

350kHz, Zero-Drift, CMOS, Rail-to-Rail Operational Amplifier

Advanced

1. Features

- Single-Supply Operation from +2.2V ~ +5.5V
- Rail-to-Rail Input / Output
- Gain-Bandwidth Product: 350kHz (Typ.)
- Low Input Bias Current: 10pA (Typ.)
- Low Offset Voltage: 20 μ V (Max.)
- Zero Drift: 0.05 μ V/ $^{\circ}$ C (Max.)
- Quiescent Current: 20 μ A (Typ.)
- Operating Temperature: -40 $^{\circ}$ C ~ +125 $^{\circ}$ C
- Available in SOT23-5 and SOP8 Packages

2. General Description

The GT7131 amplifier is single supply, micro-power, zero-drift CMOS operational amplifier, the amplifier offer bandwidth of 350kHz, rail-to-rail inputs and outputs, and single-supply operation from 2.2V to 5.5V. GT7131 uses chopper stabilized technique to provide very low offset voltage (less than 20 μ V maximum) and near zero drift over temperature. Low quiescent supply current of 20 μ A and very low input bias current of 10pA make the devices an ideal choice for low offset, low power consumption and high impedance applications. The single GT7131 is available in space-saving, SOT23-5 and SOP-8 package. The extended temperature range of -40 $^{\circ}$ C to +125 $^{\circ}$ C over all supply voltages offers additional design flexibility.

3. Applications

- Portable Equipment
- Mobile Communications
- Smoke Detector
- Sensor Interface
- Medical Instrumentation
- Battery-Powered Instruments
- Handheld Test Equipment

4. Pin Configuration

4.1 GT7131 SOT23-5 and SOP8 (Top View)

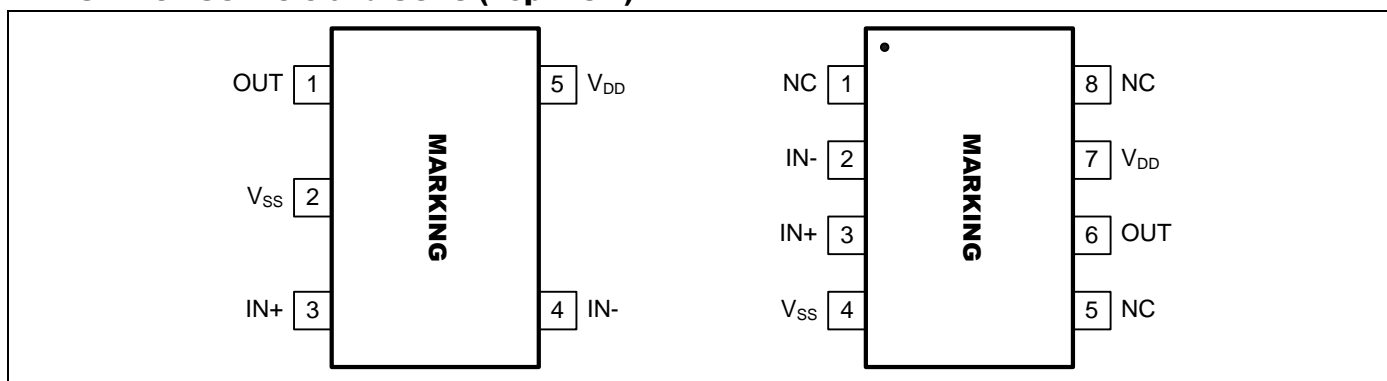


Figure 1. Pin Assignment Diagram (SOP23-5 and SOP8 Package)

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Note: Please see section “**Part Markings**” for detailed Marking Information.



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5. Application Information

5.1 Size

GT7131 series op amps are unity-gain stable and suitable for a wide range of general-purpose applications. The small footprints of the GT7131 series packages save space on printed circuit boards and enable the design of smaller electronic products.

5.2 Power Supply Bypassing and Board Layout

GT7131 series operates from a single 2.2V to 5.5V supply or dual $\pm 1.1V$ to $\pm 2.75V$ supplies. For best performance, a $0.1\mu F$ ceramic capacitor should be placed close to the V_{DD} pin in single supply operation. For dual supply operation, both V_{DD} and V_{SS} supplies should be bypassed to ground with separate $0.1\mu F$ ceramic capacitors.

5.3 Low Supply Current

The low supply current (typical $20\mu A$) of GT7131 series will help to maximize battery life. They are ideal for battery powered systems

5.4 Operating Voltage

GT7131 series operate under wide input supply voltage (2.2V to 5.5V). In addition, all temperature specifications apply from $-40^{\circ}C$ to $+125^{\circ}C$. Most behavior remains unchanged throughout the full operating voltage range. These guarantees ensure operation throughout the single Li-Ion battery lifetime

5.5 Rail-to-Rail Input

The input common-mode range of GT7131 series extends 100mV beyond the supply rails ($V_{SS}-0.1V$ to $V_{DD}+0.1V$). This is achieved by using complementary input stage. For normal operation, inputs should be limited to this range.

Normally, input bias current is about 10pA; however, if the input voltages exceed the power supplies, excessive current can flow into or out of the pins. Momentary voltages greater than the power supply can be tolerated if the input current is limited to 10mA. This limitation can be accomplished with an $5k\Omega$ series input resistor.

5.6 Rail-to-Rail Output

Rail-to-Rail output swing provides maximum possible dynamic range at the output. This is particularly important when operating in low supply voltages. The output voltage of GT7131 series can typically swing to less than 10mV from supply rail in light resistive loads ($>100k\Omega$), and 60mV of supply rail in moderate resistive loads ($10k\Omega$).

5.7 Capacitive Load Tolerance

The GT7131 series can directly drive 250pF capacitive load in unity-gain without oscillation. Increasing the gain enhances the amplifier's ability to drive greater capacitive loads. In unity-gain configurations, the capacitive load drive can be improved by inserting an isolation resistor R_{ISO} in series with the capacitive load, as shown in **Figure 2**.

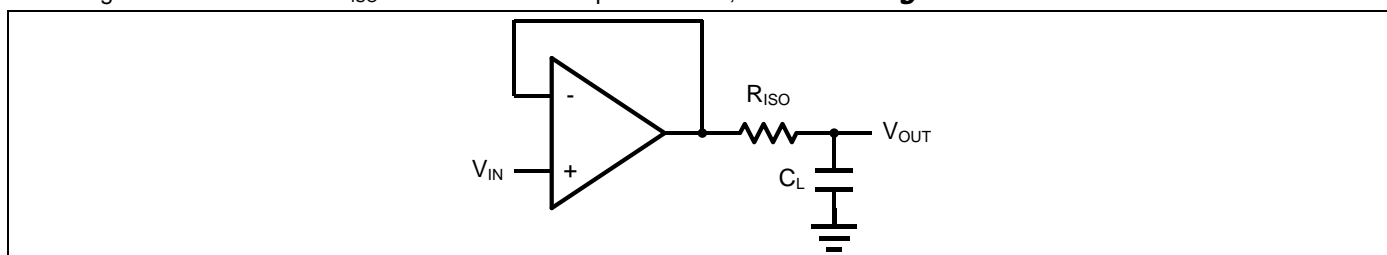


Figure 2. Indirectly Driving a Capacitive Load Using Isolation Resistor

The bigger the R_{ISO} resistor value, the more stable V_{OUT} will be. However, if there is a resistive load R_L in parallel with the capacitive load, a voltage divider (proportional to R_{ISO}/R_L) is formed, this will result in a gain error.

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The circuit in **Figure 3** is an improvement to the one in **Figure 2**. R_F provides the DC accuracy by feed-forward the V_{IN} to R_L . C_F and R_{ISO} serve to counteract the loss of phase margin by feeding the high frequency component of the output signal back to the amplifier's inverting input, thereby preserving the phase margin in the overall feedback loop. Capacitive drive can be increased by increasing the value of C_F . This in turn will slow down the pulse response.

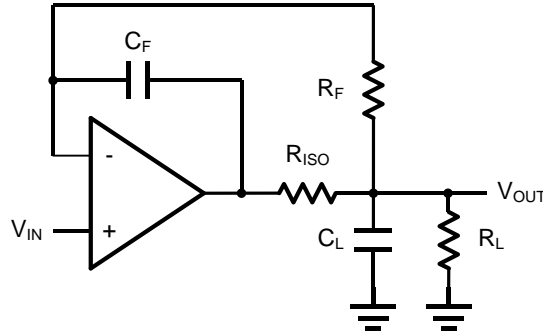


Figure 3. Indirectly Driving a Capacitive Load with DC Accuracy

5.8 Differential amplifier

The differential amplifier allows the subtraction of two input voltages or cancellation of a signal common the two inputs. It is useful as a computational amplifier in making a differential to single-end conversion or in rejecting a common mode signal. **Figure 4.** shown the differential amplifier using GT7131.

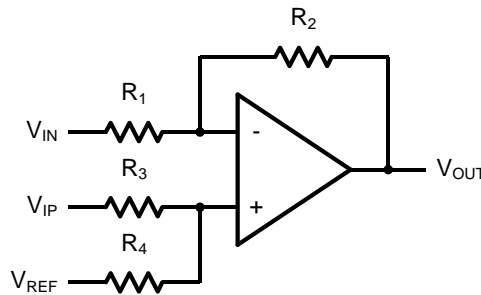


Figure 4. Differential Amplifier

$$V_{OUT} = \left(\frac{R_1+R_2}{R_3+R_4} \right) \frac{R_4}{R_1} V_{IN} - \frac{R_2}{R_1} V_{IP} + \left(\frac{R_1+R_2}{R_3+R_4} \right) \frac{R_3}{R_1} V_{REF}$$

If the resistor ratios are equal (i.e. $R_1=R_3$ and $R_2=R_4$), then

$$V_{OUT} = \frac{R_2}{R_1} (V_{IP} - V_{IN}) + V_{REF}$$

5.9 Instrumentation Amplifier

The input impedance of the previous differential amplifier is set by the resistors R_1 , R_2 , R_3 , and R_4 . To maintain the high input impedance, one can use a voltage follower in front of each input as shown in the following two instrumentation amplifiers.

5.10 Three-Op-Amp Instrumentation Amplifier

The triple GT7131 can be used to build a three-op-amp instrumentation amplifier as shown in **Figure 5**.

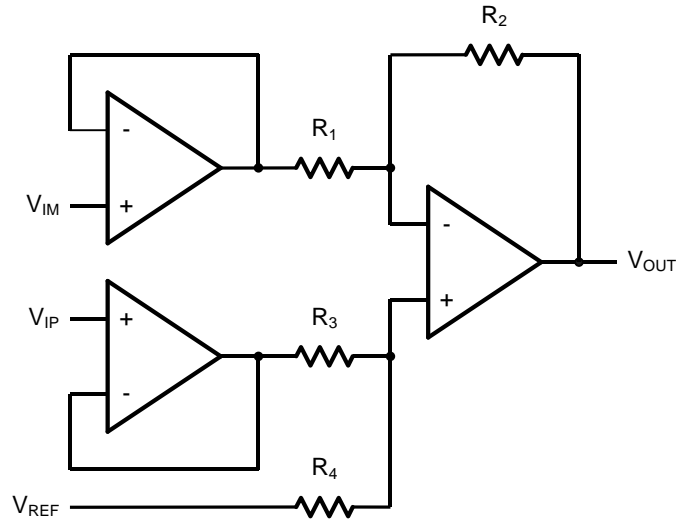


Figure 5. Three-Op-Amp Instrumentation Amplifier

The amplifier in **Figure 5** is a high input impedance differential amplifier with gain of R_2/R_1 . The two differential voltage followers assure the high input impedance of the amplifier.

$$V_o = (1 + \frac{R_4}{R_3})(V_{IP} - V_{IN})$$

5.11 Two-Op-Amp Instrumentation Amplifier

GT7131 can also be used to make a high input impedance two-op-amp instrumentation amplifier as shown in **Figure 6**.

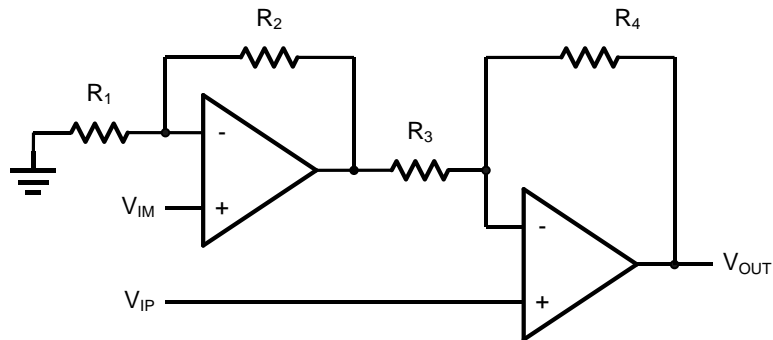


Figure 6. Two-Op-Amp Instrumentation Amplifier

Where $R_1=R_3$ and $R_2=R_4$. If all resistors are equal, then $V_o=2(V_{IP}-V_{IN})$

5.12 Single-Supply Inverting Amplifier

The inverting amplifier is shown in Figure 6. The capacitor C_1 is used to block the DC signal going into the AC signal source V_{IN} . The value of R_1 and C_1 set the cut-off frequency to $f_C = 1/(2\pi R_1 C_1)$. The DC gain is defined by $V_{OUT} = -(R_2/R_1)V_{IN}$

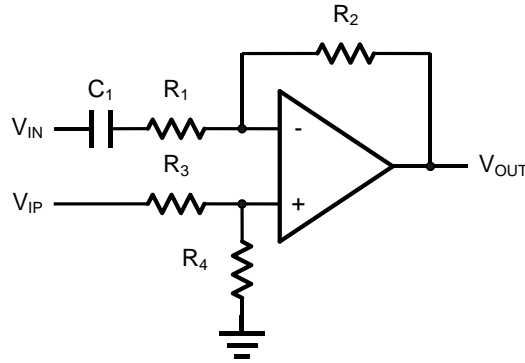


Figure 7. Single Supply Inverting Amplifier

5.13 Low Pass Active Filter

The low pass active filter is shown in **Figure 8**. The DC gain is defined by $-R_2/R_1$. The filter has a -20dB/decade roll-off after its corner frequency $f_C = 1/(2\pi R_3 C_1)$.

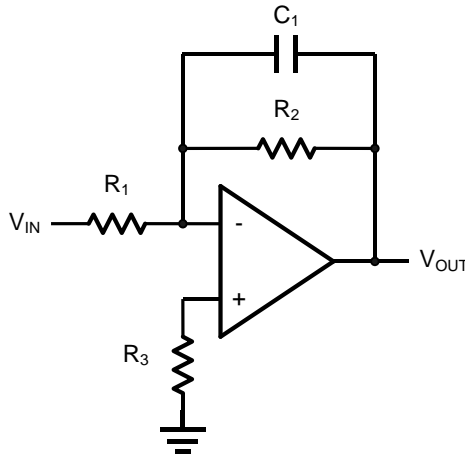


Figure 8. Low Pass Active Filter

5.14 Sallen-Key 2nd Order Active Low-Pass Filter

GT7131 can be used to form a 2nd order Sallen-Key active low-pass filter as shown in **Figure 9**. The transfer function from V_{IN} to V_{OUT} is given by

$$\frac{V_{OUT}}{V_{IN}}(S) = \frac{\frac{1}{C_1 C_2 R_1 R_2} A_{LP}}{S^2 + S \left(\frac{1}{C_1 R_1} + \frac{1}{C_1 R_2} + \frac{1}{C_2 R_2} - \frac{A_{LP}}{C_2 R_2} \right) + \frac{1}{C_1 C_2 R_1 R_2}}$$

Where the DC gain is defined by $A_{LP} = 1 + R_3/R_4$, and the corner frequency is given by

$$\omega_C = \sqrt{\frac{1}{C_1 C_2 R_1 R_2}}$$

The pole quality factor is given by

$$\frac{\omega C}{Q} = \frac{1}{C_1 R_1} + \frac{1}{C_1 R_2} + \frac{1}{C_2 R_2} - \frac{A_{LP}}{C_2 R_2}$$

Let $R_1=R_2=R$ and $C_1=C_2=C$, the corner frequency and the pole quality factor can be simplified as below

$$\omega_C = \frac{1}{CR}$$

And $Q=2-R_3/R_4$

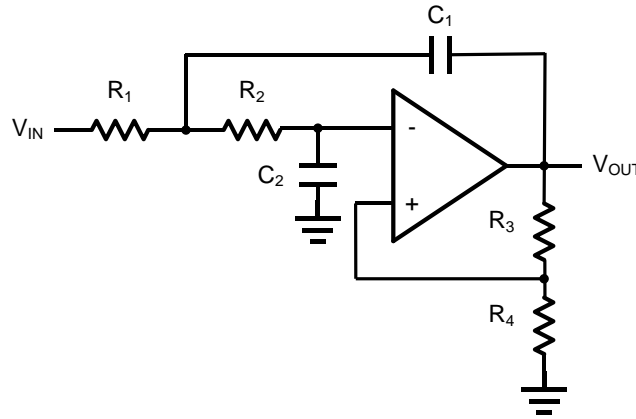


Figure 9. Sallen-Key 2nd Order Active Low-Pass Filter

5.15 Sallen-Key 2nd Order high-Pass Active Filter

The 2nd order Sallen-key high-pass filter can be built by simply interchanging those frequency selective components R_1 , R_2 , C_1 , and C_2 as shown in **Figure 10**.

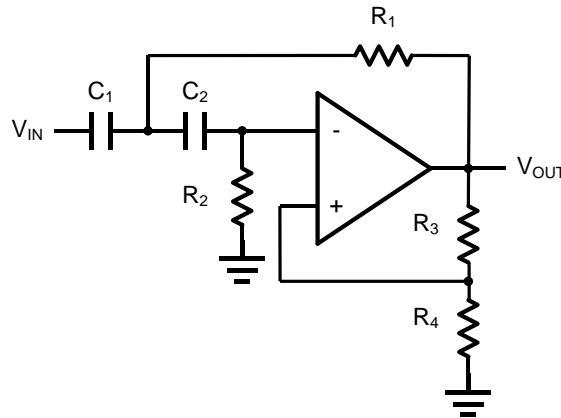


Figure 10. Sallen-Key 2nd Order Active High-Pass Filter

$$\frac{V_{OUT}}{V_{IN}}(S) = \frac{S^2 A_{HP}}{S^2 + S\left(\frac{1}{C_1 R_1} + \frac{1}{C_2 R_2} + \frac{1-A_{HP}}{C_1 R_1}\right) + \frac{1}{C_1 C_2 R_1 R_2}}$$

Where $A_{HP}=1+R_3/R_4$



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6. Electrical Characteristics

6.1 Absolute Maximum Ratings

Condition	Min	Max
Power Supply Voltage (V _{DD} to V _{SS})	-0.5V	+7V
Analog Input Voltage (IN+ or IN-)	V _{SS} -0.5V	V _{DD} +0.5V
PDB Input Voltage	V _{SS} -0.5V	+7V
Operating Temperature Range	-40°C	+125°C
Junction Temperature	+150°C	
Storage Temperature Range	-65°C	+150°C
Lead Temperature (soldering, 10sec)	+300°C	
Package Thermal Resistance (T _A =+25°C)		
SOP23-5, θ _{JA}	190°C	
SOP8, θ _{JA}	130°C	

Note: Stress greater than those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions outside those indicated in the operational sections of this specification are not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.



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6.2 Electrical Characteristics

($V_{DD} = +5V$, $V_{SS} = 0V$, $V_{CM} = 0V$, $V_{OUT} = V_{DD}/2$, $R_L = 100K$ tied to $V_{DD}/2$, $SHDNB = V_{DD}$, $T_A = -40^{\circ}C$ to $+125^{\circ}C$, unless otherwise noted. Typical values are at $T_A = +25^{\circ}C$.) (Notes 1)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Supply-Voltage Range	V_{DD}	Guaranteed by the PSRR test	2.2	-	5.5	V
Quiescent Supply Current (per Amplifier)		$V_{DD} = 5V$	14	20	26	μA
Input Offset Voltage	V_{OS}		-	-	± 20	μV
Input Offset Voltage Tempco	$\Delta V_{OS}/\Delta T$		-	-	0.05	$\mu V/^{\circ}C$
Input Bias Current	I_B	(Note 2)	-	10	-	pA
Input Offset Current	I_{OS}	(Note 2)	-	10	-	pA
Input Common-Mode Voltage Range	V_{CM}		-0.1	-	$V_{DD}+0.1$	V
Common-Mode Rejection Ratio	CMRR	$V_{DD}=5.5$ $V_{SS}-0.1V \leq V_{CM} \leq V_{DD}+0.1V$	90	110	-	dB
		$V_{SS} \leq V_{CM} \leq 5V$	95	115	-	dB
Power-Supply Rejection Ratio	PSRR	$V_{DD} = +2.5V$ to $+5.5V$	85	105	-	dB
Open-Loop Voltage Gain	A_V	$V_{DD}=5V$, $R_L=100k\Omega$, $0.05V \leq V_O \leq 4.95V$	100	120	-	dB
Output Voltage Swing	V_{OUT}	$ V_{IN+}-V_{IN-} \geq 10mV$ $V_{DD}-V_{OH}$	-	6	-	mV
		$R_L = 100k\Omega$ to $V_{DD}/2$ $V_{OL}-V_{SS}$	-	6	-	mV
		$ V_{IN+}-V_{IN-} \geq 10mV$ $V_{DD}-V_{OH}$	-	60	-	mV
		$R_L = 5k\Omega$ to $V_{DD}/2$ $V_{OL}-V_{SS}$	-	60	-	mV
Output Short-Circuit Current	I_{SC}	Sinking or Sourcing	-	± 5	-	mA
Gain Bandwidth Product	GBW	$A_V = +1V/V$	-	350	-	kHz
Slew Rate	SR	$A_V = +1V/V$	-	0.1	-	V/ μs
Settling Time	t_s	To 0.1%, $V_{OUT} = 2V$ step $A_V = +1V/V$	-	20	-	μs
Over Load Recovery Time		$V_{IN} \times \text{Gain} = V_S$	-	100	-	μs
Input Voltage Noise Density	e_n	$f = 1kHz$	-	30	-	nV/ \sqrt{Hz}
		$f = 10kHz$	-	20	-	

Note 1: All devices are 100% production tested at $T_A = +25^{\circ}C$; all specifications over the automotive temperature range is guaranteed by design, not production tested.

Note 2: Parameter is guaranteed by design.



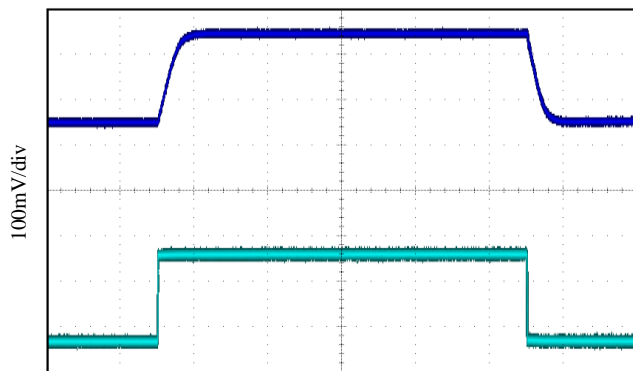
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6.3 Typical characteristics

At $T_A=+25^{\circ}\text{C}$, $R_L=10\text{ k}\Omega$ connected to $V_S/2$ and $V_{OUT}=V_S/2$, unless otherwise noted.

Small Signal Step Response

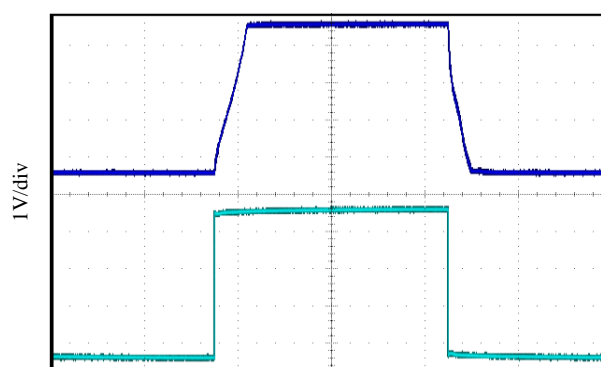
$G=+1\text{ V/V}$, $R_L=10\text{ k}\Omega$, $C_L=0\text{ pF}$



4μs/div

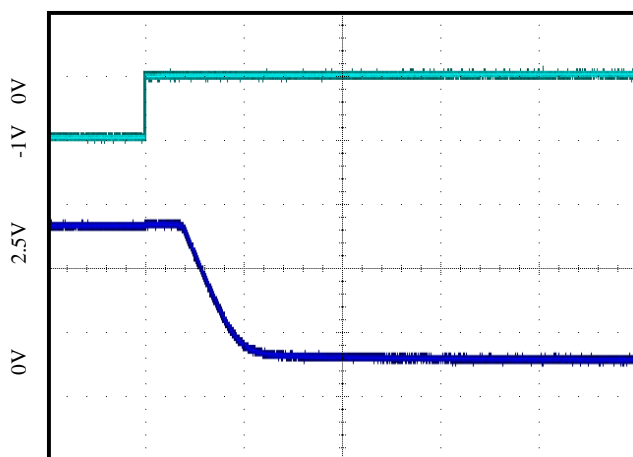
Large Signal Step Response

$G=+1\text{ V/V}$, $R_L=100\text{ k}\Omega$, $C_L=100\text{ pF}$



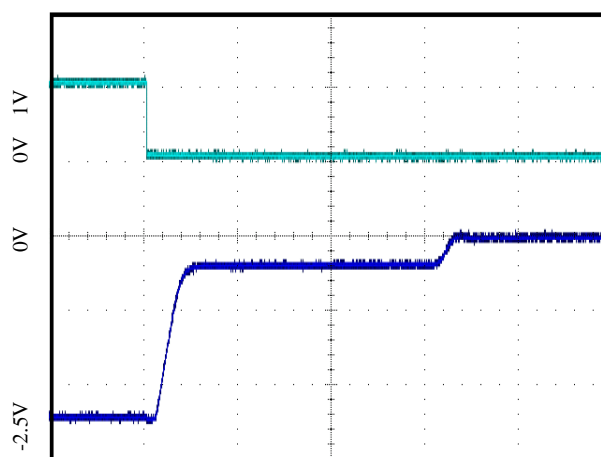
100μs/div

Positive Over-Voltage Recovery



40μs/div

Negative Over-Voltage Recovery



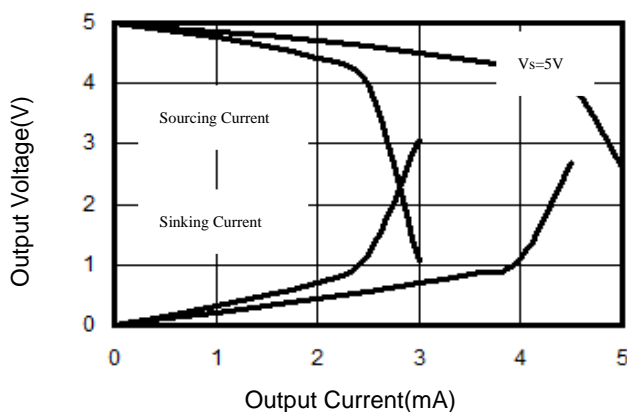
40μs/div



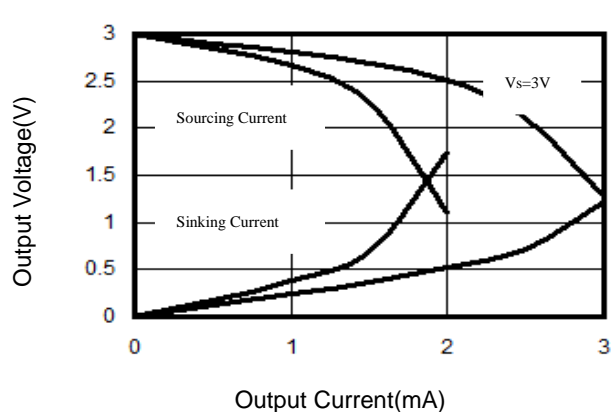
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At $T_A=+25^{\circ}\text{C}$, $R_L=10\text{ k}\Omega$ connected to $V_S/2$ and $V_{OUT}=V_S/2$, unless otherwise noted.

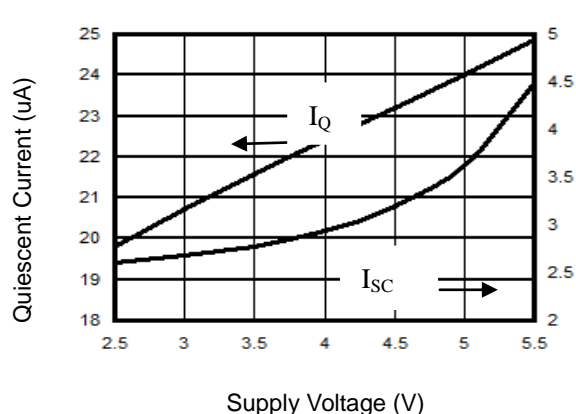
Output Voltage Swing vs. Output Current



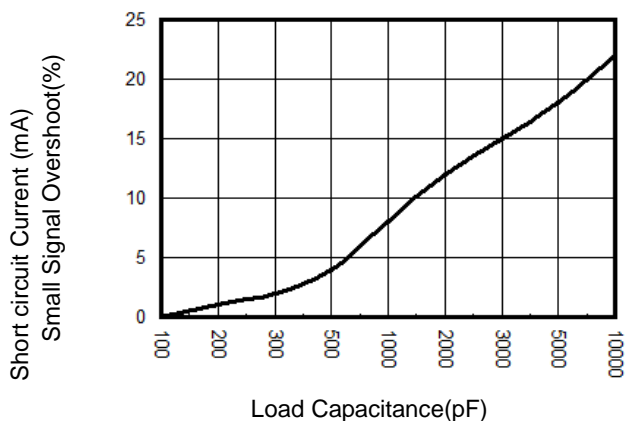
Output Voltage Swing vs. Output Current



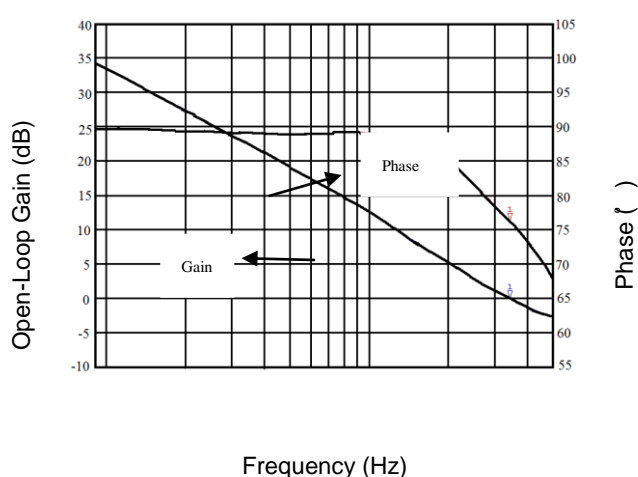
Quiescent and Short-Circuit Current Vs. Supply Voltage



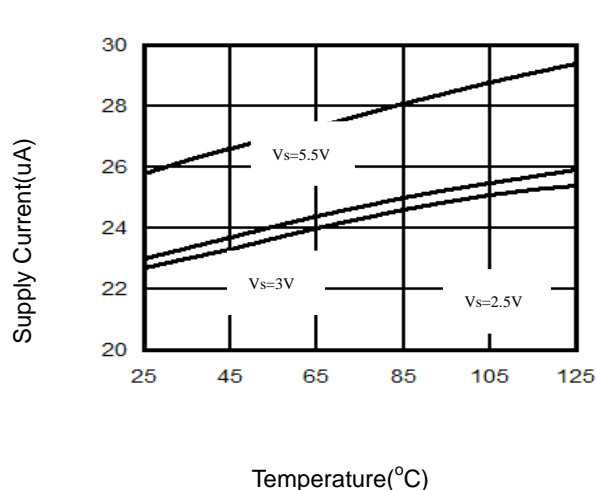
Small Signal Overshoot vs. Load Capacitance



Open-Loop Gain And Phase VS. Frequency



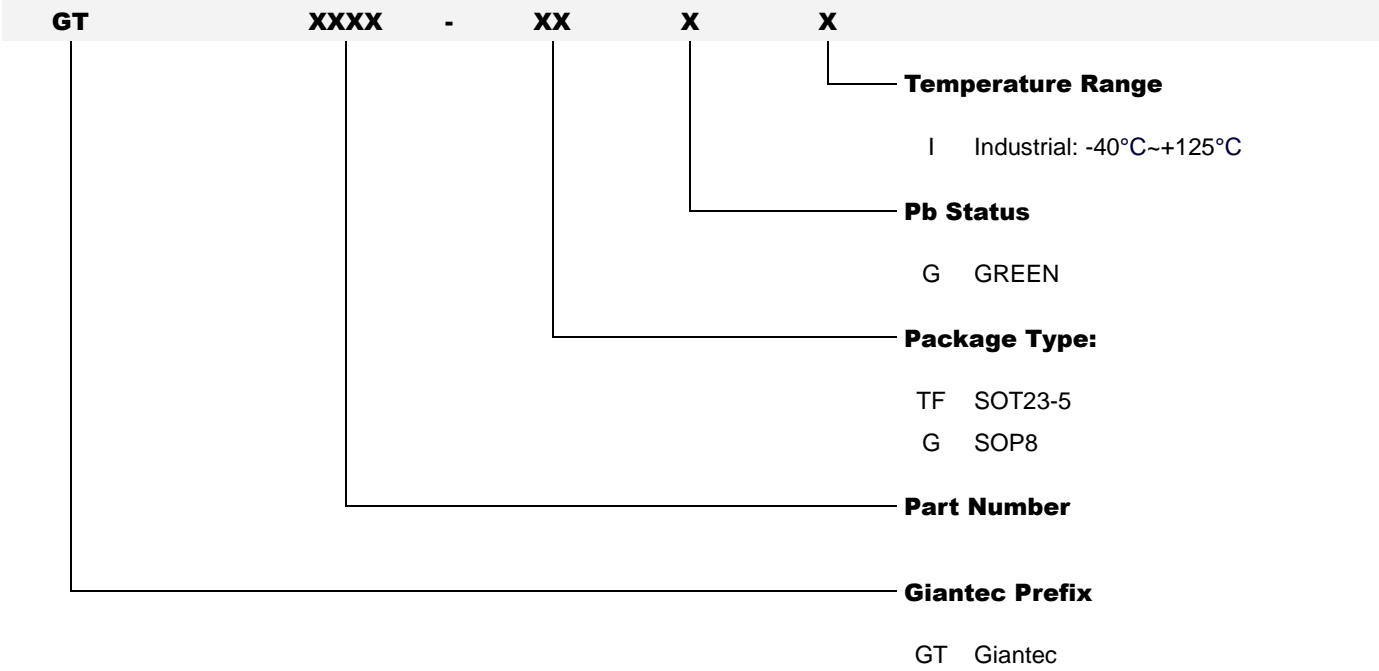
Supply Current vs. Temperature





GT7131

7. Ordering Information



Order Number	Package Description	Package Option
GT7131-TFGI-TR	SOT23-5	Tape and Reel 3000
GT7131-GGI-TR	SOP8	Tape and Reel 4000



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8. Part Markings

8.1 GT7131-TFGI (Top View)



131	GT7131-TFGI		
●	Pin 1 Indicator		
Y	Seal Year	W	Seal Week
2010 (1st half year)	A	Week 01	A
2010 (2nd half year)	B	Week 02	B
2011 (1st half year)	C	
2011 (2nd half year)	D	Week 26	Z
2012 (1st half year)	E	Week 27	A
2012 (2nd half year)	F	Week 28	B
.....
2022 (2nd half year)	Z	Week 52	Z



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8.2 GT7131-GGI (Top View)

<u>G</u>	<u>T</u>	<u>7</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>G</u>	<u>G</u>	<u>I</u>
—	—	—	—	Lot Number	—	—	—	—
•		<u>Y</u>	<u>Y</u>	<u>W</u>	<u>W</u>	<u>S</u>	<u>V</u>	

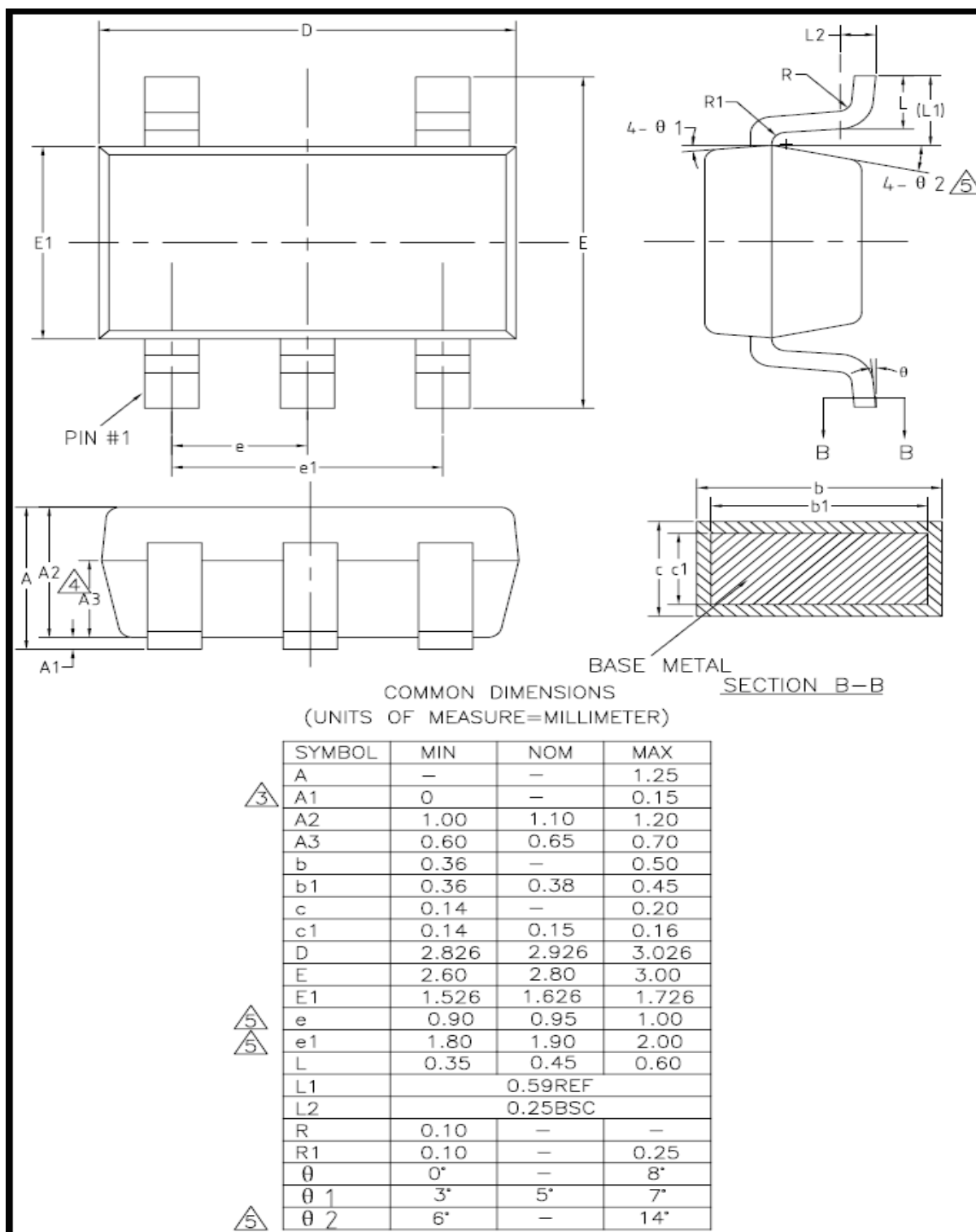
GT7131GGI

Lot Number	States the last 9 characters of the wafer lot information
•	Pin 1 Indicator
YY	Seal Year 00 = 2000 01 = 2001 99 = 2099
WW	Seal Week 01 = Week 1 02 = Week 2 . . . 51 = Week 51 52 = Week 52
S	Subcon Code J = ASESH L = ASEKS
V	Die Version

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9. Package Information

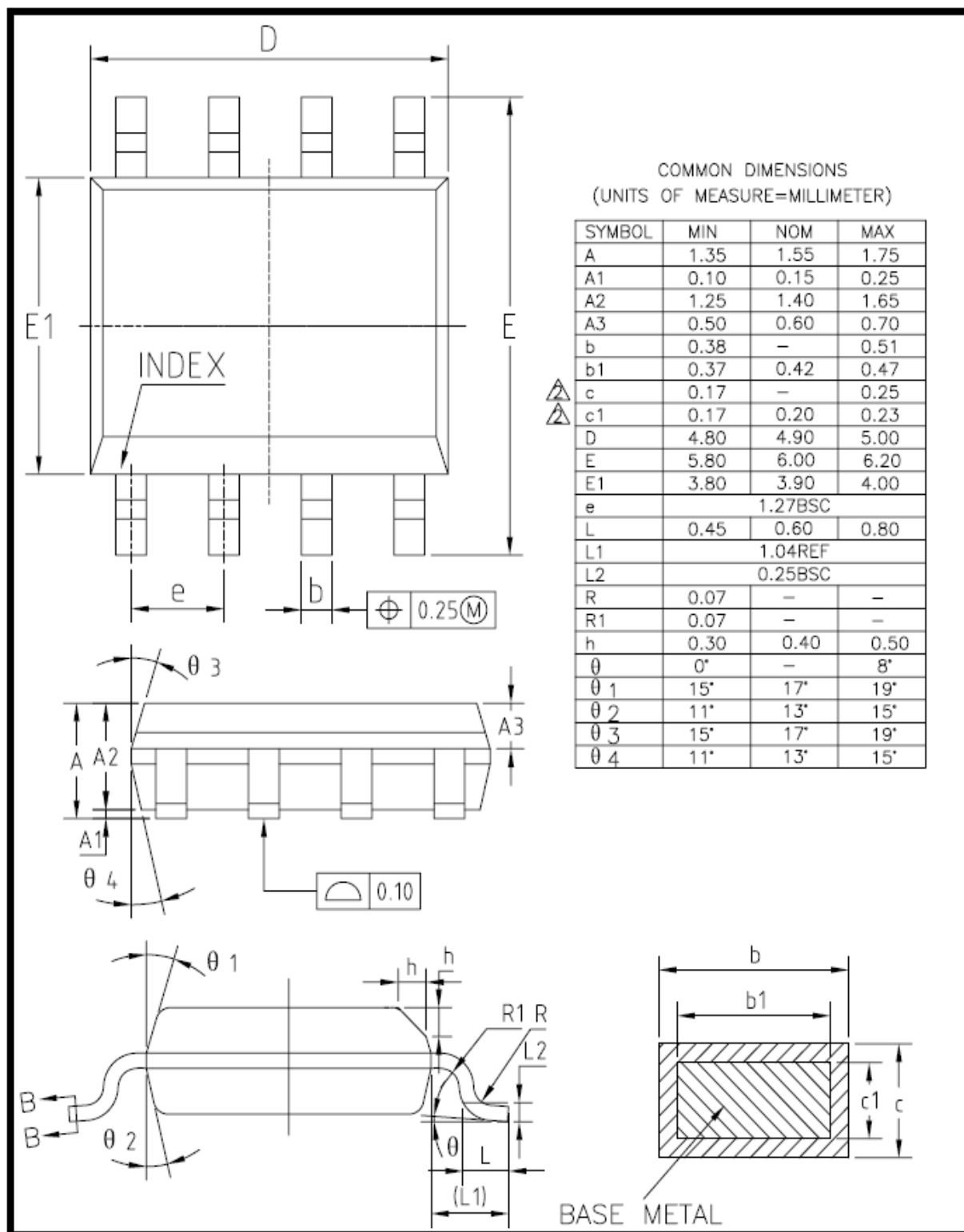
9.1 SOP23-5





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9.2 SOP8





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10. Revision History

Revision	Date	Descriptions
A0	Sept.,2011	Initial Version