# SGM61410
# 1.2MHz, 600mA, 45V Synchronous Step-Down Converter

## GENERAL DESCRIPTION

The SGM61410 is a high frequency, synchronous step-down converter. It provides 600mA current output with current mode control for fast loop response and compensation inside.

The wide 5V to 45V input voltage range accommodates a variety of step-down applications, including those in an automotive input environment. A 14μA sleep mode quiescent current makes SGM61410 the ideal solution for battery-powered applications. High power conversion efficiency over a wide load range is achieved by scaling down the switching frequency at light load condition to reduce the switching and gate driving losses.

The frequency fold-back helps prevent inductor current runaway during startup and thermal shutdown provides reliable, fault tolerant operation. By switching at 1.2MHz, the SGM61410 is able to prevent EMI (Electromagnetic Interference) noise problems, such as those found in AM radio, ADSL and PLC applications.

SGM61410 is available in Green SOT-23-6 package. It operates over an ambient temperature range of -40℃ to +125℃.

## FEATURES

- **Wide 5V to 45V Operating Input Voltage Range**
- **Low Quiescent Current: 14μA (TYP)**
- **0.8μA (TYP) Shutdown Current**
- **Current Output up to 600mA**
- **Internal Synchronous Rectifier**
- **1.2MHz Switching Frequency**
- **Compensation Inside and Internal Soft-Start**
- **Up to 95% Efficiency at 12V/400mA**
- **0.8V to 20V Adjustable Output Voltage**
- **Current Limit and Short-Circuit Protection**
- **Output Over-Voltage Protection and Thermal Shutdown**
- **Available in Green SOT-23-6 Package**
- **-40℃ to +125℃ Operating Temperature Range**

## APPLICATIONS

High Voltage Power Conversion
Automotive Systems
Industrial Power Systems
Distributed Power Systems
Battery Powered Systems
Power Meter

## TYPICAL APPLICATION

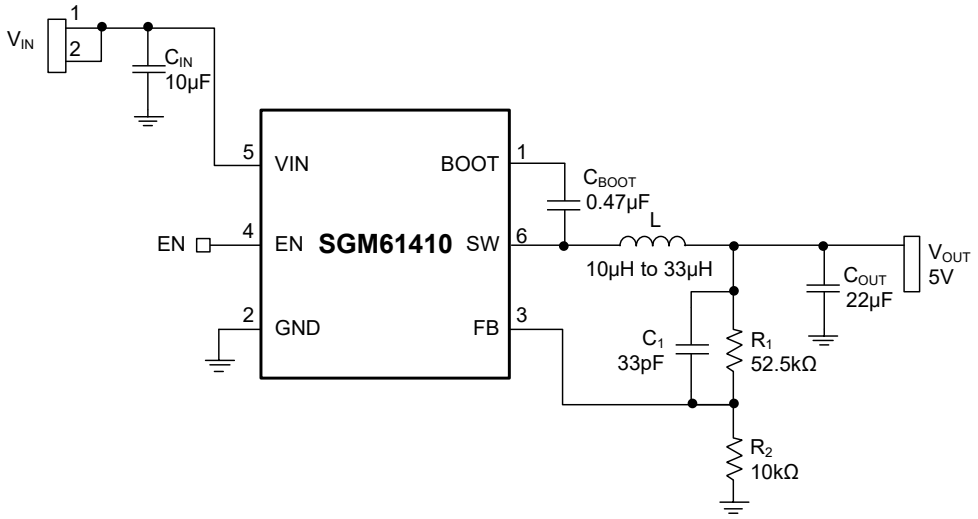


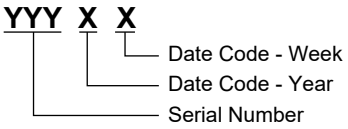

**Figure 1. Typical Application Circuit**

# PACKAGE/ORDERING INFORMATION

| MODEL | PACKAGE DESCRIPTION | SPECIFIED TEMPERATURE RANGE | ORDERING NUMBER | PACKAGE MARKING | PACKING OPTION |
|---|---|---|---|---|---|
| SGM61410 | SOT-23-6 | -40℃ to +125℃ | SGM61410XN6G/TR | MPEXX | Tape and Reel, 3000 |

## MARKING INFORMATION

NOTE: XX = Date Code.




Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

## ABSOLUTE MAXIMUM RATINGS

Supply Input Voltage ..... 50V
EN Pin ..... 50V
Junction Temperature ..... +150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃

## RECOMMENDED OPERATING CONDITIONS

Supply Input Voltage Range ..... 5V to 45V
Operating Junction Temperature Range ..... -40℃ to +125℃
Operating Ambient Temperature Range ..... -40℃ to +125℃

## OVERSTRESS CAUTION

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions section is not implied.

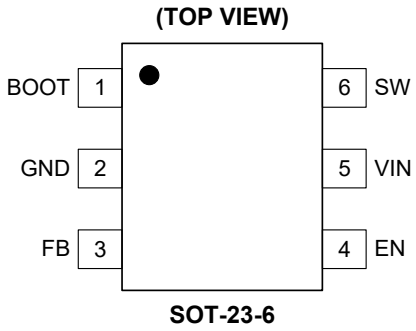
## ESD SENSITIVITY CAUTION

This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## DISCLAIMER

SG Micro Corp reserves the right to make any change in circuit design, or specifications without prior notice.

## PIN CONFIGURATION




## PIN DESCRIPTION

| PIN | NAME | FUNCTION |
|---|---|---|
| 1 | BOOT | Bootstrap. This pin is used to provide a drive voltage, higher than the input voltage, to the topside power switch. Place a 0.47μF boost capacitor ($C_{BOOT}$) as close as possible to the IC. Do not place a resistor in series with this pin. |
| 2 | GND | Ground. Voltage reference for the regulated output voltage. Requires special layout considerations. |
| 3 | FB | Feedback Pin. Set the output voltage. The SGM61410 regulates the FB pin to 0.8V. Connect the feedback resistor divider tap to this pin. |
| 4 | EN | Enable Pin. Pull $V_{EN}$ above 1.2V to turn the device ON; pull $V_{EN}$ below 0.4V to turn the device OFF. For automatic enable, connect to VIN pin using a 100kΩ resistor. |
| 5 | VIN | Supply Voltage. The SGM61410 operates from a 5V to 45V unregulated input voltage. Requires $C_{IN}$ to prevent large voltage spikes from appearing at the input. |
| 6 | SW | Switching Node. The SW pin is the output of the internal power switches. Connect this pin to the inductor and boost capacitor. This node should be kept small on the PCB for good performance. |

## ELECTRICAL CHARACTERISTICS

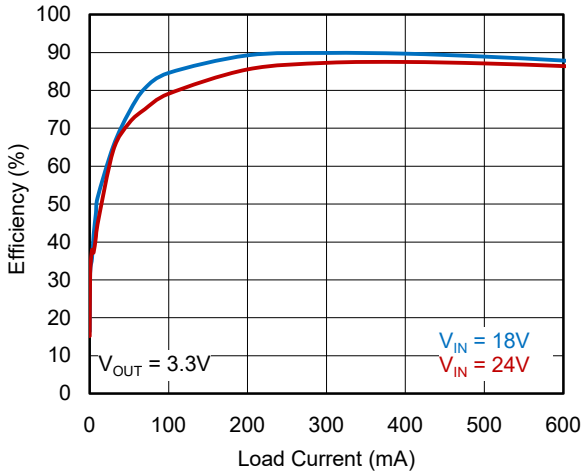
($V_{IN}$ = 18V, typical values are at $T_A$ = +25℃, unless otherwise noted.)

| PARAMETER | | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Supply Input Voltage | | $V_{IN}$ | | 5 | | 45 | V |
| Under-Voltage Lockout Threshold | | $V_{UVLO}$ | | | 4.6 | | V |
| Under-Voltage Lockout Threshold Hysteresis | | $V_{UVLO\_HYS}$ | | | 350 | | mV |
| VIN Quiescent Current | Shutdown | $I_Q$ | $V_{EN/UV}$ = 0V | | 0.8 | | μA |
| | Sleep Mode | | $V_{EN/UV}$ = 2V, Not Switching, $V_{IN}$ ≤ 36V | | 14 | | |
| Feedback Reference Voltage | | $V_{FB}$ | $V_{IN}$ = 6V | | 0.800 | | V |
| Feedback Pin Input Current | | $I_{FB}$ | $V_{FB}$ = 1V | | 5 | | nA |
| Minimum On-Time | | $t_{ON}$ | $I_{LOAD}$ = 600mA | | 100 | | ns |
| Switching Frequency | | $f_{SW}$ | | | 1.2 | | MHz |
| Top Power NMOS Current Limit | | $I_{LIM}$ | | | 1.2 | | A |
| Top Power NMOS On-Resistance | | $R_{DSON}$ | $I_{LOAD}$ = 0.1A | | 700 | | mΩ |
| Bottom Power NMOS On-Resistance | | | $I_{LOAD}$ = 0.1A | | 300 | | mΩ |
| EN Threshold | Logic-High Voltage | $V_{ENH}$ | $V_{EN}$ Rising | 1.2 | | | V |
| | Logic-Low Voltage | $V_{ENL}$ | $V_{EN}$ Falling | | | 0.4 | |
| EN Threshold, Hysteresis | | | | | 120 | | mV |
| Enable Leakage Current | | $I_{EN}$ | | | 0.1 | | μA |
| Output Over-Voltage Threshold | | $V_{OUT\_OV}$ | OVP Rising | | 0.892 | | V |
| | | | OVP Falling | | 0.844 | | |
| Thermal Shutdown | | | | | 150 | | ℃ |
| Thermal Shutdown Hysteresis | | | | | 20 | | ℃ |

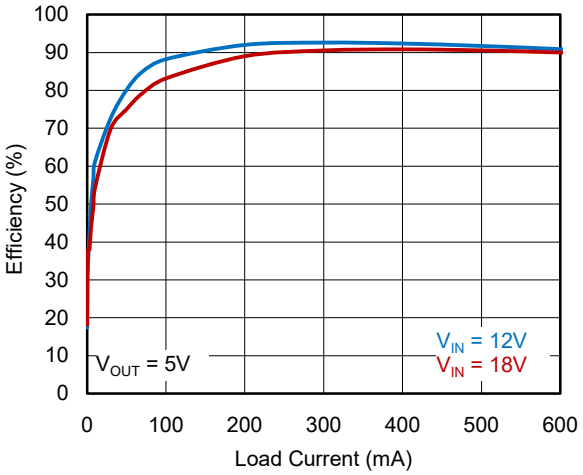
## TYPICAL PERFORMANCE CHARACTERISTICS

$T_A$ = +25℃, $V_{IN}$ = 18V, L = 22μH and $C_{OUT}$ = 10μF, unless otherwise noted.

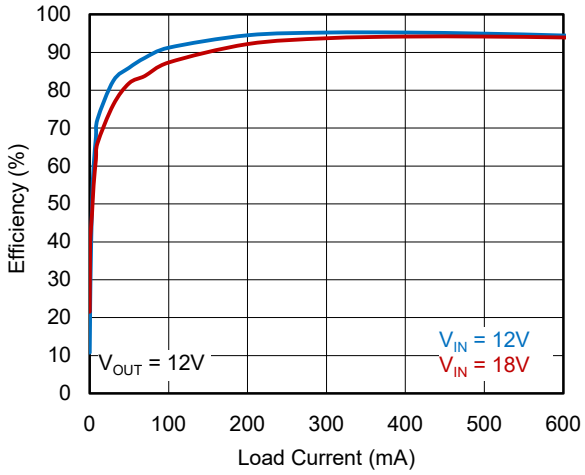
Efficiency vs. Load Current



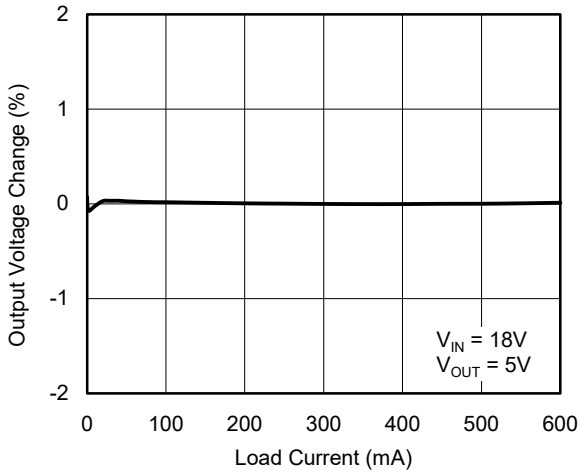

Efficiency vs. Load Current



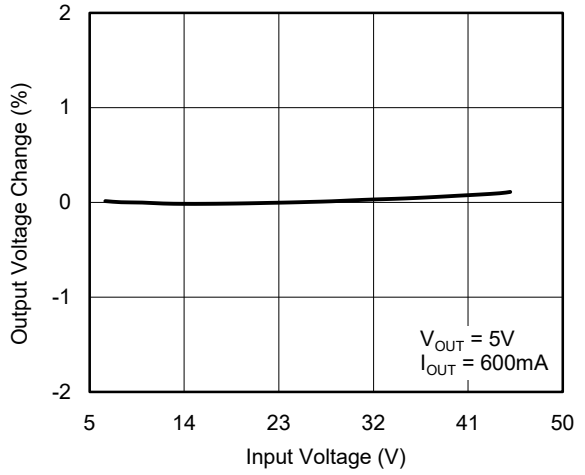

Efficiency vs. Load Current



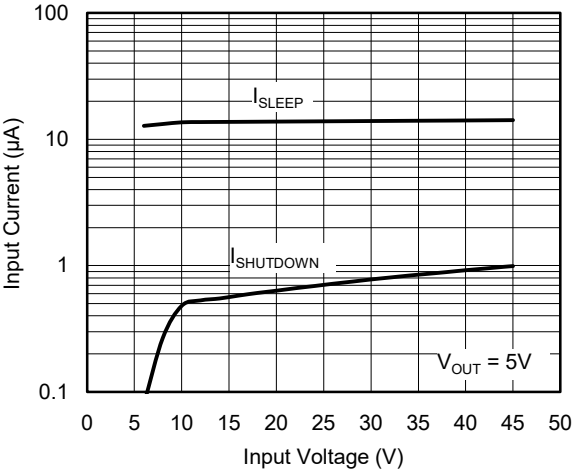

Load Regulation




Line Regulation



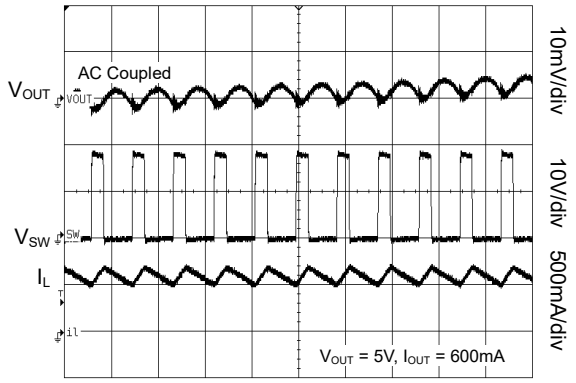

Shutdown Current and Quiescent Current



## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

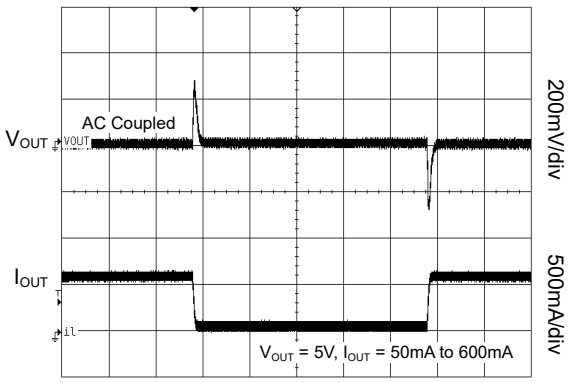
$T_A$ = +25℃, $V_{IN}$ = 18V, L = 22μH and $C_{OUT}$ = 10μF, unless otherwise noted.

Output Voltage Ripple



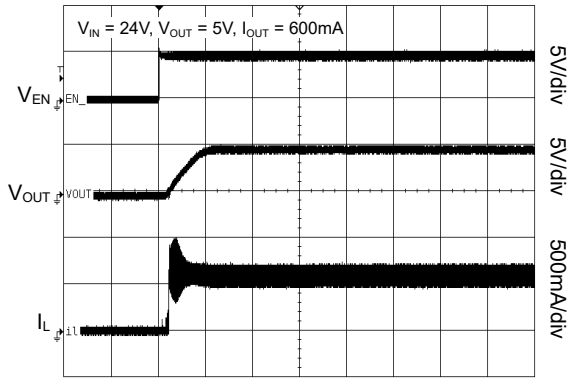

Time (1μs/div)

Load Transient Response



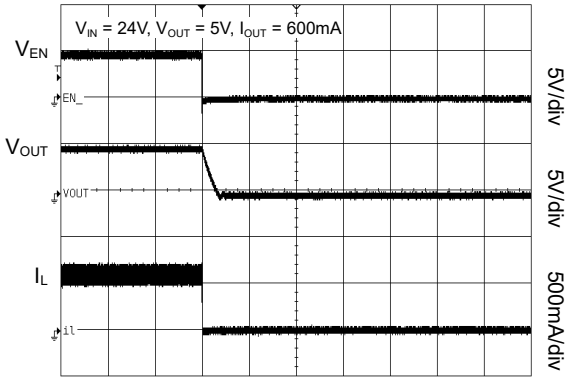

Time (1ms/div)

Startup



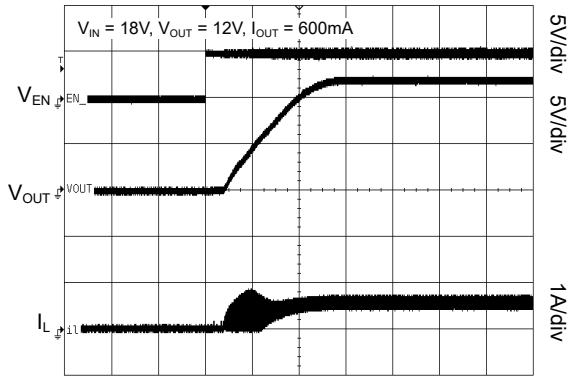

Time (2ms/div)

Shutdown



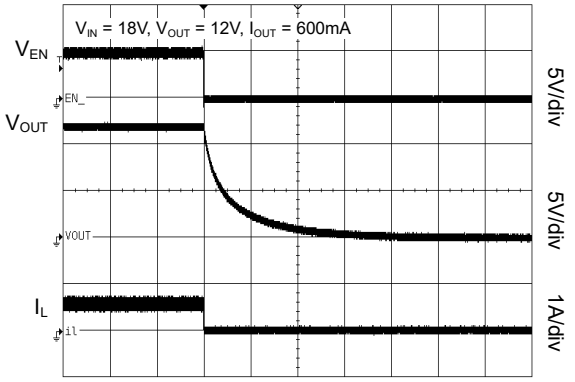

Time (200μs/div)

Startup




Time (800μs/div)

Shutdown

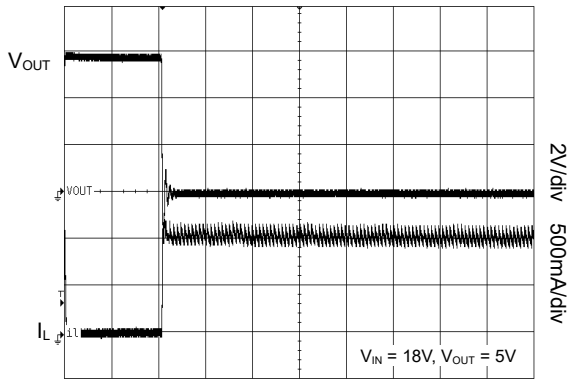



Time (200μs/div)

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

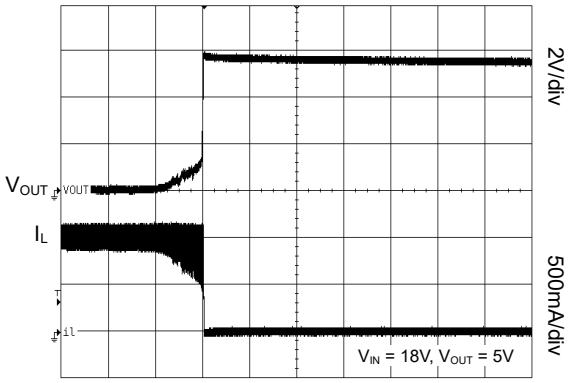
$T_A$ = +25℃, $V_{IN}$ = 18V, L = 22μH and $C_{OUT}$ = 10μF, unless otherwise noted.

Short Circuit Entry



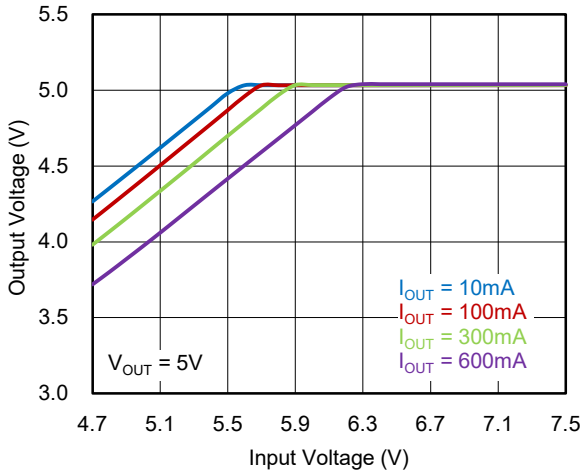

Time (100μs/div)

Short Circuit Recovery




Time (800μs/div)

Dropout Curve



## FUNCTIONAL BLOCK DIAGRAM

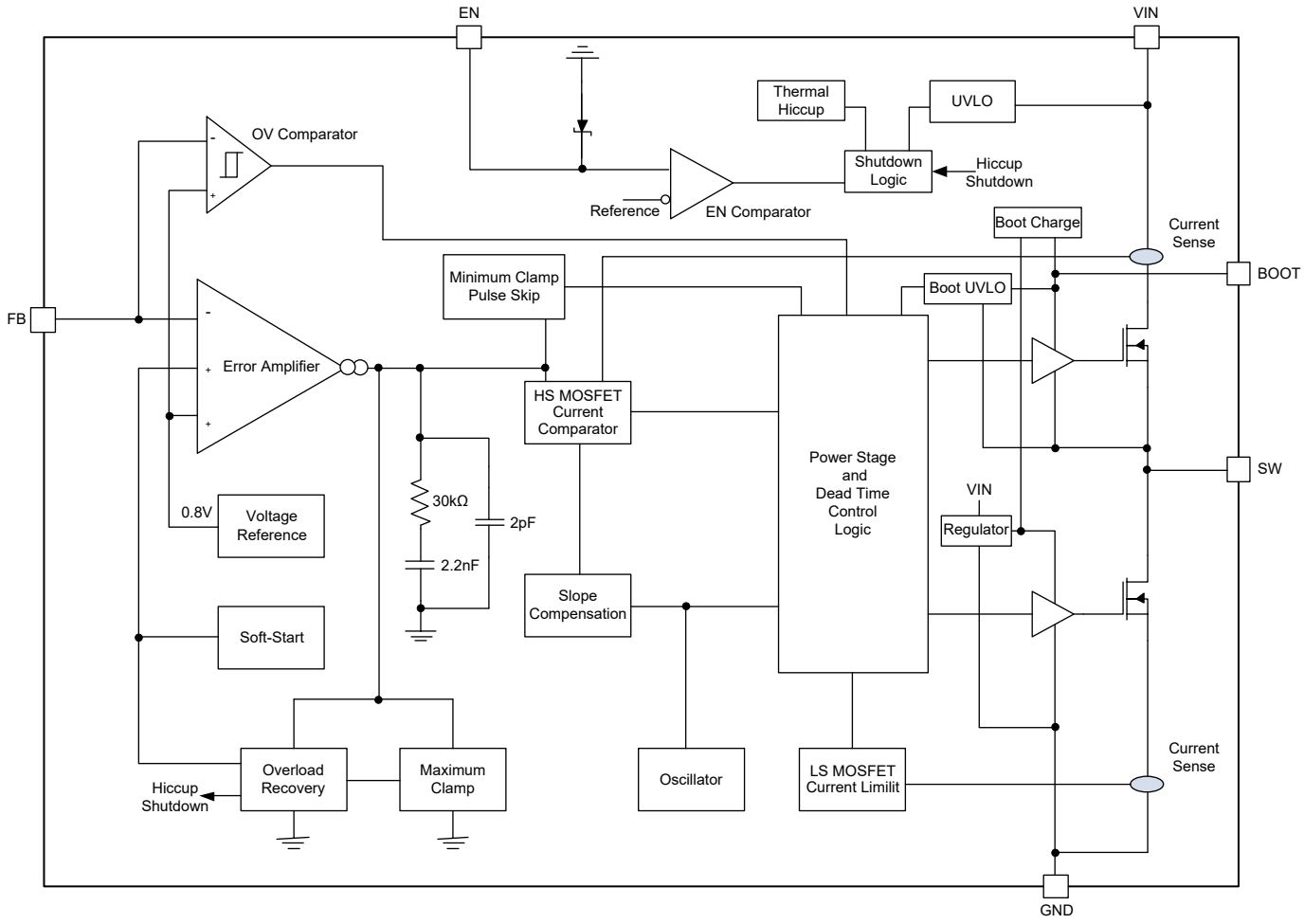



**Figure 2. SGM61410 Block Diagram**

# DETAILED DESCRIPTION

## Floating Driver and Bootstrap Charging UVLO Protection

The floating power MOSFET driver is powered by an external bootstrap capacitor. This floating driver has its own UVLO protection. This UVLO's rising threshold is about 4.6V with a threshold of about 350mV. During this UVLO, the reference voltage of the controller is reset to zero. When the UVLO is removed, the controller follows soft-start process.

The bootstrap capacitor is charged and regulated to about 5V by the dedicated internal bootstrap regulator. When the voltage between BOOT and SW nodes is lower than its regulation, a PMOS pass transistor connected from VIN to BOOT is turned on. The charging current path is from VIN, BOOT and then to SW. External circuit should provide enough voltage headroom to facilitate the charging.

## Enable

The voltage on the EN pin controls the ON or OFF operation of SGM61410. A voltage of less than 0.4V shuts down the device, while a voltage of more than 1.2V is required to start the regulator. The EN pin is an input and cannot be left open or floating. The simplest way to enable the operation of the SGM61410 is to connect the EN pin to VIN pin using 100kΩ resistor. This allows self-startup of the SGM61410 when VIN is within the operating range.

An external logic signal can also be used to drive EN input for system sequencing and protection. Kindly note that, the EN pin voltage should never be higher than $V_{IN}$ + 0.3V. So it's not recommended to apply EN voltage when $V_{IN}$ is 0V.

## Output Over-Voltage Protection (OVP)

The SGM61410 also includes an over-voltage comparator that monitors the FB pin exceeding 110%. When the voltage at the FB pin exceeds the over-voltage threshold ($V_{OUT\_OV}$), SGM61410 will stop PWM switching, i.e. both high-side and low-side switches will be turned off.

In most cases, the error amplifier will be able to maintain regulation since the synchronous output stage has excellent sink and source capability. However the error amplifier and its regulation voltage clamp are not effective when the FB pin is disconnected or when the output is shorted to the input supply. When the FB pin is disconnected from the feedback resistor divider, a tiny internal current source will force the voltage at the FB pin to rise above $V_{OUT\_OV}$ and disable the regulator, preventing the load from being significantly over-voltage. If a higher external voltage is accidently shorted to the SGM61410's output, $V_{FB}$ will rise above the over-voltage threshold, triggering an OVP event and thus protecting the low-side switch. In either case, if the conditions causing the over-voltage are corrected, the regulator will automatically recover.

## Output Voltage Programming

Output voltage can be set by feeding back the output to the FB pin with a resistor divider network. In the application circuit shown in Figure 1. The resistor divider network includes $R_1$ and $R_2$. Usually, a design is started by picking a fixed $R_2$ value and calculating the required $R_1$ with equation below.

$$V_{OUT} = V_{REF} \times \left(1 + \frac{R_1}{R_2}\right)$$

where an internal reference voltage $V_{REF}$ = 0.8V (TYP).

To keep the operating quiescent current to a minimum, it is recommended that $R_2$ be set in the range of 10kΩ to 100kΩ.

## Thermal Shutdown

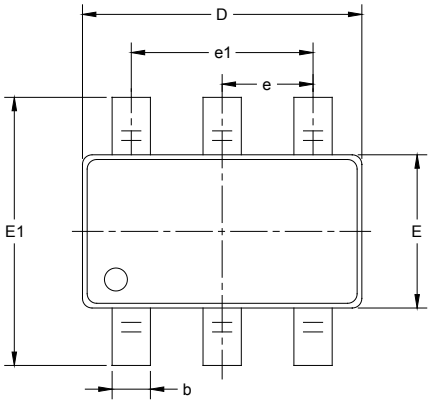
The SGM61410 provides an internal thermal shutdown to protect the device when the junction temperature exceeds +150℃. Both HS and LS FETs stop switching in thermal shutdown. Once the die temperature falls below +130℃, the device reinitiates the power up sequence controlled by the internal soft-start circuitry.

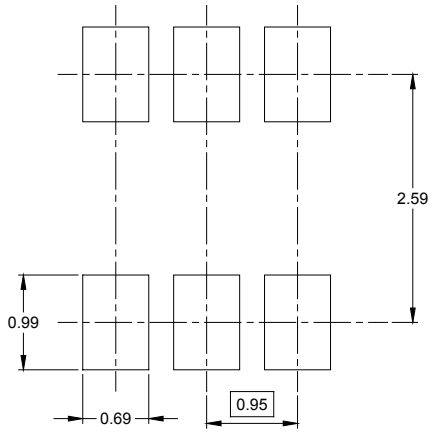
## Component Selection

| $f_{SW}$ (MHz) | $V_{OUT}$ (V) | L (μH) | $C_{OUT}$ (μF) | $C_{IN}$ (μF) | $C_{BOOT}$ (μF) | $R_1$ (kΩ) | $R_2$ (kΩ) |
|---|---|---|---|---|---|---|---|
| 1.2 | 3.3 | 10 | 22 | 10 | 0.47 | 31.2 | 10 |
| | 5 | 22 | 22 | 10 | 0.47 | 52.5 | 10 |
| | 12 | 33 | 22 | 10 | 0.47 | 140 | 10 |

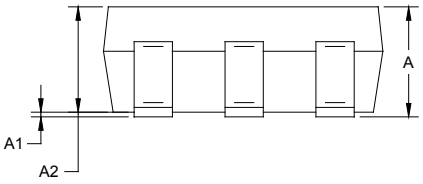
# PACKAGE OUTLINE DIMENSIONS

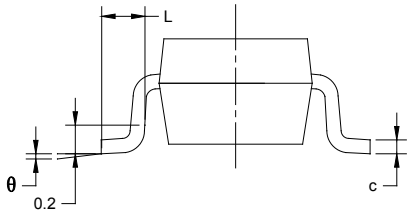
## SOT-23-6




**RECOMMENDED LAND PATTERN** (Unit: mm)

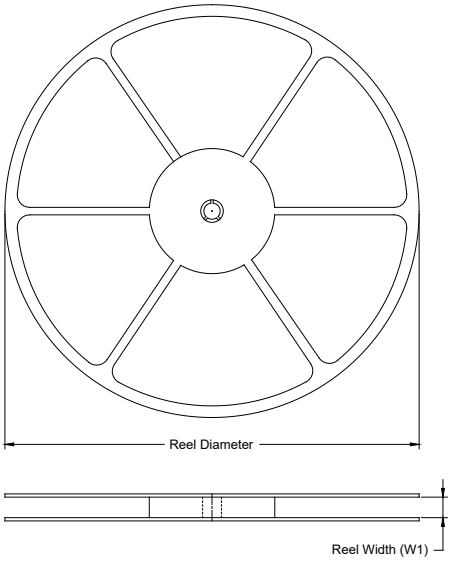


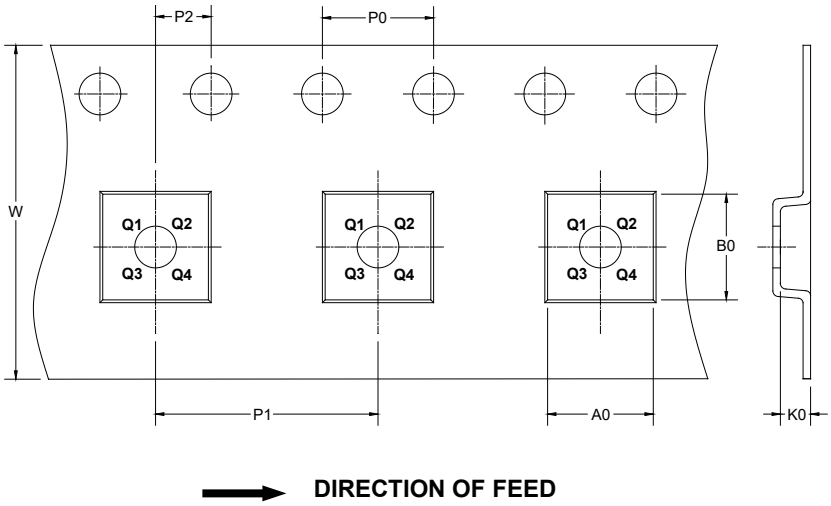

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 1.050 | 1.250 | 0.041 | 0.049 |
| A1 | 0.000 | 0.100 | 0.000 | 0.004 |
| A2 | 1.050 | 1.150 | 0.041 | 0.045 |
| b | 0.300 | 0.500 | 0.012 | 0.020 |
| c | 0.100 | 0.200 | 0.004 | 0.008 |
| D | 2.820 | 3.020 | 0.111 | 0.119 |
| E | 1.500 | 1.700 | 0.059 | 0.067 |
| E1 | 2.650 | 2.950 | 0.104 | 0.116 |
| e | 0.950 BSC | | 0.037 BSC | |
| e1 | 1.900 BSC | | 0.075 BSC | |
| L | 0.300 | 0.600 | 0.012 | 0.024 |
| θ | 0° | 8° | 0° | 8° |

# TAPE AND REEL INFORMATION

### REEL DIMENSIONS




### TAPE DIMENSIONS




DIRECTION OF FEED

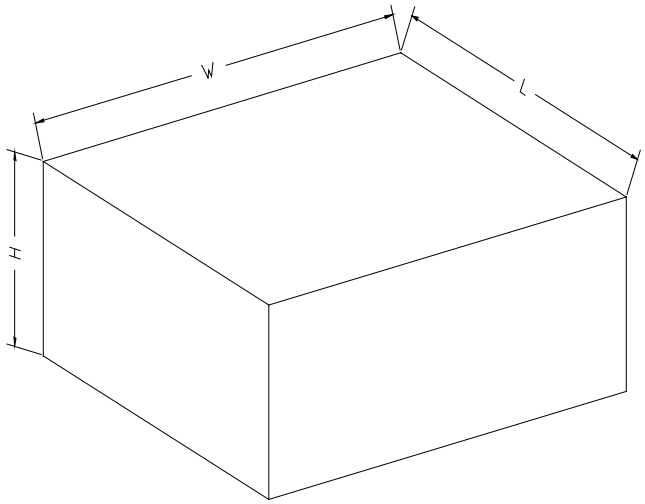
NOTE: The picture is only for reference. Please make the object as the standard.

## KEY PARAMETER LIST OF TAPE AND REEL

| Package Type | Reel Diameter | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P0 (mm) | P1 (mm) | P2 (mm) | W (mm) | Pin1 Quadrant |
|---|---|---|---|---|---|---|---|---|---|---|
| SOT-23-6 | 7″ | 9.5 | 3.17 | 3.23 | 1.37 | 4.0 | 4.0 | 2.0 | 8.0 | Q3 |

DD0001

## CARTON BOX DIMENSIONS




NOTE: The picture is only for reference. Please make the object as the standard.

## KEY PARAMETER LIST OF CARTON BOX

| Reel Type | Length (mm) | Width (mm) | Height (mm) | Pizza/Carton |
|---|---|---|---|---|
| 7″ (Option) | 368 | 227 | 224 | 8 |
| 7″ | 442 | 410 | 224 | 18 |

DD0002