

FEATURES

- Wide Supply Voltage Range 6V to 20V
- Input range 500mV beyond the rails
- Rail-to-Rail Output Swing
- Large DC Voltage Gain 90dB (Typical)
- High slew rate 40V/ μ s
- Protection Function
 - Over Temperature Protection (OTP)
 - Over Current Protection (OCP)
- -3dB Bandwidth (unit gain) 30MHz
- \pm 350mA Output Short Circuit Current
- Unity-gain stable
- Ultra-small Package TSSOP-14

APPLICATIONS

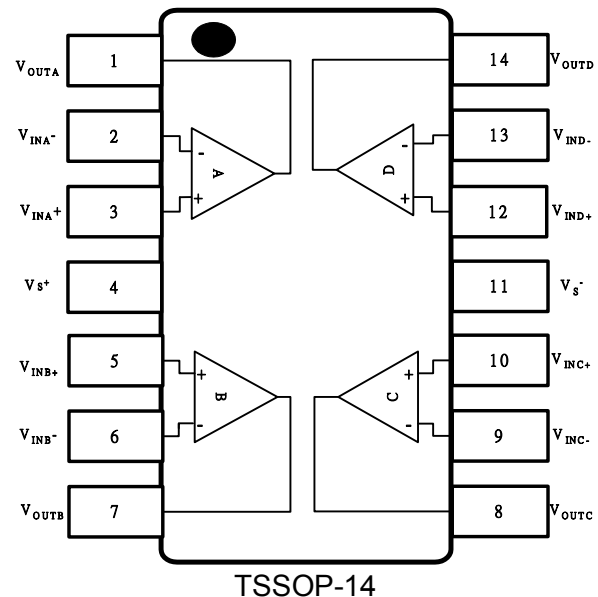
- TFT-LCD Reference Driver
- Touch-Screen Display
- Wireless LANs
- Personal Communication Devices
- Direct Access Arrangement
- Personal Digital Assistant (PDA)
- Active Filter
- Sampling ADC Amplifier
- ADC/DAC Buffer
- Electronic Notebook
- Office Automation

GENERAL DESCRIPTION

The EC5604 is a 100mA output current rail-to-rail quad channels operational amplifier with wide supply range from 6V to 18V while consumes only 2.0mA per channel. It provides 0.5V beyond the supply rails of common mode input range and capability of rail-to-rail output swing as well. This enables the amplifier to offer maximum dynamic range at any supply voltage among many applications. A 20MHz gain bandwidth product allows EC5604 to perform more stable than other devices in Internet applications.

With features of 40V/ μ s high slew rate and 500ns of fast settling time, as well as 100mA (sink and source) of high output driving capability, the EC5604 is ideal for the requirements of flat panel Thin Film Transistor Liquid Crystal Displays (TFT-LCD) panel reference buffers application. Due to insensitive to power supply variation, EC5604 offers flexibility of use in multitude of applications such as battery power, portable devices and anywhere low power consumption is concerned. With standard operational amplifier pin assignment, the EC5604 is offered in space saving 14-Pin TSSOP package and specified over the -40°C to $+85^{\circ}\text{C}$ temperature range.

PIN ASSIGNMENT





18V High Performance Rail-to-Rail Quad Operational Amplifiers

EC5604

ABSOLUTE MAXIMUM RATINGS (TA = 25 °C)

Values beyond absolute maximum ratings may cause permanent damage to the device. These are stress ratings only; functional device operation is not implied. Exposure to AMR conditions for extended periods may affect device reliability.

Supply Voltage between V_{S+} and V_{S-}	+20V	Storage Temperature	-65°C to +150°C
Input Voltage	$V_{S-} - 0.5V, V_{S+} + 0.5V$	Operating Temperature	-40°C to +85°C
Maximum Continuous Output Current	100mA	Lead Temperature	260°C
Maximum Die Temperature	+125°C	ESD Voltage	2kV

Important Note:

All parameters having Min/Max specifications are guaranteed. Typical values are for information purposes only. Unless otherwise noted, all tests are at the specified temperature and are pulsed tests, therefore: $T_J = T_C = T_A$

ELECTRICAL CHARACTERISTICS

$V_{S+} = +5V, V_{S-} = -5V, R_L = 10k\Omega$ and $C_L = 10pF$ to 0V, $T_A = 25^\circ C$ unless otherwise specified.

Parameter	Description	Condition	Min	Typ	Max	Units
Input Characteristics						
V_{OS}	Input Offset Voltage	$V_{CM} = 0V$		2	12	mV
TCV_{OS}	Average Offset Voltage Drift	[1]		5		$\mu V/^\circ C$
I_B	Input Bias Current	$V_{CM} = 0V$		2	50	nA
R_{IN}	Input Impedance			1		G
C_{IN}	Input Capacitance			1.35		pF
CMIR	Common-Mode Input Range		-0.5		+5.5	V
CMRR	Common-Mode Rejection Ratio	for V_{IN} from -0.5V to 5.5V	50	70		dB
A_{VOL}	Open-Loop Gain	$-4.5V \leq V_{OUT} \leq 4.5V$	75	90		dB
Output Characteristics						
V_{OL}	Output Swing Low	$I_L = -5mA$		-4.92	-4.85	mV
V_{OH}	Output Swing High	$I_L = 5mA$	4.85	4.92		V
I_{SC}	Short Circuit Current			± 350		mA
I_{OUT}	Output Current			± 100		mA
I_{PK}	Peak Output Current	$V_{S+} = 18V, V_{IN} = V_{S+}/2$ $V_{S-} = 0V$		550		mA
		Source Current: I load V_{OUT} to GND				
		Sink Current: I load V_{OUT} to V_{S+}				
Power Supply Performance						
PSRR	Power Supply Rejection Ratio	V_S is moved from $\pm 2.25V$ to $\pm 7.75V$	60	80		dB
I_S	Supply Current (Per Amplifier)	No Load,		2		mA
Dynamic Performance						
SR	Slew Rate [2]	$-4.0V \leq V_{OUT} \leq 4.0V, 20\% \text{ to } 80\%$		40		$V/\mu s$
t_s	Settling to +0.1% ($AV = +1$)	($AV = +1$), $V_O = 2V$ Step		500		ns
BW	-3dB Bandwidth	$R_L = 10k\Omega, C_L = 10pF$		30		MHz
GBWP	Gain-Bandwidth Product	$R_L = 10k\Omega, C_L = 10pF$		20		MHz
PM	Phase Margin	$R_L = 10k\Omega, C_L = 10pF$		50		Degrees
CS	Channel Separation	$f = 1 \text{ MHz}$		75		dB
TSD	Thermal Shutdown			150		$^\circ C$
1. Measured over operating temperature range 2. Slew rate is measured on rising and falling edges						

TYPICAL PERFORMANCE CURVES

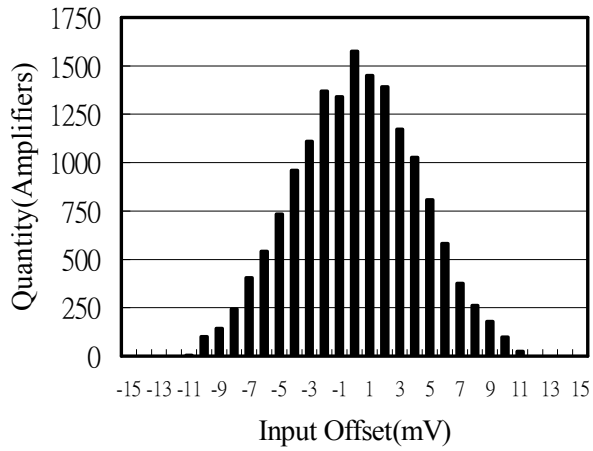


Figure (a) Input Offset Voltage Distribution

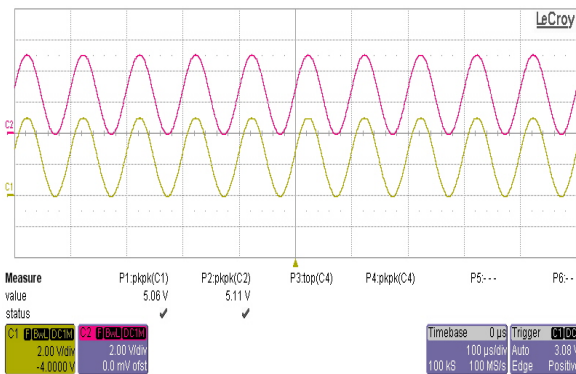


Figure (b) Rail to Rail Capability

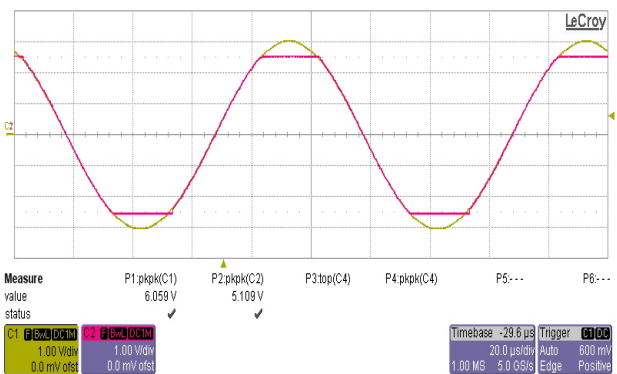


Figure (c) Input beyond the rails

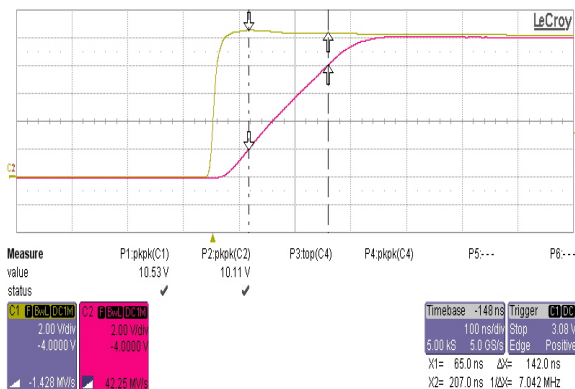


Figure (d) Large Signal Transient Response

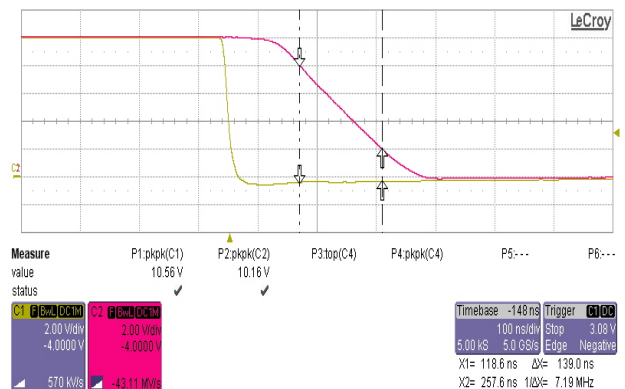


Figure (e) Large Signal Transient Response

APPLICATIONS INFORMATION

Product Description

The EC5604 rail-to-rail quad channels amplifier is built on an advanced high voltage CMOS process. It's beyond rails input capability and full swing of output range made itself an ideal amplifier for use in a wide range of general-purpose applications. The features of 40V/ μ S high slew rate, fast settling time, 20MHz of GBWP as well as high output driving capability have proven the EC5604 a good voltage reference buffer for TFT-LCD for applications. High phase margin make the EC5604 ideal for Connected in voltage follower mode for high drive applications

Supply Voltage, Input Range and Output Swing

The EC5604 can be operated with a single nominal wide supply voltage ranging from 6V to 18V with stable performance over operating temperatures of -40°C to $+85^{\circ}\text{C}$.

With 500mV greater than rail-to-rail input common mode voltage range and 80dB of Common Mode Rejection Ratio, the EC5604 allows a wide range sensing among many applications without having any concerns over exceeding the range and no compromise in accuracy. The output swings of the EC5604 typically extend to within 80mV of positive and negative supply rails with load currents of 5mA. The output voltage swing can be even closer to the supply rails by merely decreasing the load current. Figure 1 shows the input and output waveforms for the device in the unity-gain configuration. The amplifier is operated under $\pm 5\text{V}$ supply with a 10k Ω load connected to GND. The input is a 10Vp-p sinusoid. An approximately 9.985 Vp-p of output voltage swing can be easily achieved.

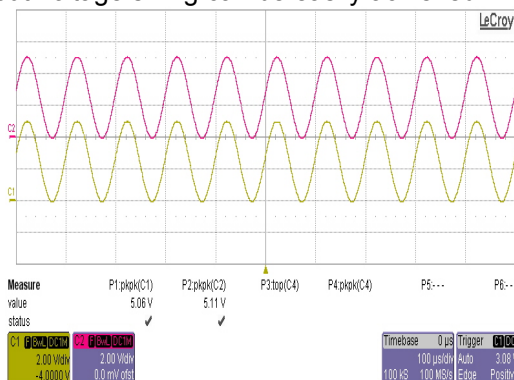


Figure 1. Operation with Rail-to-Rail Input and Output.

Output Short Circuit Current Limit

A $\pm 350\text{mA}$ short circuit current will be limited by the EC5604 if the output is directly shorted to the positive or the negative supply. For an indefinitely output short circuit, the power dissipation could easily increase such that the device may be damaged. The internal metal interconnections are

well designed to prevent the output continuous current from exceeding $\pm 100\text{mA}$ such that the maximum reliability can be well maintained.

Output Phase Reversal

The EC5604 is designed to prevent its output from being phase reversal as long as the input voltage is limited from $V_{S-} - 0.5\text{V}$ to $V_{S+} + 0.5\text{V}$. Figure 2 shows a photo of the device output with its input voltage driven beyond the supply rails. Although the phase of the device's output will not be reversed, the input's over-voltage should be avoided. An improper input voltage exceeds supply range by more than 0.6V may result in an over stress damage.

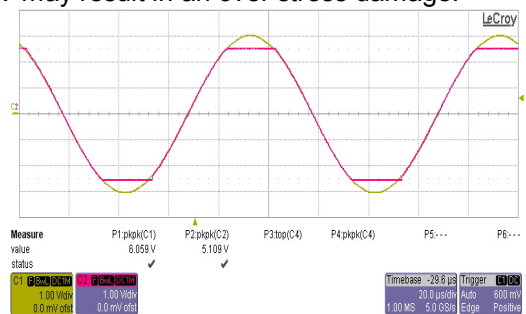


Figure 2. Operation with Beyond-the Rails Input

Power Dissipation

The EC5604 is designed for maximum output current capability. Even though momentary output shorted to ground causes little damage to the device.

For the high drive amplifier EC5604, it is possible to exceed the 'absolute-maximum junction temperature' under certain load current conditions. Therefore, it is important to calculate the maximum junction temperature for the application to determine if load conditions need to be modified for the amplifier to remain in the safe operating area. The maximum power dissipation allowed in a package is determined according to:

$$P_{Dmax} = \frac{T_{Jmax} - T_{Amax}}{\Theta_{JA}}$$

Where:

T_{Jmax} = Maximum Junction Temperature

T_{Amax} = Maximum Ambient Temperature

Θ_{JA} = Thermal Resistance of the Package

P_{Dmax} = Maximum Power Dissipation in the Package.

The maximum power dissipation actually produced by an IC is the total quiescent supply current times the total power supply voltage, plus the power in the IC due to the loads, or:

$$P_{Dmax} = \sum_i [V_S \times I_{Smax} + (V_{S+} - V_O) \times I_L]$$

When sourcing, and

$$P_{Dmax} = \sum_i [V_{S+} \times I_{Smax} + (V_O - V_{S-}) \times I_L]$$

When sinking.

Where:

$i = 1$ to 4

V_S = Total Supply Voltage

I_{Smax} = Maximum Supply Current Per Amplifier

V_O = Maximum Output Voltage of the Application

I_L = Load current

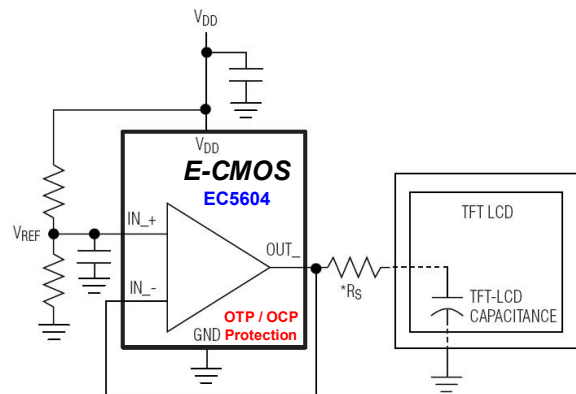
R_L = Load Resistance = $(V_{S+} - V_O) / I_L = (V_O - V_{S-}) / I_L$

Package	θ_{ja} ($^{\circ}C/W$)
TSSOP14	165
TSSOP14 1.98x2.23	75
TSSOP14 3x3	59

Driving Capacitive Loads

The EC5604 is designed to drive a wide range of capacitive loads. In addition, the output current handling capability of the device allows for good slewing characteristics even with large capacitive loads. The combination of these features make the EC5604 ideally for applications such as TFT LCD panel buffers, ADC input amplifiers, etc.

As load capacitance increases on the device output, resulting in additional pole in the op amp's feedback loop. Depending on the application, a small value of series resistance must be placed in series with the output (usually between 5Ω and 50Ω). However, the op amp remains stable because the load capacitance and the series resistance create a zero that cancels the effect of this pole. It improves the performance of the device to ensure stability and fast settling with very large capacitive loads. Figure3. shows the typical application configuration.



* R_S BE NEEDED FOR SOME APPLICATIONS.

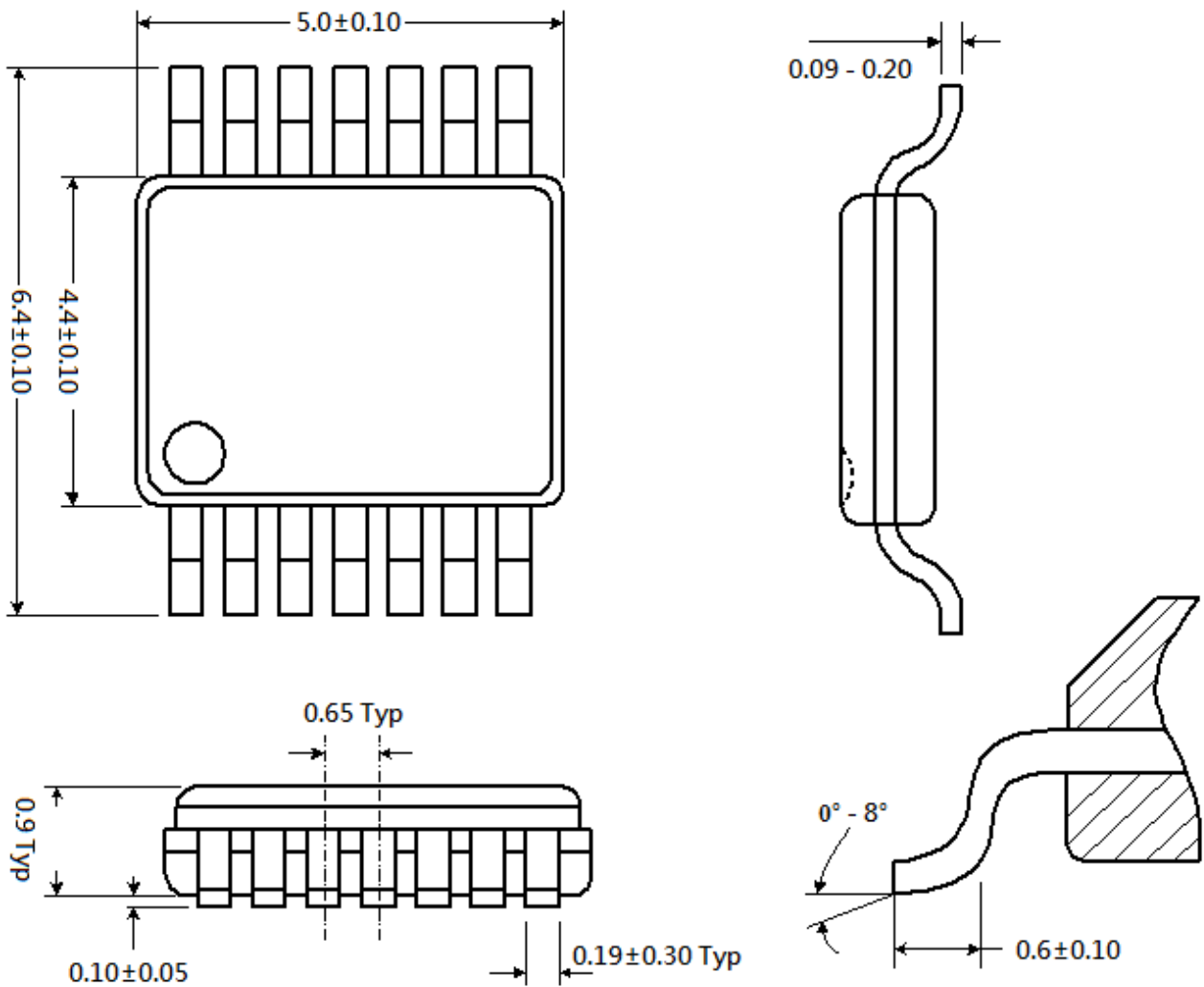
Figure 3. Typical Application Configuration.

Power Supply Bypassing and Printed Circuit Board Layout

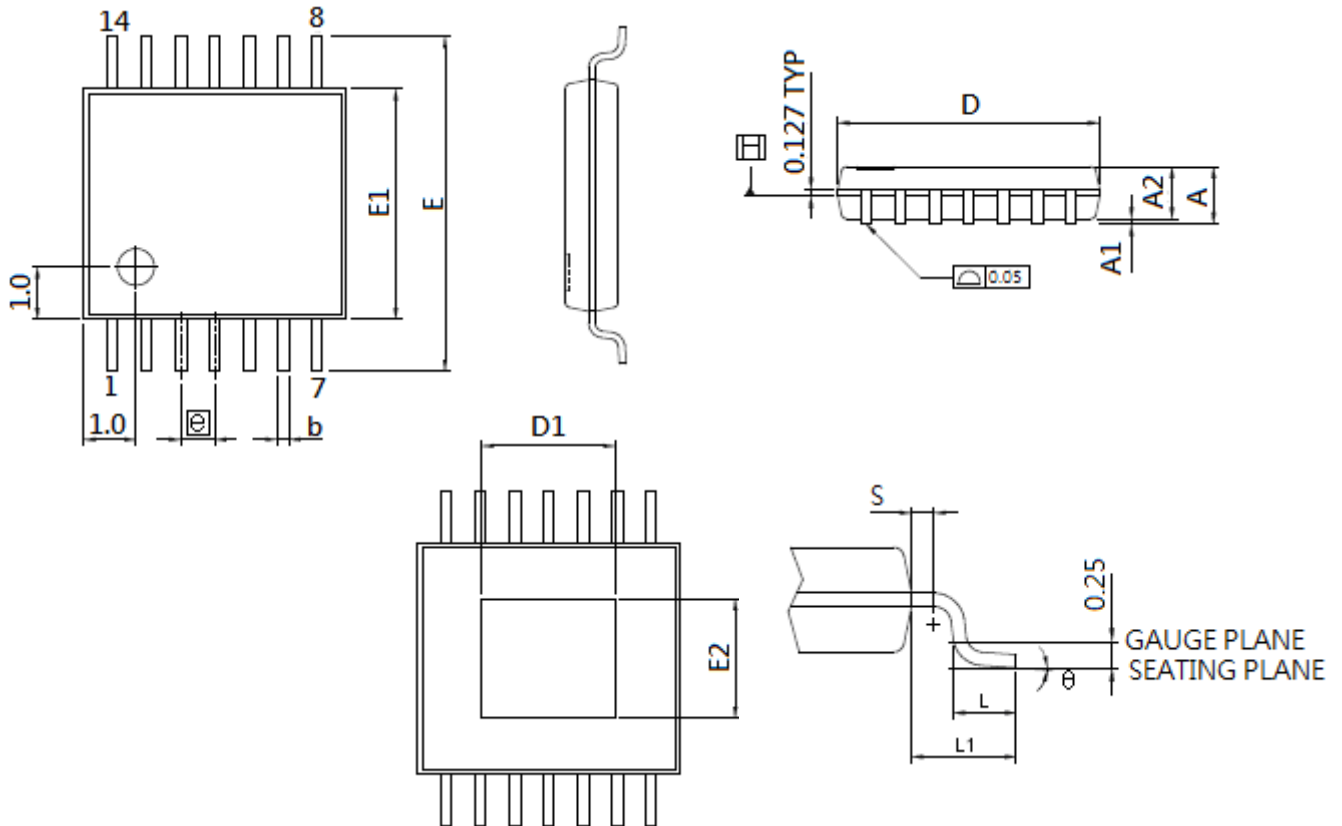
With high phase margin, the EC5604 performs stable gain at high frequency. Like any high-frequency device, good layout of the printed circuit board usually comes with optimum performance. Ground plane construction is highly recommended, lead lengths should be as short as possible and the power supply pins must be well bypassed to reduce the risk of oscillation. For normal single supply operation, where the V_{S-} pin is connected to ground, a $0.1\mu F$ ceramic capacitor should be placed from V_{S+} pin to V_{S-} pin as a bypassing capacitor. A $4.7\mu F$ tantalum capacitor should then be connected in parallel, placed in the region of the amplifier. One $4.7\mu F$ capacitor may be used for multiple devices. This same capacitor combination should be placed at each supply pin to ground if split supplies are to be used.

OUTLINE DIMENSIONS (Dimensions shown in millimeters)

TSSOP (Thin-Shrink Small Outline Package)



TSSOP (Thin-Shrink Small Outline Package, Exposed Pad)



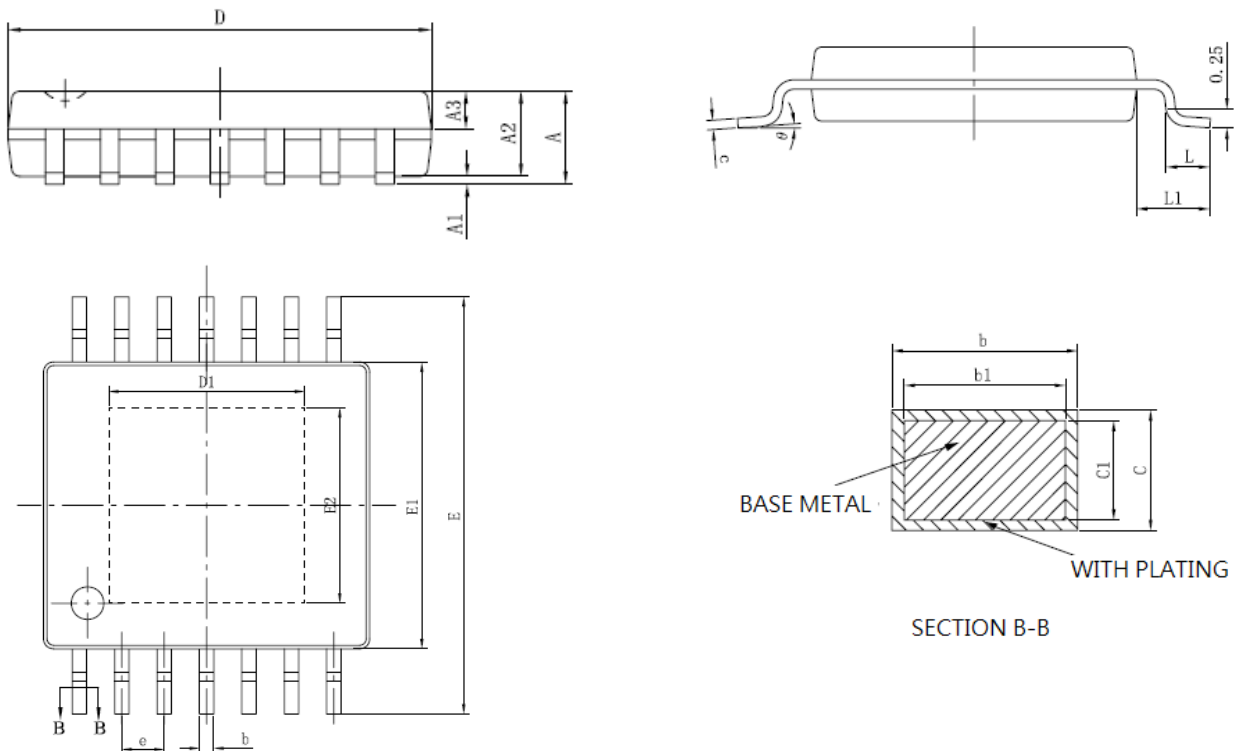
VARIATIONS (ALL DIMENSIONS SHOWN IN MM)

SYMBOLS		MIN.	NOM.	MAX.
A		-	-	1.20
A1	STANDARD	0.05	-	0.15
	THERMALLY ENHANCED	0.00	-	0.15
A2		0.80	1.00	1.05
b		0.19	-	0.30
D		4.90	5.00	5.10
D1		1.92	2.23	2.54
E2		1.67	1.98	2.29
E1		4.30	4.40	4.50
E		6.40 BSC		
e		0.65 BSC		
L1		1.00 BSC		
L		0.50	0.60	0.75
S		0.20	-	-
θ		0°	-	8°

NOTES:

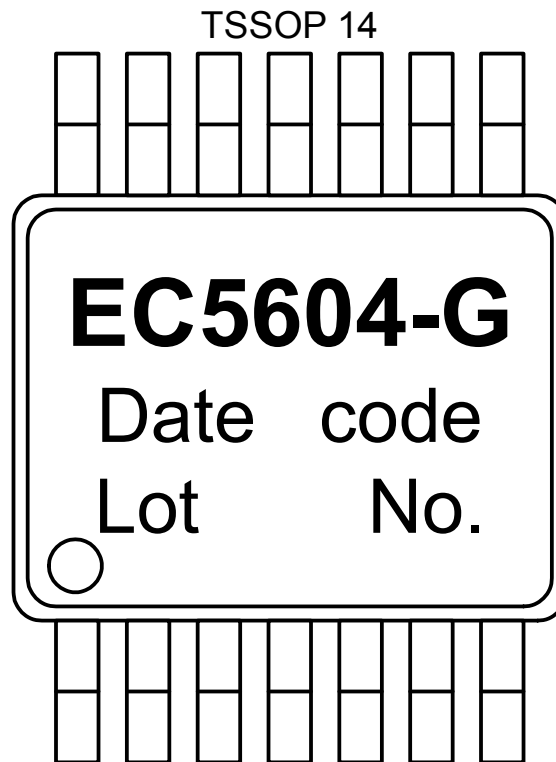
- JEDEC OUTLINE
STANDARD: MO-153 AB-1
THERMALLY ENHANCED: MO-153 ABT-1
- DIMENSION 'D' DOES NOT INCLUDE MOLD FLASH. PROTRUSION OR GATE BURRS. MOLD FLASH. PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.15 PER SIDE.
- DIMENSION 'E1' DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 PER SIDE.
- DIMENSION 'b' DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08MM TOTAL IN EXCESS OF THE 'b' DIMENSION AT MAXIMUM MATERIAL CONDITION. DAMBAR CANNOT BE LOCATED ON THE LOWER RADIUS OF THE FOOT. MINIMUM SPACE BETWEEN PROTRUSION AND ADJACENT LEAD IS 0.07 MM.
- DIMENSIONS 'D' AND 'E1' TO BE DETERMINED AT DATUM PLANE \square

TSSOP (Thin-Shrink Small Outline Package, Exposed Pad)



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	-	-	1.20
A1	0.05	-	0.15
A2	0.90	1.00	1.05
A3	0.39	0.44	0.49
b	0.20	-	0.30
b1	0.19	0.22	0.25
c	0.13	-	0.19
c1	0.12	0.13	0.14
D	4.86	4.96	5.06
D1	2.90	3.00	3.10
E2	2.90	3.00	3.10
E1	4.30	4.40	4.50
E	6.25	6.40	6.55
e	0.65BSC		
L	0.45	-	0.75
L1	1.00BSC		
θ	0	-	8°

PACKAGE MARKING INDICATION



ORDERING INFORMATION

PART NUMBER	TOP MARK	PACKAGE
EC5604I-G	EC5604-G	Green mode TSSOP-14
EC5604I-HG	EC5604HG	Green mode TSSOP-14(EP Size: 1.98mm x 2.23mm)
EC5604I-H1G	EC5604H1	Green mode TSSOP-14(EP Size: 3mm x 3mm)



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