# Low Quiescent Current Regulator

## Features

- Low quiescent current: 0.7μ A
- Input Voltage Range: 1.5V~5.5V
- Output Voltage: 1.1V ~ 5.0V (0.1V increments)
- Output Voltage Accuracy: ±2%@VOUT
- Temperature Stability: ±50ppm/℃
- Maximum Output Current: 150mA
- Low On Resistance: 3.5Ω @VOUT=3.0V
- Current Limit Protection
- CE Function: Active High, CL Auto Discharge
- Output Capacitor: Low ESR Ceramic Capacitor (CL Capacitor-Less Compatible)
- Operating Ambient Temperature: -40℃~ +85℃
- Available in SOT-25J and DFN1x1-4L Package
- EU ROHS Compliant, Pb Free

## General Description

The LPL1504 series is a highly accurate voltage regulator that achieves very low supply current operation of 0.7μ A.

Even output current is light load, the LPL1504 can provide high accurate outputs, which is ideally suited for the applications to draw less output current. The advantage of capacitor-less stable operation can contribute the board space saving outstandingly. The IC consists of a reference voltage source, an error amplifier, a driver transistor, over-current protection circuit, and a phase compensation circuit.

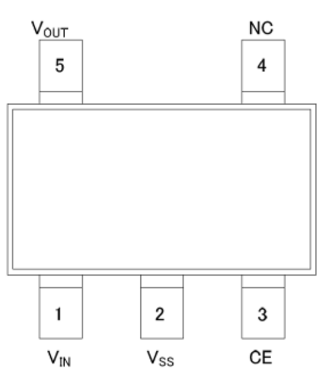
Output voltage is fixed internally by laser trimming technology and can be selectable in 0.1V increments within the range of 1.1V to 5.0V.

## Applications

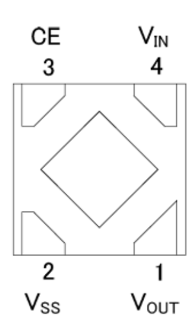
- Mobile devices/terminals
- Wireless LAN
- Modules (wireless, cameras, etc.)
- Mobile phones

## Pin Configuration

**TOP VIEW**




**BOTTOM VIEW**



## Typical Application Circuit

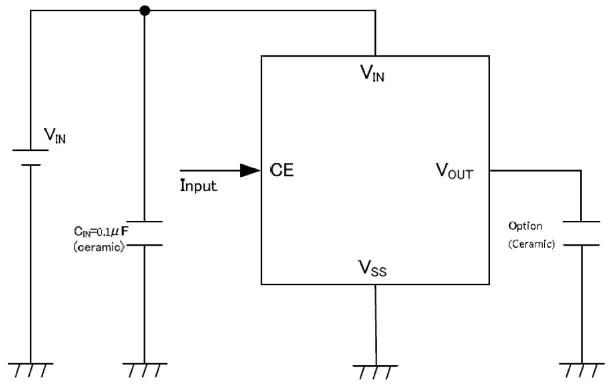



Figure.1 Typical Application Circuit

## Pin Function Description

| Pin# | | Pin Name | Pin Description |
|---|---|---|---|
| DFN1x1-4L | SOT-25J | | |
| 1 | 5 | $V_{OUT}$ | Regulator output. |
| 2 | 2 | $V_{SS}$ | Ground. |
| 3 | 3 | CE | Chip On/Off Control. pull High to Active and Low to Stand-by. |
| 4 | 1 | $V_{IN}$ | Power Supply Input. Connecting a ceramic bypass capacitor between VIN and GND to eliminate noise. |
| | 4 | NC | No connection. |

## Absolute Maximum Ratings

| Parameter | RATINGS | | UNITS |
|---|---|---|---|
| Input Voltage | $V_{SS}$-0.3 ~ Vss+7.0 | | V |
| Output Current | 450 (*1) | | mA |
| Output Voltage | Vss-0.3 ~ VIN + 0.3 or 5.5 (*2) | | V |
| Power Dissipation | SOT-25J | 200 (IC Only) | mW |
| | | 550(40mm x 40mm Standard board) (*3) | |
| | DFN1x1-4L | 100 (IC Only) | |
| | | 550(40mm x 40mm Standard board) (*3) | |
| Operating Ambient Temperature | - 40 ~ + 85 | | ℃ |
| Storage Temperature | - 55 ~ + 125 | | ℃ |

All voltages are described based on the $V_{SS}$.

(*1) Please use within the range of $I_{OUT}$≦ Pd / ($V_{IN}$-$V_{OUT}$)

(*2) The maximum rating corresponds to the lowest value between $V_{IN}$+0.3V or 5.5V.

(*3) The power dissipation figure shown is PCB mounted and is for reference only Please see the power dissipation page for the mounting condition.

## Electrical Characteristic

($T_A$ = 25℃, unless otherwise specified)

| Parameter | Symbol | Test Conditions (*1) | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Input Voltage | $V_{IN}$ | $I_{OUT}$=1μA | 1.4 | | 5.5 | V |
| Output Voltage | $V_{OUT(E)}$ (*1) | | x0.98 | $V_{OUT(T)}$ (*2) | x1.02 | V |
| Quiescent Current | $I_Q$ | $I_{OUT}$=0mA, $V_{OUT(T)}$<1.9V | - | 0.7 | 1.27 | μA |
| | | $I_{OUT}$=0mA, 1.9V≦$V_{OUT(T)}$ <4.0V | | 0.75 | 1.50 | |
| | | $I_{OUT}$=0mA, $V_{OUT(T)}$ ≧4V | | 0.9 | 1.80 | |
| Stand-by Current | $I_{STB}$ | $V_{IN}$=6.0V, $V_{CE}$= $V_{SS}$ | - | 0.01 | 0.1 | μA |
| Load Regulation | $\Delta V_{OUT}$ | 1uA≦$I_{OUT}$≦1mA | - | 3 | 16 | mV |
| | | 1mA≦$I_{OUT}$≦150mA | - | 17 | 50 | |
| Dropout Voltage | $V_{dif1}$(*3) | $V_{CE}$= $V_{IN}$, $I_{OUT}$=50mA | - | E-1(*4) | | mV |
| | $V_{dif2}$(*3) | $V_{CE}$= $V_{IN}$, $I_{OUT}$=150mA | - | E-2(*4) | | |
| Line Regulation | $\Delta V_{OUT}$ / ($\Delta V_{IN}$・ $V_{OUT}$ ) | $I_{OUT}$=1μA, $V_{OUT(T)}$+0.5V≦$V_{IN}$≦6V | - | 0.01 | 0.14 | %/V |
| | | $I_{OUT}$=1mA, $V_{OUT(T)}$<1.2V, 1.7V≦$V_{IN}$≦6V; $V_{OUT(T)}$ ≧1.2V, $V_{OUT(T)}$+0.5V≦$V_{IN}$≦6V | - | 0.01 | 0.20 | |
| Maximum Output Current | $I_{OUTMAX}$ | $V_{CE}$= $V_{IN}$ | 150 | | - | mA |
| Current Limit | $I_{LIM}$ | $V_{OUT}$ =$V_{OUT(E)}$ X 0.95 | 150 | 270 | - | mA |
| Short Circuit Current | $I_{SHORT}$ | $V_{OUT}$ = $V_{SS}$ | | 85 | | mA |
| CE High Level Voltage | $V_{CEH}$ | - | 0.91 | - | 5.5 | V |
| CE Low Level Voltage | $V_{CEL}$ | - | $V_{SS}$ | - | 0.38 | V |
| CE High Level Current | $I_{CEH}$ | $V_{IN}$= $V_{CE}$=6.0V | -0.1 | 5.5 | 0.1 | μA |
| CE Low Level Current | $I_{CEL}$ | $V_{IN}$=6.0V, $V_{CE}$ = $V_{SS}$ | -0.1 | - | 0.1 | μA |
| CL Auto-Discharge Resistance | $R_{DCHG}$ | $V_{CE}$= $V_{SS}$, $V_{OUT}$ =$V_{OUT(T)}$ | 280 | 450 | 740 | Ω |
| Output Voltage Temperature Characteristics | $\Delta V_{OUT}$/ ($\Delta$Topr*$V_{OUT}$) | $I_{OUT}$=10mA, -40℃≦$T_A$≦85℃ | - | ±50 | - | ppm/℃ |

NOTE:

Unless otherwise stated, VCE=VIN, IOUT=1mA, CIN=CL=open, VIN is below:

$V_{OUT(T)}$ < 2.5V : $V_{IN}$=3.5V

$V_{OUT(T)}$≧2.5V : $V_{IN}$=$V_{OUT(T)}$+1.0V

(*1) $V_{OUT(E)}$: Effective output voltage.

(*2) $V_{OUT(T)}$: Nominal output voltage.

(*3) $V_{dif}$ =$V_{IN1}$ -$V_{OUT1}$

VIN1 is the input voltage when VOUT1 appears at the VOUT pin while input voltage is gradually decreased.

VOUT1 is the voltage equal to 98% of the normal output voltage when amply stabilized VOUT(T) +1.0V is input at the VIN pin.

(*4) E-1 / E-2: DROPOUT VOLTAGE (Refer to Output Voltage Chart)

## OUTPUT VOLTAGE CHART

| NOMINAL OUTPUT VOLTAGE (V) | OUTPUT VOLTAGE (V) | | E-1 | | E-2 | |
|---|---|---|---|---|---|---|
| | | | DROPOUT VOLTAGE (V) | | | |
| VOUT(T) | VOUT(E) | | $V_{dif1}$ | | $V_{dif2}$ | |
| | Min | Max | Typ | Max | Typ | Max |
| 1.10 | 1.0780 | 1.1220 | 0.96 | 1.35 | 1.51 | 2.05 |
| 1.20 | 1.1760 | 1.2240 | 0.87 | 1.23 | 1.41 | 1.93 |
| 1.30 | 1.2740 | 1.3260 | 0.77 | 1.12 | 1.33 | 1.83 |
| 1.40 | 1.3720 | 1.4280 | 0.69 | 1.01 | 1.24 | 1.72 |
| 1.50 | 1.4700 | 1.5300 | 0.62 | 0.91 | 1.17 | 1.63 |
| 1.60 | 1.5680 | 1.6320 | 0.56 | 0.84 | 1.1 | 1.54 |
| 1.70 | 1.6660 | 1.7340 | 0.51 | 0.77 | 1.04 | 1.47 |
| 1.80 | 1.7640 | 1.8360 | 0.47 | 0.72 | 0.99 | 1.4 |
| 1.90 | 1.8620 | 1.9380 | 0.42 | 0.64 | 0.92 | 1.29 |
| 2.00 | 1.9600 | 2.0400 | 0.37 | 0.58 | 0.86 | 1.20 |
| 2.10 | 2.0790 | 2.1210 | | | | |
| 2.20 | 2.1780 | 2.2220 | 0.31 | 0.47 | 0.75 | 1.05 |
| 2.30 | 2.2770 | 2.3230 | | | | |
| 2.40 | 2.3760 | 2.4240 | 0.26 | 0.40 | 0.67 | 0.92 |
| 2.50 | 2.4750 | 2.5250 | | | | |
| 2.60 | 2.5740 | 2.6260 | 0.23 | 0.34 | 0.60 | 0.82 |
| 2.70 | 2.6730 | 2.7270 | | | | |
| 2.80 | 2.7720 | 2.8280 | 0.20 | 0.30 | 0.54 | 0.74 |
| 2.90 | 2.8710 | 2.9290 | | | | |
| 3.00 | 2.9700 | 3.0300 | 0.17 | 0.26 | 0.50 | 0.67 |
| 3.10 | 3.0690 | 3.1310 | | | | |
| 3.20 | 3.1680 | 3.2320 | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3.30 | 3.2670 | 3.3330 | | | | |
| 3.40 | 3.3660 | 3.4340 | | | | |
| 3.50 | 3.4650 | 3.5350 | | | | |
| 3.60 | 3.5640 | 3.6360 | | | | |
| 3.70 | 3.6630 | 3.7370 | 0.15 | 0.22 | 0.43 | 0.59 |
| 3.80 | 3.7620 | 3.8380 | | | | |
| 3.90 | 3.8610 | 3.9390 | | | | |
| 4.00 | 3.9600 | 4.0400 | | | | |
| 4.10 | 4.0590 | 4.1410 | | | | |
| 4.20 | 4.1580 | 4.2420 | 0.13 | 0.19 | 0.38 | 0.51 |
| 4.30 | 4.2570 | 4.3430 | | | | |
| 4.40 | 4.3560 | 4.4440 | | | | |
| 4.50 | 4.4550 | 4.5450 | | | | |
| 4.60 | 4.5540 | 4.6460 | | | | |
| 4.70 | 4.6530 | 4.7470 | 0.11 | 0.17 | 0.35 | 0.47 |
| 4.80 | 4.7520 | 4.8480 | | | | |
| 4.90 | 4.8510 | 4.9490 | | | | |
| 5.00 | 4.9500 | 5.0500 | 0.10 | 0.16 | 0.32 | 0.43 |

## Functional Block Diagram

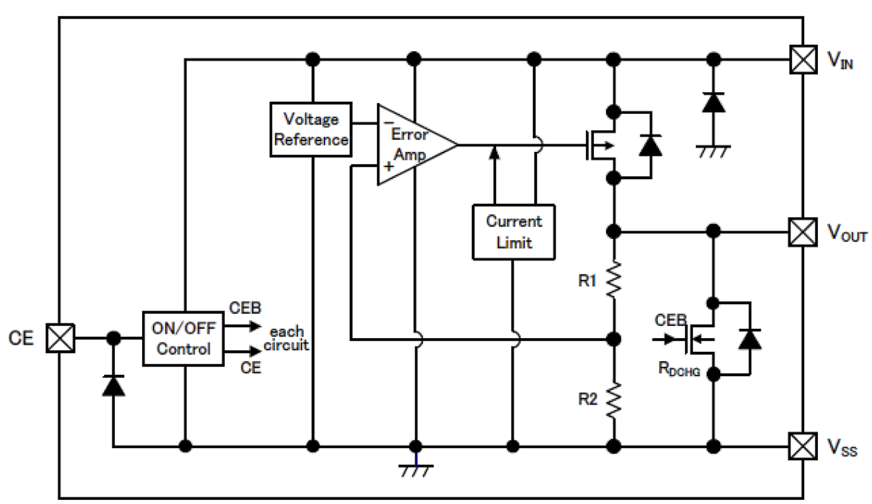



Figure.2 LPL1504D Functional Block Diagram

*Diodes inside the circuit are an ESD protection diode and a parasitic diode.

# PRODUCT CLASSIFICATION

- Ordering Information

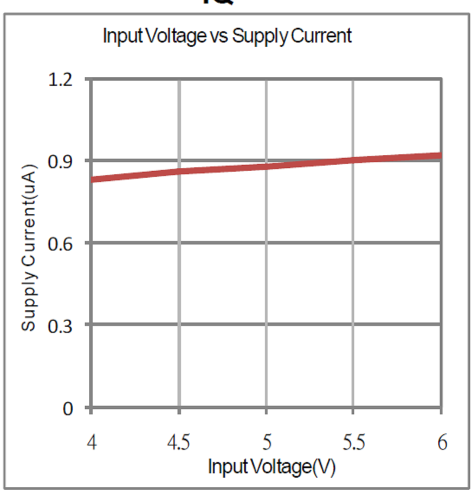
LPL1504①②③④⑤

| DESIGNATOR | CONTENTS | SYMBOL | DESCRIPTIONS |
|---|---|---|---|
| ① | Regulator Type | A | |
| ②③ | VOUT | 11 ~ 50 | e.g. Vout:3.3v→33; 2.0v→20 |
| ④ | Accuracy | 2 | 2% |
| ⑤⑥ | Package（MOQ） | M5 | SOT-25J(3,000pcs/Reel) |
| | | N4 | DFN1x1-4L(5,000pcs/Reel) |

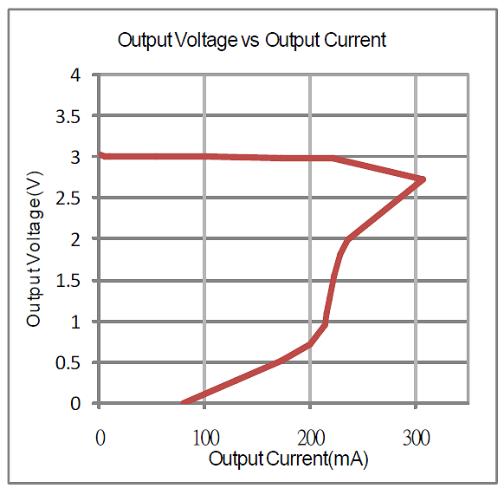
## Typical Operating Characteristics

CIN = 1uF, CL = 1uF, TA = +25℃, VOUT=3.0V, unless otherwise noted.

IQ

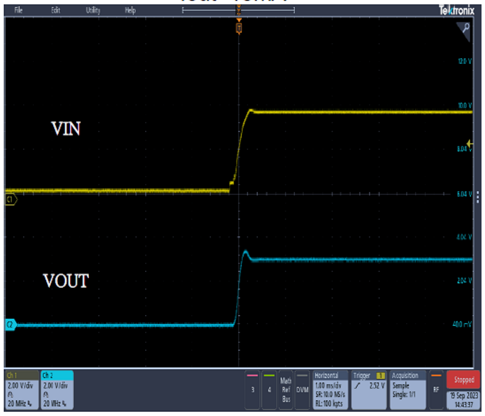



Current Fold Back



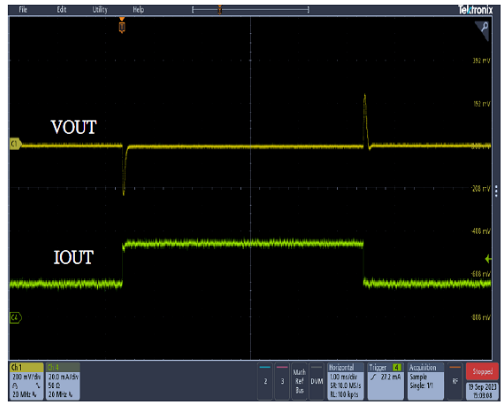
**Start-up**

Iout=10mA



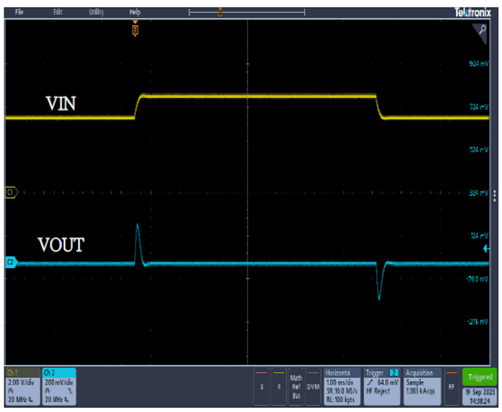

**Dynamic loading**

Vin=4.0V,Iout=10 to 30mA




**Input Transient Response**

Iout=10mA




## Function Description:

From LPL1504 block diagram, the voltage divided by resistors R1 and R2 is compared with the internal reference voltage by the error amplifier. The VOUT pin is then driven by the subsequent output signal. The output voltage at the VOUT pin is controlled and stabilized by a system of negative feedback.

The LPL1504 series can provide a stable output voltage even if without CL capacitor or with a low ESR CL capacitor because of a built-in phase compensation circuit. In case of adding a CL capacitor, we suggest that an output capacitor (CL) is connected as close as possible to the VOUT pin and the VSS pin. When VIN stabilization is needed, please place an input capacitor (CIN) as close as to the VIN pin and the VSS pin.

The LPL1504 series includes a combination of a fixed current limiter circuit & a foldback circuit, which aid the operations of the current limiter and circuit protection. When the load current reaches the current limit level, the fixed current limiter circuit operates and output voltage drops. As a result of this drop in output voltage, the foldback circuit operates, output voltage drops further and output current decreases.

The LPL1504 internal circuitry can be shutdown via the signal from the CE pin with the LPL1504 series. In shutdown mode with CE low level voltage is input, output at the VOUT pin will be pulled down to the VSS level via parallel to R1 & R2 and CL discharge resistance (RDCHG). If this IC is used with the correct output voltage for the CE pin, the logic is fixed and the IC will operate normally. However, supply current may increase as a result of through current in the IC's internal circuitry when medium voltage is input. The output voltage becomes unstable when the CE pin is opened.

The LPL1504 series can quickly discharge the electric charge at the output capacitor (CL), when a low signal to the CE pin, which enables a whole IC circuit put into OFF state, is inputted via an internal switch located between the VOUT pin and the VSS pin. In this state, the application is protected from a glitch operation caused by the electric charge at the output capacitor (CL).

Moreover, discharge time of the output capacitor (CL) is set by the CL auto-discharge resistance (RDCHG) and the output capacitor (CL). By setting time constant of a CL auto-discharge resistance value (RDCHG) and an output capacitor value (CL) as τ (τ = CL x RDCHG), the output voltage after discharge via the internal switch is calculated by the following formulas. Please also note RDCHG is depended on VIN and When VIN is high, RDCHG is low.

$t = \tau \ln (VOUT(E) / V)$

V: Output voltage after discharge

VOUT(E): Output voltage

t: Discharge time

τ: CL x RDCHG.

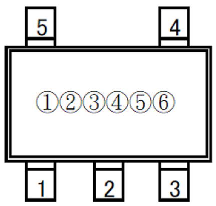
## NOTES ON USE:

1. For temporary, transitional voltage drop or voltage rising phenomenon, the IC is liable to malfunction should the ratings be exceeded.
2. Where wiring impedance is high, operations may become unstable due to the noise and/or phase lag depending on output current. Please strengthen VIN and VSS wiring in particular.
3. The input capacitor CIN and the output capacitor CL should be placed to the as close as possible with a shorter wiring.
4. The IC is controlled with constant current start-up. Start-up sequence control is requested to draw a load current after

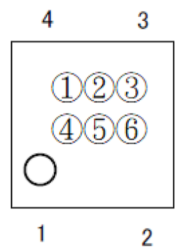
even nominal output voltage rising up the output voltage.

5. LFC places an importance on improving our products and its reliability. However, by any possibility, we would request user fail-safe design and post-aging treatment on system or equipment.

## MARKING RULE



SOT-25J
(TOP VIEW)



DFN1x1-4L

**① represents product number**

| Mark | Product Series |
|---|---|
| A | LPL1504A***** |

**②③ represents output voltage**

| Mark | Vout (v) |
|---|---|
| 11 | 1.1 |
| 15 | 1.5 |
| 18 | 1.8 |
| 25 | 2.5 |
| 28 | 2.8 |
| 30 | 3.0 |
| 33 | 3.3 |
| 36 | 3.6 |
| 50 | 5.0 |
| XX | X.X |

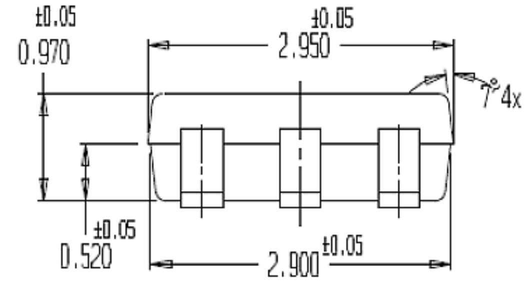
**④⑤⑥represents production lot number**

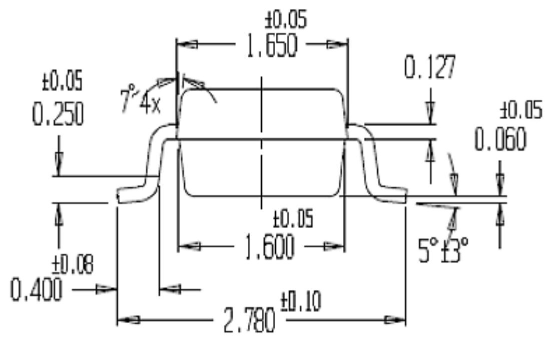
0 to 9, A to Z repeated.

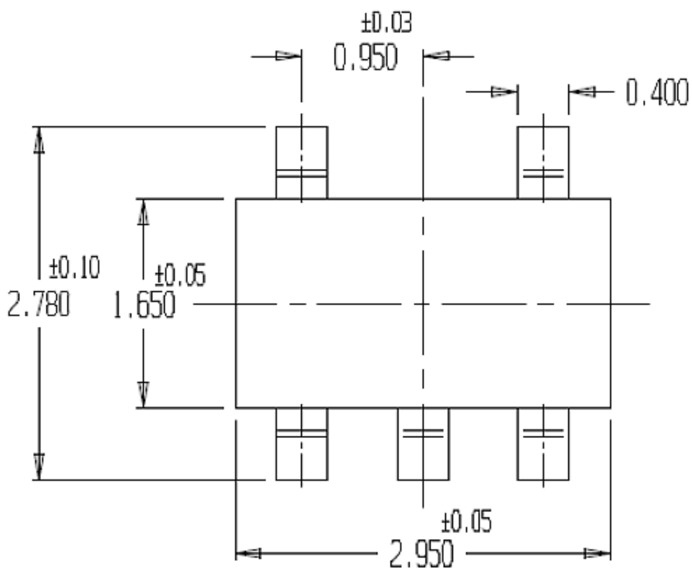
## Package Information

SOT-25J

UNIT: mm



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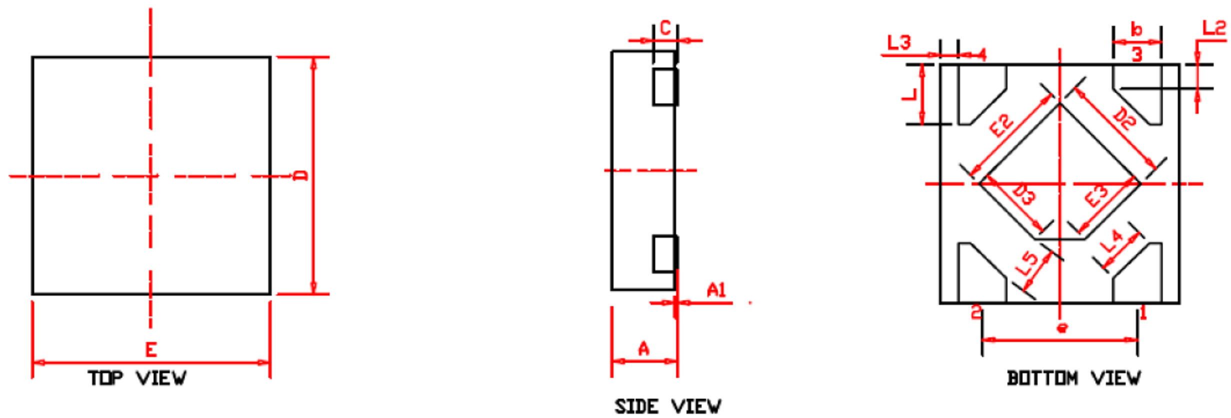
## Package Information

DFN1X1-4L




UNIT:MM

| SYMBOLS | Min | Typ | Max |
|---|---|---|---|
| A | 0.35 | 0.40 | 0.45 |
| A1 | 0.00 | 0.02 | 0.05 |
| C | 0.127REF | | |
| b | 0.15 | 0.20 | 0.25 |
| D | 0.95 | 1.0 | 1.05 |
| E | 0.95 | 1.0 | 1.05 |
| e | 0.650 BSC | | |
| D2 | 0.38 | 0.48 | 0.58 |
| D3 | 0.23 | 0.33 | 0.43 |
| E2 | 0.38 | 0.48 | 0.58 |
| E3 | 0.23 | 0.33 | 0.43 |
| L | 0.20 | 0.25 | 0.30 |
| L2 | 0.103REF | | |
| L3 | 0.075REF | | |
| L4 | 0.208REF | | |
| L5 | 0.200REF | | |

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