JIANGSU CHANGJING ELECTRONICS TECHNOLOGY CO., LTD.

**Industry-standard Quad Operational Amplifiers**

# LM324E Operational Amplifiers

## 1 Introduction

The LM324E consists of four independent, high gain and internally frequency compensated operational amplifiers. With a high unity gain frequency and a guaranteed 0.4V/μs slew rate, the quiescent current is only 200μA/amplifier (5V). The input common mode range includes ground and therefore the device is able to operate in single supply applications as well as in dual supply applications. It is also capable of comfortably driving large capacitive loads. The LM324E is available in the SOT package. Overall the LM324E is a low power, wide supply range performance op amp that can be designed into a wide range of applications at an economical price without sacrificing valuable board space.

## 2 Applications

- Chargers
- Power supplies
- Industrial: controls, instruments
- Desktops
- Communications infrastructure

## 3 Features

- Power Supply Range:
  Single supply: 3.0 to 36V
  Dual supplies: ±1.5 to ±18V
- Low supply current: 700μA
- Low Input Offset Voltage:
  0.5mV (Typ.) at 25°C
- Low Input Bias Current:
  15nA (Typ.) at 25°C
- Unity-gain Bandwidth: 1.0MHz (Typ.)
- Wide operating ambient temperature:
  -40 ~ 85°C
- Internally frequency compensated for unity gain
- Common-mode input voltage range includes ground

## 4 Available Packages

| PART NUMBER | PACKAGE |
|---|---|
| LM324E-PHN | SOP14 |

# 5 Pin Configuration and Marking Information

## 5.1 Pin Configuration and Function

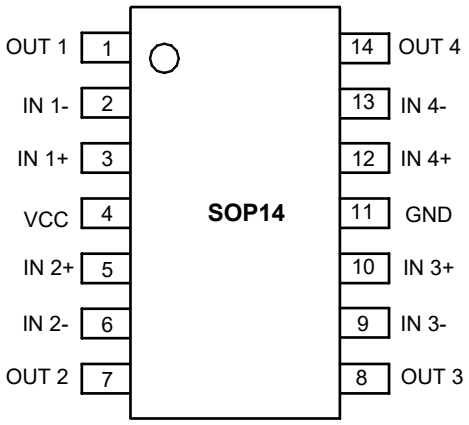
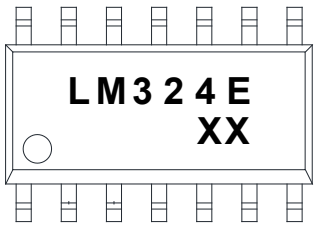



**Figure 5-1. LM324E Pin Map**

| PIN NAME | LM324E SOP14 | I / O | DESCRIPTION |
|---|---|---|---|
| OUT1 | 1 | O | Output of the operational amplifier 1. |
| IN1- | 2 | I | Negative input of the operational amplifier 1. |
| IN1+ | 3 | I | Positive input of the operational amplifier 1. |
| V+ | 4 | - | Positive (highest) supply. |
| IN2+ | 5 | I | Positive input of the operational amplifier 2. |
| IN2- | 6 | I | Negative input of the operational amplifier 2. |
| OUT2 | 7 | O | Output of the operational amplifier 2. |
| OUT3 | 8 | O | Output of the operational amplifier 3. |
| IN3- | 9 | I | Negative input of the operational amplifier 3. |
| IN3+ | 10 | I | Positive input of the operational amplifier 3. |
| V- | 11 | - | Negative (lowest) supply or ground for single supply. |
| IN4+ | 12 | I | Positive input of the operational amplifier 4. |
| IN4- | 13 | I | Negative input of the operational amplifier 4. |
| OUT4 | 14 | O | Output of the operational amplifier 4. |

# 5 Pin Configuration and Marking Information

## 5.2 Marking Information




**SOP14**

"**LM324E**": Device number.

"**XX**": Code, indicates weekly record information.

# 6 Specifications

## 6.1 Absolute Maximum Ratings

**(over operating ambient temperature range, unless otherwise specified)(1)**

| CHARACTERISTIC | | SYMBOL | VALUE | UNIT |
|---|---|---|---|---|
| Maximum power supply | Single supply | $V_S$ | 40 | V |
| | Dual supplies | | ±20 | |
| Maximum differential input range(2) | | $V_{ID}$ | -32 ~ 32 | V |
| Maximum input range (either input) | | $V_{IN}$ | -0.3 ~ 40 | V |
| Duration of output short circuit (one amplifier) to ground (or below) at $T_A$ = 25°C, $V_S$ ≤ 15V | | $t_{SC}$ | Continuous(3) | s |
| Maximum junction temperature | | $T_{J\ MAX}$ | 150 | °C |
| Storage temperature | | $T_{stg}$ | -65 ~ 150 | °C |
| Soldering temperature & time | | $T_{solder}$ | 260°C, 10s | - |

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum rated conditions for extended periods may affect device reliability.

(2) Differential voltages are at IN+, with respect to IN−.

(3) Short circuits from outputs to $V_S$ can cause excessive heating and eventual destruction. A heat sink may be required to keep the junction temperature below the absolute maximum. This depends on the power supply voltage and how many amplifiers are shorted. Thermal resistance varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads.

## 6.2 Recommend Operating Conditions

**(over operating ambient temperature range, unless otherwise specified)**

| PARAMETER | | SYMBOL | MIN. | NOM. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| Power supply range | Single supply | $V_S$ | 3.0 | - | 36 | V |
| | Dual supplies | | ±1.5 | - | ±18 | |
| Common-mode voltage range | | $V_{CM}$ | V- | - | (V+) - 2.0 | V |
| Operating ambient temperature | LM324E | $T_A$ | -40 | - | 85 | °C |

# 6 Specifications

## 6.3 ESD Ratings

| ESD RATINGS | | | SYMBOL | VALUE | UNIT |
|---|---|---|---|---|---|
| Electrostatic discharge(4) | Human body model | LM324E | $V_{ESD-HBM}$ | 3500 | V |

(4) ESD testing is conducted in accordance with the relevant specifications formulated by the Joint Electronic Equipment Engineering Commission (JEDEC). The human body model (HBM) electrostatic discharge test is based on the JESD22-A114D test standard, using a 100pF capacitor and discharging to each pin of the device through a resistance of 1.5kΩ.

## 6.4 Thermal Information

| THERMAL METRIC(5) | SYMBOL | SOP14 | UNIT |
|---|---|---|---|
| Junction-to-ambient thermal resistance | $R_{\Theta JA}$ | 115.7 | °C/W |
| Junction-to-case thermal resistance | $R_{\Theta JC}$ | 40.0 | °C/W |
| Reference maximum power dissipation (continuous) | $P_{D\ Ref}$ | 1.08 | W |

(5) $T_A$ = 25°C, measured on evaluation board with 1oz. copper traces of minimum pad size, all device outputs were active.

# 6 Specifications

## 6.5 Electrical Characteristics

**LM324E ($V_S$ = (V+) - (V-) = 5.0V, $T_A$ = 25°C, unless otherwise specified)**

| CHARACTERISTIC | SYMBOL | TEST CONDITIONS[6] | | | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|---|---|
| **Offset Voltage** | | | | | | | | |
| Input offset voltage | $V_{OS}$ | $V_S$ = 5.0 to 30V, $V_{CM}$ = 0V, $V_{OUT}$ = 1.4V | | $T_A$ = 25°C | - | 0.5 | 3.0 | mV |
| | | | | Full range | - | - | 5.0 | |
| Input offset voltage vs power supply ($\Delta V_{IO}$ / $\Delta V_S$) | PSRR | $V_S$ = 5.0 to 30V | | | 65 | 100 | - | dB |
| Input offset voltage drift | $dV_{OS}$ / dT | - | | Full range | - | 4.0 | - | µV / °C |
| Channel separation | CS | f = 1k to 20kHz | | | - | 120 | - | dB |
| **Input Voltage Range** | | | | | | | | |
| Common-mode voltage range | $V_{CM}$ | $V_S$ = 5.0 to 30V | | $T_A$ = 25°C | V- | - | (V+) - 1.5 | V |
| | | | | Full range | V- | - | (V+) - 2.0 | |
| Common-mode rejection ratio | CMRR | $V_S$ = 5.0 to 30V; $V_{CM}$ = 0V | | | 70 | 80 | - | dB |
| **Power Supply** | | | | | | | | |
| Quiescent current both amplifiers | $I_Q$ | $V_S$ = 5.0V, $R_L$ = ∞ | | | - | 0.7 | 1.45 | mA |
| | | $V_S$ = 30V, $R_L$ = ∞ | | | - | 0.85 | 1.75 | mA |
| **Input Bias Current** | | | | | | | | |
| Input bias current | $I_{IB}$ | $V_{CM}$ = 0V, $V_{OUT}$ = 1.4V | | $T_A$ = 25°C | - | ±15 | ±150 | nA |
| | | | | Full range | - | - | ±250 | |
| Input offset current | $I_{OS}$ | $V_{CM}$ = 0V, $V_{OUT}$ = 1.4V | | $T_A$ = 25°C | - | ±3.0 | ±30 | nA |
| | | | | Full range | - | - | ±150 | |
| **Frequency Response** | | | | | | | | |
| Gain bandwidth product | GBW | - | | | - | 1.0 | - | MHz |
| Slew rate | SR | G = +1 | | | - | 0.4 | - | V / µs |
| **Output** | | | | | | | | |
| Voltage output swing from rail | $V_{OUT}$ | $V_S$ = 30V, $R_L$ ≥ 10kΩ | Positive rail | $T_A$ = 25°C | - | 2.0 | 3.0 | V |
| | | | | Full range | - | 2.5 | - | |
| | | $V_S$ = 30V, $R_L$ = 2kΩ | | $T_A$ = 25°C | - | 3.0 | 4.0 | |
| | | | | Full range | - | 3.5 | - | |
| | | $V_S$ = 5.0V, $R_L$ = 10kΩ | Negative rail | Full range | - | 5.0 | 20 | mV |
| Output current | $I_{OUT}$ | $V_S$ = 15V, $V_{OUT}$ = 0V, $V_{ID}$ = 1V, Source | | | 20 | 40 | - | mA |
| | | $V_S$ = 15V, $V_{OUT}$ =2V, $V_{ID}$ = -1V, Sink | | | 10 | 15 | - | mA |
| | | $V_{OUT}$ =0.2V, $V_{ID}$ = -2V | | | 12 | 50 | - | µA |
| Short-circuit current | $I_{SC}$ | $V_S$ = 15V | | | - | ±40 | ±60 | mA |
| **Open-loop Gain** | | | | | | | | |
| Open-loop voltage gain | $A_{OL}$ | $V_S$ = 15V, $V_{OUT}$ = 1.0 to 11V, $R_L$ ≥ 2kΩ | | | 25 | 100 | - | V / mV |

# 6 Specifications

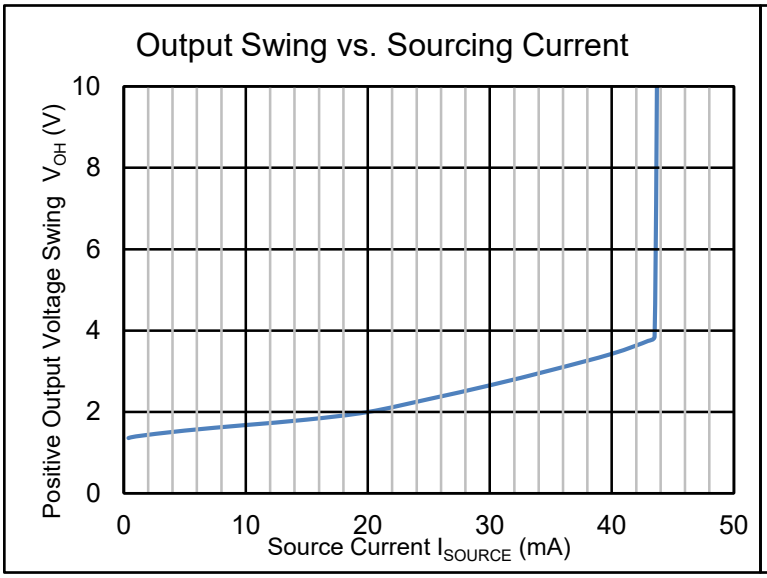
## 6.5 Electrical Characteristics (continued)

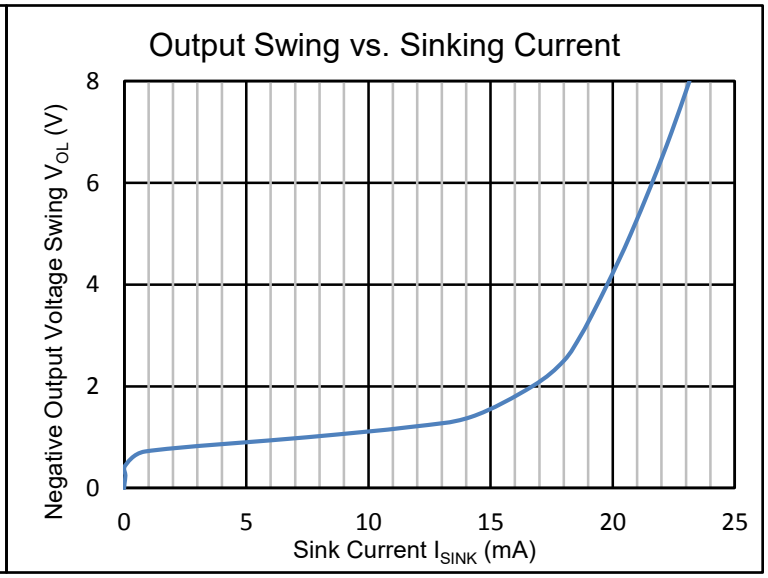
**Note:**

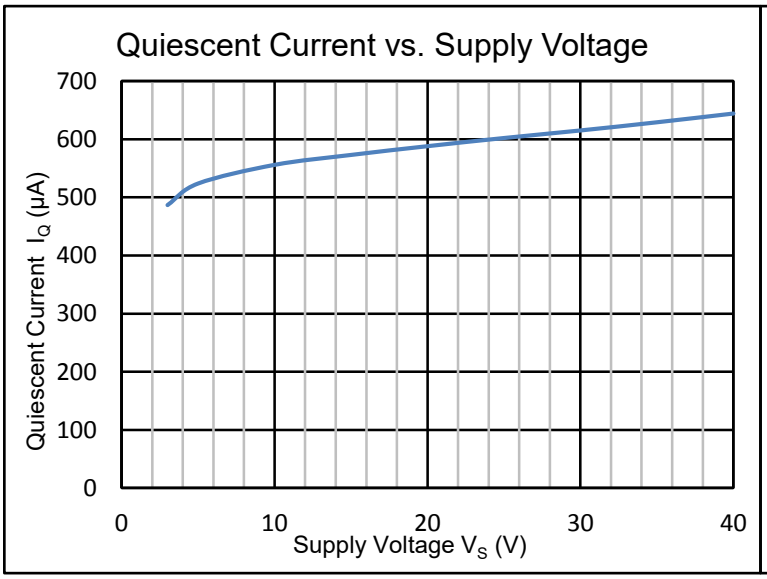
(6) All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified. All typical values are $T_A$ = 25°C. For the LM324E, "Full range" refers to $T_A$ ranging from -40 to 85°C.

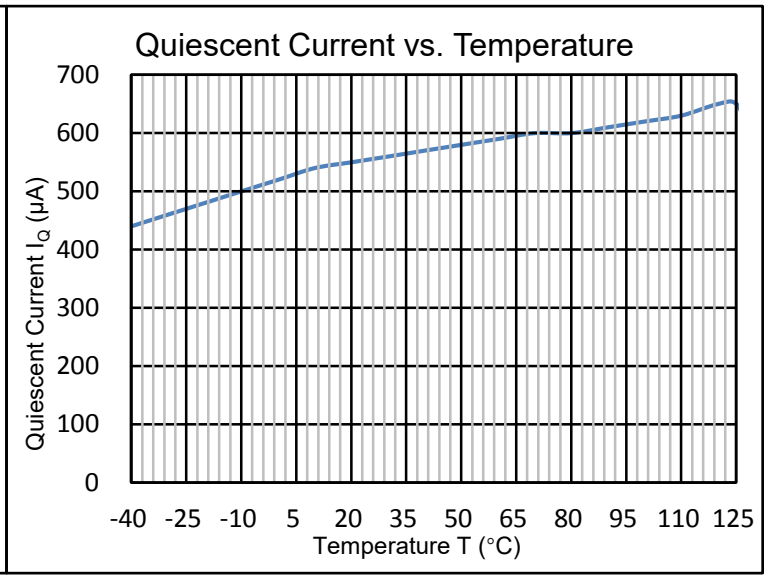
## 6.6 Typical Characteristics

**LM324E ($V_S$ = (V+) - (V-) = 5.0V, $V_{CM}$ = 0V, $R_L$ = ∞, $T_A$ = 25°C, unless otherwise specified)**



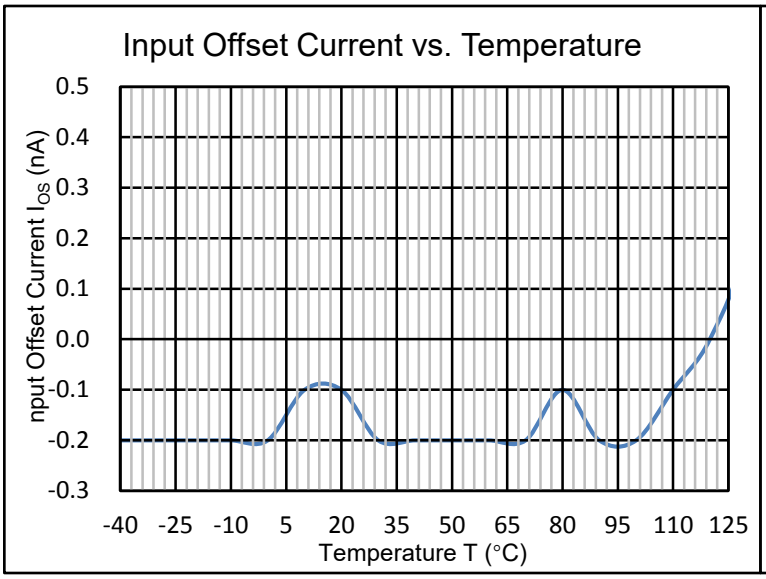



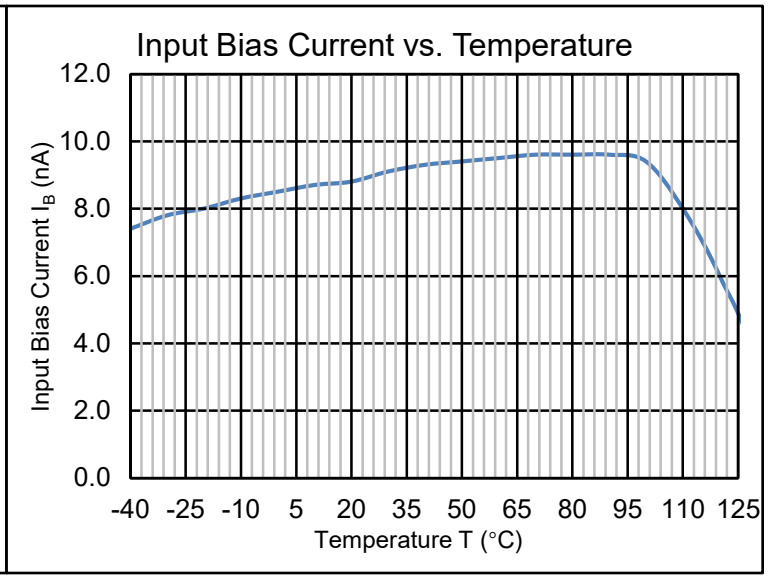



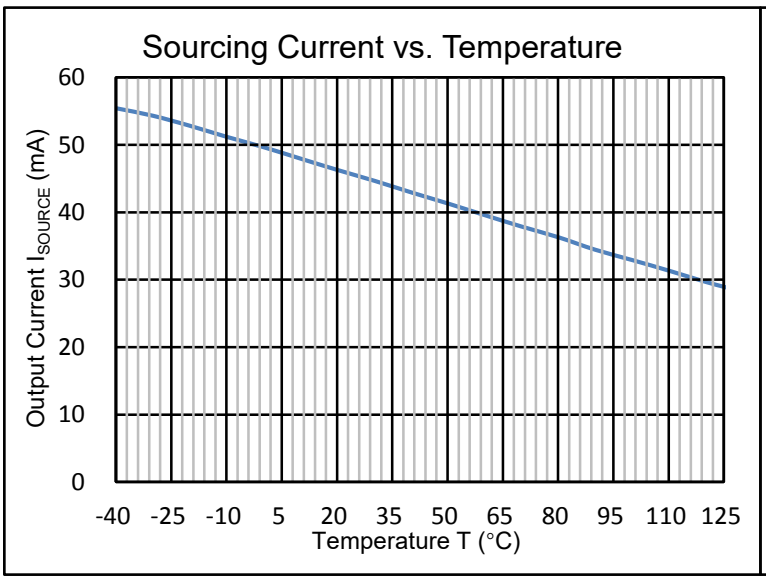
# 6 Specifications

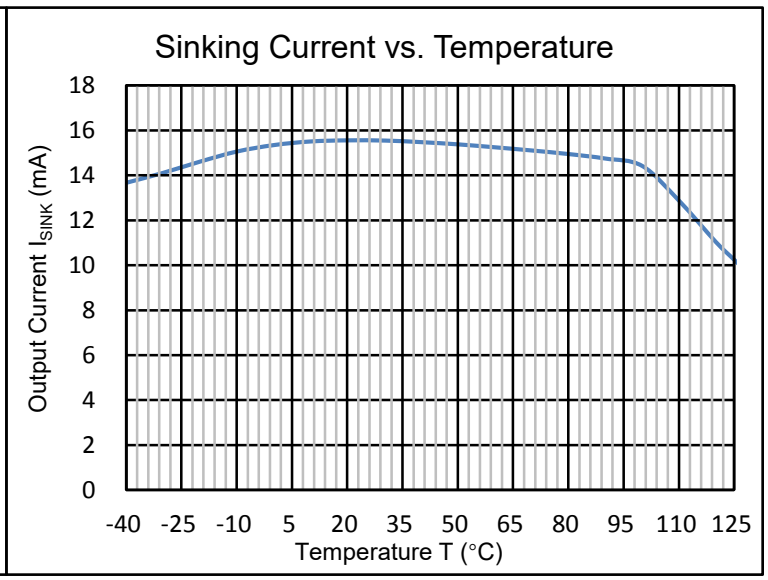
## 6.6 Typical Characteristics (continued)

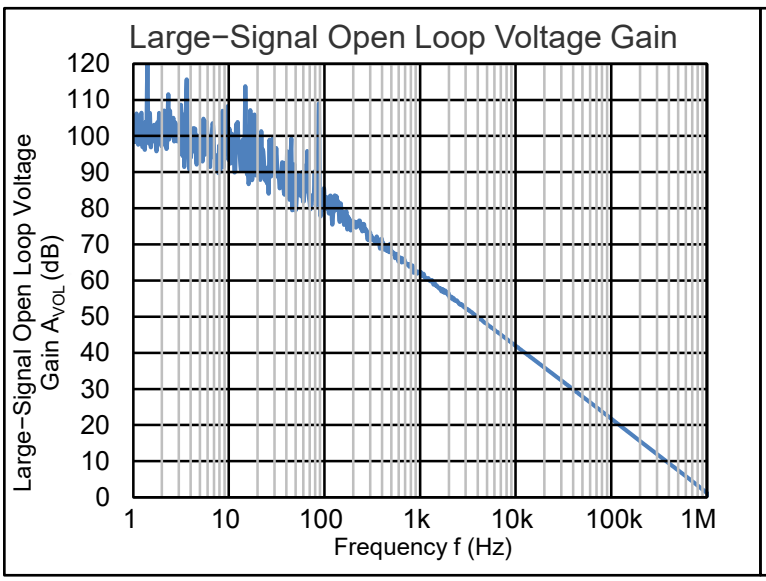
**LM324E ($V_S$ = (V+) - (V-) = 5.0V, $V_{CM}$ = 0V, $R_L$ = ∞, $T_A$ = 25°C, unless otherwise specified)**

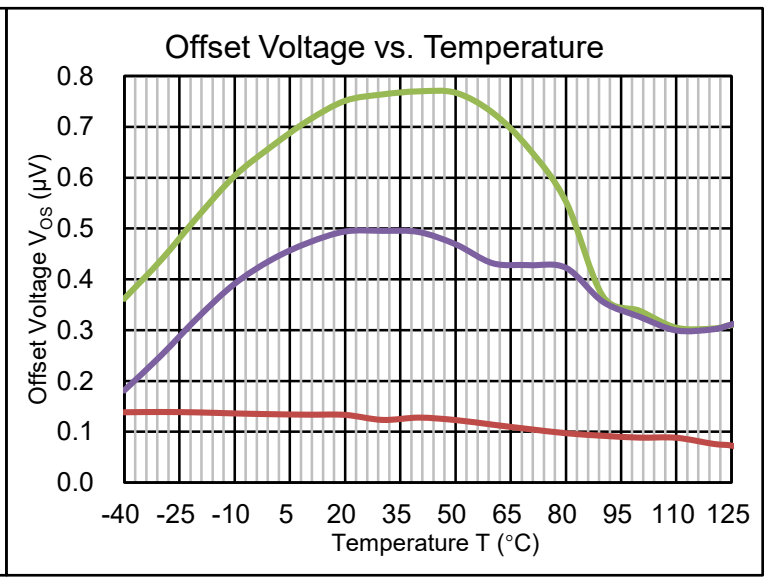


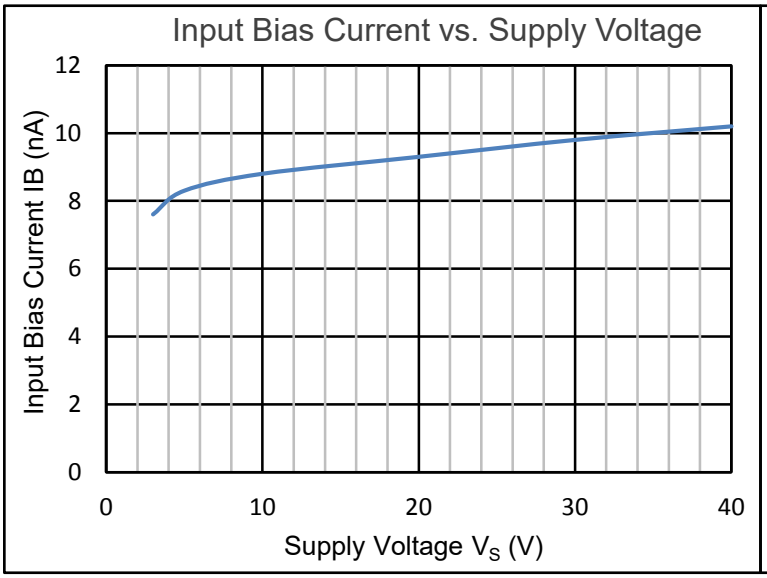



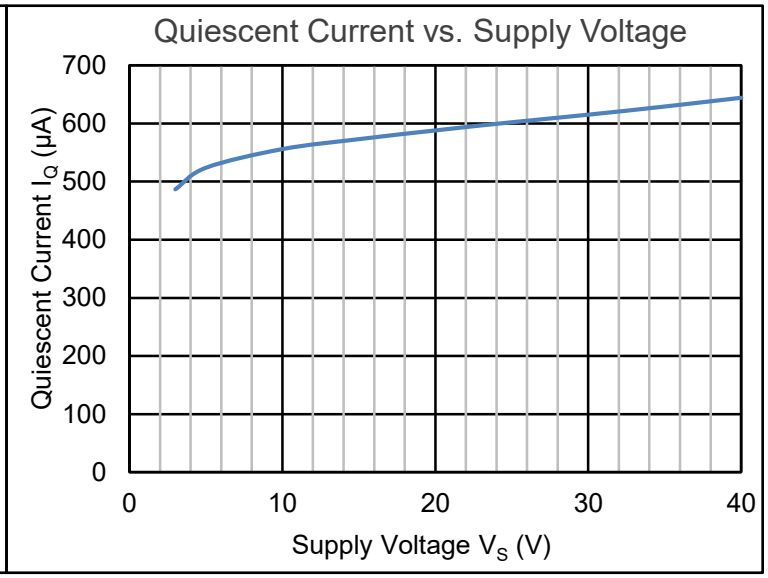



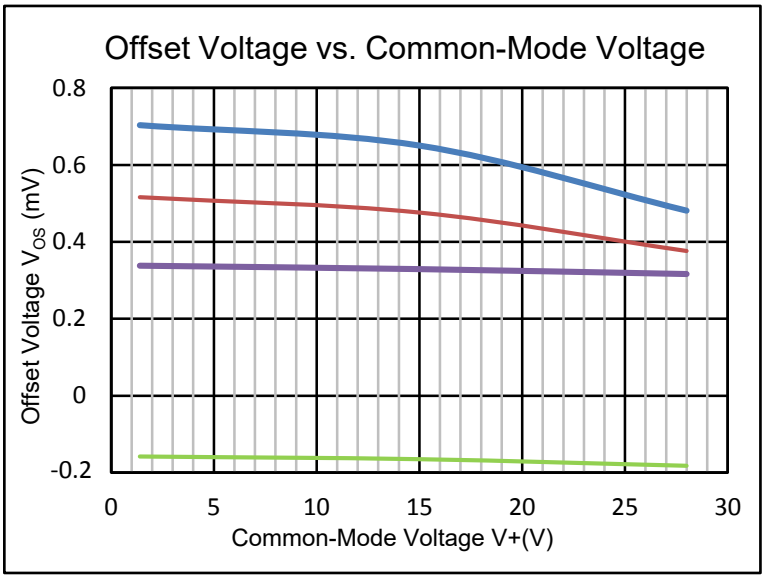
# 6 Specifications

## 6.6 Typical Characteristics (continued)

**LM324E ($V_S$ = (V+) - (V-) = 5.0V, $V_{CM}$ = 0V, $R_L$ = ∞, $T_A$ = 25°C, unless otherwise specified)**




**Large-Signal Step Response**
**($V_S$ = 15V)**

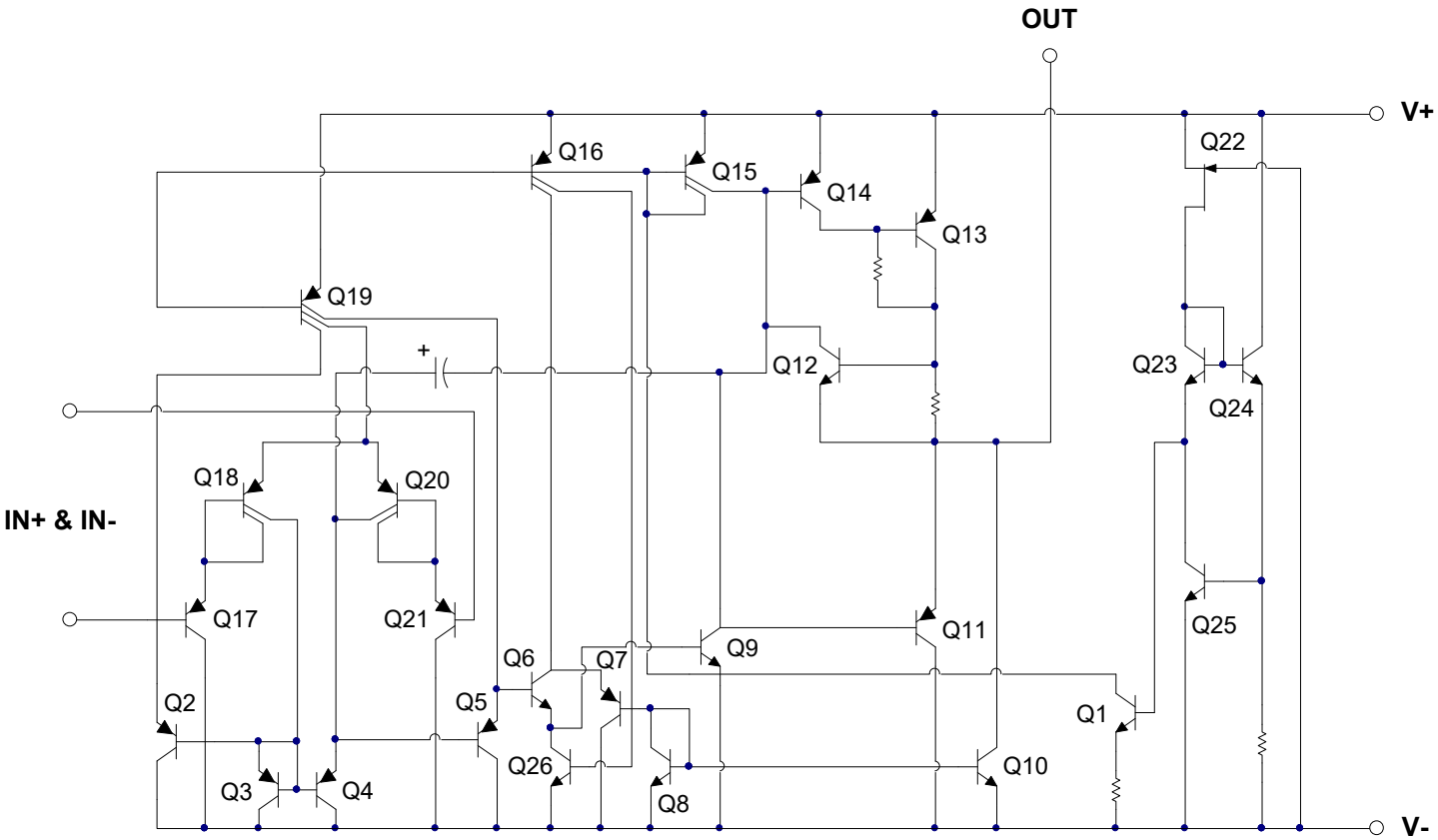

**Small-Signal Step Response**
**($V_S$ = 15V)**

# 7 Detail Description

## 7.1 Description

The LM324E operational amplifer can operate with a single or dual power supply voltage, has true-differential inputs, and remains in the linear mode with an input common-mode voltage of $0V_{DC}$. This amplifier operates over a wide range of power supply voltages, with little change in performance characteristics. At 25°C amplifier operation is possible down to a minimum supply voltage of 3V. Large differential input voltages can be easily accommodated and, as input differential voltage protection diodes are not needed, no large input currents result from large differential input voltages. The differential input voltage may be larger than V+ without damaging the device. Protection should be provided to prevent the input voltages from going negative more than $-0.3V_{DC}$ (at 25°C). An input clamp diode with a resistor to the IC input terminal can be used.

## 7.2 Representative Schematic Diagram



# 8 Application and Implementation

## 8.1 Typical Application Circuits

The LM324E is specified for operation up to 32V; many specifications apply from –40°C to 85°C. Parameters that can exhibit significant variance with regard to operating voltage or temperature are presented in Typical Characteristics. Place 0.1μF bypass capacitors close to the power-supply terminals to reduce errors coupling in from noisy or high-impedance power supplies. For more detailed information on bypass capacitor placement, see Layout.

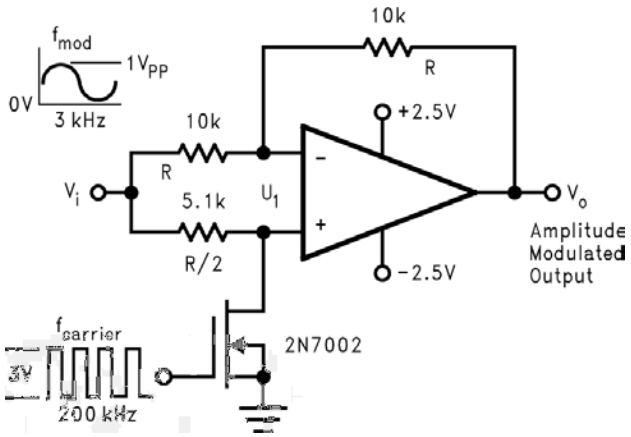
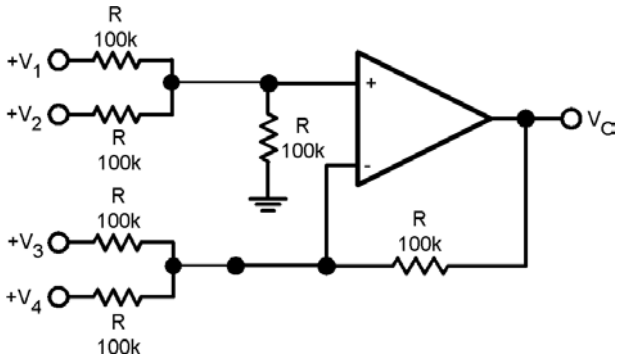
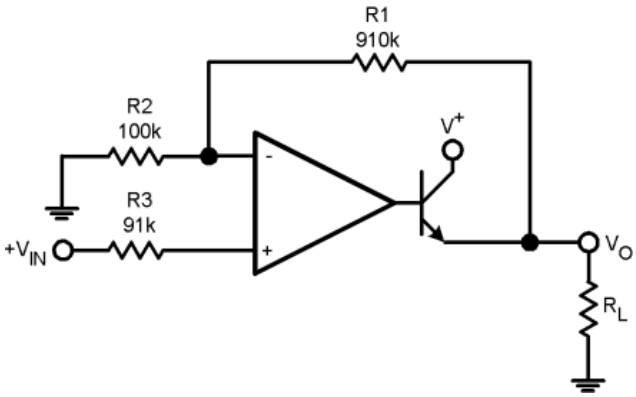



**Figure 8-1. Amplitude Modulator Circuit**




Where：$V_O = V_1+V_2-V_3-V_4$,$(V_1+V_2) \geq (V_3+V_4)$ to keep $V_O \geq 0V_{DC}$

**Figure 8-2. DC Summing Amplifie ($V_{IN's} \geq 0V_{DC}$,$V_O \geq V_{DC}$)**




$V_O$=0 $V_{DC}$ for $V_{IN}$=0 $V_{DC}$， $A_V$=10

**Figure 8-3. Power Amplifier**

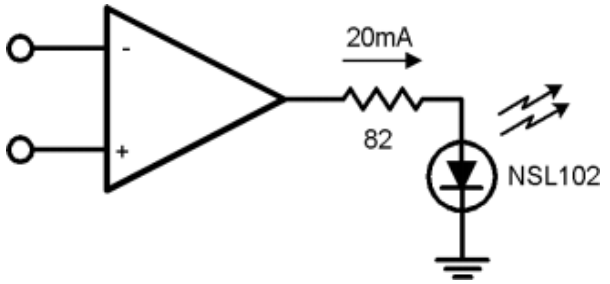



**Figure 8-4. LED Driver**

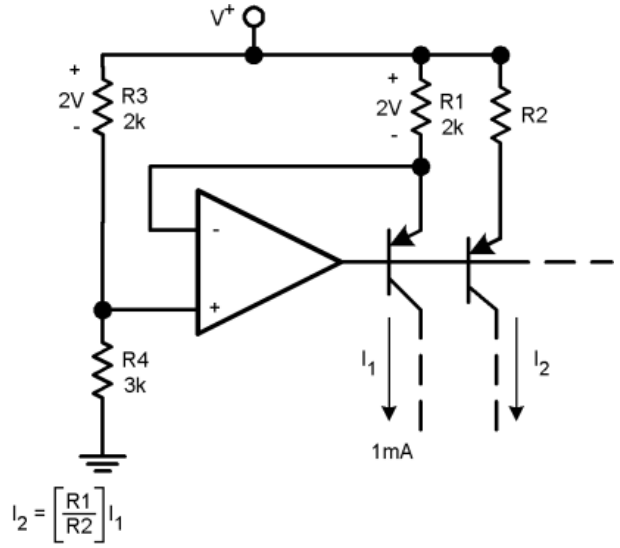



**Figure 8-5. Fixed Current Sources**

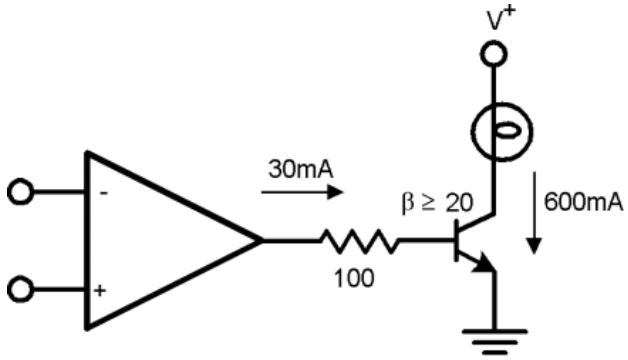



**Figure 8-6. Lamp Driver**

# 8 Application and Implementation

## 8.2 Layout Guidelines

The LM324E is widely used in various operational amplifier circuits. The following points should be taken in circuit design and PCB layout to help devices obtain the best operating performance:

1. Signal transmission traces should be as far away as possible from power supply traces to reduce parasitic coupling. It is recommended that signal traces be kept at least 5mm away from power supply lines. If the layout of the circuit does not allow this, it is better to lay out these traces vertically to avoid being parallel to each other as much as possible;
2. The length of the power supply traces should be as short as possible and bypass the power supply appropriately so as to reduce the power disturbance caused by current changes, such as when driving an AC signal to a heavy load;
3. It is recommended to use a bypass capacitor between each power supply pin (single power supply is V+, dual power supply is V+ and V-) and ground to reduce coupling noise transmitted through the power supply pins and operational amplifiers to the entire circuit. It is recommended to use ceramic bypass capacitors with low ESR and 0.1μF, and ensure that they are placed as close as possible to the corresponding pins of the device;
4. External components should be placed as close as possible to the device, and keeping $R_I$ and $R_F$ close to the input can minimize parasitic capacitance.
5. Analog grounding and digital grounding should be physically separated. Grounding the analog and digital parts of the circuit separately is a very simple but effective method for suppressing noise. When designing and laying out a multi-layer PCB circuit, one or more layers can be dedicated to a grounding layer, which can reduce EMI noise and help distribute appropriate heat on the circuit board;
6. Make sure the surface of the printed circuit board is clean and moisture-free. Use a surface coating to prevent moisture accumulation and help reduce parasitic resistance on the printed circuit board. Consider setting a low impedance guard ring (as shown in Figure 8-7 ) for the driver around the critical trace. The guard ring can significantly reduce the leakage current of nearby traces at different potentials.

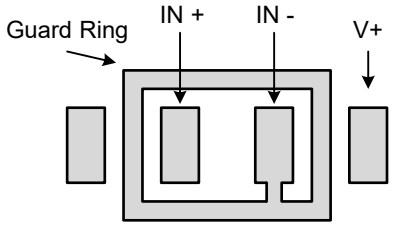



**Figure 8-7. Guard Ring**

**NOTE**

The application information in this section is not part of the data sheet component specification, and JSCJ makes no commitment or statement to guarantee its accuracy or completeness. Customers are responsible for determining the rationality of corresponding components in their circuit design and making tests and verifications to ensure the normal realization of their circuit design.

# 9 Notes and Revision History

## 9.1 Associated Product Family and Others

To view other products of the same type or IC products of other types, click the official website of JSCJ -- https: ***www.jscj-elec.com*** for more details.

## 9.2 Notes

**Electrostatic Discharge Caution**

This IC may be damaged by ESD. Relevant personnel shall comply with correct installation and use specifications to avoid ESD damage to the IC. If appropriate measures are not taken to prevent ESD damage, the hazards caused by ESD include but are not limited to degradation of integrated circuit performance or complete damage of integrated circuit. For some precision integrated circuits, a very small parameter change may cause the whole device to be inconsistent with its published specifications.

## 9.3 Revision History

**September 2025: released LM324E rev - 1.0.**

# 10 Orderable, Mechanical, and Packaging Information

The following pages include mechanical packaging and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser based versions of this data sheet, refer to the left hand navigation.

## Orderable Information

| MODEL | DEVICE | PACKAGE | OP TEMP | ECO PLAN | MSL | PACKING OPTION | SORT |
|---|---|---|---|---|---|---|---|
| LM324E | LM324E-PHN | SOP14 | -40 ~ 85°C | RoHS & Green | Level 3<br>168 HR | Tape and Reel<br>2500 Units / Reel | Active |
| Others | - | - | - | - | - | - | Customized |

**Note:**

**ECO PLAN:** For the RoHS and Green certification standards of this product, please refer to the official report provided by JSCJ.

**MSL:** Moisture Sensitivity Level. Determined according to JEDEC industry standard classification.

**SORT:** Specifically defined as follows:

Active: Recommended for new products;

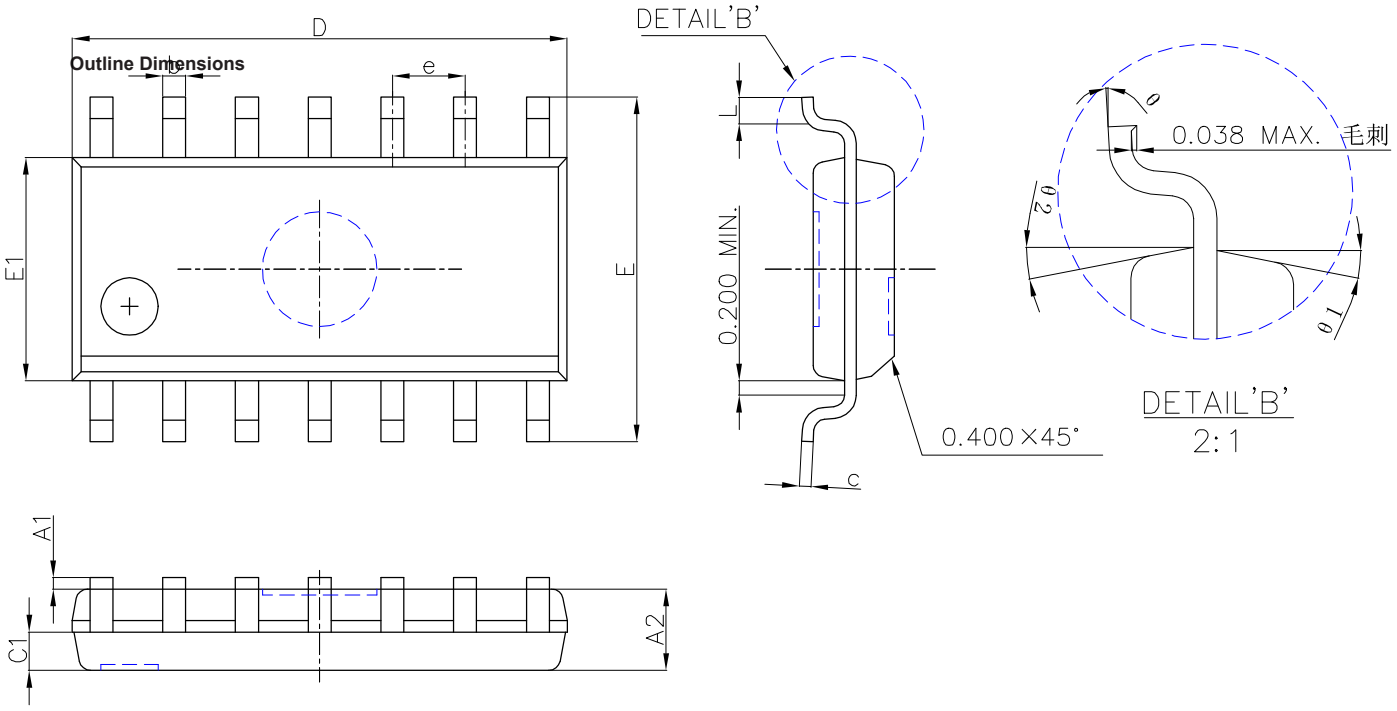
Customized: Products manufactured to meet the specific needs of customers;

Preview: The device has been released and has not been fully mass produced. The sample may or may not be available;

NoRD: It is not recommended to use the device for new design. The device is only produced for the needs of existing customers; Obsolete: The device has been discontinued.

# Mechanical Information

## SOP14 Mechanical Information




| SYMBOL | DISMENSIONS IN MILLIMETERS | | | DISMENSIONS IN INCHES | | |
|---|---|---|---|---|---|---|
| | MIN | NOM | MAX | MIN | NOM | MAX |
| D | 8.550 | 8.650 | 8.750 | 0.337 | 0.341 | 0.344 |
| b | 0.356 | 0.400 | 0.456 | 0.014 | 0.016 | 0.018 |
| e | 1.270 TYP. | | | 0.050 TYP. | | |
| E1 | 3.800 | 3.900 | 4.000 | 0.150 | 0.154 | 0.157 |
| E | 5.800 | 6.000 | 6.200 | 0.228 | 0.236 | 0.244 |
| A2 | 1.400 | 1.500 | 1.600 | 0.055 | 0.059 | 0.063 |
| C1 | 0.600 | 0.670 | 0.700 | 0.024 | 0.026 | 0.028 |
| A1 | 0.050 | 0.200 | 0.250 | 0.002 | 0.008 | 0.010 |
| c | 0.193 | 0.203 | 0.213 | 0.008 | 0.008 | 0.008 |
| L | 0.400 | 0.550 | 0.700 | 0.016 | 0.022 | 0.028 |
| θ | 0° | 3° | 8° | 0° | 3° | 8° |
| θ1 | 8° | 11° | 12° | 8° | 11° | 12° |
| θ2 | 8° | 11° | 12° | 8° | 11° | 12° |

# DISCLAIMER

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