SGM42606
Low On-Resistance, Single H-Bridge DC Motor Driver

GENERAL DESCRIPTION

The SGM42606 is a motor driver device with one integrated H-bridge that can run a DC motor, a solenoid, one winding of a bipolar stepper motor, or other devices. It can be used in a variety of applications such as consumer products, toys and other battery-powered motion-control applications.

This device integrates four N-MOSFETs, which can operate over a supply voltage range of 2V to 12V. With proper heatsinking, the SGM42606 can deliver up to 6A peak output current and 3A continuous output current. The required gate drive voltages are generated by an internal charge pump.

A number of protection features are provided in the device including over-current, short-circuit, over-voltage, under-voltage lockout and thermal shutdown.

The SGM42606 is available in a Green TQFN-5.5×3.5-24L package.

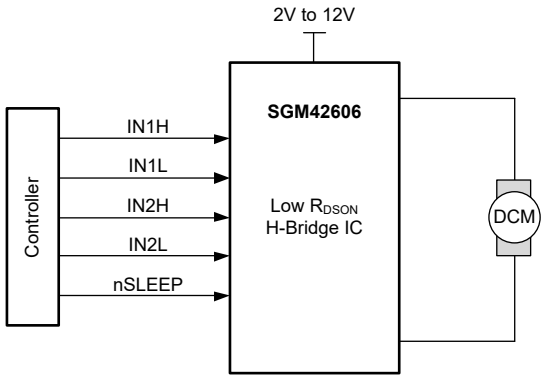
APPLICATIONS

Electric Toothbrushes
Shavers
Robotics
Toys
RC Helicopters and Cars

FEATURES

- **Power Supply Voltage Range: 2V to 12V**
- **Single H-Bridge Motor Driver**
- **Low On-Resistance: 72mΩ for HS + LS**
- **Up to 6A Peak Output Current**
- **3A Continuous Output Current**
- **Protection Features**
  - **Over-Voltage Protection**
  - **Under-Voltage Lockout**
  - **Over-Current Protection**
  - **Short-Circuit Protection**
  - **Thermal Shutdown**
- **Low Power Sleep Mode**
- **Available in a Green TQFN-5.5×3.5-24L Package**

SIMPLIFIED DIAGRAM

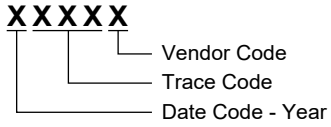


PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM42606	TQFN-5.5×3.5-24L	-40℃ to +85℃	SGM42606YTQQ24G/TR	SGM42606 YTQQ XXXXX	Tape and Reel, 3000

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 Range, V_{CC} ..... -0.3V to 13.2V
Charge Pump Voltage, V_{CP} .....-0.3V to V_{CC} + 6V
Regulator Voltage, V_{INT} ..... -0.3V to 6V
Logic Level Input Voltage Range (IN1H, IN1L, IN2H, IN2L, nSLEEP, nCLIP_EN)..... -0.3V to 6V
Other Pins, OUTx .....-0.3V to V_{CC} + 0.3V
Peak Output Current (Motor Drive)..... Internally Limited
Package Thermal Resistance
TQFN-5.5×3.5-24L, θ_{JA}..... 40℃/W
Junction Temperature .....+150℃
Storage Temperature Range.....-65℃ to +150℃
Lead Temperature (Soldering, 10s) .....+260℃
ESD Susceptibility
HBM.....5000V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Power Supply Voltage Range, V_{CC} .....2V to 12V
Logic Level Input Voltage Range, (IN1H, IN1L, IN2H, IN2L, nSLEEP, nCLIP_EN).....0V to 5.5V
Continuous Output Current (Motor Drive).....0A to 3A
Peak Output Current (Motor Drive).....0A to 6A
Operating Temperature Range..... -40℃ to +85℃

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

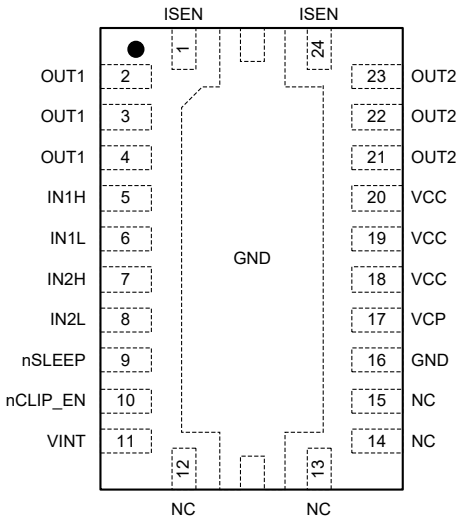
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance 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 CONFIGURATION

(TOP VIEW)



TQFN-5.5×3.5-24L

PIN DESCRIPTION

PIN	NAME	TYPE	FUNCTION
1, 24	ISEN	I/O	Bridge Ground or I_{SENSE}. Connect to current sense resistor for bridge current control when nCLIP_EN is enabled. Connect to GND directly if current control is not needed.
2, 3, 4	OUT1	O	Output 1 of the Device.
5	IN1H	I	Input Signal. Input signal for high-side MOSFET of output 1, active high. Pull-down internally.
6	IN1L	I	Input Signal. Input signal for low-side MOSFET of output 1, active high. Pull-down internally.
7	IN2H	I	Input Signal. Input signal for high-side MOSFET of output 2, active high. Pull-down internally.
8	IN2L	I	Input Signal. Input signal for low-side MOSFET of output 2, active high. Pull-down internally.
9	nSLEEP	I	Sleep Mode Input. Active low sleep mode logic input with weak internal pull-down. Apply high to enable device, and low to enter into the low power sleep mode.
10	nCLIP_EN	I	Current Limit Protect Function Enable. Logic low enables current limit protect function. Logic high disables the function. Internal pull-down resistor enables this function if this pin is floating in application.
11	VINT	-	Internal Supply Bypass. A 2.2μF (> 6V) bypass capacitor is used between VINT and GND pins.
12, 13, 14, 15	NC	-	No Connection. Not internally connected.
16	GND	-	Device Ground.
17	VCP	-	Gate Drive Voltage. A 0.1μF (> 19.2V) ceramic capacitor is placed between VCP and VCC pins.
18, 19, 20	VCC	-	Device Supply. Connect a 0.1μF bypass capacitor and a 10μF or larger (> 13.2V) ceramic capacitor between VCC and GND pins.
21, 22, 23	OUT2	O	Output 2 of the Device.
Exposed Pad	GND	-	Ground.

NOTE: I = input, O = output, I/O = input/output.

ELECTRICAL CHARACTERISTICS

(V_{CC} = 4.2V, T_J = -40℃ to +85℃, typical values are at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Power Supply (VCC)							
Power Supply Voltage	V_{CC}			2		12	V
Power Supply Current	I_{VCC}	V_{CC} = 12V, nSLEEP = 3.3V, INxH = INxL = 0V	T_J = +25℃		1.6	2.2	mA
			T_J = -40℃ to +85℃			2.5	
Sleep Mode Supply Current	I_{VCCQ}	V_{CC} = 12V, nSLEEP = 0V, INxH = INxL = 0V	T_J = +25℃		1.5	2.5	μA
			T_J = -40℃ to +85℃			4.5	
VCC Under-Voltage Lockout Threshold	V_{UVLO}	V_{CC} rising				1.98	V
		V_{CC} falling		1.6			
VCC Over-Voltage Lockout Voltage	V_{OVLO}	V_{CC} rising				13.5	V
		V_{CC} falling		12			
Logic-Level Inputs (IN1H, IN1L, IN2H, IN2L, nSLEEP, nCLIP_EN)							
Input Logic Low Voltage	V_{IL}			0		0.4	V
Input Logic High Voltage	V_{IH}			1.5		5.5	V
Input Logic Low Current	I_{IL}	V_{CC} = 12V, V_{IN} = 0V			±0.1	±1	μA
Input Logic High Current	I_{IH}	V_{IN} = 3.3V			20	35	μA
Pull-Down Resistance	R_{PD}	nSLEEP			300		kΩ
		INxH, INxL			170		kΩ
H-Bridge FETs (OUT1, OUT2)							
HS FET On-Resistance	R_{DSON}	I_{OUT} = 2A	T_J = +25℃		40	60	mΩ
			T_J = -40℃ to +85℃			75	
LS FET On-Resistance		I_{OUT} = -2A	T_J = +25℃		32	50	mΩ
			T_J = -40℃ to +85℃			65	
Off-State Leakage Current	I_{OFF}	V_{OUT} = 0V			15	25	μA
Current Control (ISEN)							
ISEN Trip Voltage	V_{TRIP}	T_J = +25℃		180	200	225	mV
Current Sense Blanking Time	t_{BLANK}				2.5		μs
Current Control PWM Frequency	f_{PWM}	Internal PWM Frequency			33		kHz
Protection Circuits							
Over-Current Protection Trip Level	I_{OCP}	T_J = +25℃		6			A
Over-Current Protection Deglitch Time	t_{OCP}				1.8		μs
Over-Current Retry Time	t_{RETRY}				7.5		ms
Thermal Shutdown Temperature	T_{TSD}	Die temperature rising			165		℃
Thermal Shutdown Temperature Hysteresis	T_{HYS}				50		℃

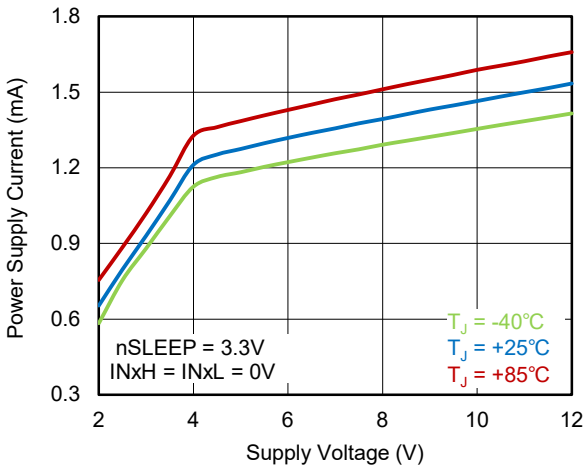
TIMING REQUIREMENTS

(T_J = +25℃, V_{CC} = 4.2V, R_L = 16Ω, unless otherwise noted.)

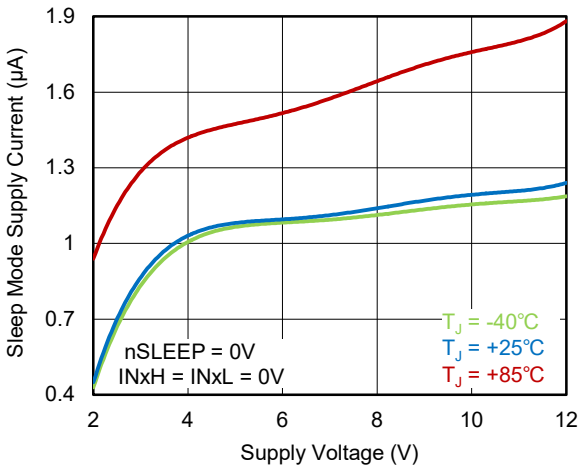
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Rise Time	t_R			95		ns
Fall Time	t_F			60		ns
Propagation Delay	t_{DELAY}	Measured as time between input edge to output change.		560		ns
Dead Time (measured as time OUTx FET is Hi-Z)	t_{DEAD}	LS off to HS on		220		ns
		HS off to LS on		170		ns

TYPICAL PERFORMANCE CHARACTERISTICS

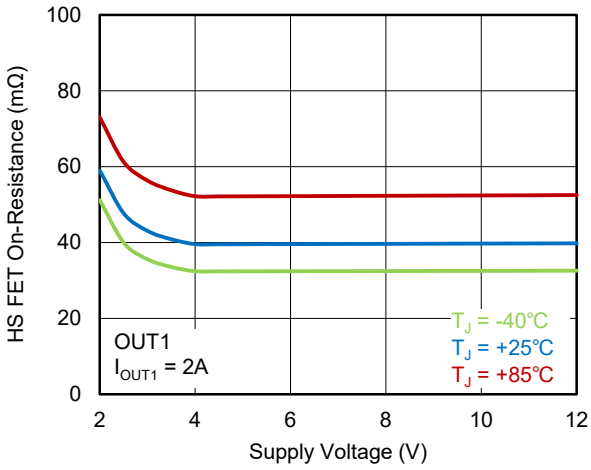
Power Supply Current vs. Supply Voltage



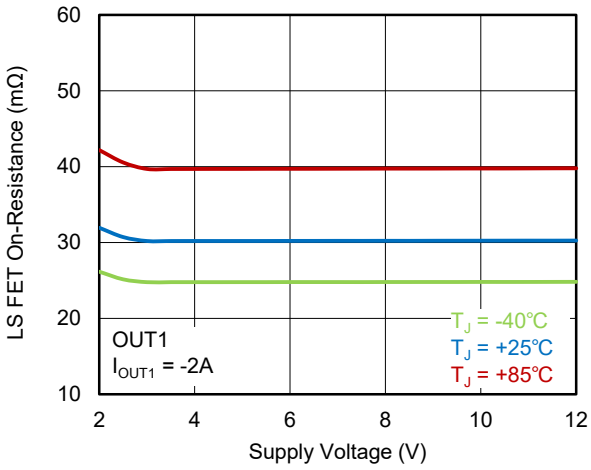
Sleep Mode Supply Current vs. Supply Voltage



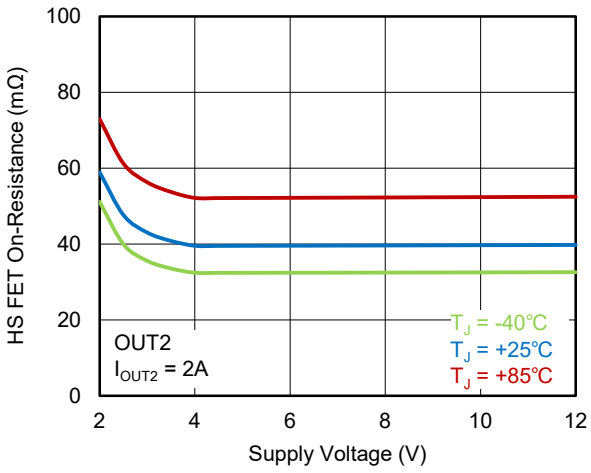
HS FET On-Resistance vs. Supply Voltage



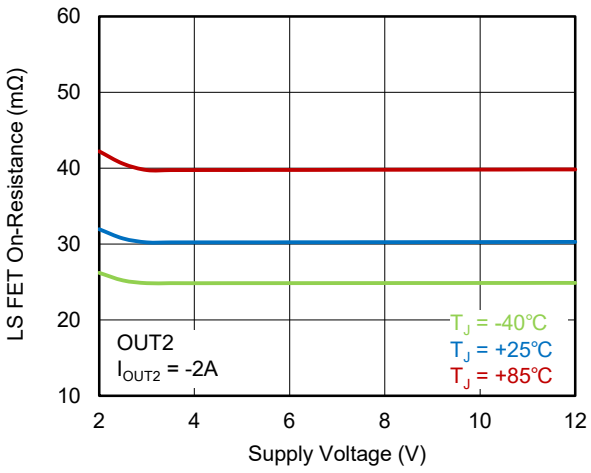
LS FET On-Resistance vs. Supply Voltage



HS FET On-Resistance vs. Supply Voltage



LS FET On-Resistance vs. Supply Voltage



FUNCTIONAL BLOCK DIAGRAM

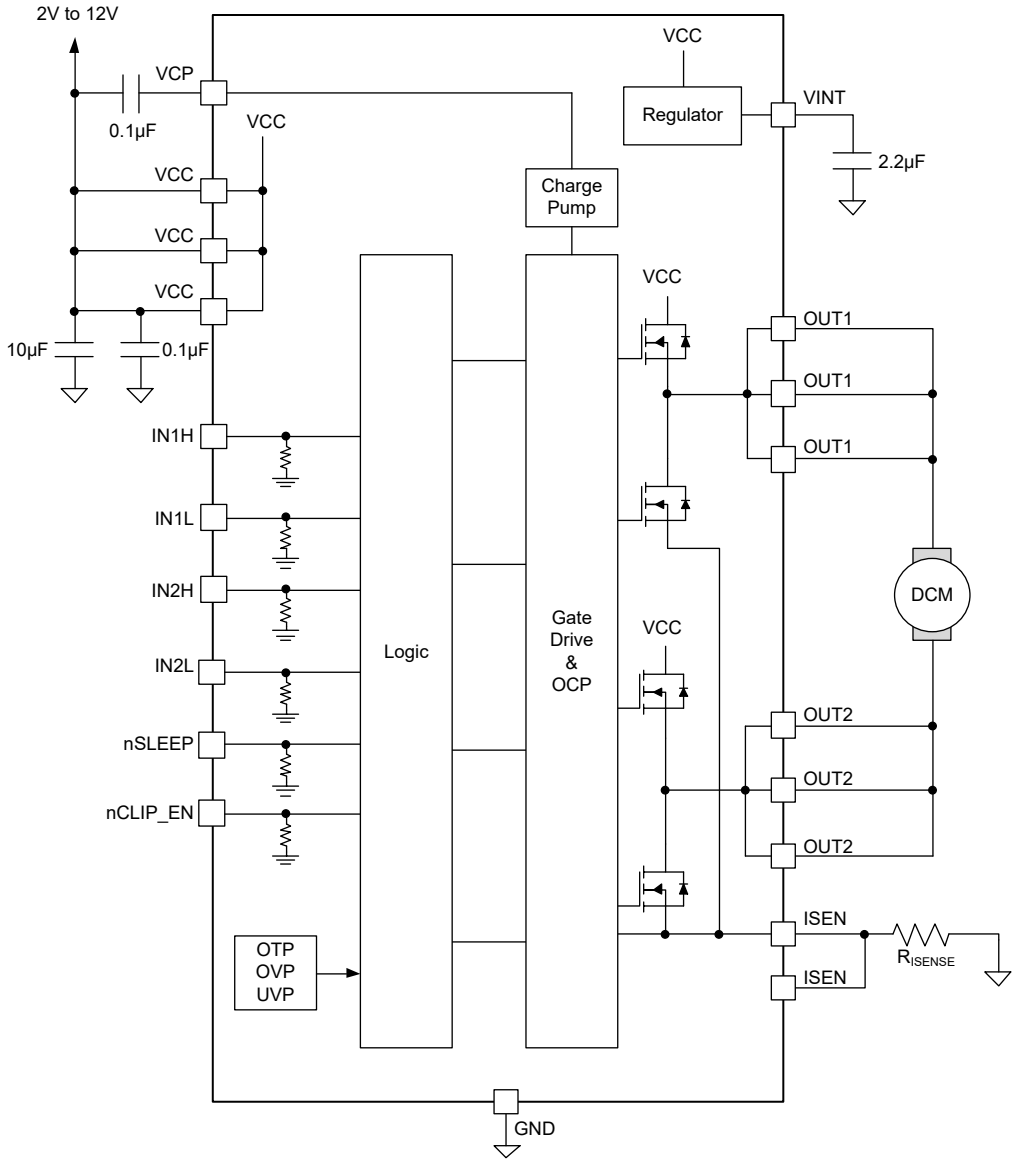


Figure 1. Functional Block Diagram

DETAILED DESCRIPTION

Overview

The SGM42606 is a single H-bridge motor driver with current regulation circuitry. A number of protection circuits are also provided in the device.

The device can operate from 2V to 12V single supply and has the ability to drive up to 6A peak output current.

Table 1 lists the operation mode for the SGM42606.

Table 1. SGM42606 Device Operation Mode (1)

nSLEEP	Driver
0	Sleep
1	Active

NOTE: 1. When nSLEEP is logic low for longer than 5μs, the device will enter into sleep mode. And it is at least 8ms from nSLEEP inactive logic high to H-bridge on.

Bridge Control and Decay Modes

Please refer to the input control logic below on Table 2. Shoot-through is prevented inside the device, if INxL and INxH are both high, the high-side and low-side N-MOSFETs of output will both be off.

Table 2. SGM42606 Device Logic

INxL	INxH	OUTx
0	0	Z
0	1	H
1	0	L
1	1	Z

Figure 2 shows the current paths in different drive and decay modes.

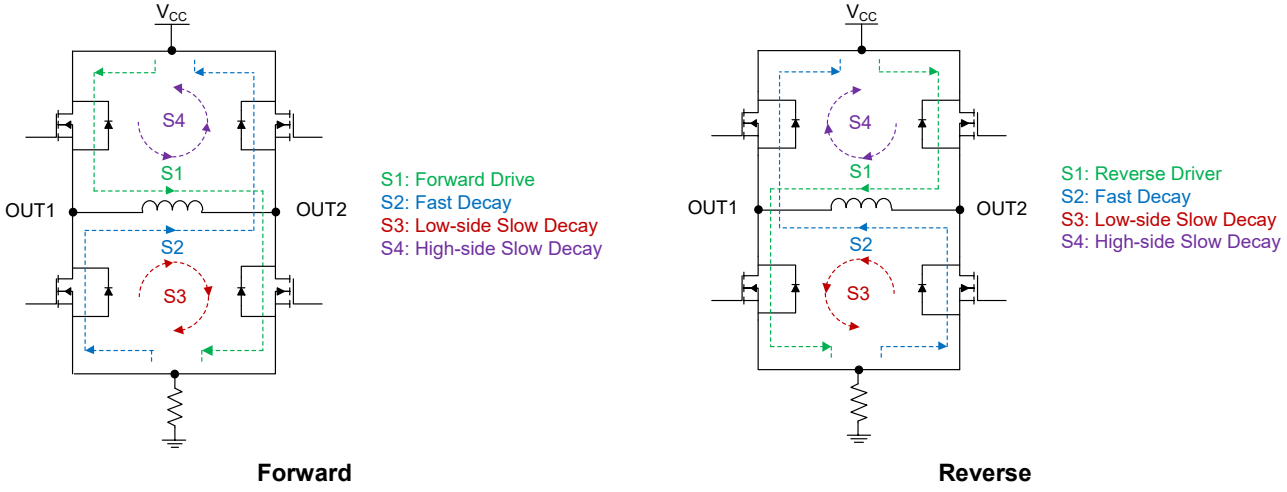


Figure 2. Forward and Reverse Operation

DETAILED DESCRIPTION (continued)

Current Limit Protection

The current through the motor windings may be limited, or controlled, by a fixed-frequency PWM current regulation, or current chopping. For DC motors, current control is used to limit the start-up and stall current of the motor. For stepper motors, current control is often used at all times.

When an H-bridge and current limit protection function are enabled, current rises through the winding at a rate dependent on the DC voltage and inductance of the winding. If the current reaches the current chopping threshold, the bridge disables the current until the beginning of the next PWM cycle. Note that immediately after the current is enabled, the voltage on the ISEN pin is ignored for a fixed period of time before enabling the current sense circuitry. This blanking time is fixed at 2.5μs. This blanking time also sets the minimum on-time of the PWM when operating in current chopping mode.

The PWM chopping current is set by a comparator which compares the voltage across a current sense resistor connected to the ISEN pins with a reference voltage. The reference voltage is fixed at 200mV. The chopping current is calculated in Equation 1.

$$I_{CHOP} = \frac{200mV}{R_{ISENSE}} \quad (1)$$

For example, If a 1Ω sense resistor is used, the chopping current will be 200mV/1Ω = 200mA. Once the chopping current threshold is reached, the H-bridge switches slow decay mode. Winding current is re-circulated by enabling both of the low-side MOSFETs in the bridge. This state is held until the beginning of the next fixed-frequency PWM cycle.

The current limit protection function is disabled when nCLIP_EN = high and enabled when nCLIP_EN = low.

Dead Time

Dead time is used to prevent the crossover during high-side and low-side MOSFETs switching. The SGM42606 has a dead time (t_{DEAD}) of about 220ns (low-side off to high-side on)/170ns (high-side off to low-side on).

Power Supplies and Input Pins

The charge pump is used to generate a gate supply greater than V_{CC} to turn on the internal N-MOSFETs. A 0.1μF ceramic capacitor is required between VCP and VCC pins. Connect a 0.1μF capacitor and a 10μF or larger (ceramic) capacitor between VCC and GND pins as close to the device as possible.

Device Functional Modes

The nSLEEP is an active low input to put the device in low-power (sleep mode) state. In sleep mode, all internal logic, bridges and charge pump are disabled (stopped).

Protection Circuits

A number of protection features are provided in the SGM42606 including over-current, under-voltage lockout, over-voltage protection and thermal shutdown.

Over-Current Protection (OCP)

All switches of the H-bridge are current limit and if an over-current is detected on one of them, its gate drive signal is removed. If the current limit persists for a period longer than the OCP time, all H-bridge MOSFETs are disabled. The driver will be re-enabled after the OCP retry period (t_{RETRY}) has passed.

Over-current will occur due to an output short to ground, to power supply, or across the motor windings.

Under-Voltage Lockout (UVLO)

If the voltages on VCC pin fall below their under-voltage lockout threshold, the device will be disabled, and the internal logic will be reset. Device resumes operation when all of them go back above their UVLO thresholds.

Over-Voltage Lockout (OVLO)

If the voltages on VCC pin rise more than their over-voltage lockout threshold, the device will be disabled. Device resumes operation when power supply voltage falls back below OVLO thresholds.

Thermal Shutdown (TSD)

All bridges and drivers are shutdown if a junction over-temperature occurs in the device. Once the temperature goes back to the safe level, device resumes its operation.

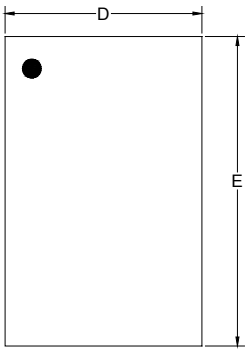
REVISION HISTORY

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

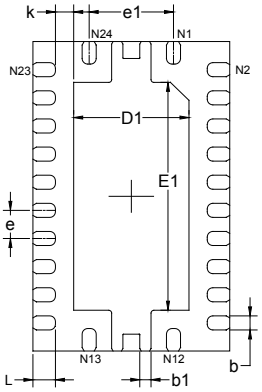
Changes from Original (MAY 2022) to REV.A	Page
Changed from product preview to production data	All

PACKAGE OUTLINE DIMENSIONS

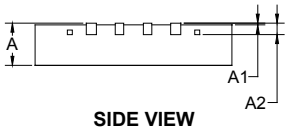
TQFN-5.5×3.5-24L



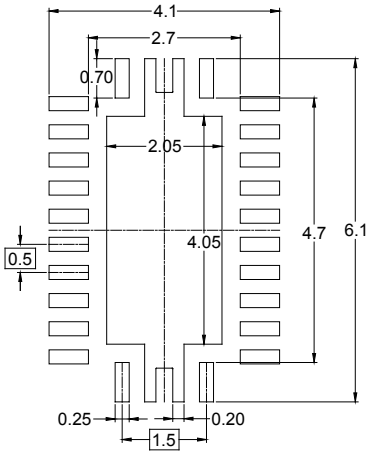
TOP VIEW



BOTTOM VIEW



SIDE VIEW

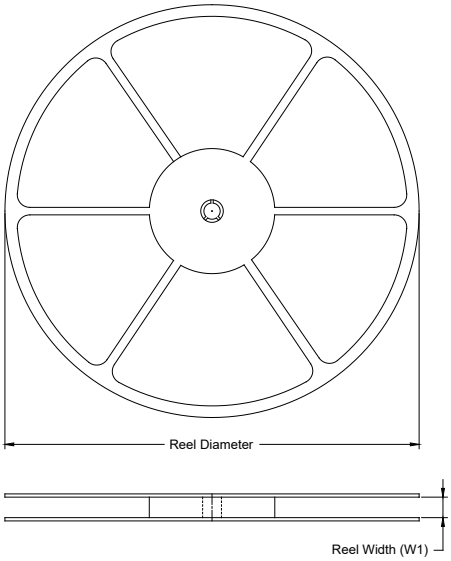


RECOMMENDED LAND PATTERN (Unit: mm)

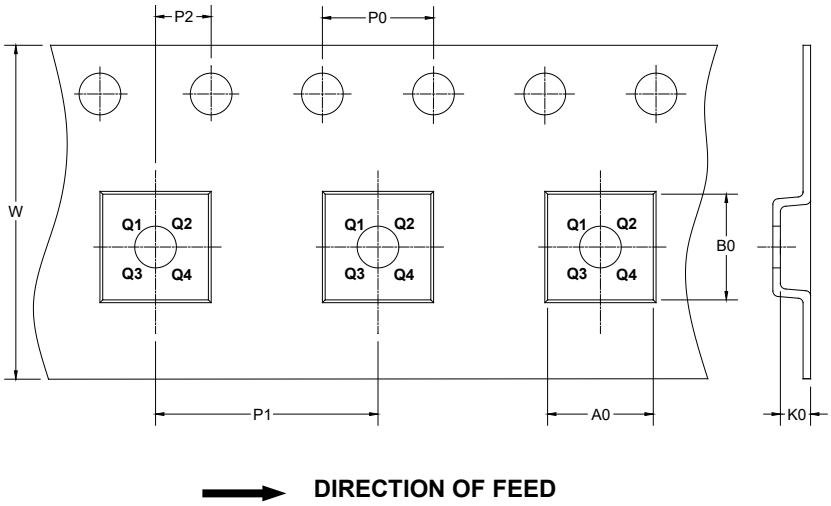
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	3.400	3.600	0.134	0.142
D1	1.950	2.150	0.077	0.085
E	5.400	5.600	0.213	0.220
E1	3.950	4.150	0.156	0.163
k	0.325 REF		0.013 REF	
b	0.200	0.300	0.008	0.012
b1	0.150	0.250	0.006	0.010
L	0.300	0.500	0.012	0.020
e	0.500 BSC		0.020 BSC	
e1	1.500 BSC		0.059 BSC	

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



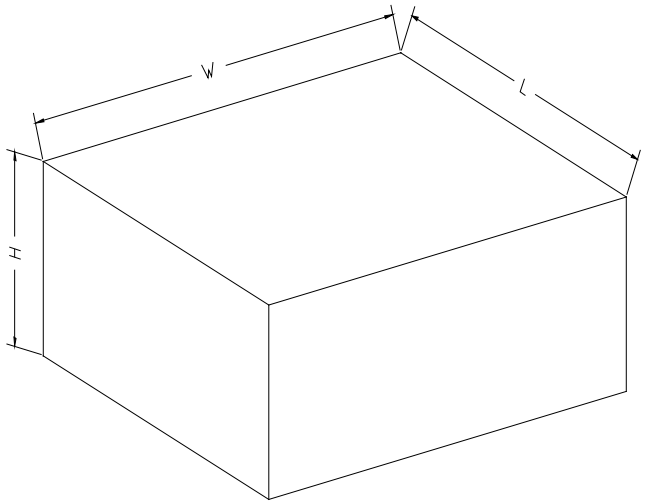
NOTE: The picture is only for reference. Please make the object as the standard.

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
TQFN-5.5×3.5-24L	13″	12.4	3.80	5.80	1.00	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