# SGM42505/SGM42506
# 3.6A Brushed DC Motor Drivers

## GENERAL DESCRIPTION

The SGM42505 and SGM42506 devices are brushed DC motor drivers. These devices integrate four N-MOSFETs, which can supply up to 3.6A peak current at 40V voltage.

The SGM42505 supports IN1/IN2 PWM interface and the SGM42506 supports PH/EN interface. PWM signal can be implemented on the input interface to adjust motor speed. Customer can adjust PWM current limit or torque in real-time by VREF pin with a controller's DAC output or PWM signal after RC filter.

A number of protection features are provided in the device including over-current, short-circuit, under-voltage lockout and thermal shutdown. When the fault condition is removed, the device automatically resumes normal operation.

The SGM42505 and SGM42506 are available in a Green SOIC-8 (Exposed Pad) package.

## FEATURES

- **H-Bridge Motor Driver**
- **Operating Voltage Range: 7V to 40V**
- **Low On-Resistance: 0.41Ω (HS + LS) at +25℃**
- **3.6A Peak Output Current**
- **Interface**
  - **SGM42505: IN1/IN2**
  - **SGM42506: PH/EN**
- **Adjustable PWM Current Limit in Real-Time**
- **Low Power Standby Mode**
- **Integrated Protection Features**
  - **Over-Current Protection (OCP)**
  - **Under-Voltage Lockout (UVLO)**
  - **Thermal Shutdown (TSD)**
  - **Auto-Retry**
- **Available in a Green SOIC-8 (Exposed Pad) Package**

## APPLICATIONS

Printers
Vacuum Cleaners Robotics
Industrial Pumps and Valves

## TYPICAL APPLICATION

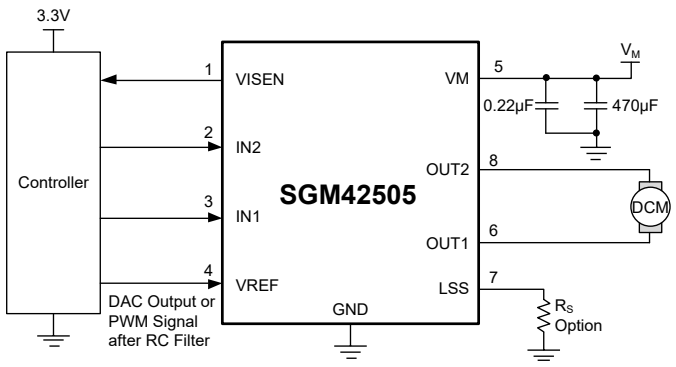


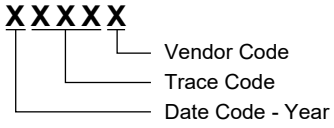

**Figure 1. Typical Application Circuit**

# PACKAGE/ORDERING INFORMATION

| MODEL | PACKAGE DESCRIPTION | SPECIFIED TEMPERATURE RANGE | ORDERING NUMBER | PACKAGE MARKING | PACKING OPTION |
|---|---|---|---|---|---|
| SGM42505 | SOIC-8 (Exposed Pad) | -40℃ to +125℃ | SGM42505XPS8G/TR | SGM<br>42505XPS8<br>XXXXX | Tape and Reel, 4000 |
| SGM42506 | SOIC-8 (Exposed Pad) | -40℃ to +125℃ | SGM42506XPS8G/TR | SGM<br>42506XPS8<br>XXXXX | Tape and Reel, 4000 |

## MARKING INFORMATION

NOTE: XXXXX = Date Code, Trace Code and Vendor 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

Power Supply Voltage, $V_M$ ..... 45V
EN, PH, IN1, IN2..... -0.3V to 6V
VREF ..... -0.3V to 5V
LSS..... ±0.5V (DC Condition)
..... ±2.5V (< 200ns)
Peak Output Current (Duty Cycle = 100%)..... 3.6A
Package Thermal Resistance
SOIC-8 (Exposed Pad), $\theta_{JA}$..... 37℃/W
Junction Temperature .....+150℃
Storage Temperature Range..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) .....+260℃
ESD Susceptibility
HBM..... 2000V
CDM ..... 1000V

## RECOMMENDED OPERATING CONDITIONS

Power Supply Voltage, $V_M$ .....7V to 40V
Logic Input PWM Frequency (IN1, IN2), $f_{PWM}$ .....
..... 0kHz to 100kHz
Junction Temperature Range ..... -40℃ to +150℃
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

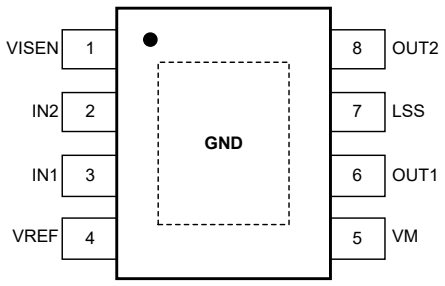
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because even small parametric changes could cause the device not to meet the published specifications.

## DISCLAIMER

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

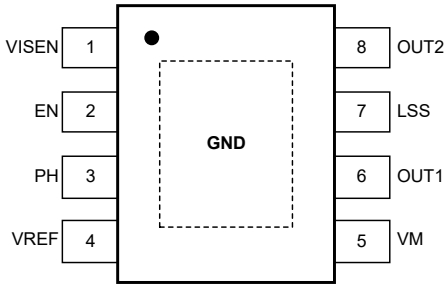
## PIN CONFIGURATIONS

SGM42505 (TOP VIEW)




SOIC-8 (Exposed Pad)

SGM42506 (TOP VIEW)




SOIC-8 (Exposed Pad)

## PIN DESCRIPTION

| PIN | NAME | | TYPE | FUNCTION |
|---|---|---|---|---|
| | SGM42505 | SGM42506 | | |
| 1 | VISEN | VISEN | O | Current Sense Output Voltage. |
| 2 | IN2 | - | I | Logic Input 2. |
| | - | EN | I | Enable Input. Logic low to place the H-bridge in brake mode or coast mode. |
| 3 | IN1 | - | I | Logic Input 1. |
| | - | PH | I | Direction Input. Control the direction and speed of the H-bridge. |
| 4 | VREF | VREF | I | Analog Input. Analog input to set current limit. |
| 5 | VM | VM | P | Supply Voltage. |
| 6 | OUT1 | OUT1 | O | H-Bridge Output 1. Output of H-bridge driving stage. |
| 7 | LSS | LSS | O | Power Return. Sense resistor connection (option) or connect to power pad ground directly. |
| 8 | OUT2 | OUT2 | O | H-Bridge Output 2. Output of H-bridge driving stage. |
| Exposed Pad | GND | GND | - | Exposed Pad. Exposed pad for enhanced thermal dissipation. Exposed pad is the only ground of this IC, so it must be closely connected with ground. |

NOTE: I: input, O: output, G: ground, P: power for the circuit.

## ELECTRICAL CHARACTERISTICS

($T_J$ = +25℃, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **Power Supply (VM)** | | | | | | |
| Power Supply Voltage | $V_M$ | | 7 | | 40 | V |
| Power Supply Current | $I_{VM}$ | $V_M$ = 12V | | 2 | 3 | mA |
| Standby Mode Supply Current | $I_{VMQ}$ | $V_M$ = 12V | | 3 | 5 | μA |
| **Logic Level Inputs** | | | | | | |
| Input Logic Low Voltage | $V_{IL}$ | $T_J$ = -40℃ to +125℃ | | | 0.5 | V |
| Input Logic High Voltage | $V_{IH}$ | $T_J$ = -40℃ to +125℃ | 1.5 | | | V |
| Input Logic Hysteresis | $V_{HYS}$ | | | 350 | | mV |
| Input Logic Low Current | $I_{IL}$ | $V_{IN}$ = 0V | -1 | | 1 | μA |
| Input Logic High Current | $I_{IH}$ | $V_{IN}$ = 3.3V | | 25 | 100 | μA |
| Pull-Down Resistance | $R_{PD}$ | To GND | | 130 | | kΩ |
| Propagation Delay Time | $t_{PD}$ | INx to OUTx change | | 1.1 | | μs |
| **Motor Driver Outputs (OUT1 and OUT2)** | | | | | | |
| High-side FET On-Resistance | $R_{DSON}$ | $V_M$ = 24V, $I_{OUT}$ = 0.5A | | 250 | 300 | mΩ |
| Low-side FET On-Resistance | | $V_M$ = 24V, $I_{OUT}$ = 0.5A | | 160 | 190 | mΩ |
| Body Diode Forward Voltage (1) | $V_D$ | $I_{OUT}$ = 1A | | 0.8 | | V |
| **Timing** | | | | | | |
| Turn-On Time (2) | $t_{ON}$ | $V_M$ > $V_{UVLO}$ with IN1 or IN2 high | | 130 | | μs |
| Crossover Delay | $t_{COD}$ | | | 400 | | ns |
| VREF Input Voltage Range | $V_{REF}$ | | 0 | | 4 | V |
| VREF Voltage Gain | $A_V$ | $V_{REF}/V_{LSS}$, $V_{REF}$ = 2.5V | 9.2 | 10 | 11.3 | V/V |
| Constant Off-Time | $t_{OFF}$ | | | 12.5 | | μs |
| Standby Timer | $t_{ST}$ | SGM42505: IN1 = IN2 = 0V | | 1 | 1.5 | ms |
| | | SGM42506: EN = PH = 0V | | 1 | 1.5 | ms |
| **Protection Circuits** | | | | | | |
| VM Under-Voltage Lockout | $V_{UVLO}$ | $V_M$ falls until UVLO triggers | | 6 | 6.6 | V |
| | | $V_M$ rises until operation recovers | | 6.2 | 6.8 | |
| VM Under-Voltage Hysteresis | $V_{HYS}$ | Rising to falling threshold | 100 | 200 | | mV |
| Over-Current Protection Trip Level | $I_{OCP}$ | | | 4 | | A |
| Over-Current Deglitch Time | $t_{OCP}$ | | | 2 | | μs |
| Over-Current Retry Time | $t_{RETRY}$ | | | 10 | | ms |
| Thermal Shutdown Temperature | $T_{SD}$ | | | 165 | | ℃ |
| Thermal Shutdown Temperature Hysteresis | $T_{HYS}$ | | | 30 | | ℃ |
| **Current Detection Amplifier** | | | | | | |
| Slew Rate | SR | | | 7 | | V/μs |
| Drift Offset | $V_{DRIFT}$ | | | 2 | | μV/℃ |
| Settling Time to ±1% | $t_{SET}$ | Gain = 5 | | 100 | | ns |
| High-Gain Bandwidth | | $C_L$ = 100pF, $R_L$ = 600Ω | | 4 | | MHz |
| Input Offset Voltage | | | | 360 | | μV |
| VISEN Voltage Gain | $A_O$ | $V_{ISEN}/V_{LSS}$ | | 5 | | V/V |

NOTES:

1. It is recommended that the maximum current of the body diode should be less than 1.5A.
2. $t_{ON}$ applies when the device initially powers up, and when it exits standby mode.

## PWM CONTROL TIMING DIAGRAM AND TRUTH TABLE

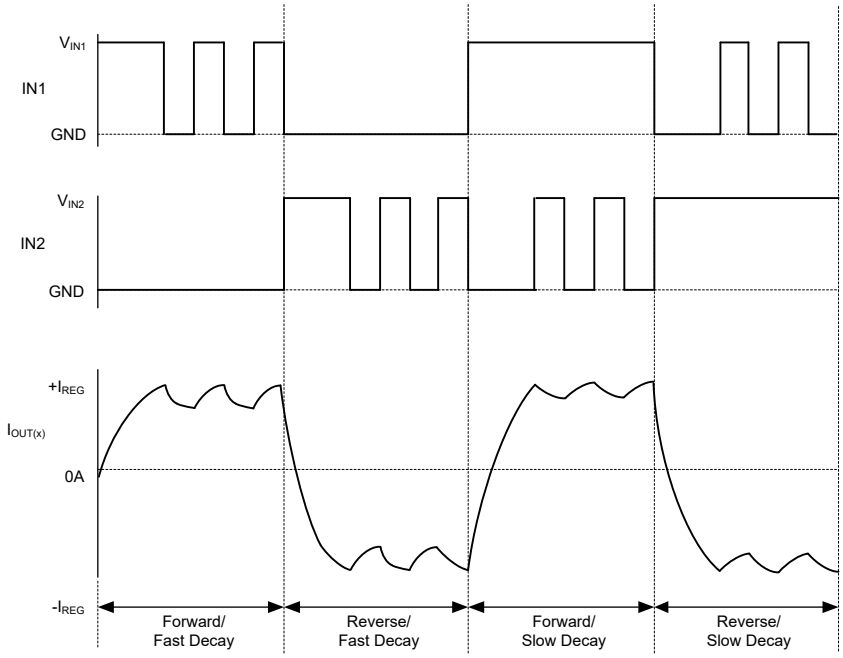



**Figure 2. SGM42505 PWM Control Timing**

**Table 1. SGM42505 PWM Control Truth Table**

| IN1 | IN2 | OUT1 | OUT2 | Function |
|---|---|---|---|---|
| 0 | 1 | L | H | Reverse |
| 1 | 0 | H | L | Forward |
| 1 | 1 | L | L | Brake (Slow Decay) |
| 0 | 0 | Z | Z | Coast, enter in the low power standby mode after 1ms.<br>It will be a fast decay that discharges through the body diode. |

NOTE: Z = high-impedance.

**Table 2. SGM42505 PWM Decay Logic**

| IN1 | IN2 | Decay Logic |
|---|---|---|
| PWM | 1 | Slow Decay |
| PWM | 0 | Fast Decay |
| 1 | PWM | Slow Decay |
| 0 | PWM | Fast Decay |

The inputs can also be used for PWM control, for example, the speed of a DC motor. The PWM signal can be applied to IN1 or IN2 pin.

If one input is set to high and the other input is set to PWM, the decay mode is slow decay. When IN1 is high and IN2 is PWM, the motor is running forward. When IN2 is high and IN1 is PWM, the motor is running reverse.

If one input is set to PWM and the other input is set to low, the decay mode is fast decay. When IN1 is PWM and IN2 is low, the motor is running forward. When IN2 is PWM and IN1 is low, motor is running reverse.

## PWM CONTROL TIMING DIAGRAM AND TRUTH TABLE (continued)

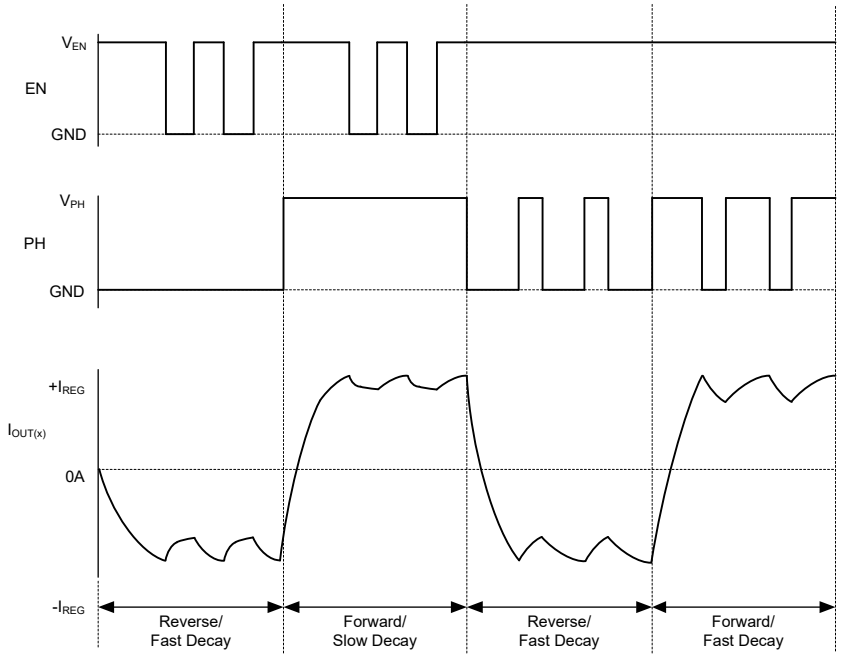



**Figure 3. SGM42506 PWM Control Timing**

**Table 3. SGM42506 PH/EN Control Truth Table**

| EN | PH | OUT1 | OUT2 | Function |
|---|---|---|---|---|
| 1 | 0 | L | H | Reverse |
| 1 | 1 | H | L | Forward |
| 0 | 1 | L | L | Brake (Slow Decay) |
| 0 | 0 | Z | Z | Coast, enter in the low power standby mode after 1ms.<br>It will be a fast decay that discharges through the body diode. |

NOTE: Z = high-impedance.

**Table 4. SGM42506 PWM Decay Logic**

| EN | PH | Decay Logic |
|---|---|---|
| 1 | PWM | Fast Decay |
| PWM | 0 | Fast Decay |
| PWM | 1 | Slow Decay |

The inputs can also be used for PWM control, for example, the speed of a DC motor.

The PWM signal can be applied to EN or PH pin.

If PWM signal is applied to EN pin, the PH pin is set to high or low to control the motor direction. When PH is high, the motor is running forward, and the decay mode is the slow decay. When PH is low, the motor is running reverse, and the decay mode is the fast decay.

If PWM signal is applied to PH pin, the decay mode is fast decay and the EN pin needs to be set high to enable the output. When PWM duty cycle is from 50% to 100%, the motor is running forward. When PWM duty cycle is from 0% to 50%, the motor is running reverse.

## FUNCTIONAL BLOCK DIAGRAMS

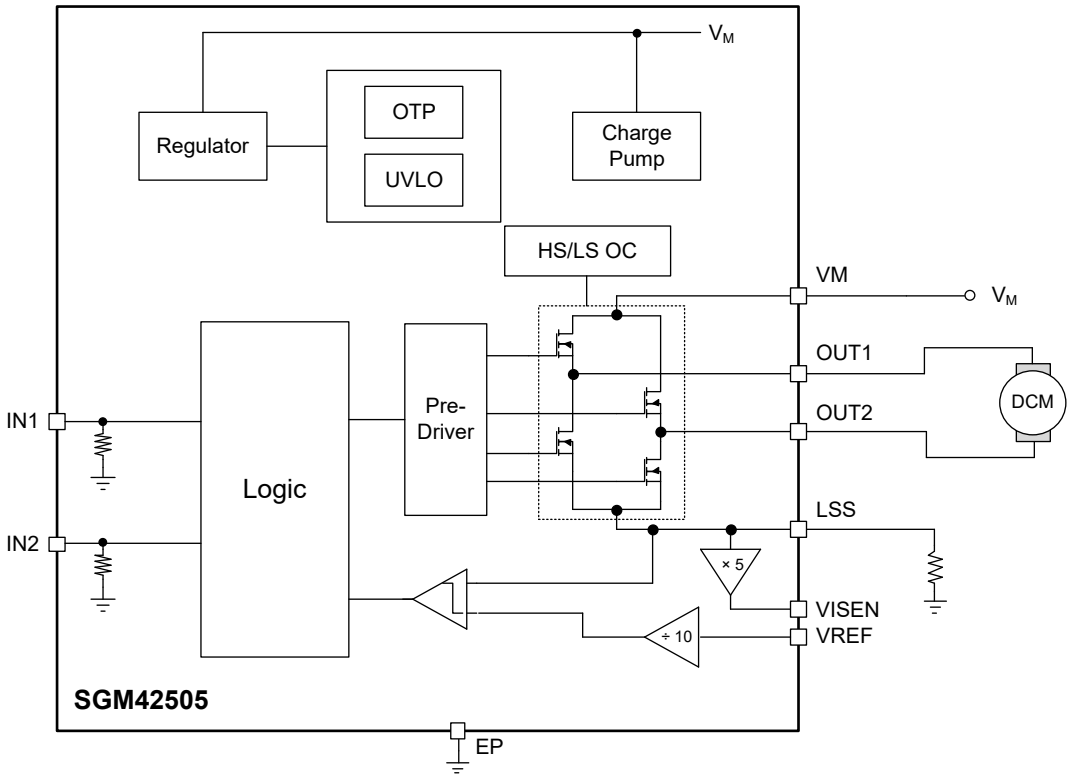



**Figure 4. SGM42505 Functional Block Diagram**

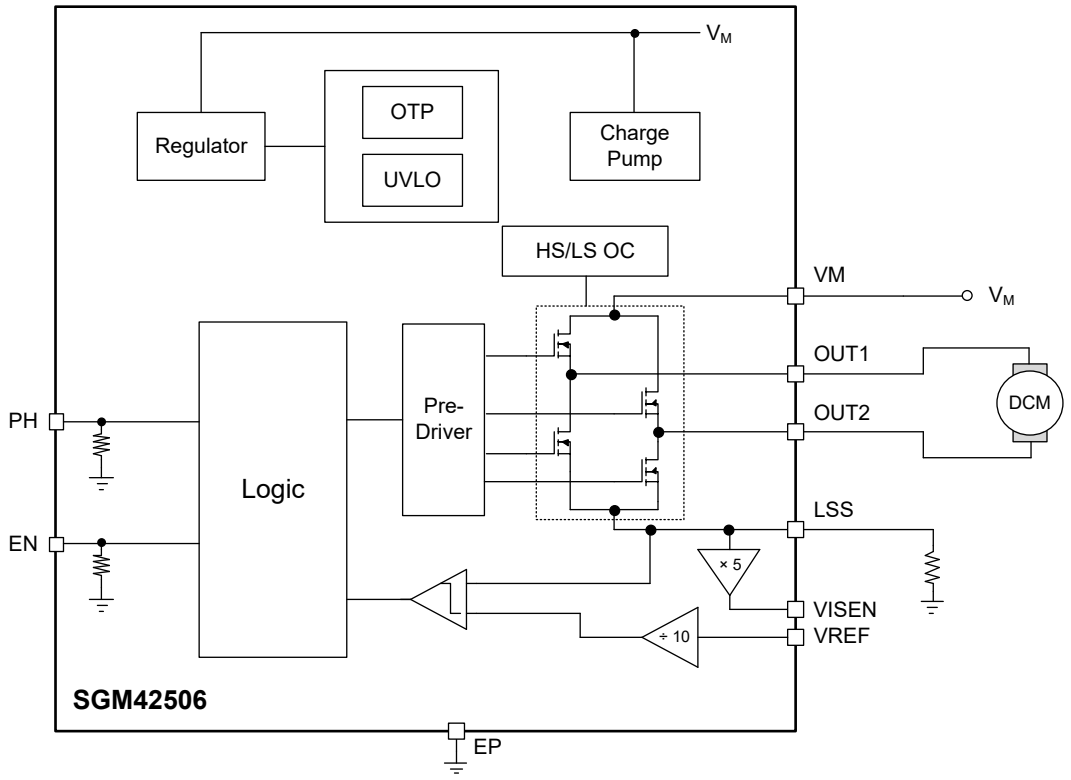
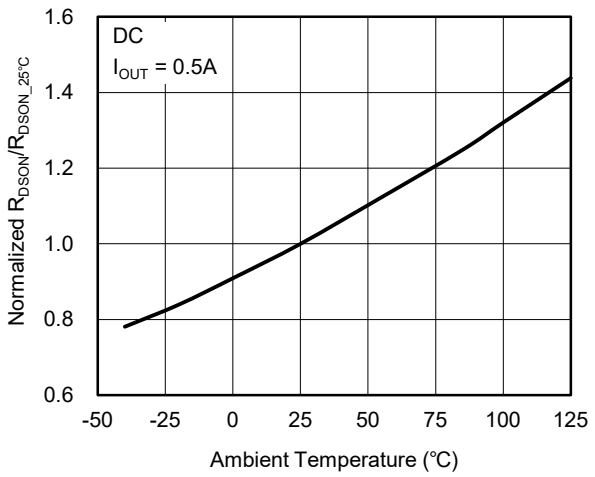


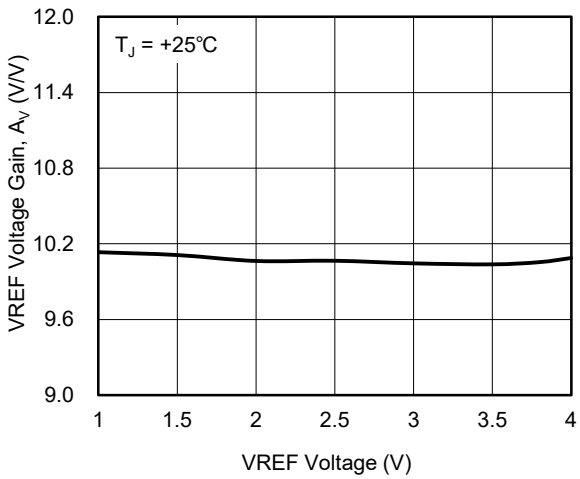

**Figure 5. SGM42506 Functional Block Diagram**

## TYPICAL PERFORMANCE CHARACTERISTICS

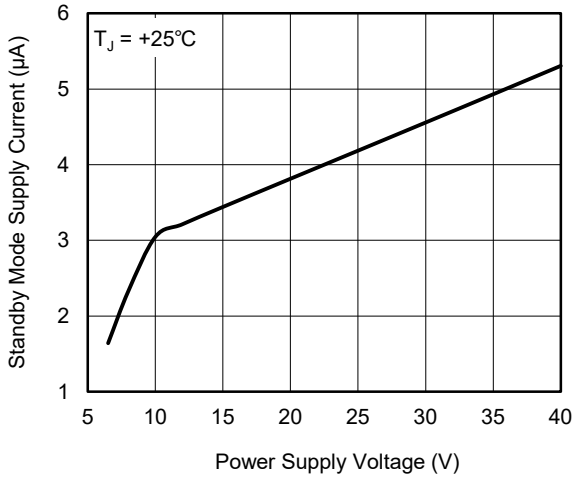
$R_{DSON}$ vs. Temperature




VREF Voltage Gain vs. VREF Voltage




Standby Mode Supply Current vs. Power Supply Voltage



# DETAILED DESCRIPTION

## Device Operation

The SGM42505 and SGM42506 are typically used to drive a DC motor. An internal charge pump generates the necessary gate-drive voltage. The SGM42505 and SGM42506 operate from 7V to 40V motor power supply, which can supply a 3.6A peak current. Full protection features include over-current protection, under-voltage lockout and over-temperature protection.

## Standby Mode

For SGM42505, if both input pins (IN1/IN2) are low for longer than 1ms, the device will go to standby mode. For SGM42506, the device will go to standby mode if EN/PH pins are low for longer than 1ms. If entering the standby mode, the output MOSFET, charge pump, and regulator are turned off for saving power.

## Internal PWM Current Control

The current in the output is limited using fixed off-time control circuitry. If the motor current goes over the current limit setting, the two low-side MOSFETs are both turned on for $t_{OFF}$ time, slow decay mode is used to adjust the current.

### $V_{REF}$

The current limit is decided by $V_{REF}$ and $R_S$ together, please refer to Equation 1:

$$I_{TRIPMAX}=\frac{V_{REF}}{10\times R_S} \quad (1)$$

## VISEN Current Sensing Output

An analog output can be used to monitor the load current flowing through the external sense resistor (if a sense resistor is installed). Positive voltage on the sense resistor is gained by 5 and output on the VISEN terminal. Negative voltage on the sense resistor is gained by -5 and output on the VISEN terminal. As the load current does not flow through the sense resistor during a slow decay (brake) condition, the VISEN output is approximately 0V when in slow decay.

The analog output $V_{ISEN}$ varies proportionally with the LSS voltage according to Equation 2:

$$V_{ISEN} = 5 \times |V_{LSS}| \quad (2)$$

An RC network in series with the $V_{ISEN}$ output is recommended, if this voltage is sampled by an analog to digital converter.

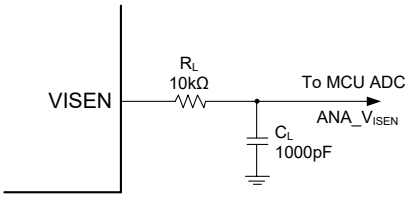



**Figure 6. RC Network in Series with the $V_{ISEN}$ Output**

It is necessary to realize that $V_{ISEN}$ will decrease to 0V when the H-bridge enters slow decay recirculation.

## Over-Current Protection (OCP)

Each MOSFET is protected by its own preset over-current limit. In case of an over-current (any direction), the whole bridge will be disabled (shutdown), and the device will retry after $t_{RETRY}$. An over-current will occur due to a short between a switching node and ground, VM supply line, or the other node of the bridge (a winding short).

## Under-Voltage Lockout (UVLO)

If the voltage on VM pin falls below its under-voltage lockout threshold, the device will be disabled. The device resumes operation when the power supply goes back above UVLO thresholds.

## Thermal Shutdown (TSD)

The driver is shutdown if a junction over-temperature occurs in the device. Once the temperature goes back to the safe level, the device resumes its operation.

# APPLICATION INFORMATION

## Sense Pin (LSS)

If PWM current control is used, it is recommended to place a low-value resistor between the LSS and GND pins for current sensing. In order to detect the output current, the ground trace IR drop should be minimized. Surface mounted and low inductance sense resistor is recommended. It is necessary to consider the package, since $I^2$ × R heat is generated in the sense resistor. And during PCB layout, place the resistor near to the motor driver as close as possible.

Ensure that the maximum voltage of LSS (±500mV) is not exceeded at the maximum load, and select the appropriate resistance value. This rating may be exceeded for a short time during an over-current event.

## Ground and Layout Guidelines

The power supply VM is suggested to be decoupled with a bulk capacitor in parallel with a lower value ceramic capacitor placed as close as practicable to the device.

The exposed pad on the bottom of the device provides a path for heat dissipation. The pad should be soldered directly to an exposed surface on the PCB board to achieve better thermal performance. Thermal vias are also helpful to dissipate the heat.

It is good to have a low impedance single-point ground, known as a star ground, which is located close to the device. The copper ground plane located under the device thermal pad is typically used as the star ground.

# REVISION HISTORY

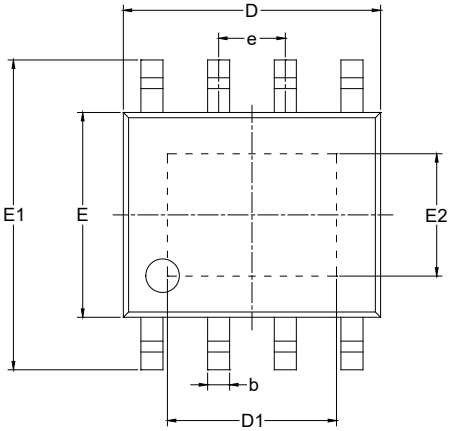
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

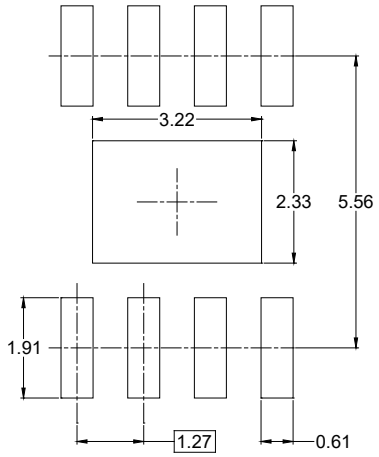
| JANUARY 2023 – REV.A to REV.A.1 | Page |
|---|---|
| Updated Electrical Characteristics section | 4 |

| Changes from Original (OCTOBER 2022) to REV.A | Page |
|---|---|
| Changed from product preview to production data | All |

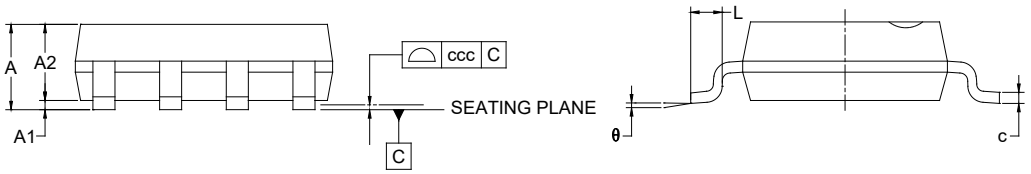
# PACKAGE OUTLINE DIMENSIONS

## SOIC-8 (Exposed Pad)




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

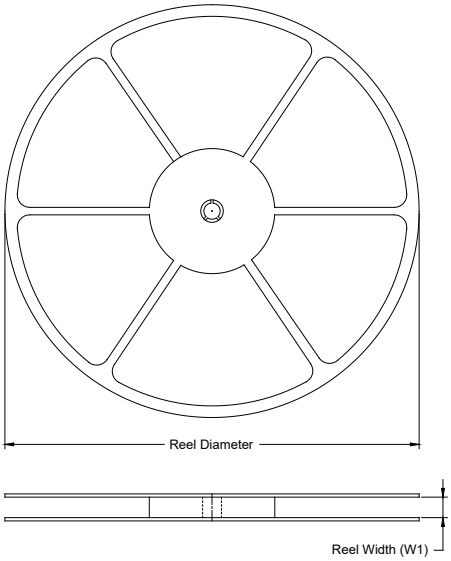



| Symbol | Dimensions In Millimeters | | |
|---|---|---|---|
| | MIN | MOD | MAX |
| A | | | 1.700 |
| A1 | 0.000 | - | 0.150 |
| A2 | 1.250 | - | 1.650 |
| b | 0.330 | - | 0.510 |
| c | 0.170 | - | 0.250 |
| D | 4.700 | - | 5.100 |
| D1 | 3.020 | - | 3.420 |
| E | 3.800 | - | 4.000 |
| E1 | 5.800 | - | 6.200 |
| E2 | 2.130 | - | 2.530 |
| e | 1.27 BSC | | |
| L | 0.400 | - | 1.270 |
| θ | 0° | - | 8° |
| ccc | 0.100 | | |

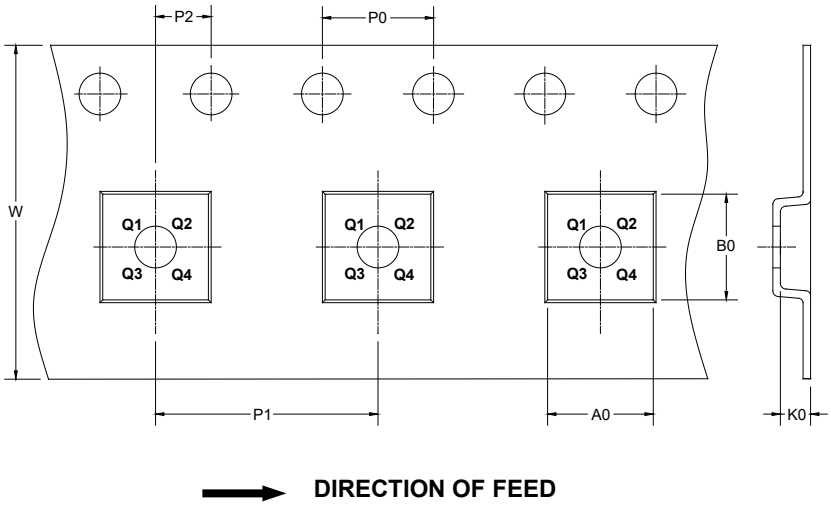
NOTES:
1. This drawing is subject to change without notice.
2. The dimensions do not include mold flashes, protrusions or gate burrs.
3. Reference JEDEC MS-012.

# TAPE AND REEL INFORMATION

### REEL DIMENSIONS




### TAPE DIMENSIONS



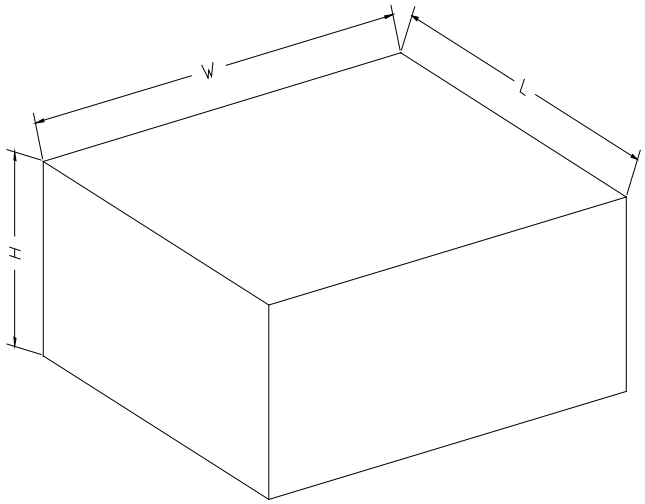

NOTE: The picture is only for reference. Please make the object as the standard.

## 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| SOIC-8 (Exposed Pad) | 13″ | 12.4 | 6.40 | 5.40 | 2.10 | 4.0 | 8.0 | 2.0 | 12.0 | Q1 |

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 |
|---|---|---|---|---|
| 13″ | 386 | 280 | 370 | 5 |

DD0002