

### ■ FEATURES

- **Wide supply voltage range 4.5V ~ 18V**
- **Input range 500mV beyond the rails**
- **Unity-gain stable**
- **Rail-to-rail output swing**
- **High slew rate 3.2V/μs**
- **GBWP 3.5 MHz**
- **6 MHz -3dB Bandwidth**
- **Ultra-small Package TSSOP-14**

### ■ APPLICATIONS

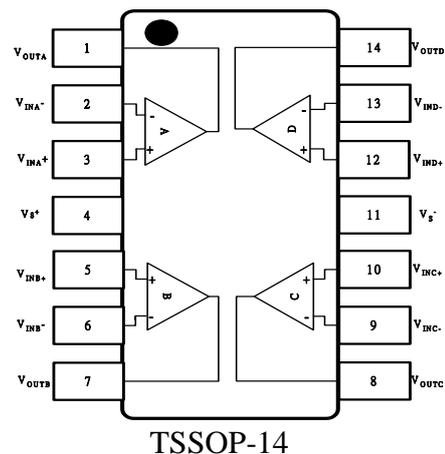
- **TFT-LCD Reference Driver**
- **Touch-Screen Display**
- **Wireless LANs**
- **Personal Communication Devices**
- **Direct Access Arrangement**
- **Personal Digital Assistant (PDA)**
- **Active Filter**
- **Sampling ADC Amplifier**
- **ADC/DAC Buffer**
- **Electronic Notebook**
- **Office Automation**

### ■ GENERAL DESCRIPTION

The EC5534 is a 100mA output current rail-to-rail quad channels operational amplifier with wide supply range from 4.5V to 18V while consumes only 1.1mA 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 3.5MHz gain bandwidth product allows EC5534 to perform more stable than other devices in Internet applications.

With features of 3.2V/μs high slew rate and 1.3 μs of fast settling time, as well as 100mA (sink and source) of high output driving capability, the EC5534 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, EC5534 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 EC5534 is offered in space saving 14-Pin TSSOP package and specified over the -40°C to +85°C temperature range.

### ■ PIN ASSIGNMENT





# 18V 100mA Output Current Rail-to-Rail Quad Operational Amplifiers

EC5534

## ■ 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: TJ = TC = TA

## ■ 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
<b>Input Characteristics</b>						
$V_{OS}$	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		$G\Omega$
$C_{IN}$	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	$0.5V \leq V_{OUT} \leq 4.5V$	75	100		dB
<b>Output Characteristics</b>						
$V_{OL}$	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			$\pm 300$		mA
$I_{OUT}$	Output Current			$\pm 100$		mA
<b>Power Supply Performance</b>						
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		1.5	1.7	mA
<b>Dynamic Performance</b>						
SR	Slew Rate [2]	$-4.0V \leq V_{OUT} \leq 4.0V,$ 20% to 80%		3.2		$V/\mu s$
$t_s$	Settling to +0.1% ( $AV = +1$ )	( $AV = +1$ ), $V_O = 2V$ Step		1.3		$\mu s$
BW	-3dB Bandwidth	$R_L = 10k\Omega, C_L = 10pF$		6		MHz
GBWP	Gain-Bandwidth Product	$R_L = 10k\Omega, C_L = 10pF$		3.5		MHz
PM	Phase Margin	$R_L = 10k\Omega, C_L = 10 pF$		60		Degrees
CS	Channel Separation	$f = 1 MHz$		75		dB
1. Measured over operating temperature range 2. Slew rate is measured on rising and falling edges						

### ■ TYPICAL PERFORMANCE CURVES

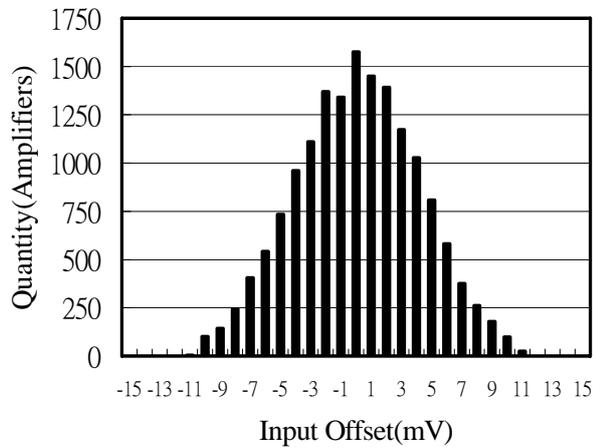


Figure (a) Input Offset Voltage Distribution

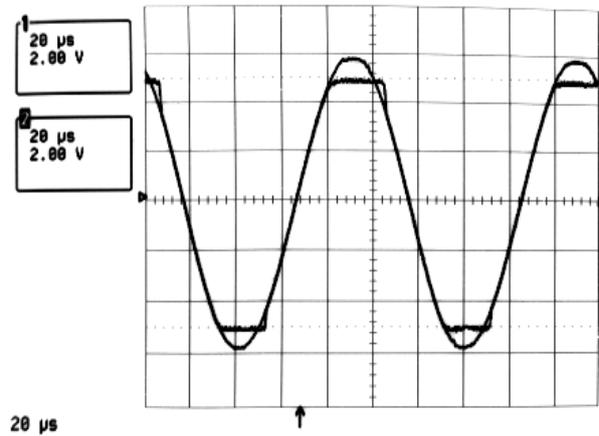


Figure (b) Input beyond the rails

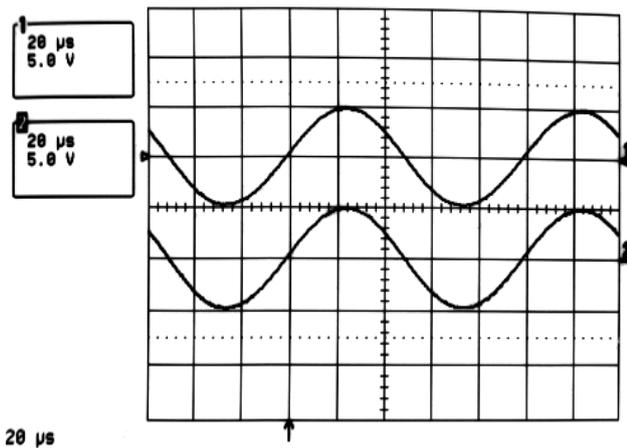


Figure (c) Rail to Rail Capability

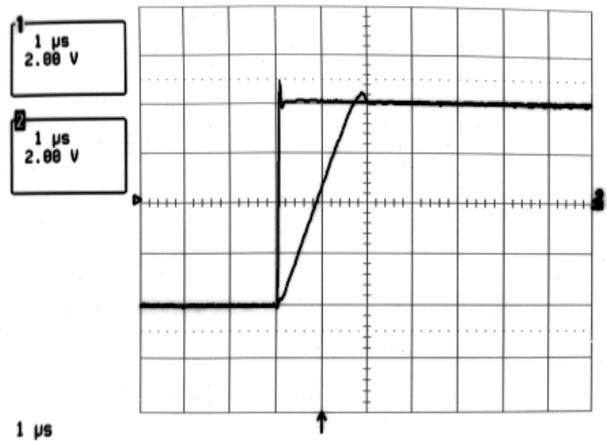


Figure (d) Large Signal Transient Response

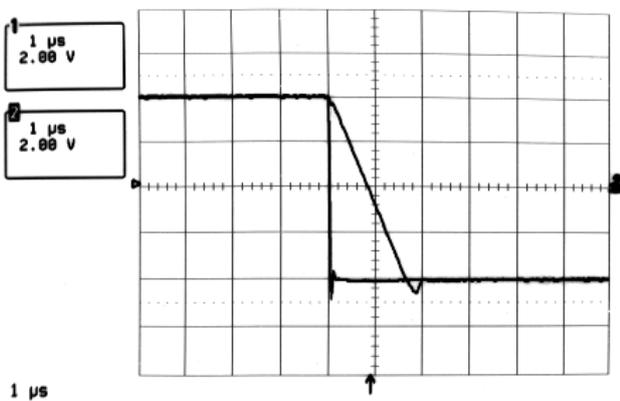


Figure (e) Large Signal Transient Response

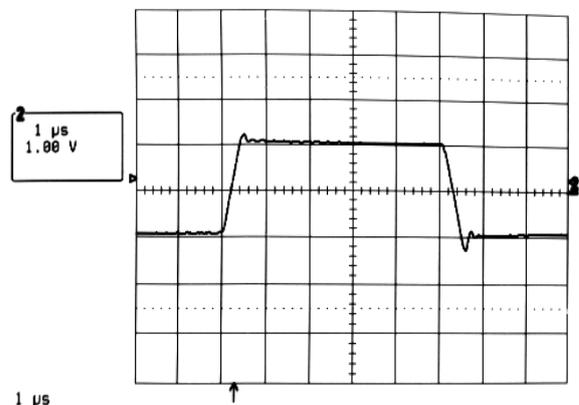


Figure (f) Small Signal Transient Response

### TYPICAL PERFORMANCE CURVES

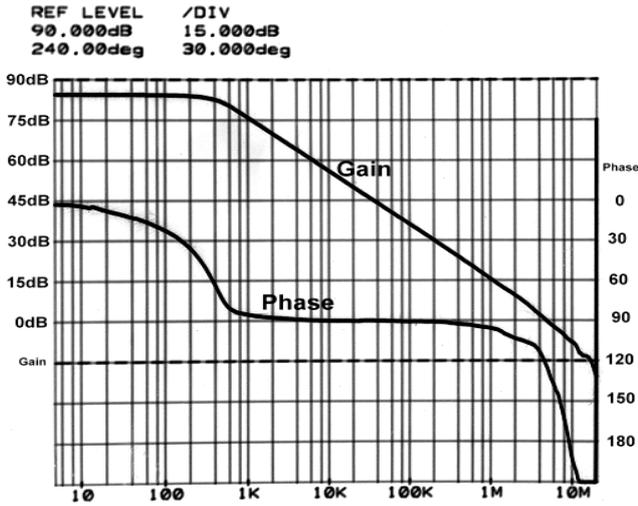


Figure (g) Open Loop Gain & Phase vs. Frequency

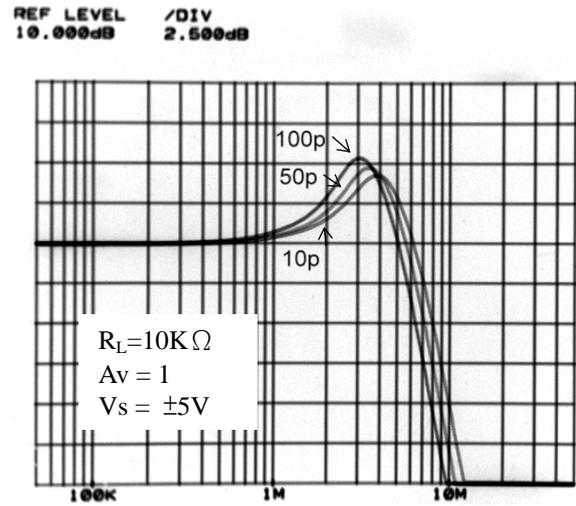


Figure (h) Frequency Response for Various  $C_L$

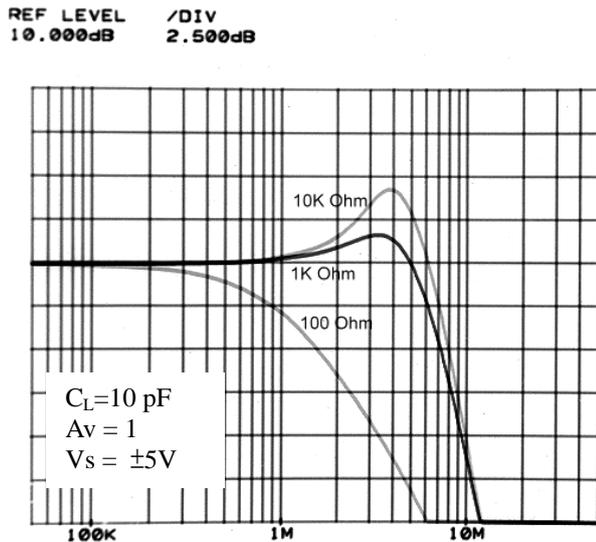


Figure (h) Frequency Response for Various  $R_L$

### ■ APPLICATIONS INFORMATION

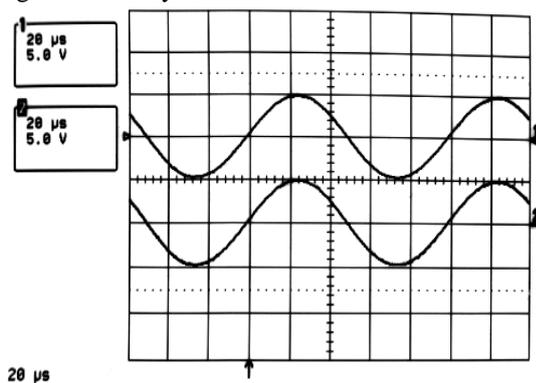
#### Product Description

The EC5534 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 3.2V/μS high slew rate, fast settling time, 3.5MHz of GBWP as well as high output driving capability have proven the EC5534 a good voltage reference buffer for TFT-LCD for applications. High phase margin make the EC5534 ideal for Connected in voltage follower mode for high drive applications

#### Supply Voltage, Input Range and Output Swing

The EC5534 can be operated with a single nominal wide supply voltage ranging from 4.5V to 18V with stable performance over operating temperatures of -40 °C to +85 °C.

With 500mV greater than rail-to-rail input common mode voltage range and 70dB of Common Mode Rejection Ratio, the EC5534 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 EC5534 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 ±5V supply with a 10kΩ 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**

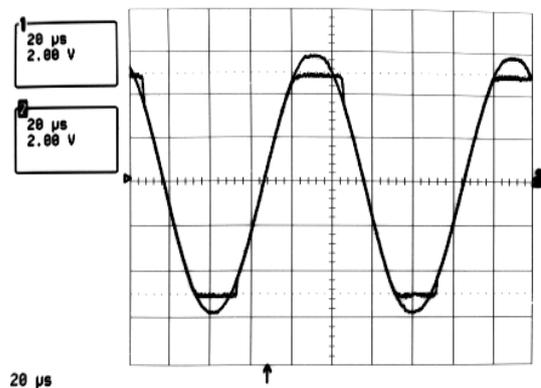
#### Output Short Circuit Current Limit

A +/-300mA short circuit current will be limited by the EC5534 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 +/-100 mA such that the maximum reliability can be well maintained.

#### Output Phase Reversal

The EC5534 is designed to prevent its output from being phase reversal as long as the input voltage is limited from  $V_{S-} - 0.5V$  to  $V_{S+} + 0.5V$ . 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 EC5534 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 EC5534, 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

$\Theta_{JA}$  = 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:

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

When sourcing, and

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

When sinking.

Where:

$i = 1$  to 4

$V_S$  = Total Supply Voltage

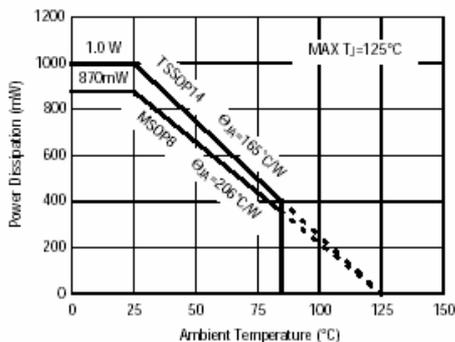
$I_{Smax}$  = Maximum Supply Current Per Amplifier

$V_O$  = Maximum Output Voltage of the Application

$I_L$  = Load current

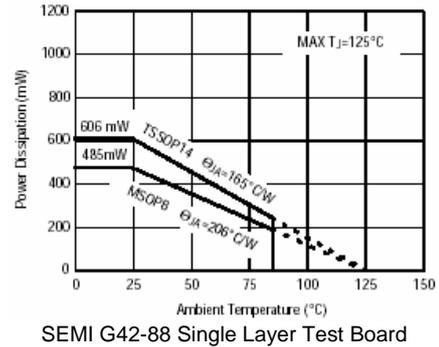
$R_L$  = Load Resistance =  $(V_{S+} - V_O) / I_L = (V_O - V_{S-}) / I_L$

A calculation for  $R_L$  to prevent device from overheat can be easily solved by setting the two  $P_{Dmax}$  equations equal to each other. Figure 3 and Figure 4 show the relationship between package power dissipation and ambient temperature under the JEDEC JESD 51-7 high effective thermal conductivity test board and SEMI G42-88 single layer test board respectively. From these charts, conditions of the device overheat then can be easily found. The maximum safe power dissipation can be found graphically, based on the package type and the ambient temperature. By using the previous equation, it is a simple matter to see if  $P_{Dmax}$  exceeds the device's power de-rating curves. To ensure proper operation, it is important to observe the recommended de-rating curves shown in Figure 3 and Figure 4.



JEDEC JESD 51-7 High Effective Thermal Conductivity Test Board

**Figure 3. Package Power Dissipation vs. Ambient Temperature**



**Figure 4. Package Power Dissipation vs. Ambient Temperature**

### Driving Capacitive Loads

The EC5534 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 EC5534 ideally for applications such as TFT LCD panel buffers, ADC input amplifiers, etc.

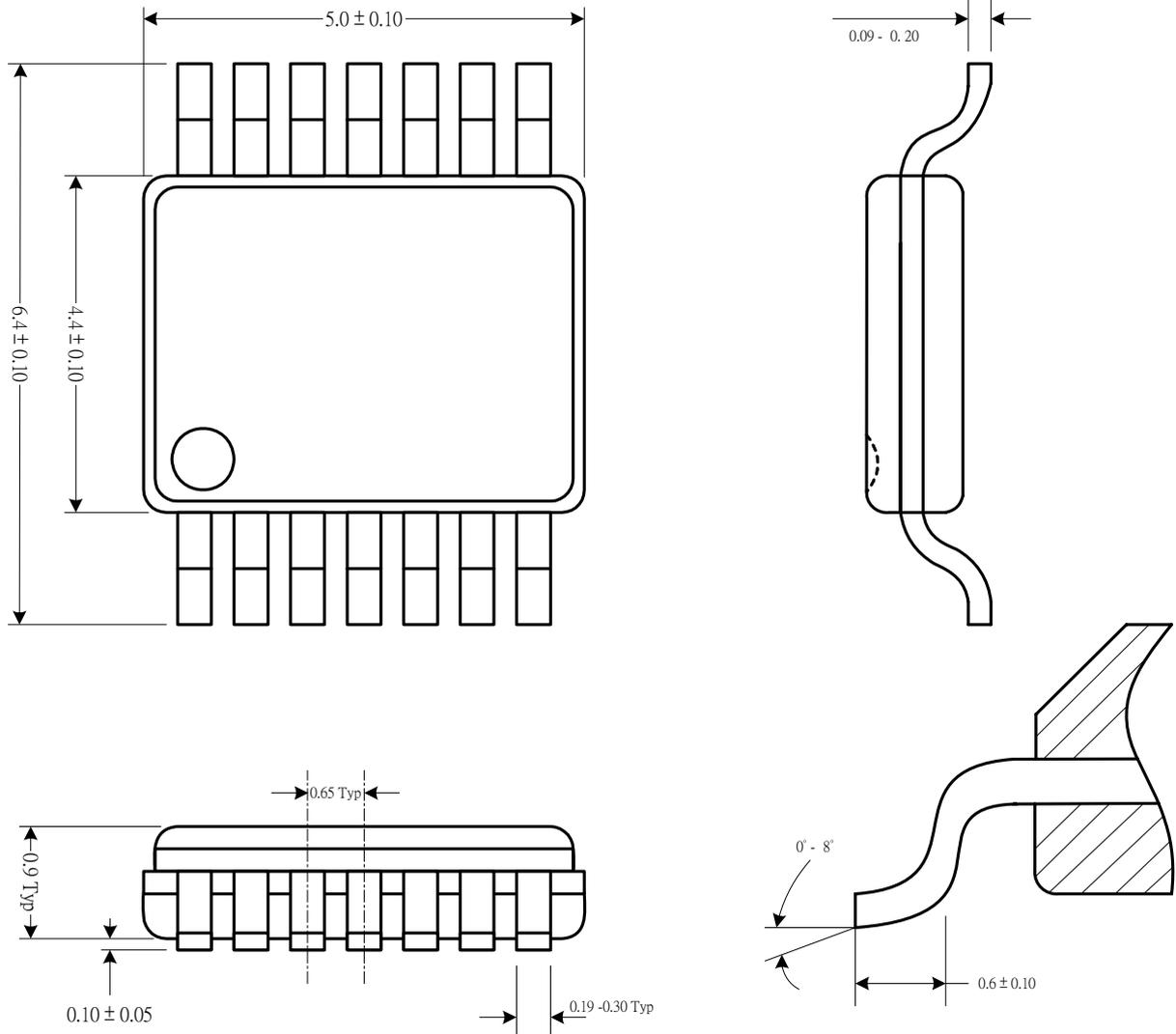
As load capacitance increases, however, the -3dB bandwidth of the device will decrease and the peaking increase. The amplifiers drive 10pF loads in parallel with 10 kΩ with just 1.5dB of peaking, and 100pF with 6.4dB of peaking. If less peaking is desired in these applications, a small series resistor (usually between 5 Ω and 50 Ω) can be placed in series with the output. However, this will obviously reduce the gain slightly. Another method of reducing peaking is to add a "snubber" circuit at the output. A snubber is a shunt load consisting of a resistor in series with a capacitor. Values of 150Ω and 10nF are typical. The advantage of a snubber is that it improves the settling and overshooting performance while does not draw any DC load current or reduce the gain.

### Power Supply Bypassing and Printed Circuit Board Layout

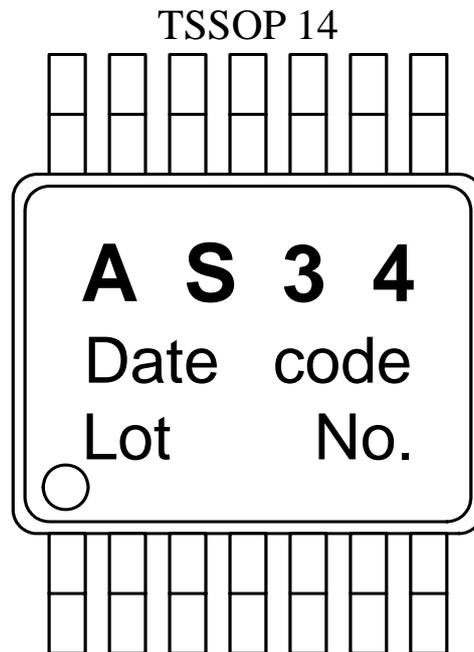
With high phase margin, the EC5534 performs stable gain at high frequency. Like any high-frequency device, good layout of the printed circuit board usually comes with optimum performance. Ground plane construction is highly recommended, lead lengths should be as short as possible and the power supply 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 μF ceramic capacitor should be placed from  $V_{S+}$  pin to  $V_{S-}$  pin as a bypassing capacitor. A 4.7μF tantalum capacitor should then be connected in parallel, placed in the region of the amplifier. One 4.7μF 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)**



■ **PACKAGE MARKING INDICATION**



■ **ORDERING INFORMATION**

PART NUMBER	TOP MARK	PACKAGE
EC5534I	AS34	14-Pin TSSOP
EC5534I-F	AS34-F	Leadfree 14-pin TSSOP
EC5534I-G	AS34-G	Green mode TSSOP-14



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