SGM42633
Dual H-Bridge Motor Driver

GENERAL DESCRIPTION

The SGM42633 is a bipolar stepper motor driver with dual, built-in H-bridges. It operates from a supply voltage range of 2.5V to 12V, and each H-bridge of the SGM42633 can deliver motor current up to 700mA RMS (or DC) continuously, at +25℃ with a V_{CC} supply of 5V. The internal safety features include sinking and sourcing current limits implemented with external sensors.

Internal over-current and over-temperature circuits prevent the device from being in over-stress condition, while a fault output simplifies stalling sensing, which is a useful feature for most applications. A low power sleep mode is also provided.

The device is available in Green TQFN-3×3-16L and TSSOP-16 (Exposed Pad) packages.

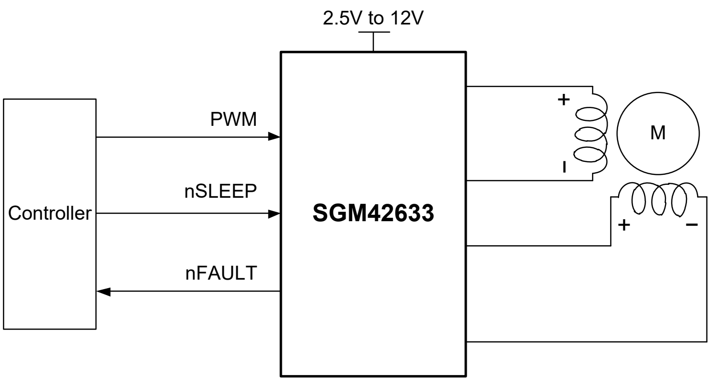
APPLICATIONS

Robotics
Point-of-Sale Printers
Battery-Powered Toys
Video Security Cameras
Office Automation Machines

FEATURES

- **Wide Power Supply Voltage Range: 2.5V to 12V**
- **Dual H-Bridge Motor Driver**
- **Low Quiescent Current: 150μA (TYP)**
- **Sleep Mode Supply Current: 0.32μA (TYP)**
- **xINx (PWM) Interface**
- **Output Current Capability (at V_{CC} = 5V, +25℃)**
  - **TSSOP Package:**
    0.7A RMS, 1A Peak per H-Bridge
    1.4A RMS in Parallel Mode
  - **TQFN Package:**
    0.6A RMS, 1A Peak per H-Bridge
    1.2A RMS in Parallel Mode
- **UVLO for VCC Voltage**
- **Over-Current Protection (OCP)**
- **Thermal Shutdown (TSD)**
- **Fault Indication Pin (nFAULT)**
- **Available in Green TSSOP-16 (Exposed Pad) and TQFN-3×3-16L Packages**

TYPICAL APPLICATION



PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM42633	TSSOP-16 (Exposed Pad)	-40℃ to +125℃	SGM42633XPTS16G/TR	SGM42633 XPTS16 XXXXX	Tape and Reel, 4000
	TQFN-3×3-16L	-40℃ to +125℃	SGM42633XTQ16G/TR	42633TQ XXXXX	Tape and Reel, 4000

MARKING INFORMATION

NOTE: XXXXX = Date Code, Trace Code and Vendor Code.

X XXX X

- Vendor Code
- Trace Code
- Date Code - Year

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
Control Pins
(AIN1, AIN2, BIN1, BIN2, nSLEEP, nFAULT) to GND ....
.... -0.3V to 6V
Package Thermal Resistance
TSSOP-16 (Exposed Pad), θ_{JA} .... 41℃/W
TQFN-3×3-16L, θ_{JA} .... 47℃/W
Operating Junction Temperature.................................+150℃
Storage Temperature Range ....-65℃ to +150℃
Lead Temperature (Soldering, 10s)............................+260℃
ESD Susceptibility
HBM..6000V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Power Supply Voltage Range, V_{CC} ....2.5V to 12V
Motor RMS Current, I_{RMS}
TSSOP-16 (Exposed Pad) Package......................0A to 0.7A
TQFN-3×3-16L Package..0A to 0.6A
Applied PWM Signal to AIN1, AIN2, BIN1, or BIN2, f_{PWM} ......
.... 0 to 200kHz
Operating Ambient Temperature Range......-40℃ to +125℃
Operating Junction 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

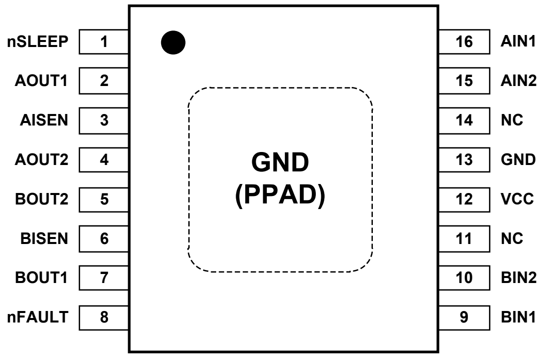
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance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

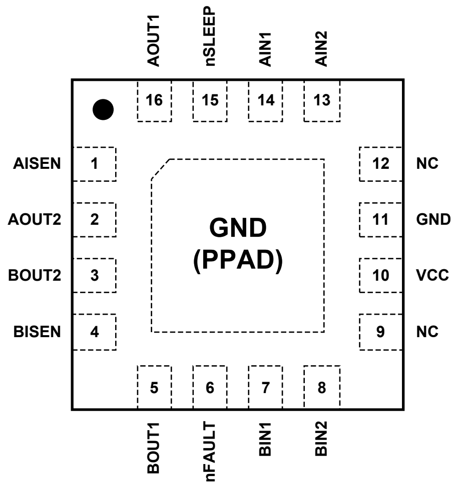
PIN CONFIGURATIONS

(TOP VIEW)



TSSOP-16 (Exposed Pad)

(TOP VIEW)



TQFN-3×3-16L

PIN DESCRIPTION

PIN		NAME	TYPE	FUNCTION
TSSOP-16 (Exposed Pad)	TQFN-3×3-16L			
2	16	AOUT1	O	Bridge A Nodes.
4	2	AOUT2		
7	5	BOUT1	O	Bridge B Nodes.
5	3	BOUT2		
16	14	AIN1	I	H-Bridge A PWM Inputs. Control the state of AOUT1 and AOUT2. Internal pull-down.
15	13	AIN2		
9	7	BIN1	I	H-Bridge B PWM Inputs. Control the state of BOUT1 and BOUT2. Internal pull-down.
10	8	BIN2		
1	15	nSLEEP	I	Sleep Mode Input. Apply logic high to enable device, and apply logic low to enter in the low power sleep mode. Internal pull-down.
8	6	nFAULT	OD	Fault Indication Pin. The logic is pulled low with a fault condition. Open-drain output requires an external pull-up.
3	1	AISEN	I/O	Bridge A Ground or I_{CHOP}.
6	4	BISEN	I/O	Bridge B Ground or I_{CHOP}.
12	10	VCC	P	Device Power Supply. Connect to motor supply. A 10μF (MIN) ceramic bypass capacitor to GND is recommended.
13	11	GND	G	Ground.
11, 14	9, 12	NC	–	No Connection.
Exposed Pad	Exposed Pad	GND (PPAD)	G	Exposed Pad. Exposed pad is internally connected to GND. Connect it to a large ground plane to maximize thermal performance. It is not intended as an electrical connection point.

NOTE: I = input, O = output, I/O = input or output, OD = open-drain output, G = ground, P = power for the circuit.

ELECTRICAL CHARACTERISTICS

(V_{CC} = 5V, Full = -40℃ to +125℃. Typical values are at T_A = +25℃, unless otherwise noted.)

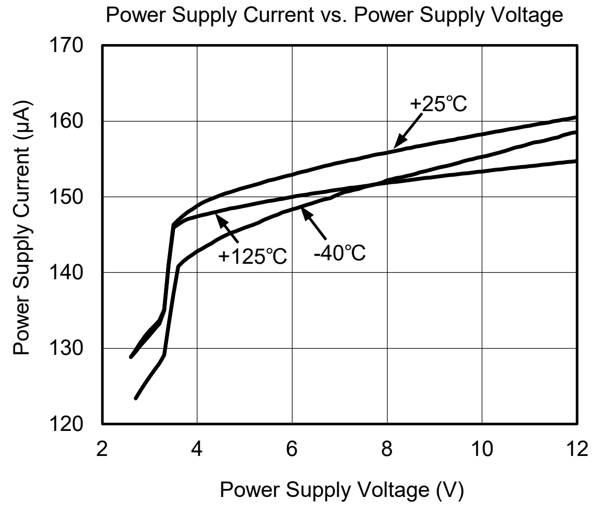
PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
Power Supplies (VCC)							
Power Supply Voltage	V_{CC}		Full	2.5		12	V
Power Supply Current	I_{VCC}	xINx low, nSLEEP high	+25℃		150	220	μA
			Full			230	
Sleep Mode Supply Current	I_{VCCQ}	nSLEEP low	+25℃		0.32	0.6	μA
			Full			5	
Time to Enter Sleep Mode	t_{SLEEP}	nSLEEP low to sleep mode	+25℃		10		μs
Wake-Up Time	t_{WAKE}	nSLEEP high to output transition	+25℃		100		μs
Turn-On Time	t_{ON}	V_{CC} > V_{UVLO} to output transition	+25℃		30		μs
Control Inputs (AIN1, AIN2, BIN1, BIN2 and nSLEEP)							
Input Logic Low Voltage	V_{IL}	xINx	Full	0		0.5	V
		nSLEEP	Full	0		0.5	
Input Logic High Voltage	V_{IH}	xINx	Full	1.5		5.5	V
		nSLEEP	Full	1.5		5.5	
Input Logic Hysteresis	V_{HYS}		+25℃		200		mV
Input Logic Low Current	I_{IL}	V_{IN} = 0V	+25℃	-0.5	0.01	0.5	μA
			Full	-1		1	
Input Logic High Current	I_{IH}	xINx, V_{IN} = 5V	+25℃		33	45	μA
			Full			52	
		nSLEEP, V_{IN} = 5V	+25℃		10	14	
			Full			17	
Pull-Down Resistance	R_{PD}	xINx	+25℃	110	150	190	kΩ
			Full	80		220	
		nSLEEP	+25℃	380	500	620	
			Full	280		730	
Input Deglitch Time	t_{DEG}		+25℃		610		ns
Propagation Delay INx to OUTx	t_{PROP}		+25℃		800		ns
Control Output (nFAULT)							
Output Logic Low Voltage	V_{OL}	I_O = 5mA	+25℃		0.22	0.3	V
			Full			0.35	
Output Logic High Leakage Current	I_{OH}	R_{PULLUP} = 1kΩ to 5V	+25℃	-1	0.01	1	μA
			Full	-2		2	

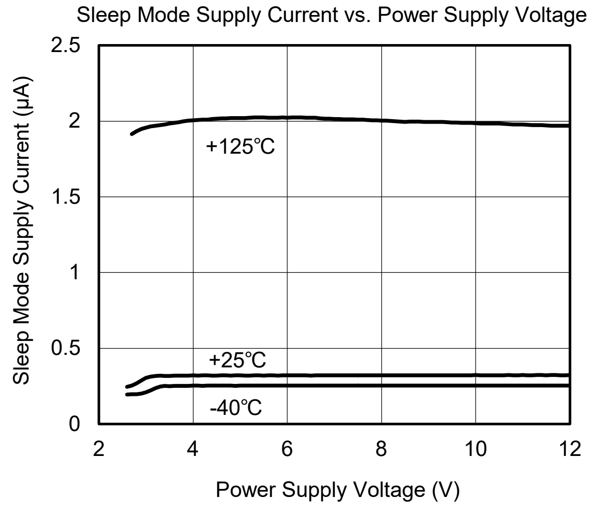
ELECTRICAL CHARACTERISTICS (continued)

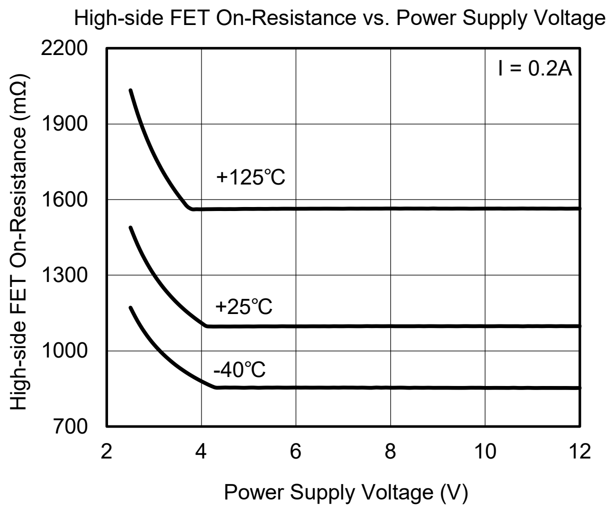
(V_{CC} = 5V, Full = -40℃ to +125℃. Typical values are at T_A = +25℃, unless otherwise noted.)

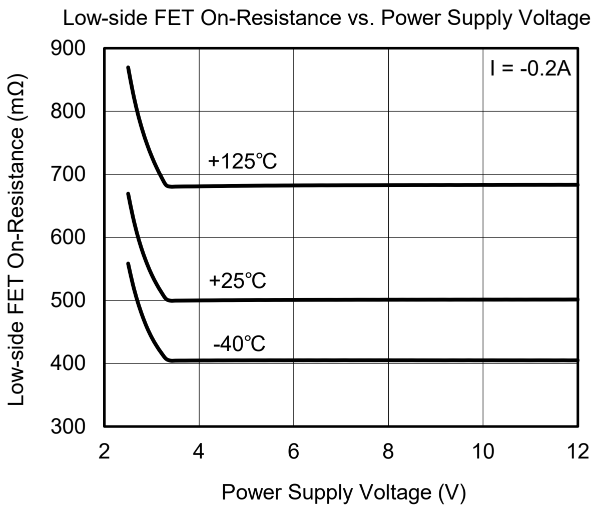
PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
Motor Driver Outputs (AOUT1, AOUT2, BOUT1 and BOUT2)							
High-side FET On-Resistance	R_{DSON_H}	V_{CC} = 5V, I = 0.2A	+25℃		1120	1380	mΩ
			Full			2000	
		V_{CC} = 2.5V, I = 0.2A	+25℃		1480	1750	
			Full			2400	
Low-side FET On-Resistance	R_{DSON_L}	V_{CC} = 5V, I = -0.2A	+25℃		490	560	mΩ
			Full			800	
		V_{CC} = 2.5V, I = -0.2A	+25℃		655	900	
			Full			1150	
Off-State Leakage Current	I_{OFF}		+25℃	-0.5	0.01	0.5	μA
			Full	-1.5		1.5	
Output Rise Time	t_{RISE}	R_L = 16Ω to GND	+25℃		70		ns
Output Fall Time	t_{FALL}	R_L = 16Ω to V_{CC}	+25℃		60		ns
Output Dead Time	t_{DEAD}	Internal dead time	+25℃		90		ns
PWM Current Controls (AISEN and BISEN)							
xISEN Trip Voltage	V_{TRIP}		+25℃	185	202	219	mV
			Full	180		224	
Current Control Constant Off-Time	t_{OFF}	Internal PWM constant off-time	+25℃		25		μs
Protection Circuits							
VCC Under-Voltage Lockout	V_{UVLO}	V_{CC} falling, UVLO report	+25℃	2.02	2.1		V
			Full	2			
		V_{CC} rising, UVLO recovery	+25℃		2.3	2.42	
			Full			2.45	
VCC Under-Voltage Hysteresis	V_{UVLO_HYS}	Rising to falling threshold	+25℃		200		mV
Over-Current Protection Trip Level	I_{OCP}		+25℃	1.01	1.5		A
Over-Current Deglitch Time	t_{DEG}		+25℃		2.6		μs
Over-Current Protection Period	t_{OCP}		+25℃		2.3		ms
Thermal Shutdown Temperature	T_{TSD}				160		℃
Thermal Shutdown Hysteresis	T_{HYS}				20		℃

TYPICAL PERFORMANCE CHARACTERISTICS









FUNCTIONAL BLOCK DIAGRAM

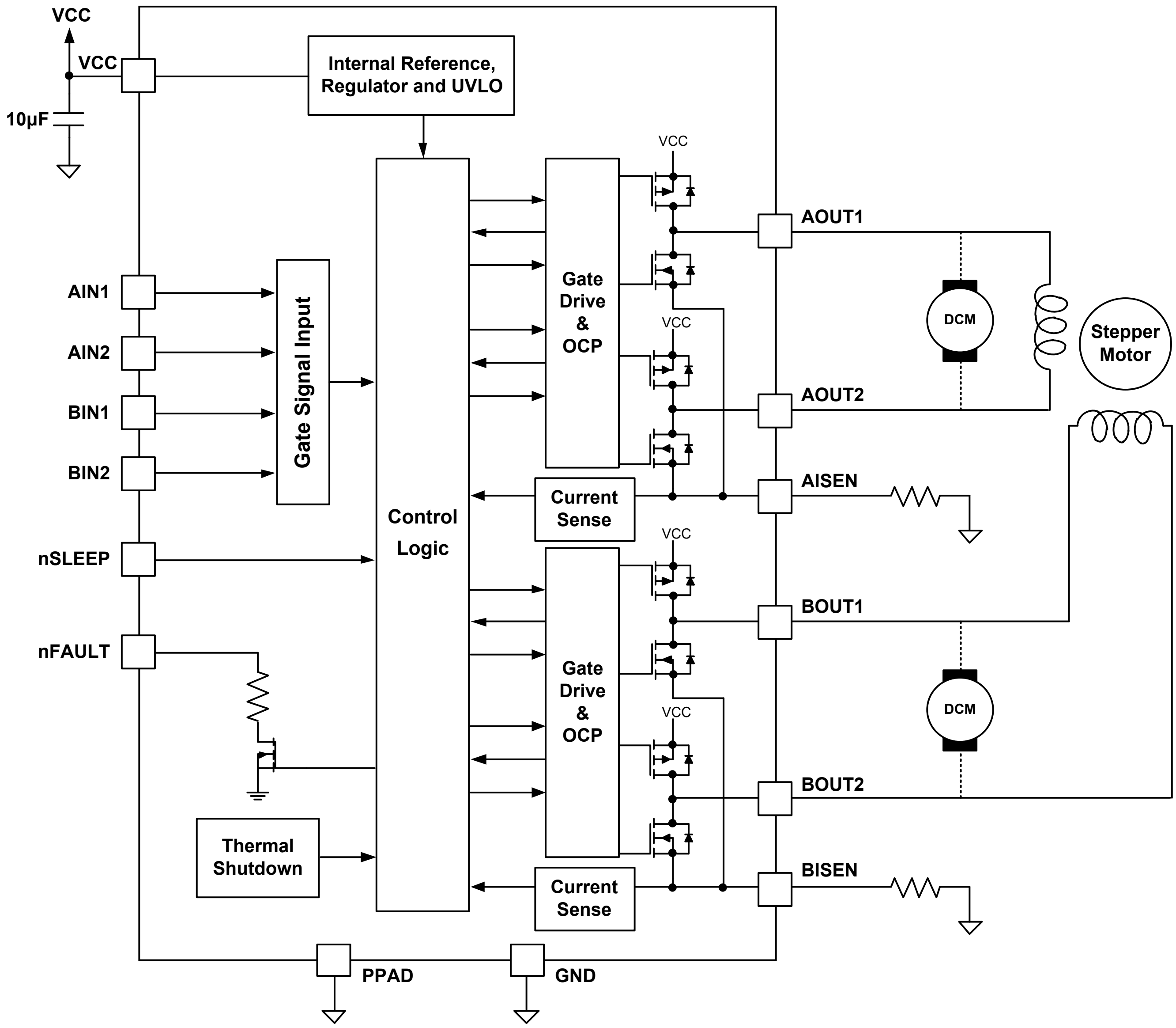


Figure 1. SGM42633 Block Diagram

DETAILED DESCRIPTION

The SGM42633 is a motor driver that integrates two PMOS and NMOS H-bridges and current regulation circuitry. Each of the internal H-bridges has 700mA output current capability over an input voltage range of 2.5V to 12V. It can drive a stepper motor or two DC motors. The motor output current can be either controlled by an external pulse width modulation (PWM) signal or by internal PWM current controller.

The SGM42633 includes the following fault protections: under-voltage lockout, over-current protection, and over-temperature protection. A low power sleep mode is also provided.

DETAILED DESCRIPTION (continued)

PWM Motor Drivers

Block diagram of the integrated motor driver including current control PWM H-bridges is shown in Figure 2.

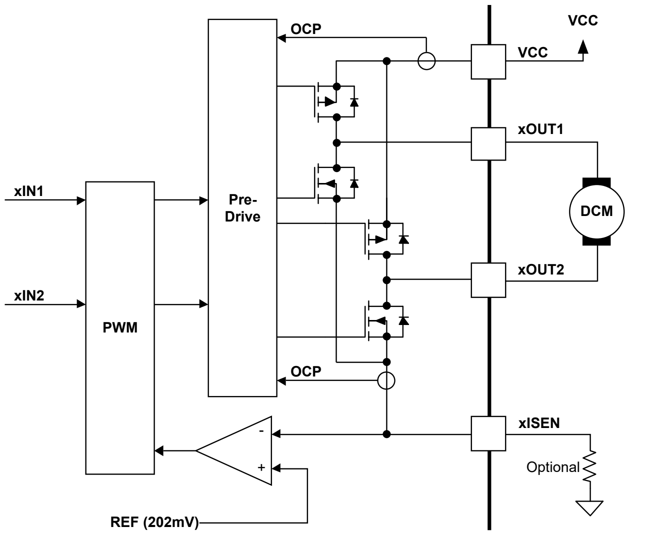


Figure 2. H-Bridge and Current Chopping Circuitry

Bridge Control and Decay Modes

The AINx input pins control the state of the AOUTx outputs; similarly, the BINx input pins control the state of the BOUTx outputs. Table 1 shows the logic.

Table 1. H-Bridge Logic

xIN1	xIN2	xOUT1	xOUT2	Function
0	0	Z	Z	Coast/Fast Decay
0	1	L	H	Reverse
1	0	H	L	Forward
1	1	L	L	Brake/Slow Decay

The SGM42633 also supports PWM mode of input to control the motor speed. When controlling a winding with PWM and the drive current is interrupted, the inductive nature of the motor requires that the current must continue to flow (called recirculation current). To handle this recirculation current, the H-bridge can operate in two different states, fast decay or slow decay. In fast decay mode, the H-bridge is disabled and recirculation current flows through the body diodes. In slow decay mode, the motor winding is shorted by enabling both low-side FETs.

When external PWM modulate signal is applied to one xIN pin while the other is held low, the bridge is in fast decay mode; when the other xIN pin is held high, the bridge is in slow decay mode (see Table 2).

Table 2. PWM Control of Motor Speed

xIN1	xIN2	Function
PWM	0	Forward PWM, Fast Decay
1	PWM	Forward PWM, Slow Decay
0	PWM	Reverse PWM, Fast Decay
PWM	1	Reverse PWM, Slow Decay

The internal current control is still enabled when applying external PWM to xINx. To disable the current control when applying external PWM, the xISEN pins should be connected directly to ground. Figure 3 shows the current paths in different drive and decay modes.

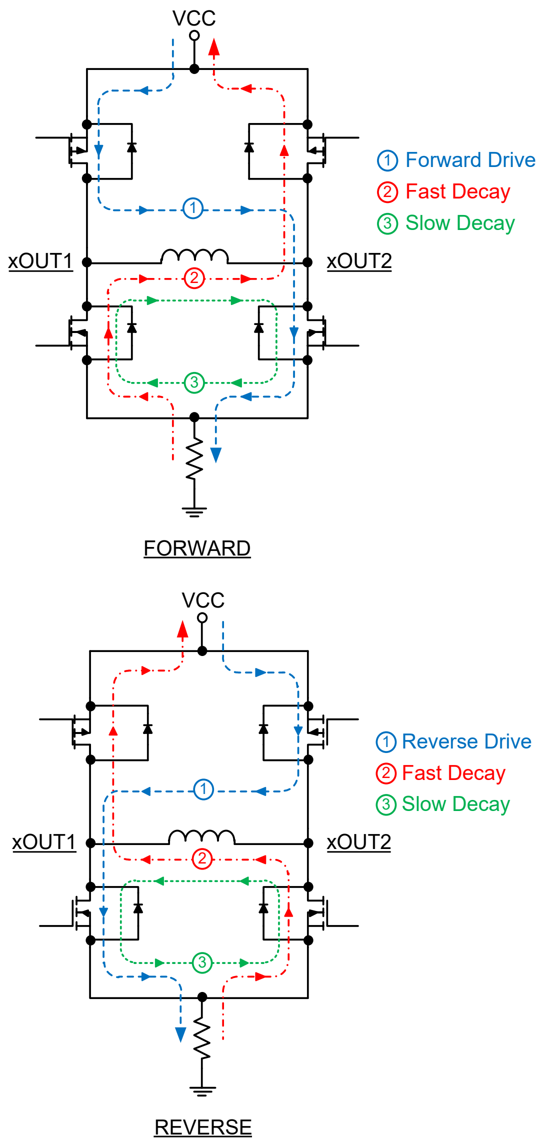


Figure 3. Drive and Decay Modes

DETAILED DESCRIPTION (continued)

Current Control

The current through the motor windings is regulated by a 25μs constant off-time PWM current regulation, or current chopping. For DC motor application, current control is used to limit the startup and stall current of the motor. For stepper motors, current control is often used at all times.

When an H-bridge is 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 output is enabled, the voltage on the xISEN pin is ignored for a fixed period of time before enabling the current sense circuitry. This blanking time is fixed at 3.2μs.

The PWM chopping current is set by a comparator that compares the voltage across a current sense resistor connected to the xISEN pins with a reference voltage. The reference voltage (V_{TRIP}), is fixed at 202mV nominally.

The chopping current is calculated in Equation 1.

$$I_{CHOP} = \frac{202mV}{R_{xISEN}} \quad (1)$$

Example: If a 0.5Ω sense resistor is used, the chopping current will be 202mV/0.5Ω = 404mA.

Note that if current control is not needed, the xISEN pins should be connected directly to ground.

Decay Mode

After any drive phase, when a motor winding current reaches the current chopping threshold (I_{CHOP}), the SGM42633 will place the bridge in slow decay mode. In slow decay mode, the high-side MOSFETs are turned off and both of the low-side MOSFETs are turned on. The motor current decreases while flowing in the two low-side MOSFETs until reaching its fixed off-time (25μs). Then, the high-side MOSFETs are enabled to increase the winding current again.

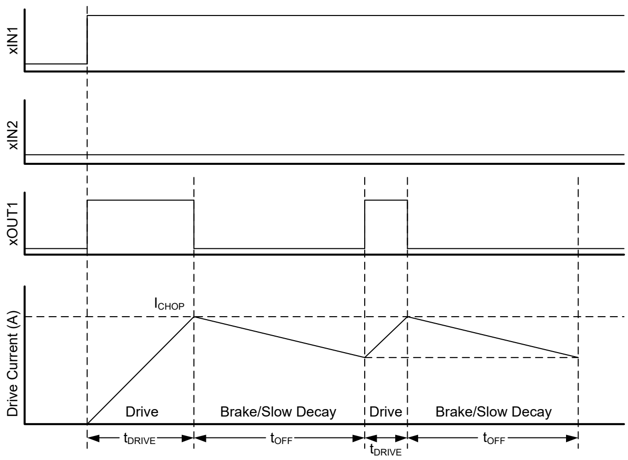


Figure 4. Current Chopping Operation

Sleep Mode

To idle the device and put it in the low power sleep mode, the nSLEEP pin can be pulled low. In the sleep mode, all H-bridges are disabled. All inputs are ignored until nSLEEP returns inactive high. When returning from sleep mode, t_{WAKE} needs to pass before the motor driver becomes fully operational.

DETAILED DESCRIPTION (continued)

Parallel Mode

The SGM42633 can be parallel connected for doubling the current of a single H-bridge to drive a DC motor. The dead time of the SGM42633 prevents any risk of cross-conduction (shoot-through) between the two H-bridges. Figure 5 shows this configuration.

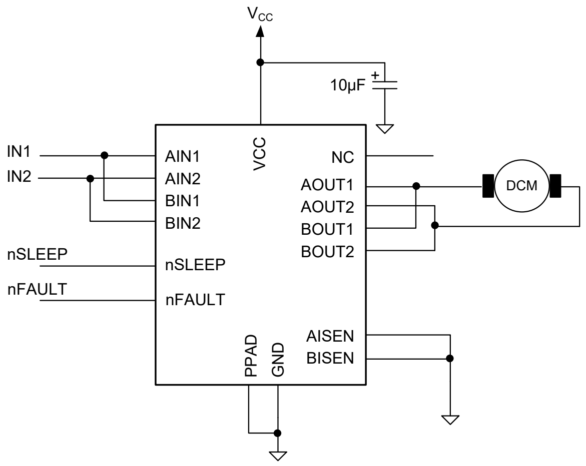


Figure 5. Parallel Mode Schematic

Protection Circuits

The SGM42633 is fully protected against over-current, over-temperature, and under-voltage events.

Over-Current Protection (OCP)

An analog current limit circuit on each FET limits the current through the FET by removing the gate drive. If over-current persists for longer than the OCP deglitch time, all FETs in the H-bridge will be disabled and the nFAULT pin will be driven low. The driver is re-enabled after the OCP retry period has passed.

Note that over-current protection does not use the current sense circuitry used for PWM current control, so it functions even without the presence of the xISEN resistors.

Thermal Shutdown (TSD)

The junction temperature of the IC is internally monitored. If the junction temperature exceeds the threshold value (typically 160℃), all FETs in the H-bridge are disable (the fault pin goes low) and recover once the junction temperature drops to about 140℃ (20℃ hysteresis).

Under-Voltage Lockout (UVLO)

If at any time the voltage on the VCC pin falls below the UVLO threshold voltage, all circuitry in the device is disabled, and all internal logic is reset. Operation resumes when V_{CC} rises above the UVLO threshold. The nFAULT pin is not driven low during an under-voltage condition.

Table 3. Device Protection

Fault	Condition	Error Report	H-Bridge	Internal Circuits	Recovery
V_{CC} Under-Voltage Lockout (UVLO)	V_{CC} < 2.1V	None	Disabled	Disabled	V_{CC} > 2.3V
Over-Current Protection (OCP)	$I_{OUT} > I_{OCP}$	nFAULT	Disabled	Operating	OCP
Thermal Shutdown (TSD)	$T_J > T_{TSD}$	nFAULT	Disabled	Operating	$T_J < T_{TSD} - T_{HYS}$

Table 4. Modes of Operation

Fault	Condition	H-Bridge	Internal Circuits
Operating	nSLEEP pin high	Operating	Operating
Sleep Mode	nSLEEP pin low	Disabled	Disabled
Fault Encountered	Any fault condition met	Disabled	See Table 3

APPLICATION INFORMATION

Power Supply Recommendations

The SGM42633 operates from a supply voltage range of 2.5V to 12V. A more than 10μF ceramic capacitor rated for V_{CC} must be placed as close to the SGM42633 as possible.

Bypass Capacitance for Motor Drive Systems

Bypass capacitance sizing is an important factor in motor drive system design. It depends on a variety of factors, including:

- Maximum power supply voltage
- Parasitic inductance in the power supply wiring
- Type of motor (brushed DC, brushless DC, stepper)
- Motor speed
- Motor braking method

Motor datasheets generally specify the capacitance value, however, it is recommended to do a system level test to size the bypass capacitors properly.

Layout Guidelines

Use a low ESR ceramic bypass capacitor connected between VCC pin and GND pin. This capacitor should be placed as close to the VCC pin as possible with a thick trace or ground plane connection to the device GND pin and PPAD.

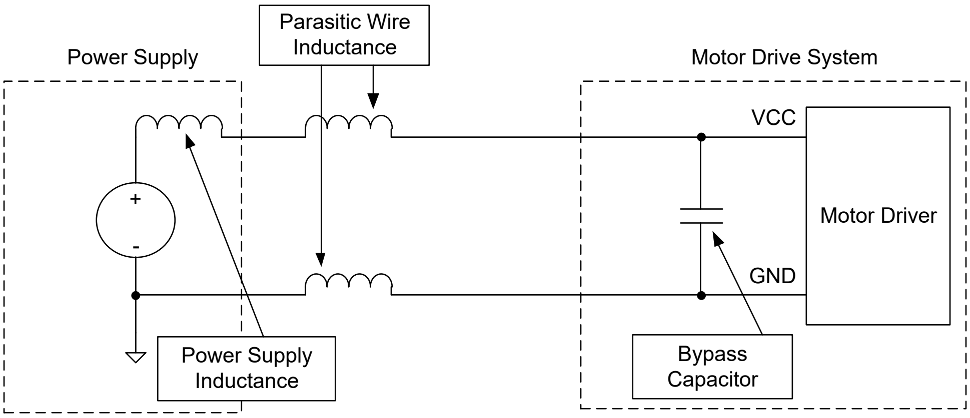


Figure 6. Setup of Motor Drive System with External Power Supply

REVISION HISTORY

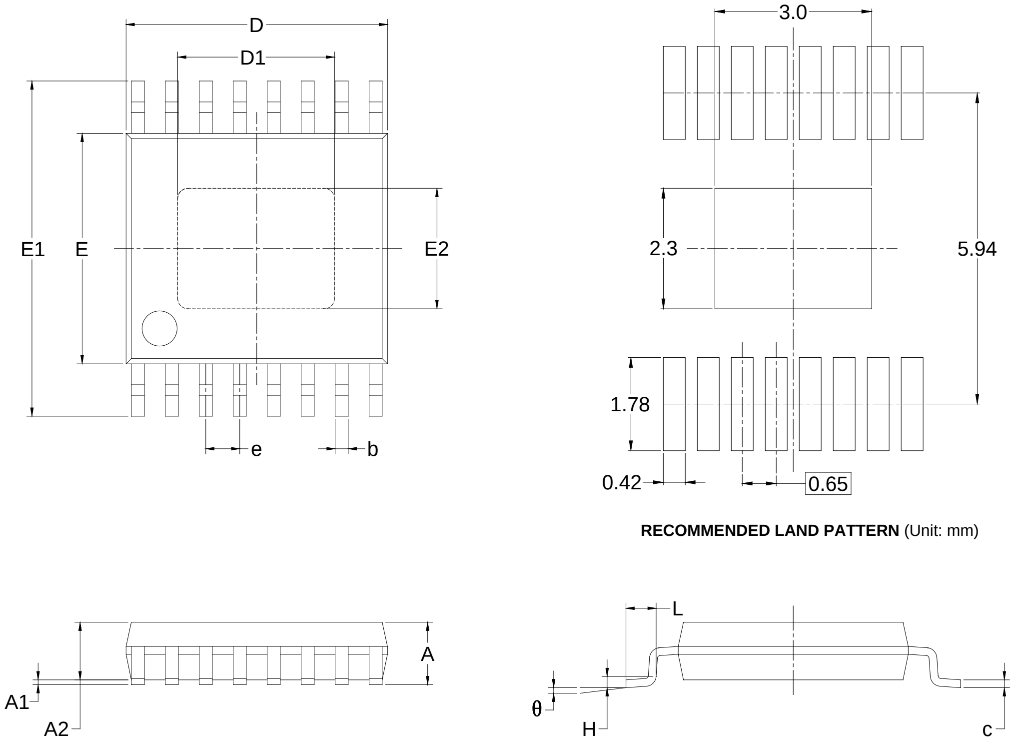
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

JULY 2021 – REV.A to REV.A.1	Page
Updated Electrical Characteristics section	4, 5

Changes from Original (DECEMBER 2019) to REV.A	Page
Changed from product preview to production data	All

PACKAGE OUTLINE DIMENSIONS

TSSOP-16 (Exposed Pad)

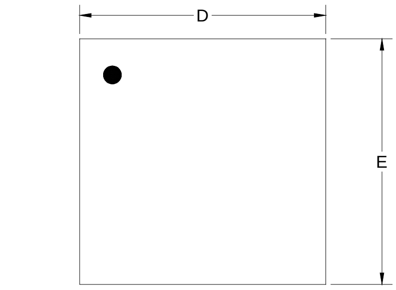


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.100		0.043
A1	0.050	0.150	0.002	0.006
A2	0.800	1.000	0.031	0.039
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.900	5.100	0.193	0.201
D1	2.900	3.100	0.114	0.122
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
E2	2.200	2.400	0.087	0.094
e	0.650 BSC		0.026 BSC	
L	0.500	0.700	0.02	0.028
H	0.25 TYP		0.01 TYP	
θ	1°	7°	1°	7°

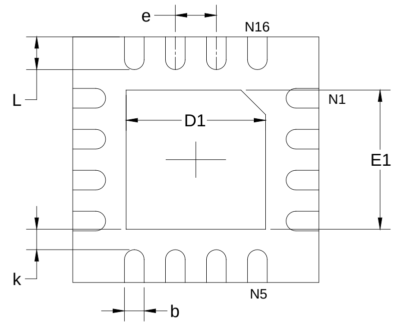
NOTES:
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

PACKAGE OUTLINE DIMENSIONS

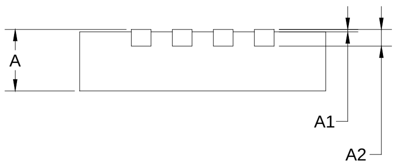
TQFN-3×3-16L



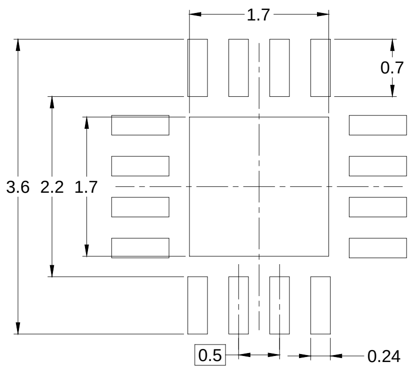
TOP VIEW



BOTTOM VIEW



SIDE VIEW



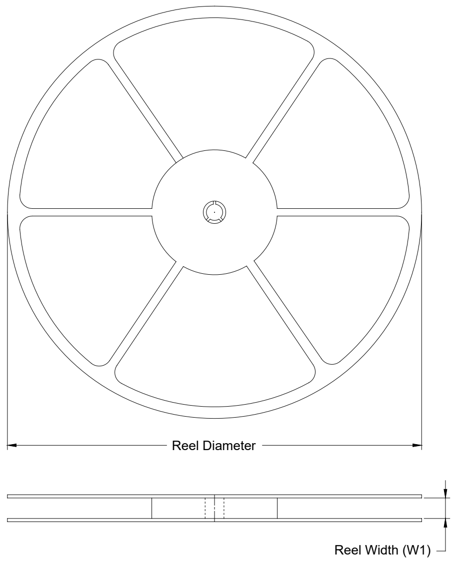
RECOMMENDED LAND PATTERN (Unit: mm)

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	2.900	3.100	0.114	0.122
D1	1.600	1.800	0.063	0.071
E	2.900	3.100	0.114	0.122
E1	1.600	1.800	0.063	0.071
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	0.012
e	0.500 TYP		0.020 TYP	
L	0.300	0.500	0.012	0.020

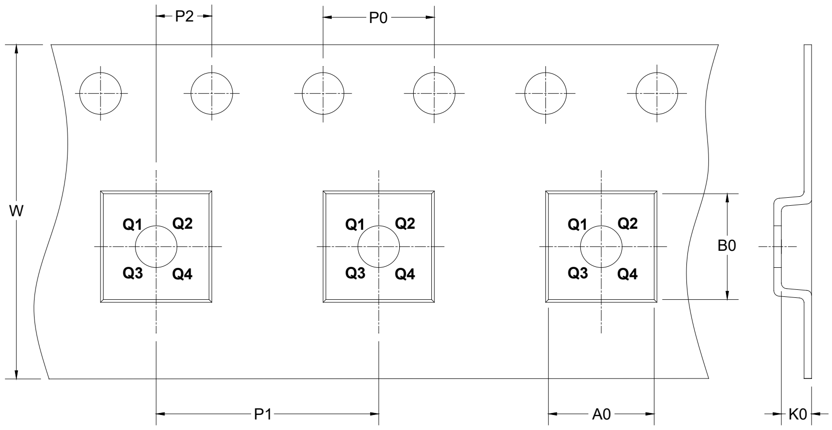
NOTE: This drawing is subject to change without notice.

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
TSSOP-16 (Exposed Pad)	13″	12.4	6.90	5.60	1.20	4.0	8.0	2.0	12.0	Q1
TQFN-3×3-16L	13″	12.4	3.35	3.35	1.13	4.0	8.0	2.0	12.0	Q2

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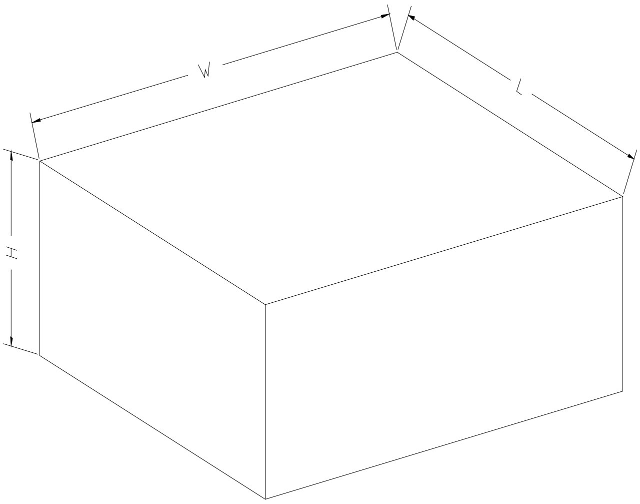
CARTON BOX DIMENSIONS



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