AME

AME5259A

1.2A, 1.5MHz Synchronous Step-Down Converter

■ General Description

The AME5259A is a high efficiency monolithic synchronous buck regulator using a constant frequency, current mode architecture. Capable of delivering 1.2A output current 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 AME5259A 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 AME5259A 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 AME5259A is available in small DFN-6D, QFN-16C and SOT-25 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 < 1µA Supply Current
- 2.5V to 5.5V Input Range
- Adjustable Output From 0.6V to V_{IN}
- 1.0V, 1.2V. 1.5V, 1.6V, 1.8V, 2.5V and 3.3V Fixed/Adjustable Output Voltage
- 1.2A Output Current
- Low dropout Operation: 100% Duty Cycle
- No Schottky Diode Required
- 1.5MHz Constant Frequency PWM Operation
- Green Product Meet RoHS Standard

■ Applications

- Cellular Telephones
- Personal Information Applicances
- Wireless and DSL Modems
- MP3 Players
- Portable Instruments

■ Typical Application

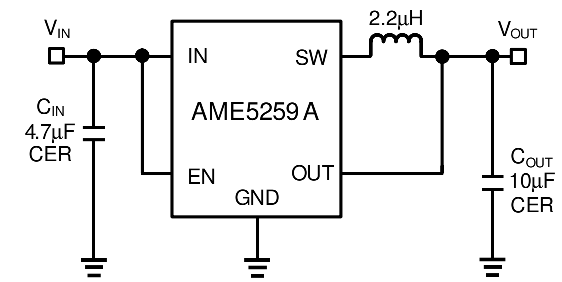
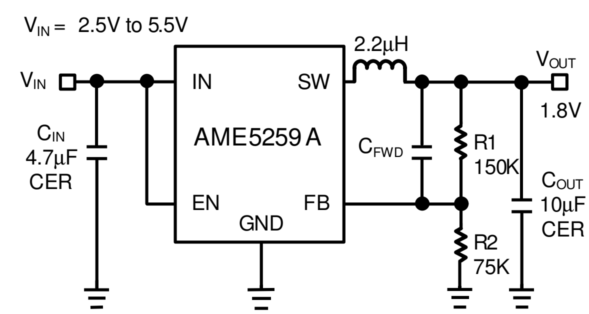


Figure 1. Fixed Output Voltage
High Efficiency Step-Down Conventer



$V_{OUT}=V_{FB}$ (R1+R2)/R2

Figure 2. Adjustable Output Voltage
1.8V at 1000mA Step-Down Requlator
C_{FWD}: 22pF~220pF

■ Functional Block Diagram

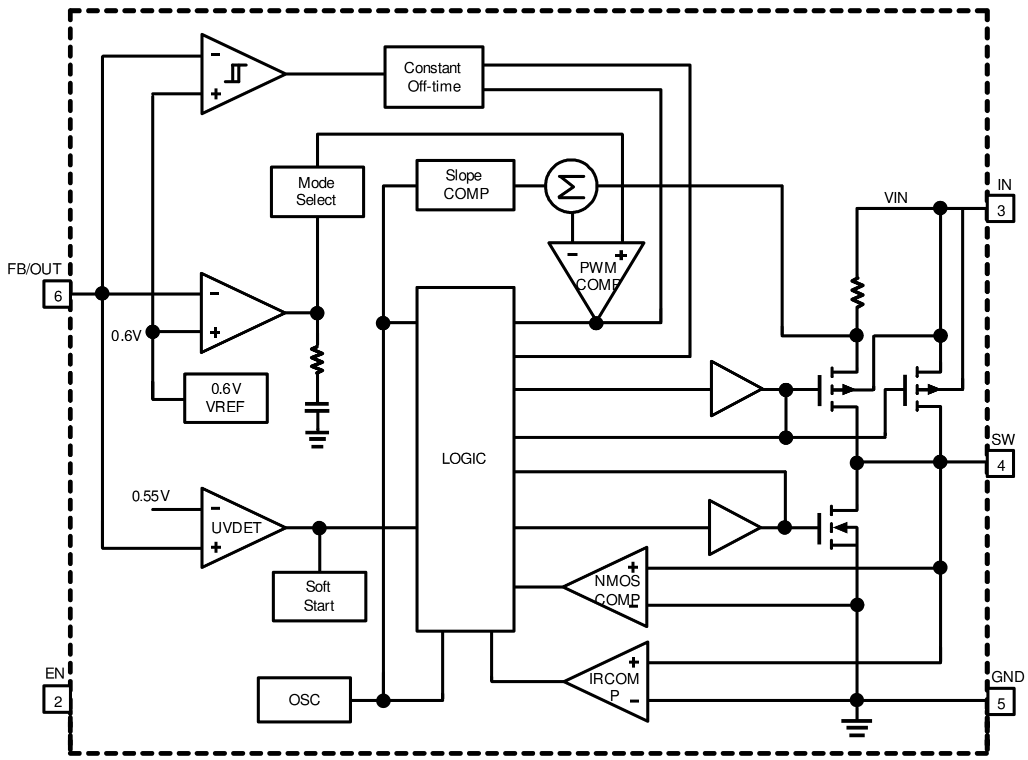
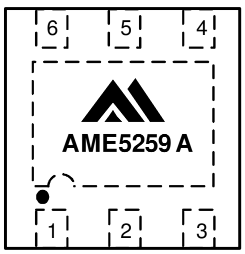


Figure 3. Function Block Diagram

■ Pin Configuration

DFN-6D
(2mmx2mmx0.75mm)
Top View

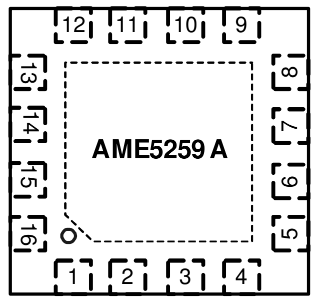


AME5259A-AVYxxx

1. NC
2. EN
3. IN
4. SW
5. GND
6. FB/OUT

*** Die Attach:**
Conductive Epoxy

QFN-16C
(3mmx3mmx0.75mm)
Top View

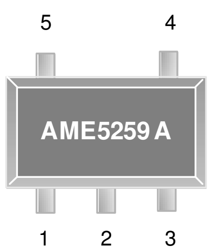


AME5259A-AWExxx

1. GND	9. IN
2. GND	10. IN
3. GND	11. IN
4. FB/OUT	12. IN
5. GND	13. SW
6. NC	14. SW
7. EN	15. SW
8. NC	16. NC

*** Die Attach:**
Conductive Epoxy

SOT-25
Top View



AME5259A-AEVADJ

1. EN
2. GND
3. SW
4. IN
5. FB/OUT

*** Die Attach:**
Conductive Epoxy

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

■ Pin Description

Pin Number			Pin Name	Pin Description
DFN-6D	QFN-16C	SOT-25		
1	6, 8, 16	N/A	NC	No connection. Not internally connected. Can left floating or connected to GND.
2	7	1	EN	Enable Control Input, active high.
3	9, 10, 11, 12	4	IN	Input Supply Voltage Pin. Bypass this pin with a capacitor as close to the device as possible.
4	13, 14, 15	3	SW	Switch Node Connection to Inductor.
5	1, 2, 3, 5	2	GND	Ground. Tie directly to ground plane.
6	4	5	FB/OUT	Output voltage Feedback input.

■ Ordering Information

AME5259A - x x x xxx

- xxx: **Output Voltage**
- 3rd x: **Number of Pins**
- 2nd x: **Package Type**
- 1st x: **Pin Configuration & Special Feature**

Pin Configuration & Special Feature	Package Type	Number of Pins	Output Voltage
A (DFN-6D) 1. NC 2. EN 3. IN 4. SW 5. GND 6. FB/OUT A (QFN-16C) 1. GND 2. GND 3. GND 4. FB/OUT 5. GND 6. NC 7. EN 8. NC 9. IN 10. IN 11. IN 12. IN 13. SW 14. SW 15. SW 16. NC A (SOT-25) 1. EN 2. GND 3. SW 4. IN 5. FB/OUT	E: SOT-2X V: DFN W: QFN	E: 16 V: 5 Y: 6	100: 1.0V 120: 1.2V 150: 1.5V 160: 1.6V 180: 1.8V 250: 2.5V 330: 3.3V ADJ: Adjustable

■ Absolute Maximum Ratings

Parameter		Maximum	Unit
Input Supply Voltage		-0.3 to 6.5	V
EN, V_{OUT} Voltage		-0.3 to V_{IN}	
SW Voltage		-0.3 to V_{IN}	
ESD Classification	HBM	2	kV
	MM	200	V

■ 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-6D	Conductive Epoxy	θ_{JC}	85	^oC / W
Thermal Resistance (Junction to Ambient)			θ_{JA}	160	
Internal Power Dissipation			P_D	625	mW
Thermal Resistance* (Junction to Case)	QFN-16C	Conductive Epoxy	θ_{JC}	67	^oC / W
Thermal Resistance (Junction to Ambient)			θ_{JA}	149	
Internal Power Dissipation			P_D	670	mW
Thermal Resistance* (Junction to Case)	SOT-25	Conductive Epoxy	θ_{JC}	81	^oC / W
Thermal Resistance (Junction to Ambient)			θ_{JA}	260	
Internal Power Dissipation			P_D	400	mW
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}=1.2A unless otherwise specified.

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
Input voltage	V_{IN}		2.5		5.5	V
Output Voltage Accuracy	ΔV_{OUT}	V_{IN}=2.5 to 5.5V, in PWM mode For Fixed Output Voltage	-3		3	%
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		1.6		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		°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

■ Detailed Description

Main Control Loop

AME5259A 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 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 AME5259A 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 DI_L increases with higher V_{IN} and decreases with higher inductance.

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

A reasonable starting point for setting ripple current is ΔI_L=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:

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

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:

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

■ Detailed Description

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 :

$$V_{OUT} = V_{REF} \cdot (1 + \frac{R_1}{R_2})$$

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 4.

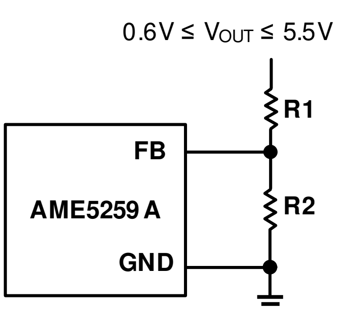


Figure 4. Setting the AME5259A Output Voltage

Thermal Considerations

In most applications the AME5259A does not dissipate much heat due to its high efficiency. But, in applications where the AME5259A 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 AME5259A 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.

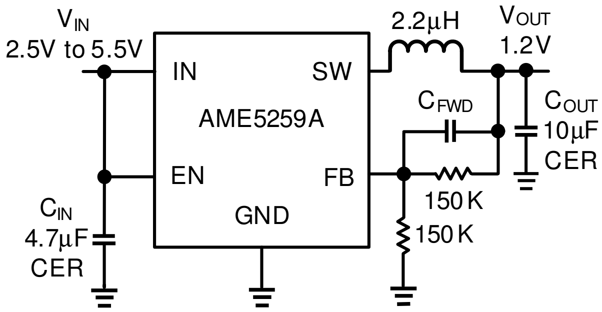


Figure 5. 1.2V Step-Down Regulator
C_{FWD}: 22pF~220pF

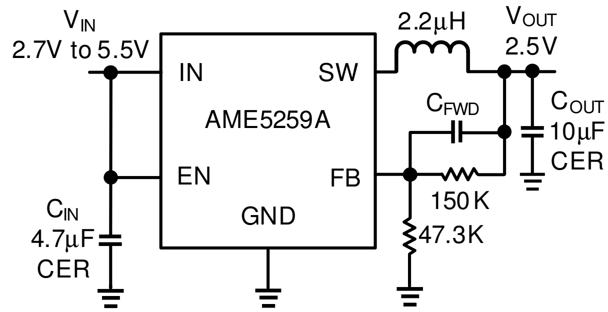


Figure 8. 2.5V Step-Down Regulator
C_{FWD}: 22pF~220pF

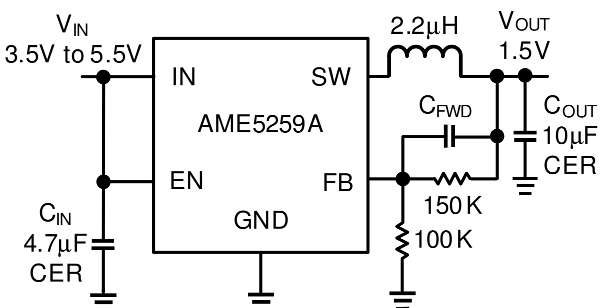


Figure 6. 1.5V Step-Down Regulator
C_{FWD}: 22pF~220pF

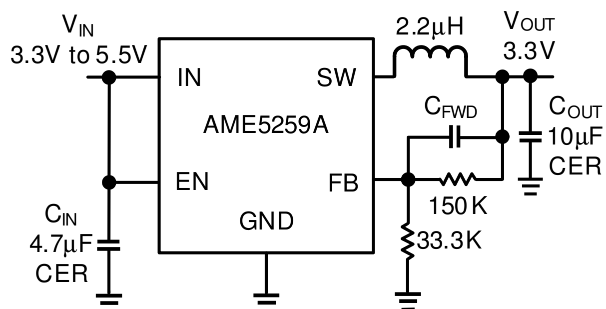


Figure 9. 3.3V Step-Down Regulator
C_{FWD}: 22pF~220pF

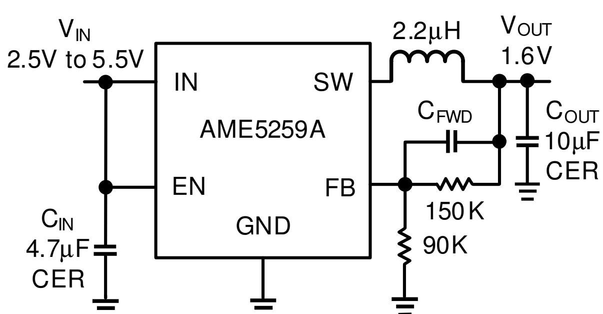


Figure 7. 1.6V Step-Down Regulator
C_{FWD}: 22pF~220pF

PC Board Layout Checklist

When laying out the printed circuit board, the following checklist should be used to ensure proper operation of the AME5259A. These items are also illustrated graphically in Figures 10 and Figures 11 . 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.

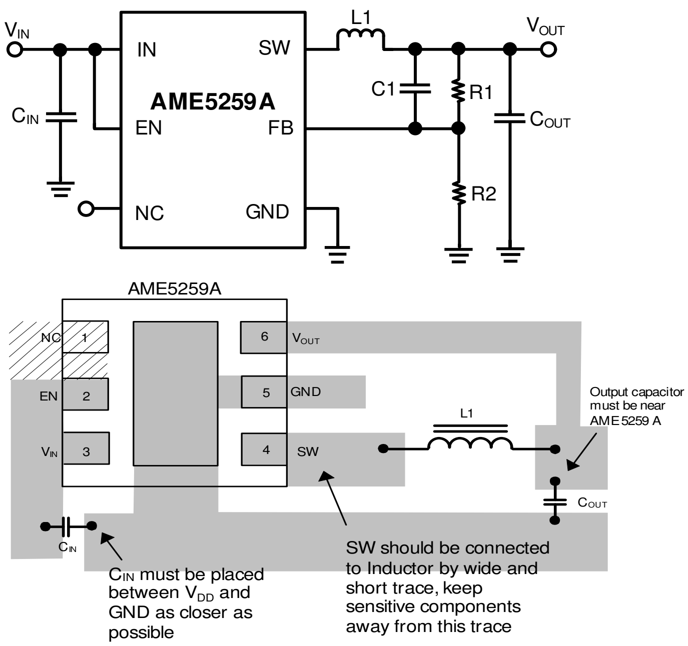


Figure 10. AME5259A Adjustable Voltage Regulator Layout Diagram

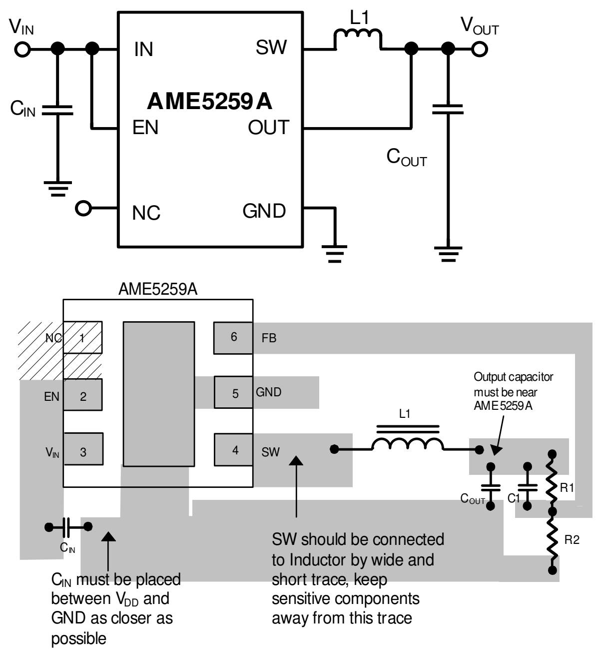


Figure 11. AME5259A Fixed Voltage Regulator Layout Diagram

■ Application Information

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	NR3015
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

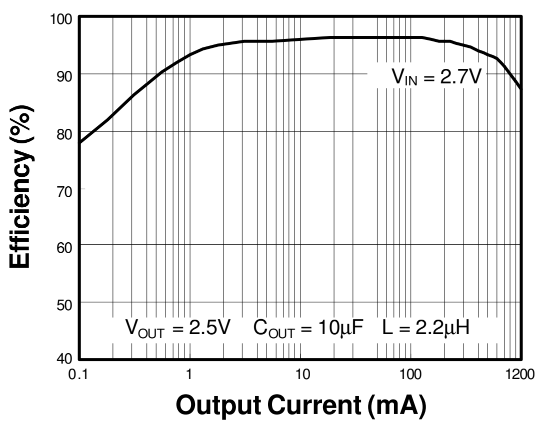
Table 1. Recommended Inductors

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	JMK107BJ475RA
TDK	10	805	C2012JB0J106M
MURATA	10	805	GRM219R60J106ME19
MURATA	10	805	GRM219R60J106ME19
TAIYO YUDEN	10	805	JMK212BJ106RD

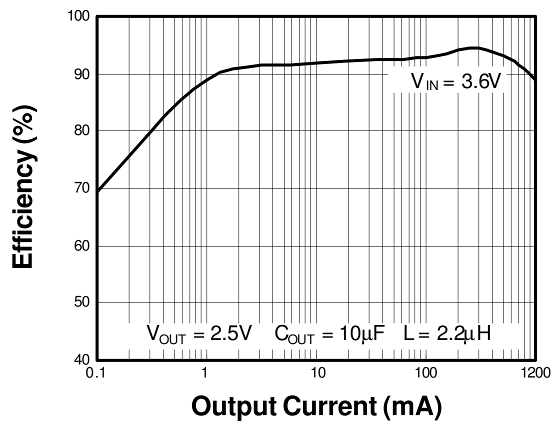
Table 2. Recommended Capacitors for C_{IN} and C_{OUT}

■ Characterization Curve

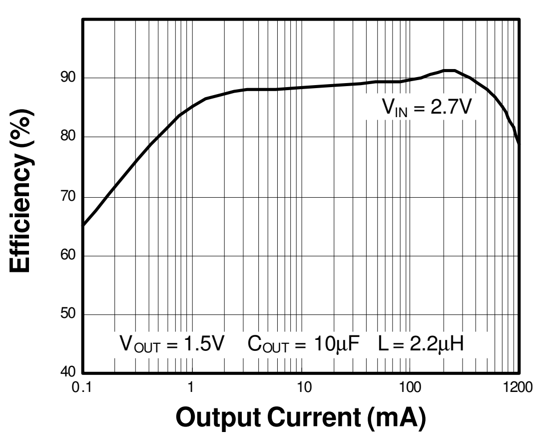
Efficiency vs. Output Current



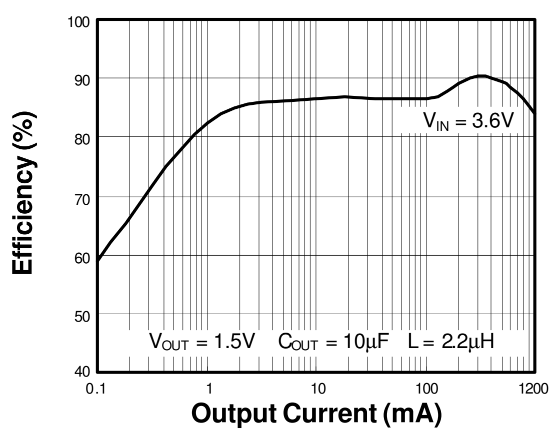
Efficiency vs. Output Current



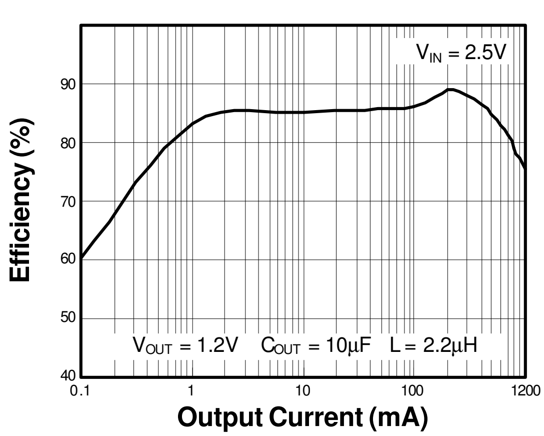
Efficiency vs. Output Current



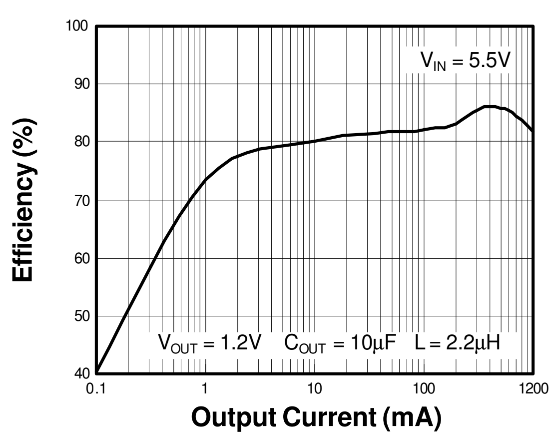
Efficiency vs. Output Current



Efficiency vs. Output Current

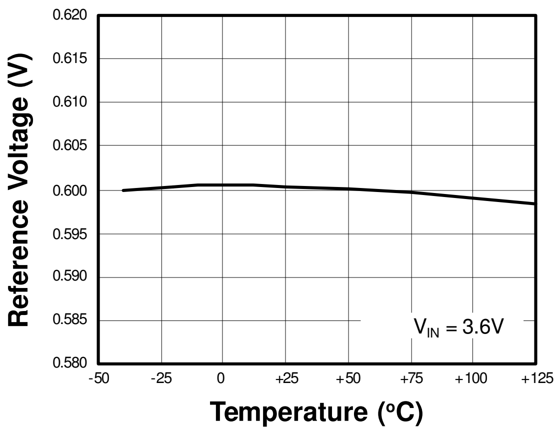


Efficiency vs. Output Current

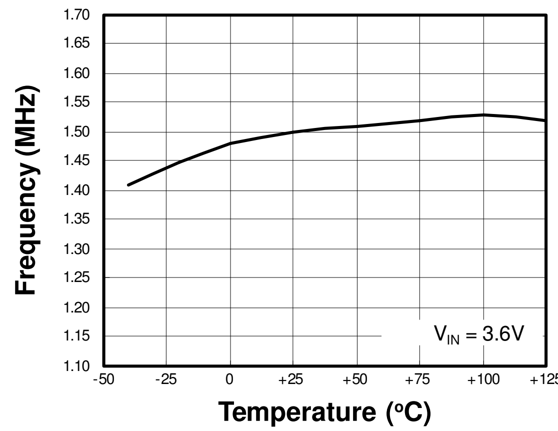


■ Characterization Curve (Contd.)

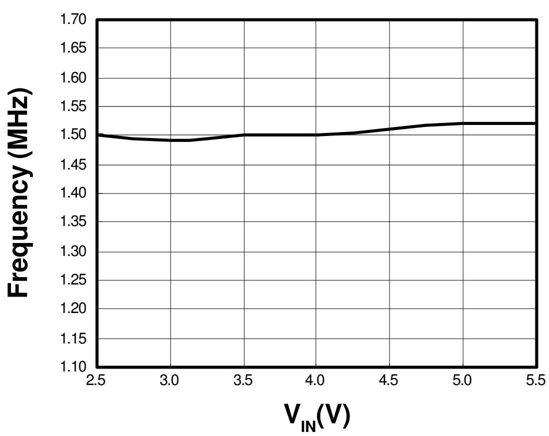
Reference Voltage vs. Temperature



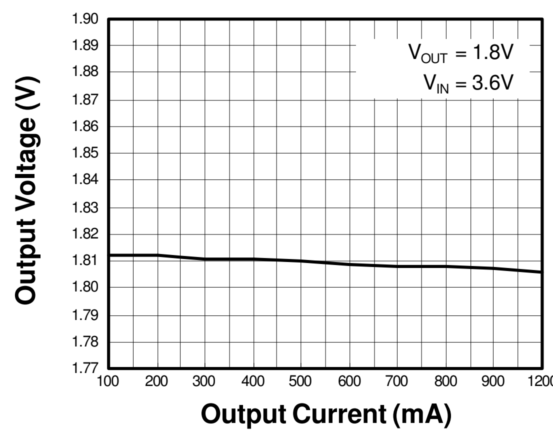
Frequency vs. Temperature



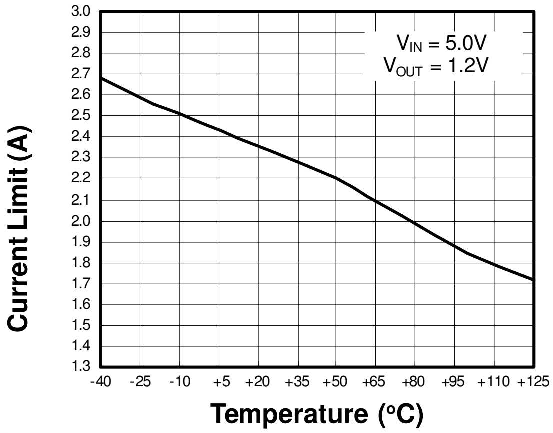
Frequency vs. Supply Voltage



Output Voltage vs. Output Current

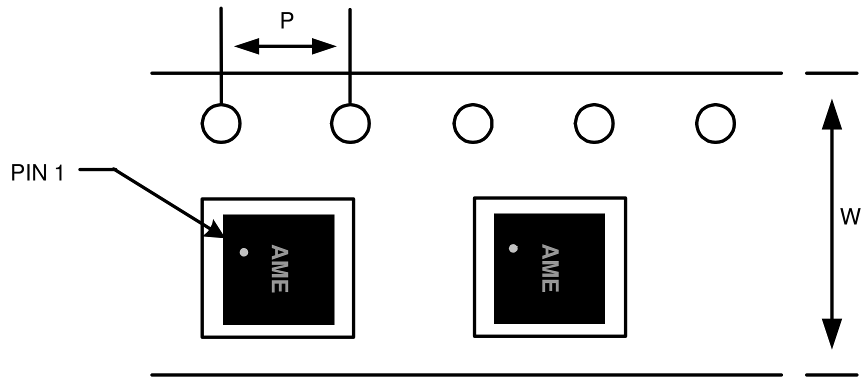


Current Limit vs. Temperature



■ Tape and Reel Dimension

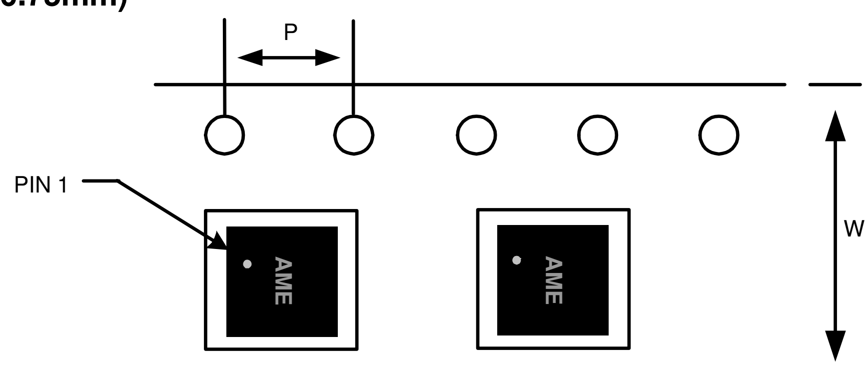
DFN-6D
(2mmx2mmx0.75mm)



Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
DFN-6D (2x2x0.75mm)	8.0±0.1 mm	4.0±0.1 mm	3000pcs	180±1 mm

QFN-16C
(3mmx3mmx0.75mm)

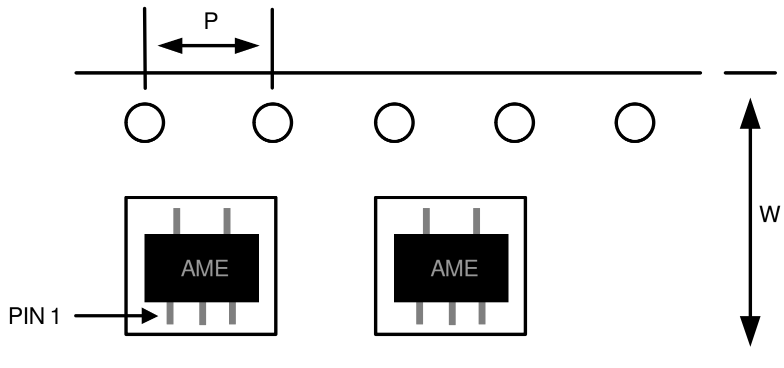


Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
QFN-16C (3x3x0.75mm)	12.0±0.1 mm	4.0±0.1 mm	3000pcs	330±1 mm

■ Tape and Reel Dimension (Contd.)

SOT-25

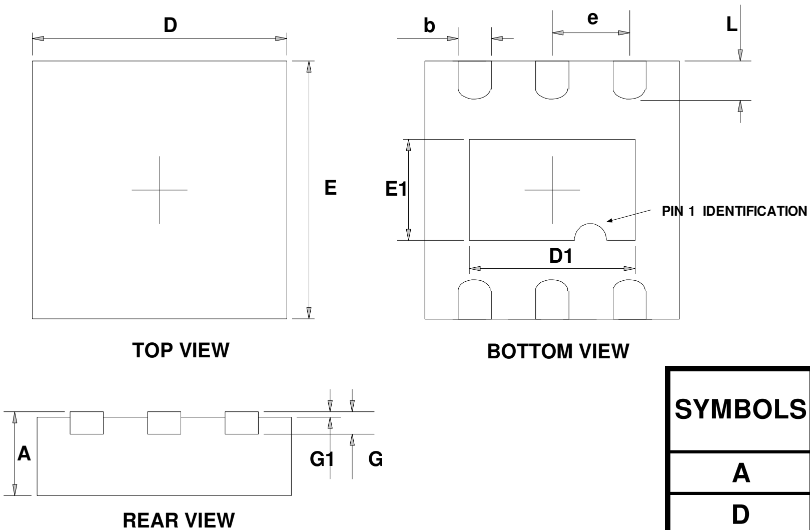


Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
SOT-25	8.0±0.1 mm	4.0±0.1 mm	3000pcs	180±1 mm

■ Package Dimension

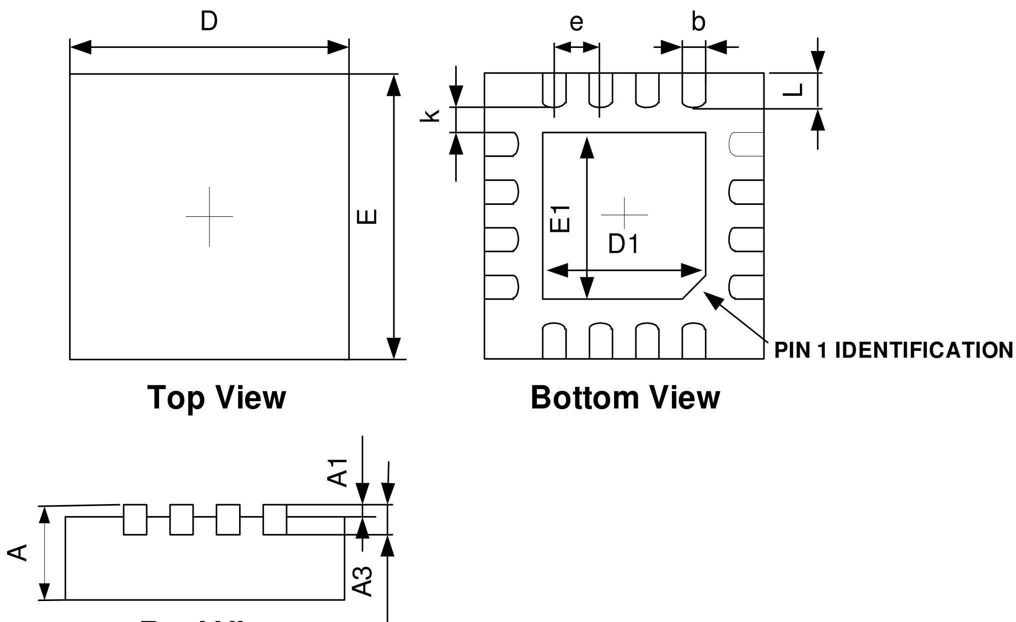
DFN-6D
(2mmx2mmx0.75mm)



SYMBOLS	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
D	1.900	2.100	0.075	0.083
E	1.900	2.100	0.075	0.083
e	0.650 TYP		0.026 TYP	
D1	1.100	1.650	0.043	0.065
E1	0.600	1.050	0.024	0.041
b	0.180	0.350	0.007	0.014
L	0.200	0.450	0.008	0.018
G	0.178	0.228	0.007	0.009
G1	0.000	0.050	0.000	0.002

■ Package Dimension

QFN-16C
(3mmx3mmx0.75mm)



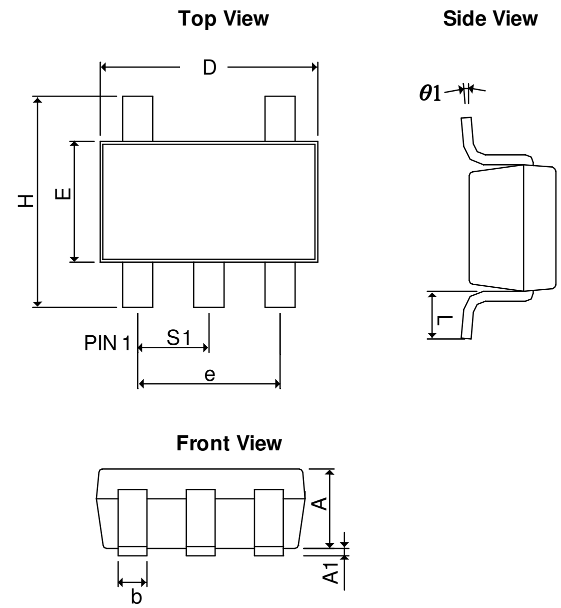
Top View **Bottom View**

Real View

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	1.600	1.800	0.063	0.071
E1	1.600	1.800	0.063	0.071
k	0.200MIN.		0.008MIN.	
b	0.180	0.280	0.007	0.011
e	0.500TYP.		0.020TYP.	
L	0.324	0.476	0.013	0.019

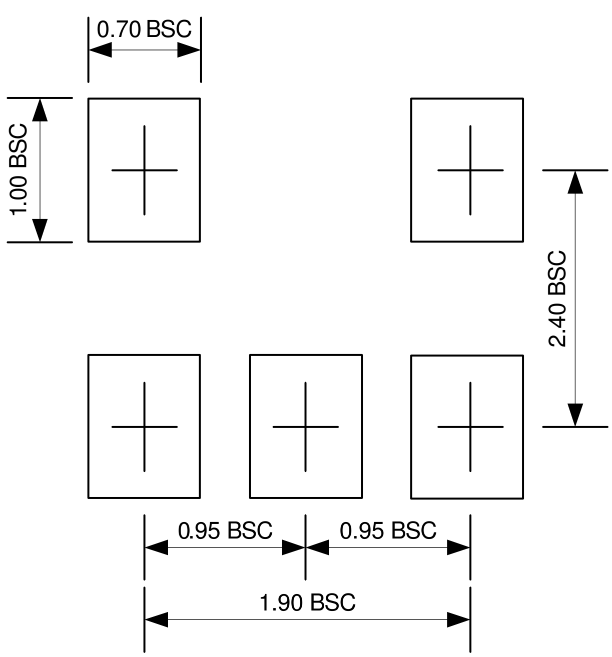
■ Package Dimension

SOT-25



SYMBOLS	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	0.90	1.30	0.0354	0.0512
A_1	0.00	0.15	0.0000	0.0059
b	0.30	0.55	0.0118	0.0217
D	2.70	3.10	0.1063	0.1220
E	1.40	1.80	0.0551	0.0709
e	1.90 BSC		0.0748 BSC	
H	2.60	3.00	0.1024	0.1181
L	0.37 BSC		0.0146 BSC	
θ1	0°	10°	0°	10°
S_1	0.95 BSC		0.0374 BSC	

■ Lead Pattern



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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