SGM42512
1.5A, 5.5V H-Bridge Driver for Motor/Coil

GENERAL DESCRIPTION

The SGM42512 is an H-bridge driver designed for actuating motors and coils bi-directionally turning. It translates logic level input to power driving outputs to motors or coils, for different spinning or moving directions by PH-EN/FAULT interface. Internal over-current (OC) and under-voltage (UV) protection circuits, together with over-temperature (OT) circuit prevent the device from being in over-stress condition, while an alert output simplifies stalling sensing, which is a useful feature for most applications.

The SGM42512 is available in a Green TSOT-23-6 package. It operates over an ambient temperature range of -40℃ to +125℃.

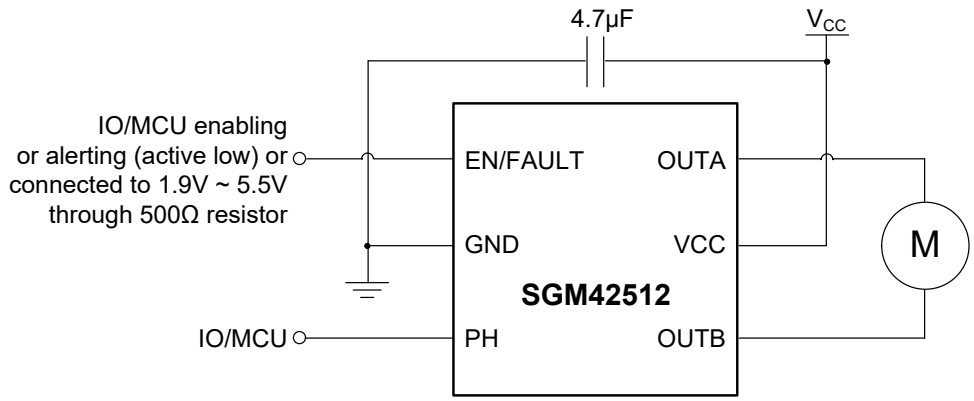
FEATURES

- **Compact Size and Smart Protection**
- **Support Fast Decay and Slow Decay Modes**
- **Sleep Mode Supply Current: 140nA (TYP)**
- **Internal OC/UV/OT Protections**
  - **Over-Current Threshold Options: 0.45A/0.9A/1.5A**
  - **Under-Voltage Threshold Options: 1.75V/2.8V/3.6V**
- **Up to 5.5V Supply Range for Applications Powered by:**
  - **1 Li+/Poly Cell**
  - **1/2/3 Dry Cell(s)**
  - **1 $LiSOCl_2$ Cell**
- **-40℃ to +125℃ Operating Temperature Range**
- **Available in a Green TSOT-23-6 Package**

APPLICATIONS

Utility Meters, Robots, Solenoid

TYPICAL APPLICATION

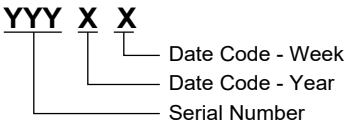


PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM42512A-1.75	TSOT-23-6	-40℃ to +125℃	SGM42512A-1.75XTN6G/TR	MO0XX	Tape and Reel, 3000
SGM42512A-2.8	TSOT-23-6	-40℃ to +125℃	SGM42512A-2.8XTN6G/TR	MO1XX	Tape and Reel, 3000
SGM42512A-3.6	TSOT-23-6	-40℃ to +125℃	SGM42512A-3.6XTN6G/TR	MO2XX	Tape and Reel, 3000
SGM42512B-1.75	TSOT-23-6	-40℃ to +125℃	SGM42512B-1.75XTN6G/TR	MO3XX	Tape and Reel, 3000
SGM42512B-2.8	TSOT-23-6	-40℃ to +125℃	SGM42512B-2.8XTN6G/TR	MO4XX	Tape and Reel, 3000
SGM42512B-3.6	TSOT-23-6	-40℃ to +125℃	SGM42512B-3.6XTN6G/TR	MO5XX	Tape and Reel, 3000
SGM42512C-1.75	TSOT-23-6	-40℃ to +125℃	SGM42512C-1.75XTN6G/TR	MO6XX	Tape and Reel, 3000
SGM42512C-2.8	TSOT-23-6	-40℃ to +125℃	SGM42512C-2.8XTN6G/TR	MH9XX	Tape and Reel, 3000
SGM42512C-3.6	TSOT-23-6	-40℃ to +125℃	SGM42512C-3.6XTN6G/TR	MHAXX	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.

SELECTABLE MODEL

MODEL	OVER-CURRENT PROTECTION THRESHOLD (A)	UNDER-VOLTAGE PROTECTION THRESHOLD (V)
SGM42512A-1.75	1.5	1.75
SGM42512A-2.8	1.5	2.8
SGM42512A-3.6	1.5	3.6
SGM42512B-1.75	0.9	1.75
SGM42512B-2.8	0.9	2.8
SGM42512B-3.6	0.9	3.6
SGM42512C-1.75	0.45	1.75
SGM42512C-2.8	0.45	2.8
SGM42512C-3.6	0.45	3.6

ABSOLUTE MAXIMUM RATINGS

V_{CC} ..... -0.3V to 6V
Digital Input Pin Voltage Range ..... -0.3V to V_{CC} + 0.3V
Package Thermal Resistance
TSOT-23-6, θ_{JA} ..... 217.8℃/W
Junction Temperature ..... +150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃
ESD Susceptibility
HBM 6000V
MM 400V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

V_{CC} ..... 1.9V to 5.5V
Digital Input Pin Voltage Range ..... 0V to 5.5V
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.

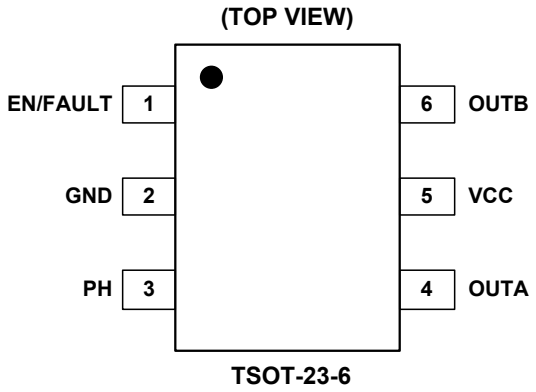
ESD SENSITIVITY CAUTION

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

NAME	TYPE	FUNCTION
EN/FAULT	I/O	Enable Input or Alert Output (OTP, OCP, UVP). Logic high to enable normal operation, logic low (> t_{SLEEP}) to enter low power dissipation sleep mode and reset all internal logic. Internal pull-down. This output is not valid when the device into minimum power dissipation sleep mode.
GND	G	Ground.
PH	I	Direction Input ($V_{PH} \le V_{CC}$). Logic high for sourcing from OUTA and sinking into OUTB; logic low for reverse driving. Internal pull-down.
OUTA	O	Output A of H-Bridge Driving Stage.
VCC	P	Power Input. A 4.7μF (MIN) ceramic bypass capacitor to GND is recommended.
OUTB	O	Output B of H-Bridge Driving Stage.

NOTE: I: Input, O: Output, I/O: Input or Output, G: Ground, P: Power for the circuit.

ELECTRICAL CHARACTERISTICS

(T_A = +25℃, V_{CC} = 5V, EN/FAULT pin connected to 5V through 500Ω resistor, Full = -40℃ to +125℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
POWER SUPPLIES							
Power Supply Voltage	V_{CC}		+25℃	1.9		5.5	V
Digital Input Voltage Range (EN/FAULT, PH)	V_{IN}		+25℃	0		5.5	V
Power Supply Current	I_{VCC}	No PWM	+25℃		40	70	μA
Sleep Mode Supply Current	I_{VCCQ}	EN/FAULT = GND	+25℃		140	500	nA
VCC Under-Voltage Lockout Voltage	V_{UVLO}	SGM42512A/B/C-1.75	+25℃		1.7	1.9	V
		SGM42512A/B/C-2.8	+25℃		1.95	2.15	
		SGM42512A/B/C-3.6	+25℃		1.7	1.85	
VCC Under-Voltage Lockout Voltage Hysteresis	V_{HYS}		+25℃		100		mV
VCC Under-Voltage Protection Voltage	V_{UVP}	SGM42512A/B/C-1.75	+25℃		1.75	1.9	V
		SGM42512A/B/C-2.8	+25℃		2.8	3.05	
		SGM42512A/B/C-3.6	+25℃		3.6	3.75	
VCC Under-Voltage Protection Voltage Hysteresis	V_{HYS}		+25℃		100		mV
LOGIC LEVEL INPUTS							
Input Low Voltage	V_{IL}		Full			0.4	V
Input High Voltage	V_{IH}		Full	1.6			V
Input Low Current	I_{IL}	V_{IN} = 0V	+25℃	-500		500	nA
Input High Weak Pull-Down Current	I_{IH_weak}	V_{IN} = 5.5V	+25℃		60	85	μA
Input High Strong Pull-Down Current	I_{IH_strong}	V_{IN} = 0.88V	+25℃		220	350	μA
Input Deglitch Time	t_{DEG}		+25℃		300		ns
EN/FAULT OUTPUT (OPEN-DRAIN OUTPUT)							
Output Low Voltage	V_{OL}	V_{CC} = 1.8V, I_{OUT} = -5mA	+25℃			300	mV
Output High Leakage Current	I_{OH}		+25℃			85	μA
H-BRIDGE FETS							
HS FET On-Resistance	$R_{DS(ON)}$	SGM42512A-X, I_{OUT} = 200mA	+25℃		365		mΩ
			Full			520	
		SGM42512B-X, I_{OUT} = 200mA	+25℃		370		
			Full			540	
		SGM42512C-X, I_{OUT} = 200mA	+25℃		395		
			Full			570	
LS FET On-Resistance	$R_{DS(ON)}$	SGM42512A-X, I_{OUT} = -200mA	+25℃		180		mΩ
			Full			320	
		SGM42512B-X, I_{OUT} = -200mA	+25℃		185		
			Full			340	
		SGM42512C-X, I_{OUT} = -200mA	+25℃		210		
			Full			360	
Off-State Leakage Current	I_{OFF}	V_{OUT} = 0V or 5.5V	+25℃	-500		500	nA

ELECTRICAL CHARACTERISTICS (continued)

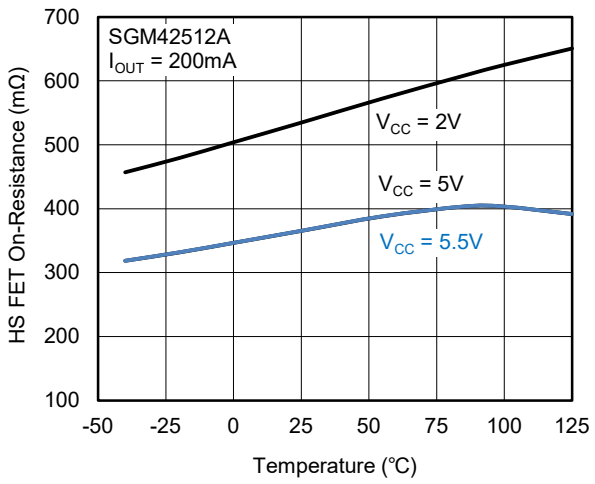
(T_A = +25℃, V_{CC} = 5V, EN/FAULT pin connected to 5V through 500Ω resistor, Full = -40℃ to +125℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
MOTOR DRIVER							
Rise Time	t_R	R_L = 16Ω to GND, 10% to 90% V_{CC}	+25℃		125		ns
Fall Time	t_F	R_L = 16Ω to V_{CC}, 90% to 10% V_{CC}	+25℃		155		ns
Propagation Delay INx to OUTx	t_{PROP}		+25℃		1		μs
Dead Time (1)	t_{DEAD}		+25℃		255		ns
PROTECTION CIRCUITS							
Over-Current Protection Trip Level	I_{OCP}	SGM42512A-X	+25℃		1.5		A
		SGM42512B-X	+25℃		0.9		
		SGM42512C-X	+25℃		0.45		
PROTECTION CIRCUITS							
Thermal Shutdown Temperature	T_{TSD}				165		℃
Thermal Shutdown Temperature Hysteresis	T_{HYS}				30		℃
SLEEP MODE							
Time to Enter Sleep Mode	t_{SLEEP}		+25℃	60		105	ms
Wake Time	t_{WAKE}	EN/FAULT inactive high to H-bridge on	+25℃			8.5	ms

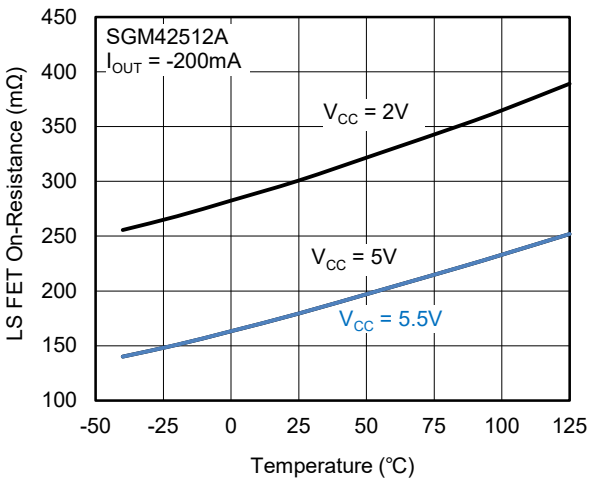
NOTE: 1. Internal dead time. External implementation is not necessary.

TYPICAL PERFORMANCE CHARACTERISTICS

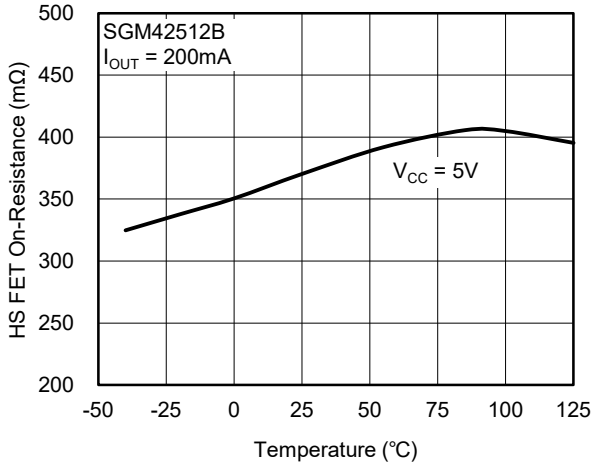
HS FET On-Resistance vs. Temperature



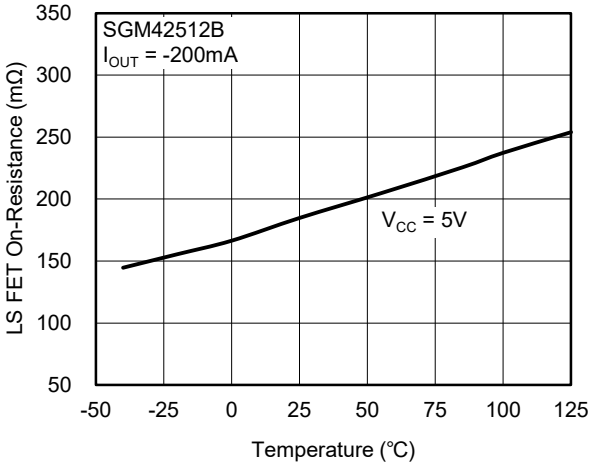
LS FET On-Resistance vs. Temperature



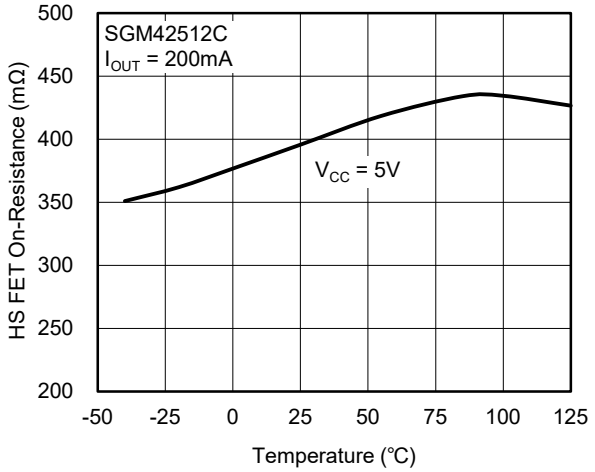
HS FET On-Resistance vs. Temperature



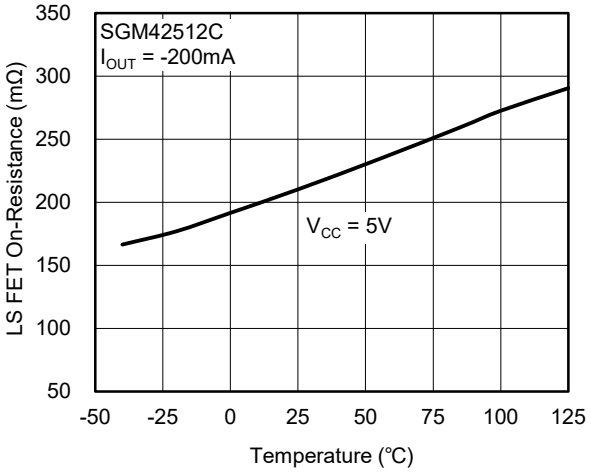
LS FET On-Resistance vs. Temperature



HS FET On-Resistance vs. Temperature

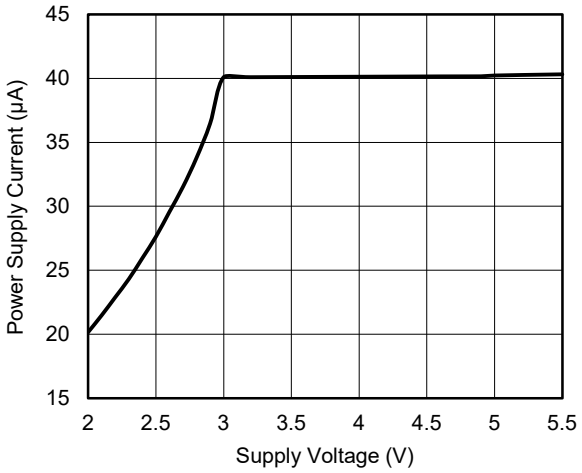


LS FET On-Resistance vs. Temperature

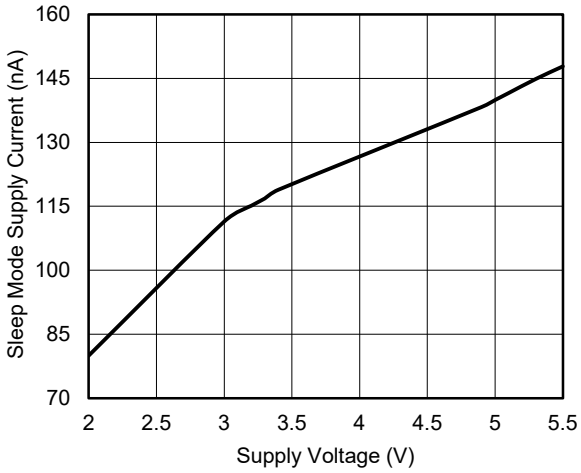


TYPICAL PERFORMANCE CHARACTERISTICS (continued)

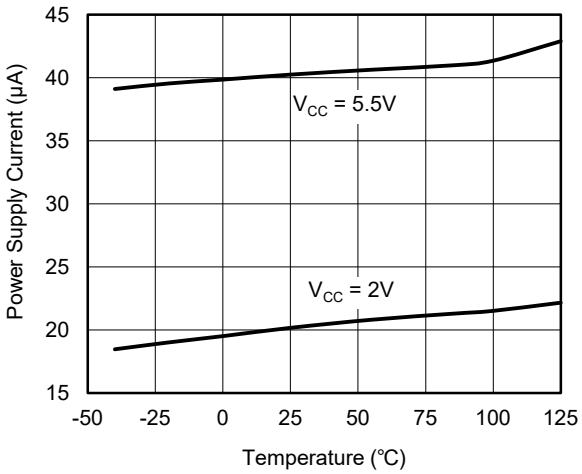
Power Supply Current vs. Supply Voltage



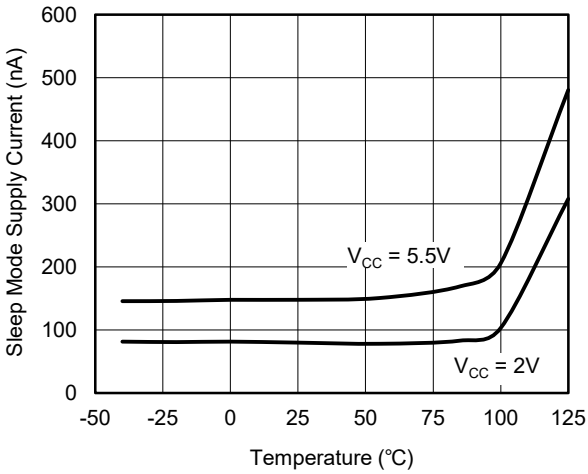
Sleep Mode Supply Current vs. Supply Voltage



Power Supply Current vs. Temperature



Sleep Mode Supply Current vs. Temperature



FUNCTIONAL BLOCK DIAGRAM

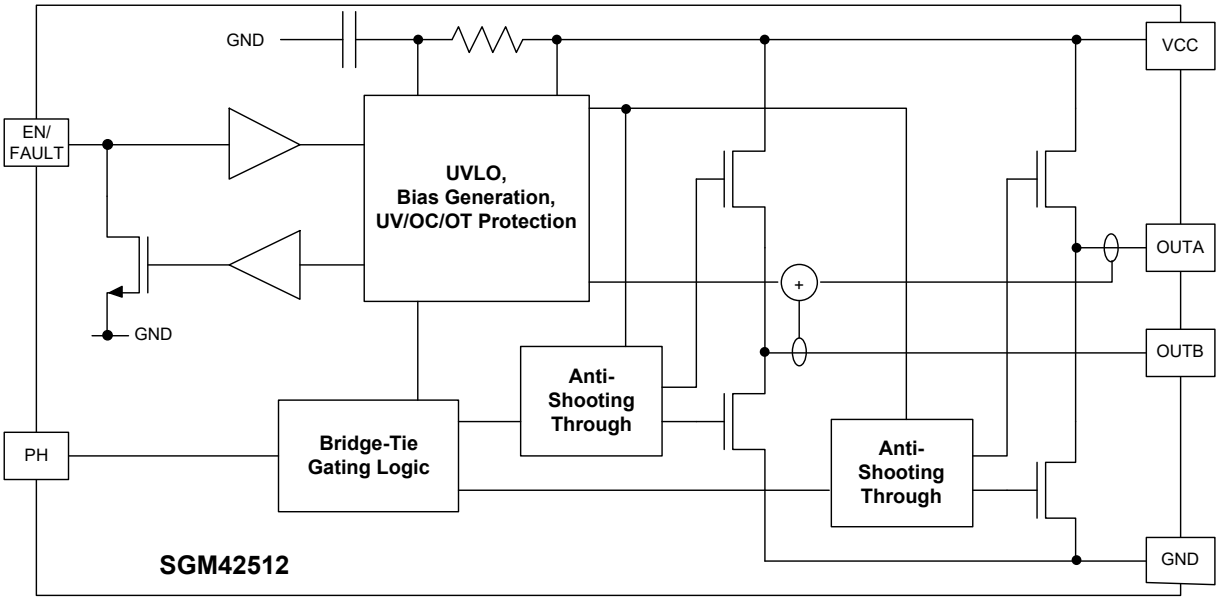
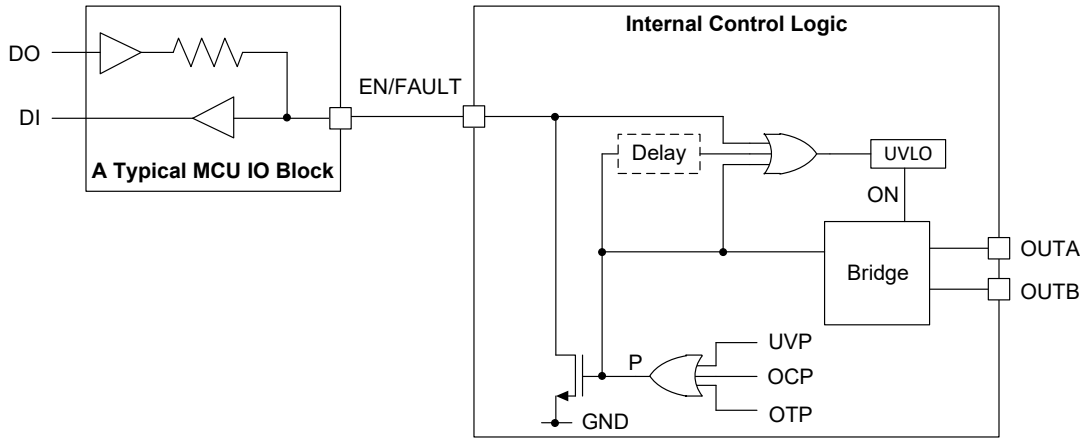


Figure 1. Block Diagram

INTERNAL CONTROL LOGIC



DETAILED DESCRIPTION

H-Bridge Control and Sleep Mode

The device has two push-pull stages that drive a bridge-tied load between those stages. When the stages are enabled, input PH selects driving direction into the load. When PH = 1, OUTA is H and OUTB is L; when PH = 0, OUTA is L and OUTB is H.

EN/FAULT is a dual function bi-directional input or output. When EN/FAULT is driven externally, if using EN/FAULT to alert stalling or other protections, the driving capability of external driver needs to be verified, to ensure that EN/FAULT has the sinking capability to pull down the driver. EN/FAULT can be tied to 1.9V ~ 5.5V through 500Ω resistor.

EN/FAULT as Output Port:

When any of over-current protection, under-voltage protection or over-temperature protection occurs, the device sinks current from EN/FAULT, pulling the pin down to alert the host.

EN/FAULT changes back to an input port, only after the device is released from a protection action.

EN/FAULT as Input Port:

EN/FAULT = 1 enables driving load in the direction set by PH input, as shown in **Table 1 (a, b)**.

When EN/FAULT changes from 1 to 0, the state of PH is latched at this time. After the current direction of the load is consistent with the PH, the output stages will drive both OUTA and OUTB to ground, as shown in **Table 1 (c)**; if the duration of EN/FAULT = 0 is greater than t_{SLEEP}, the device will enter low power dissipation sleep mode, and keep both OUTA and OUTB to ground.

After EN/FAULT becomes 0, if PH changes even once at any time during EN/FAULT = 0, the output stages will immediately drive both OUTA and OUTB to high-impedance state, as shown in **Table 1 (d, e)**; if the duration of EN/FAULT = 0 is greater than t_{SLEEP}, the device will enter low power dissipation sleep mode, and keep both OUTA and OUTB to high-impedance state.

Table 1. H-Bridge Logic

STATE	EN/ FAULT	PH	OUTA	OUTB	FUNCTION
(a)	1	1	H	L	Forward
(b)	1	0	L	H	Reverse
(c)	0	X	L	L	Slow Decay/Brake
(d)	0	1→0	Z	Z	Fast Decay/Coast
(e)	0	0→1	Z	Z	Fast Decay/Coast

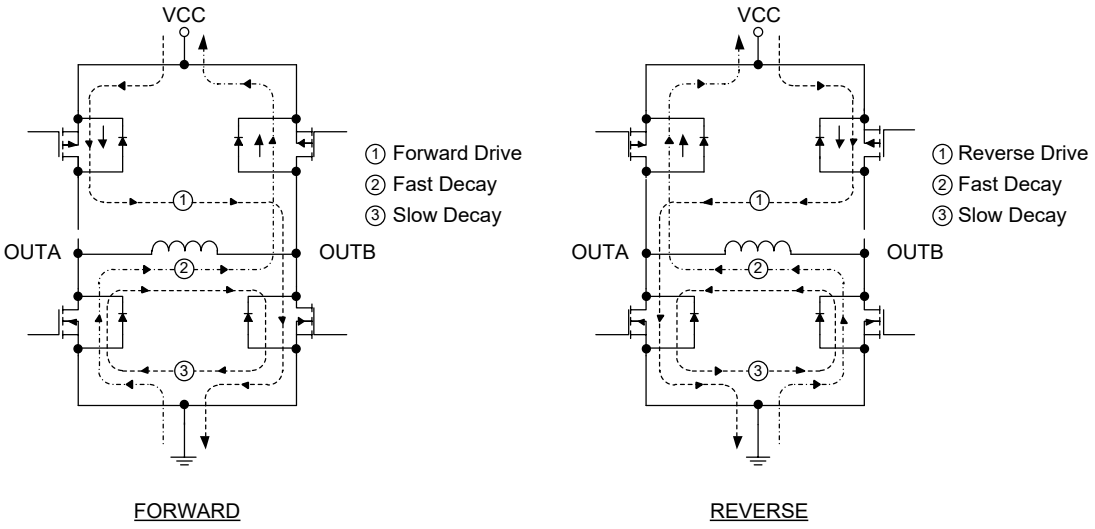


Figure 2. Decay Modes

DETAILED DESCRIPTION (continued)

PWM Motor Drivers

The inputs can be used for PWM control of the motor speed and/or direction.

Loading PWM signal to EN/FAULT port, the output stages can realize single-side PWM output, in the direction set by PH, as shown in **Table 2** and **Figure 3**.

Loading PWM signal to PH port, the output stages can realize complementary PWM output in the direction set by PWM duty cycle, as shown in **Table 2** and **Figure 4**.

Table 2. PWM Control of Motor Speed

EN/FAULT	PH	OUTA, OUTB	FUNCTION	PWM MODE
PWM (1)	H	OUTA = PWM, OUTB = GND	Forward PWM Control of Motor Speed	Single-side PWM Mode
PWM (1)	L	OUTA = GND, OUTB = PWM	Reverse PWM Control of Motor Speed	Single-side PWM Mode
H	PWM (D < 50%)	OUTA = -PWM, OUTB = +PWM	Reverse PWM Control of Motor Speed	Complementary PWM Mode
H	PWM (D > 50%)	OUTA = +PWM, OUTB = -PWM	Forward PWM Control of Motor Speed	Complementary PWM Mode

NOTE: 1. The duration of EN/FAULT = L must be less than t_{SLEEP}, in a PWM period. Otherwise the device may enter the low power dissipation sleep mode.

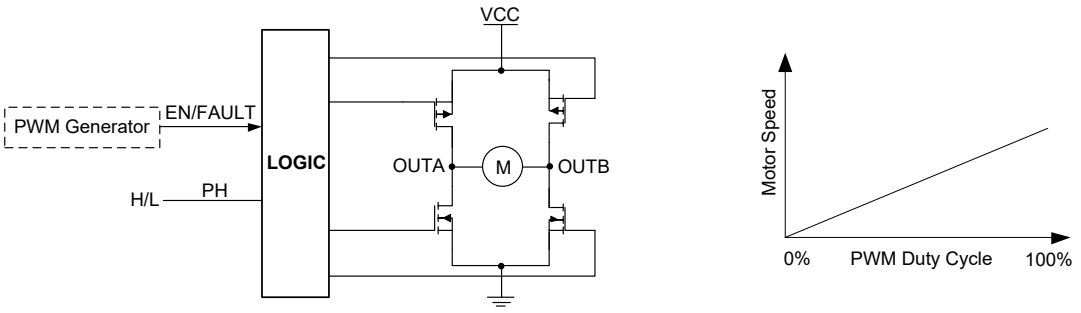


Figure 3. Loading PWM Signal to EN/FAULT Port

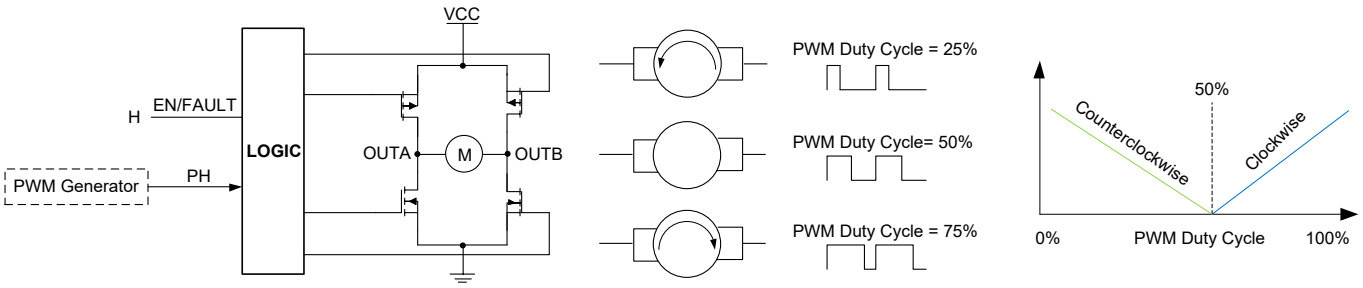


Figure 4. Loading PWM Signal to PH Port

DETAILED DESCRIPTION (continued)

Over-Current Protection

When spinning starts or rotator stalls, driving current may increase sharply. The over-current protection is designed to alert the starting or stalling situation while providing necessary protection. The device drives both OUTA and OUTB to high-impedance state when the current is above the protection threshold for longer than the blanking time (10μs), and restores driving when the driving current falls below the threshold plus given hysteresis, while asserting an alert by pulling EN/FAULT low during the protection action.

Under-Voltage and Over-Temperature Protections

In any situations, including starting, stalling or functioning abnormally, if input voltage is lower than under-voltage threshold, the device drives both OUTA and OUTB to ground, or if die temperature rises higher than the over-temperature threshold, the device drives both OUTA and OUTB to high-impedance state to prevent the power system from collapsing or the die from thermal over-stress.

Internal Pull-Down on Inputs

Both PH and EN/FAULT have a continuous weak pull-down and a conditional strong pull-down. The strong pull-down is active when input low is recognized and inactive when input high is recognized. This ensures a known and stable status for an input even when the input is floating, while keeping a low sinking current when the input is driven high.

FMEA Fault Tolerance

Any of two adjacent pin short does not cause damage to this device and its loading.

Table 3. Adjacent Pin Short Effect

SHORT PINS	EFFECT
VCC-PH	Equals to PH = 1. If EN/FAULT is high, OUTA to OUTB driving is selected, and all protections function normally.
PH-GND	Equals to PH = 0. If EN/FAULT is high, OUTB to OUTA driving is selected, and all protections function normally.
VCC-EN/FAULT	Equals to EN/FAULT = 1. EN/FAULT = 1 enables driving load in the direction set by PH, while all protections function normally.
EN/FAULT-GND	Equals to EN/FAULT = 0. The device will drive both OUTA and OUTB to ground/high-impedance state, or enter low power dissipation sleep mode.
OUTx-GND	The device will enter the over-current protection mode.
VCC-OUTx	The device will enter the over-current protection mode.
OUTA-OUTB	The device will enter the over-current protection mode.

REVISION HISTORY

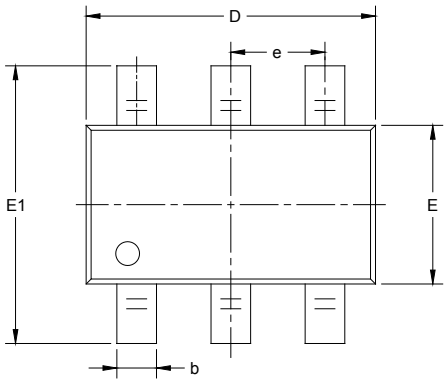
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

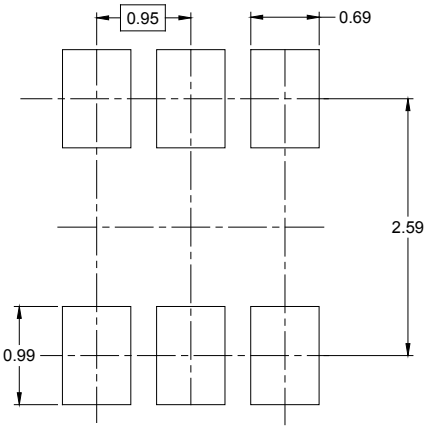
Changes from Original (DECEMBER 2018) to REV.A

Changed from product preview to production data ..... All

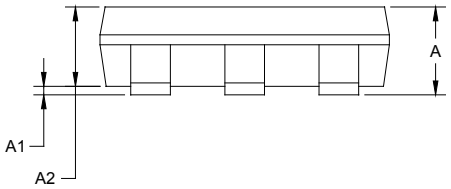
PACKAGE OUTLINE DIMENSIONS

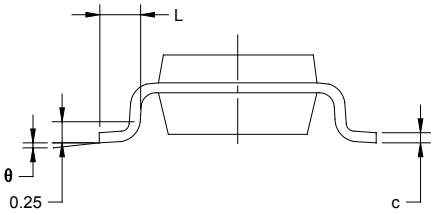
TSOT-23-6





RECOMMENDED LAND PATTERN (Unit: mm)

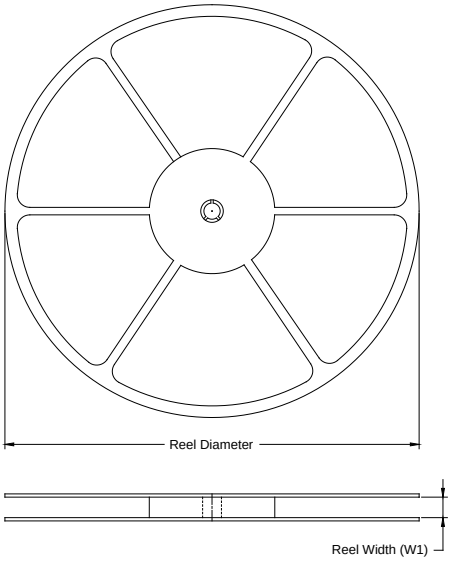




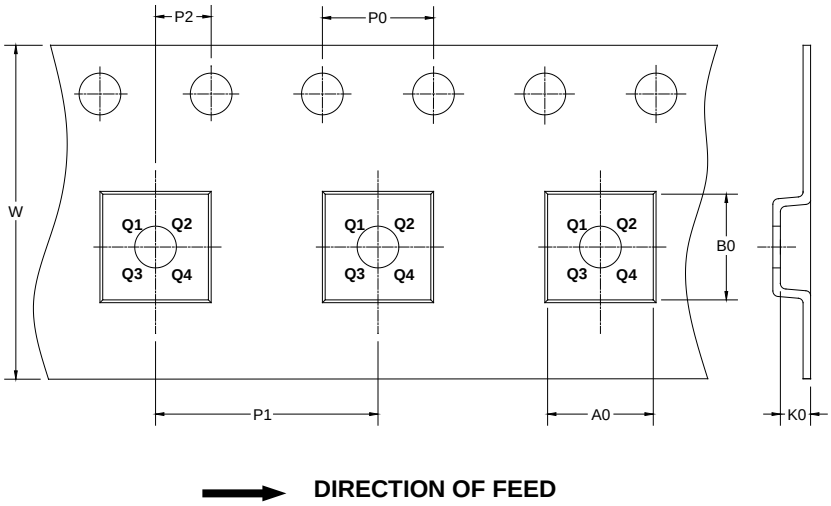
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.000		0.043
A1	0.000	0.100	0.000	0.004
A2	0.700	0.900	0.028	0.039
b	0.300	0.500	0.012	0.020
c	0.080	0.200	0.003	0.008
D	2.850	2.950	0.112	0.116
E	1.550	1.650	0.061	0.065
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 BSC	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



DIRECTION OF FEED

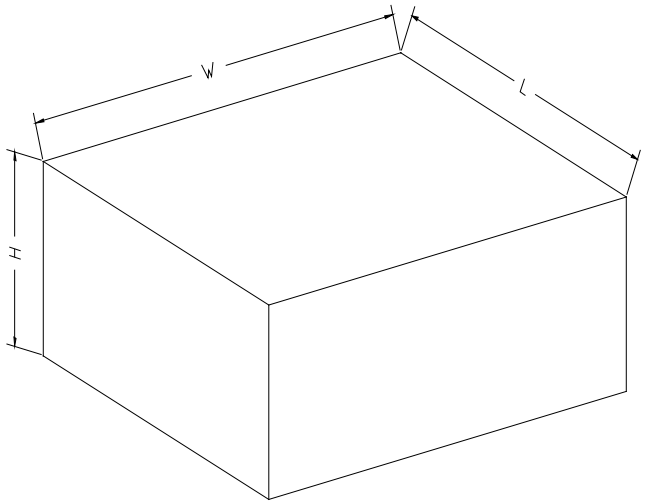
NOTE: The picture is only for reference. Please make the object as the standard.

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
TSOT-23-6	7″	9.5	3.20	3.10	1.10	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