■ General Description

The AME5254 is a high efficiency monolithic synchronous buck regulator using a constant frequency, current mode architecture. The device is available in an adjustable version. Supply current with no load is 45µA and drops to <1µA in shutdown.

The 2.7V to 5.5V input voltage range makes the AME5254 ideally suited for single Li-Ion, two to four AA battery-powered applications. 100% duty cycle provides low dropout operation, extending battery life in portable systems. In power saving mode, 45µA quiescent current is very suitable for DSP/MCU in standby operation; and in PWM mode, low output ripple voltage is good enough for noise sensitive applications. The two modes can be automatically switched according to the load current. Switching frequency is internally set at 1.5MHz, allowing the use of small surface mount inductors and capacitors.

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 AME5254 is available in a small SOT-25 package and SOT-26 package.

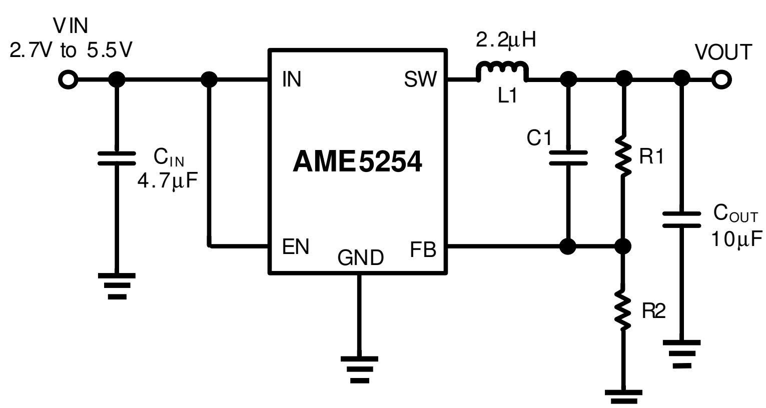
■ Features

- High Efficiency: Up to 95%
- 1.5MHz Constant Switching Frequency
- Integrated Main Switches and Synchronous Rectifier. No Schottky Diode Required.
- Shutdown Current: <1µA
- 2.7V to 5.5V Input Voltage Range
- Output Voltage as Low as 0.6V
- 100% Duty Cycle in Dropout
- Quiescent Current : 45µA (TYP.)
- Slope Compensated Current Mode Control for Excellent Line and Load Transient Response
- Short Circuit Protection
- Green Products Meet RoHS Standards

■ Applications

- Smart Phones
- Set Top Box
- Personal Information Appliances
- Wireless and DSL Modems
- MP3 Players
- Portable Instruments

■ Typical Application



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

Figure 1. Typical Step-Down Regulator

C_{FWD}:22pF~220pF

■ Function Block Diagram

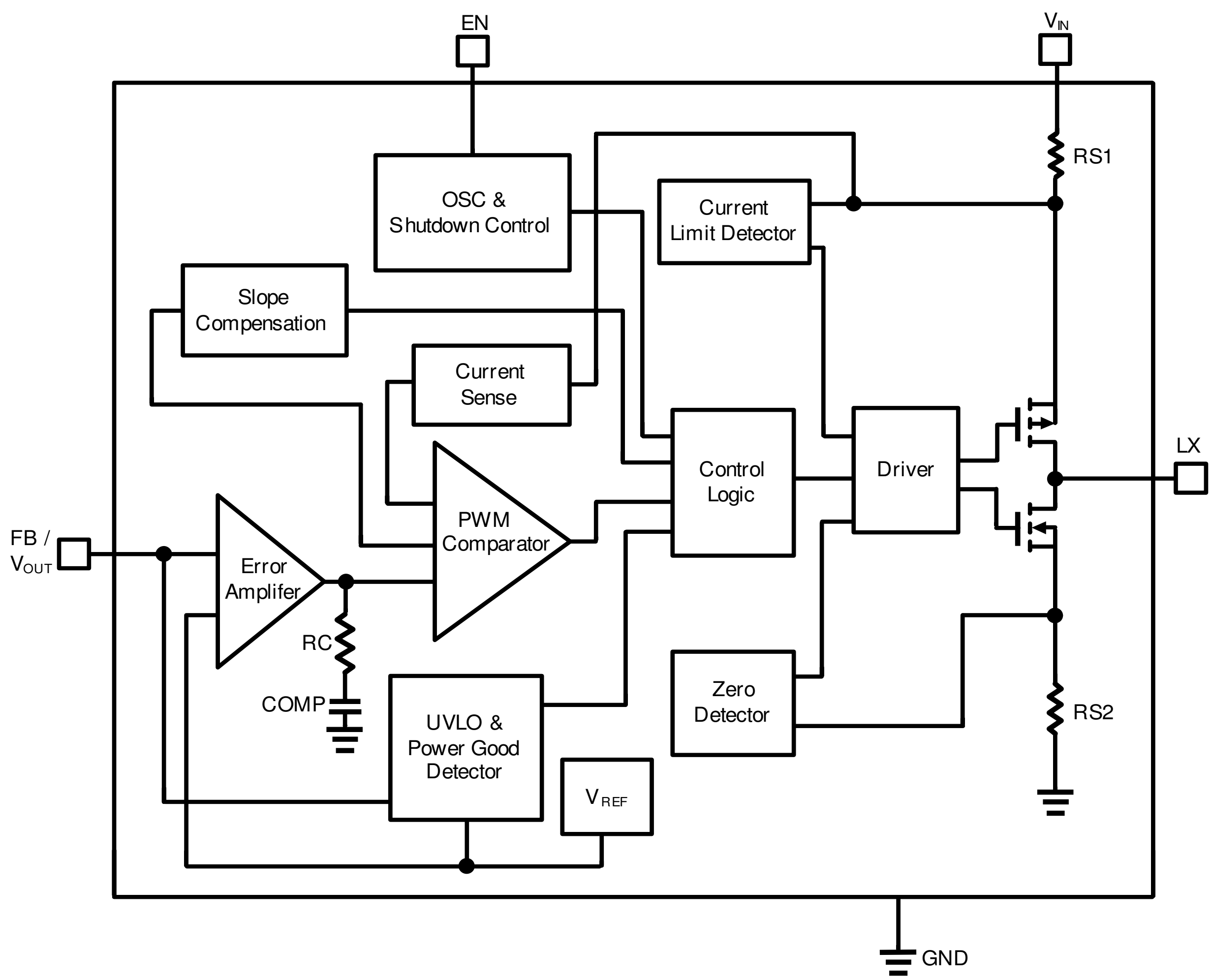
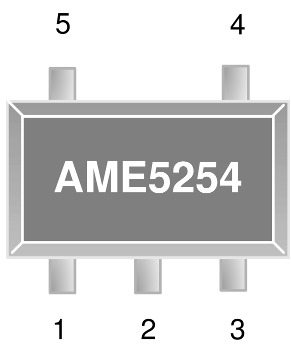


Figure 2. Founction Block Diagram

■ Pin Configuration

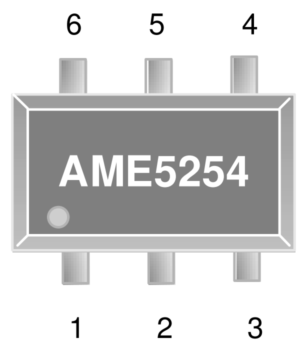
SOT-25
Top View



AME5254-AEVxxx
1. EN
2. GND
3. LX
4. IN
5. FB

Die Attach:
Conductive Epoxy

SOT-26
Top View



AME5254-AEYxxx
1. EN
2. GND
3. LX
4. IN
5. NC
6. FB

Die Attach:
Conductive Epoxy

■ Pin Description

Pin No.		Pin Name	Pin Description
SOT-25	SOT-26		
1	1	EN	Regulator Enable control input. Drive LX above 1.25V to turn on the part. Drive LX below 0.55V to turn it off. In shutdown, all functions are disabled drawing <1μA supply current. Do not leave LX floating.
2	2	GND	Ground connection pin.
3	3	LX	Power Switch Output. It is the Switch node connection to Inductor. This pin connects to the drains of the internal P-CH and N-CH MOSFET switches.
4	4	IN	Supply Input Pin. Must be closely decoupled to GND, Pin 2, with a 2.2μF or greater ceramic capacitor.
NA	5	NC	No connect.
5	6	FB	Feedback Input Pin. Connect FB to the center point of the external resistor divider. The feedback threshold voltage is 0.6V.

■ Ordering Information

AME5254 - x x x xxx

- Output Voltage
- Number of Pins
- Package Type
- Pin Configuration

Pin Configuration	Package Type	Number of Pins	Output Voltage
A (SOT-25): 1. EN 2. GND 3. LX 4. IN 5. FB A (SOT-26): 1. EN 2. GND 3. LX 4. IN 5. NC 6. FB	E: SOT-2X	V: 5 Y: 6	ADJ: Adjustable

Absolute Maximum Ratings

Parameter	Symbol	Maximum	Unit
Input Supply Voltage	V_{IN}	-0.3 to 6	V
EN, V_{OUT} Voltages	V_{EN}, V_{OUT}	-0.3 to V_{IN}	
SW Voltage	V_{SW}	-0.3 to V_{IN}	
ESD Classification	B*		

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

* HBM B:2000V~3999V

Recommended Operating Conditions

Parameter	Symbol	Rating	Unit
Input Voltage	V_{IN}	2.7 to 5.5	V
Ambient Temperature Range	T_A	-40 to +85	^oC
Junction Temperature Range	T_J	-40 to +125	^oC
Storage Temperature Range	T_{STG}	-65 to +150	^oC

Thermal Information

Parameter	Package	Die Attach	Symbol	Maximum	Unit
Thermal Resistance* (Junction to Case)	SOT-25 SOT-26	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)**				260	^oC

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

**MIL-STD-202G 210F

■ Electrical Specifications

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
Input Voltage Range	V_{IN}	Adjustable output range	2.7		5.5	V
Quiescent Current	I_Q	No load		45	90	μA
Shutdown Current	I_{SD}	V_{EN} = 0V			1	μA
UVLO Threshold	V_{UVLO}	V_{IN} Rising		2.5	2.7	V
		Hysteresis		200		mV
		V_{IN} Falling	2	2.3		V
Regulated Feedback Voltage	V_{FB}	No Load	0.588	0.6	0.612	V
FB Input Bias Current	I_{FB}	V_{OUT} = 1V			200	nA
Regulated Output Voltage Accuracy	V_{OUT}	I_{OUT} = 0 to 2A , V_{IN} = 2.7 to 5.5V T_A = -40℃ to 85℃	-3		3	%
Output Voltage Range	V_{OUT}		V_{FB}		V_{IN}	V
Current Limit	I_{LIM}		3			A
Output Voltage Line Regulation	LNR	V_{IN} = 2.7V to 5.5V, I_{OUT} = 100mA		0.3	3	%V
Output Voltage Load Regulation	LDR	I_{OUT} = 1mA to 2A	-2		2	%
Oscillator Frequency	f_{OSC}	V_{IN}=3.6V, I_{OUT} = 100mA	1.2	1.5	1.8	MHz
RDS(ON) of P-Channel MOSFET	$R_{DS(ON)\_P}$	I_{DS} = 100mA		0.13	0.15	Ω
RDS(ON) of N-Channel MOSFET	$R_{DS(ON)\_N}$	I_{DS} = 100mA		0.08	0.10	Ω
SW Leakage Current	I_{LSW}	V_{BOOT}-GND=30V, V_{PHASE}=25V,V_{PVCC}		±0.1	±1	μA
EN High-Level Input Voltage	V_{EN_H}		1			V
EN Low-Level Input Voltage	V_{EN_L}				0.80	V
EN Leakage Current	I_{EN}		-0.01		0.01	μA
Start up Time	T_S	From Enable to Output Regulation		500	650	μS
Over Temperature Protection	T_{OTP}			150		℃
OTP Hysteresis	T_{OTH}			30		℃
Maximum Duty Cycle	I_{SHORT}			100		%

■ Detailed Description

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-Channel MOSFET) and synchronous rectifier (N-Channel MOSFET). During normal operation, the internal P-Channel 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 O_{VDET} comparator controls output transient overshoots by turning the main switch off and keeping it off until the fault is no longer present.

Power Saving Mode Operation

At very light loads, the AME5254 automatically enters Power Saving Mode. In power saving mode at light load, a control circuit puts most of the circuit into sleep in order to reduce quiescent current and improve efficiency at light load. When the output voltage drops to certain threshold, the control circuit turns back on the oscillator and the PWM control loop, boosting output backup. When an upper threshold is reached, the control circuit again puts most of circuit into sleep, reducing quiescent current. During Power Saving Mode operation, the converter positions the output voltage slightly higher than the nominal output voltage during PWM operation, allowing additional headroom for voltage drop during a load transient from light to heavy load. While the power saving mode improves light load efficiency, however, with the turning on and off, the noise or ripple voltage is larger than that in the PWM Mode.

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

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 ΔI_L. 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 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:

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

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 3.

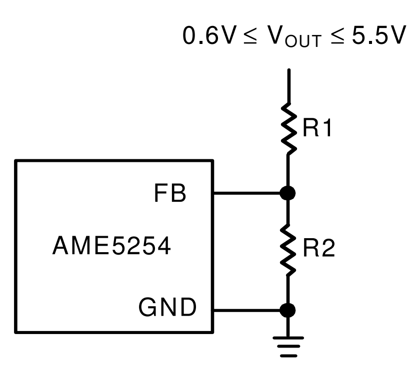


Figure 3: Setting the AME5254 Output Voltage

■ Application Information

Over-Temperature Protection

Thermal protection completely disables switching when internal dissipation becomes excessive. The junction over-temperature threshold is 150°C with 30°C of hysteresis. Once an over-temperature or over-current fault conditions is removed, the output voltage automatically recovers.

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.

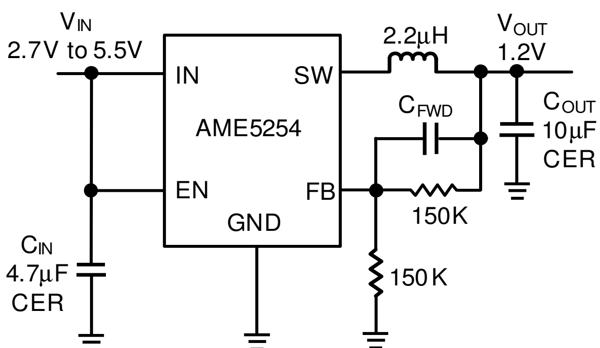


Figure 4: 1.2V Step-Down Regulator

C_{FWD}: 22pF~220pF

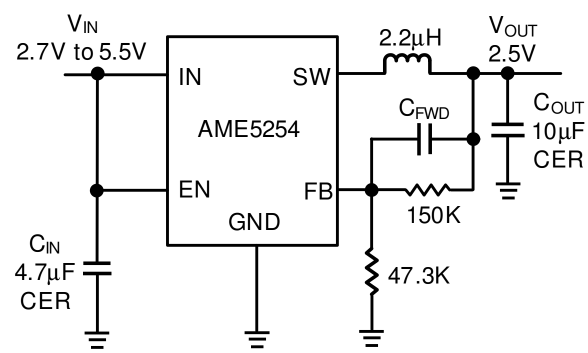


Figure 6: 2.5V Step-Down Regulator

C_{FWD}: 22pF~220pF

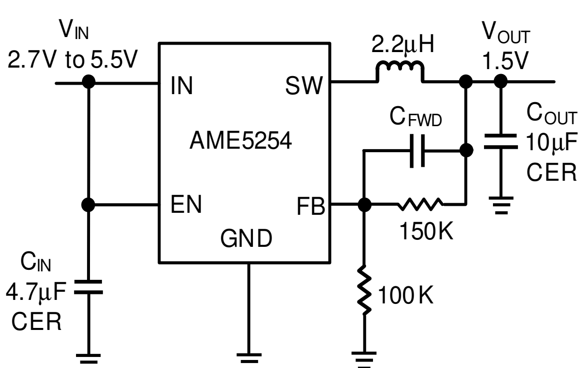


Figure 5: 1.5V Step-Down Regulator

C_{FWD}: 22pF~220pF

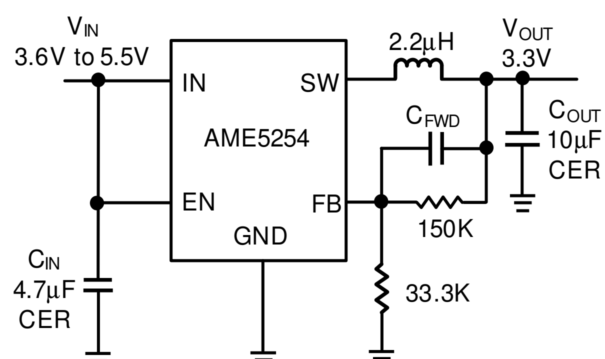


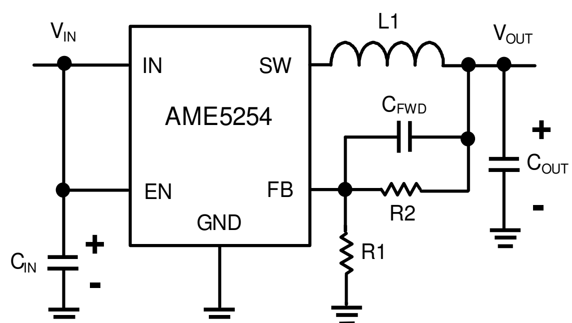
Figure 7: 3.3V Step-Down Regulator

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 AME5254. These items are also illustrated graphically in Figure 8. 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.



C_{FWD}: 22pF~220pF

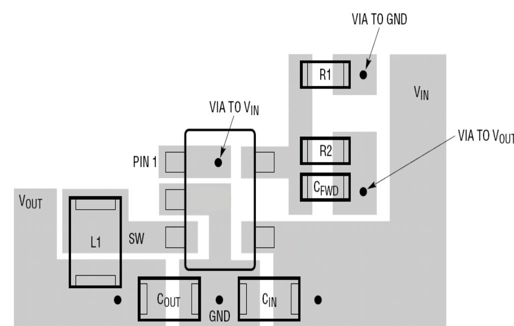
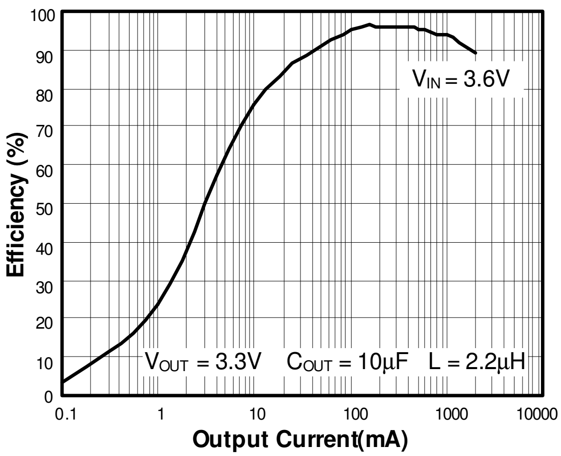


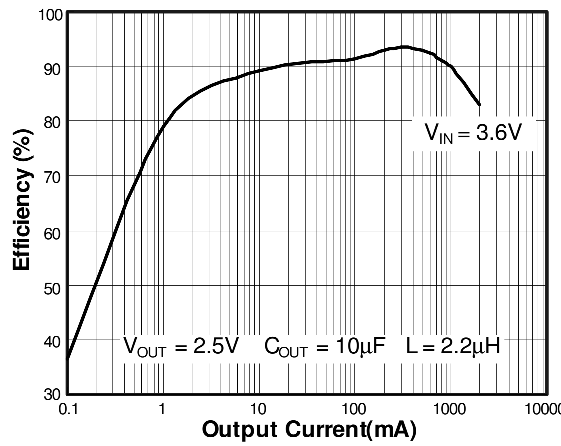
Figure 8 : AME5254 Adjustable Voltage Regulator Layout Diagram

■ Characterization Curve

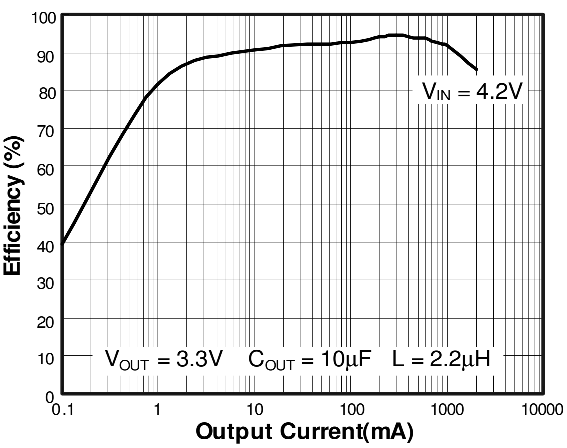
Efficiency vs. Output Current



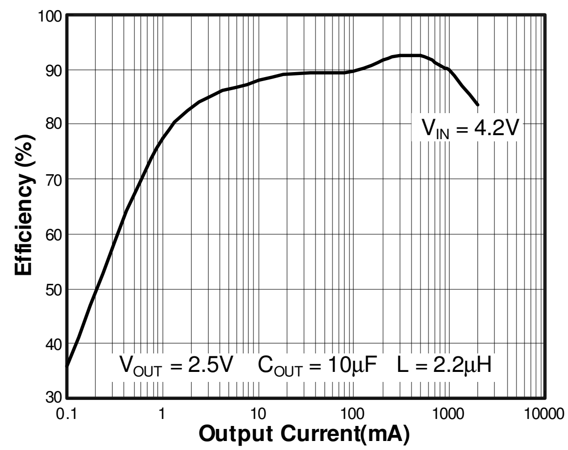
Efficiency vs. Output Current



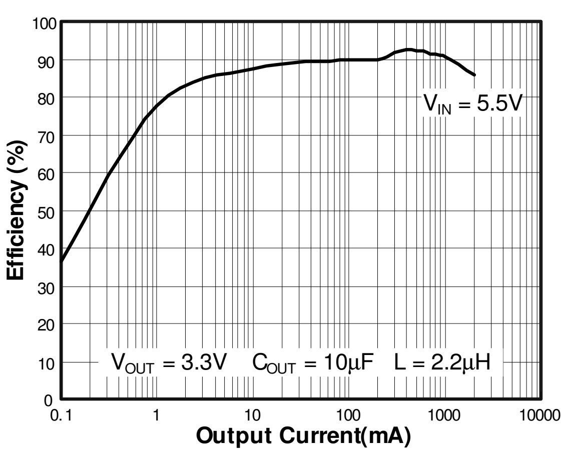
Efficiency vs. Output Current



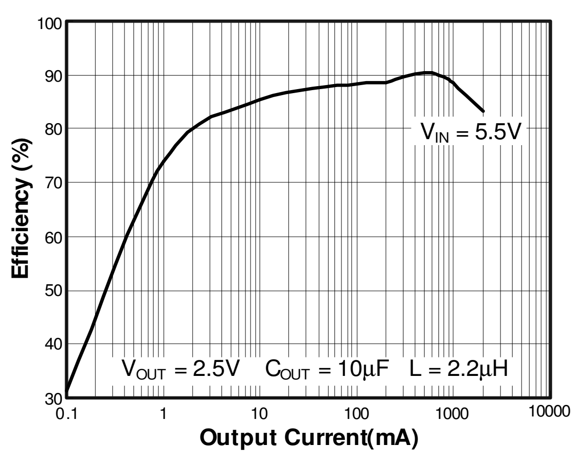
Efficiency vs. Output Current



Efficiency vs. Output Current

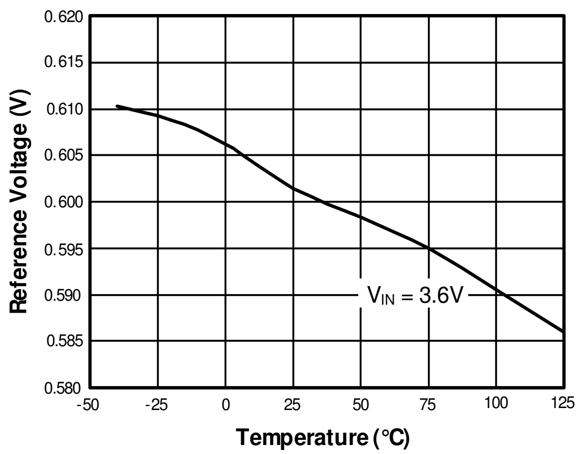


Efficiency vs. Output Current

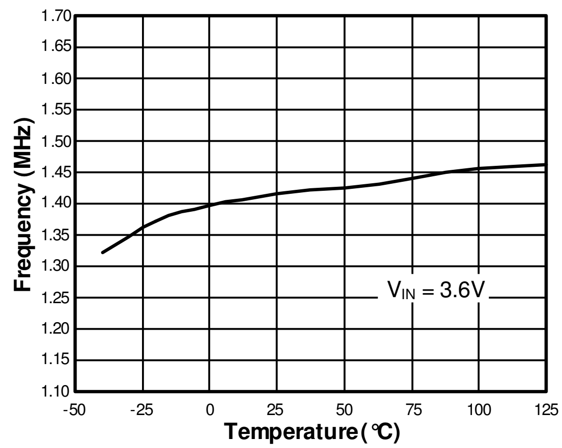


■ Characterization Curve

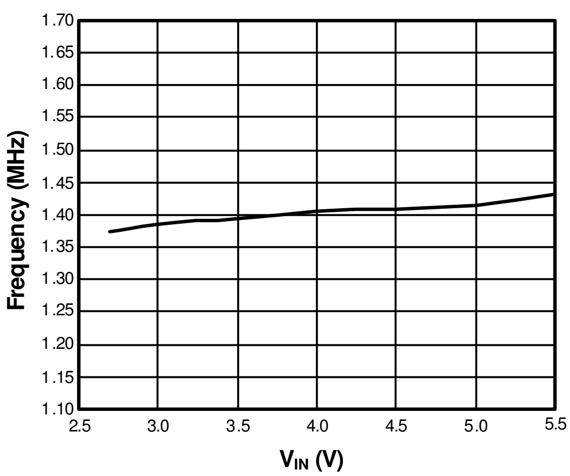
Reference Voltage vs. Temperature



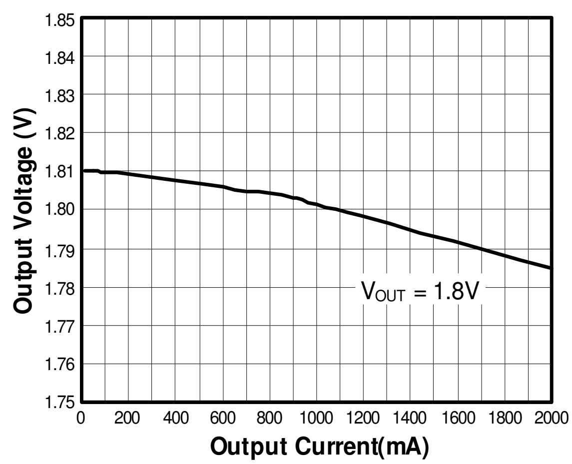
Frequency vs. Temperature



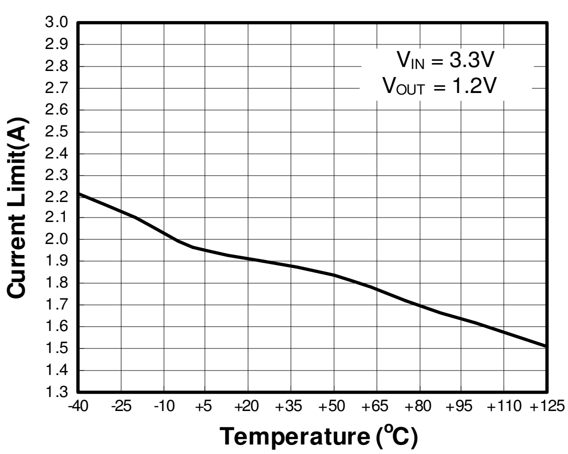
Frequency vs. Supply Voltage



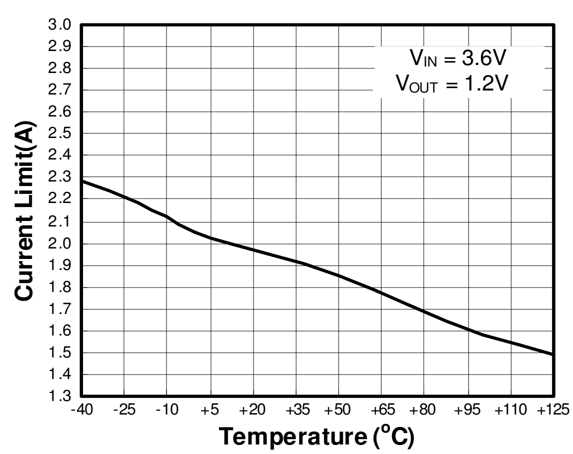
Output Voltage vs. Output Current



Current Limit vs. Temperature

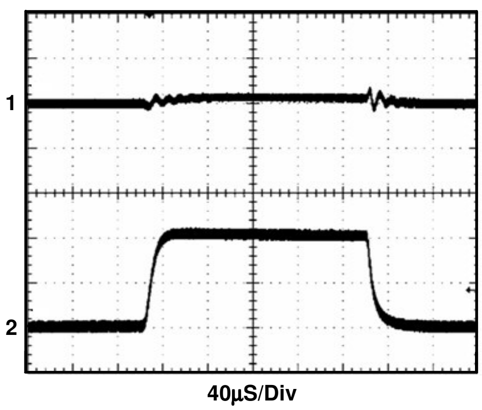


Current Limit vs. Temperature



■ Characterization Curve

Load Step

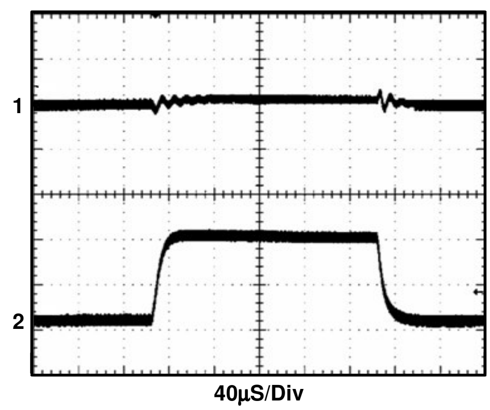


V_{IN} = 3.6V
V_{OUT} = 1.8V
I_{OUT} = 0A~2A~0A

1) V_{OUT} = 200mV/div

2) I_{OUT} = 1A/div

Load Step

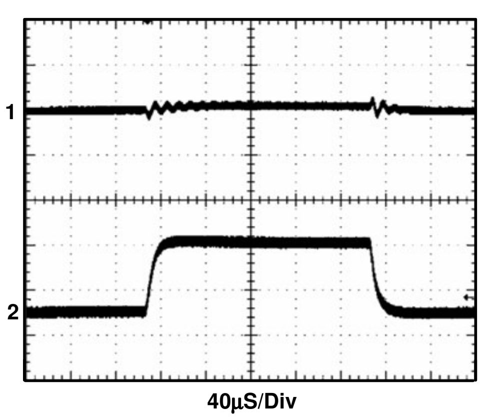


V_{IN} = 3.6V
V_{OUT} = 1.8V
I_{OUT} = 0.2A~2A~0.2A

1) V_{OUT} = 200mV/div

2) I_{OUT} = 1A/div

Load Step

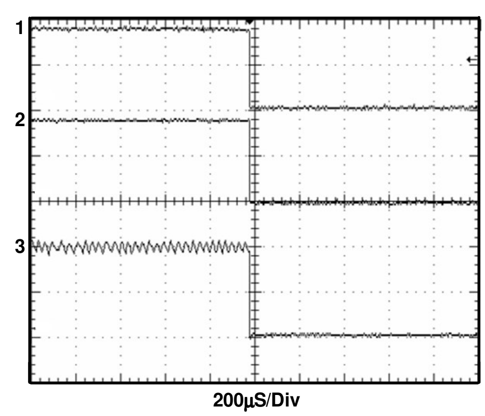


V_{IN} = 3.6V
V_{OUT} = 1.8V
I_{OUT} = 0.5A~2A~0.5A

1)V_{OUT} = 200mV/div

2)I_{OUT} = 1A/div

Power Off from EN



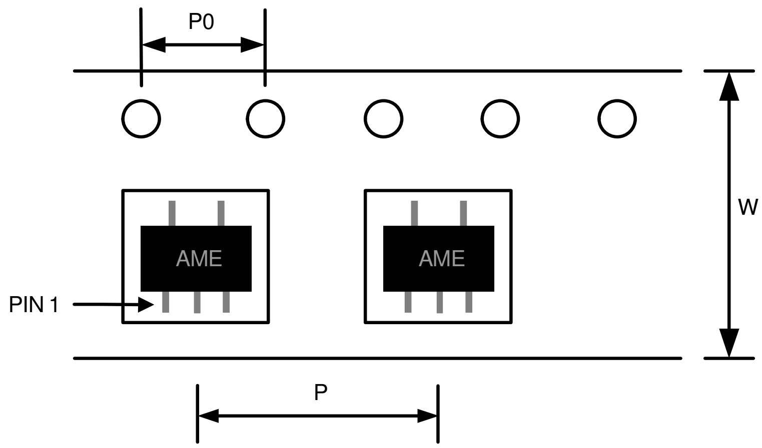
V_{IN}=3.6V
V_{OUT}=1.8V
I_{OUT}=2A

1) EN=2V/div

2) V_{OUT}=2V/div
3) IL=1A/div

■ Tape and Reel Dimension

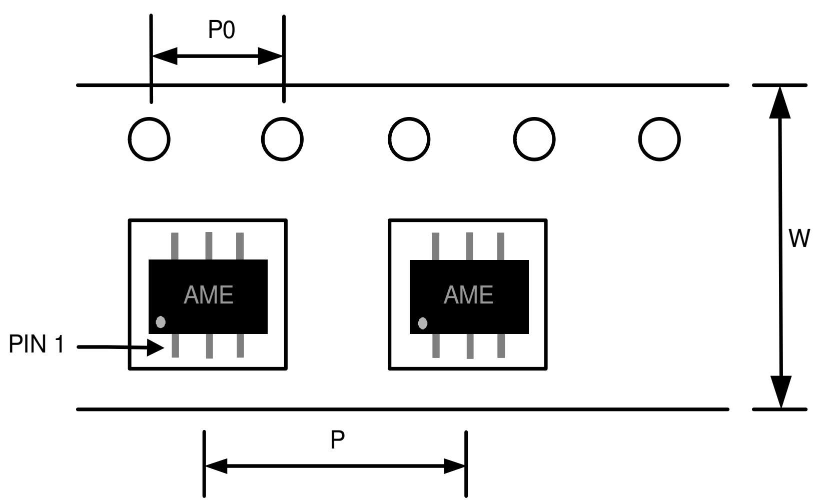
SOT-25



Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Pitch (P0)	Part Per Full Reel	Reel Size
SOT-25	8.0±0.1 mm	4.0±0.1 mm	4.0±0.1 mm	3000pcs	180±1 mm

SOT-26

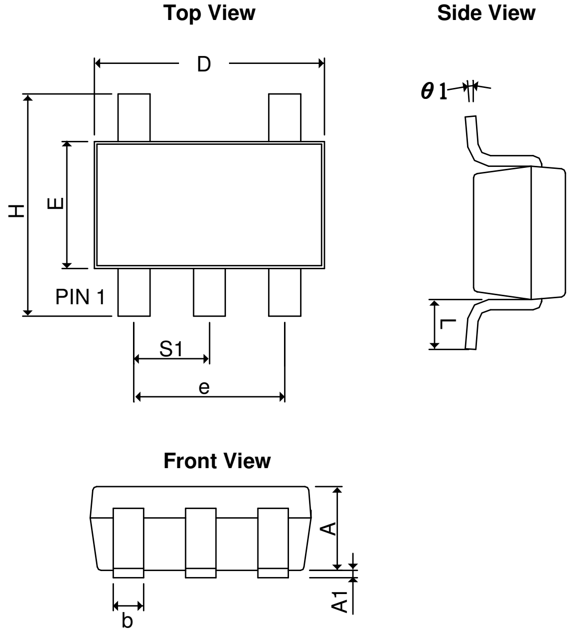


Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Pitch (P0)	Part Per Full Reel	Reel Size
SOT-26	8.0±0.1 mm	4.0±0.1 mm	4.0±0.1 mm	3000pcs	180±1 mm

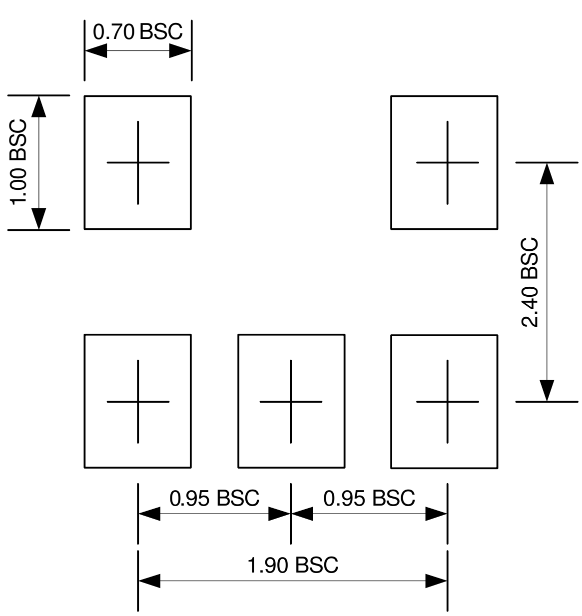
■ Package Dimension (Contd.)

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

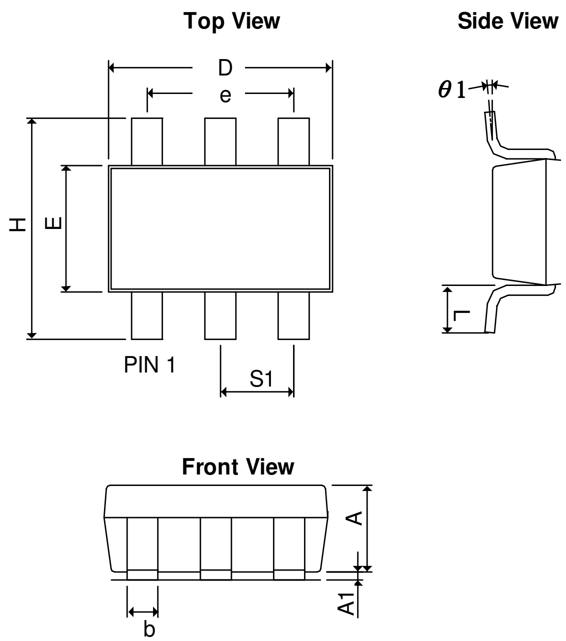


Note:

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.

■ Package Dimension

SOT-26



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		0.075 BSC	
H	2.60	3.00	0.1024	0.1181
L	0.37 BSC		0.015 BSC	
θ1	0°	10°	0°	10°
S_1	0.95 BSC		0.037 BSC	

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