

## ■ General Description

The AME5251A is a high efficiency monolithic synchronous dual buck regulator using a constant frequency, current mode architecture. Capable of delivering 1A output current each channel over a wide input voltage range from 2.5V to 5.5V.

Supply current with no load is 400 $\mu$ A and drops to <1 $\mu$ A in shutdown. The 2.5V to 5.5V input voltage range makes the AME5251A ideally suited for single Li-Ion battery-powered applications. 100% duty cycle provides low dropout operation, extending battery life in portable systems. PWM pulse skipping mode operation provides very low output ripple voltage for noise sensitive applications. At very light load, the AME5251A will automatically skip pulses in pulse skip mode operation to maintain output regulation.

The internal synchronous switch increases efficiency and eliminates the need for an external Schottky diode. Low output voltages are easily supported with the 0.6V feedback reference voltage. The AME5251A is available in small DFN-12A packages.

Other features include soft start, lower internal reference voltage with 2% accuracy, over temperature protection, and over current protection.

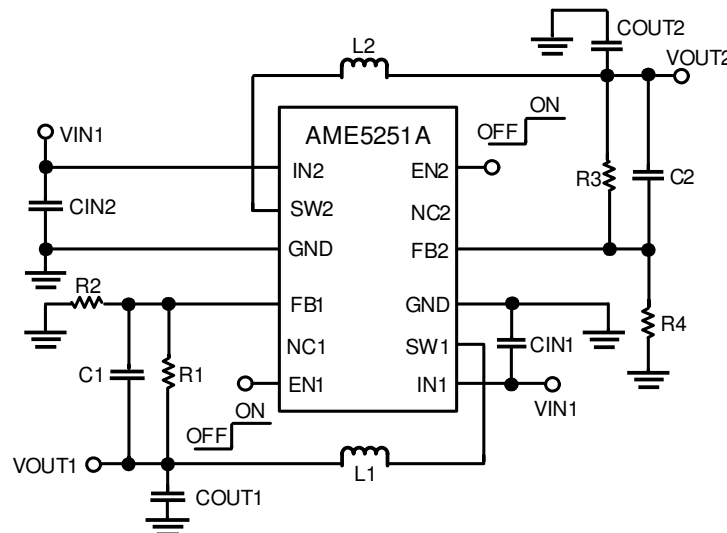
## ■ Features

- High Efficiency: Up to 95%
- Shutdown Mode Draws <1 $\mu$ A Supply Current
- 2.5V to 5.5V Input Range
- Adjustable Output From 0.6V to  $V_{IN}$
- 1A Output Current Per Channel
- Low Dropout Operation: 100% Duty Cycle
- No Schottky Diode Required
- 1.5MHz Constant Frequency PWM Operation
- Small DFN-12A Packages
- Green Products Meet RoHS Standard

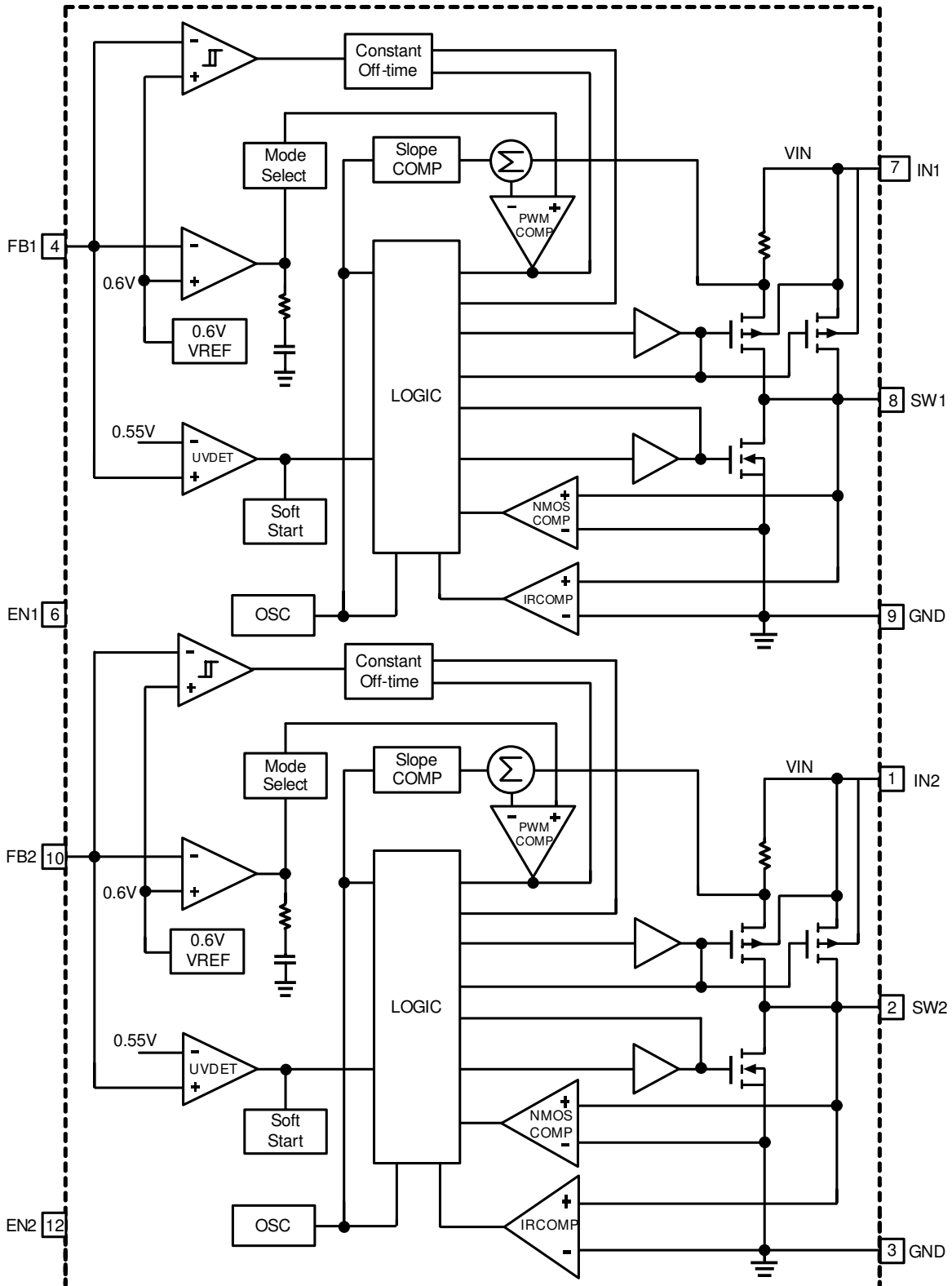
## ■ Applications

- Cellular Telephones
- Personal Information Appliances
- Wireless and DSL Modems
- MPS Players
- Portable Instruments

## ■ Typical Application



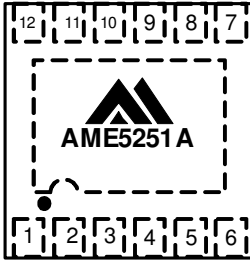
## ■ Function Block Diagram



## AME5251A

### ■ Pin Configuration

DFN-12A  
(3mmx3mmx0.75mm)  
Top View



**AME5251A-AVCxxxxxx**

1. IN2
2. SW2
3. GND
4. FB1
5. NC1
6. EN1
7. IN1
8. SW1
9. GND
10. FB2
11. NC2
12. EN2

**\* Die Attach:  
Conductive Epoxy**

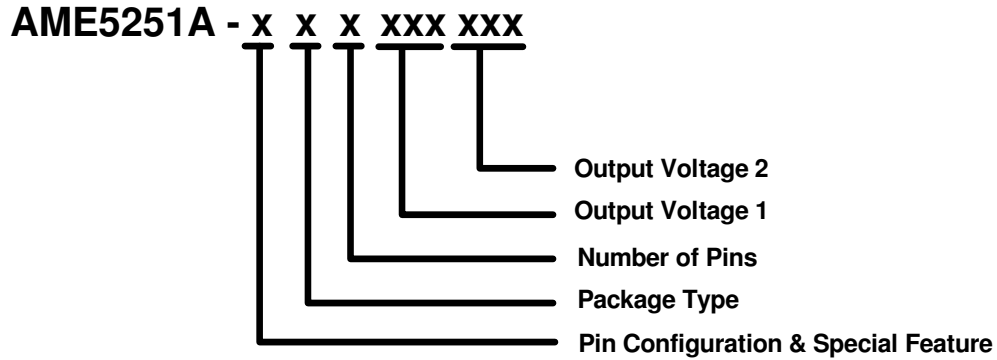
**Note:**  
Connect exposed pad (heat sink on the back) to GND.

### ■ Pin Description

| Pin Name | Pin Description   |
|----------|---|
| NC       | No connection. Not internally connected. Can left floating or connected to GND.                   |
| EN       | Enable Control Input, active high.  |
| IN       | Input Supply Voltage Pin.<br>Bypass this pin with a capacitor as close to the device as possible. |
| SW       | Switch Node Connection to Inductor.   |
| GND      | Ground. Tie directly to ground plane.   |
| FB       | Output voltage Feedback input.  |

## AME5251A

### ■ Ordering Information



| Pin Configuration & Special Feature   | Package Type | Number of Pins | Output Voltage1 | Output Voltage2 |
|---|--------------|----------------|-----------------|-----------------|
| A<br>(DFN-12A)<br>1. IN2<br>2. SW2<br>3. GND<br>4. FB1<br>5. NC1<br>6. EN1<br>7. IN1<br>8. SW1<br>9. GND<br>10. FB2<br>11. NC2<br>12. EN2 | V: DFN       | C: 12          | ADJ: Adjustable | ADJ: Adjustable |

## AME5251A

### ■ Absolute Maximum Ratings

| Parameter             | Symbol            | Maximum          | Unit |
|-----------------------|-------------------|------------------|------|
| Input Supply Voltage  | $V_{IN}$          | -0.3 to 6.5      | V    |
| EN, $V_{OUT}$ Voltage | $V_{EN}, V_{OUT}$ | -0.3 to $V_{IN}$ |      |
| SW Voltage            | $V_{SW}$          | -0.3 to $V_{IN}$ |      |
| ESD Classification    | B*                |                  |      |

Caution: Stress above the listed absolute maximum rating may cause permanent damage to the device.

\* HBM B: 2000V~3999V

### ■ Recommended Operating Conditions

| Parameter                  | Symbol   | Rating      | Unit |
|----------------------------|----------|-------------|------|
| Supply Voltage Voltage     | $V_{IN}$ | 2.5 to 5.5  | V    |
| Ambient Temperature Range  | $T_A$    | -40 to +85  | °C   |
| Junction Temperature Range | $T_J$    | -40 to +125 | °C   |

### ■ Thermal Information

| Parameter                                   | Package | Die Attach       | Symbol        | Maximum | Unit   |
|---|---------|------------------|---------------|---------|--------|
| Thermal Resistance*<br>(Junction to Case)   | DFN-12A | Conductive Epoxy | $\theta_{JC}$ | 8.5     | °C / W |
| Thermal Resistance<br>(Junction to Ambient) |         |                  | $\theta_{JA}$ | 65      |        |
| Internal Power Dissipation                  |         |                  | $P_D$         | 1.54    | W      |
| Solder Iron (10Sec)**                       |         |                  |               | 350     | °C     |

\* Measure  $\theta_{JC}$  on backside center of Exposed Pad.

\*\* MIL-STD-202G 210F

## AME5251A

### ■ Electrical Specifications

$V_{IN}=3.6V$ ,  $V_{OUT}=2.5V$ ,  $V_{FB}=0.6V$ ,  $L=2.2\mu H$ ,  $C_{IN}=4.7\mu F$ ,  $C_{OUT}=10\mu F$ ,  $T_A=25^\circ C$ ,  $I_{MAX}=1A$  unless otherwise specified.

| Parameter                             | Symbol           | Test Condition                                   | Min      | Typ  | Max          | Units      |
|---------------------------------------|------------------|--|----------|------|--------------|------------|
| Input voltage                         | $V_{IN}$         |  | 2.5      |      | 5.5          | V          |
| Adjustable Output Range               | $V_{out}$        |  | $V_{FB}$ |      | $V_{IN}-0.2$ | V          |
| Feedback Voltage                      | $V_{FB}$         | For Adjustable Output Voltage                    | 0.588    | 0.6  | 0.612        | V          |
| Feedback Pin Bias Current             | $I_{FB}$         | $V_{FB}=V_{IN}$                                  | -50      |      | 50           | nA         |
| Quiescent Current                     | $I_Q$            | $I_{OUT}=0mA$ , $V_{FB}=1V$                      |          | 0.4  | 0.5          | mA         |
| Shutdown Current                      | $I_{SHDN}$       | $V_{EN}=GND$                                     |          | 0.1  | 1            | $\mu A$    |
| Switch Frequency                      | $f_{OSC}$        |  | 1.2      | 1.5  | 1.8          | MHz        |
| High-side Switch On-Resistance        | $R_{DS,ON, LHI}$ | $I_{SW}=200mA$ , $V_{IN}=3.6V$                   |          | 0.28 |              | $\Omega$   |
| Low-side Switch On-Resistance         | $R_{DS,ON, LO}$  | $I_{SW}=200mA$ , $V_{IN}=3.6V$                   |          | 0.25 |              | $\Omega$   |
| Switch Current Limit                  | $I_{SW,CL}$      | $V_{IN}=2.5$ to $5.5V$                           | 1.4      | 1.6  |              | A          |
| EN High (Enabled the Device)          | $V_{EN,HI}$      | $V_{IN}=2.5$ to $5.5V$                           | 1.5      |      |              | V          |
| EN Low (Shutdown the Device)          | $V_{EN,LO}$      | $V_{IN}=2.5$ to $5.5V$                           |          |      | 0.4          | V          |
| Input Undervoltage Lockout            | $V_{UVLO}$       | rising edge                                      |          | 1.8  |              | V          |
| Input Undervoltage Lockout Hysteresis | $V_{UVLO,HYST}$  |  |          | 0.1  |              | V          |
| Thermal Shutdown Temperature          | OTP              | Shutdown, temperature increasing                 |          | 160  |              | $^\circ C$ |
| Maximum Duty Cycle                    | $D_{MAX}$        |  | 100      |      |              | %          |
| SW Leakage Current                    |                  | $EN=0V$ , $V_{IN}=5.0V$<br>$V_{SW}=0V$ or $5.0V$ | -1       |      | 1            | $\mu A$    |

Note 1. Spec. for per channel

## ■ Detailed Description

### Main Control Loop

AME5251A uses a constant frequency, current mode step-down architecture. Both the main (P-channel MOSFET) and synchronous (N-channel MOSFET) switches are internal. During normal operation, the internal top power MOSFET is turned on each cycle when the oscillator sets the RS latch, and turned off when the current comparator resets the RS latch. While the top MOSFET is off, the bottom MOSFET is turned on until either the inductor current starts to reverse as indicated by the current reversal comparator IRCMP.

### Pulse Skipping Mode Operation

At light loads, the inductor current may reach zero or reverse on each pulse. The bottom MOSFET is turned off by the current reversal comparator, IRCMP, and the switch voltage will ring. This is discontinuous mode operation, and is normal behavior for the switching regulator.

### Short-Circuit Protection

When the output is shorted to ground, the frequency of the oscillator is reduced to about 180KHz. This frequency foldback ensures that the inductor current has more time to decay, thereby preventing runaway. The oscillator's frequency will progressively increase to 1.5MHz when  $V_{FB}$  or  $V_{OUT}$  rises above 0V.

### Dropout Operation

As the input supply voltage decreases to a value approaching the output voltage, the duty cycle increases toward the maximum on-time. Further reduction of the supply voltage forces the main switch to remain on for more than one cycle until it reaches 100% duty cycle. The output voltage will then be determined by the input voltage minus the voltage drop across the P-channel MOSFET and the inductor.

## ■ Application Information

The basic AME5251A application circuit is shown in Typical Application Circuit. External component selection is determined by the maximum load current and begins with the selection of the inductor value and followed by  $C_{IN}$  and  $C_{OUT}$ .

### Inductor Selection

For a given input and output voltage, the inductor value and operating frequency determine the ripple current. The ripple current DIL increases with higher  $V_{IN}$  and decreases with higher inductance.

$$\Delta I_L = \frac{1}{(f)(L)} V_{OUT} \left( 1 - \frac{V_{OUT}}{V_{IN}} \right)$$

A reasonable starting point for setting ripple current is  $\Delta I_L = 0.4(I_{MAX})$ . 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. For better efficiency, choose a low DC-resistance inductor.

### $C_{IN}$ and $C_{OUT}$ Selection

The input capacitance,  $C_{IN}$  is needed to filter the trapezoidal current at the source of the top MOSFET. To prevent large voltage transients, a low ESR input capacitor sized for the maximum RMS current must be used. The maximum RMS capacitor current is given by:

$$I_{RMS} = I_{OUT(MAX)} \frac{V_{OUT}}{V_{IN}} \sqrt{\frac{V_{IN}}{V_{OUT}} - 1}$$

This formula has a maximum at  $V_{IN}=2V_{OUT}$ , where  $I_{RMS}=I_{OUT}/2$ . This simple worst-case condition is commonly used for design because even significant deviations do not offer much relief. Note that the capacitor manufacturer ripple current ratings are often based on 2000 hours of life. This makes it advisable to further derate the capacitor, or choose a capacitor rated at a higher temperature than required.

The selection of  $C_{OUT}$  is determined by the effective series resistance (ESR) that is required to minimize voltage ripple and load step transients. The output ripple,  $V_{OUT}$ , is determined by:

$$\Delta V_{OUT} \cong \Delta I_L \left( ESR + \frac{1}{8fC_{OUT}} \right)$$

### Using Ceramic Input and Output Capacitors

Higher values, lower cost ceramic capacitors are now becoming available in smaller case sizes. Their high ripple current, high voltage rating and low ESR make them ideal for switching regulator applications. However, care must be taken when these capacitors are used at the input and output. When a ceramic capacitor is used at the input and the power is supplied by a wall adapter through long wires, a load step at the output can induce ringing at the input,  $V_{IN}$ . At best, this ringing can couple to the output and be mistaken as loop instability. At worst, a sudden inrush of current through the long wires can potentially cause a voltage spike at  $V_{IN}$  large enough to damage the part.

### Output Voltage Programming

The output voltage is set by an external resistive divider according to the following equation:

$$V_{OUT} = V_{REF} \times \left( 1 + \frac{R_1}{R_2} \right)$$

Where  $V_{REF}$  equals to 0.6V typical. The resistive divider allows the FB pin to sense a fraction of the output voltage as shown in Figure 1.

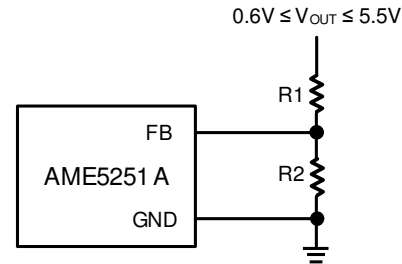


Figure 1: Setting the AME5251A Output Voltage

### Thermal Considerations

In most applications the AME5251A does not dissipate much heat due to its high efficiency. But, in applications where the AME5251A is running at high ambient temperature with low supply voltage and high duty cycles, such as in dropout, the heat dissipated may exceed the maximum junction temperature of the part. If the junction temperature reaches approximately 160°C, both power switches will be turned off and the SW node will become high impedance. To avoid the AME5251A from exceeding the maximum junction temperature, the user will need to do some thermal analysis. The goal of the thermal analysis is to determine whether the power dissipated exceeds the maximum junction temperature of the part. The temperature rise is given by:

$$T_R = (PD)(\theta_{JA})$$

Where PD is the power dissipated by the regulator and  $\theta_{JA}$  is the thermal resistance from the junction of the die to the ambient temperature.



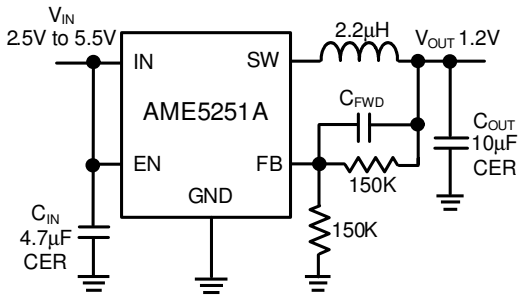


Figure 2: 1.2V Step-Down Regulator

$C_{FWD}$ : 22pF~220pF

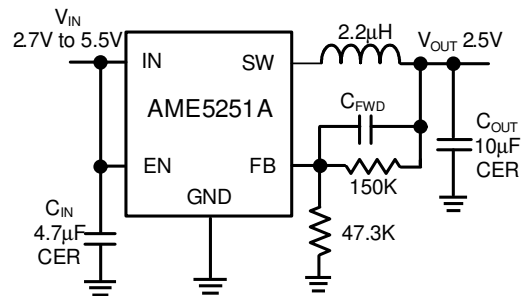


Figure 5: 2.5V Step-Down Regulator

$C_{FWD}$ : 22pF~220pF

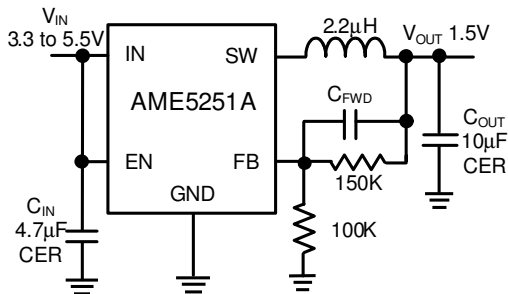


Figure 3: 1.5V Step-Down Regulator

$C_{FWD}$ : 22pF~220pF

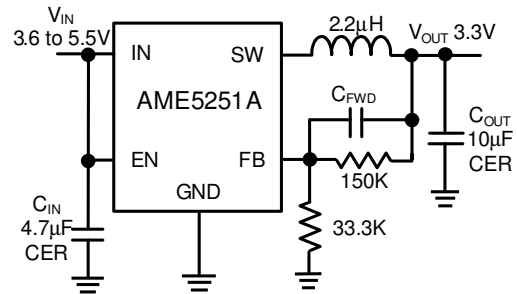


Figure 6: 3.3V Step-Down Regulator

$C_{FWD}$ : 22pF~220pF

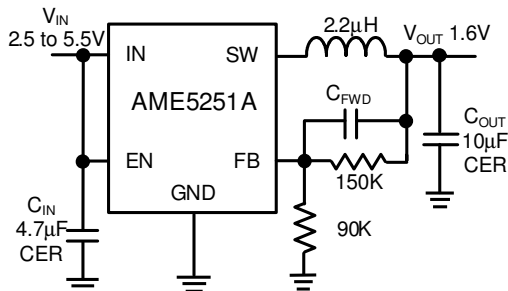


Figure 4: 1.6V Step-Down Regulator

$C_{FWD}$ : 22pF~220pF

**PC Board Layout Checklist**

When laying out the printed circuit board, the following checklist should be used to ensure proper operation of the AME5251A. Check the following in your layout:

1. The power traces, consisting of the GND trace, the SW trace and the  $V_{IN}$  trace should be kept short, direct and wide.
2. Does the  $V_{FB}$  pin connect directly to the feedback resistors? The resistive divider R2/R1 must be connected between the (+) plate of  $C_{OUT}$  and ground.
3. Does the (+) plate of  $C_{IN}$  connect to  $V_{IN}$  as closely as possible? This capacitor provides the AC current to the internal power MOSFETs.
4. Keep the switching node, SW, away from the sensitive  $V_{FB}$  node.
5. Keep the (-) plates of  $C_{IN}$  and  $C_{OUT}$  as close as possible.

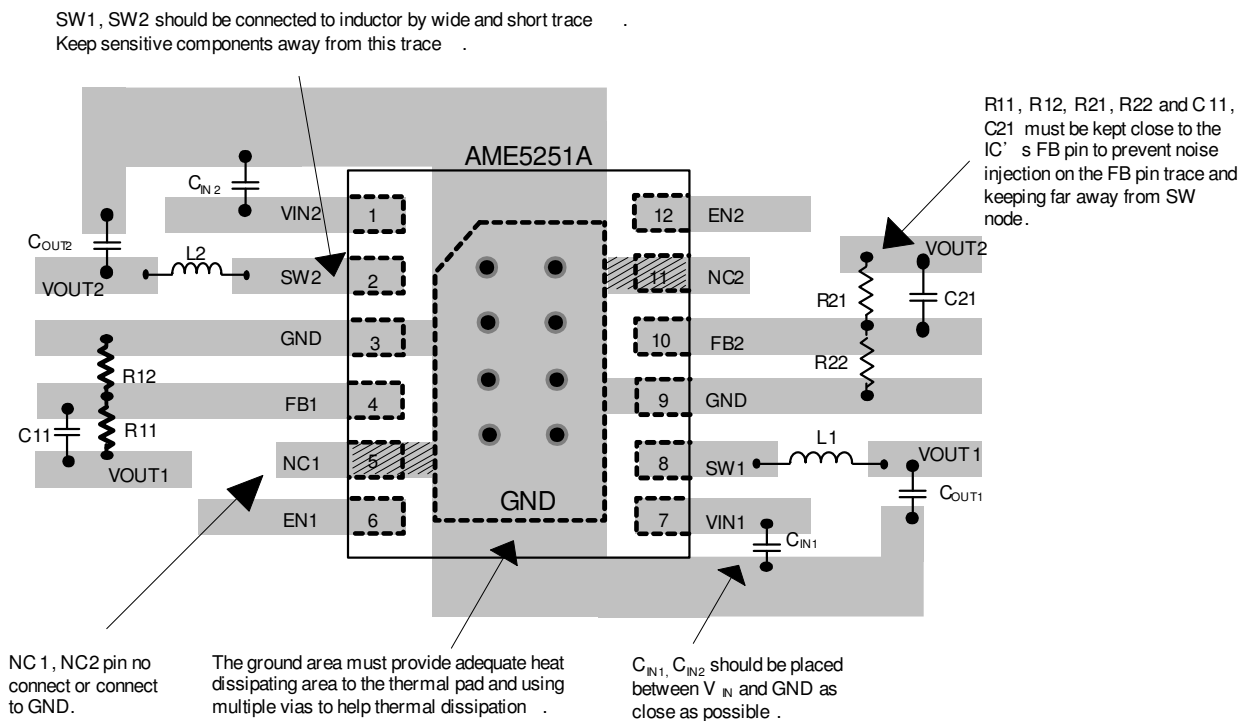


Figure 7: AME5251A Adjustable Voltage Regulator Layout Diagram

### ■ Application Information

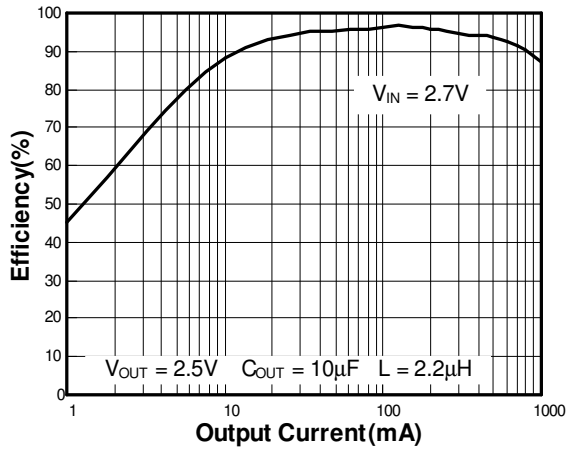
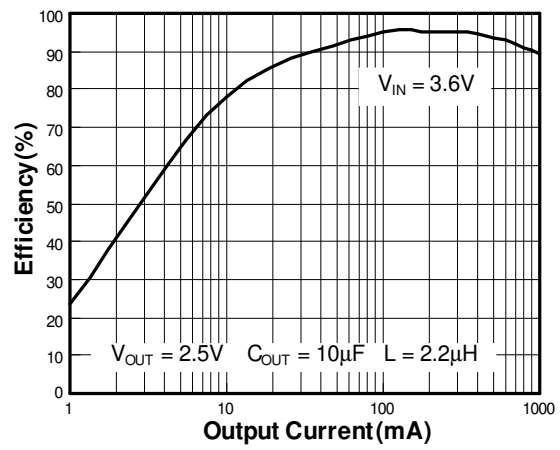
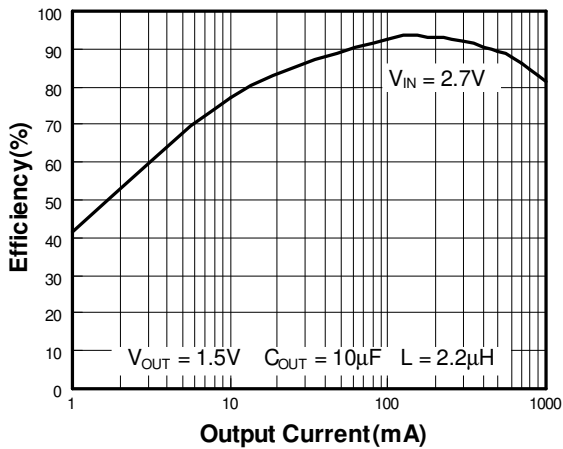
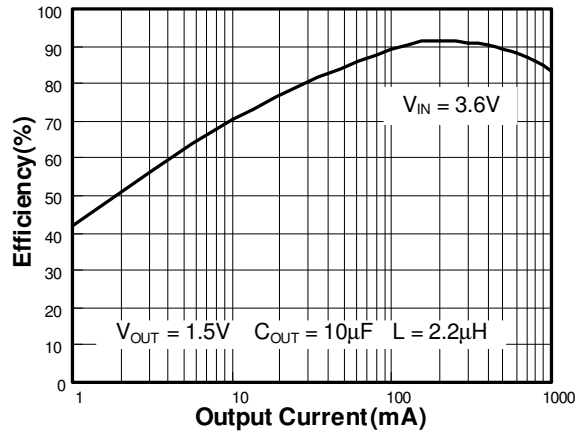
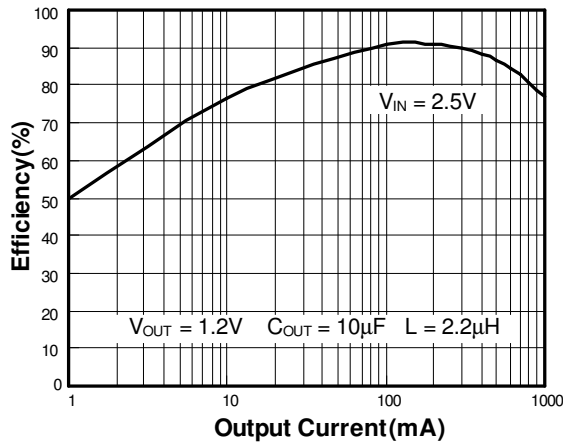
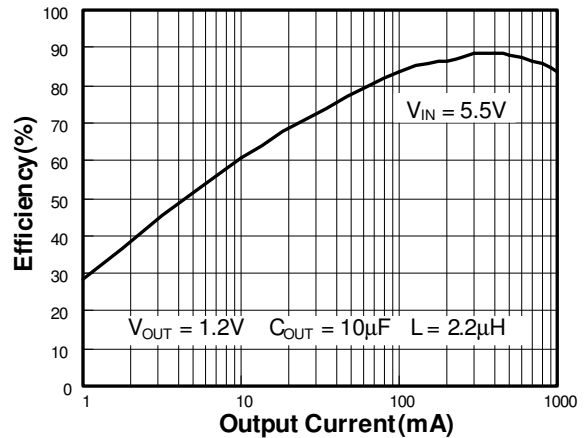
#### External components selection

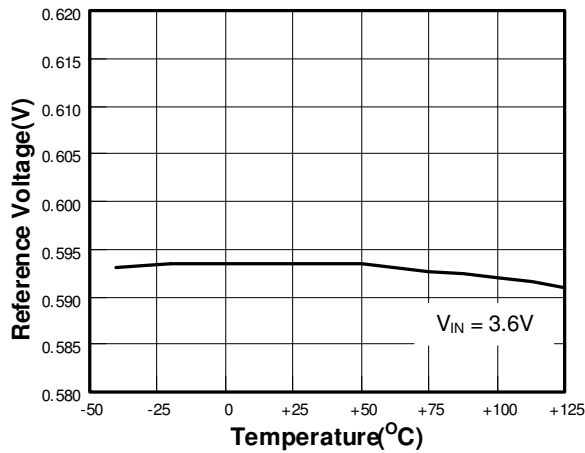
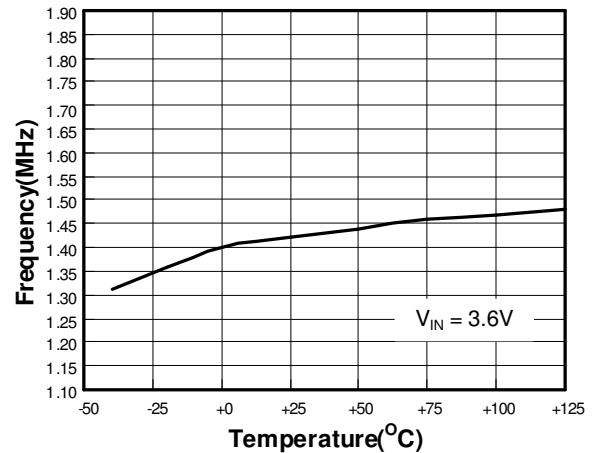
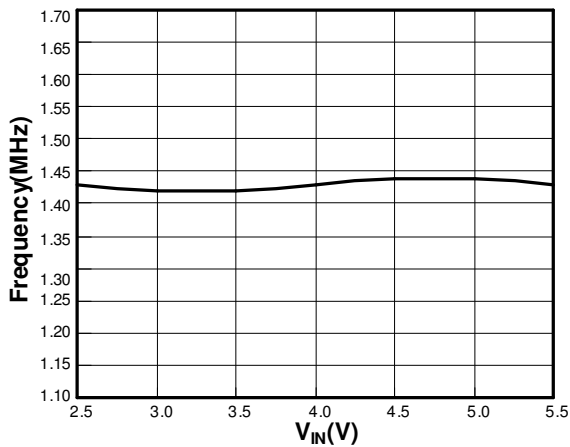
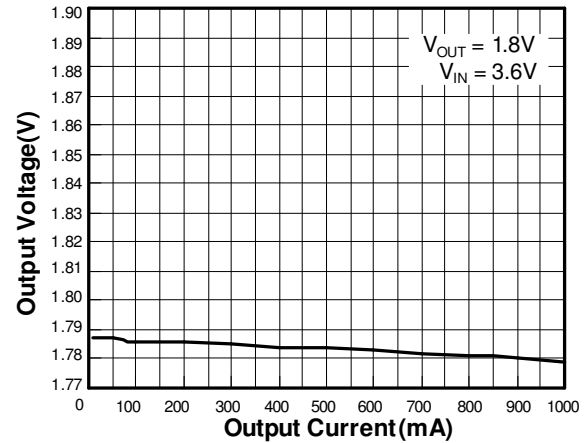
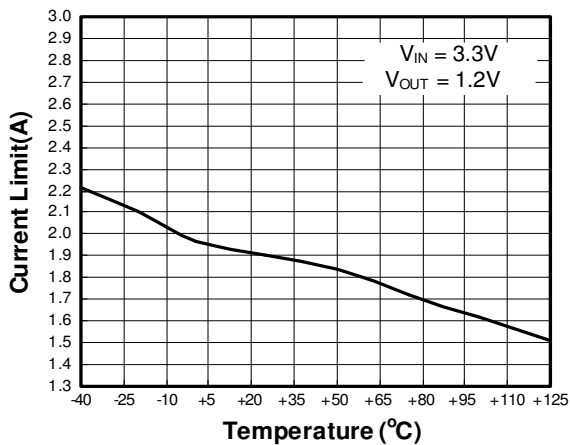
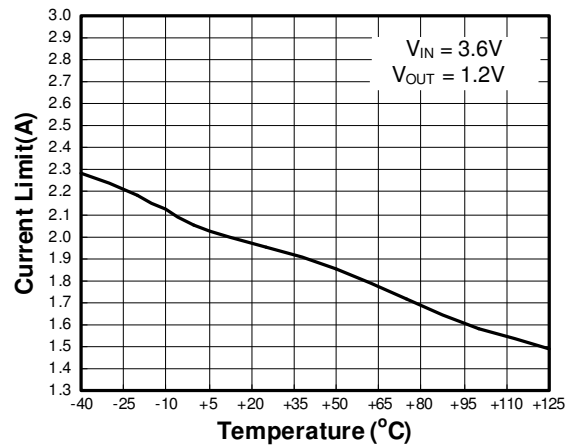
| Supplier    | Inductance (μH) | Current Rating (mA) | DCR (mΩ) | Dimensions (mm)    | Series   |
|-------------|-----------------|---------------------|----------|--------------------|----------|
| TAIYO YUDEN | 2.2             | 1480                | 60       | 3.00 x 3.00 x 1.50 | NR 3015  |
| GOTREND     | 2.2             | 1500                | 58       | 3.85 x 3.85 x 1.80 | GTSD32   |
| Sumida      | 2.2             | 1500                | 75       | 4.50 x 3.20 x 1.55 | CDRH2D14 |
| Sumida      | 4.7             | 1000                | 135      | 4.50 x 3.20 x 1.55 | CDRH2D14 |
| TAIYO YUDEN | 4.7             | 1020                | 120      | 3.00 x 3.00 x 1.50 | NR 3015  |
| GOTREND     | 4.7             | 1100                | 146      | 3.85 x 3.85 x 1.80 | GTSD32   |

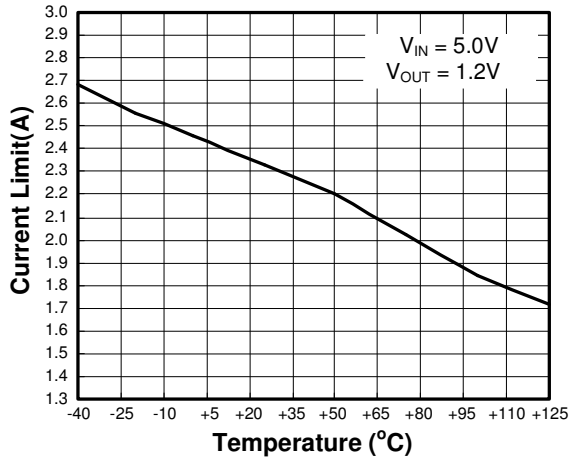
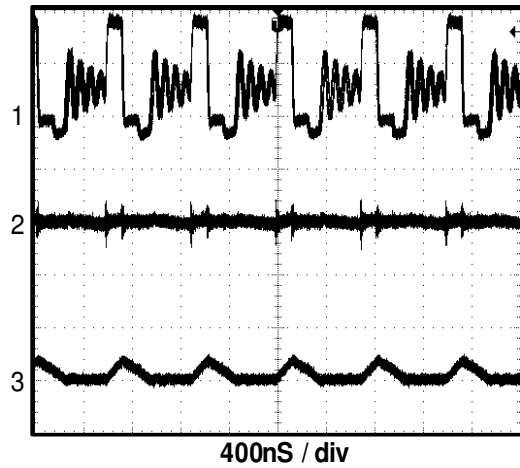
**Table 1. Recommended Inductors**

| Supplier    | Capacitance (μF) | Package | Part Number       |
|-------------|------------------|---------|-------------------|
| TDK         | 4.7              | 603     | C1608JB0J475M     |
| MURATA      | 4.7              | 603     | GRM188R60J475KE19 |
| TAIYO YUDEN | 4.7              | 603     | JMK107BJ475RA     |
| TAIYO YUDEN | 10               | 603     | JMK107BJ106MA     |
| TDK         | 10               | 805     | C2012JB0J106M     |
| MURATA      | 10               | 805     | GRM219R60J106ME19 |
| MURATA      | 10               | 805     | GRM219R60J106KE19 |
| TAIYO YUDEN | 10               | 805     | JMK212BJ106RD     |

**Table 2. Recommended Capacitors for C<sub>IN</sub> and C<sub>OUT</sub>**

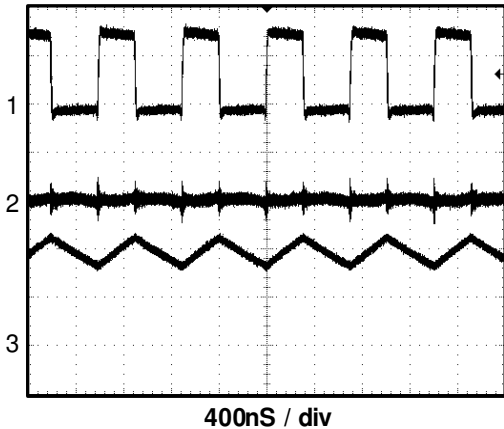
**■ Characterization Curve**
**Efficiency vs. Output Current**

**Efficiency vs. Output Current**

**Efficiency vs. Output Current**

**Efficiency vs. Output Current**

**Efficiency vs. Output Current**

**Efficiency vs. Output Current**


**■ Characterization Curve (Contd.)**
**Reference Voltage vs. Temperature**

**Frequency vs. Temperature**

**Frequency vs. Supply Voltage**

**Output Voltage vs. Output Current**

**Current Limit vs. Temperature**

**Current Limit vs. Temperature**


**■ Characterization Curve (Contd.)**
**Current Limit vs. Temperature**

**Light Load Mode Output Voltage Ripple**


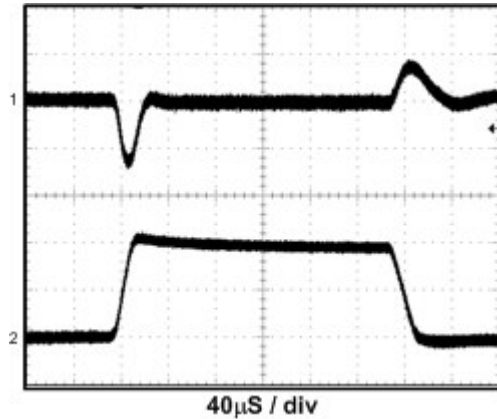
$V_{IN} = 3.6V$   
 $V_{OUT} = 1.2V$   
 $I_{OUT} = 50mA$

- 1)  $V_{SW} = 2V/div$
- 2)  $V_{OUT} = 10mV/div$
- 3)  $I_L = 500mA/div$

**Heavy Load Mode Output Voltage Ripple**


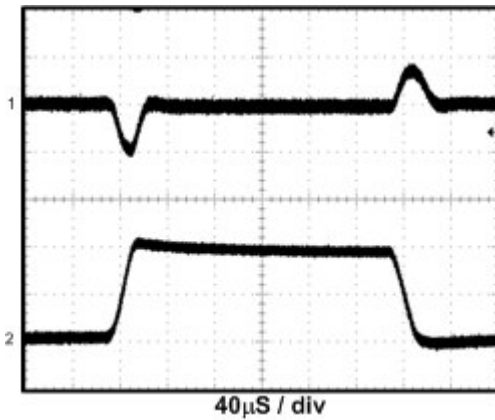
$V_{IN} = 3.6V$   
 $V_{OUT} = 1.2V$   
 $I_{OUT} = 1A$

- 1)  $V_{SW} = 2V/div$
- 2)  $V_{OUT} = 10mV/div$
- 3)  $I_L = 500mA/div$

**Load Step**


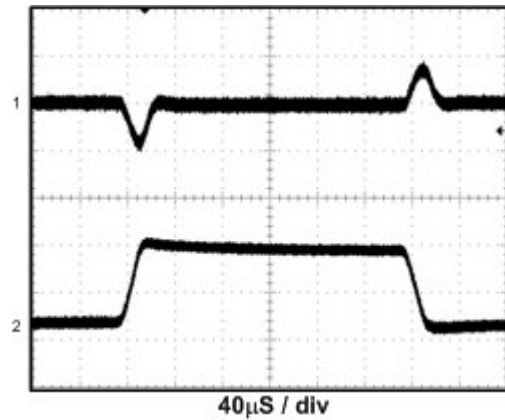
$V_{IN} = 3.6V$   
 $V_{OUT} = 1.8V$   
 $I_{OUT} = 0A \sim 1A \sim 0A$

- 1)  $V_{OUT} = 100mV/div$
- 2)  $I_{OUT} = 500mA/div$

**■ Characterization Curve (Contd.)**
**Load Step**


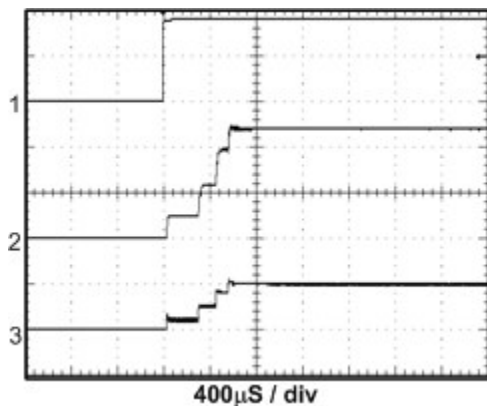
$V_{IN} = 3.6V$   
 $V_{OUT} = 1.8V$   
 $I_{OUT} = 50mA \sim 1A \sim 50mA$

1)  $V_{OUT} = 100mV/div$   
 2)  $I_{OUT} = 500mA/div$

**Load Step**


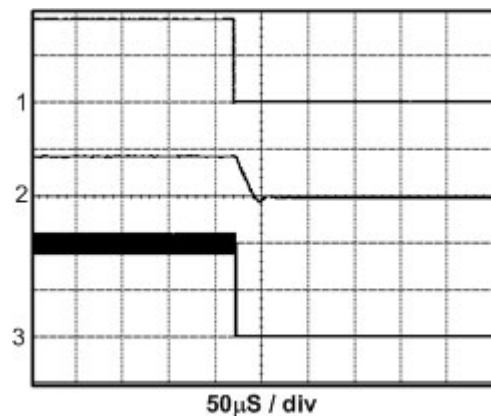
$V_{IN} = 3.6V$   
 $V_{OUT} = 1.8V$   
 $I_{OUT} = 200mA \sim 1A \sim 200mA$

1)  $V_{OUT} = 100mV/div$   
 2)  $I_{OUT} = 500mA/div$

**Power On from EN**


$V_{OUT} = 1.2V$   
 $I_{OUT} = 1A$

1)  $EN = 2V/div$   
 2)  $V_{OUT} = 500mV/div$   
 3)  $I_L = 1A/div$

**Power Off from EN**


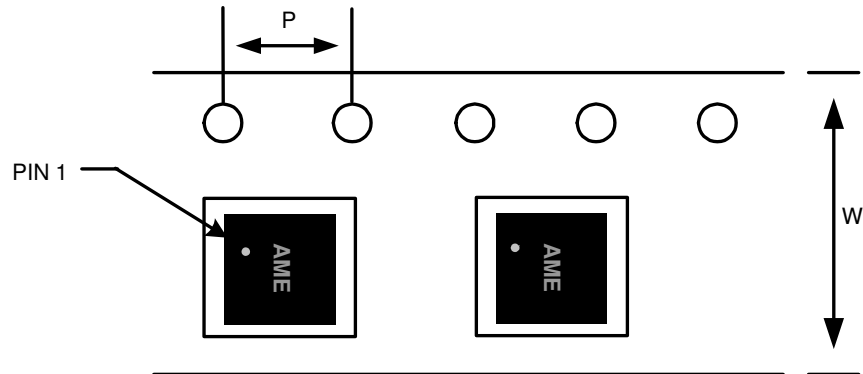
$V_{IN} = 3.6V$   
 $V_{OUT} = 1.8V$   
 $I_{OUT} = 1A$

1)  $EN = 2V/div$   
 2)  $V_{OUT} = 2V/div$   
 3)  $I_L = 500mA/div$

## AME5251A

### ■ Tape and Reel Dimension

DFN-12A  
(3mmx3mmx0.75mm)



Carrier Tape, Number of Components Per Reel and Reel Size

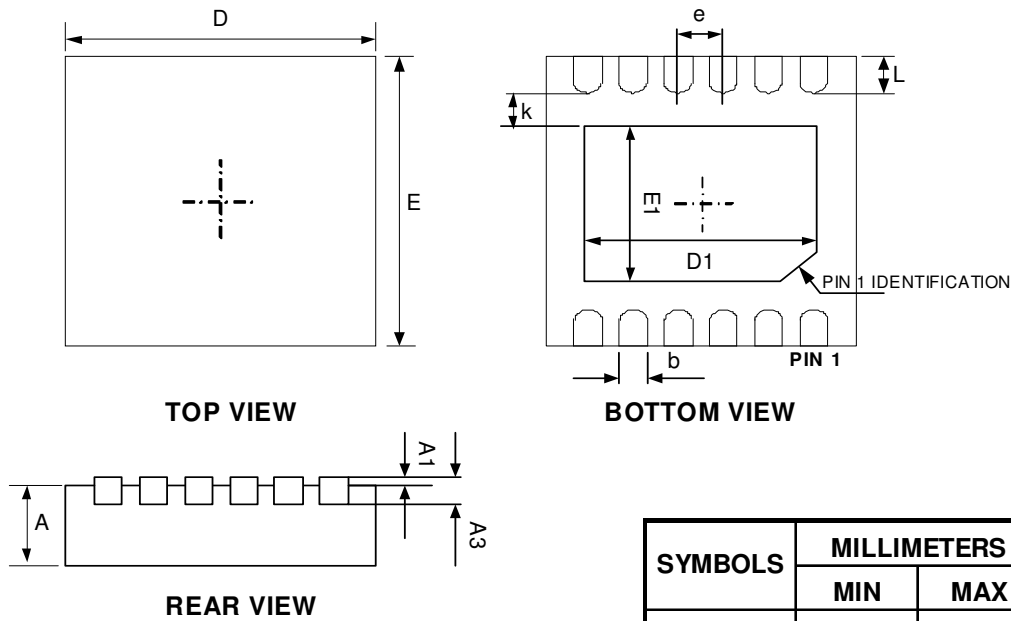
| Package                 | Carrier Width (W) | Pitch (P)  | Part Per Full Reel | Reel Size |
|-------------------------|-------------------|------------|--------------------|-----------|
| DFN-12A<br>(3x3x0.75mm) | 12.0±0.1 mm       | 4.0±0.1 mm | 5000pcs            | 330±1 mm  |



## AME5251A

### ■ Package Dimension

**DFN-12A**  
(3mmx3mmx0.75mm)



| SYMBOLS   | MILLIMETERS |       | INCHES    |       |
|-----------|-------------|-------|-----------|-------|
|           | MIN         | MAX   | MIN       | MAX   |
| <b>A</b>  | 0.700       | 0.800 | 0.028     | 0.031 |
| <b>A1</b> | 0.000       | 0.050 | 0.000     | 0.002 |
| <b>A3</b> | 0.203REF.   |       | 0.008REF. |       |
| <b>D</b>  | 2.924       | 3.076 | 0.115     | 0.121 |
| <b>E</b>  | 2.924       | 3.076 | 0.115     | 0.121 |
| <b>D1</b> | 2.450       | 2.650 | 0.096     | 0.104 |
| <b>E1</b> | 1.500       | 1.700 | 0.059     | 0.067 |
| <b>k</b>  | 0.200MIN.   |       | 0.008MIN  |       |
| <b>b</b>  | 0.150       | 0.250 | 0.006     | 0.010 |
| <b>e</b>  | 0.450TYP.   |       | 0.018TYP. |       |
| <b>L</b>  | 0.324       | 0.476 | 0.013     | 0.019 |





**www.ame.com.tw**  
**E-Mail: sales@ame.com.tw**

**Life Support Policy:**

These products of AME, Inc. are not authorized for use as critical components in life-support devices or systems, without the express written approval of the president of AME, Inc.

AME, Inc. reserves the right to make changes in the circuitry and specifications of its devices and advises its customers to obtain the latest version of relevant information.

© AME, Inc. , January 2014  
Document: 1283-DS5251A-A.04

**Corporate Headquarter**

**AME, Inc.**

8F, 12, WenHu St., Nei-Hu

Taipei 114, Taiwan.

Tel: 886 2 2627-8687

Fax: 886 2 2659-2989