



AME5140

1.6 MHz Boost Converter With 30V Internal FET Switch

General Description

The AME5140 switching regulator is current-mode boost converters operating at fixed frequency of 1.6 MHz.

The use of SOT-25/TSOT-25, DFN-8(3mmx3mmx 0.75mm) & MSOP-8 packages, made possible by the minimal power loss of the internal 1.8A switch, and use of small inductor and capacitors result in the industry's highest power density. The 30V internal switch makes these solutions perfect for boosting to voltages up to 30V.

These parts have a logic-level shutdown pin that can be used to reduce quiescent current and extend battery life. Protection is provided through cycle-by-cycle current limiting and thermal shutdown. Internal compensation simplifies and reduces component count.

Typical Application

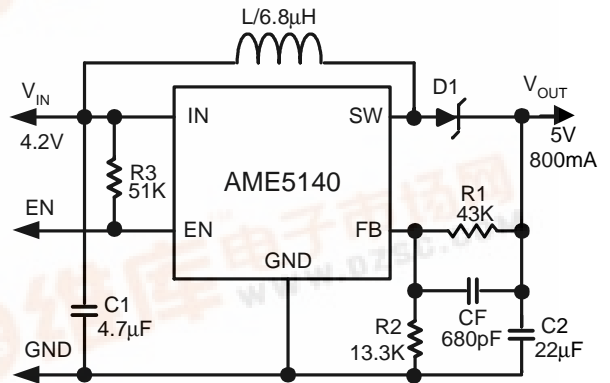


Figure 1. 4.2V to 5V Boost Converter

Features

- 30V DMOS FET Switch
- 1.6 MHz Switching Frequency
- Low $R_{DS(ON)}$ DMOS FET
- Switch Current Up to 1.8A
- Wide Input Voltage Range (2.7V-5.5V)
- Low Shutdown Current ($<1\mu A$)
- SOT-25/TSOT-25, DFN-8(3mmx3mmx0.75mm) & MSOP-8 Packages
- Uses Tiny Capacitors and Inductor
- Cycle-by-Cycle Current Limiting
- All AME's Lead Free Products Meet RoHS Standards

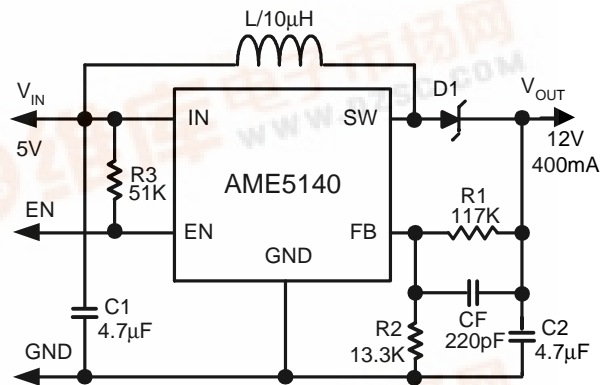


Figure 2. 5V to 12V Boost Converter

Applications

- White LED Current Source
- PDA's and Palm-Top Computers
- Digital Cameras
- Portable Phones and Games
- Local Boost Regulator

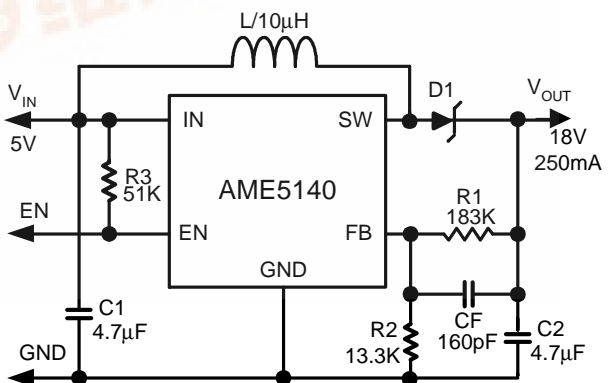


Figure 3. 5V to 18V Boost Converter



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■ Function Block Diagram

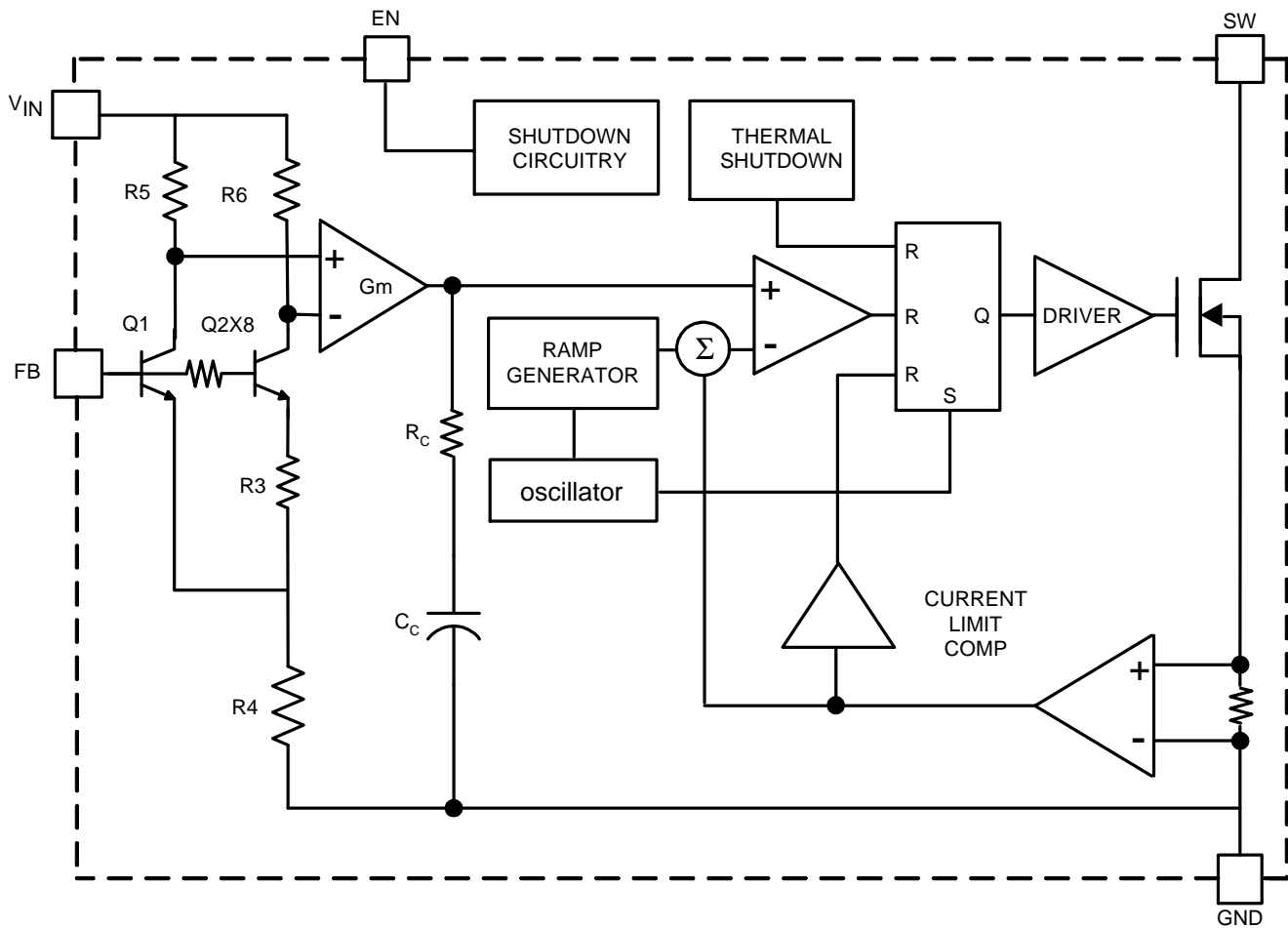
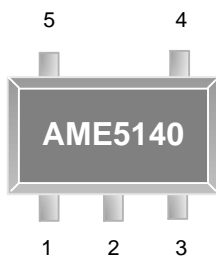


Figure 4. Functional Block Diagram

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■ Pin Configuration

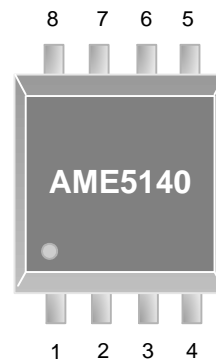
**SOT-25/TSOT-25
Top View**



AME5140AEEV

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

**MSOP-8
Top View**



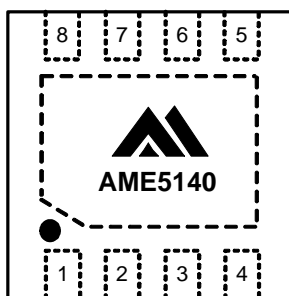
AME5140BEQA

1. IN
2. EN
3. GND
4. FB
5. SW
6. SW
7. GND
8. GND

*** Die Attach:
Conductive Epoxy**

*** Die Attach:
Conductive Epoxy**

**DFN-8
(3mmx3mmx0.75mm)
Top View**



AME5140AEVA

1. NC
2. FB
3. NC
4. SW
5. NC
6. IN
7. EN
8. NC

*** Die Attach:
Conductive Epoxy**

Note: The trapezoid area enclosed by dashed line represents Exposed Pad and is GND.

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■ Pin Description (Continued)
AME5140AEEV SOT-25/TSOT-25

Pin Number	Pin Name	Pin Description
1	SW	Power Switch input. This is the drain of the internal NMOS power switch. Minimize the metal trace area connected to this pin to minimize EMI.
2	GND	Ground. Tie directly to ground plane.
3	FB	Output voltage feedback input. Set the output voltage by selecting values for R1 and R2 using: $R1 = R2 \left(\frac{V_{out}}{1.23V} - 1 \right)$ Connect the ground of the feedback network to a GND plane.
4	EN	Enable, active high. The enable pin is an active high control. Tie this pin above 2V to enable the device. Tie this pin below 0.4V to turn off the device.
5	IN	Analog and Power input. Input Supply Pin. Place bypass capacitor as close to V_{IN} as possible.

AME5140BEQA MSOP-8

Pin Number	Pin Name	Pin Description
1	IN	Analog and Power input. Input Supply Pin. Place bypass capacitor as close to V_{IN} as possible.
2	EN	Enable, active high. The enable pin is an active high control. Tie this pin above 2V to enable the device. Tie this pin below 0.4V to turn off the device.
3	GND	Ground. Tie directly to ground plane.
4	FB	Output voltage feedback input. Set the output voltage by selecting values for R1 and R2 using: $R1 = R2 \left(\frac{V_{out}}{1.23V} - 1 \right)$ Connect the ground of the feedback network to a GND plane.
5	SW	Power Switch input. This is the drain of the internal NMOS power switch. Minimize the metal trace area connected to this pin to minimize EMI.
6	SW	Power Switch input. This is the drain of the internal NMOS power switch. Minimize the metal trace area connected to this pin to minimize EMI.
7	GND	Ground. Tie directly to ground plane.
8	GND	Ground. Tie directly to ground plane.



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■ Pin Description

AME5140AEVADFN-8(3mmx3mmx0.75mm)

Pin Number	Pin Name	Pin Description
1	NC	Not Connected
2	FB	Output voltage feedback input. Set the output voltage by selecting values for R1 and R2 using: $R1 = R2 \left(\frac{V_{out}}{1.23V} - 1 \right)$ Connect the ground of the feedback network to a GND plane.
3	NC	Not Connected
4	SW	Power Switch input. This is the drain of the internal NMOS power switch. Minimize the metal trace area connected to this pin to minimize EMI.
5	NC	Not Connected
6	IN	Analog and Power input. Input Supply Pin. Place bypass capacitor as close to V_{IN} as possible.
7	EN	Enable, active high. The enable pin is an active high control. Tie this pin above 2V to enable the device. Tie this pin below 0.4V to turn off the device.
8	NC	Not Connected

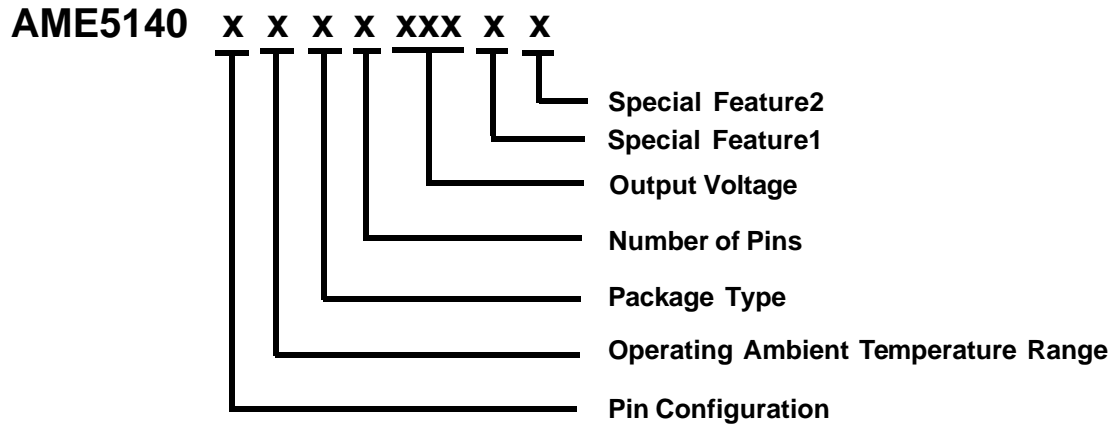


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1.6 MHz Boost Converter with 30V Internal FET Switch

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■ Ordering Information



Pin Configuration	Operating Ambient Temperature Range	Package Type	Number of Pins	Output Voltage	Special Feature1	Special Feature2 (For DFN package only)
A 1. SW (SOT-25) 2. GND (TSOT-25) 3. FB 4. EN 5. IN A 1. NC (DFN-8) 2. FB 3. NC 4. SW 5. NC 6. IN 7. EN 8. NC B 1. IN (MSOP-8) 2. EN 3. GND 4. FB 5. SW 6. SW 7. GND 8. GND	E: -40°C to 85°C	E: SOT-2X V: DFN Q: MSOP	V: 5 A: 8	ADJ: Adjustable	Lead free & Y: Low profile (For TSOT-25 only) Z: Lead free	3: 3x3x0.75(mm) (LxWxH)



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■ Ordering Information

Part Number	Marking*	Output Voltage	Package	Operating Ambient Temperature Range
AME5140AEEVADJZ	BDRww	ADJ	SOT-25	-40°C to 85°C
AME5140AEEVADJY	BDRww	ADJ	TSOT-25	-40°C to 85°C
AME5140AEVAADJZ-3	BFK yyww	ADJ	DFN-8 (3mmx3mmx0.75mm)	-40°C to 85°C
AME5140BEQAADJZ	5140 Cyww	ADJ	MSOP-8	-40°C to 85°C

Note: ww represents the date code and pls refer to Date Code Rule before Package Dimension.

* A line on top of the first letter represents lead free plating such as BDRww.

Please consult AME sales office or authorized Rep./Distributor for the availability of package type.



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30V Internal FET Switch

■ Absolute Maximum Ratings

Parameter	Symbol	Maximum	Unit
Input Supply Voltage	V_{IN}	6	V
EN, FB Voltages	V_{EN}, V_{FB}	V_{IN}	V
SW Voltage	V_{SW}	30	V
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
Ambient Temperature Range	T_A	-40 to 85	°C
Junction Temperature Range	T_J	-40 to 125	
Storage Temperature Range	T_{STG}	-65 to 150	

■ Thermal Information

Parameter	Package	Die Attach	Symbol	Maximum	Unit
Thermal Resistance* (Junction to Case)	SOT-25 / TSOT-25	Conductive Epoxy	θ_{JC}	81	°C / W
	MSOP-8			100	
	DFN-8 (3mmx3mmx0.75mm)			17	
Thermal Resistance (Junction to Ambient)	SOT-25 / TSOT-25		θ_{JA}	260	
	MSOP-8			206	
	DFN-8 (3mmx3mmx0.75mm)			125	
Internal Power Dissipation	SOT-25 / TSOT-25		P_D	400	mW
	MSOP-8			625	
	DFN-8 (3mmx3mmx0.75mm)			800	
Maximum Junction Temperature				150	°C
Solder Iron (10 Sec)**				350	

* Measure θ_{JC} on backside center of molding compound if IC has no tab.



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■ Electrical Specifications

$V_{IN} = 5V$, $EN = V_{IN}$, $T_A = 25^{\circ}C$, $I_L = 0A$, unless otherwise noted.

Parameter	Symbol	Test Condition	Min	Typ	Max	Units	
Input Voltage	V_{IN}		2.7		5.5	V	
Switch Current Limit	I_{CL}	$T_A = 25^{\circ}C$	1.5	1.8		A	
		$T_A = -40$ to $85^{\circ}C$	1.2				
Switch ON Resistance	R_{DSON}	$V_{IN} = 5V$	$T_A = 25^{\circ}C$		0.4	0.6	Ω
			$T_A = -40$ to $85^{\circ}C$			0.7	
		$V_{IN} = 3.3V$	$T_A = 25^{\circ}C$		0.5	0.7	
			$T_A = -40$ to $85^{\circ}C$			0.8	
EN Pin Bias Current	I_{EN}	$EN = 0V$		0		μA	
		$EN = 5V$		0	2		
Feedback Pin Reference Voltage	V_{FB}	$V_{IN} = 3V$	1.205	1.23	1.255	V	
Feedback Pin Bias Current	I_{FB}	$V_{FB} = 1.23V$		60	500	nA	
Quiescent Current	I_Q	FB = 1.15V (Switching)	$T_A = 25^{\circ}C$		2		mA
			$V_{IN} = 5V$ $T_A = -40$ to $85^{\circ}C$			3	
		FB = 1.3V (Not Switching)	$T_A = 25^{\circ}C$		400		μA
			$V_{IN} = 5V$ $T_A = -40$ to $85^{\circ}C$			500	
Shutdown Current		$EN = 0V$		0.01	1	μA	
Undervoltage Lockout	UVP	Rising Edge	2.15	2.35	2.55	V	
Over Temperature Protection	OTP	$V_{IN} = 2.7V$ to $5.5V$		160		$^{\circ}C$	
OTP Hysteresis Temperature				20		$^{\circ}C$	
FB Voltage Line Regulation	$\frac{\Delta V_{FB}}{\Delta V_{IN}}$	$2.7V \leq V_{IN} \leq 5.5V$		0.02		%V	
Switching Frequency	f_{SW}	$V_{IN} = 3V$, $T_A = -40$ to $85^{\circ}C$	1	1.6	1.85	MHz	
Maximum Duty Cycle	D_{MAX}	$V_{IN} = 3V$, $T_A = -40$ to $85^{\circ}C$	86	93		%	
Switch Leakage	I_{SW}	$EN = 0V$		0.1	2	μA	
EN Input Threshold (Low) (Shutdown)	EN Threshold	$T_A = -40$ to $85^{\circ}C$			0.4	V	
EN Input Threshold (High) (Enable the device)		$T_A = -40$ to $85^{\circ}C$	2				



■ Detailed Description

The AME5140 is a switching converter IC that operates at a fixed frequency (1.6MHz) for fast transient response over a wide input voltage range and incorporates pulse-by-pulse current limiting protection. Operation can be best understood by referring to Figure 4. Because this is current mode control, a 33mΩ sense resistor in series with the switch FET is used to provide a voltage (which is proportional to the FET current) to both the input of the pulse width modulation (PWM) comparator and the current limit amplifier.

At the beginning of each cycle, the S-R latch turns on the FET. As the current through the FET increases, a voltage (proportional to this current) is summed with the ramp coming from the ramp generator and then fed into the input of the PWM comparator. When this voltage exceeds the voltage on the other input (coming from the Gm amplifier), the latch resets and turns the FET off. Since the signal coming from the Gm amplifier is derived from the feedback (which samples the voltage at the output), the action of the PWM comparator constantly sets the correct peak current through the FET to keep the output voltage in regulation.

Q1 and Q2 along with R3 - R6 form a bandgap voltage reference used by the IC to hold the output in regulation. The currents flowing through Q1 and Q2 will be equal, and the feedback loop will adjust the regulated output to maintain this. Because of this, the regulated output is always maintained at a voltage level equal to the voltage at the FB node "multiplied up" by the ratio of the output resistive divider.

The current limit comparator feeds directly into the flip-flop that drives the switch FET. If the FET current reaches the limit threshold, the FET is turned off and the cycle terminated until the next clock pulse. The current limit input terminates the pulse regardless of the status of the output of the PWM comparator.

■ Application Hints

Selecting The External Capacitors

The best capacitors for use with the AME5140 are multilayer Ceramic capacitors. They have the lowest ESR (equivalent series resistance) and highest resonance frequency, which makes them optimum for use with high frequency switching Converters. When selecting a ceramic capacitor, only X5R and X7R dielectric types should be used. Other types such as Z5U and Y5F have such severe loss of capacitance due to effects of temperature variation and applied voltage, they may provide as little as 20% of rated capacitance in many typical applications. Always consult capacitor manufacturer's data curves before selecting a capacitor. High-quality ceramic capacitors can be obtained from Taiyo-Yuden, AVX, and Murata.

Selecting The Output Capacitor

A single ceramic capacitor of value 4.7μF to 10μF will provide sufficient output capacitance for most applications. If larger amounts of capacitance are desired for improved line support and transient response, tantalum capacitors can be used. Aluminum electrolytic with ultra low ESR such as Sanyo Oscon can be used, but are usually prohibitively expensive. Typical Al electrolytic capacitors are not suitable for switching frequencies above 500kHz due to significant ringing and temperature rise due to self-heating from ripple current. An output capacitor with excessive ESR can also reduce phase margin and cause instability. In general, if electrolytic are used, it is recommended that they be paralleled with ceramic capacitors to reduce ringing, switching losses, and output voltage ripple.

Selecting The Input Capacitor

An input capacitor is required to serve as an energy reservoir for the current which must flow into the coil each time the switch turns ON. This capacitor must have extremely low ESR, so ceramic is the best choice. We recommend a nominal value of 4.7μF, but larger values can be used. Since this capacitor reduces the amount of voltage ripple seen at the input pin, it also reduces the amount of EMI passed back along that line to other circuitry.

■ Application Hints

Feed-Forward Compensation

Although internally compensated, the feed-forward capacitor C_f is required for stability. Adding this capacitor puts a zero in the loop response of the Converter. The recommended frequency for the zero f_z should be approximately 6kHz. C_f can be calculated using the formula:

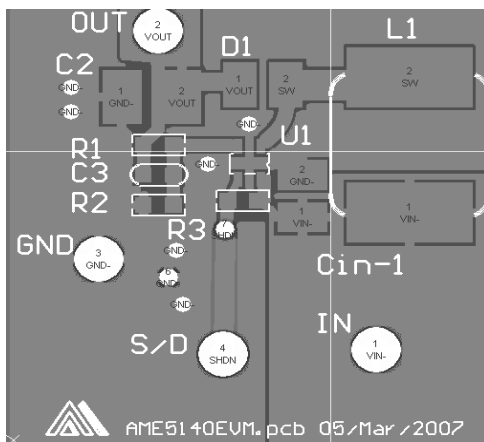
$$C_f = 1 / (2 \times p \times R1 \times f_z)$$

Selecting Diodes

The external diode used in the typical application should be a Schottky diode. A 20V diode such as the MBR0520 is recommended. The MBR05XX series of diodes are designed to handle a maximum average current of 0.5A. For applications exceeding 0.5A average but less than 1A, a Microsemi UPS5817 can be used.

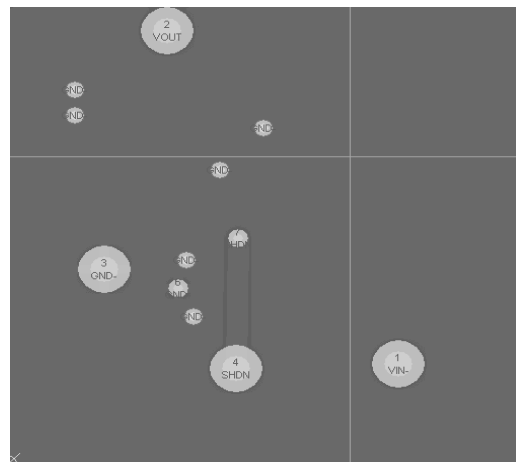
Layout Hints

High frequency switching regulators require very careful layout of components in order to get stable operation and low noise. All components must be as close as possible to the AME5140 device. It is recommended that a 4-layer PCB be used so that internal ground planes are available. As an example, a recommended layout of components is shown:



Recommended PCB Component Layout (Top)

Layout Hints



Recommended PCB Component Layout (Bottom)

Some additional guidelines to be observed:

1. Keep the path between L1, D1, and C2 extremely short. Parasitic trace inductance in series with D1 and C2 will increase noise and ringing.

2. The feedback components R1, R2 and CF must be kept close to the FB pin of U1 to prevent noise injection on the FB pin trace.

3. If internal ground planes are available use vias to connect directly to ground at pin 2 of U1, as well as the negative sides of capacitors C1 and C2.

Duty Cycle

The maximum duty cycle of the switching regulator determines the maximum boost ratio of output-to-input voltage that the converter can attain in mode of operation. The duty cycle for a given boost application is defined as: This applies for continuous mode operation.

$$D = \frac{V_{OUT} + V_{DIODE} - V_{IN}}{V_{OUT} + V_{DIODE} - V_{SW}}$$

■ Application Hints

Calculating Load Current

The load current is related to the average inductor current by the relation:

$$I_{LOAD} = I_{IND} (AVG) \times (1 - D)$$

Where “D” is the duty cycle of the application. The switch current can be found by:

$$I_{SW} = I_{IND} (AVG) + 1/2 (I_{RIPPLE})$$

Inductor ripple current is dependent on inductance, duty cycle, input voltage and frequency:

$$I_{RIPPLE} = D \times (V_{IN} - V_{SW}) / (f \times L)$$

Combining all terms, we can develop an expression which allows the maximum available load current to be calculated:

$$I_{LOAD} = (1 - D) \times (I_{SW} (max) - \frac{D (V_{IN} - V_{SW})}{2fL})$$

Thermal Considerations

At higher duty cycles, the increased ON time of the FET means the maximum output current will be determined by power dissipation within the AME5140 FET switch. The switch power dissipation from ON-state conduction is calculated by:

$$P_{(SW)} = D \times I_{IND(AVG)2} \times R_{DS(ON)}$$

There will be some switching losses as well, so some derating needs to be applied when calculating IC power dissipation.

Inductor Suppliers

Recommended suppliers of inductors for this product include, but are not limited to Sumida, Coilcraft, Panasonic, TDK and Murata. When selecting an inductor, make certain that the continuous current rating is high enough to avoid saturation at peak currents. A suitable core type must be used to minimize core (switching) losses, and wire power losses must be considered when selecting the current rating.

Shutdown Pin Operation

The device is turned off by pulling the shutdown pin low. If this function is not going to be used, the pin should be tied directly to V_{IN} . If the SHDN function will be needed, a pull-up resistor must be used to V_{IN} (approximately 50k-100k recommended). The EN pin must not be left unterminated.

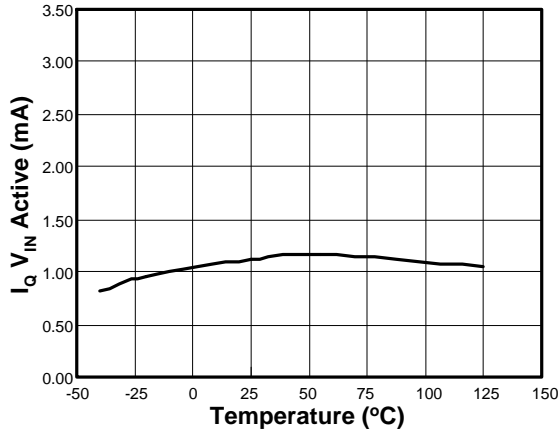


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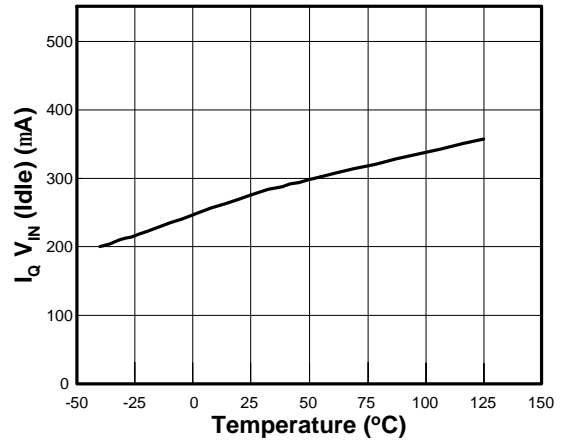
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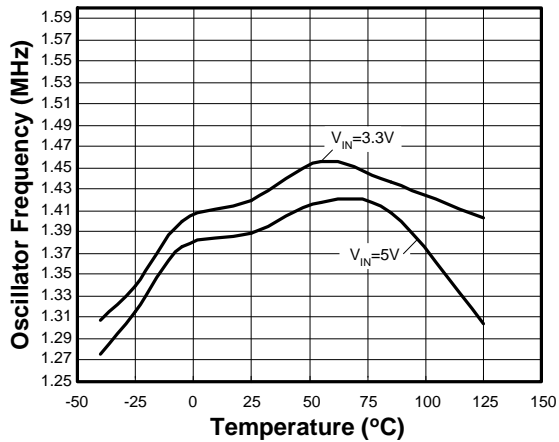
$I_Q V_{IN}$ (Active) vs Temperature



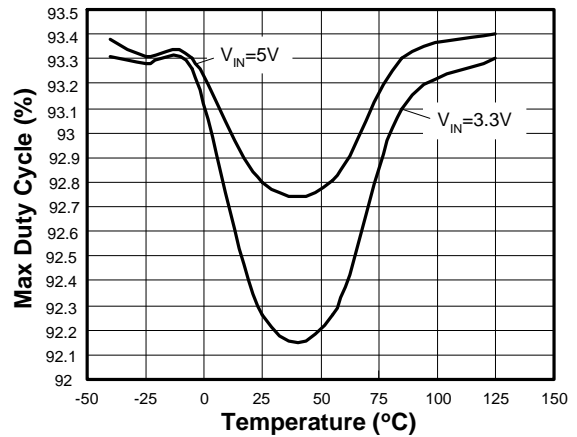
$I_Q V_{IN}$ (Idle) vs Temperature



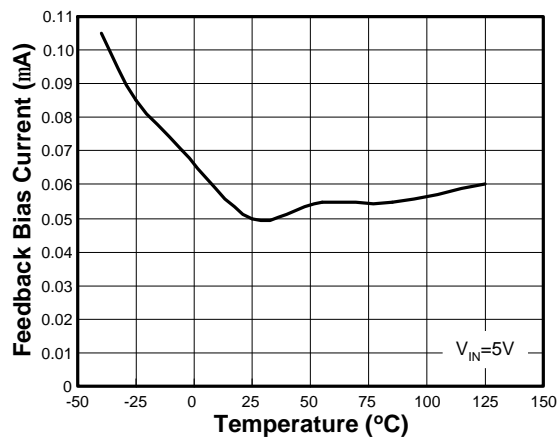
Oscillator Frequency vs Temperature



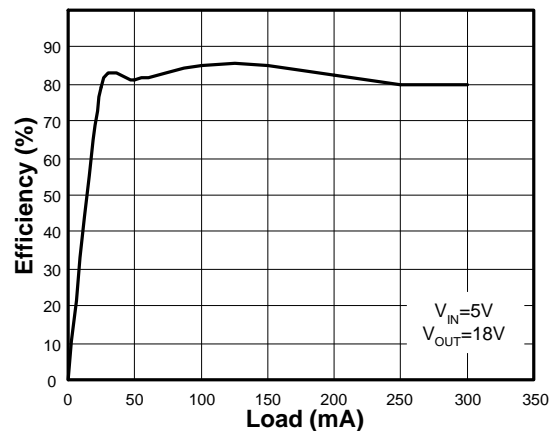
Max. Duty Cycle vs Temperature



Feedback Bias Current vs Temperature



Efficiency vs Load Current



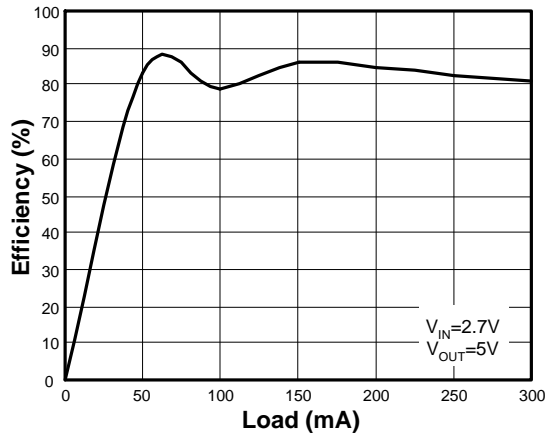


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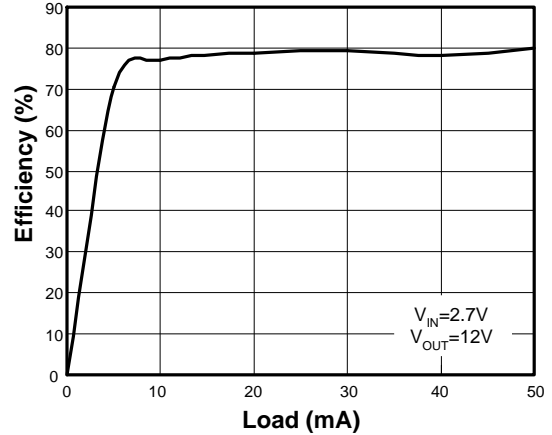
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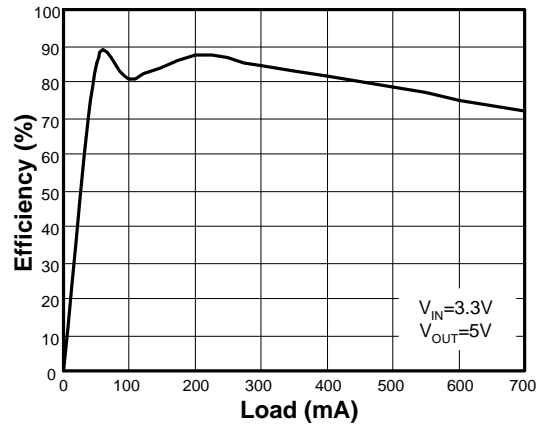
Efficiency vs Load Current



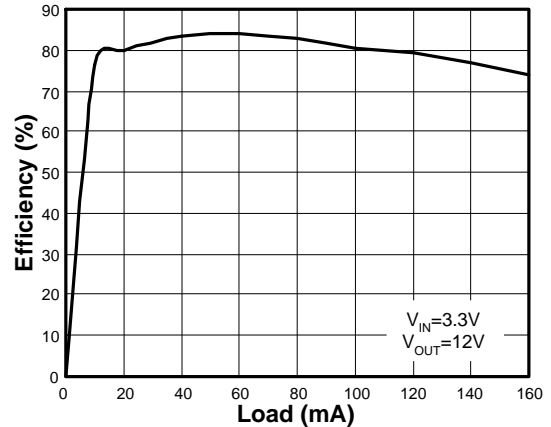
Efficiency vs Load Current



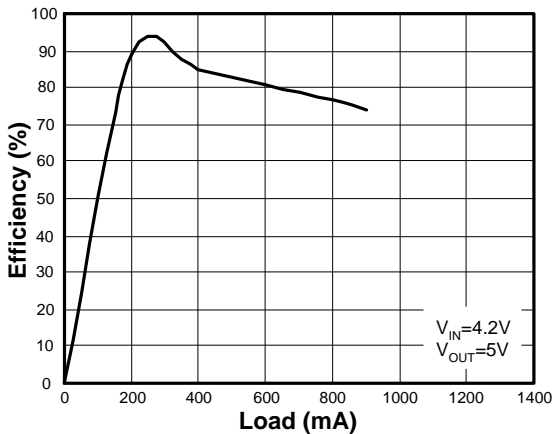
Efficiency vs Load Current



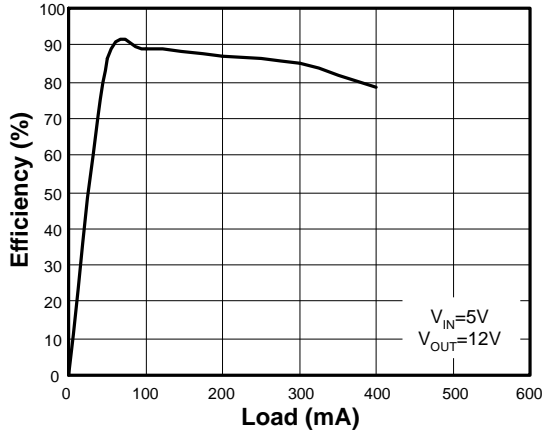
Efficiency vs Load Current



Efficiency vs Load Current



Efficiency vs Load Current



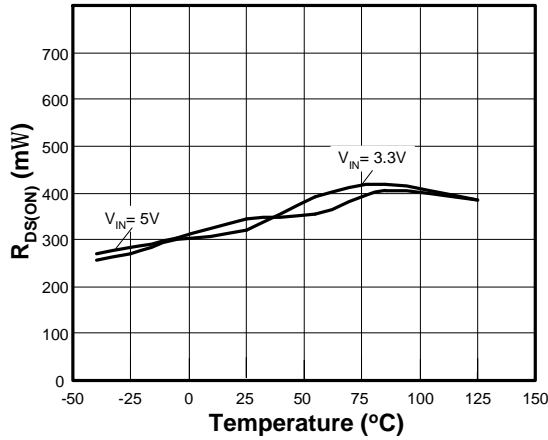


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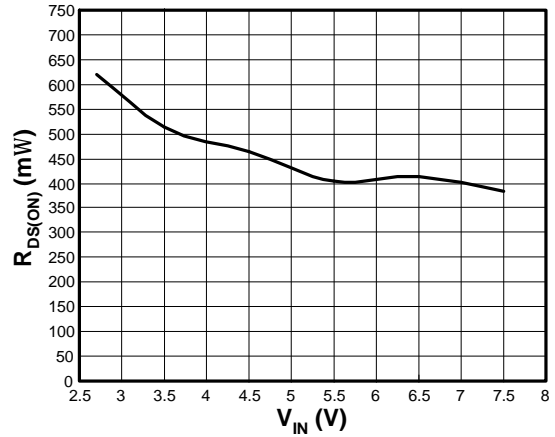
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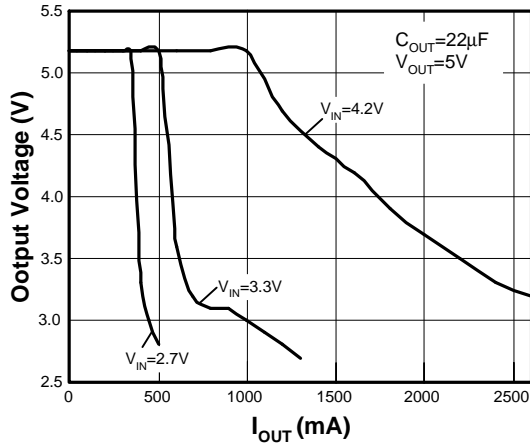
$R_{DS(ON)}$ vs Temperature



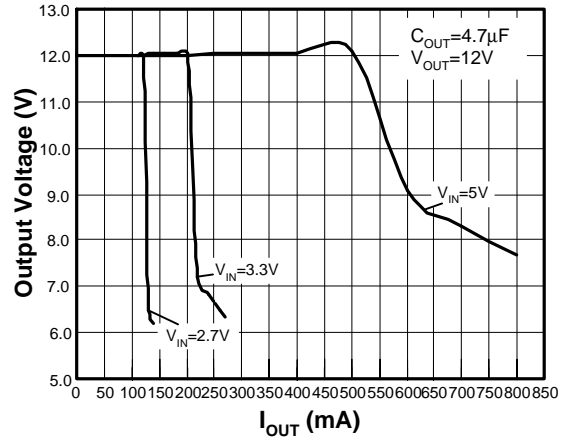
$R_{DS(ON)}$ vs V_{IN}



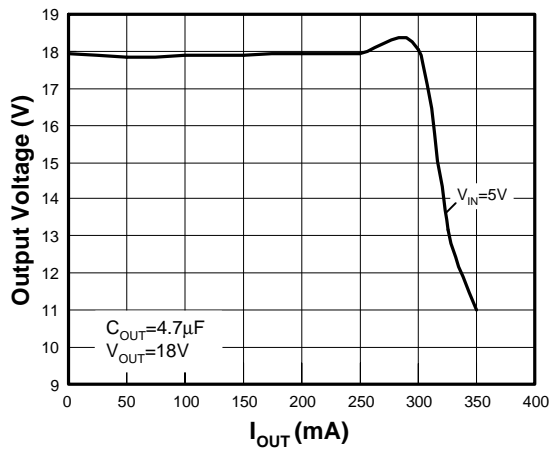
Output Voltage vs Load Current



Output Voltage vs Load Current

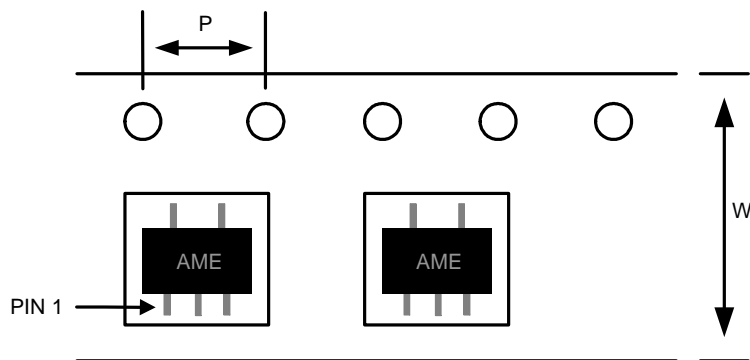


Output Voltage vs Load Current

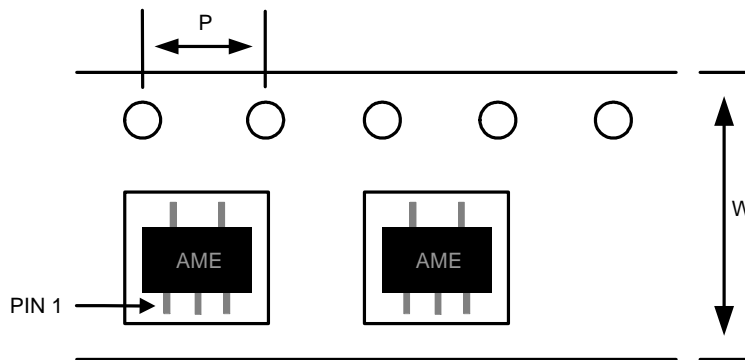


■ Date Code Rule

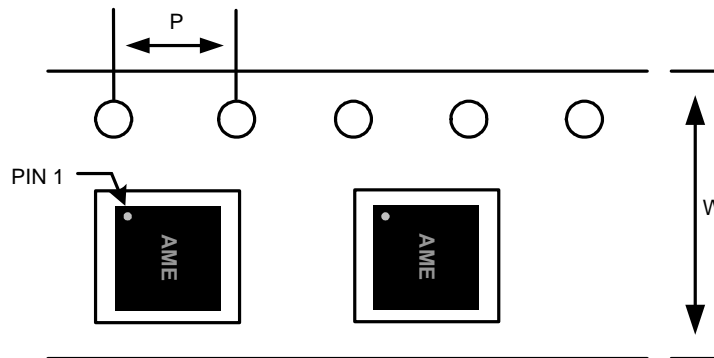
Marking			Date Code		Year
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A	A	A	W	<u>W</u>	xxx1
A	A	A	<u>W</u>	W	xxx2
A	A	A	<u>W</u>	<u>W</u>	xxx3
A	A	<u>A</u>	W	W	xxx4
A	A	<u>A</u>	W	<u>W</u>	xxx5
A	A	<u>A</u>	<u>W</u>	W	xxx6
A	A	<u>A</u>	<u>W</u>	<u>W</u>	xxx7
A	<u>A</u>	A	W	W	xxx8
A	<u>A</u>	A	W	<u>W</u>	xxx9

■ Tape and Reel Dimension
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

AME5140
■ Tape and Reel Dimension
TSOT-25

Carrier Tape, Number of Components Per Reel and Reel Size

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

**DFN-8
(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-8 (3x3x0.75mm)	12.0±0.1 mm	4.0±0.1 mm	3000pcs	330±1 mm



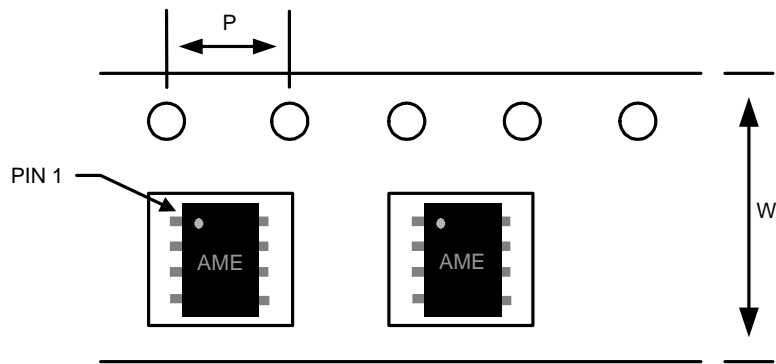
AME, Inc.

AME5140

1.6 MHz Boost Converter with
30V Internal FET Switch

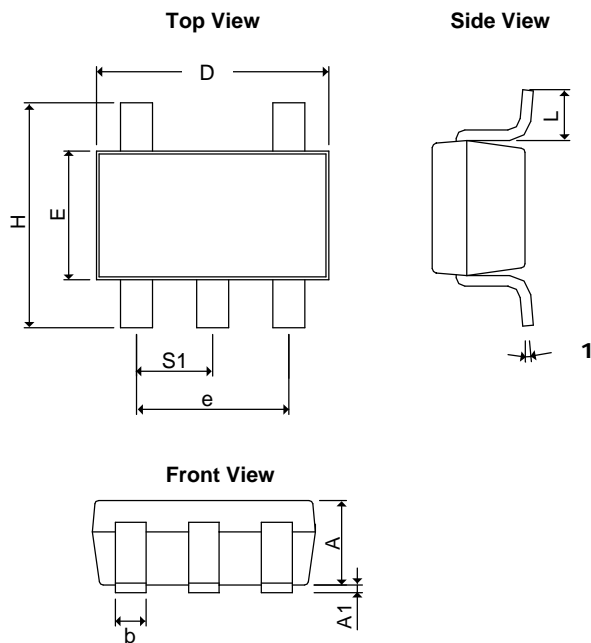
■ Tape and Reel Dimension

MSOP-8

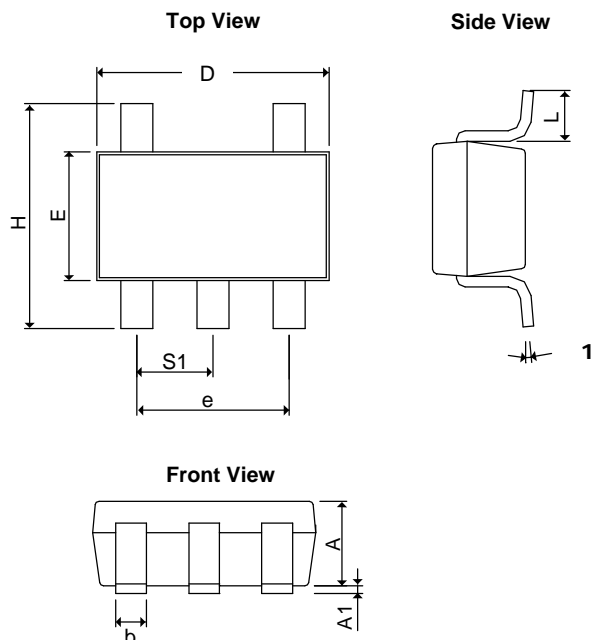


Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
MSOP-8	12.0±0.1 mm	4.0±0.1 mm	4000pcs	330±1 mm

■ Package Dimension
SOT-25


SYMBOLS	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.20REF		0.0472REF	
A₁	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		0.07480 BSC	
H	2.60	3.00	0.10236	0.11811
L	0.37BSC		0.0146BSC	
q1	0°	10°	0°	10°
S₁	0.95BSC		0.0374BSC	

TSOT-25


SYMBOLS	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A+A₁	0.90	1.25	0.0354	0.0492
b	0.30	0.50	0.0118	0.0197
c	0.09	0.25	0.0035	0.0098
D	2.70	3.10	0.1063	0.1220
E	1.40	1.80	0.0551	0.0709
e	1.90 BSC		0.07480 BSC	
H	2.40	3.00	0.09449	0.11811
L	0.35BSC		0.0138BSC	
q1	0°	10°	0°	10°
S₁	0.95BSC		0.0374BSC	



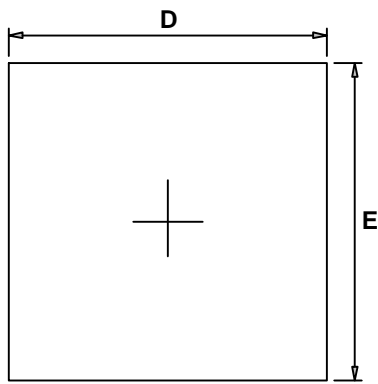
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AME5140

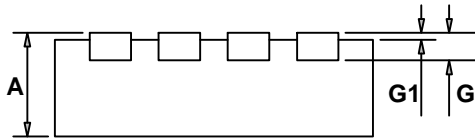
1.6 MHz Boost Converter with
30V Internal FET Switch

■ Package Dimension

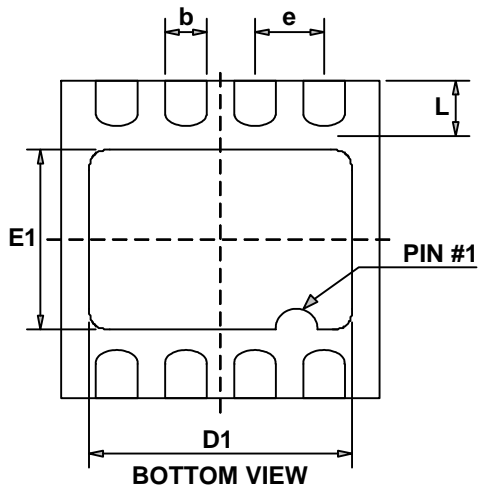
DFN-8 (3mmx3mmx0.75mm)



TOP VIEW

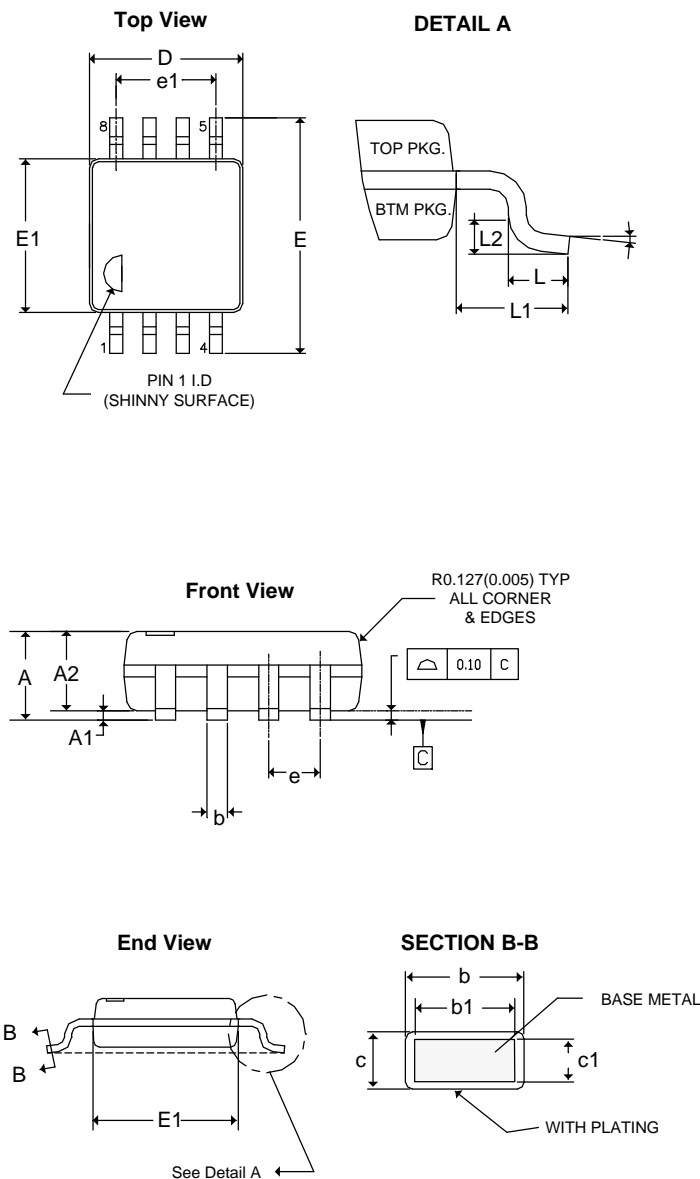


REAR VIEW



BOTTOM VIEW

SYMBOLS	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
e	0.600	0.700	0.024	0.028
D1	2.200	2.400	0.087	0.094
E1	1.400	1.600	0.055	0.063
b	0.200	0.320	0.008	0.013
L	0.375	0.575	0.015	0.023
G	0.153	0.253	0.0060	0.010
G1	0.000	0.050	0.0000	0.002

■ Package Dimension
MSOP-8


SYMBOLS	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	-	1.07	-	0.04197
A ₁	0.05	0.20	0.002	0.008
A ₂	0.81	0.92	0.032	0.036
b	0.28	0.38	0.011	0.015
b ₁	0.28	0.33	0.011	0.013
c	0.13	0.23	0.005	0.009
c ₁	0.13	0.17	0.005	0.006
D	2.90	3.10	0.114	0.122
E	4.77	4.98	0.188	0.196
E ₁	2.90	3.10	0.114	0.122
e	0.65 TYP		0.0255 TYP	
e ₁	1.95 TYP		0.0767 TYP	
L	0.406	0.686	0.01598	0.02701
L ₁	0.94 REF		0.037 REF	
L ₂	0.254 TYP		0.010 TYP	
q	0°	8°	0°	8°



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