



5V/12V Synchronous Buck PWM Controller

EM5303/A

General Description

EM5303/A is a synchronous rectified PWM controller operating with 5V or 12V supply voltage. This device operates at 200/300 kHz and provides an optimal level of integration to reduce size and cost of the power supply.

This part includes internal soft start, internal compensation networks, over current protection, under voltage protection, and shutdown function. This part is available in PSOP-8 package.

Features

- Operate from 5V to 12V Voltage Supply
- 0.6V V_{REF} with 1.5% Accuracy
- Voltage Mode PWM Control
- 200kHz or 300kHz Fixed Frequency Oscillator
- 0% to 80% Duty Cycle
- Internal Soft Start
- Over Current Protection
- Integrated Bootstrap Diode
- Adaptive Non-Overlapping Gate Driver
- Under Voltage Protection
- Over Voltage Protection

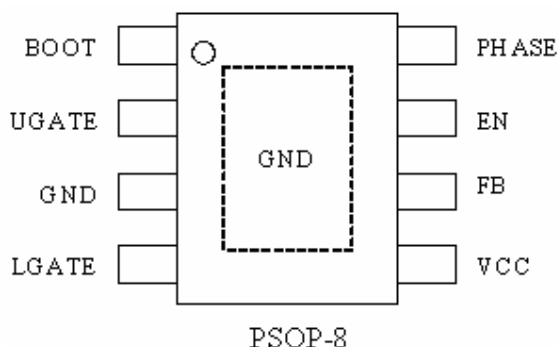
Applications

- Notebook & Netbook
- Graphic Cards & MB
- Low Voltage Logic Supplies

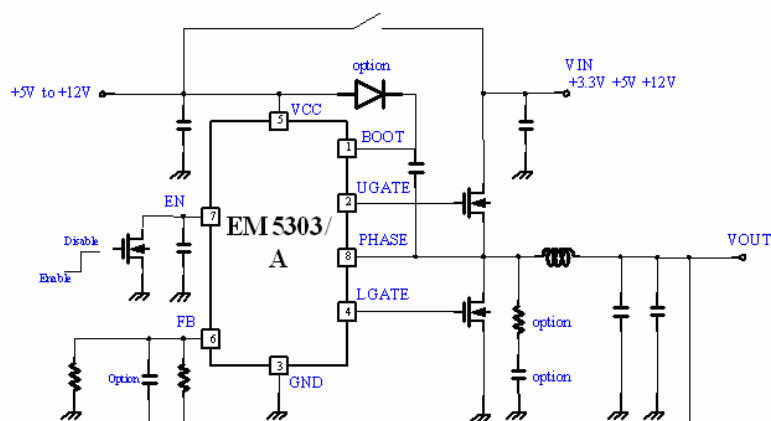
Ordering Information

Part Number	Package	Frequency
EM5303QP	PSOP-8	200kHz
EM5303AQP	PSOP-8	300kHz

Pin Configuration



Typical Application Circuit

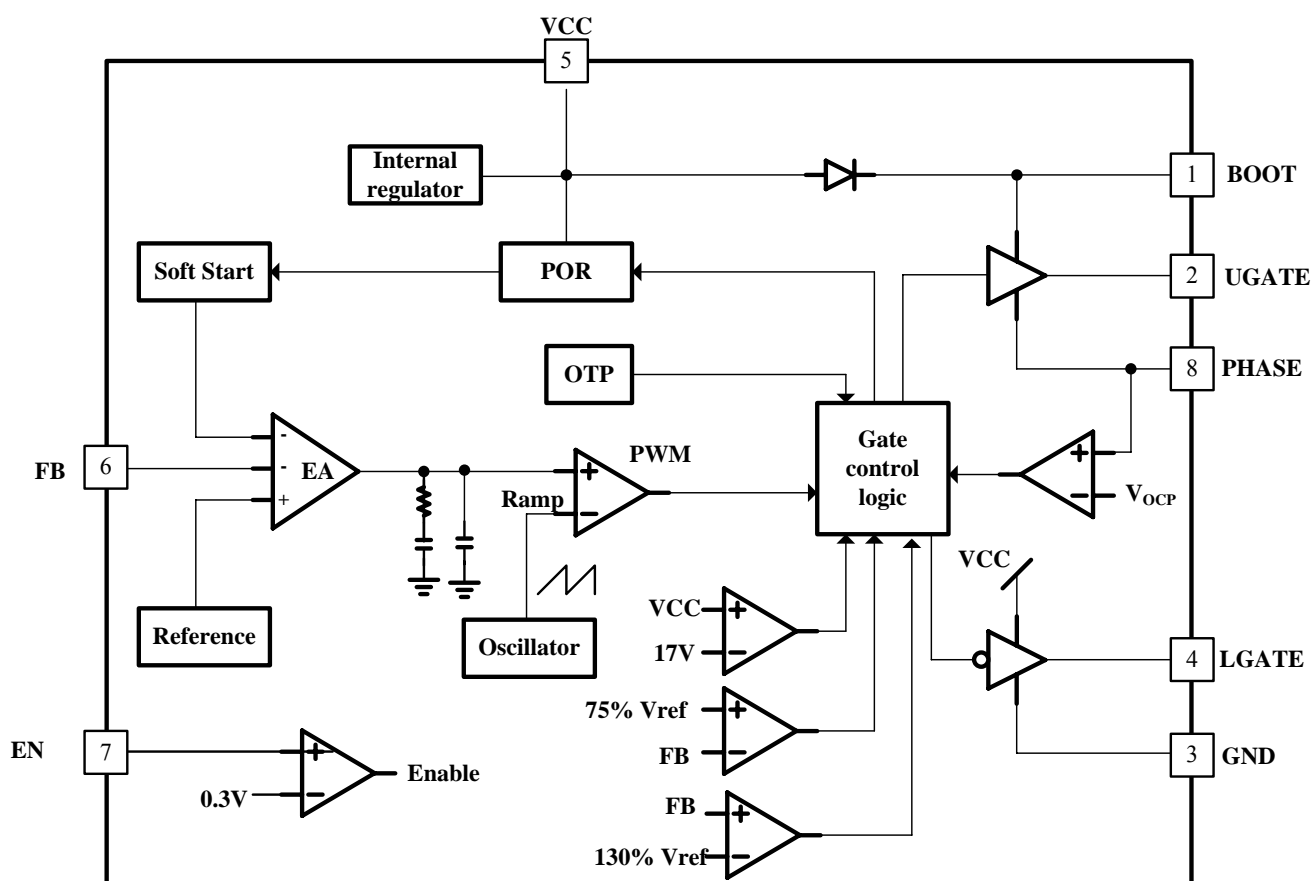


Pin Assignment

Pin Name	Pin No.	Pin Function
BOOT	1	Bootstrap Supply for the floating upper gate driver. Connect the bootstrap capacitor C_{BOOT} between BOOT pin and the PHASE pin to form a bootstrap circuit. The bootstrap capacitor provides the charge to turn on the upper MOSFET. Typical values for C_{BOOT} range from 0.1uF to 0.47uF. Ensure that C_{BOOT} is placed near the IC.
UGATE	2	Upper Gate Driver Output. Connect this pin to the gate of upper MOSFET. This pin is monitored by the adaptive shoot-through protection circuitry to determine when the upper MOSFET has turned off.
GND	3	Signal and Power Ground for the IC. All voltages levels are measured with respect to this pin. Tie this pin to the ground island/plane through the lowest impedance connection available.

LGATE	4	Lower Gate Driver Output. Connect this pin to the gate of lower MOSFET. This pin is monitored by the adaptive shoot-through protection circuitry to determine when the lower MOSFET has turn off.
VCC	5	Supply Voltage. This pin provides the bias supply for the EM5303/A and the lower gate driver. The supply voltage is internally regulated to 4VDD for internal control circuit. Connect a well-decoupled 4.5V to 13.2V supply voltage to this pin. Ensure that a decoupling capacitor is placed near the IC.
FB	6	Feedback Voltage. This pin is the inverting input to the error amplifier. A resistor divider from the output to GND is used to set the regulation voltage.
EN	7	Enable Pin. Pulling this pin lower than 0.3V disables the controller and causes the oscillator to stop, the UGATE and LGATE outputs to be held low.
PHASE	8	PHASE Switch Node. Connect this pin to the source of the upper MOSFET and the drain of the lower MOSFET. This pin is used as the sink for the UGATE driver, and to monitor the voltage drop across the lower MOSFET for over current protection. This pin is also monitored by the adaptive shoot-through protection circuitry to determine when the upper MOSFET has turned off. A Schottky diode between this pin and ground is recommended to reduce negative transient voltage which is common in a power supply system.

Function Block Diagram



**Absolute Maximum Ratings** (Note 1)

- Supply voltage, VCC----- -0.3V to 16V
- PHASE to GND
DC----- -5V to 16V
<200nS----- -10V to 32V
- BOOT to PHASE----- 16V
- BOOT to GND
DC----- -0.3V to PHASE+16V
<200nS----- -0.3V to 42V
- UGATE----- PHASE – 0.3V to BOOT + 0.3V
- LGATE----- -0.3V to VCC + 0.3V
- EN & FB----- -0.3V to 6V
- Power Dissipation, PD @ TA = 25°C, PSOP-8 ----- 0.625W
- Package Thermal Resistance, Θ_{JA} , PSOP-8 (Note 2)----- 160°C/W
- Junction Temperature----- 150°C
- Lead Temperature (Soldering, 10 sec.)----- 260°C
- Storage Temperature Range----- 65°C to 150°C
- ESD susceptibility (Note3)
HBM (Human Body Mode)----- 2KV
MM (Machine Mode)----- 200V

Recommended Operating Conditions (Note5)

- Supply Voltage, VCC ----- 4.5V to 13.2V
- Junction Temperature ----- -40°C to 125°C
- Ambient Temperature ----- -40°C to 85°C

Electrical Characteristics

VCC=12V, TA=25°C, unless otherwise specified

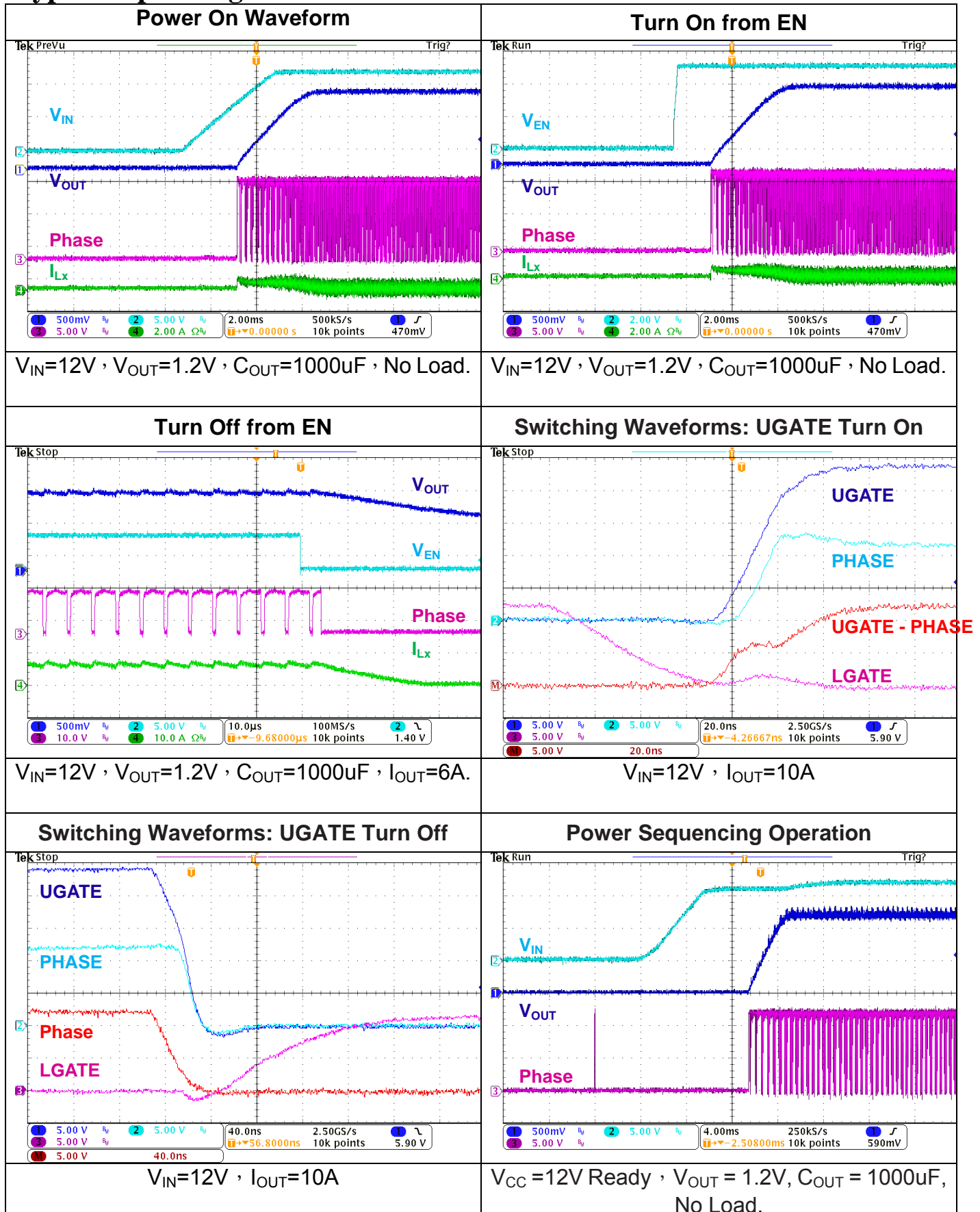
Parameter	Symbol	Test Conditions	Pin	Min	Typ	Max	Units
Supply Input Section							
Supply Voltage	VCC		5	4.5		13.2	V
Supply Current	ICC	LGATE, UGATE open, Switching.	5		3		mA
Quiescent Supply Current	ICCQ	No Switching.	5		2		mA
Power on Reset Threshold	VCCRTH		5	4	4.2	4.4	V
Power on Reset Hysteresis	VCCHYS		5		0.2		V
Internal Oscillator							
Free Running Frequency	Fsw	EM5303		170	200	230	KHz
		EM5303A		255	300	345	KHz
Ramp Amplitude	ΔV_{osc}				1		Vp-p
Error Amplifier							
Open Loop DC Gain	Ao	Guaranteed by Design		55	70		dB
Gain-Bandwidth Product	GBW	Guaranteed by Design			10		MHz
Slew Rate	SR	Guaranteed by Design		3	6		V/uS
Trans-conductance	gm	Guaranteed by Design			0.2	0.7	mS



PWM Controller Gate Drivers							
Upper Gate Sourcing Current	I _{UG_SRC}	V _{BOOT} - V _{PHASE} = 12V, V _{BOOT} - V _{UGATE} = 6V	2		-1		A
Upper Gate Sinking Current	I _{UG_SNK}	V _{BOOT} - V _{PHASE} = 12V, V _{UGATE} - V _{PHASE} = 6V	2		1.5		A
Upper Gate R _{DS(ON)} Sinking	R _{UG_SNK}	V _{BOOT} - V _{PHASE} = 12V, V _{UGATE} - V _{PHASE} = 0.1V	2		2	4	Ω
Lower Gate Sourcing Current	I _{LG_SRC}	V _{CC} - V _{LGATE} = 6V	4		-1		A
Lower Gate Sinking Current	I _{LG_SNK}	V _{LGATE} = 6V	4		1.5		A
Lower Gate R _{DS(ON)} Sinking	R _{LG_SNK}	V _{LGATE} = 0.1V	4		2	4	Ω
PHASE Falling to LGATE Rising Delay		V _{CC} = 12V; V _{PHASE} < 1.2V to V _{LGATE} > 1.2V			30	90	nS
LGATE Falling to UGATE Rising Delay		V _{CC} = 12V; V _{LGATE} < 1.2V to (V _{UGATE} - V _{PHASE}) > 1.2V			30	90	ns
Reference Voltage							
Nominal Feedback Voltage	V _{FB}		6	0.591	0.6	0.609	V
Enable Voltage							
EN Enable Threshold	V _{EN}		7		0.3	0.35	V
Protection section							
FB Under Voltage Protection	V _{FB_UVP}	FB falling	6	55	65	75	%
FB Over Voltage Protection	V _{FB_OVP}	FB rising	6	115	130	145	%
VCC Over Voltage Protection	V _{CC_OVP}		5	16	17	18	V
Over Current Threshold	V _{OCP}			-425	-375	-325	mV
Soft-Start Interval	T _{SS}			2.4	3.6	5.4	mS
Temperature Shutdown	T _{SD}	Guaranteed by Design		150	165		°C

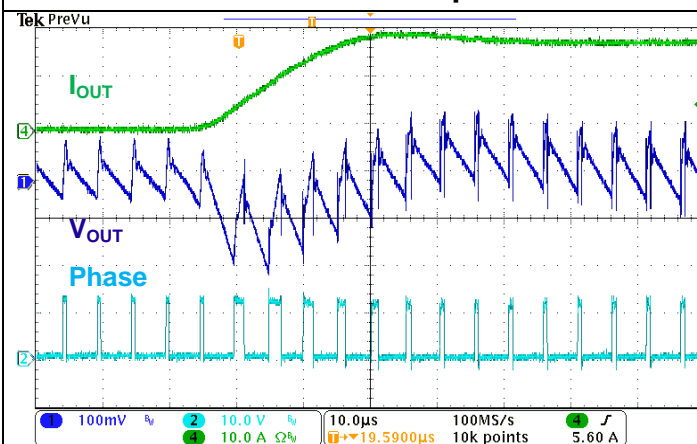
- Note 1.** Stresses listed as the above “Absolute Maximum Ratings” may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.
- Note 2.** θ_{JA} is measured in the natural convection at T_A=25°C on a 4-layers high effective thermal conductivity test board with minimum copper area of JEDEC 51-7 thermal measurement standard. The case point of θ_{JC} is on the expose pad for PSOP-8 package.
- Note 3.** θ_{JA} PSOP-8 packages is 52°C /W on JEDEC 51-7 (4 layers,2S2P) thermal test board with 50mm² copper area.
- Note 4.** Devices are ESD sensitive. Handling precaution is recommended.
- Note 5.** The device is not guaranteed to function outside its operating conditions.

Typical Operating Characteristics



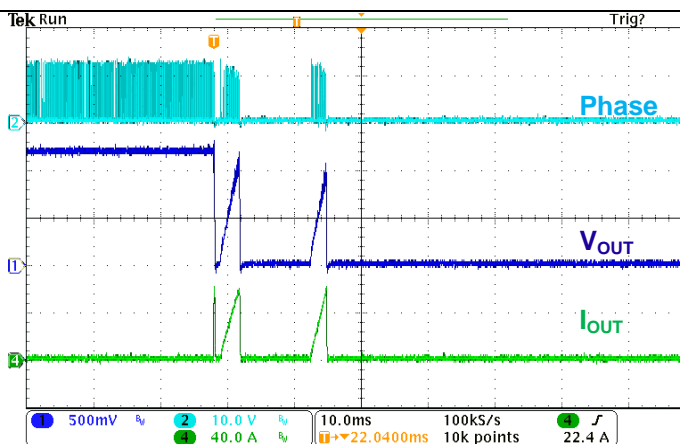


Load Transient Response



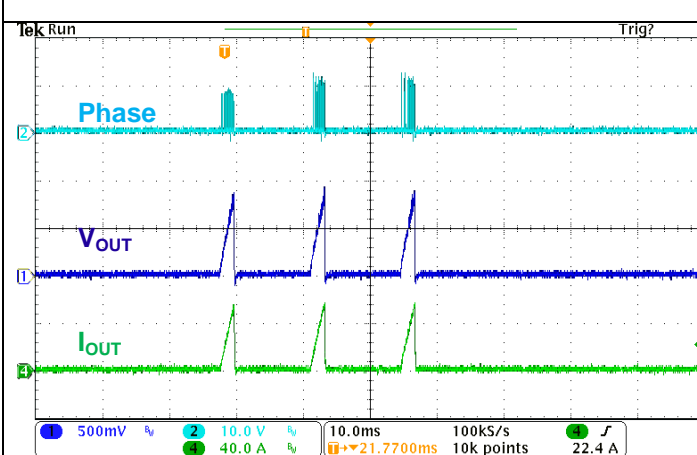
$V_{IN}=12V$, $V_{OUT}=1.2V$, $C_{OUT}=1000\mu F$.

Over Current Protection



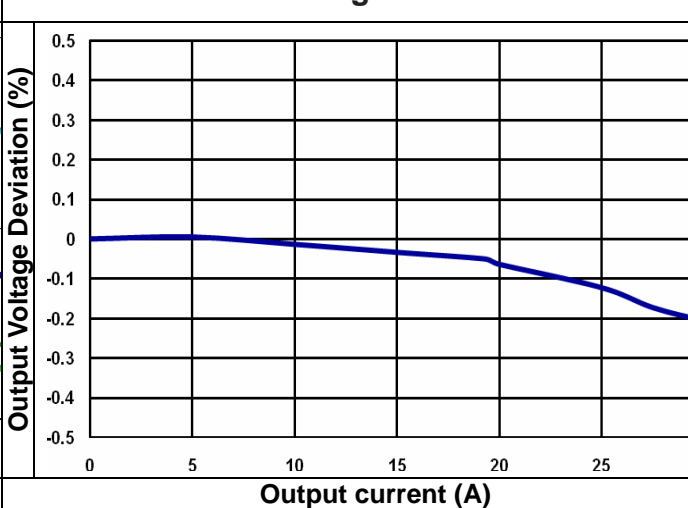
$V_{IN}=12V$, $V_{OUT}=1.2V$, $C_{OUT}=1000\mu F$.
Output short Ground

Over Current Protection

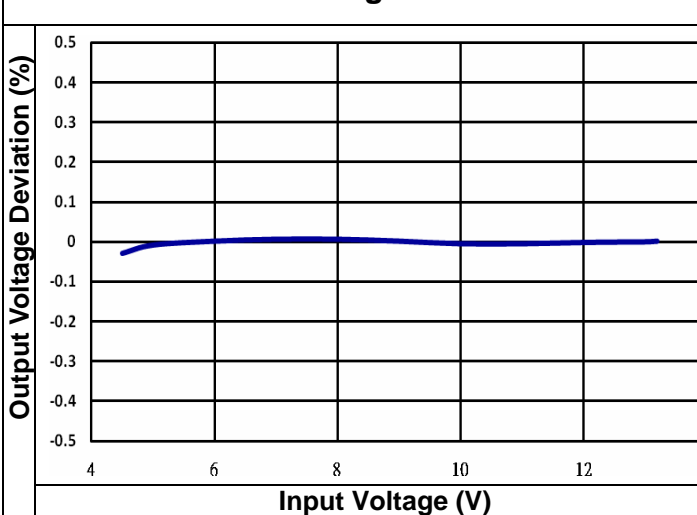


$V_{IN}=12V$, $V_{OUT}=1.2V$, $C_{OUT}=1000\mu F$.
Turn On to Short Circuit

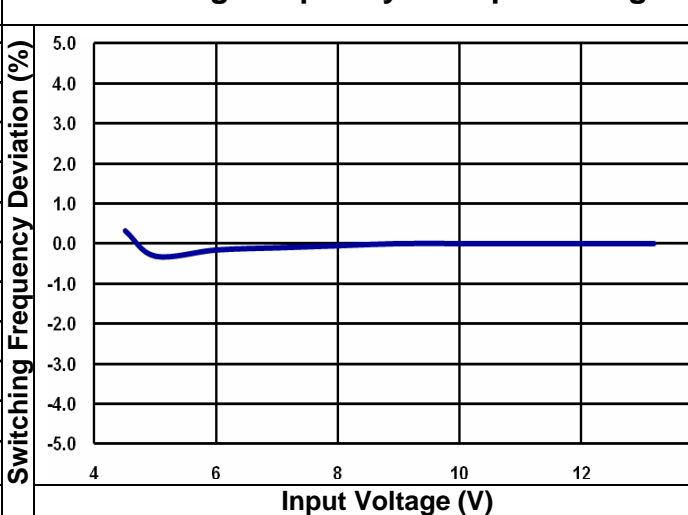
Load Regulation



Line Regulation

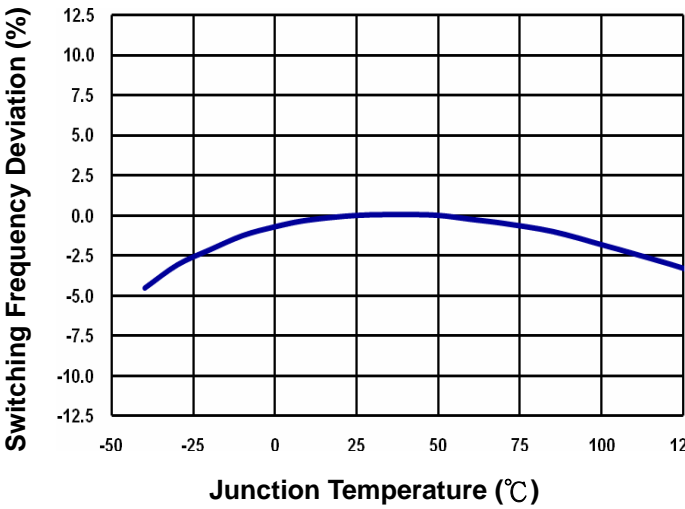


Switching Frequency vs. Input Voltage

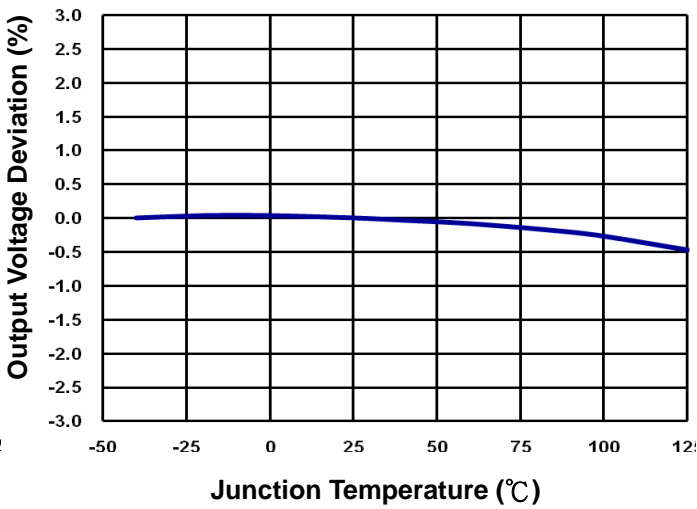




Switching Frequency vs. Junction Temperature



Output Voltage vs. Junction Temperature





Functional Description

EM5303/A is a voltage mode synchronous buck PWM controller. The compensation circuit is implemented internally to minimize the external component count. This device provides complete protection function such as over current protection, under voltage protection and over voltage protection.

Supply Voltage

The V_{CC} pin provides the bias supply of EM5303/A control circuit, as well as lower MOSFET's gate and the BOOT voltage for the upper MOSFET's gate. A minimum 0.1 μ F ceramic capacitor is recommended to bypass the supply voltage.

Power ON Reset

To let EM5303/A start to operation, V_{CC} voltage must be higher than its POR voltage even when EN voltage is pulled higher than enable high voltage. Typical POR voltage is 4.2V.

Enable

To let EM5303/A start to operation, EN voltage must be higher than its enable voltage. Typical enable voltage is 0.3V.

Soft Start

EM5303/A provides soft start function internally. The FB voltage will track the internal soft start signal, which ramps up from zero during soft start period.

OCP, Over Current Protection

The over current function protects the converter from a shorted output by using lower MOSFET's on-resistance to monitor the current. The OCP level can be calculated as the following equation:

$$I_{OCP} = -\frac{V_{OCP}}{R_{DS(ON)}}$$

When OCP is triggered, EM5303/A will shut down the converter and cycles the soft start function in a hiccup mode. If over current condition still exist after 3 times of hiccup, EM5303/A will shut down the controller and latch.

UVP, Under Voltage Protection

The FB voltage is monitored for under voltage protection. The UVP threshold is typical 0.4V. When UVP is triggered, EM5303/A will shut down the converter and cycles the soft start function in a hiccup mode.

OVP, Over Voltage Protection

The FB voltage is monitored for over voltage protection. The OVP threshold is typical 0.8V. When OVP is triggered, EM5303/A will turn off upper MOSFET and turn on lower MOSFET.

Output Inductor Selection

The output inductor is selected to meet the output voltage ripple requirements and minimize the response time to the load transient. The inductor value determines the current ripple and voltage ripple. The ripple current is approximately the following equation:

$$\Delta I_L = \frac{V_{IN} - V_{OUT}}{L} * \frac{V_{OUT}}{V_{IN} * F_{SW}}$$

**Output Capacitor Selection**

An output capacitor is required to filter the output and supply the load transient. The selection of output capacitor depends on the output ripple voltage. The output ripple voltage is approximately bounded by the following equation:

$$\Delta V_{OUT} = \Delta I_L * (ESR + \frac{1}{8 * F_{SW} * C_{OUT}})$$

Input Capacitor Selection

Use a mix of input bypass capacitors to control the voltage overshoot across the MOSFET. Use small ceramic capacitors for high frequency decoupling and bulk capacitors to supply the current needed each time the upper MOSFET turn on. Place the small ceramic capacitors physically close to the MOSFETs and between the drain of the upper MOSFET and the source of the lower MOSFET. The important parameters of the input capacitor are the voltage rating and the RMS current rating. The capacitor voltage rating should be at least 1.25 times greater than the maximum input voltage and a voltage rating of 1.5 times is a conservative guideline. The RMS current rating requirement can be expressed as the following equation:

$$I_{RMS} = I_{OUT} \sqrt{D(1-D)}$$

For a through hole design, several electrolytic capacitors may be needed. For surface mount designs, solid tantalum capacitors can also be used but caution must be exercised with regard to the capacitor surge current rating. These capacitors must be capable of handling the surge current at power-up. Some capacitor series available from reputable manufacturers are surge current tested.

Power MOSFET Selection

The EM5303/A requires two N-Channel power MOSFETs. These should be selected based upon on-resistance, breakdown voltage, gate supply requirement, and thermal management requirements.

In high current applications, the MOSFET power dissipation, package selection and heat sink are the dominate design factor. The power dissipation includes two loss components: conduction loss and switching loss. The conduction losses are the largest component of power dissipation for both the upper and lower MOSFETs. These losses are distributed between the two MOSFETs according to duty factor.

The power dissipations in the two MOSFETs are approximately the following equation:

$$PD_{UPPER} = I_{OUT}^2 * R_{DS(ON)} * D + 0.5 * I_{OUT} * V_{IN} * F_{SW} * t_{SW}$$

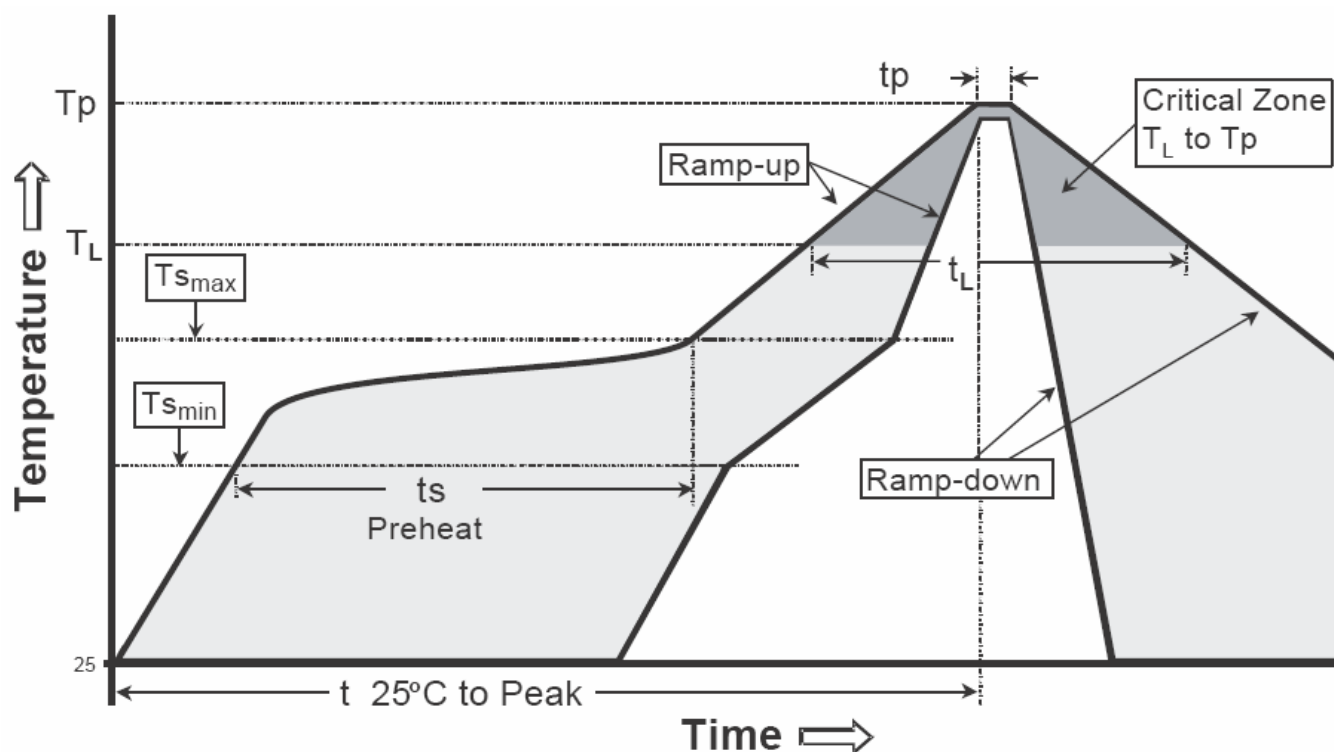
$$PD_{LOWER} = I_{OUT}^2 * R_{DS(ON)} * (1-D)$$

Where D is the duty cycle, t_{SW} is the combined switch ON and OFF time.

Recommended wave soldering condition

Product	Peak Temperature	Soldering Time
Pb-free devices	260 +0/-5 °C	5 +1/-1 seconds

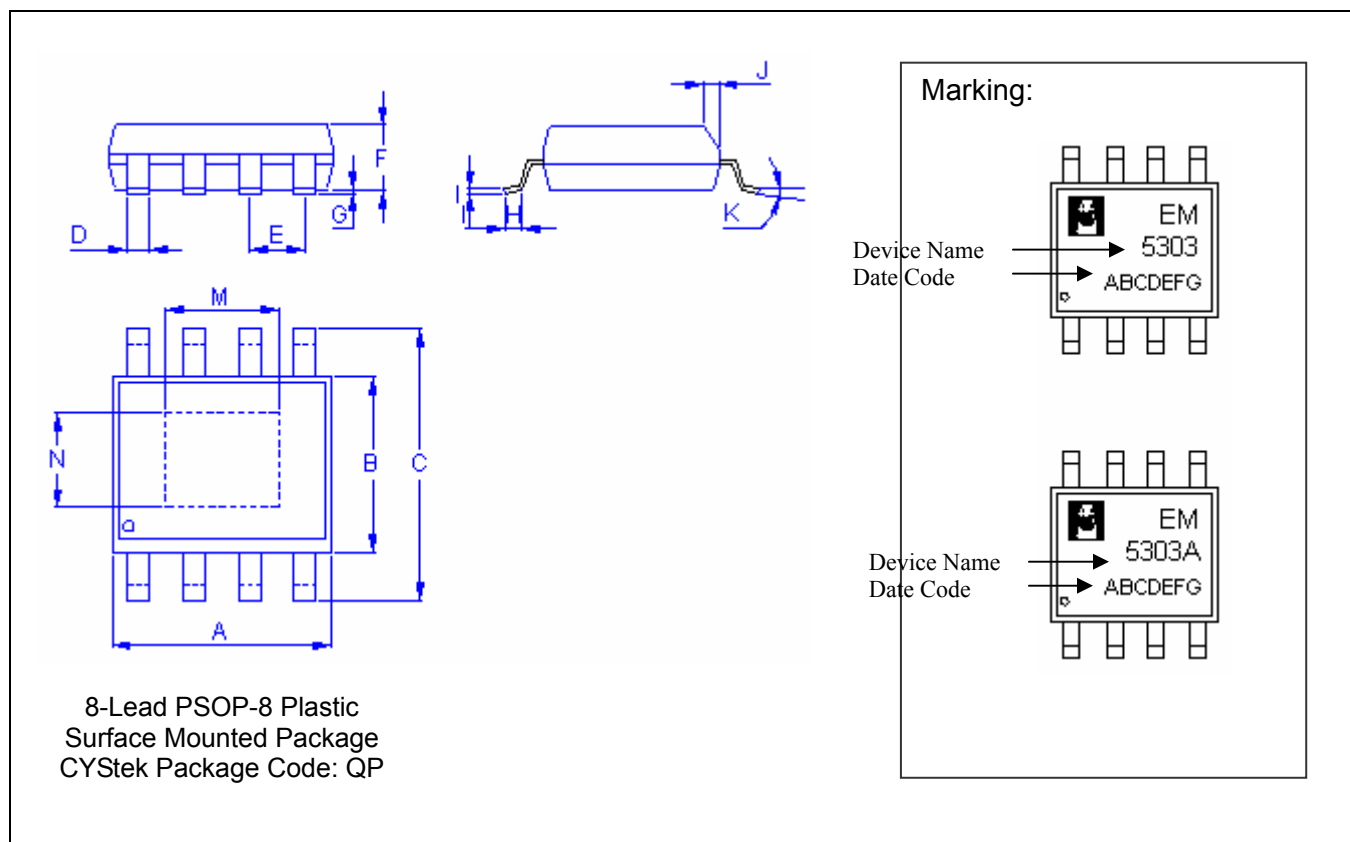
Recommended temperature profile for IR reflow



Profile feature	Sn-Pb eutectic Assembly	Pb-free Assembly
Average ramp-up rate (T_{smax} to T_p)	3°C/second max.	3°C/second max.
Preheat		
-Temperature Min(T_{smin})	100°C	150°C
-Temperature Max(T_{smax})	150°C	200°C
-Time(t_{smin} to t_{smax})	60-120 seconds	60-180 seconds
Time maintained above:		
-Temperature (T_L)	183°C	217°C
- Time (t_L)	60-150 seconds	60-150 seconds
Peak Temperature(T_p)	240 +0/-5 °C	260 +0/-5 °C
Time within 5°C of actual peak temperature(t_p)	10-30 seconds	20-40 seconds
Ramp down rate	6°C/second max.	6°C/second max.
Time 25 °C to peak temperature	6 minutes max.	8 minutes max.

Note : All temperatures refer to topside of the package, measured on the package body surface.

PSOP-8 Dimension



*:Typical

DIM	Inches		Millimeters		DIM	Inches		Millimeters	
	Min.	Max.	Min.	Max.		Min.	Max.	Min.	Max.
A	0.1850	0.2008	4.70	5.10	H	0.0157	0.0327	0.40	0.83
B	0.1457	0.1614	3.70	4.10	I	0.0075	0.0102	0.19	0.26
C	0.2283	0.2441	5.80	6.20	J	0.0098	0.0197	0.25	0.50
D	0.0130	0.0200	0.33	0.51	K	0°	8°	0°	8°
E	0.05*		1.27 *		M	0.0764	0.0980	1.94	2.49
F	0.0472	0.0638	1.20	1.62	N	0.0764	0.0980	1.94	2.49
G	0.0032	0.0110	0.08	0.28					

Notes : 1.Controlling dimension : millimeters.

2.Maximum lead thickness includes lead finish thickness, and minimum lead thickness is the minimum thickness of base material.

3.If there is any question with packing specification or packing method, please contact your local CYStek sales office.

Material :

- Mold Compound : Epoxy resin family, flammability solid burning class:UL94V-0

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