■ 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 cur-rent each channel over a wide input voltage range from 2.5V to 5.5V.

Supply current with no load is 400μA and drops to<1μA 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 package.

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

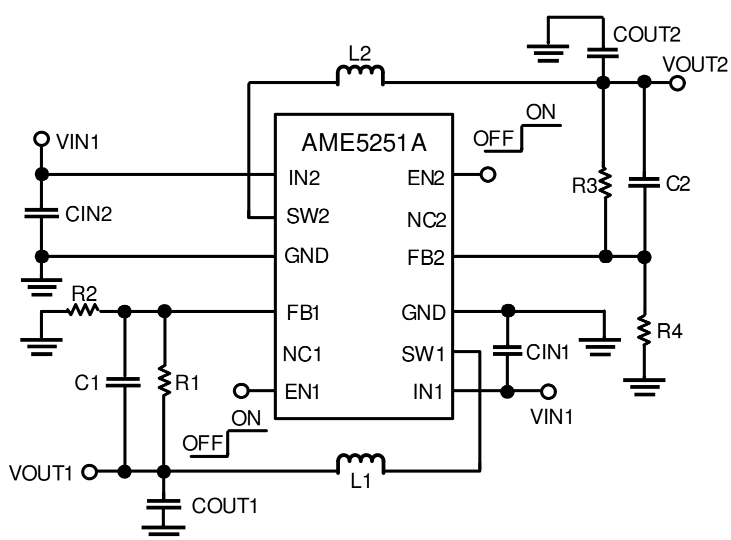
■ Features

- High Efficiency: Up to 95%
- Shutdown Mode Draws <1μA 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 Opera tion
- Small DFN-12A Package
- Green Products Meet RoHS Standard

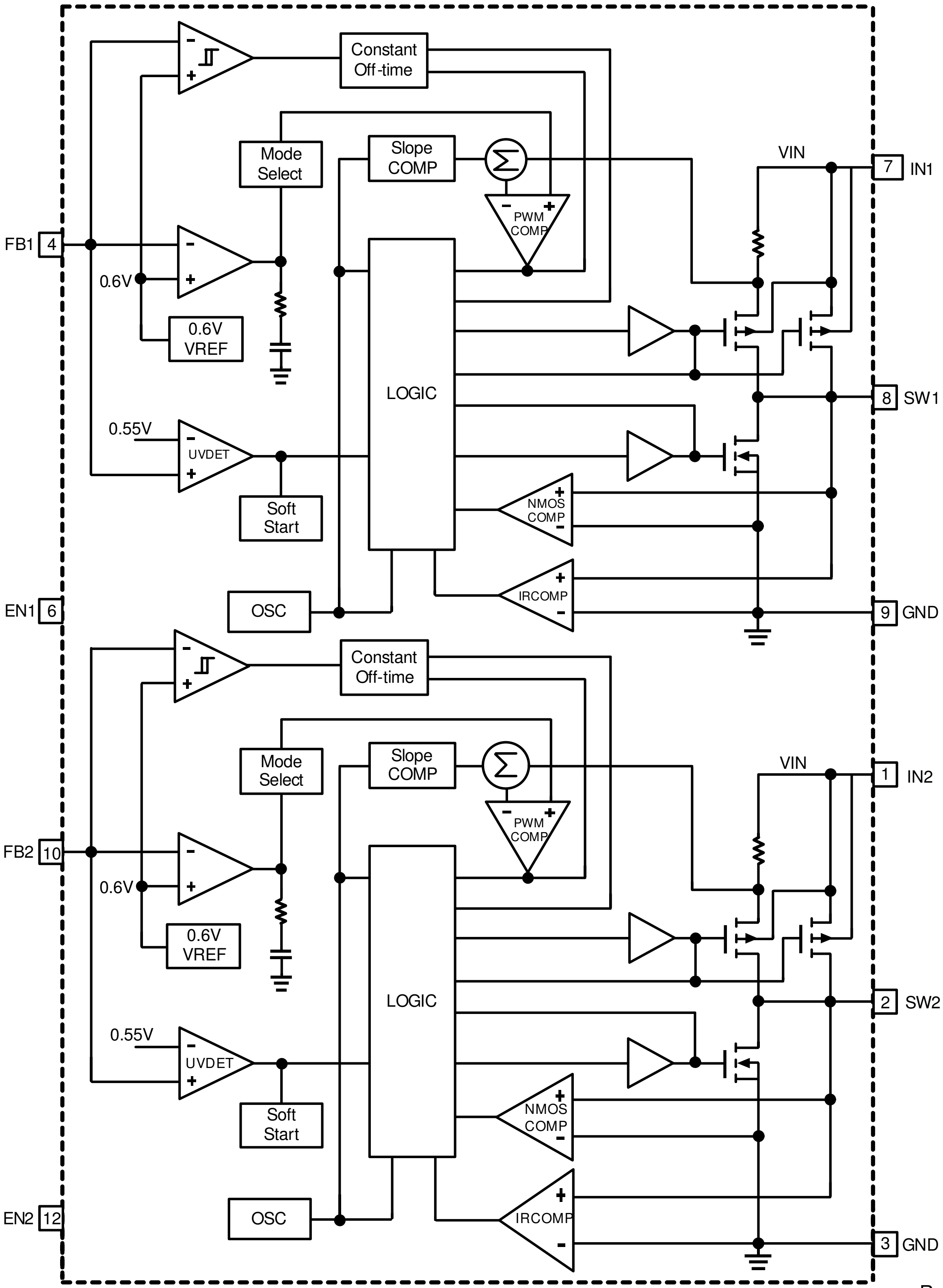
■ Applications

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

■ Typical Application

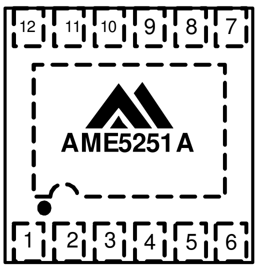


■ Function Block Diagram



■ 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. 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.

■ Ordering Information

AME5251A - x x x xxx xxx

- Output Voltage 2
- Output Voltage 1
- Number of Pins
- Package Type
- Pin Configuration & Special Feature

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

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	^oC
Junction Temperature Range	T_J	-40 to +125	^oC

Thermal Information

Parameter	Package	Die Attach	Symbol	Maximum	Unit
Thermal Resistance* (Junction to Case)	DFN-12A	Conductive Epoxy	θ_{JC}	8.5	^oC / W
Thermal Resistance (Junction to Ambient)			θ_{JA}	65	
Internal Power Dissipation			P_D	1.54	W
Solder Iron (10Sec)**				350	^oC

* Measure θ_{JC} on backside center of Exposed Pad.

** MIL-STD-202G 210F

■ Electrical Specifications

V_{IN}=3.6V, V_{OUT}=2.5V, V_{FB}=0.6V, L=2.2µH, C_{IN}=4.7µF, C_{OUT}=10µF, T_A=25°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 OutputVoltage	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	µA
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		Ω
Low-side Switch On-Resistance	$R_{DS,ON,\ LO}$	I_{SW}=200mA, V_{IN}=3.6V		0.25		Ω
Switch Current Limit	$I_{SW,CL}$	V_{IN}=2.5 to 5.5V	1.4	1.6		A
EN High (Enabled the Device)[Note1]	$V_{EN,HI}$	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		°C
Thermal Shutdown Hysteresis	OTH	Restore, temperature decreasing		20		°C
Maximum Duty Cycle	D_{MAX}		100			%
SW Leakage Current		EN=0V, V_{IN}=5.0V V_{SW}=0V or 5.0V	-1		1	µA

Note 1. V_{EN} must be <= V_{IN}
Note 2. 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 hsa more time do decay, thereby preventing runaway. The oscillator′s frequency will progressively increase to 1.5MHz when V_{FB} or V_{OUT} rises abole 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.

■ Applincation 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 ΔIL=0.4(Imax). 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 capacitorsized 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 IRMS=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 VREF 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.

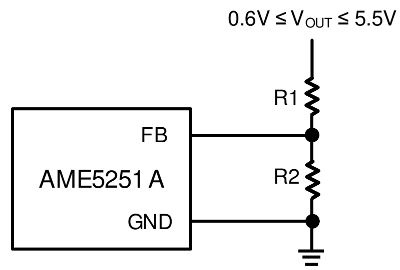


Figure 1: Setting the AME5251A Output Voltage

Enable

The EN pin provides electrical on/off control of the regulator. When the EN pin voltage exceeds the lockout threshold voltage, the regulator starts to operate.

If the EN pin voltage is pulled below the lockout threshold voltage, the regulator stops switching.

Connecting the EN pin to ground or to any voltage less than 1.5V will disable the regulator and activate the shutdown mode.

The EN pin voltage must be less than or equal to V_{IN} pin voltage. When EN pin voltage more than V_{IN} pin voltage 0.4V ~ 0.7V.

AME5251A SW pin will be terminated.

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^{O}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 θ_{JA} is the thermal resistance from the junction of the die to the ambient temperature.

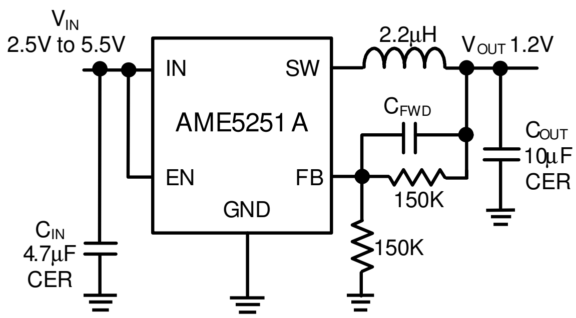


Figure 2: 1.2V Step-Down Regulator

C_{FWD}: 22pF~220pF

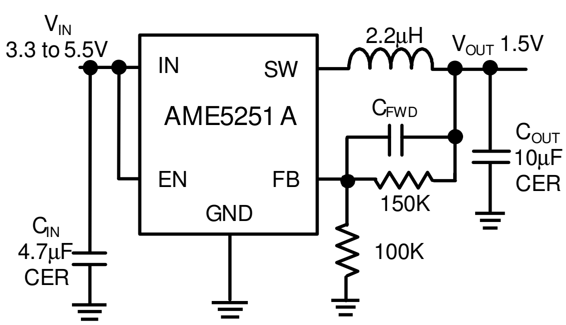


Figure 3: 1.5V Step-Down Regulator

C_{FWD}: 22pF~220pF

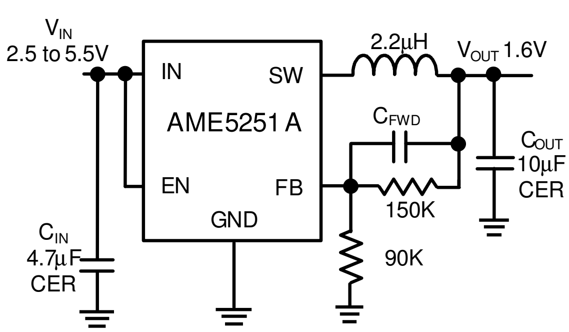


Figure 4: 1.6V Step-Down Regulator

C_{FWD}: 22pF~220pF

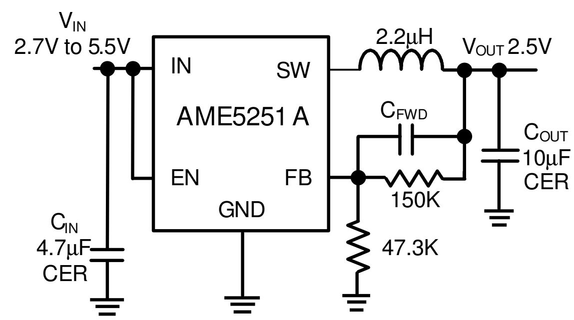


Figure 5: 2.5V Step-Down Regulator

C_{FWD}: 22pF~220pF

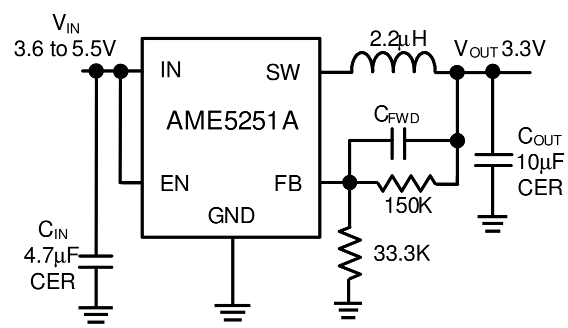


Figure 6: 3.3V Step-Down Regulator

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 CIN 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.

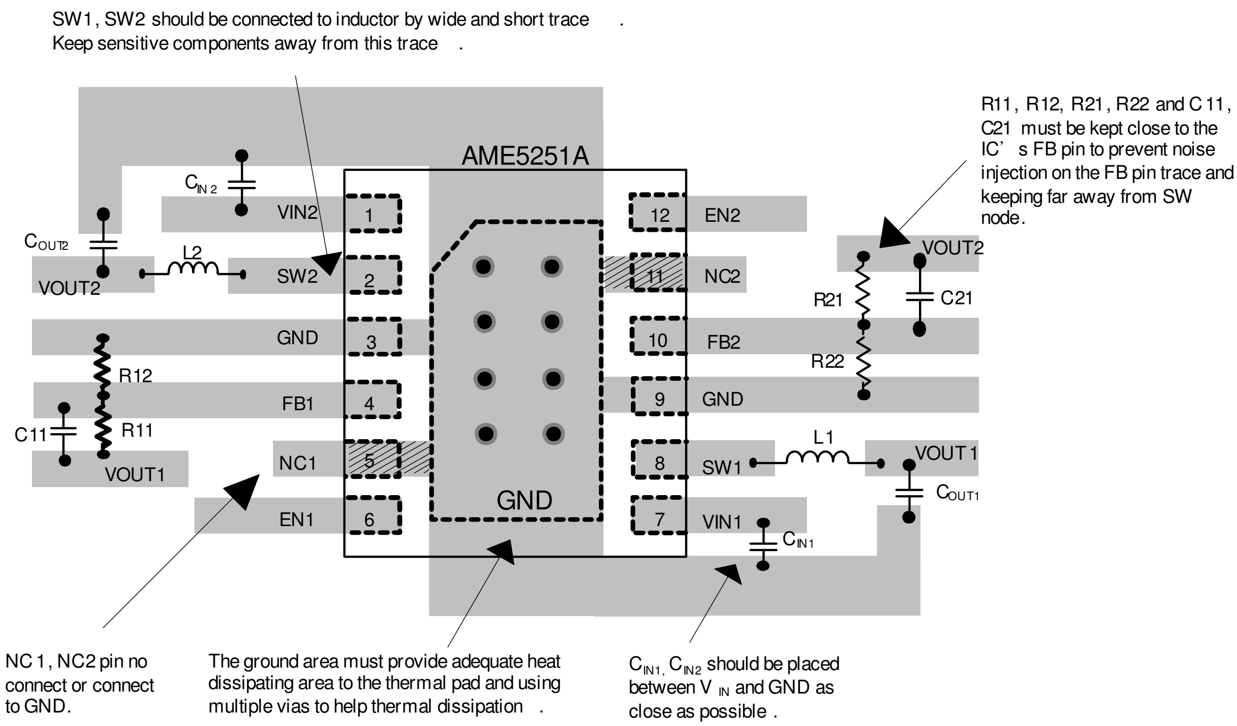


Figure 7: AME5251A Adjustable Voltage Regulator Layout Diagram

■ 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

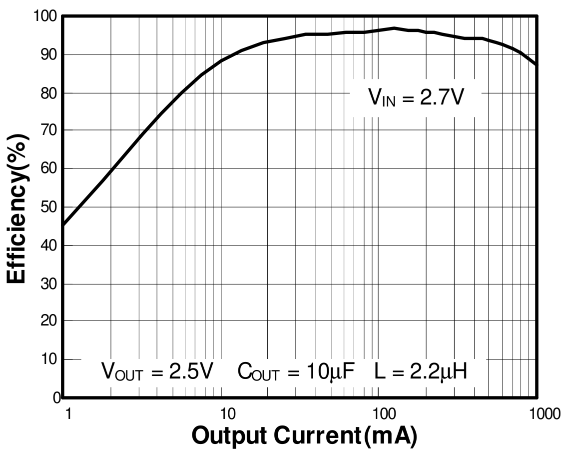
Table 1. Recommended Inductors

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

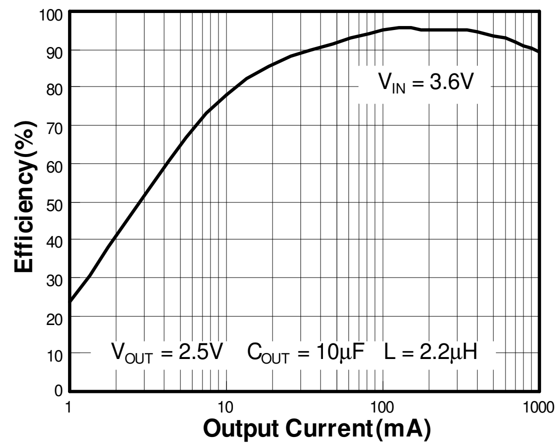
Table 2. Recommended Capacitors for C_{IN} and C_{OUT}

■ Characterization Curve

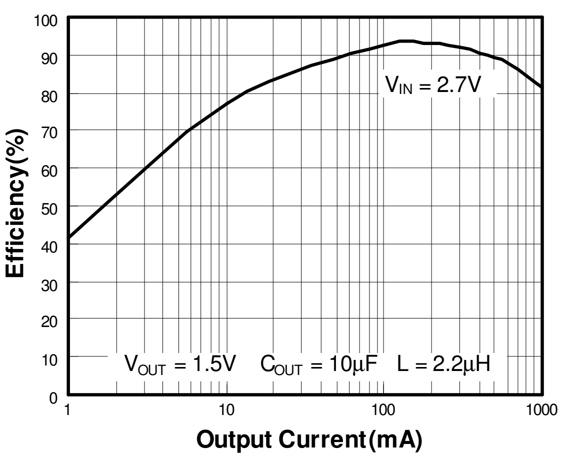
Efficiency vs. Output Current



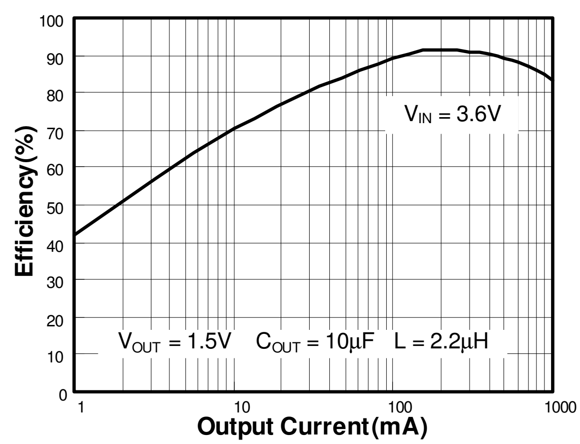
Efficiency vs. Output Current



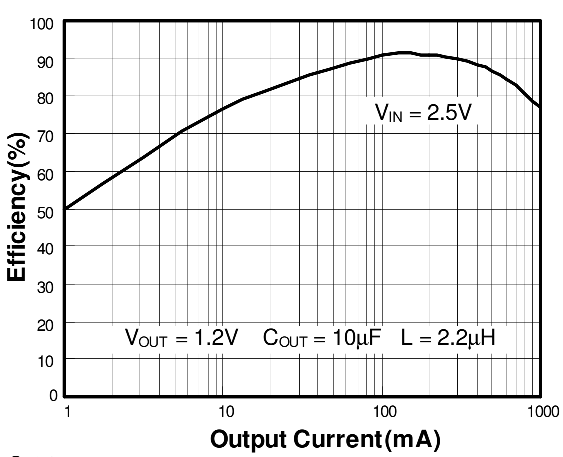
Efficiency vs. Output Current



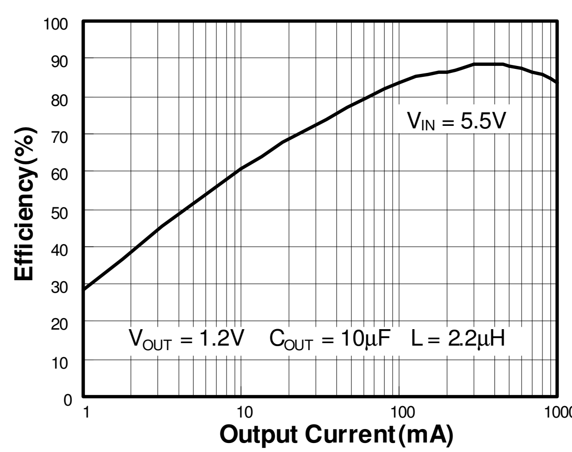
Efficiency vs. Output Current



Efficiency vs. Output Current

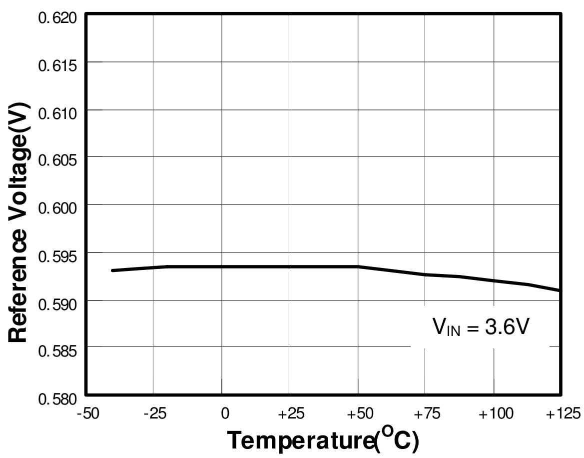


Efficiency vs. Output Current

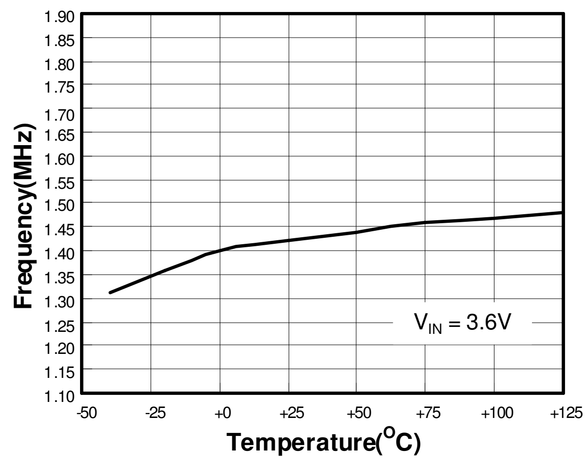


■ Characterization Curve (Contd.)

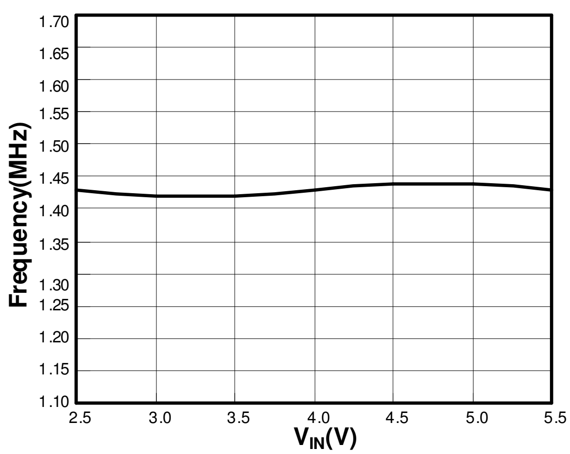
Reference Voltage vs. Temperature



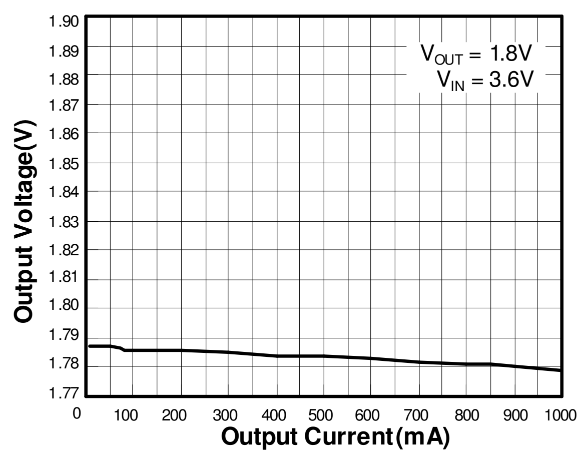
Frequency vs. Temperature



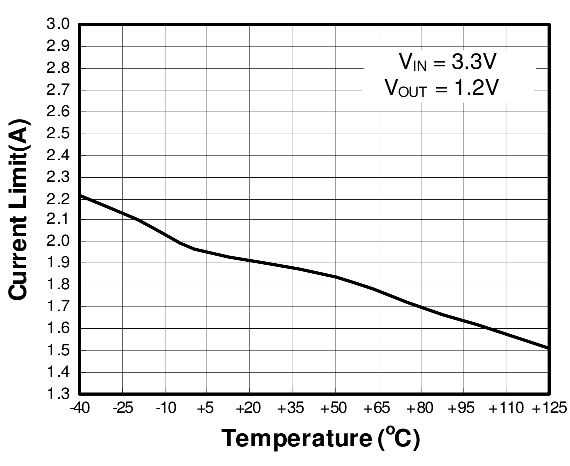
Frequency vs. Supply Voltage



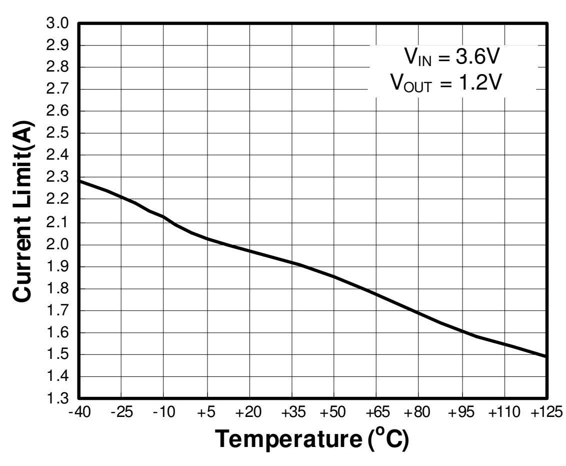
Output Voltage vs. Output Current



Current Limit vs. Temperature

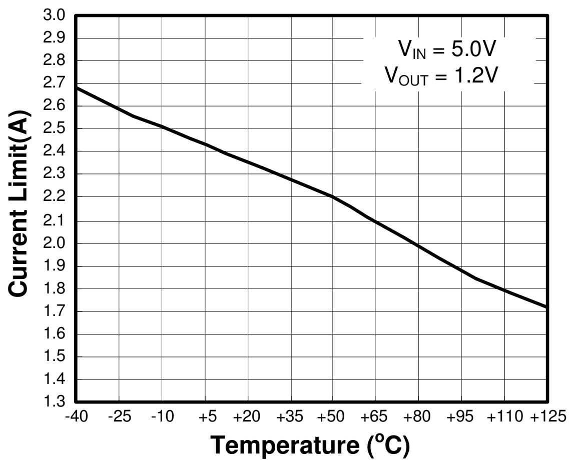


Current Limit vs. Temperature

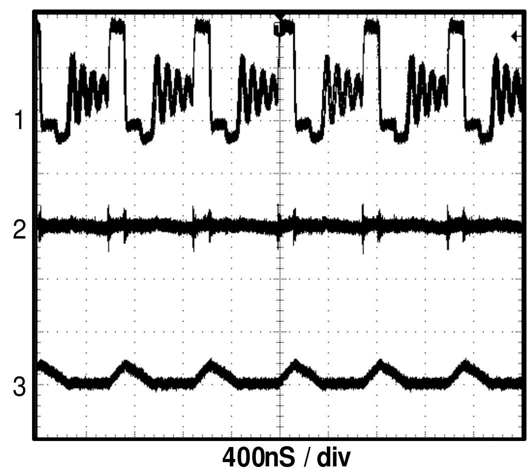


■ Characterization Curve (Contd.)

Current Limit vs. Temperature



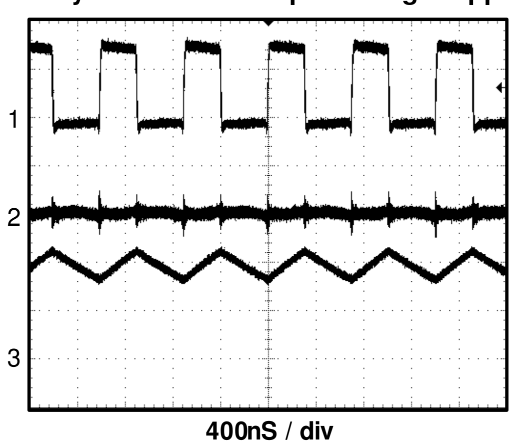
Light Load Mode Output Voltage Ripple



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

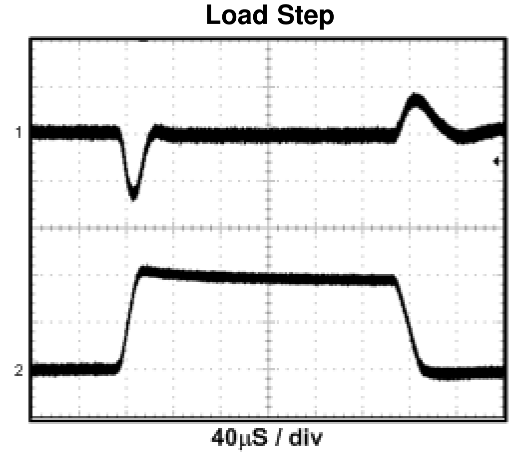
Heavy Load Mode Output Voltage Ripple



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

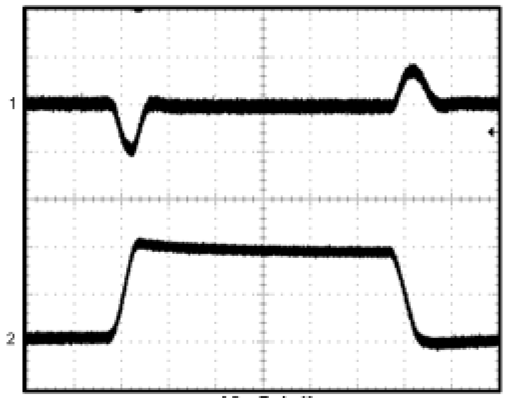


V_{IN} = 3.6V
V_{OUT} = 1.8V
I_{OUT} = 0A~1A~0A

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

■ Characterization Curve (Contd.)

Load Step



40µS / div

V_{IN} = 3.6V
V_{OUT} = 1.8V
I_{OUT} = 50mA~1A~50mA

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

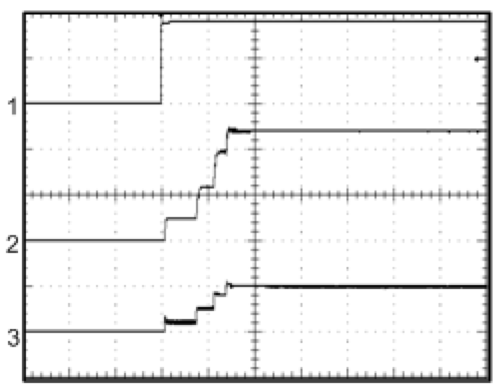
Load Step

40µS / div

V_{IN} = 3.6V
V_{OUT} = 1.8V
I_{OUT} = 200mA~1A~200mA

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

Power On from EN

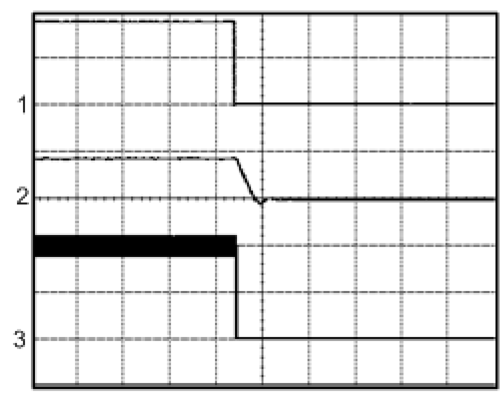


400µS / div

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



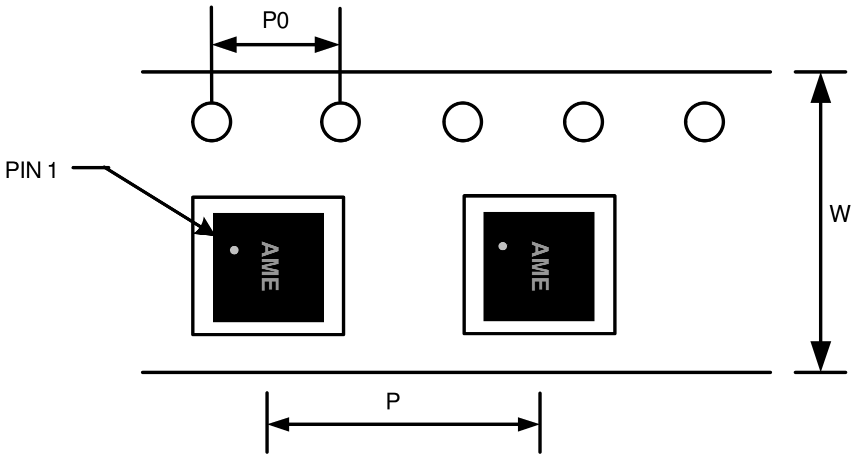
50µS / div

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

■ Tape and Reel Dimension

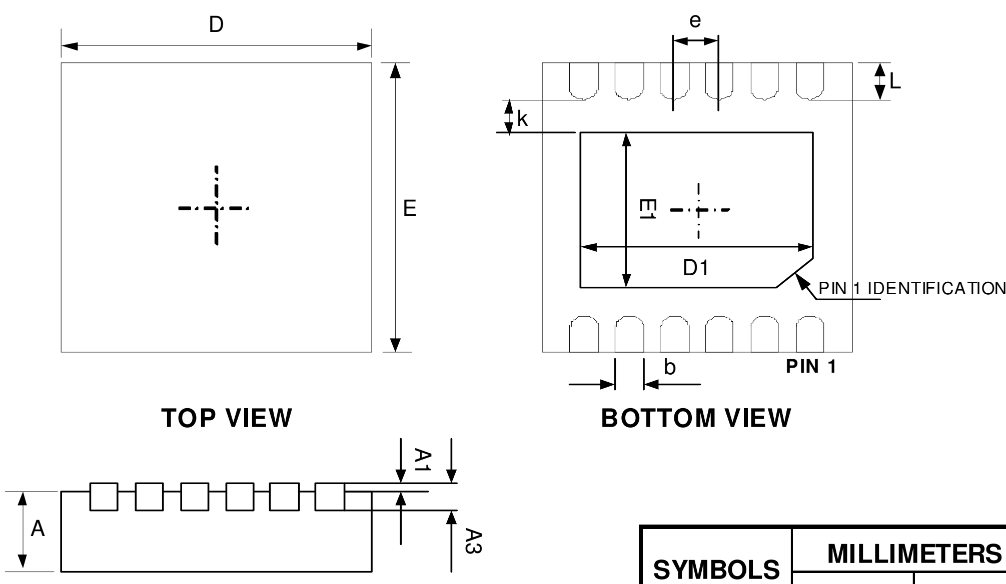
DFN-12A
(3mmx3mmx0.75mm)



Package	Carrier Width (W)	Pitch (P)	Pitch (P0)	Part Per Full Reel	Reel Size
DFN-12A (3x3x0.75mm)	12.0±0.1 mm	8.0±0.1 mm	4.0±0.1 mm	3000pcs	330±1 mm

■ Package Dimension

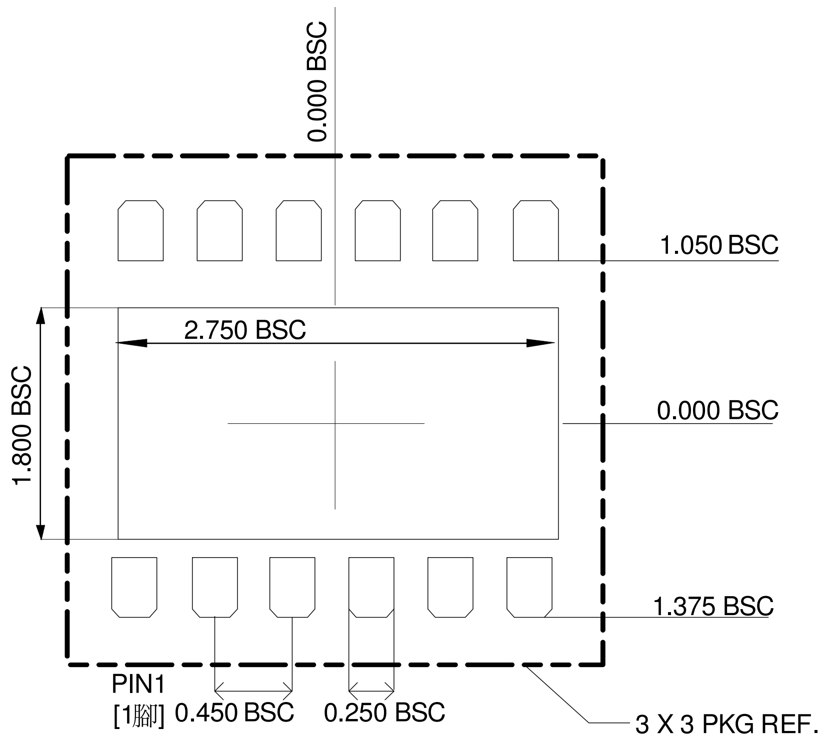
DFN-12A
(3mmx3mmx0.75mm)



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

■ Lead Pattern

DFN-12A
(3mmx3mmx0.75mm)



Note:

1. Lead pattern unit description:
   BSC: Basic. Represents theoretical exact dimension or dimension target.
2. Dimensions in Millimeters.
3. General tolerance ±0.05mm unless otherwise specified.

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