# 1.2MHz, 2A Synchronous Step-Down Converter

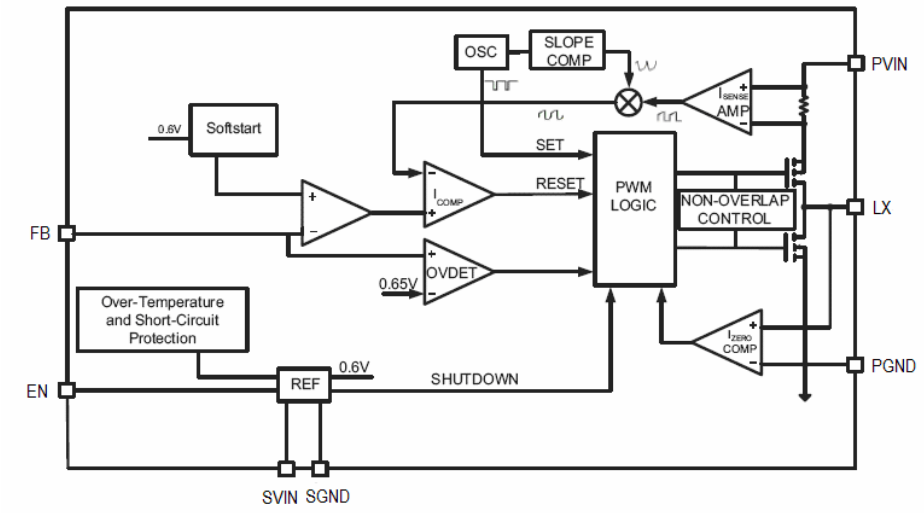
## ❖ GENERAL DESCRIPTION

The AX3504/A is a 1.2MHz constant frequency current mode PWM step-down converter. It is ideal for portable equipment requiring very high current up to 2A from single-cell Lithium-ion batteries while still achieving over 90% efficiency during peak load conditions. The AX3504/A also can run at 100% duty cycle for low dropout operation, extending battery life in portable systems while light load operation provides very low output ripple for noise sensitive applications. The AX3504/A can supply up to 2A output load current from a 2.5V to 5.5V input voltage and the output voltage can be regulated as low as 0.6V. The high switching frequency minimizes the size of external components while keeping switching losses low. The internal slope compensation setting allows the device to operate with smaller inductor values to optimize size and provide efficient operation. The AX3504/A is available in adjustable (0.6V to VIN) output voltage. The device is available in SOP8 Pb-free and DFN-10L packages.

## ❖ FEATURES

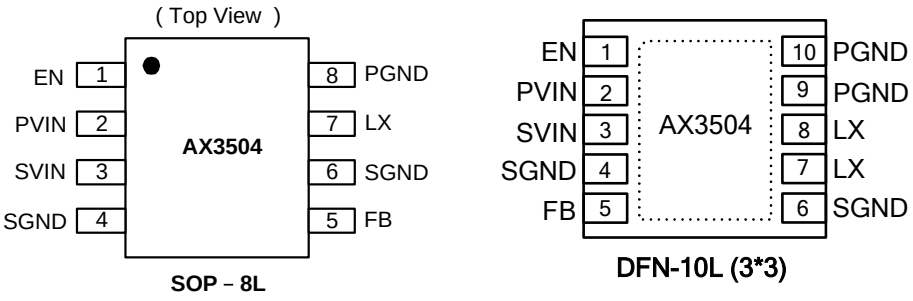
- 2.5V to 5.5V Input Voltage Range
- Output Voltages from 0.6V to VIN
- High Efficiency: Up to 95%
- 1.2MHz Constant Frequency Operation
- 2A Output Current
- No Schottky Diode Required
- Low $R_{DS(ON)}$ Internal Switches: 0.15Ω
- Current Mode Operation for Excellent Line and Load Transient Response
- Current limit, Enable function
- Short Circuit Protect (SCP)
- Build-in Soft Start function
- ≤ 1μA Shutdown Current
- SOP8 Pb-Free and DFN-10L packages

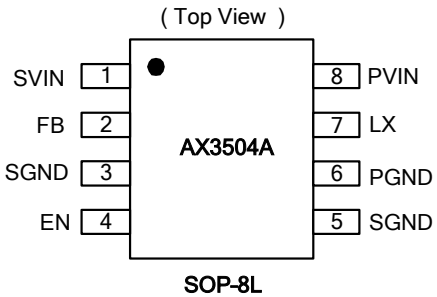
## ❖ Block Diagram




## ❖ PIN ASSIGNMENT

The packages of AX3504/A are SOP-8L and DFN-10L; the pin assignment is given by:



| Name | Description |
|---|---|
| EN | Enable pin<br>H：normal operation<br>L：Shutdown |
| PVIN | Power Supply Input Pin |
| SVIN | Signal Supply Input Pin |
| LX | Switch output pin. Connect external inductor here. Minimize trace area at this pin to reduce EMI. |
| SGND | Signal Ground Pin |
| PGND | Power Ground Pin |
| FB | Output Feedback pin |

## ❖ RDER/MARKING INFORMATION

| Order Information | Top Marking |
|---|---|
| AX3504 X XX X<br>Pin Type: Blank: AX3504, A: AX3504A<br>Package Type: S: SOP-8L, Z1: DFN-10L (3*3)<br>Packing: A : Taping | Logo ← AX 3504 → Part number<br>X X X X X → ID code: internal<br>WW: 01~52<br>Year : 07 = 2007<br>Blank:AX3504<br>A:AX3504A |

## ❖ Absolute Maximum Ratings (at $T_A$=25℃)

| Characteristics | Symbol | Rating | | Unit |
|---|---|---|---|---|
| PVIN, SVIN Pin Voltage | $V_{IN}$ | $V_{SS}$ - 0.3 to $V_{SS}$ + 6 | | V |
| Feedback Pin Voltage | $V_{FB}$ | $V_{SS}$ - 0.3 to $V_{CC}$ + 0.3 | | V |
| EN Pin Voltage | $V_{RUN}$ | $V_{SS}$ - 0.3 to $V_{CC}$ + 0.3 | | V |
| Switch Pin Voltage | $V_{SW}$ | $V_{SS}$ - 0.3 to $V_{CC}$ + 0.3 | | V |
| Power Dissipation | PD | ( $T_J$-$T_A$ ) / $\theta_{JA}$ | | mW |
| Storage Temperature Range | $T_{ST}$ | -40 to +150 | | ℃ |
| Operating Temperature Range | $T_{OP}$ | -40 to +85 | | ℃ |
| Junction Temperature | $T_J$ | +125 | | ℃ |
| Thermal Resistance from Junction to case | $\theta_{JC}$ | SOP8 | 20 | ℃/W |
| Thermal Resistance from Junction to ambient | $\theta_{JA}$ | SOP8 | 55 | ℃/W |

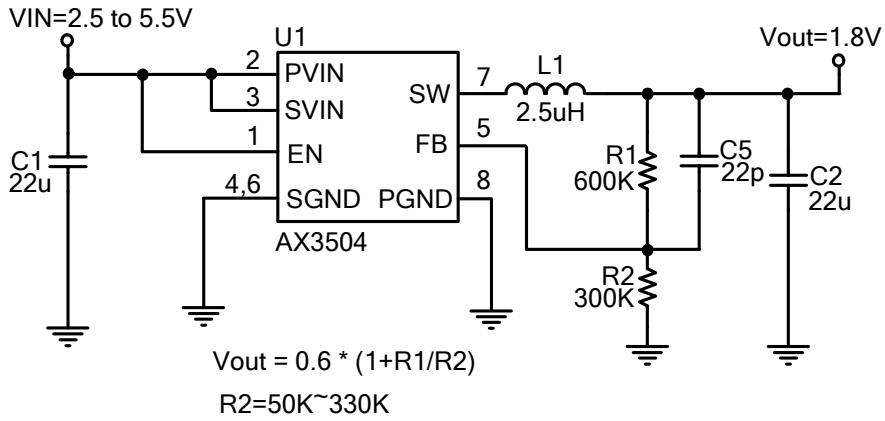
Note1： $\theta_{JA}$ is measured with the PCB copper area of approximately 1 $in^2$(Multi-layer). that need connect to $V_{SS}$ pin of the AX3504/A.

## ❖ Electrical Characteristics ($V_{IN}$ = $V_{EN}$=3.6V, $T_A$ =25℃, unless otherwise specified)

| Characteristics | Symbol | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| Supply Voltage Range | $V_{IN}$ | | 2.5 | - | 5.5 | V |
| Feedback Voltage | $V_{FB}$ | $T_A$ = +25°C | 0.5880 | 0.6000 | 0.6120 | V |
| | | $T_A$ = 0°C ≤ $T_A$ ≤ 85°C | 0.5865 | 0.6000 | 0.6135 | |
| | | $T_A$ = -40°C ≤ $T_A$ ≤ 85°C | 0.5820 | 0.6000 | 0.6180 | |
| Feedback Bias Current | $I_{FB}$ | $V_{FB}$=0.65V | - | - | ±30 | nA |
| Quiescent Current | $I_{CCQ}$ | $V_{FB}$=0.8V | - | 250 | 400 | uA |
| Shutdown Supply Current | $I_{SD}$ | $V_{EN}$ =0V | - | 0.1 | 1 | uA |
| Switching Current Limit | $I_{LIMIT}$ | | 2.2 | 2.5 | - | A |
| Line Regulation | △$V_{OUT}$/$V_{OUT}$ | $V_{CC}$ = 2.5V~5.5V | - | 0.04 | 0.4 | %/V |
| Load Regulation | △$V_{OUT}$/$V_{OUT}$ | $I_{OUT}$ = 0.01 to 2A | - | 1 | - | % |
| Oscillation Frequency | $F_{OSC}$ | SW pin | 1 | 1.2 | 1.4 | MHz |
| $R_{DS(ON)}$ of P-CH MOSFET | $R_{DSON}$ | $I_{SW}$ = 300mA | - | 0.20 | 0.30 | Ω |
| $R_{DS(ON)}$ of N-CH MOSFET | $R_{DSON}$ | $I_{SW}$ = -300mA | - | 0.15 | 0.25 | Ω |
| EN pin logic input threshold voltage | $V_{ENL}$ | | - | - | 0.3 | V |
| | $V_{ENH}$ | | 1.0 | - | - | |
| EN Pin Input Current | $I_{EN}$ | | - | ±0.1 | ±1 | uA |
| Efficiency | EFFI | VIN=5V, $V_{OUT}$=3.3V,$I_{OUT}$=2A | - | 88 | - | % |

Note2: 100% production test at +25°C. Specifications over the temperature range are guaranteed by design and characterization.

## ❖ Application Circuit




## ❖ Function Descriptions

### Operation

AX3504/A is a monolithic switching mode Step-Down DC-DC converter. It utilizes internal MOSFETs to achieve high efficiency and can generate very low output voltage by using internal reference at 0.6V. It operates at a fixed switching frequency, and uses the slope compensated current mode architecture. This Step-Down DC-DC Converter supplies 2000mA output current at input voltage range from 2.5V to 5.5V.

### Current Mode PWM Control

Slope compensated current mode PWM control provides stable switching and cycle-by-cycle current limit for excellent load and line responses and protection of the internal main switch (P-CH MOSFET) and synchronous rectifier (N-CH MOSFET). During normal operation, the internal P-CH MOSFET is turned on for a certain time to ramp the inductor current at each rising edge of the internal oscillator, and switched off when the peak inductor current is above the error voltage. The current comparator, $I_{COMP}$, limits the peak inductor current. When the main switch is off, the synchronous rectifier will be turned on immediately and stay on until either the inductor current starts to reverse, as indicated by the current reversal comparator, $I_{ZERO}$, or the beginning of the next clock cycle. The OVDET comparator controls output transient overshoots by turning the main switch off and keeping it off until the fault is no longer present.

## ❖ Application Information

### Setting the Output Voltage

Application circuit item shows the basic application circuit with AX3504/A adjustable output version. The external resistor sets the output voltage according to the following equation:

$$V_{OUT} = 0.6V \times \left(1 + \frac{R1}{R2}\right)$$

Table 1 Resistor select for output voltage setting

| $V_{OUT}$ | R2 | R1 |
|---|---|---|
| 1.2V | 300K | 300K |
| 1.5V | 300K | 450K |
| 1.8V | 300K | 600K |
| 2.5V | 300K | 950K |

### Inductor Selection

For most designs, the AX3504/A operates with inductors of 1μH to 4.7μH. Low inductance values are physically smaller but require faster switching, which results in some efficiency loss. The inductor value can be derived from the following equation:

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times f_{OSC}}$$

Where is inductor Ripple Current. Large value inductors lower ripple current and small value inductors result in high ripple currents. Choose inductor ripple current approximately 35% of the maximum load current 2000mA, $\Delta I_L$=700mA.

Table 2 Inductor select for output voltage setting ($V_{CC}$=3.6V)

| $V_{OUT}$ | 1.2V | 1.5V | 1.8V | 2.5V |
|---|---|---|---|---|
| Inductor | 3uH | 3uH | 3uH | 2.5uH |
| Part Number WE-TPC | 744052003 | 744052003 | 744052003 | 744052002 |

Note: Part type L (www.we-online.com)

For output voltages above 2.0V, when light-load efficiency is important, the minimum recommended inductor is 2.5μH. For optimum voltage-positioning load transients, choose an inductor with DC series resistance in the 30mΩ to 100mΩ range. For higher efficiency at heavy loads (above 200mA), or minimal load regulation (but some transient overshoot), the resistance should be kept below 100mΩ. The DC current rating of the inductor should be at least equal to the maximum load current plus half the ripple current to prevent core saturation (2000mA+350mA).

## Input Capacitor Selection

The input capacitor reduces the surge current drawn from the input and switching noise from the device. The input capacitor impedance at the switching frequency shall be less than input source impedance to prevent high frequency switching current passing to the input. A low ESR input capacitor sized for maximum RMS current must be used. Ceramic capacitors with X5R or X7R dielectrics are highly recommended because of their low ESR and small temperature coefficients. A 22μF ceramic capacitor for most applications is sufficient.

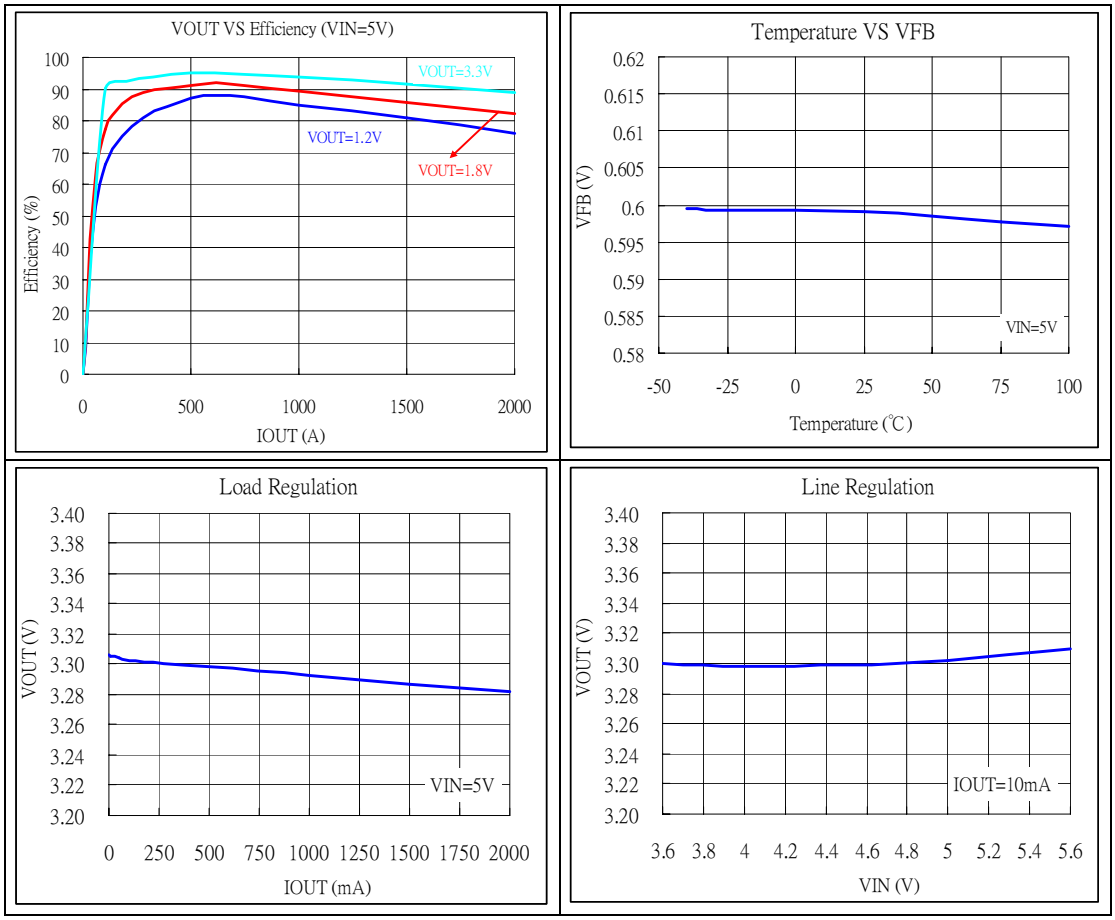
## Output Capacitor Selection

The output capacitor is required to keep the output voltage ripple small and to ensure regulation loop stability. The output capacitor must have low impedance at the switching frequency. Ceramic capacitors with X5R or X7R dielectrics are recommended due to their low ESR and high ripple current.

## Compensation Capacitor Selection

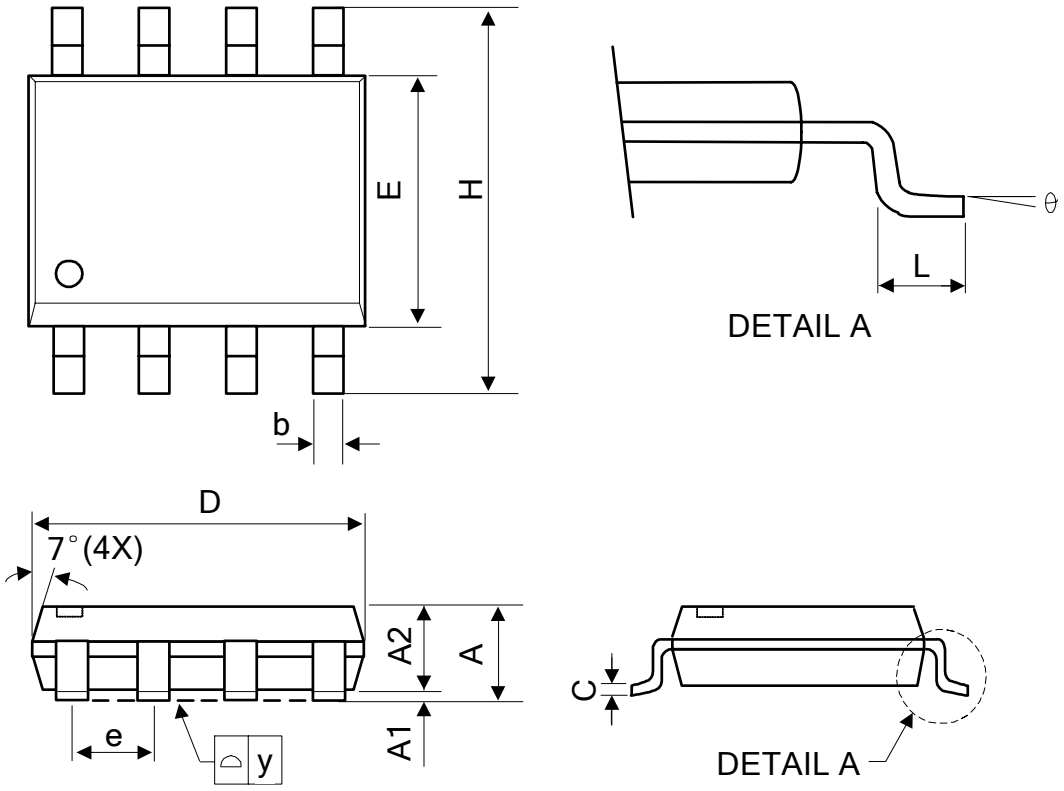
The compensation capacitors for increasing phase margin provide additional stability. It is required and more than 22p, Refer to Demo Board Schematic, The optimum values for C4 is 47pF.

## ❖ Typical Characteristics



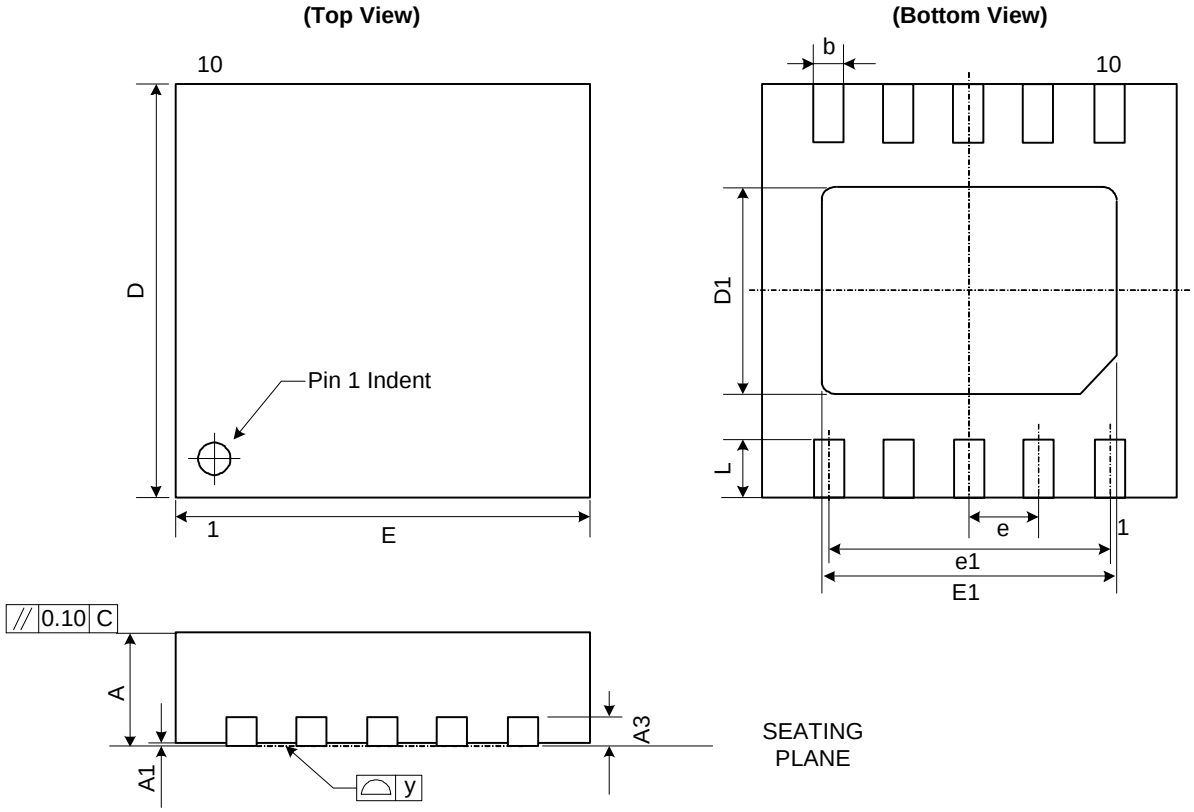
## ❖ Package Outlines

(1) SOP-8L




| Symbol | Dimensions In Millimeters | | | Dimensions In Inches | | |
|---|---|---|---|---|---|---|
| | Min. | Nom. | Max. | Min. | Nom. | Max. |
| A | 1.40 | 1.60 | 1.75 | 0.055 | 0.063 | 0.069 |
| A1 | 0.10 | - | 0.25 | 0.040 | - | 0.100 |
| A2 | 1.30 | 1.45 | 1.50 | 0.051 | 0.057 | 0.059 |
| C | 0.19 | 0.20 | 0.25 | 0.0075 | 0.008 | 0.010 |
| D | 4.80 | 4.90 | 5.00 | 0.189 | 0.193 | 0.197 |
| E | 3.80 | 3.90 | 4.00 | 0.150 | 0.154 | 0.157 |
| H | 5.79 | 5.99 | 6.20 | 0.228 | 0.236 | 0.244 |
| L | 0.38 | 0.71 | 1.27 | 0.015 | 0.028 | 0.050 |
| b | 0.33 | 0.41 | 0.51 | 0.013 | 0.016 | 0.020 |
| e | 1.27 TYP | | | 0.050 TYP | | |
| y | - | - | 0.10 | - | - | 0.004 |
| θ | 0° | - | 8° | 0° | - | 8° |

(2) DFN-10L (3*3*0.8mm)




| Symbol | Dimensions In Millimeters | | | Dimensions In Inches | | |
|---|---|---|---|---|---|---|
| | Min. | Nom. | Max. | Min. | Nom. | Max. |
| A | - | - | 0.90 | - | - | 0.036 |
| A1 | 0.00 | 0.02 | 0.05 | 0.000 | 0.001 | 0.002 |
| A3 | 0.20 REF. | | | 0.008 REF. | | |
| b | 0.18 | 0.25 | 0.30 | 0.007 | 0.010 | 0.012 |
| D | 2.90 | 3.00 | 3.10 | 0.114 | 0.118 | 0.122 |
| D1 | 1.10 | 1.20 | 1.30 | 0.043 | 0.047 | 0.051 |
| E | 2.90 | 3.00 | 3.10 | 0.114 | 0.118 | 0.122 |
| E1 | 2.10 | 2.20 | 2.30 | 0.083 | 0.087 | 0.091 |
| L | 0.45 | 0.55 | 0.65 | 0.018 | 0.022 | 0.026 |
| e | 0.50 BSC. | | | 0.020 BSC. | | |
| e1 | 2.00 BSC. | | | 0.079 BSC. | | |
| y | 0.00 | - | 0.08 | 0.000 | - | 0.003 |