AME

AME5252

Dual Synchronous, 600mA, 1.5MHz Step-Down DC/DC Converter

■ General Description

The AME5252 is a dual, constant frequency, synchronous step down DC/DC converter. Intended for low power applications, it operates from 2.5V to 5.5V input voltage range and has a constant 1.5MHz switching frequency, allowing the use of tiny, low cost capacitors and inductors 2mm or less in height. Each output voltage is adjustable from 0.6V to 5V. Internal synchronous 0.35Ω, 1A power switches provide high efficiency without the need for external Schottky diodes.

To further maximize battery life, the P-channel MOSFETs are turned on continuously in dropout (100% duty cycle). In shutdown model, the device draws <1µA.

■ Applications

- PDAs/Palmtop PCs
- Digital Cameras
- Cellular Phones
- Portable Media Players
- PC Cards
- Wireless and DSL Modems

■ Features

- High Efficiency: Up to 96%
- Internal soft start
- 1.5MHz Constant Frequency Operation
- High Switch Current: 1A on Each Channel
- No Schottky Diodes Required
- Low R_{DSON} Internal Switches: 0.35Ω
- Current Mode Operation for Excellent Line and Load Transient Response
- Short-Circuit Protected
- Low Dropout Operation: 100% Duty Cycle
- Ultralow Shutdown Current: I_Q<1µA
- Output Voltages from 5V down to 0.6V
- Power-On Reset Output
- Externally Synchronizable Oscillator
- All AME's Lead Free Products Meet RoHS Standards

■ Typical Application

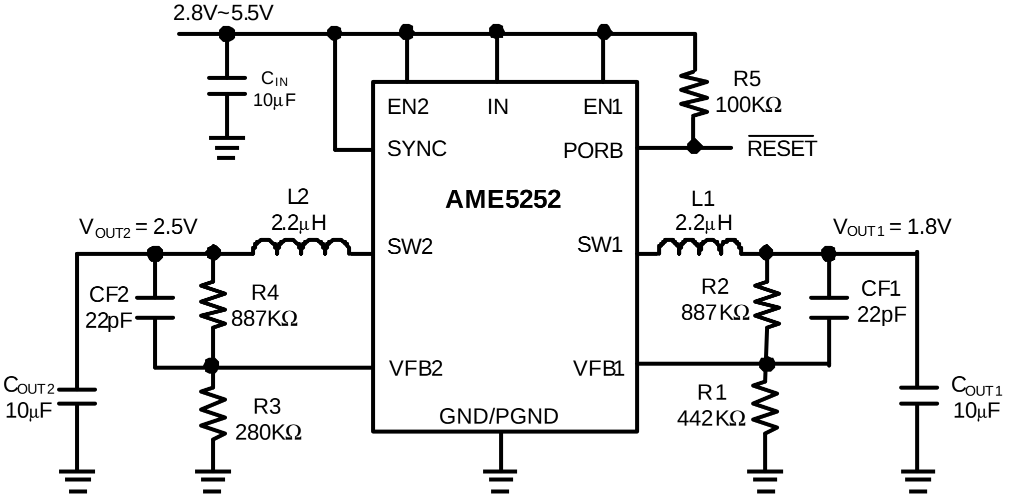


Figure 1. 2.5V/1.8V at 600mA Step-Down Regulators

■ Typical Application

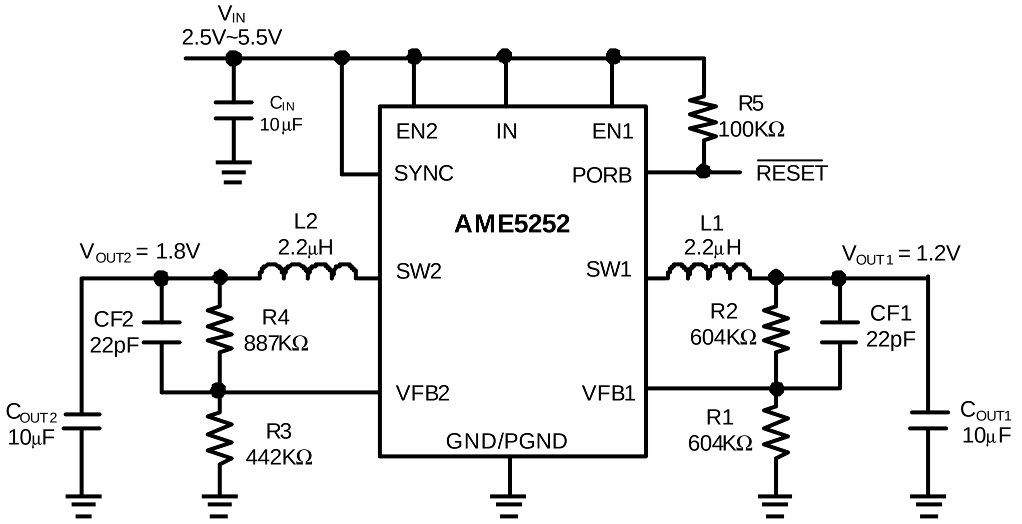


Figure 2. 1.8V/1.2V at 600mA Step-Down Regulators

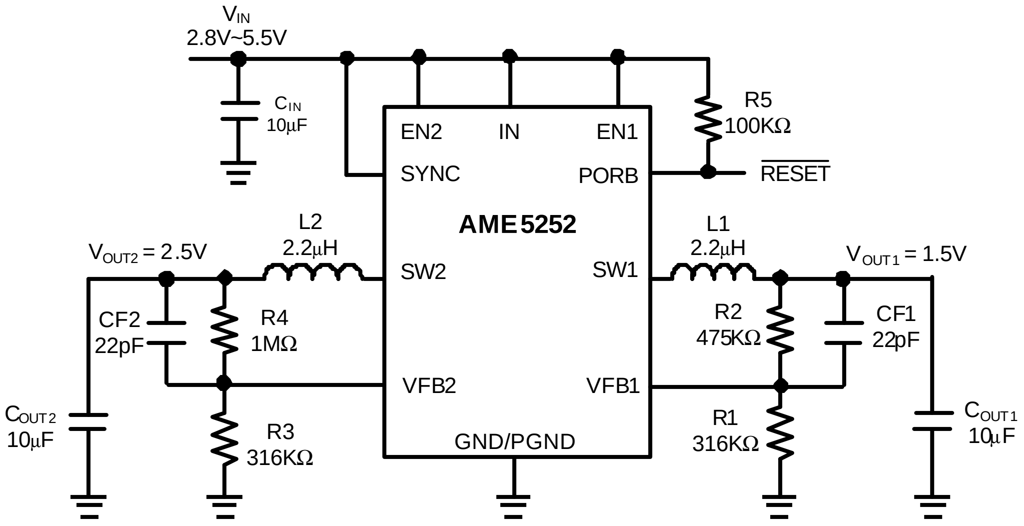


Figure 3. 2.5V/1.5V at 600mA Step-Down Regulators

■ Typical Application

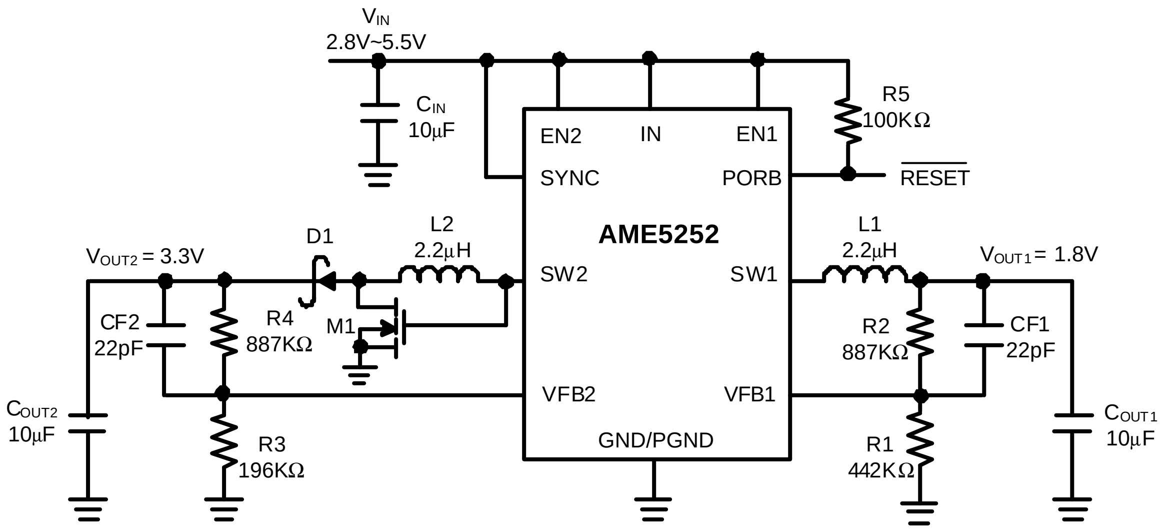
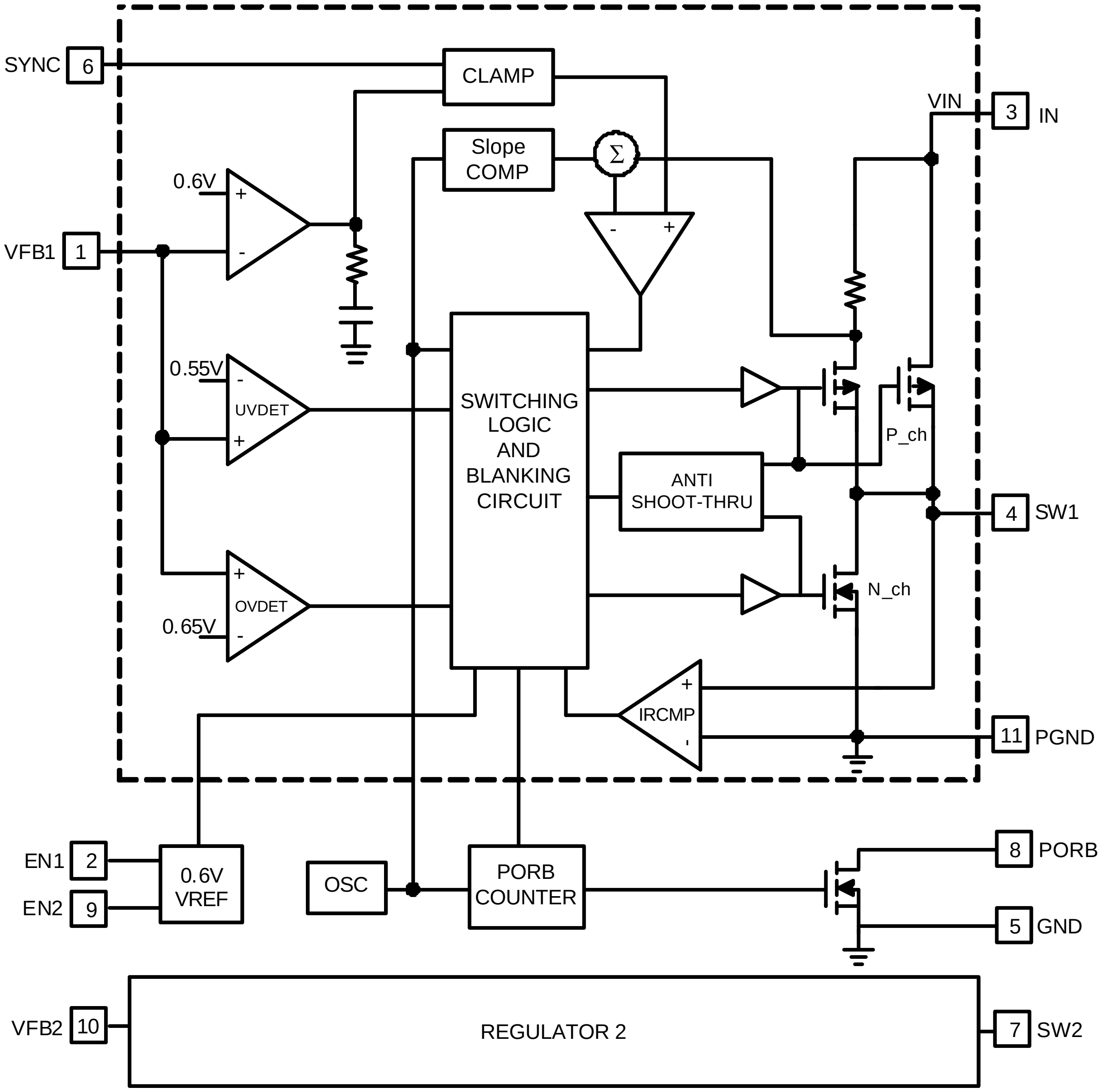


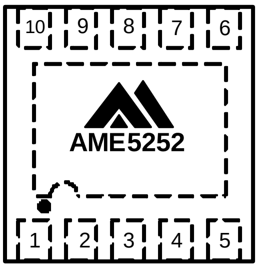
Figure 4. 3.3V/1.8V at 600mA Step-Down Regulators

■ Function Diagram



■ Pin Configuration

DFN-10B
(3mmx3mmx0.75mm)
Top View



AME5252-AVBxxx

1. VFB1
2. EN1
3. IN
4. SW1
5. GND
6. SYNC
7. SW2
8. PORB
9. EN2
10. VFB2
11. *PGND

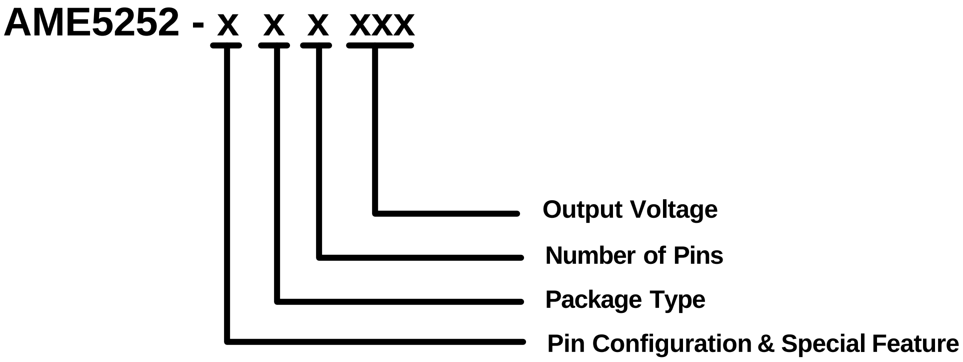
Die Attach:
Conductive Epoxy

Note:
*** The area enclosed by dashed line represents Exposed Pad (Pin11) and must be connected to GND.**

■ Pin Description

Pin Number	Pin Name	Pin Description
1	VFB1	Regulator 1 Output Feedback. Receives the feedback voltage from the external resistive divider across the output. Nominal voltage for this pin is 0.6V.
2	EN1	Regulator 1 Enable. Forcing this pin to V_{IN} enables regulator 1, while forcing it to GND caused regulator 1 to shutdown.
3	IN	Main Power Supply. Must be closely decoupled to GND.
4	SW1	Regulator 1 Switch Node Connection to the Inductor. This pin swings from V_{IN} to GND.
5	GND	Main Ground. Connect to the (-) terminal of C_{OUT}, and (-) terminal of C_{IN}.
6	SYNC	The oscillation frequency can be syncronized to an external oscillator applied to this pin and pulse skipping mode is automatically selected. Do not float this pin.
7	SW2	Regulator 2 Switch Node Connection to the Inductor. This pin swings from V_{IN} to GND.
8	PORB	Power-on Reset. This common-drain logic output is pulled to GND when the output voltage is not within 8.5% of regulation and goes high after 175ms when both channels are within regulation.
9	EN2	Requlator 2 Enable. Output Feedback. Forcing this pin to V_{IN} enables regulator 2, while forcing it to GND causes regulator 2 to shut down.
10	VFB2	Regulator 2 Output Feedback Reveives the feedback voltage from the external resistive divider across the output Nominal voltage for this pin is 0.6V.
11	PGND	Must be Connected to GND.

■ Ordering Information



Pin Configuration & Special Feature		Package Type	Number of Pins	Output Voltage
A (DFN-10B)	1. VFB1 2. EN1 3. IN 4. SW1 5. GND 6. SYNC 7. SW2 8. PORB 9. EN2 10.VFB2 11.PGND	V: DFN	B: 10	ADJ: Adjustable

■Available Options

Part Number	Marking	Output Voltage	Package	Operating Ambient Temperature Range
AME5252-AVBADJ	A5252 BMyMXX	ADJ	DFN-10B	-40^{O}C to +85^{O}C

Note:
1. The first 2 places represent product code. It is assigned by AME such as BM.
2. y is year code and is the last number of a year. Such as the year code of 2008 is 8.
3. A bar on top of first letter represents Green Part such as $\overline{\text{A}}$5252.
4. The last 3 places MXX represent Marking Code. It contains M as date code in "month", XX as LN code and that is for AME internal use only. Please refer to date code rule section for detail information.
5. Please consult AME sales office or authorized Rep./Distributor for the availability of output voltage and package type.

■ Absolute Maximum Ratings

Parameter	Symbol	Maximum	Unit
Input Supply Voltage	IN	-0.3V to 6V	V
V_{FB1}, V_{FB2}, EN1,EN2 Voltage	V_{EN}, V_{FB}	-0.3V to V_{IN}+0.3	
SYNC ,SW1, SW2 Voltage	V_{SW}	-0.3V to V_{IN}+0.3	
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	^{o}C
Junction Temperature Range	T_J	-40 to +125	^{o}C
Storage Temperature Range	T_{STG}	-65 to +150	^{o}C

■ Thermal Information

Parameter	Package	Die Attach	Symbol	Maximum	Unit
Thermal Resistance* (Junction to Case)	DFN-10B	Conductive Epoxy	θ_{JC}	17	^{o}C / W
Thermal Resistance (Junction to Ambient)			θ_{JA}	125	
Internal Power Dissipation			P_D	800	mW
Solder Iron (10 Sec)**				350	^{o}C

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

** MIL-STD-202G 210F

■ Electrical Specifications

V_{IN}=3.6V, EN =V_{IN}, T_A= 25ºC, C_{IN}=10µF, I_{LOAD}=0A, unless otherwise noted.

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
Input Voltage	V_{IN}		2.5		5.5	V
FB Pin Input Current	I_{FB}			30		nA
Feedback Trip Point	V_{FB}		0.588	0.6	0.612	V
		-40ºC≦T_A≦+85ºC	0.585	0.6	0.615	V
Reference voltage line regulation	$REG_{LINE,FB}$			0.3	0.5	%/V
Output voltage Load regulation	REG_{LOAD}			0.05		%
Quiescent Current	I_Q	V_{FB1}=V_{FB2}=0.5V (Switching)		600	800	µA
Shutdown Current	I_{SHDN}	EN=0V		0.1	1	µA
Switching Frequency	f_{OSC}		1.2	1.5	1.8	MHz
Top Switch On-Resistance	R_{DSON}			0.35	0.55	Ω
Bottom switch On-Resistance						
Switch Current Limit	I_{CL}	V_{IN}=3V, V_{OUT}=1.2V	0.95	1.2		A
Switch Leakage Current	I_{SW}	V_{IN}=3.6V, V_{EN}=0V, V_{SW}=0V or 3.6V		0.1	1	µA
Power-on Reset Threshold	PORB	V_{FBX} Ramping UP, SYNC=0V		8.5		%
		V_{FBX} Ramping Down, SYNC=0V		-8.5		%
Power-on Reset on-resistance				100	200	Ω
Power-on Reset delay				175		ms
EN Input Threshold (High) (Enable the device)	EN Threshold				1.5	V
EN Input Threshold (Low) (Shutdown)			0.3			V
Thermal Shutdown Temperature	OTP	Shutdown, temperature increasing		160		ºC
Thermal Shutdown Hysteresis	OTH	Restore, temperature decreasing		20		

■ Detailed Description

The AME5252 uses a constant frequency, current mode architecture. The operating frequency is set at 1.5MHz and can be synchronized to an external oscillator. Both channels share the same clock and run in-phase.

The output voltage is set by an external divider returned to the V_{FB} pins. An error amplifier compares the divided output voltage with a reference voltage of 0.6V and adjusts the peak inductor current accordingly. Overvoltage and undervoltage comparators will pull the PORB output low if the output voltage is not within 8.5%. The PORB output will go high after 262,144 clock cycles (about 175ms) of achieving regulation.

Main Control Loop

During normal operation, the top power switch (P-channel MOSFET) is turned on at the beginning of a clock cycle when the V_{FB} voltage is below the reference voltage. The current into the inductor and the load increases until the current limit is reached. The switch turns off and energy stored in the inductor flows through the bottom switch (N-channel MOSFET) into the load until the next clock cycle.

The peak inductor current is controlled by the internally compensated COMP voltage, which is the output of the error amplifier. This amplifier compares the V_{FB} pin to the 0.6V reference. When the load current increases, the V_{FB} voltage decreases slightly below the reference. This decrease causes the error amplifier to increase the COMP voltage until the average inductor current matches the new load current. The main control loop is shut down by pulling the EN pin to ground.

Short-Circuit Protection

When the output is shorted to ground, the frequency of the oscillator is reduced to about 210kHz, 1/7 the nominal frequency. This frequency foldback ensures that the inductor current has more time to decay, thereby preventing runaway. The oscillator's frequency will progressively increase to 1.5MHz when V_{FB} or V_{OUT} rises above 0V.

Dropout Operation

When the input supply voltage decreases toward the output voltage, the duty cycle increases to 100% which is the dropout condition. In dropout, the P-channel MOSFET switch is turned on continuously with the output voltage being equal to the input voltage minus the voltage drops across the internal P-channel MOSFET and the inductor.

An important design consideration is that the R_{DSON} of the P-channel switch increases with decreasing input supply voltage (See Typical Performance Characteristics).

Therefore, the user should calculate the power dissipation when the AME5252 is used at 100% duty cycle with low input voltage.

■ Application Information

Inductor Selection

For most applications, the value of the inductor will fall in the range of 1µH to 4.7µH. Its value is chosen based on the desired ripple current. Large value inductors lower ripple current and small value inductors result in higher ripple currents. Higher V_{IN} or V_{OUT} also increases the ripple current as shown in equation 1. A reasonable starting point for setting ripple current is IL = 240mA (40% of 600mA).

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

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. Thus, a 720mA rated inductor should be enough for most applications (600mA+ 120mA). For better efficiency, choose a low DC-resistance inductor.

Inductor Core Selection

Once the value for L is known, the type of inductor must be selected. High efficiency converters generally cannot afford the core loss found in low cost powdered iron cores, forcing the use of more expensive ferrite or mollypermalloy cores. Actual core loss is independent of core size for a fixed inductor value but it is very dependent on the inductance selected. As the inductance increases, core losses decrease. Unfortunately, increased inductance requires more turns of wire and therefore copper losses will increase. Ferrite designs have very low core losses and are preferred at high switching frequencies, so design goals can concentrate on copper loss and preventing saturation. Ferrite core material saturates "hard", which means that inductance collapses abruptly when the peak design current is exceeded. This result in an abrupt increase in inductor ripple current and consequent output voltage ripple. Do not allow the core to saturate! Different core materials and shapes will change the size/current and price/current relationship of an inductor. Toroid or shielded pot cores in ferrite or permalloy materials are small and don't radiate energy but generally cost more than powdered iron core inductors with similar characteristics. The choice of which style inductor to use mainly depends on the price vs. size requirements and any radiated field/EMI requirements.

C_{IN} and C_{OUT} Selection

The input capacitance, CIN, is needed to filter the trapezoidal current at the source of the top MOSFET. To prevent large ripple voltage, a low ESR input capacitor sized for the maximum RMS current should be used.RMS 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 ripple current ratings from capacitor manufacturers are often based on only 2000 hours of life which makes it advisable to further derate the capacitor, or choose a capacitor rated at a higher temperature than required.

Several capacitors may also be paralleled to meet size or height requirements in the design. The selection of COUT is determined by the effective series resistance (ESR) that is required to minimize voltage ripple and load step transients, as well as the amount of bulk capacitance that is necessary to ensure that the control loop is stable. Loop stability can be checked by viewing the load transient response as described in a later section.

The output ripple, V_{OUT}, is determined by :

$$\Delta V_{OUT} \le \Delta I_L \left[ESR + \frac{1}{8f \cdot C_{OUT}}\right]$$

The output ripple is highest at maximum input voltage since IL increases with input voltage. Multiple capacitors placed in parallel may be needed to meet the ESR and RMS current handling requirements. Dry tantalum, special polymer, aluminum electrolytic and ceramic capacitors are all available in surface mount packages. Special polymer capacitors offer very low ESR but have lower capacitance density than other types. Tantalum capacitors have the highest capacitance density but it is important to only use types that have been surge tested for use in switching power supplies. Aluminum electrolytic capacitors have significantly higher ESR but can be used in cost-sensitive applications provided that consideration is given to ripple current ratings and long term reliability. Ceramic capacitors have excellent low ESR characteristics but can have a high voltage coefficient and audible piezoelectric effects. The high Q of ceramic capacitors with trace inductance can also lead to significant ringing

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.

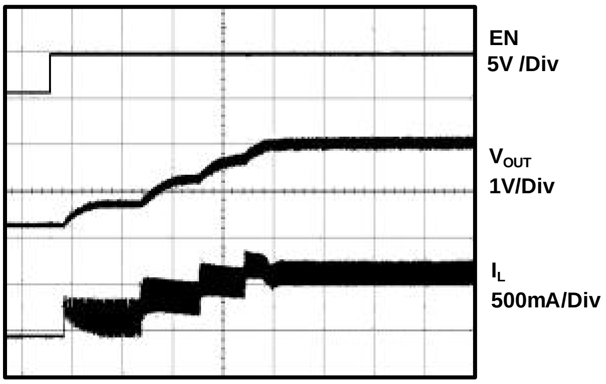
Thermal Considerations

In most applications the AME5252 does not dissipate much heat due to its high efficiency. But, in applications where the AME5252 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 AME5252 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:

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

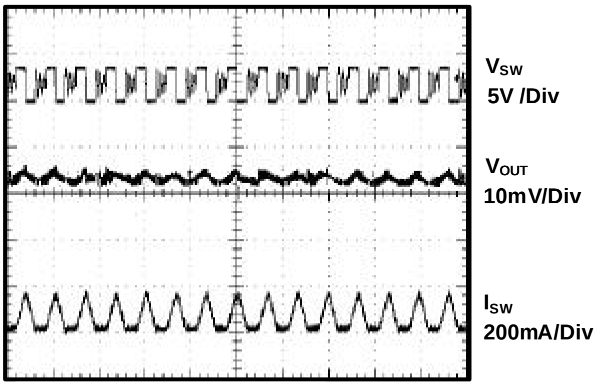
Where PD is the power dissipated by the regulator and θ_{JA} is the thermal resistance from the junction of the die to the ambient temperature.

Start-UP form Shutdown



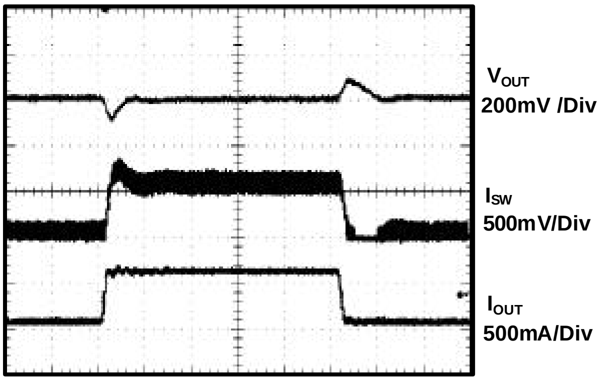
V_{IN}=3.6V 50mS/Div
V_{OUT}=1.8V
I_{OUT}=800mA

Pluse Skipping Mode



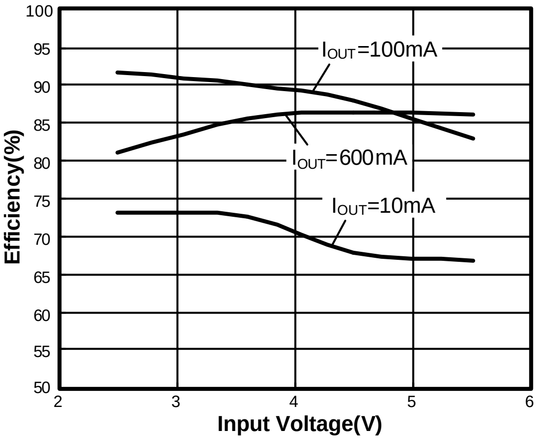
V_{IN}=3.6V 1mS/Div
V_{OUT}=1.8V
I_{LOAD}=50mA

Load Step

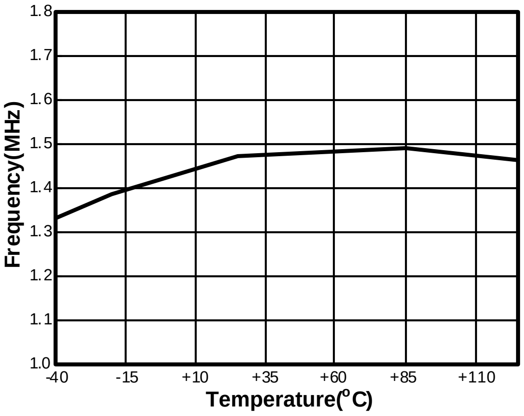


V_{IN}=3.6V 20mS/Div
V_{OUT}=1.8V
I_{LOAD}=50mA to 600mA

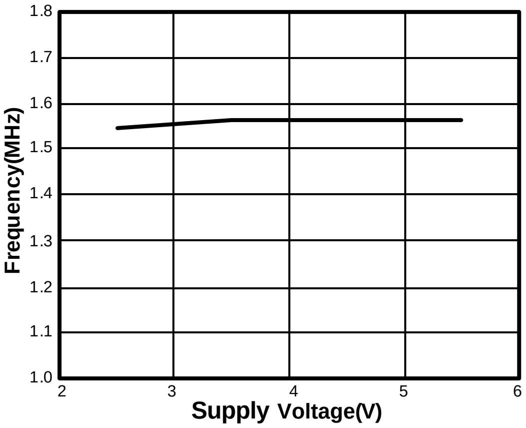
Efficiency vs Input voltage



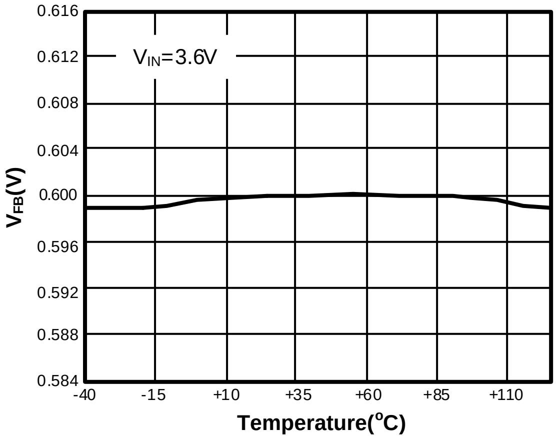
Oscillator Frequency vs Temperature



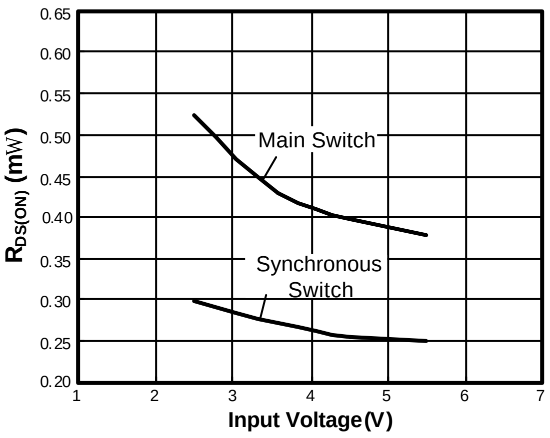
Oscillator Frequency vs Supply Voltage



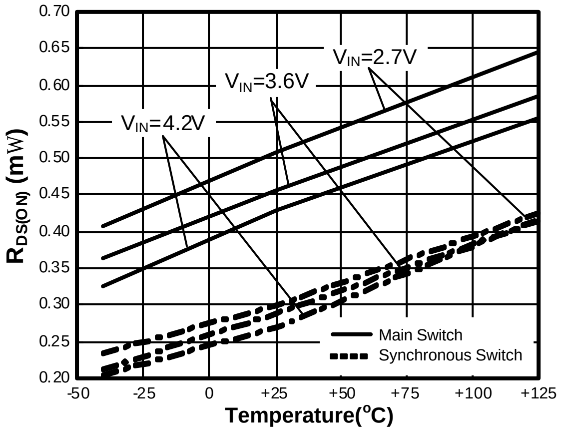
V_{FB} vs Temperature



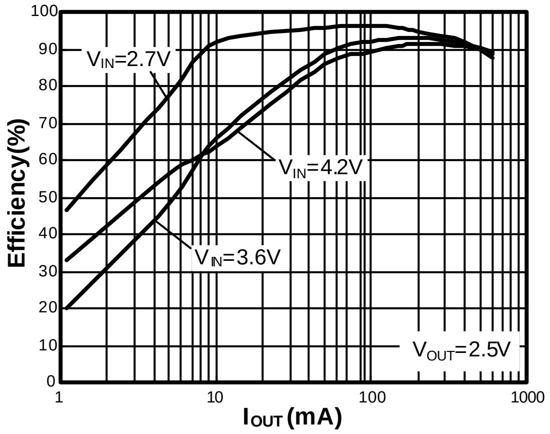
$R_{DS(ON)}$ vs Input voltage



$R_{DS(ON)}$ vs Temperature



Efficiency vs Load Current



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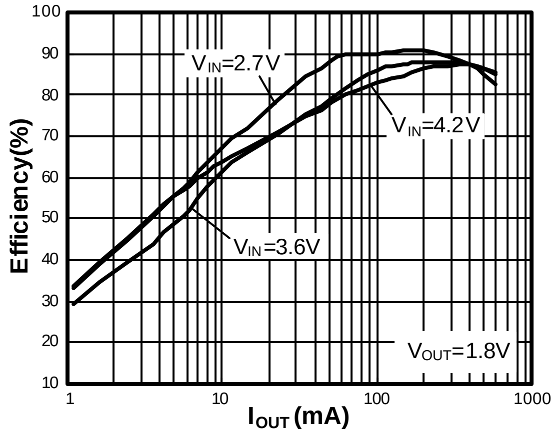
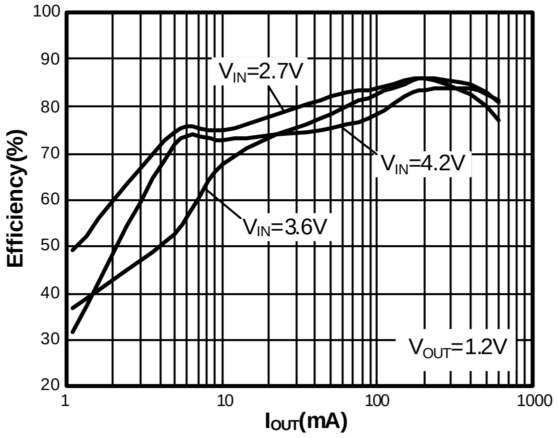


Efficiency vs Load Current



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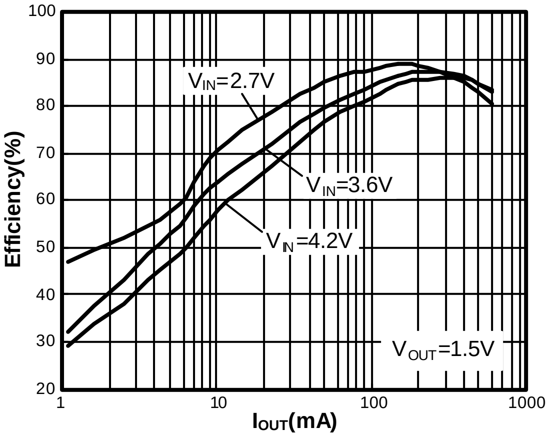
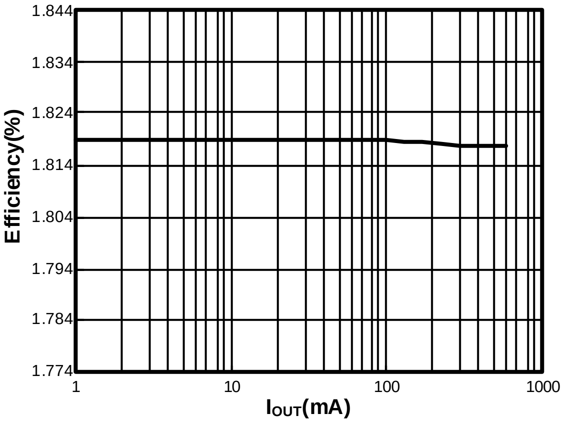
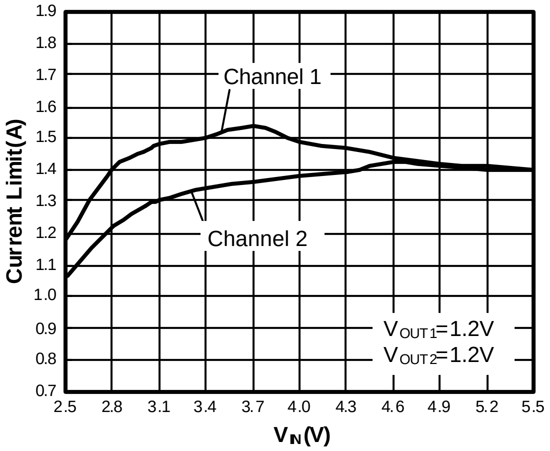


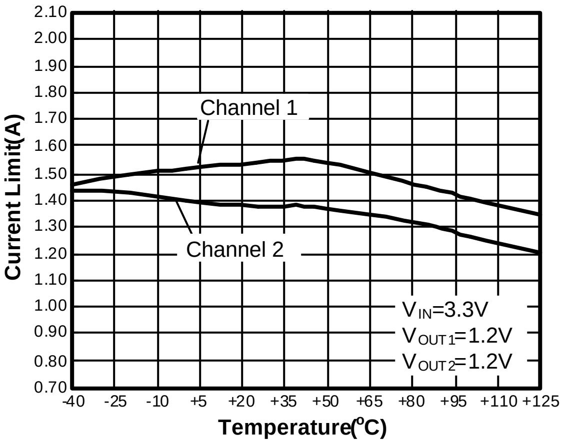
Output Voltage vs Load Current



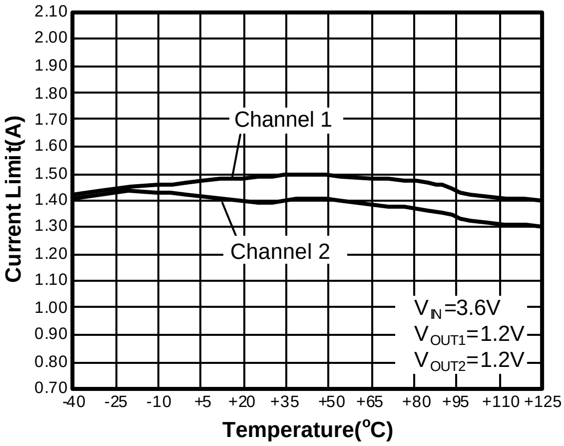
Current Limit vs V_{IN}



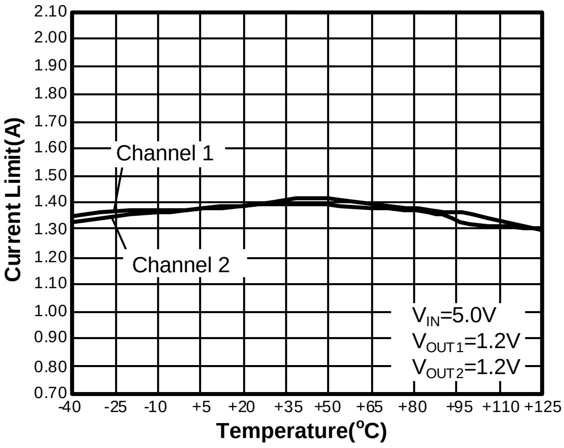
Current Limit vs Temperature



Current Limit vs Temperature



Current Limit vs Temperature

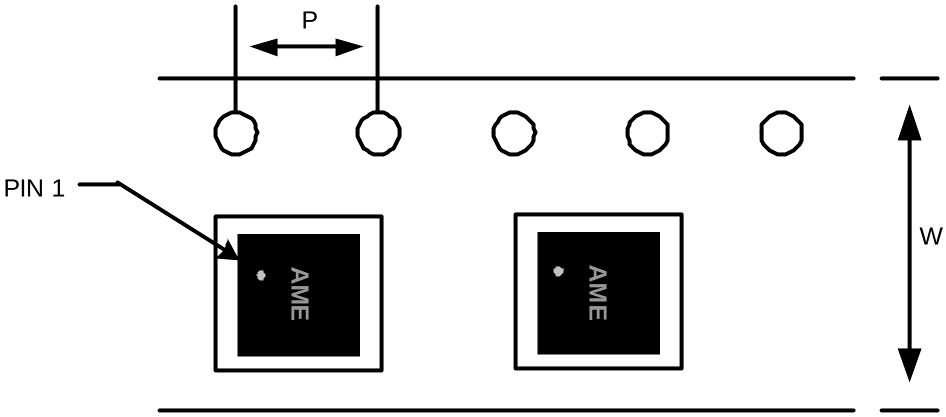


■ Date Code Rule

Month Code	
1: January	7: July
2: February	8: August
3: March	9: September
4: April	A: October
5: May	B: November
6: June	C: December

■ Tape and Reel Dimension

DFN-10B (3mmx3mmx0.75mm)

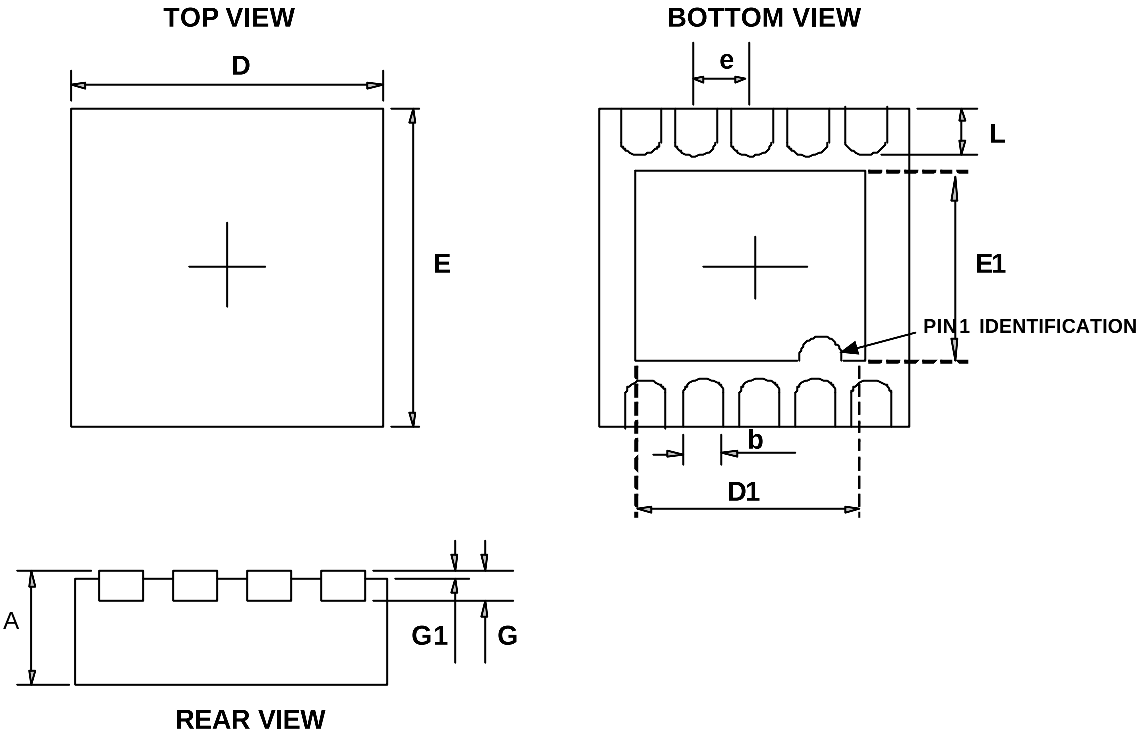


Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
DFN-10B (3x3x0.75mm)	12.0±0.1 mm	4.0±0.1 mm	3000pcs	330±1 mm

■ Package Dimension

DFN-10B (3mmx3mmx0.75mm)



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	0.450	0.550	0.018	0.022
D1	2.300	2.500	0.091	0.098
E1	1.600	1.800	0.063	0.071
b	0.180	0.300	0.007	0.012
L	0.300	0.500	0.012	0.020
G	0.153	0.253	0.006	0.010
G1	0.000	0.050	0.000	0.002

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