Product Change Notices

PCN No.: 20110807

Date: 8/23/2011

This is to inform you that AME5280 datasheet has been changed from Rev. A.01 to Rev. B.01. This notification is for your information and concurrence.

If you require data or samples to qualify this change, please contact AME, Inc. within 30 days of receipt of this notification.

If we do not receive any response from you within 30 calendar days from the date of this notification, we will consider that you have accepted this PCN.

If you have any questions concerning this change, please contact:

PCN Originator:

Name: Bill Chou

Email: bill_chou@ame.com.tw

Expected 1st Device Shipment Date: N/A

Earliest Year/Work Week of Changed Product: N/A

Description of Change : Modify absolute maximum ratings:

From:

■ Absolute Maximum Ratings

Parameter	Maximum	Unit
Supply Voltage	-0.3V to +7V	V
Switch voltage	-0.7V to V_{IN}+0.7V	V

To:

■ Absolute Maximum Ratings

Parameter	Maximum	Unit
Supply Voltage	-0.3V to +6V	V
Switch voltage	-0.7V to+6V	V

Reason for Change: To comply AME5280 part real product performance.

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AME

AME5280

4A, 300KHz ~ 1.4MHz Sync Buck Converter

■ General Description

The AME5280 is a synchronous buck converter with internal power MOSFETs. It achieves 4A continuous output current over a wide switching frequency range with excellent load and line regulation.

Current mode operation provides fast transient response and eases of loop stabilization. Internal soft-start minimizes the inrush supply current at startup. The circuit protection includes cycle-by-cycle current limiting, output short circuit frequency protection and thermal shutdown. In shutdown mode, the regulator reduces the current less than 10μA of supply current.

This device is available in SOP-8/PP package with exposed pad for low thermal resistance.

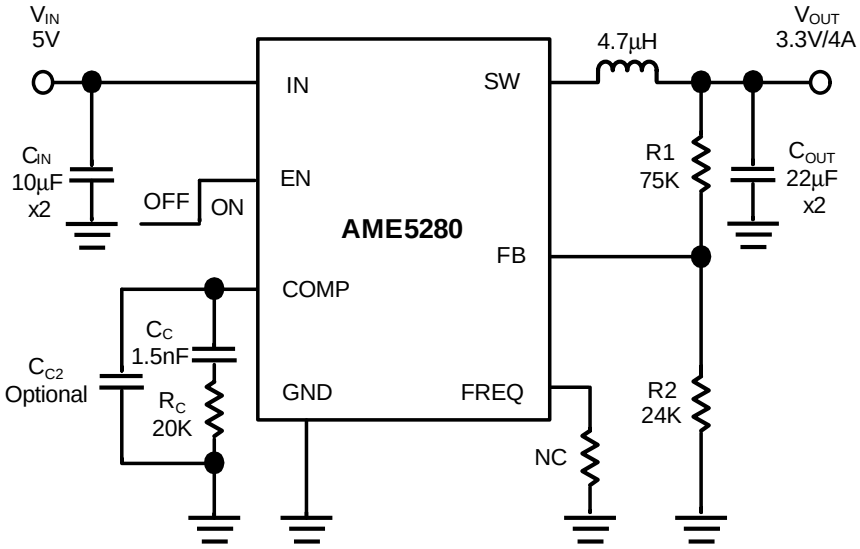
■ Features

- 4A Output Current
- 70mΩ Internal Power MOSFET Switch
- Stable with Low ESR Output Ceramic Capacitors
- Up to 95% Efficiency
- Less than 10μA Shutdown Current
- Wide Switching Frequency Range from 300KHz ~ 1.4MHz
- Thermal Shutdown
- Cycle-by-Cycle Over Current Protection
- Output Adjustable from 0.8V to V_{IN}
- Short Circuit Frequency Protection
- Available in SOP-8/PP Package
- Green Products Meet RoHS Standards

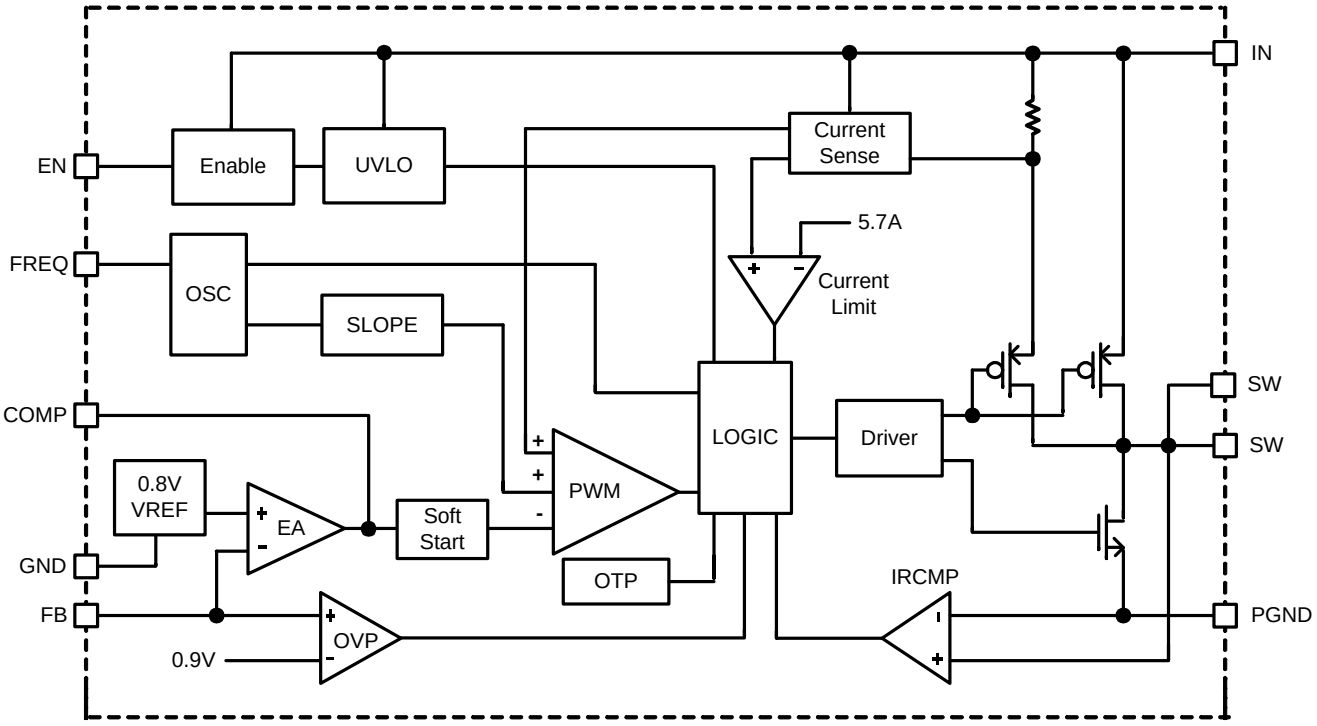
■ Applications

- TV
- Distributed Power Systems
- Pre-Regulator for Linear Regulators

■ Typical Operating Circuit

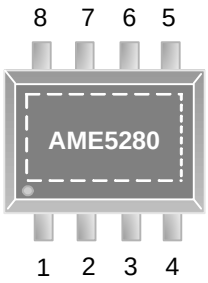


■ Functional Block Diagram



■ Pin Configuration

SOP-8/PP
Top View



AME5280-AZAxxx

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

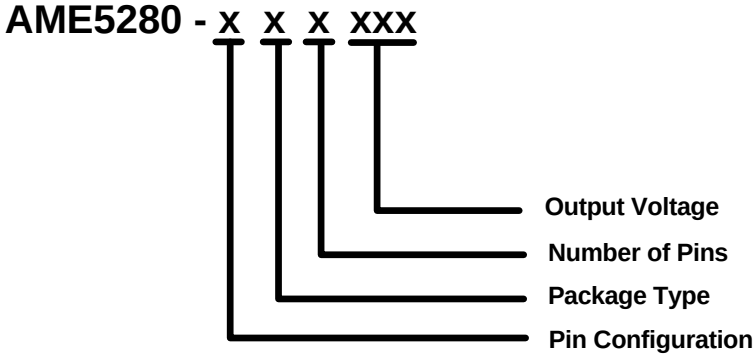
*** Die Attach:**
Conductive Epoxy

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

■ Pin Description

Pin Number	Pin Name	Pin Description
1	COMP	Compensation Node. COMP is used to compensate the regulation control loop. Connect a series RC network from COMP to GND to compensate the regulation control loop. In some cases, an additional capacitor from COMP to GND is required.
2	GND	Ground. Connect the exposed pad to GND.
3	EN	Enable. Internal pull high with a resistor. Pull EN below 0.4V to shut down the regulator.
4	IN	Power Input. IN supplies the power to the IC, as well as the step-down converter switches. Bypass IN to GND with a suitable large capacitor to eliminate noise on the input to the IC.
5, 6	SW	Power Switching Output. SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load.
7	FREQ	Frequency Adjust Pin. Add a resistor from this pin to ground determines the switching frequency.
8	FB	Feedback Input. FB senses the output voltage to regulate that voltage. Drive FB with a resistive voltage divider from the output voltage. The feedback reference voltage is 0.8V.

■ Ordering Information



Pin Configuration	Package Type	Number of Pins	Output Voltage
A (SOP-8/PP) 1. COMP 2. GND 3. EN 4. IN 5. SW 6. SW 7. FREQ 8. FB	Z: SOP/PP	A: 8	ADJ: Adjustable

■ Available Options

Part Number	Marking*	Output Voltage	Package	Operating Ambient Temperature Range
AME5280-AZAADJ	A5280 AMyMXX	ADJ	SOP-8/PP	-40°C to +85°C

Note:
1. The first 1 or 2 places represent product code. It is assigned by AME such as AM.
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{A}$5280.
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	Maximum	Unit
Supply Voltage	-0.3V to +6V	V
Switch voltage	-0.7V to +6V	V
EN, FB, COMP, FREQ to GND	-0.3V to V_{IN}+0.3V	V
ESD Classification	B*	

Caution: Stress above the listed in absolute maximum ratings 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)	SOP-8/PP	Conductive Epoxy	θ_{JC}	19	°C / W
Thermal Resistance (Junction to Ambient)			θ_{JA}	84	
Internal Power Dissipation			P_D	1450	mW
Maximum Junction Temperature				150	°C
Solder Iron (10Sec)**				350	°C

* Measure θ_{JC} on backside center of Exposed Pad.
** MIL-STD-202G 210F

■ Electrical Specifications

T_A = 25°C unless otherwise noted.

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
Input Voltage Range			3		5.5	V
Input UVLO			2	2.3	2.6	V
Quiescent Current		V_{EN}=5V, V_{FB}=1V (No Switching)		460		μA
Shutdown Current	I_{SHDN}	V_{EN}=0V			10	μA
Feedback Voltage	V_{FB}		0.784	0.8	0.816	V
Feedback Current	I_{FB}		-50		50	nA
Load Regulation		0A<I_{OUT}<4A		0.25		%
Line Regulation		3.3V<V_{IN}<6V		0.1		%/V
EN Voltage High	V_{EN}		1.4			V
EN Voltage Low					0.4	V
EN Leakage Current	I_{ENLK}	V_{EN}=3V		0.1	1	μA
Switching Frequency	F_{SW}	R_{FREQ}=NC	240	300	360	KHz
		R_{FREQ}=120KΩ	480	600	720	KHz
		R_{FREQ}=47KΩ	0.8	1	1.2	MHz
		R_{FREQ}=30KΩ	1.12	1.4	1.68	MHz
Short-Circuit Frequency	F_{SWSC}			0.25		F_{SW}
High-side Switch Current Limit			5.3	5.7		A
Low-side Switch Current Limit				1		A
Maximum Duty Cycle					100	%
Minimum Duty Cycle			2.4			%
Minimum On Time				100		ns
Error Amp Voltage Gain	A_{EA}			600		V/V
Error Amp Transconductance	G_{EA}		300	400	500	μA/V
Switch Leakage Current	I_{SWLK}	V_{SW}=0V, V_{EN}=0V		0.1	20	μA
High-side Switch On Resistance	$R_{DSON,HI}$			70		mΩ
Low-side Switch On Resistance	$R_{DSON,LO}$			70		mΩ
Thermal Shutdown Protection	OTP	Rising		170		°C
	OTH	Hysteresis		20		°C

■ Detailed Description

Normal Operation

The AME5280 uses a user adjustable frequency, current mode step-down architecture with internal MOSFET switch. During normal operation, the internal high-side (PMOS) switch is turned on each cycle when the oscillator sets the SR latch, and turned off when the comparator resets the SR latch. The peak inductor current at which comparator resets the SR latch is controlled by the output of error amplifier EA. While the high-side switch is off, the low-side switch turns on until either the inductor current starts to reverse or the beginning of the next switching cycle.

Dropout Operation

The output voltage is dropped from the input supply for the voltage which across the high-side switch. 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 high-side switch to remain on for more than one cycle until it reaches 100% duty cycle.

Over Current Protection

The AME5280 cycle-by-cycle limits the peak inductor current to protect embedded switch from damage. Hence the maximum output current (the average of inductor current) is also limited. In case the load increases, the inductor current is also increase. Whenever the current limit level is reached, the output voltage can not be regulated and starting to drop.

Soft-Start

The AME5280 employs internal soft-start circuitry to reduce supply inrush current during startup conditions.

Over Temperature Protection

The In most applications the AME5280 does not dissipate much heat due to high efficiency. But, in applications where the AME5280 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 170°C, the internal high-side power switch will be turned off and the SW switch will become high impedance.

Short-Circuit Protection

Short-circuit protection will activate once the feedback voltage falls below 0.3 V, and the operating frequency is switched to 1/4 of normal switching frequency to reduce power delivered from input to output.

■ Application Information

Inductor Selection

For most applications, the value of the inductor will fall in the range of 2.2µH 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 increase the ripple current ΔI_L:

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

A reasonable inductor current ripple is usually set as 1/3 to 1/5 of maximum out current. 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 DCR inductor.

Capacitor Selection

In continuous mode, the source current of the top MOSFET is a square wave of duty cycle V_{OUT}/V_{IN}. To prevent large voltage transients, a low ESR input capacitor sized for maximum RMS current must be used. The maximum RMS capacitor current is given by:

$$C_{IN} \text{ requires } I_{RMS} \cong I_{OMAX} \frac{\sqrt{V_{OUT}\left(V_{IN} - V_{OUT}\right)}}{V_{IN}}$$

This formula has a maximum at $V_{IN}=2V_{OUT}$, where $I_{RMS}=I_{OUT}/2$. For simplification, use an input capacitor with a RMS current rating greater than half of the maximum load current.

The selection of C_{OUT} is driven by the required effective series resistance (ESR). Typically, once the ESR requirement for C_{OUT} has been met, the RMS current rating generally far exceeds the $I_{RIPPLE(P-P)}$ requirement. The output ripple ΔV_{OUT} is determined by:

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

For a fixed output voltage, the output ripple is highest at maximum input voltage since ΔI_L increases with input voltage.

When choosing the input and output ceramic capacitors, choose the X5R or X7R dielectric formulations. These dielectrics have the best temperature and voltage characteristics of all the ceramics for given value and size.

Output Voltage Programming

The output voltage of the AME5280 is set by a resistive divider according to the following formula:

$$V_{OUT} = 0.8 \times \left[1 + \frac{R1}{R2}\right] Volt.$$

Some standard value of R1, R2 for most commonly used output voltage values are listed in Table 1.

V_{OUT}(V)	R1(KΩ)	R2(KΩ)
1.1	7.5	20
1.2	10	20
1.5	17.4	20
1.8	30	24
2.5	51	24
3.3	75	24

Loop Compensation

The AME5280 employs peak current mode control for easy use and fast transient response. Peak current mode control eliminates the double pole effect of the output L-C filter. It greatly simplifies the compensation loop design.

With peak current mode control, the buck power stage can be simplified to be a one-pole and one-zero system in frequency domain. The pole can be calculated by:

$$f_{P1} = \frac{1}{2p \times C_{OUT} \times R_L}$$

The zero is a ESR zero due to output capacitor and its ESR. It can be calculated by:

$$f_{Z1} = \frac{1}{2p \times C_{OUT} \times ESR_{COUT}}$$

Where C_{OUT} is the output capacitor, R_L is load resistance; ESR_{COUT} is the equivalent series resistance of output capacitor.

The compensation design is to shape the converter close loop transfer function to get desired gain and phase. For most cases, a series capacitor and resistor network connected to the COMP pin sets the pole-zero and is adequate for a stable high-bandwidth control loop.

In the AME5280, FB pin and COMP pin are the inverting input and the output of internal transconductance error amplifier (EA). A series RC and CC compensation network connected to COMP pin provides one pole and one zero:

for $R_C << A_{EA}/G_{EA}$,

$$f_{P2} = \frac{1}{2p \times C_C \times \left(R_C + \frac{A_{EA}}{G_{EA}} \right)} \approx \frac{G_{EA}}{2p \times C_C \times A_{EA}}$$

$$f_{Z2} = \frac{1}{2p \times C_C \times R_C}$$

where G_{EA} is the error amplifier transconductance

A_{EA} is the error amplifier voltage gain

R_C is the compensation resistor

C_C is the compensation capacitor

The desired crossover frequency f_C of the system is defined to be the frequency where the control loop has unity gain. It is also called the bandwidth of the converter. In general, a higher bandwidth means faster response to load transient. However, the bandwidth should not be too high because of system stability concern. When designing the compensation loop, converter stability under all line and load condition must be considered. Usually, it is recommended to set the bandwidth to be less than 1/10 of switching frequency. Using selected crossover frequency, f_C, to calculate R_C:

$$R_C = f_C \times \frac{V_{OUT}}{V_{FB}} \times \frac{2p \times C_{OUT}}{G_{EA} \times G_{CS}}$$

where G_{CS} is the current sense circuit transconductance.

The compensation capacitor C_C and resistor R_C together make zero. This zero is put somewhere close to the pole f_{P1} of selected frequency. C_C is selected by:

$$C_C = \frac{C_{OUT} \times R_L}{R_C}$$

Checking Transient Response

The regulator loop response can be checked by looking at the load transient response. Switching regulators take several cycles to respond to a step in load current. When a load step occurs, V_{OUT} immediately shifts by an amount equal to (ΔI_{LOAD}× ESR), where ESR is the effective series resistance of C_{OUT}. ΔI_{LOAD} also begins to charge or discharge C_{OUT}, which generates a feedback error signal. The regulator loop then acts to return V_{OUT} to its steady-state value. During this recovery time V_{OUT} can be monitored for overshoot or ringing that would indicate a stability problem.

Efficiency Considerations

Although all dissipative elements in the circuit produce losses, one major source usually account for most of the losses in AME5280 circuits: I^2R losses. The I^2R loss dominates the efficiency loss at medium to high load currents.

The I^2R losses are calculated from the resistances of the internal switches, R_{SW}, and external inductor R_L. In continuous mode, the average output current flowing through inductor L is "chopped" between the main switch and the synchronous switch. Thus the series resistance looking into the SW pin is a function of both top and bottom MOSFET $R_{DS(ON)}$ and the duty cycle (D) as follows:

$$R_{SW} = (R_{DS(ON)TOP})(D) + (R_{DS(ON)BOTTOM})(1-D)$$

The $R_{DS(ON)}$ for both the top and bottom MOSFETs can be obtained from Electrical Characteristics table. Thus, to obtained I^2R losses, simply add R_{SW} to R_L and multiply the result by the square of the average output current.

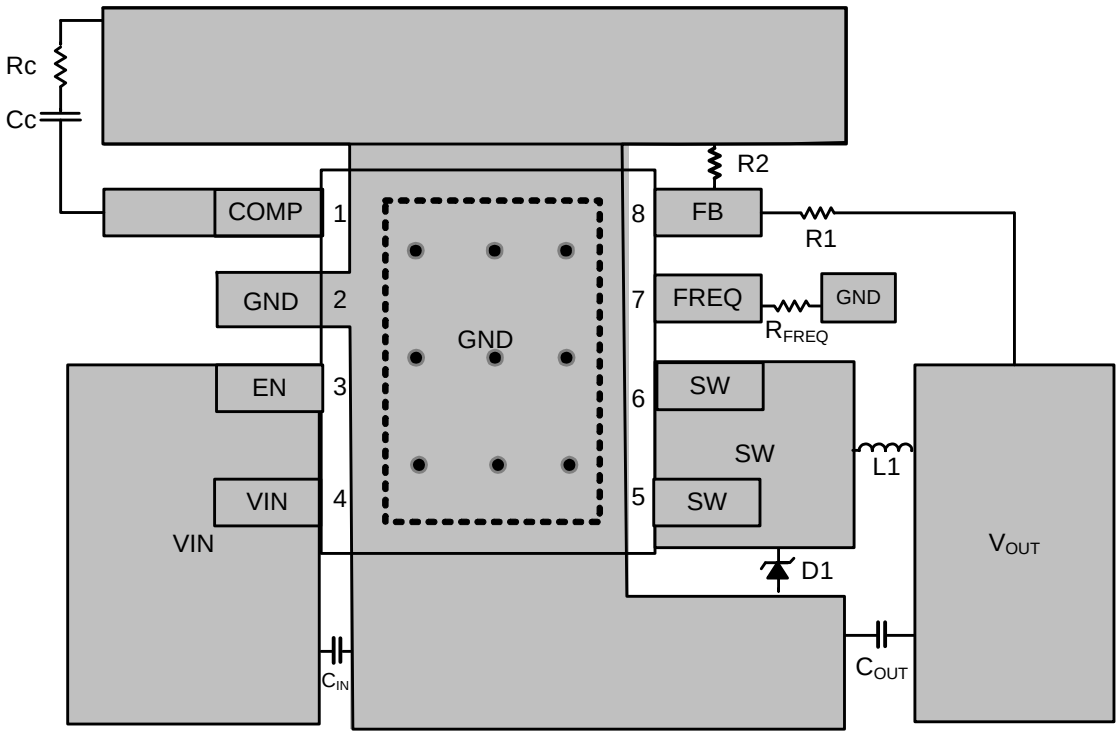
Other losses including C_{IN} and C_{OUT} ESR dissipative losses and inductor core losses generally account for less than 2% total additional loss.

Thermal Considerations

In most application the AME5280 does not dissipate much heat due to its high efficiency. But, in applications where the AME5280 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 170°C, both power switches will be turned off and the SW switch will become high impedance.

Layout Considerations

Connect the FB pin directly to feedback resistors.
The resistor divider must be connected between V_{OUT} and GND.



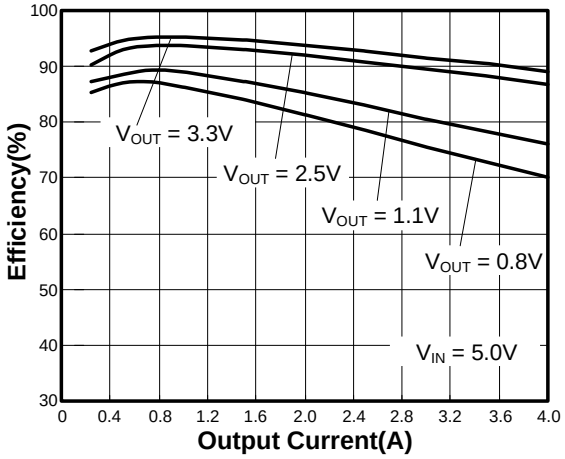
C_{IN} must be placed between VIN and GND as closer as possible

SW pad should be connected together to Inductor by wide and short trace, keep sensitive components away from this trace.

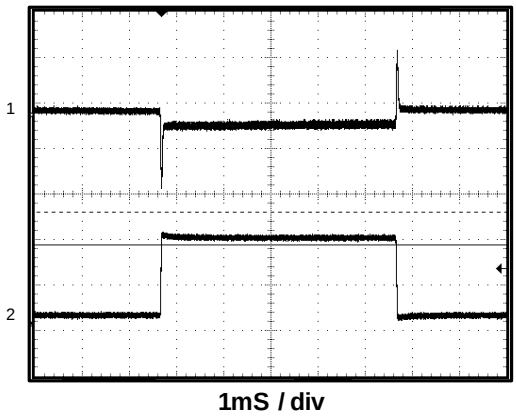
Note:
Connect exposed pad (heat sink on the back) to GND.

■ Characterization Curve

Efficiency vs. Output Current



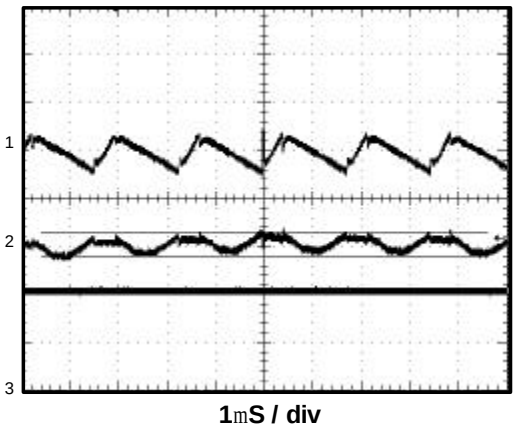
Load Step



T_A = 25°C 500mA~4A

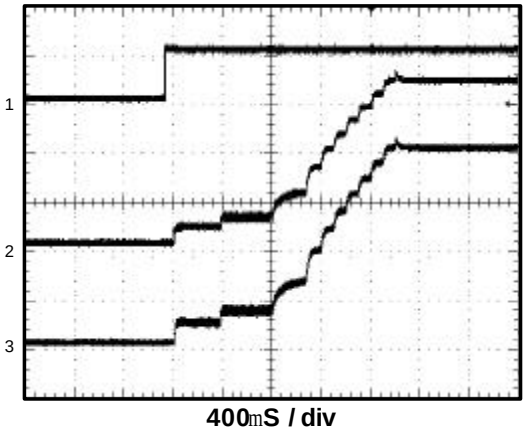
1) V_{OUT}= 200mV/div
2) I_{OUT} = 2A/div

Output Voltage Ripple (Full Load)



1) V_{IN}= 200mV/div
2) V_{OUT}= 5mV/div
3) I_{OUT} = 2A/div

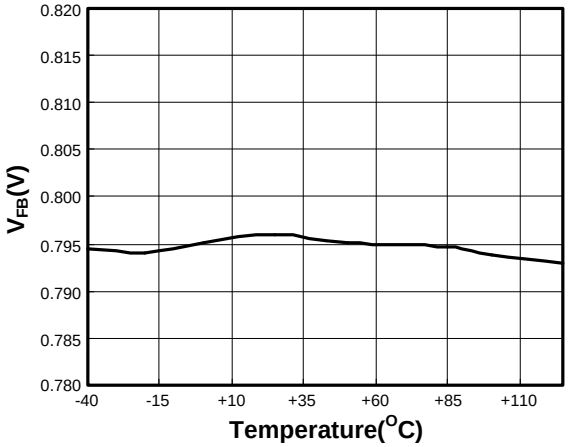
Soft Start



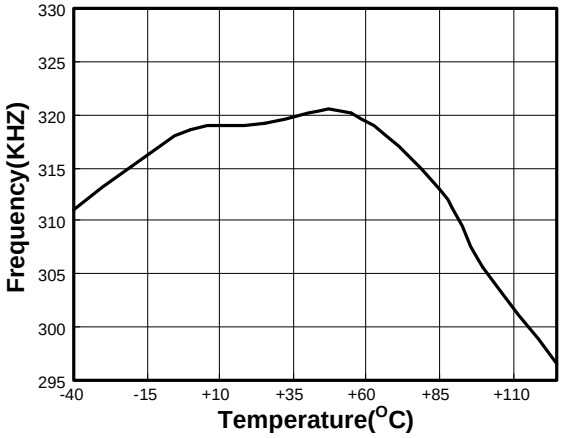
1) EN= 1V/div
2) V_{OUT}= 1V/div
3) I_{OUT} = 1A/div

■ Characterization Curve (Contd.)

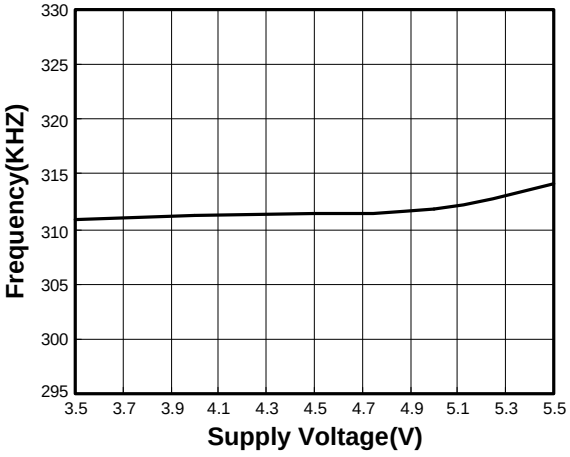
V_{FB} vs. Temperature



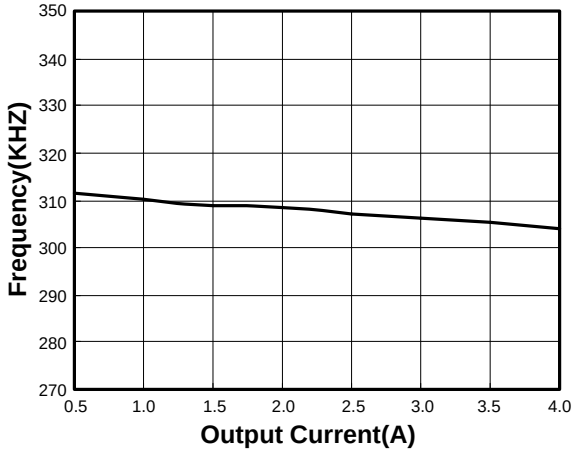
Frequency vs. Temperature



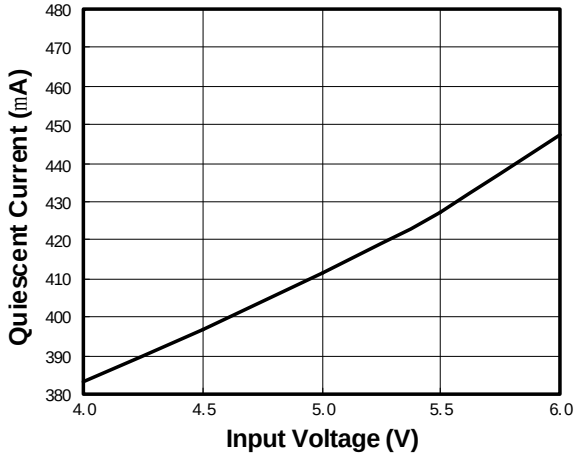
Frequency vs. Supply Voltage



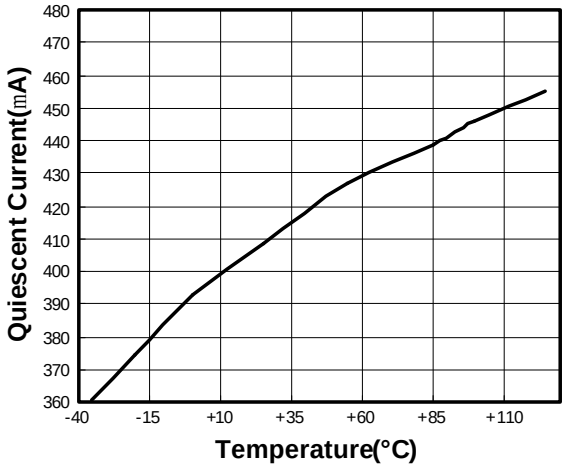
Frequency vs. Output Current



Quiescent Current vs. Input Voltage



Quiescent Current vs. Temperature

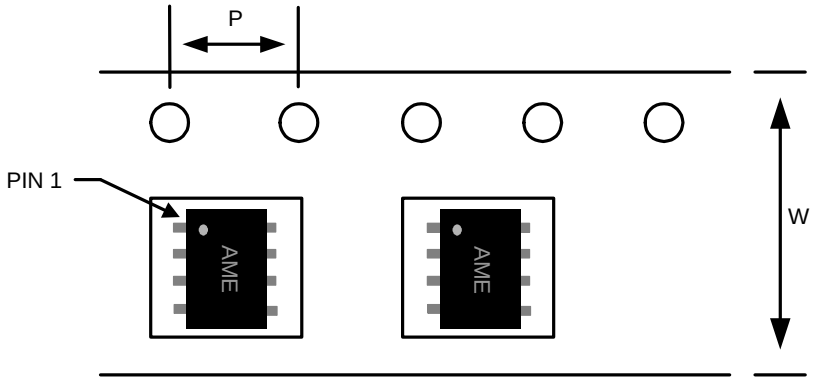


■ Date Code Rule

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

SOP-8/PP

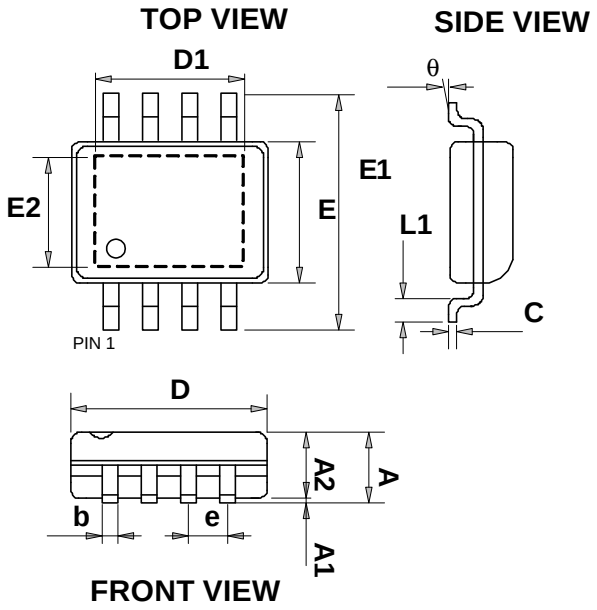


Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
SOP-8/PP	12.0±0.1 mm	4.0±0.1 mm	2500pcs	330±1 mm

■ Package Dimension

SOP-8/PP



SYMBOLS	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.000	0.150	0.000	0.006
A2	1.350	1.600	0.053	0.063
C	0.100	0.250	0.004	0.010
E	3.750	4.150	0.148	0.163
E1	5.700	6.300	0.224	0.248
L1	0.300	1.270	0.012	0.050
b	0.310	0.510	0.012	0.020
D	4.720	5.120	0.186	0.202
e	1.270 BSC		0.050 BSC	
q	0^o	8^o	0^o	8^o
E2	2.150	2.513	0.085	0.099
D1	2.150	3.402	0.085	0.134

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Document: HU001-DS5280-B.01

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