5.5V, 2.0A Continuous 2MHz Synchronous Step-Down Converter

■ General Description

AME5912 is a high efficiency 2MHz synchronous step-down DC/DC regulator capable of delivering up to 2A output current. It can operate over a wide input voltage range from 2.5V to 5.5V and integrate main switch and synchronous switch with very low R_{DSON} to minimize the conduction loss.

AME5912 also provides UVLO, Input OVP, OCP, OTP protection functions. It's available in the SOT-563 package.

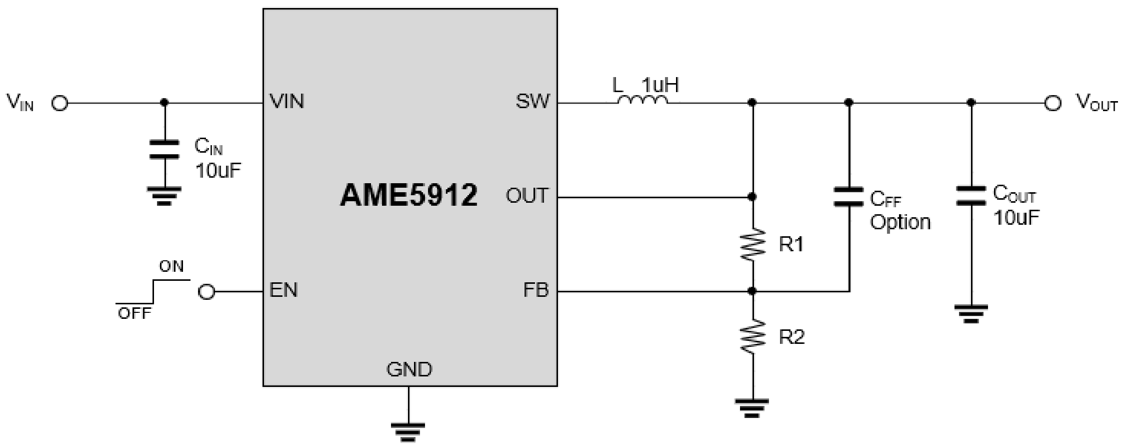
■ Features

- Input Voltage Range: 2.5V to 5.5V
- ±1%, 0.6V Feedback Voltage Accuracy
- 2.0A Continuous Load Current Capability
- 2MHz Switching Frequency
- 55μA Quiescent Current
- Adaptive COT Control
- PFM Mode at Light Load
- Low R_{DSON} Internal Switches(High/Low Side): 130mΩ / 85mΩ
- Internal 0.8ms Soft-Start Time
- Hiccup Mode at Short Circuit Protection
- Internal Over Temperature Protection
- Internal Over Current Protection
- Internal Input Under-Voltage Lockout Protection
- Internal Input Over Voltage Protection
- RoHS, TSCA & HF Compliance

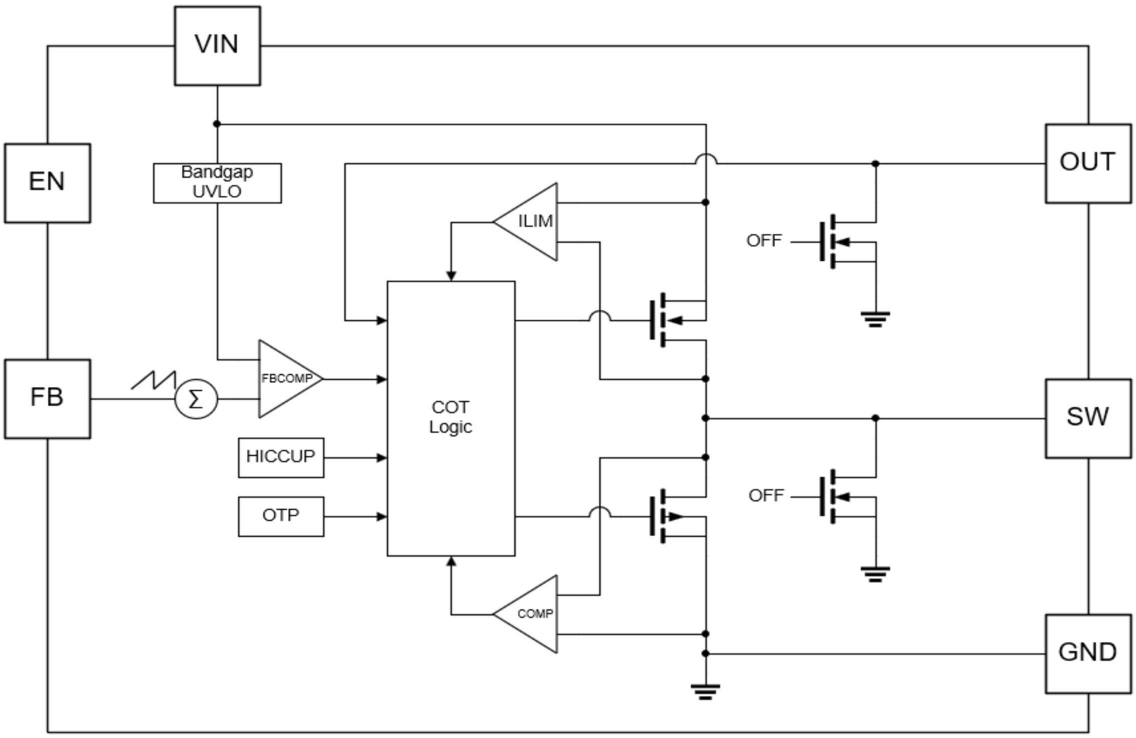
■ Application

- Networking Systems
- Personal Video Recorders
- Flat Panel Monitors
- Table PC

■ Typical Application

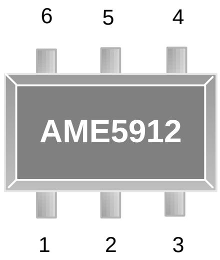


■ Function Block Diagram



■ Pin Configuration

SOT-563
Top View



AME5912-ALYADJ

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

■ Pin Description

Pin Name	Pin No.	I/O	Description
FB	1	I	Feedback pin. An external resistor divider from the output to GND, tapped to the FB pin, sets the output voltage.
GND	2	-	Power Ground.
IN	3	I	Supply Voltage Input pin. The VIN pin supplies power for internal MOSFET and regulator. An input capacitor is needed to decouple the input rail.
SW	4	O	Switch Output pin. Connect this pin to the inductor. SW node should be kept small on the PCB for good performance and low EMI.
EN	5	I	Enable Control pin. Drive this pin high to enable the part, low to disable.
OUT	6	I	Output sense pin. When the device is disabled, the part goes into output discharge mode automatically and its internal discharger connected to OUT provides a resistive discharge path for the output capacitor.

■ Ordering Information

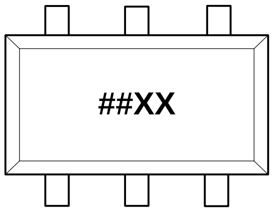
AME5912 – x x x xxx

- xxx: Output Voltage
- x (third): Number of Pins
- x (second): Package Type
- x (first): Pin Configuration

Pin Configuration	Package Type	Number of Pins	Output Voltage
A: (SOT-563) 1.FB 2.GND 3.IN 4.SW 5.EN 6.OUT	L: SOT-563	Y: 6	ADJ

■ Marking Information

SOT-563



##: Product Code
XX: XX: LN Code

■ Available Option

Part Number	Marking	Output Voltage	Packing	Package	Operating Ambient Temperature Range
AME5912-ALYADJ	CAXX	ADJ	5000pcs	SOT-563	- 40°C to +85°C

Note:

1. The first 1 to 2 places represent product code. It is assigned by AME such as CA.
2. The last 3 to 4 places XX represent LN code and that is for AME internal use only. Please refer to date code rule section for detail information.
3. Please consult AME sales office or authorized Rep./Distributor for the availability of output voltage and package type.

■ Absolute Maximum Ratings

Parameter		Rating	Unit
VIN, SW, EN Voltage		-0.3 to 7.5	V
FB Voltage		-0.3 to 6.0	V
ESD Rating	HBM	±2K	V
	CDM	±1K	V

■ Recommended Operation Conditions

Parameter	Symbol	Range	Unit
Input Voltage	V_{IN}	2.5 to 5.5	V
Output Voltage	V_{OUT}	0.6 to 5.5	V
EN Voltage	V_{EN}	0 to 5.5	V
Ambient Temperature Range	T_A	-40 to +85	^oC
Junction Temperature Range	T_J	-40 to +125	
Storage Temperature Range	T_{STG}	-55 to +150	

■ Thermal Information

Parameter	Package	Symbol	Maximum	Unit
Thermal Resistance* (Junction to Case)	SOT-563	θ_{JC}	60	^oC / W
Thermal Resistance (Junction to Ambient)		θ_{JA}	130	^oC / W
Internal Power Dissipation		P_D	1.1	W
Lead Temperature (Soldering 10s)			260	^oC

* Measured on JESD51-7, 4-Layer PCB.

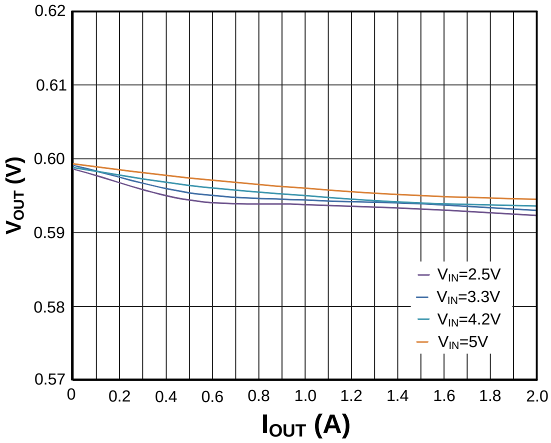
■ Electrical Specifications

V_{IN} = 5V, T_A = +25°C, unless otherwise noted.

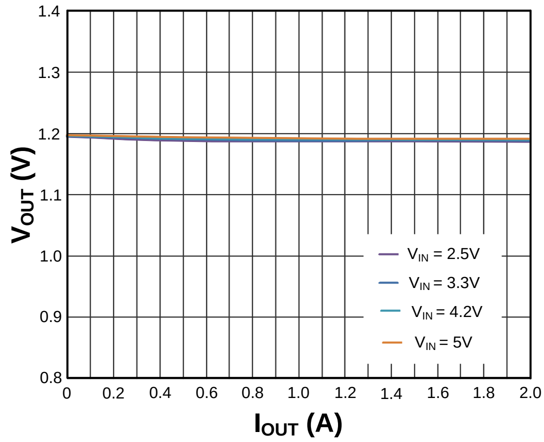
Parameter	Symbol	Test Condition	Min	Typ	Max	Units
Under Voltage Lockout Threshold	V_{UVLO}	V_{IN} Rising		2.2	2.4	V
Under Voltage Lockout Threshold Hysteresis	V_{UVLO_HYS}	V_{IN} Falling		200		mV
Input OVP	V_{IN-OVP}	V_{IN} Rising		6.3		V
Input OVP Hysteresis	V_{IN-OVP_HYS}	V_{IN} Rising		0.35		V
Quiescent Current	I_Q	V_{FB} = 0.65V, No Switching		55		μA
Shutdown Current	I_{SHDN}	V_{EN} = 0V		0	1	μA
Feedback Reference Voltage	V_{FB}	2.5V ≤ V_{IN} ≤ 5.5V	0.594	0.6	0.606	V
Feedback Input Current	I_{FB}			0	1	μA
Load Regulation	REG_{LOAD}			0.5		%/A
Line Regulation	REG_{LINE}	2.5V ≤ V_{IN} ≤ 5.5V		0.15		%/V
Switching Frequency	F_{SW}			2		MHz
Soft-Start Time	t_{SS}	V_{OUT} Rising from 10% to 90%		0.8		ms
Output Discharge Resistance on SW	R_{DSG-SW}	V_{IN} = 3.6V, V_{SW} = 1.2V, V_{EN} = 0V		5		Ω
Output Discharge Resistance on OUT	$R_{DSG-OUT}$	V_{IN} = 3.6V, V_{OUT} = 1.2V, V_{EN} = 0V		32		Ω
High Side Switch On Resistance	R_{DSON_HI}			130		mΩ
Low Side Switch On Resistance	R_{DSON_LOW}			85		mΩ
High Side Current Limit	I_{LIM}			3.5		A
Low Side Current Limit	I_{LIM}			2.5		A
SW Leakage Current	$I_{SW-LEAK}$				10	μA
EN Rising Threshold	V_{EN-HI}		1.2			V
EN Falling Threshold	V_{EN-LOW}				0.4	V
EN Input Current	I_{EN}	V_{EN} = 2.0V			1.2	μA
Short Circuit Hiccup Time	t_{SCP-ON}	On Time		1		ms
	$t_{SCP-Off}$	Off Time		7		ms
Thermal Shutdown	T_{SHDN}			150		℃
Thermal Shutdown Hysteresis	$T_{SHDN-HY}$			20		℃

■ Characterization Curve

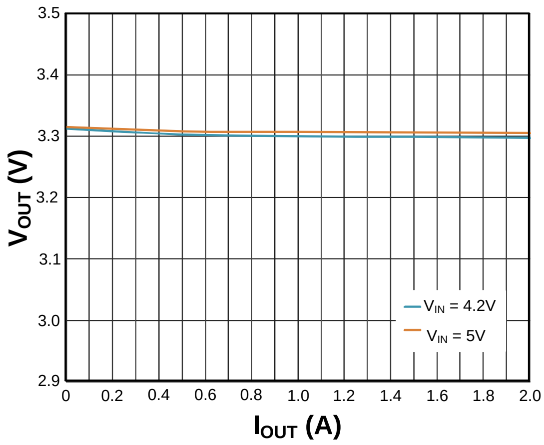
V_{OUT} vs. I_{OUT}_0.6V



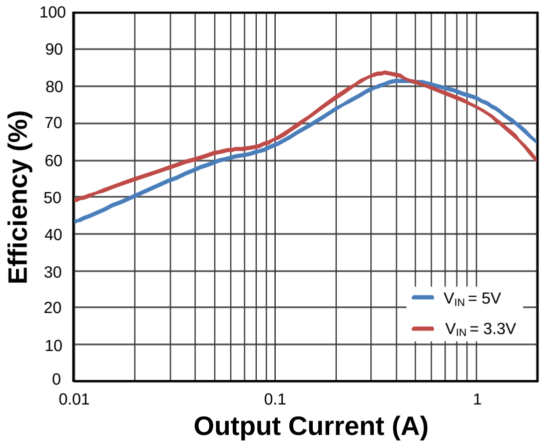
V_{OUT} vs. I_{OUT}_1.2V



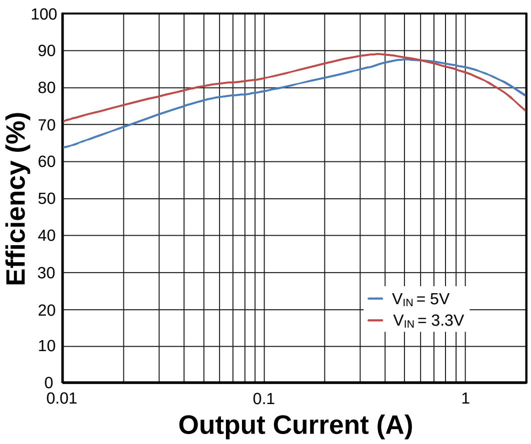
V_{OUT} vs. I_{OUT}_3.3V



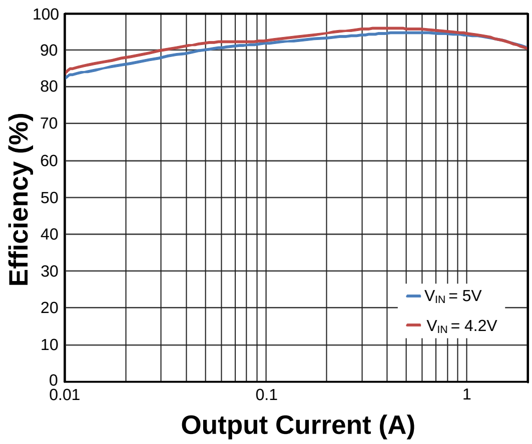
Efficiency vs. Output Current_0.6V



Efficiency vs. Output Current_1.2V

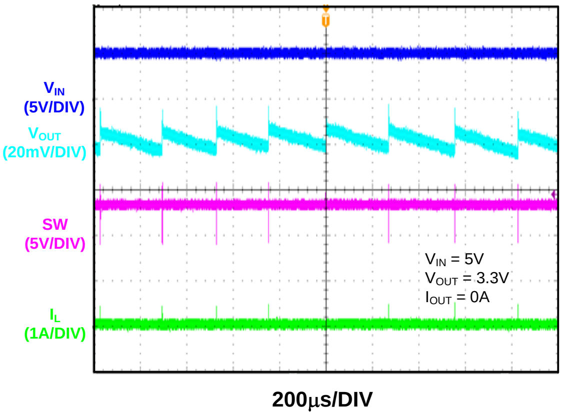


Efficiency vs. Output Current_3.3V

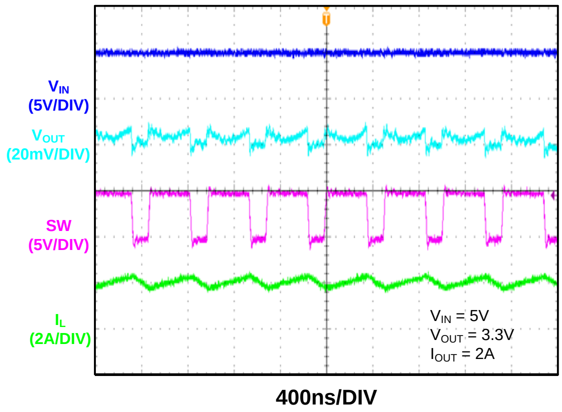


■ Characterization Curve(Contd.)

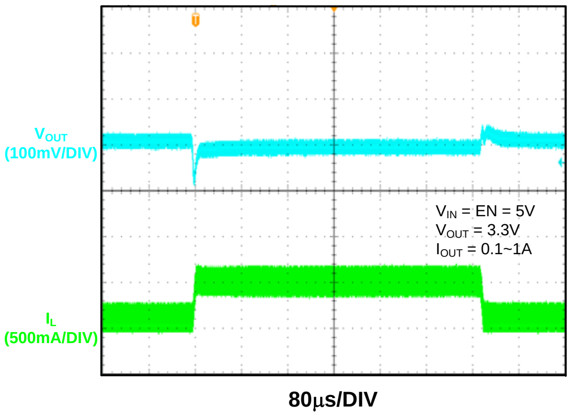
Steady State



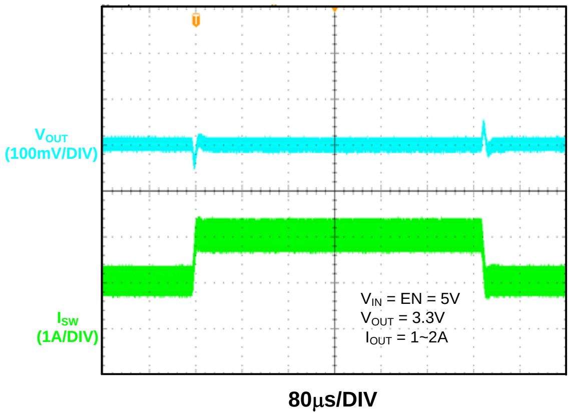
Steady State



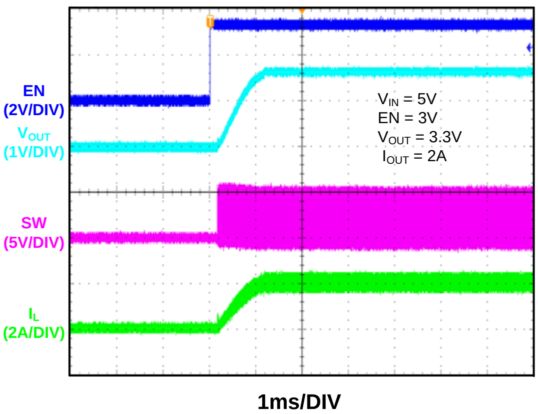
Load Transient



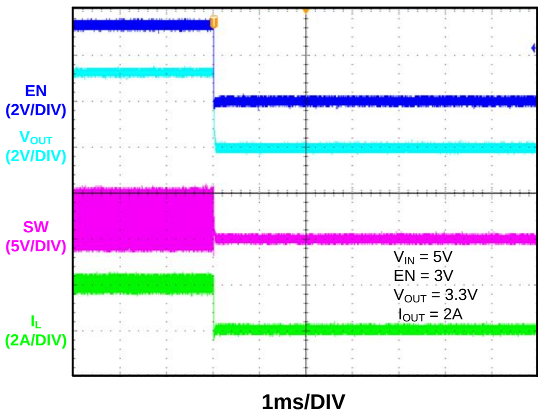
Load Transient



Power On_EN

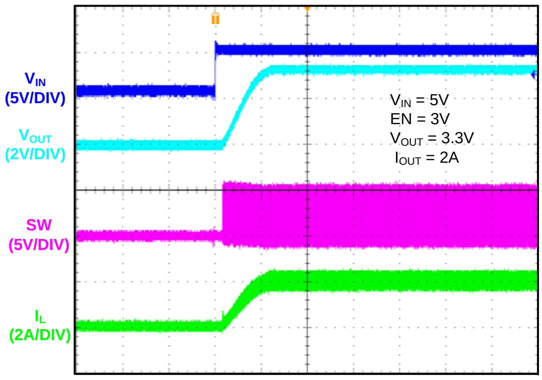


Power Off_EN



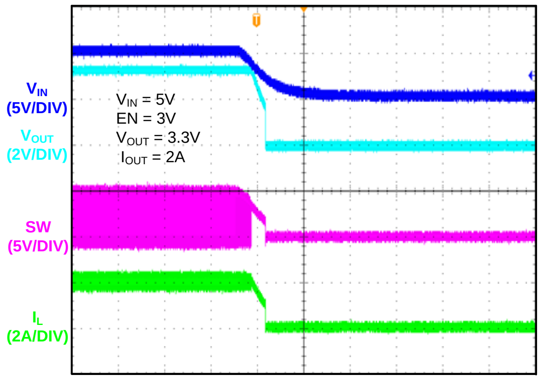
■ Characterization Curve(Contd.)

Power On_V_{IN}



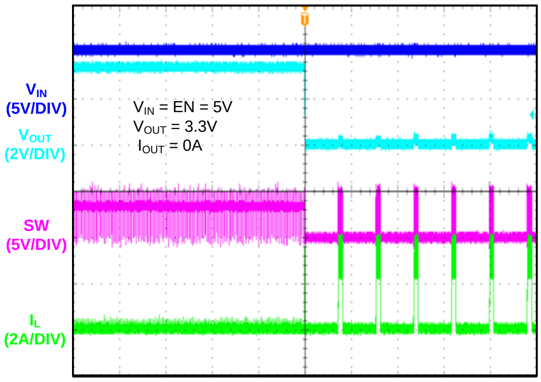
1ms/DIV

Power Off_V_{IN}



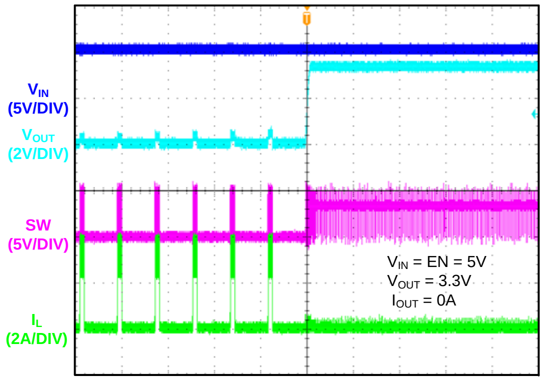
10ms/DIV

Short Circuit Protection



10ms/DIV

Short Circuit Protection Recovery



10ms/DIV

■ Detail Description

Overview

The AME5912 is fully integrated synchronous strip-down converter employing constant on-time (COT) control scheme to achieve superior transient performance. It's proprietary internal ramp compensation offers stable operation with lower ESR ceramic output capacitors without using external complex compensation networks.

Light Load Operation

In medium and heavy load condition , the AME5912 operates in PWM mode with typical switching frequency of 2MHz. When load current reduces, the AME5912 naturally transitions from PWM mode to PFM mode where the pulse width remains the calculated on-time but the switching frequency reduces to accommodate the low output current. The lower the output current, the lower the switching frequency.

Once the switching frequency drops to low enough, the devices enter sleep mode to cut down its quiescent current to maintain high efficiency in light load.

Current Limit and Hiccup mode

The AME5912 has built-in cycle-by-cycle current limit when the inductor current peak value is over the set current limit threshold. When output voltage drop until V_{FB} falls below UV threshold, the AME5912 will enter hiccup mode. If V_{FB} is higher than UV threshold, it will enter the normal mode.

Soft Start

AME5912 has built-in internal soft start of 0.8ms. During the soft start period, output voltage is ramped up linearly to the regulation level, independent of the current and output capacitor value.

UVLO

AME5912 has the function of under-voltage lockout (UVLO). If V_{IN} drops below 2.0V, the UVLO circuit inhibits switching. Once V_{IN} rises above 2.2V, the UVLO clears and the soft-start sequence activates.

Over-Temperature Protection

Thermal protection disables the output when the junction temperature rises to approximately 150° C, allowing the device to cool down. When the junction temperature cools to approximately 130° C, the output circuitry is again enabled. Depending on power dissipation, thermal resistance, and ambient temperature, the thermal protection circuit may cycle on and off. This cycling limits regulator dissipation, protecting the device from damage as a result of overheating.

Input Capacitor Selection

The input capacitor is required to supply AC current to the step-down converter and maintain the DC input voltage. It is recommended to place ceramic capacitors as close the VIN as possible to achieve optimal performance. The RMS current in the capacitor can be estimated with the equation :

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

■ Detail Description (Contd.)

Input Capacitor Selection(Contd.)

From the above, it can be seen that the input ripple current reaches its maximum at V_{IN} = 2V_{OUT} where I_{CIN} = I_{OUT} /2. Therefore, select an input capacitor with RMS current rating greater than half of maximum load current. If there is an input voltage ripple requirement in the system, choose an input capacitor that meets the specification. The input capacitor can be calculated by the following equation :

$$C_{IN} = \frac{I_{OUT}}{F_{SW} \times \Delta V_{IN}} \times \frac{V_{OUT}}{V_{IN}} \times (1 - \frac{V_{OUT}}{V_{IN}})$$

Inductor

The inductor is necessary to supply constant current to the output load while being driven by the switched input voltage. A larger-value inductor will result in less ripple current that will result in lower output ripple voltage. However, a large-value inductor will have a larger physical footprint, higher series resistance, and/or lower saturation current. A good rule for determining the inductance value is to design the peak-to-peak ripple current in the inductor to be in the range 30% to 40% of the maximum output current, and that the peak inductor current is below the maximum switch current limit. The inductance value can be calculated by :

$$L = \frac{V_{OUT}}{F_{SW} \times \Delta IL} \times (1 - \frac{V_{OUT}}{V_{IN}})$$

Where ΔIL is the peak-to-peak inductor ripple current.

To avoid overheating and poor efficiency, an inductor must be chosen with an RMS current rating that is greater than the maximum expected output load of the application. In addition, the saturation current(typically labeled ISAT) rating of the inductor bust be higher than the maximum load current plus 1/2 of in inductor ripple current. The peak inductor current can be calculated by:

$$I_{L\_PEAK} = I_{OUT} + \frac{V_{OUT}}{2F_{SW} \times L} \times (1 - \frac{V_{OUT}}{V_{IN}})$$

Output Capacitor Selection

The output capacitor is required to maintain the DC output voltage. The output voltage ripple can be estimated with the equation :

$$\Delta V_{OUT} = \frac{V_{OUT}}{F_{SW} \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times \left(R_{ESR} + \frac{1}{8 \times F_{SW} \times C_{OUT}}\right)$$

■ Detail Description (Contd.)

Output Capacitor Selection(Contd.)

To achieve better load transient response, larger output capacitors can be used. However, the maximum output capacitor limit should also be considered. If the output capacitance value is too high, the output voltage cannot reach the set value during soft start. The maximum output capacitor value C_{OUT_MAX} can be limited approximately with the equation:

$$C_{OUT\_MAX} = (I_{LIM\_AVG} - I_{OUT}) \times \frac{t_{SS}}{V_{OUT}}$$

Where I_{LIM_AVG} is the average start-up current during the soft-start period, and t_{SS} is soft-start time.

Output Voltage

External feedback resistors are used to set the output voltage. 1% resistor are recommended to maintain output voltage accuracy. Refer to typical application circuit , R1 has some impact on the loop stability, the output voltage is calculated by the following equation :

$$V_{OUT} = V_{REF} \times \left(1 + \frac{R1}{R2}\right)$$

Where : V_{REF} = 0.6V typically (the internal reference voltage)

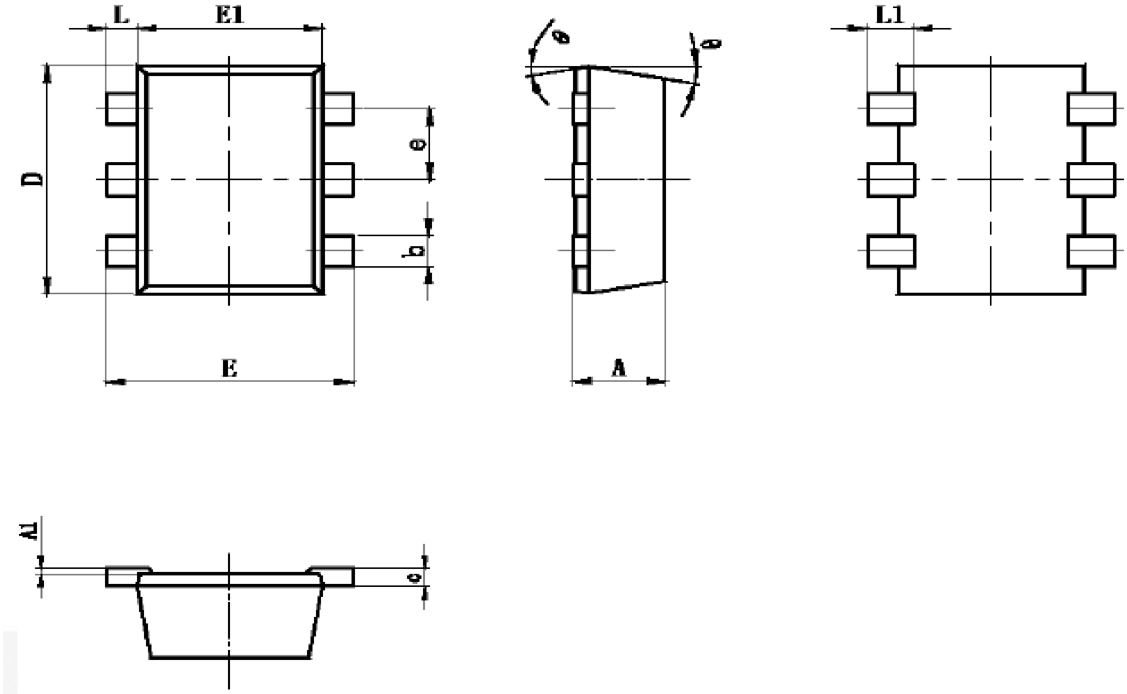
Components Selection

V_{OUT} (V)	R1 (kΩ)	R2 (kΩ)	C_{FF} (pf)	L (μH)	C_{OUT} (μF)
0.8	1	3	NC	1.0	10
1.0	2	3	NC	1.0	10
1.2	3	3	NC	1.0	10
1.8	6.04	3	NC	1.0	10
2.5	6.34	2	NC	1.0	10
3.3	9.1	2	NC	1.0	10

Table 1. Suggested Component Selections for the Application

■ Package Dimension

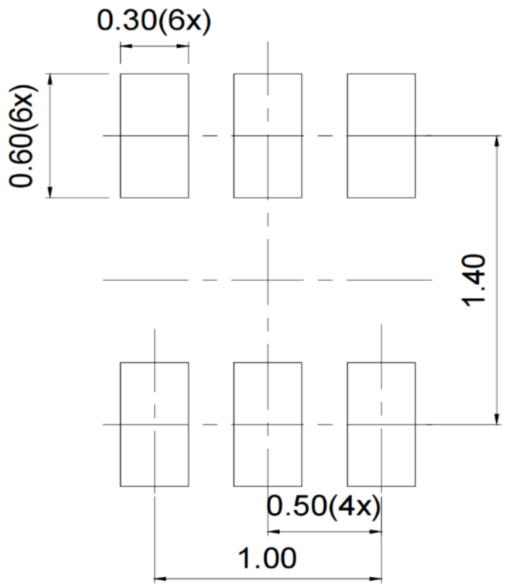
SOT-563
(1.56x1.56x0.56mm)



SYMBOL	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	0.525	0.600	0.021	0.024
A1	0.000	0.050	0.000	0.002
e	0.450	0.550	0.018	0.022
c	0.090	0.180	0.004	0.007
D	1.500	1.700	0.059	0.067
b	0.170	0.270	0.007	0.011
E1	1.100	1.300	0.043	0.051
E	1.500	1.700	0.059	0.067
L	0.100	0.300	0.004	0.012
L1	0.200	0.400	0.008	0.016
θ	9° REF.		9° REF.	

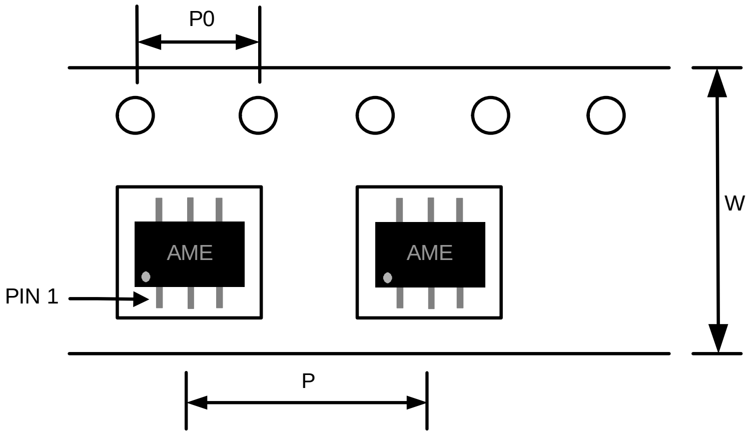
■ Land Pattern

SOT-563
(1.56x1.56x0.56mm)



■ Tape & Reel Dimension

SOT-563
(1.56x1.56x0.56mm)



Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Pitch (PO)	Part Per Full Reel	Reel Size
SOT-563	8.0±0.1 mm	4.0±0.1 mm	4.0±0.1 mm	5000pcs	180±1 mm

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