SGM42541
Dual H-Bridge Driver IC

GENERAL DESCRIPTION

The SGM42541 is a dual H-bridge motor driver suitable for automated positioning and movement control in equipment such as printers, scanners and robotic mechanisms. The SGM42541 has two H-bridge drivers, and can drive a bipolar stepper motor or two DC motors. The output driver block for each consists of N-MOSFETs configured as full H-bridge to drive the motor windings. With proper heatsinking, the SGM42541 can deliver up to 2A peak output current per channel (at V_M = 24V and T_J = +25℃).

A simple parallel digital control interface is compatible with industry-standard devices. Decay mode is programmable. Fast, slow and mixed decay modes can be provided according application requirements. A 2-bit current control scheme allows up to 4 discrete current levels.

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

The SGM42541 is available in a Green TSSOP-28 (Exposed Pad) package.

FEATURES

- **Motor Supply Voltage Range: 8V to 45V**
- **Dual H-Bridge Motor Driver**
- **PWM Control Interface**
- **2-Bit Current Control Supports up to 4 Current Levels**
- **Low On-Resistance: 0.42Ω for HS + LS, T_J = +25℃**
- **Up to 2A Drive Current at V_M = 24V, T_J = +25℃**
- **Low Current Sleep Mode**
- **Built-in 3.3V Reference Output**
- **Full Set of Protections**
  - **Under-Voltage Lockout (UVLO)**
  - **Over-Current Protection (OCP)**
  - **Thermal Shutdown (TSD)**
  - **Fault Condition Indication Pin (nFAULT)**
- **Available in a Green TSSOP-28 (Exposed Pad) Package**

APPLICATIONS

Printer and Scanner

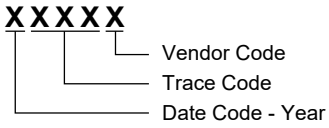
Stage Lighting

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM42541	TSSOP-28 (Exposed Pad)	-40℃ to +85℃	SGM42541YPTS28G/TR	SGM42541 YPTS28 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 Range, V_M ..... -0.3V to 55V
Power Supply Ramp Rate 1V/μs
Digital Pin Voltage ..... -0.5V to 6V
xVREF Input Voltage Range, V_{REF} ..... -0.3V to 5.5V
ISENx Pin Voltage (1) ..... -0.7V to 0.7V
Package Thermal Resistance
TSSOP-28 (Exposed Pad), θ_{JA} ..... 27℃/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 Range, V_M ..... 8V to 45V
xVREF Input Voltage (2), V_{REF} ..... 1V to 3.5V
V3P3 Load Current, I_{V3P3} ..... 0mA to 10mA
Externally Applied PWM Frequency, f_{PWM} ..... 0kHz to 100kHz
Operating Junction Temperature Range ..... -40℃ to +125℃

NOTES:
1. Transients of ±1V for less than 25ns are acceptable.
2. Operational at V_{REF} from 0V to 1V, but accuracy is degraded.

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

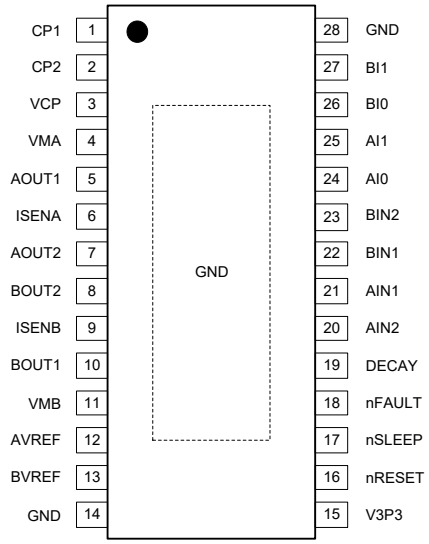
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance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



TSSOP-28 (Exposed Pad)

PIN DESCRIPTION

PIN	NAME	TYPE	FUNCTION	
1	CP1	I/O	Charge Pump Flying Capacitor Connection Pins. A 0.01μF/50V capacitor is used between CP1 and CP2 pins.	
2	CP2	I/O		
3	VCP	I/O	Gate Drive Voltage of the High-side Switches. Decouple with a 0.1μF/16V ceramic capacitor and a 1MΩ to VM pin.	
4	VMA	-	Power Supply for Bridge A.	Connect these pins to the same motor supply (8V to 45V) and bypass with a 0.1μF ceramic capacitor to GND. Connect sufficient bulk capacitance to the common supply line.
11	VMB	-	Power Supply for Bridge B.	
5	AOUT1	O	Output 1 of Bridge A.	Connect to motor winding A terminals 1 and 2 respectively.
7	AOUT2	O	Output 2 of Bridge A.	
10	BOUT1	O	Output 1 of Bridge B.	Connect to motor winding B terminals 1 and 2 respectively.
8	BOUT2	O	Output 2 of Bridge B.	
9	ISENB	I/O	Bridge B I_{SENSE} (GND). Connect through a current sense resistor to GND for bridge B.	
6	ISENA	I/O	Bridge A I_{SENSE} (GND). Connect through a current sense resistor to GND for bridge A.	
12	AVREF	I	Bridge A Current Setting Reference Voltage Input. It can be driven independently with a DAC for microstepping, or tied to a fixed reference like V3P3.	
13	BVREF	I	Bridge B Current Setting Reference Voltage Input. It can be driven independently with a DAC for microstepping, or tied to a fixed reference like V3P3.	
15	V3P3	O	3.3V Regulator Output. A 0.47μF/6.3V ceramic capacitor is used between V3P3 and GND pins. This source can be used to supply AVREF or BVREF reference inputs.	
16	nRESET	I	Reset Input. Active-low reset input with weak internal pull-down initializes internal logic and disables H-bridge outputs.	
17	nSLEEP	I	Sleep Mode Input. Active-low logic input with weak internal pull-down. Apply high to enable device, and low to enter into the low-power sleep mode.	
18	nFAULT	OD	Fault Indication Pin. Go low when a fault occurs (over-temperature, over-current).	
19	DECAY	I	Decay Mode Selection Input. Low = slow decay, open = mixed decay, high = fast decay. The pin is pulled down and pulled up internally inside the device.	
20	AIN2	I	Input 2 of Bridge A. Logic input for AOUT2. Internal pull-down.	
21	AIN1	I	Input 1 of Bridge A. Logic input for AOUT1. Internal pull-down.	
22	BIN1	I	Input 1 of Bridge B. Logic input for BOUT1. Internal pull-down.	
23	BIN2	I	Input 2 of Bridge B. Logic input for BOUT2. Internal pull-down.	
24	AI0	I	A Channel H-Bridge Current Set Inputs. 00 is for 100% full scale, 01 is for 71% full scale, 10 is for 31% full scale, 11 is for 0%. Internal pull-down.	
25	AI1	I		
26	BI0	I	B Channel H-Bridge Current Set Inputs. 00 is for 100% full scale, 01 is for 71% full scale, 10 is for 31% full scale, 11 is for 0% full scale. Internal pull-down.	
27	BI1	I		
14, 28	GND	-	Ground.	
Exposed Pad	GND	-	Ground.	

NOTE: I = input, O = output, OD = open-drain output, I/O = input/output.

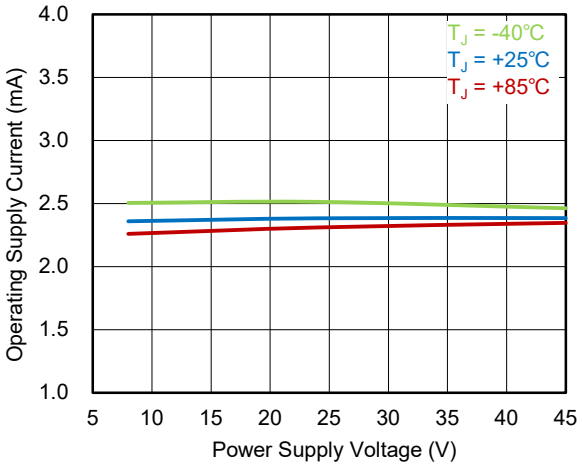
ELECTRICAL CHARACTERISTICS

(T_J = +25℃, unless otherwise noted.)

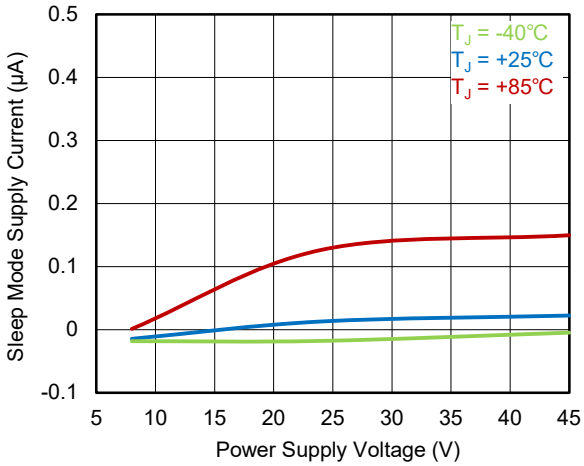
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Power Supplies						
Motor Power Supply Voltage	V_M		8		45	V
Operating Supply Current	I_{VM}	V_M = 24V		2	5	mA
Sleep Mode Supply Current	I_{VMQ}	V_M = 24V		1	2	μA
VM Under-Voltage Lockout Threshold	V_{UVLO}	V_M rising		7.7	7.98	V
V3P3 Regulator						
V3P3 Voltage	V_{V3P3}	I_{OUT} = 0mA to 10mA	3.1	3.3	3.5	V
Logic-Level Inputs						
Input Logic Low Voltage	V_{IL}	T_J = -40℃ to +85℃			0.5	V
Input Logic High Voltage	V_{IH}	T_J = -40℃ to +85℃	2.7			V
Input Hysteresis	V_{HYS}			1.2		V
Input Logic Low Current	I_{IL}	V_{IN} = 0V	-10		10	μA
Input Logic High Current	I_{IH}	V_{IN} = 3.3V			50	μA
Internal Pull-Down Resistance	R_{PD}			300		kΩ
nFAULT Output (Open-Drain Output)						
Output Low Voltage	V_{OL}	I_{OUT} = 5mA			0.5	V
Output High Leakage Current	I_{OH}	V_{OUT} = 3.3V			1	μA
DECAY Input						
Input Low Threshold Voltage	V_{IL}	For slow decay (brake) mode, T_J = -40℃ to +85℃	0		0.35	V
Input High Threshold Voltage	V_{IH}	For fast decay (coast) mode, T_J = -40℃ to +85℃	3			V
Input Current	I_{IN}		-40		40	μA
Internal Pull-Up Resistance	R_{PU}			120		kΩ
Internal Pull-Down Resistance	R_{PD}			120		kΩ
H-Bridge FETs						
HS FET On-Resistance	R_{DSON}	V_M = 24V, I_{OUT} = 1A, T_J = +25℃		0.22		Ω
		V_M = 24V, I_{OUT} = 1A, T_J = +85℃		0.28	0.35	
LS FET On-Resistance		V_M = 24V, I_{OUT} = 1A, T_J = +25℃		0.2		
		V_M = 24V, I_{OUT} = 1A, T_J = +85℃		0.27	0.33	
Off-State Leakage Current	I_{OFF}		-1		1	μA
Motor Driver						
Current Sense Blanking Time	t_{BLANK}			3		μs
Rise Time	t_R		20		150	ns
Fall Time	t_F		20		150	ns
Protection Circuits						
Over-Current Protection Trip Level	I_{OCP}			3.5		A
Thermal Shutdown Temperature	T_{TSD}	Die temperature		160		℃
Current Control						
xVREF Input Current	I_{REF}	xV_{REF} = 3.3V	-3		3	μA
xISEN Trip Voltage	V_{TRIP}	xV_{REF} = 3.3V, 100% current setting	635	660	685	mV
		xV_{REF} = 3.3V, 71% current setting	445	469	492	
		xV_{REF} = 3.3V, 38% current setting	225	251	276	
Current Sense Amplifier Gain	A_{ISENSE}	Reference only		5		V/V

TYPICAL PERFORMANCE CHARACTERISTICS

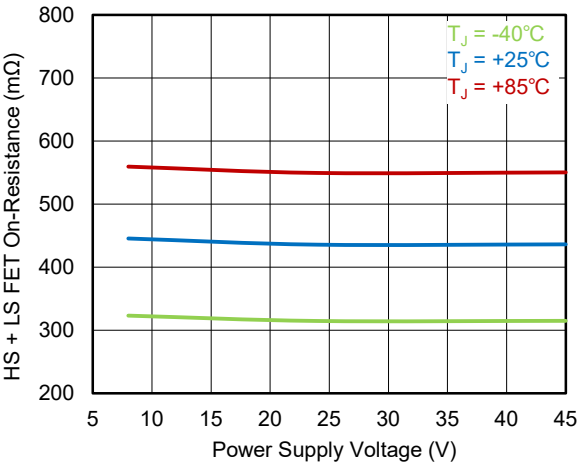
Operating Supply Current vs. Power Supply Voltage



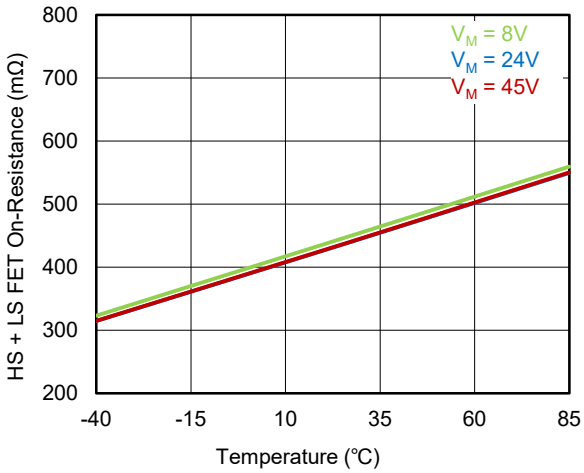
Sleep Mode Supply Current vs. Power Supply Voltage



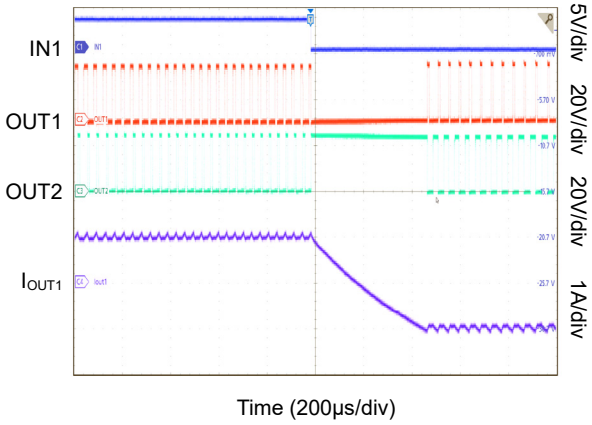
HS + LS FET On-Resistance vs. Power Supply Voltage



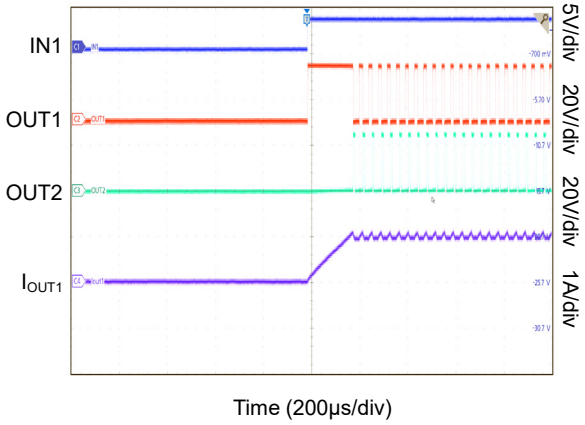
HS + LS FET On-Resistance vs. Temperature



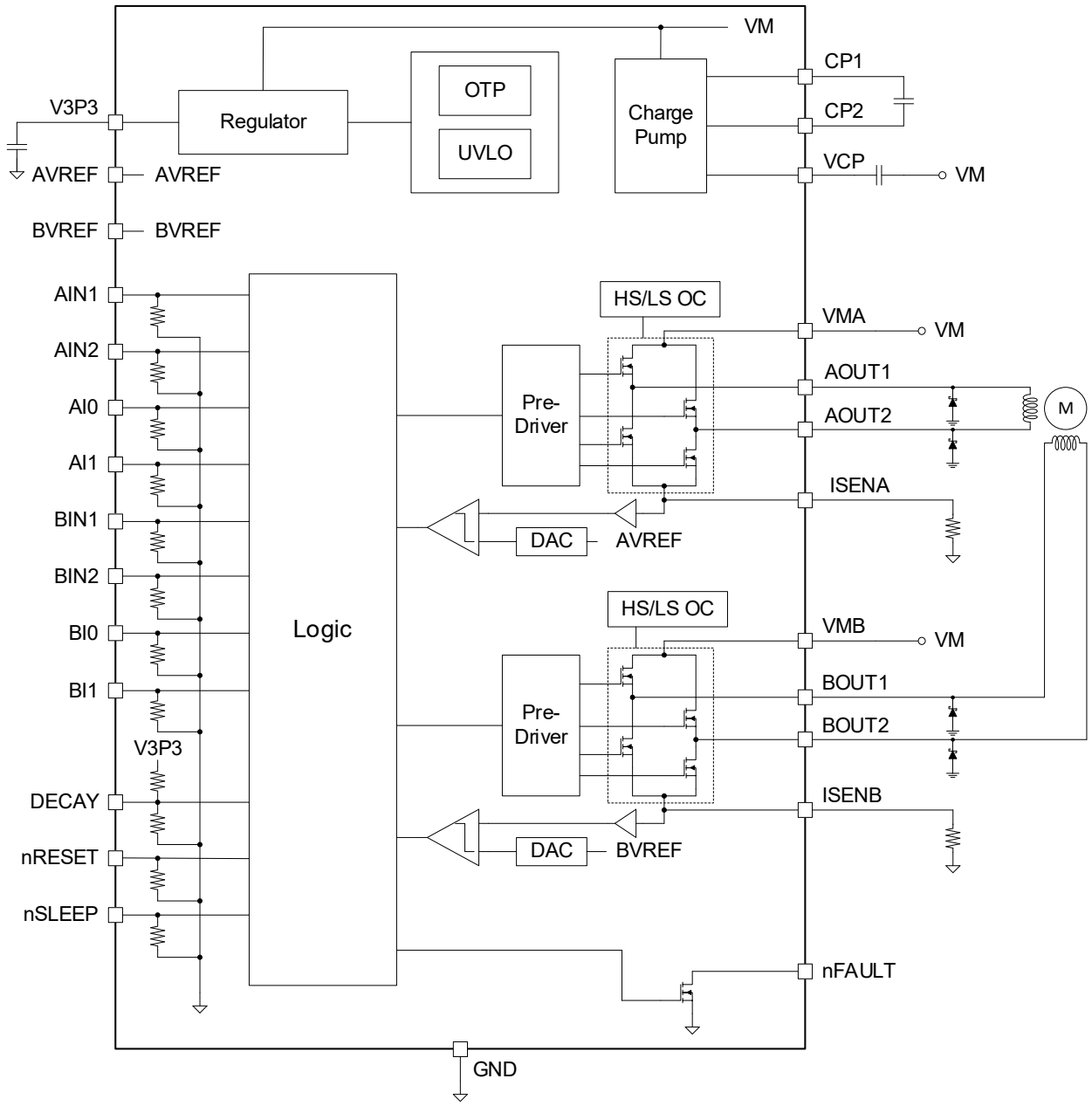
Start-Up



Current Limit



FUNCTIONAL BLOCK DIAGRAM



DETAILED DESCRIPTION

Overview

The device has two H-bridge drivers, and can drive a bipolar stepper motor or two DC motors. The output driver block for each consists of N-MOSFETs configured as full H-bridges to drive the motor windings. The SGM42541 is capable of driving up to 2A of output current (with proper heat-sinking, at 24V and +25℃).

A simple parallel digital control interface is compatible with industry-standard devices. Decay mode is configurable. The device provides three different decay modes, which can be configured according to the load characteristics and application requirements. And xI0 and xI1 can be set to control the current level. For example, current level can be set to lower level for saving power during the motor is holding.

PWM Motor Driver

Please refer to the SGM42541 motor control block diagram below:

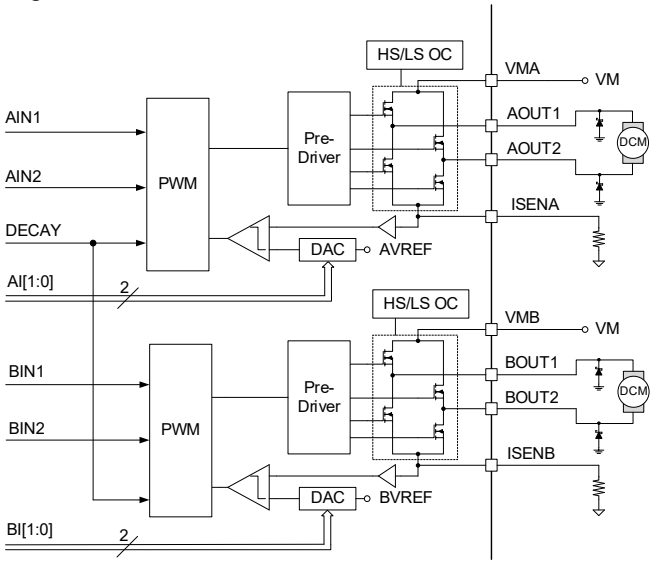


Figure 1. Motor Control Circuitry

It should be noted that, VMA and VMB should be connected on the PCB layout to the power supply.

Blanking Time

During the blanking time, the device blanks the output of the current-sense comparator when the outputs are switched by the internal current-control circuitry.

Bridge Control

The xOUT1 and xOUT2 are control by xIN1 and xIN2. Please refer to the control logic below. PWM input on the xIN1 and xIN2 can be used to control the load current.

Table 1. H-Bridge Logic

xIN1	xIN2	xOUT1	xOUT2
0	0	L	L
0	1	L	H
1	0	H	L
1	1	H	H

The xIN1 and xIN2 are both pulled low inside the device.

Current Regulation

PWM chopping is used for current regulation in the H-bridges. Motor windings typically have a large inductance of a few mH with a few ohms of DC resistance. H-bridge can apply V_M, 0 or $-V_M$ voltage across the winding and the current will start to rise or fall depending on the applied voltage and polarity with a time constant (L/R). Bridge current is sensed across shunt resistor connected to ISENx and is multiplied by a gain of 5 before being compared to the current setting reference voltage coming from xVREF input and scaling DACs. Each PWM pulse will turn off (chopped) when the comparator detects that the trip current level is reached. The maximum current deliverable to the winding (100% or full-scale) can be calculated by Equation 1.

$$I_{CHOP} = \frac{V_{REFX}}{5 \times R_{ISENSE}} \quad (1)$$

DETAILED DESCRIPTION (continued)

The current limit level is decided together by xVREF pin, sense resistor, xI0 and xI1 pins. For example, if sense resistor is 0.1Ω, xVREF is set to 1V. According to calculation 1V/(5 × 0.1Ω) = 2A. Then if xI0 and xI1 are both low, the current limit is 2A; if xI0 and xI1 are configured to 01, the current limit is 2A × 38% = 0.76A; if xI0 and xI1 are configured to 10, the current limit is 2A × 71% = 1.42A; if xI0 and xI1 are configured to 11, the output is turned off and current is 0A.

Table 2. H-Bridge Pin Functions

xI0	xI1	Relative Current (% Full-Scale Chopping Current)
1	1	0% (Bridge disabled)
0	1	38%
1	0	71%
0	0	100%

Decay Mode and Braking

Please refer to the current path of fast decay and slow decay on Figure 2.

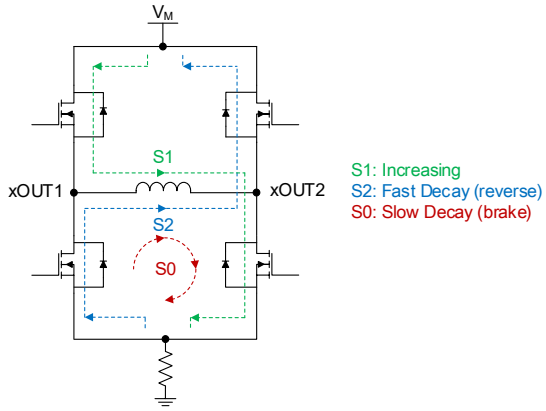


Figure 2. Decay Mode

There are 3 different decay modes provided by SGM42541, which is configured on the decay pin. If decay pin is pulled to logic high, fast decay is selected; if pulled low, slow decay is selected; if left open, mixed decay is selected.

If using mixed decay, it stays in fast mode for 33% of the off-time and then shifts to the slow decay mode for the reminder of the off-time.

Integrated Protection Circuits

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). An over-current may occur due to a short between a switching node and ground, to the VM supply line, or to the other node of the bridge (a winding short). Current protections are independent of PWM current sensing or xV_{REF} voltage.

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.

Under-Voltage Lockout (UVLO)

If any of the source voltages fall below their under-voltage lockout thresholds, the device will be disabled. Device resumes operation when all of them go back above their UVLO thresholds.

nRESET and nSLEEP Operation

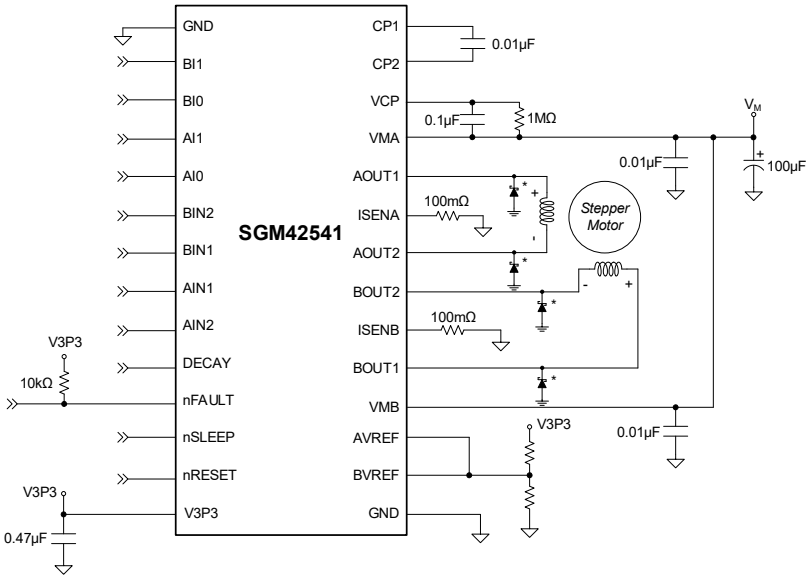
The nRESET is an active-low reset input for the internal logic. All other logic inputs are ignored if nRESET is low.

The nSLEEP is an active-low input to put the device in low-power (sleep mode) state. In sleep mode, all internal clocks, bridges, charge pump and V3P3 regulator are disabled (stopped). Also, all logic inputs are ignored.

After removing the sleep mode, a short recovery time (near 1.2ms) is needed before the driver can go back to full operation mode.

APPLICATION INFORMATION

Typical Application



NOTE: *. The Schottky diode selection depends on customer's application requirements. For example, for 36V/2A application, the Schottky diode selection refers to PMEG4030.

Figure 3. Typical Application Circuit

Sense Resistor

In order to use PWM current control, a low value resistor is placed between the ISENx pin and ground for current sensing purposes. For PCB layout consideration, the sense resistor is suggested to put near the ISENx pin.

When selecting a value for the sense resistor, it is important to ensure that the maximum voltage on the ISENx pin is not exceeded. During over-current events, this rating will be exceeded for short durations.

Power Supply Recommendations

The power supply VMx is suggested to be decoupled with a 100μF (TYP) electrolytic capacitor in parallel with a 100nF (TYP) lower valued ceramic capacitor placed as close as practicable to the device.

Bulk and Decoupling Capacitors on Motor Supply

To achieve small voltage ripple and decouple the impact of supply line inductances from interfering with the system operation, the bulk local capacitor near the motor driver is needed (V_{Mx} supply) as shown in Figure 4. Also, to decouple switching current of the H-bridge, small high frequency decoupling capacitor is recommended between VMx and GND pins.

To select the local capacitance, several factors should be considered including the following:

- Maximum current needed by the motor.
- Supply capacitance and current sourcing capability.
- Parasitic inductance of supply lines.
- Acceptable voltage ripple.
- Motor parameters and required acceleration.

The power supply inductance causes drops and oscillation on V_{Mx} line if the bulk local capacitance is insufficient.

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

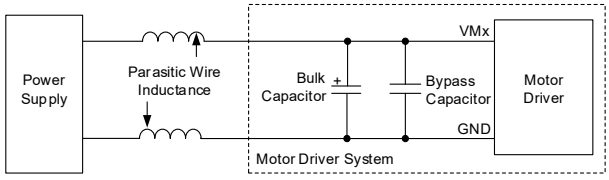


Figure 4. External Supply Connection

Capacitor voltage rating should be considered well higher than the operating voltage to provide enough margin when the energy transfer is reversed from motor windings back to the V_{Mx} supply line and they get charged by the driver.

REVISION HISTORY

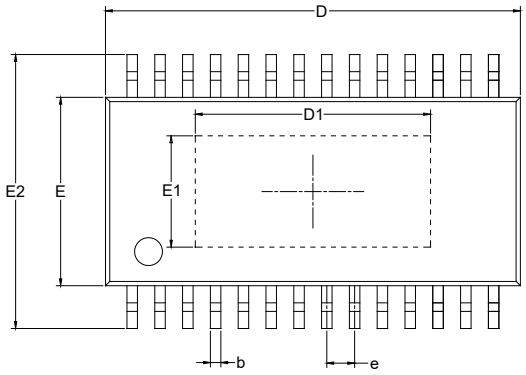
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

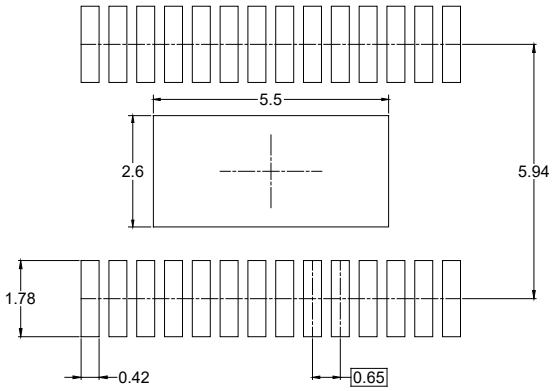
APRIL 2023 – REV.A to REV.A.1	Page
Updated General Description and Features sections	1
Updated typical application circuit section	9

Changes from Original (JANUARY 2023) to REV.A	Page
Changed from product preview to production data	All

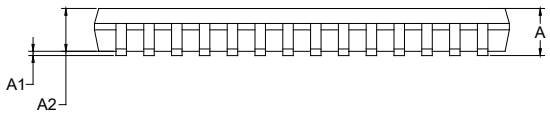
PACKAGE OUTLINE DIMENSIONS

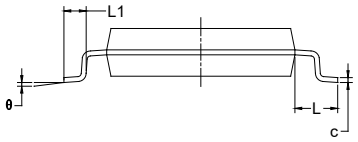
TSSOP-28 (Exposed Pad)





RECOMMENDED LAND PATTERN (Unit: mm)





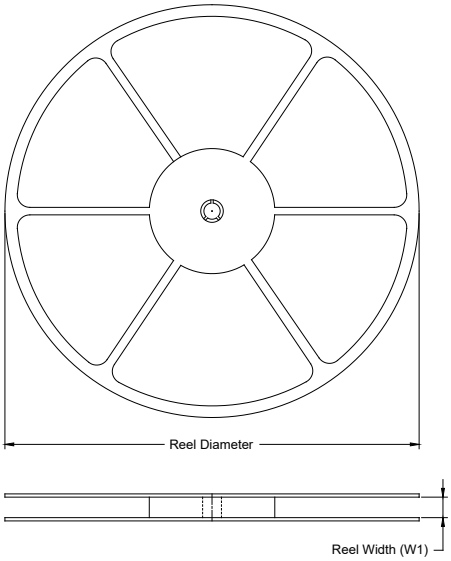
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	9.600	9.800	0.378	0.386
D1	5.300	5.700	0.209	0.224
E	4.300	4.500	0.169	0.177
E1	2.400	2.800	0.094	0.110
E2	6.200	6.600	0.244	0.260
e	0.650 BSC		0.026 BSC	
L	1.000 BSC		0.039 BSC	
L1	0.450	0.750	0.018	0.030
θ	0°	8°	0°	8°

NOTES:

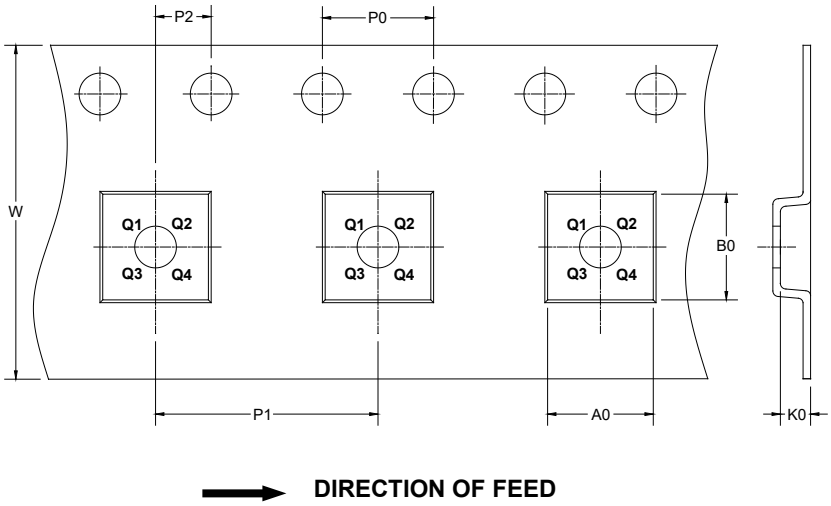
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.
3. Reference JEDEC MO-153.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



DIRECTION OF FEED

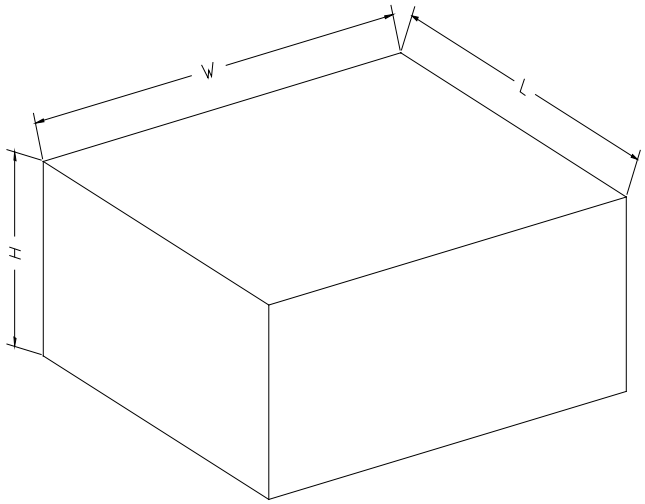
NOTE: The picture is only for reference. Please make the object as the standard.

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-28 (Exposed Pad)	13″	16.4	6.80	10.25	1.60	4.0	8.0	2.0	16.0	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