

## 5V/12V Synchronous Buck PWM Controller with Reference Input

### General Description

EM5302/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.

### Ordering Information

| Part Number | Package | Frequency |
|-------------|---------|-----------|
| EM5302GE    | PSOP-8  | 200kHz    |
| EM5302AGE   | PSOP-8  | 300kHz    |

### Features

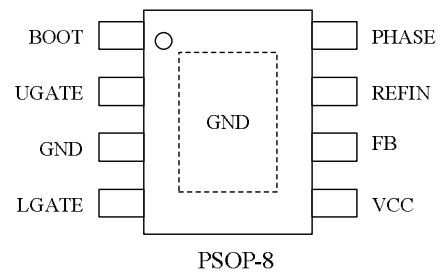
- Operate from 5V to 12V Voltage Supply
- 0.6V  $V_{REF}$  with 1.5% Accuracy
- Support Tracking Mode and Stand Alone Mode Operation
- Voltage Mode PWM Control
- 200kHz or 300kHz Fixed Frequency Oscillator
- 0% to 80% Duty Cycle
- Internal Soft Start
- Over Current Protection
- Integrated Bootstrap Diode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

### Applications

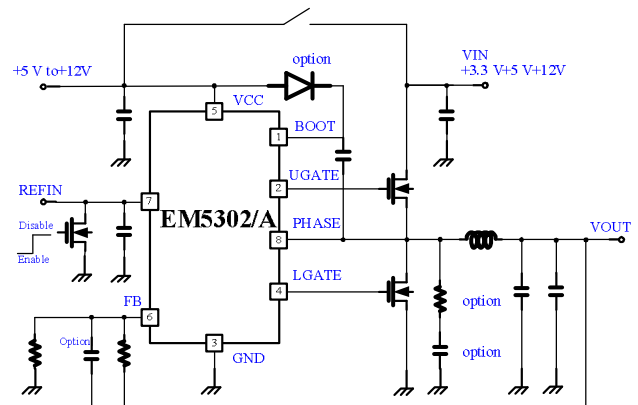
- Notebook & Netbook
- Graphic Cards & MB
- Low Voltage Logic Supplies



### Pin Configuration

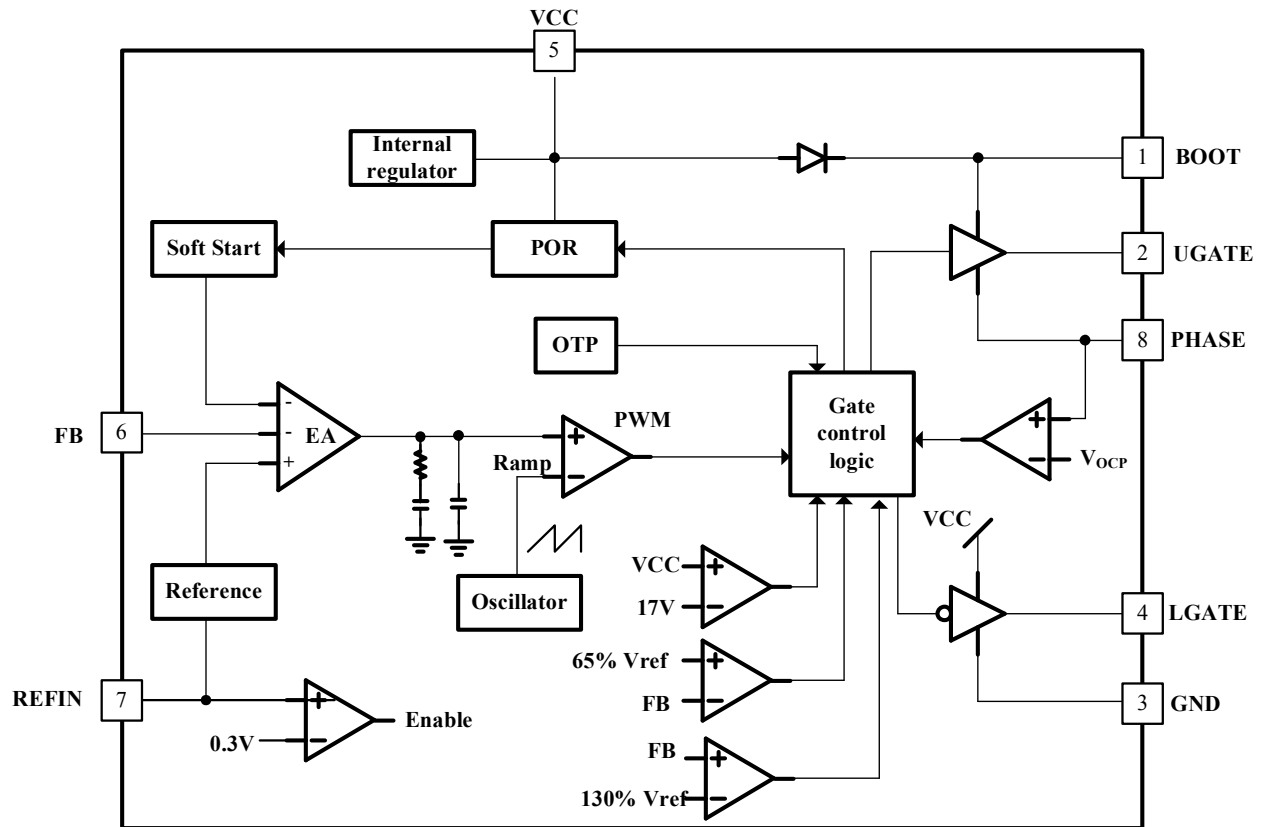


### Typical Application Circuit



## Pin Assignment

| Pin Name | Pin No. | Pin Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|----------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| BOOT     | 1       | <b>Bootstrap Supply</b> 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       | <b>Upper Gate Driver Output.</b> 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       | <b>Signal and Power Ground for the IC.</b> 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       | <b>Lower Gate Driver Output.</b> 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       | <b>Supply Voltage.</b> This pin provides the bias supply for the EM5302/A and the lower gate driver. The supply voltage is internally regulated to 5VDD 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       | <b>Feedback Voltage.</b> 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.                                                                                                                                                                                                                                                                                                                                                                   |
| REFIN    | 7       | <b>External Reference Input for Tracking Mode Operation.</b> This pin receives a voltage with range from 0.4V to 2V as the reference voltage. 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       | <b>PHASE Switch Node.</b> 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. |



**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                                                            |                                         |
| DC-----                                                            | $V_{PHASE} - 0.3V$ to $V_{BOOT} + 0.3V$ |
| <200ns-----                                                        | $V_{PHASE} - 5V$ to $V_{BOOT} + 5V$     |
| ● LGATE                                                            |                                         |
| DC-----                                                            | -0.3V to VCC + 0.3V                     |
| <200ns-----                                                        | -5V to VCC+5V                           |
| ● REFIN & FB-----                                                  | -0.3V to 6V                             |
| ● Power Dissipation, PD @ TA = 25°C, PSOP-8 -----                  | 1.33W                                   |
| ● Package Thermal Resistance, $\theta_{JA}$ , PSOP-8 (Note 2)----- | 75°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 (Note4)**

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

**Electrical Characteristics**

V<sub>CC</sub>=12V, T<sub>A</sub>=25°C, unless otherwise specified

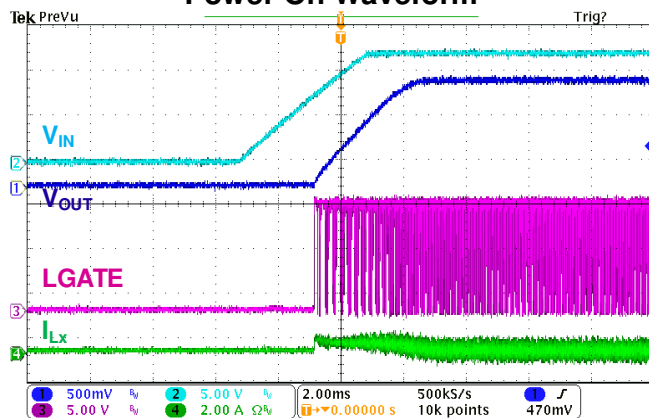
| Parameter                   | Symbol             | Test Conditions               | Pin | Min | Typ | Max  | Units |
|-----------------------------|--------------------|-------------------------------|-----|-----|-----|------|-------|
| <b>Supply Input Section</b> |                    |                               |     |     |     |      |       |
| Supply Voltage              | V <sub>CC</sub>    |                               | 5   | 4.5 |     | 13.2 | V     |
| Supply Current              | I <sub>CC</sub>    | LGATE, UGATE open, Switching. | 5   |     | 3   |      | mA    |
| Quiescent Supply Current    | I <sub>CCQ</sub>   | No Switching.                 | 5   |     | 2   |      | mA    |
| Power on Reset Threshold    | V <sub>CCRTH</sub> |                               | 5   | 4   | 4.2 | 4.4  | V     |
| Power on Reset Hysteresis   | V <sub>CCHYS</sub> |                               | 5   |     | 0.2 |      | V     |
| <b>Internal Oscillator</b>  |                    |                               |     |     |     |      |       |

|                                        |                     |                                                                                                          |   |       |      |       |                  |
|----------------------------------------|---------------------|----------------------------------------------------------------------------------------------------------|---|-------|------|-------|------------------|
| Free Running Frequency                 | F <sub>SW</sub>     | EM5302                                                                                                   |   | 170   | 200  | 230   | kHz              |
|                                        |                     | EM5302A                                                                                                  |   | 255   | 300  | 345   | kHz              |
| Ramp Amplitude                         | △V <sub>OSC</sub>   |                                                                                                          |   |       | 1    |       | V <sub>p-p</sub> |
| Error Amplifier                        |                     |                                                                                                          |   |       |      |       |                  |
| Open Loop DC Gain                      | A <sub>O</sub>      | 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                      | g <sub>m</sub>      | Guaranteed by Design                                                                                     |   |       | 0.2  | 0.7   | mS               |
| PWM Controller Gate Drivers            |                     |                                                                                                          |   |       |      |       |                  |
| Upper Gate Sourcing Current            | I <sub>UG_SRC</sub> | V <sub>BOOT</sub> - V <sub>PHASE</sub> = 12V,<br>V <sub>BOOT</sub> - V <sub>UGATE</sub> = 6V             | 2 |       | -1   |       | A                |
| Upper Gate Sinking Current             | I <sub>UG_SNK</sub> | V <sub>BOOT</sub> - V <sub>PHASE</sub> = 12V,<br>V <sub>UGATE</sub> - V <sub>PHASE</sub> = 6V            | 2 |       | 1.5  |       | A                |
| Upper Gate R <sub>DS(ON)</sub> Sinking | R <sub>UG_SNK</sub> | V <sub>BOOT</sub> - V <sub>PHASE</sub> = 12V,<br>V <sub>UGATE</sub> - V <sub>PHASE</sub> = 0.1V          | 2 |       | 2    | 4     | Ω                |
| Lower Gate Sourcing Current            | I <sub>LG_SRC</sub> | V <sub>CC</sub> - V <sub>LGATE</sub> = 6V                                                                | 4 |       | -1   |       | A                |
| Lower Gate Sinking Current             | I <sub>LG_SNK</sub> | V <sub>LGATE</sub> = 6V                                                                                  | 4 |       | 1.5  |       | A                |
| Lower Gate R <sub>DS(ON)</sub> Sinking | R <sub>LG_SNK</sub> | V <sub>LGATE</sub> = 0.1V                                                                                | 4 |       | 2    | 4     | Ω                |
| PHASE Falling to LGATE Rising Delay    |                     | V <sub>CC</sub> = 12V; V <sub>PHASE</sub> < 1.2V to<br>V <sub>LGATE</sub> > 1.2V                         |   |       | 30   | 90    | ns               |
| LGATE Falling to UGATE Rising Delay    |                     | V <sub>CC</sub> = 12V; V <sub>LGATE</sub> < 1.2V to<br>(V <sub>UGATE</sub> - V <sub>PHASE</sub> ) > 1.2V |   |       | 30   | 90    | ns               |
| Reference Voltage                      |                     |                                                                                                          |   |       |      |       |                  |
| Nominal Feedback Voltage               | V <sub>FB</sub>     | Stand Alone Mode                                                                                         | 6 | 0.591 | 0.6  | 0.609 | V                |
| Output Voltage Accuracy                |                     | V <sub>REFIN</sub> -V <sub>FB</sub>  , Tracking Mode,<br>V <sub>REFIN</sub> =0.4V ~ 1V                   |   |       |      | 15    | mV               |
|                                        |                     | V <sub>REFIN</sub> -V <sub>FB</sub>  , Tracking Mode,<br>V <sub>REFIN</sub> =1V ~ 2V                     |   |       |      | 1.5   | %                |
| Enable Voltage                         |                     |                                                                                                          |   |       |      |       |                  |
| REFIN Enable Threshold                 | V <sub>EN</sub>     |                                                                                                          | 7 |       | 0.3  | 0.35  | V                |
| Protection section                     |                     |                                                                                                          |   |       |      |       |                  |
| FB Under Voltage Protection            | V <sub>FB_UVP</sub> | FB falling                                                                                               | 6 | 55    | 65   | 75    | %                |
| FB Over Voltage Protection             | V <sub>FB_OVP</sub> | FB rising                                                                                                | 6 | 115   | 130  | 145   | %                |
| VCC Over Voltage Protection            | V <sub>CC_OVP</sub> |                                                                                                          | 5 | 16    | 17   | 18    | V                |
| Over Current Threshold                 | V <sub>OCP</sub>    |                                                                                                          |   | -425  | -375 | -325  | mV               |
| Soft-Start Interval                    | T <sub>SS</sub>     |                                                                                                          |   | 2.4   | 3.6  | 5.4   | ms               |
| Temperature Shutdown                   | T <sub>SD</sub>     | Guaranteed by Design                                                                                     |   | 150   | 165  |       | ℃                |

- 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.**  $\theta_{JA}$  is measured in the natural convection at  $T_A = 25^{\circ}C$  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  $\theta_{JC}$  is on the expose pad for PSOP-8 package.
- Note 3.** Devices are ESD sensitive. Handling precaution is recommended.
- Note 4.** The device is not guaranteed to function outside its operating conditions.

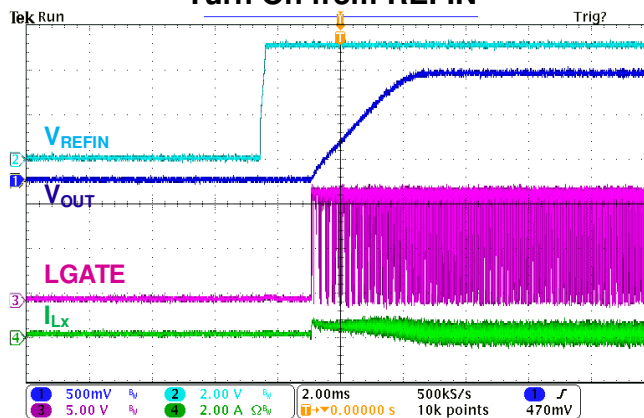
**Typical Operating Characteristics**

**Power On Waveform**



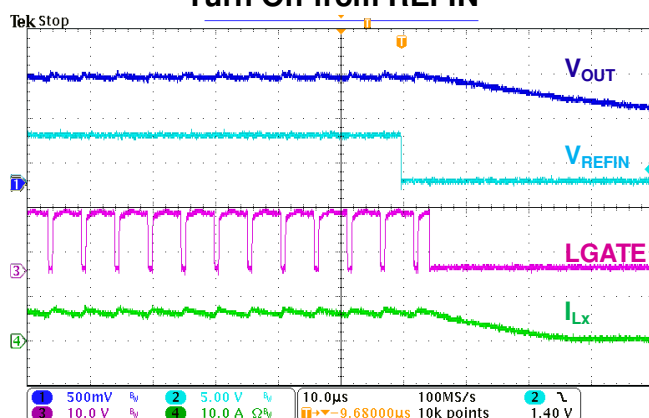
$V_{IN}=12V$ ,  $V_{OUT}=1.2V$ ,  $C_{OUT}=1000\mu F$ , No Load.

**Turn On from REFIN**



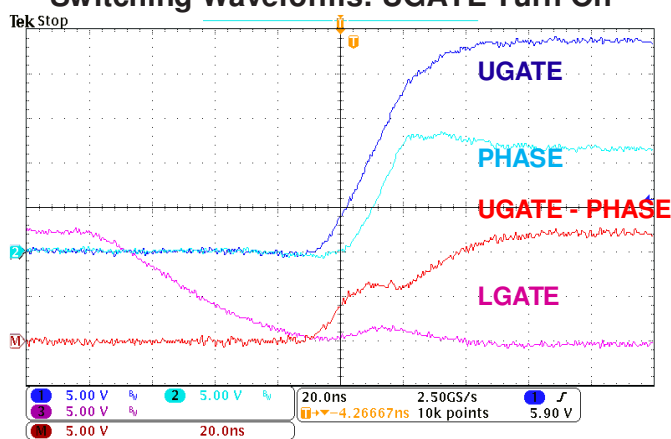
$V_{IN}=12V$ ,  $V_{OUT}=1.2V$ ,  $C_{OUT}=1000\mu F$ , No Load.

**Turn Off from REFIN**



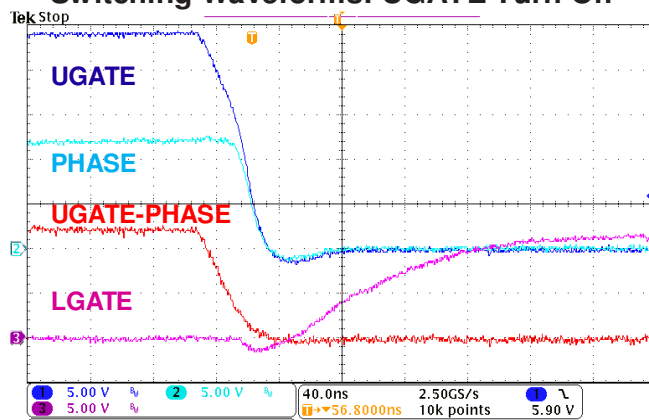
$V_{IN}=12V$ ,  $V_{OUT}=1.2V$ ,  $C_{OUT}=1000\mu F$ ,  $I_{OUT}=6A$ .

**Switching Waveforms: UGATE Turn On**



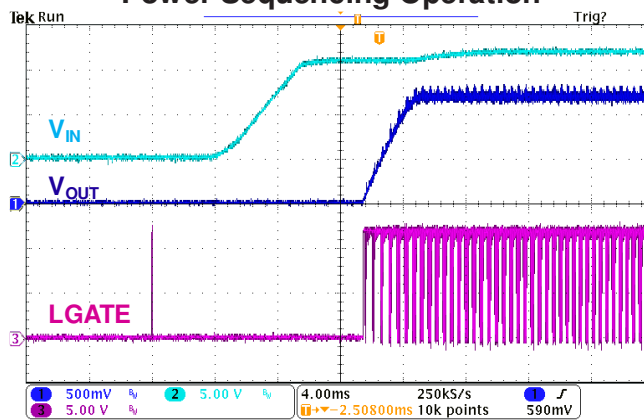
$V_{IN}=12V$ ,  $I_{OUT}=10A$

**Switching Waveforms: UGATE Turn Off**

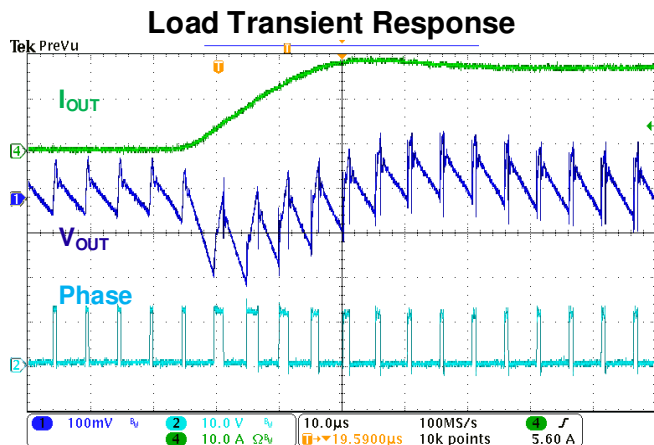


$V_{IN}=12V$ ,  $I_{OUT}=10A$

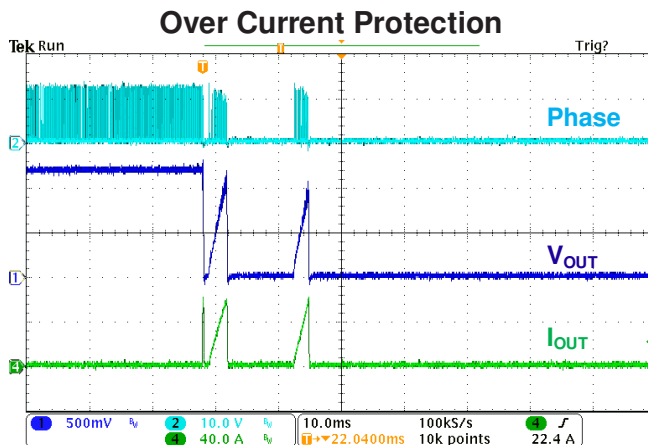
**Power Sequencing Operation**



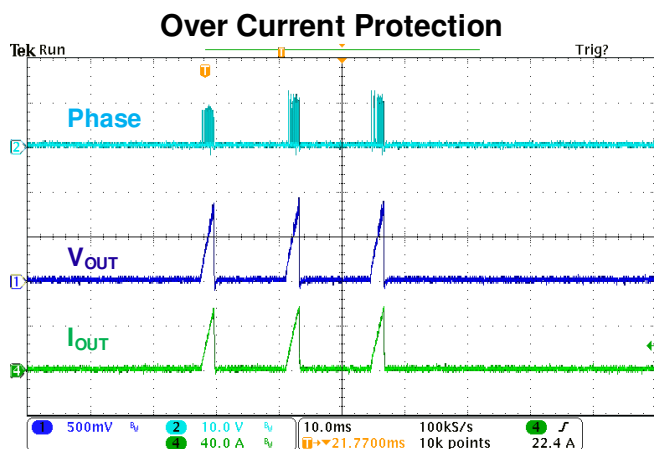
$V_{CC}=12V$  Ready,  $V_{OUT}=1.2V$ ,  $C_{OUT}=1000\mu F$ , No Load.



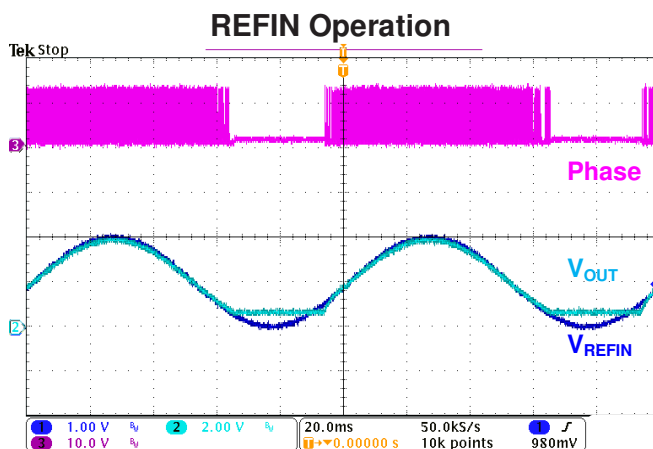
$V_{IN}=12V$ ,  $V_{OUT}=1.2V$ ,  $C_{OUT}=1000\mu F$ .



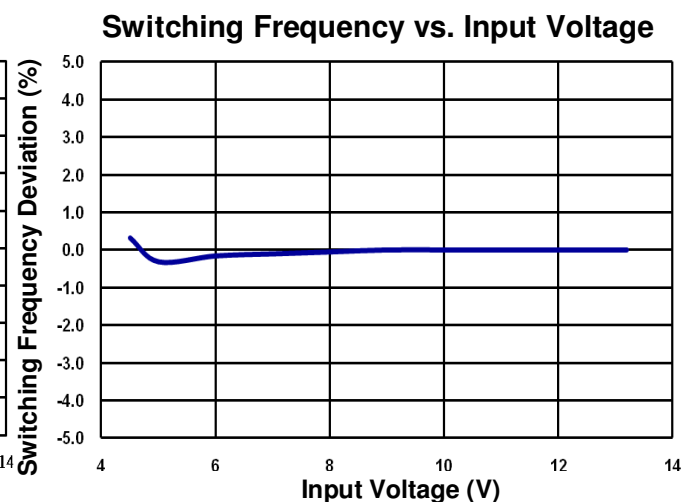
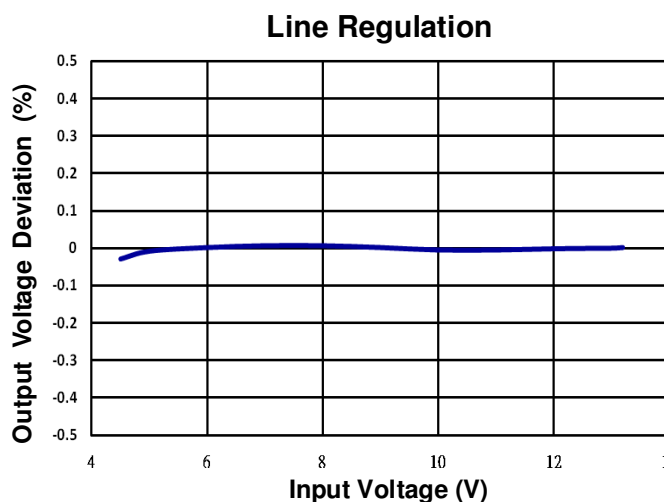
$V_{IN}=12V$ ,  $V_{OUT}=1.2V$ ,  $C_{OUT}=1000\mu F$ .  
Output short Ground



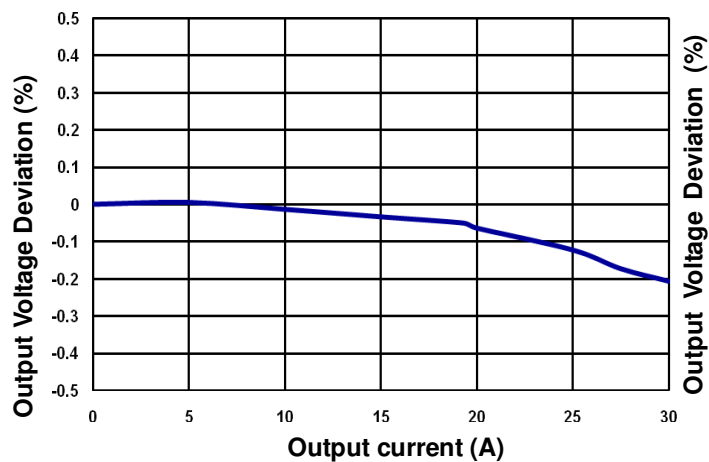
$V_{IN}=12V$ ,  $V_{OUT}=1.2V$ ,  $C_{OUT}=1000\mu F$ .  
Turn On to Short Circuit



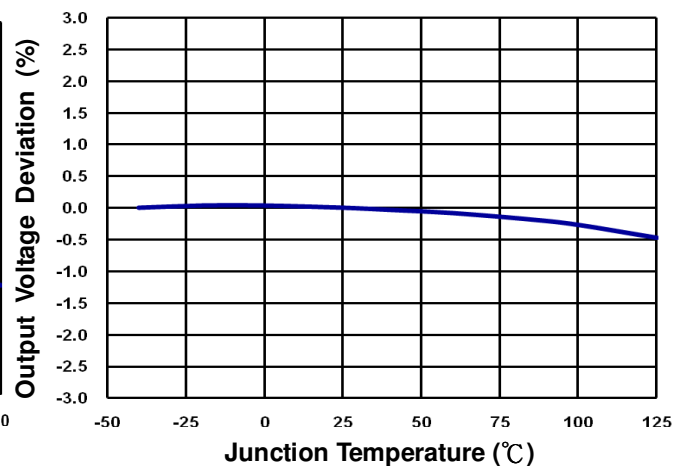
$V_{IN}=12V$ ,  $V_{OUT}=1.2V$ ,  $C_{OUT}=1000\mu F$ ,  $I_{OUT}=6A$



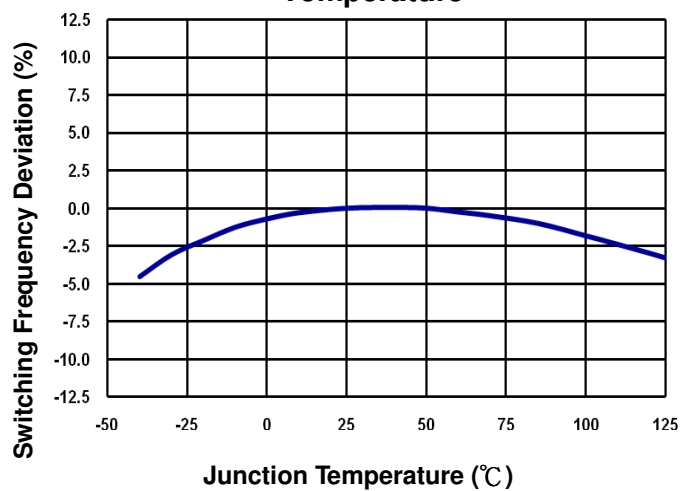
**Load Regulation**



**Output Voltage vs. Junction Temperature**



**Switching Frequency vs. Junction Temperature**



## Functional Description

EM5302/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 EM5302/A control circuit, as well as lower MOSFET's gate and the BOOT voltage for the upper MOSFET's gate. A minimum 0.1uF ceramic capacitor is recommended to bypass the supply voltage.

### Power ON Reset

To let EM5302/A start to operation,  $V_{CC}$  voltage must be higher than its POR voltage even when REFIN voltage is pulled higher than enable high voltage. Typical POR voltage is 4.2V.

### Enable

To let EM5302/A start to operation, REFIN voltage must be higher than its enable voltage. Typical enable voltage is 0.3V.

### Reference Voltage Select

The REFIN Voltage is compared with 3V to select the reference voltage with 1ms delay after chip enable. The external reference input is selected if REFIN is smaller than 3V.

### Soft Start

EM5302/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, EM5302/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, EM5302/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, EM5302/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, EM5302/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 EM5302/A requires two N-Channel power MOSFETs. These should be selected based upon

## EM5302/A

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.



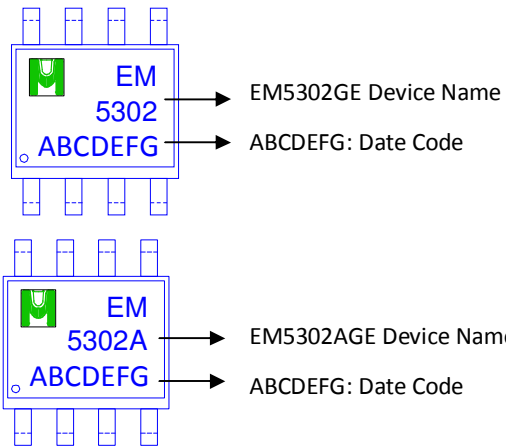
杰力科技股份有限公司

Excelliance MOS Corporation

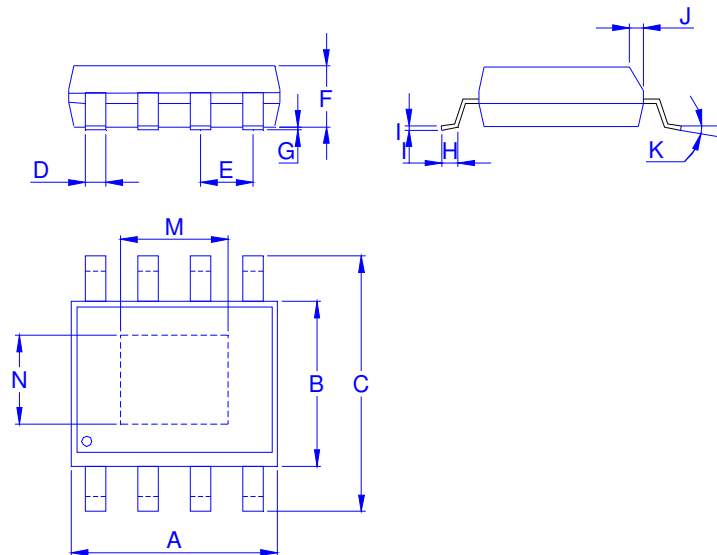
EM5302/A

## Ordering & Marking Information

Device Name: EM5302GE/EM5302AGE for PSOP-8



## Outline Drawing



Dimension in mm

| Dimension | A    | B    | C    | D    | E    | F    | G    | H    | I    | J    | K  | M    | N    |
|-----------|------|------|------|------|------|------|------|------|------|------|----|------|------|
| Min.      | 4.70 | 3.70 | 5.80 | 0.33 |      | 1.20 | 0.02 | 0.40 | 0.19 | 0.25 | 0° | 1.94 | 1.94 |
| Typ.      |      |      |      |      | 1.27 |      |      |      |      |      |    |      |      |
| Max.      | 5.10 | 4.10 | 6.20 | 0.51 |      | 1.62 | 0.15 | 0.83 | 0.26 | 0.50 | 8° | 2.49 | 2.49 |