7inch	☑ 13inch		
W	Overall width of the carrier tape	■ 8mm	■ 12mm	▼ 16mm	
P1	Pitch between successive cavity centers	2mm	4mm	₹ 8mm	
Pin1	Pin1 Quadrant	☑ Q1	□ Q2	□ Q3	□ Q4



PACKAGE OUTLINE DIMENSIONS

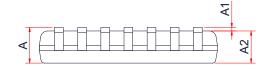
TSSOP-14L





TOP VIEW

SIDE VIEW



SIDE VIEW

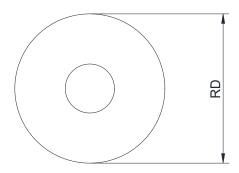
Oh al	Dir	Dimensions in Millimeters			
Symbol	Min.	Тур.	Max.		
A	-	-	1.20		
A1	0.05	-	0.15		
A2	0.80	0.90	1.00		
b	0.19	-	0.30		
С	0.09	-	0.20		
D	4.90	5.00	5.10		
E	4.30 4.40		4.50		
E1	6.25 6.40		6.55		
е		0.65 BSC			
L	0.50 0.60		0.70		
Н	0.25Typ				
θ	1 °	-	7 °		



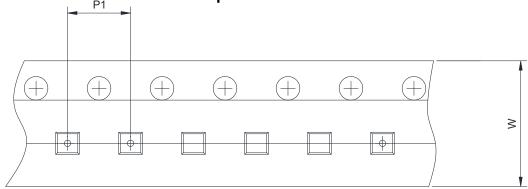
TAPE AND REEL INFORMATION

TSSOP-14L

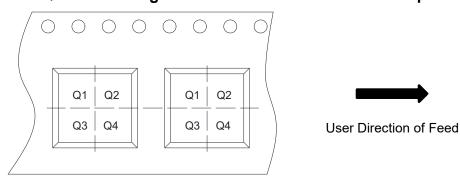
Reel Dimensions



Tape Dimensions



Quadrant Assignments For PIN1 Orientation In Tape



RD	Reel Dimension	7inch	☑ 13inch		
W	Overall width of the carrier tape	☐ 8mm	▼ 12mm	☐ 16mm	
P1	Pitch between successive cavity centers	2mm	4mm	▼ 8mm	
Pin1	Pin1 Quadrant	▼ Q1	□ Q2	□ Q3	□ Q4

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 SC2902DTBR2G
 SC2903DR2G
 SC2903VDR2G
 LM258AYDT
 LM358SNG
 430227FB
 430228DB
 460932C
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 409256CB

 430232AB
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 SC239DR2G
 SC2902DG

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 NCS2004MUTAG
 NCV33202DMR2G

 M38510/13101BPA
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 SC2904DR2G
 SC358DR2G
 LM358EDR2G
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 HA1630Q06TELL-E