

Dual H-Bridge Motor Driver

Features

- **Dual H-Bridge Motor Driver With Current Control**
 - 1 or 2 DC Motors or 1 Stepper Motor
 - **Low On-Resistance: HS + LS = 1735mΩ** (Typical, 25°C)
- **Output Current Capability (at $V_M = 5V$, 25°C)**
 - **TSSOP-16 (FD) Package**
 - 0.7A RMS, 1A Peak per H-Bridge
 - 1.4A RMS in Parallel Mode
 - **TQFN3X3-16 and TQFN4X4-16 Package**
 - 0.6A RMS, 1A Peak per H-Bridge
 - 1.2A RMS in Parallel Mode
- **Wide Power Supply Voltage Range 2.7 to 10.8V**
- **Integrated Current Regulation**
- **Easy Pulse-Width-Modulation (PWM) Interface**
- **1.6μA Low-Current Sleep Mode (at 5V)**
- **TSSOP-16 (FD), TQFN3X3-16 and TQFN4X4-16 Package**
- **Protection Features**
 - V_M Undervoltage Lockout (UVLO)
 - Overcurrent Protection (OCP)
 - Thermal Shutdown (TSD)
 - Fault Indication Pin (nFAULT)

Applications

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

General Description

The G2053 provides a dual-bridge motor driver solution for toys, printers, and other mechatronic applications.

The device has two H-bridges and can drive two DC brushed motors, a bipolar stepper motor, solenoids, or other inductive loads.

Each H-bridge output consists of a pair of N-channel and P-channel MOSFETs, with circuitry that regulates the winding current. With proper PCB design, each H-bridge of the G2053 can drive up to 700mA RMS (or DC) continuously, at 25°C with a V_M supply of 5V. The device can support peak currents of up to 1 A per bridge. Current capability is reduced slightly at lower V_M voltages.

Internal shutdown functions with a fault output pin are provided for overcurrent protection, short-circuit protection, UVLO, and overtemperature. A low-power sleep mode is also provided.

Ordering Information

ORDER NUMBER	MARKING	TEMP. RANGE	PACKAGE (Green)
G2053FC1U	G2053	-40°C to +85°C	TSSOP-16 (FD)
G2053R41U	2053	-40°C to +85°C	TQFN3X3-16
G2053R81U	2053	-40°C to +85°C	TQFN4X4-16

Note: FC: TSSOP-16 (FD) R4: TQFN3X3-16

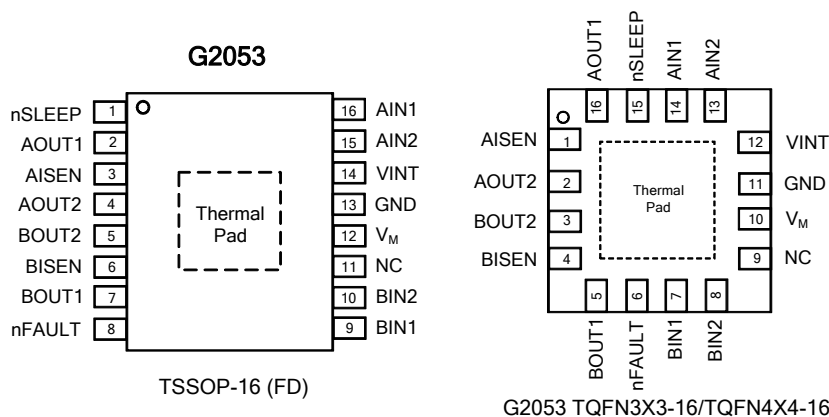
R8: TQFN4X4-16

1: Bonding Code

U : Tape & Reel

Green: Lead Free / Halogen Free

Pin Configuration



Note: Recommend connecting the Thermal Pad to the Ground for excellent power dissipation.

Absolute Maximum Ratings

Power supply (V_M)	-0.3V to 11.8V
Internal regulator (VINT)	-0.3V to 3.8V
Control pins (AIN1, AIN2, BIN1, BIN2, nSLEEP, nFAULT)	-0.3V to 7V
Continuous phase node pins (AOUT1, AOUT2, BOUT1, BOUT2)	-0.3V to $V_M+0.5V$
Pulsed 10 μ s phase node pins (AOUT1, AOUT2, BOUT1, BOUT2)	-1V to V_M+1V
Continuous shunt amplifier input pins (AISEN, BISEN)	-0.3V to +0.5V
Pulsed 10 μ s shunt amplifier input pins (AISEN, BISEN)	-1V to +1V
Peak drive current (AOUT1, AOUT2, BOUT1, BOUT2, AISEN, BISEN)	Internally limited A
Thermal Resistance of Junction to Ambient, (θ_{JA})	
TSSOP-16 (FD)	TBD $^{\circ}C/W$
TQFN3X3-16	TBD $^{\circ}C/W$
TQFN4X4-16	TBD $^{\circ}C/W$
Continuous Power Dissipation ($T_A = +25^{\circ}C$)	
TSSOP-16 (FD)	TBDmW
TQFN3X3-16	TBDmW
TQFN4X4-16	TBDmW

Thermal Resistance of Junction to Ambient, (θ_{JC})	
TSSOP-16 (FD)	TBD $^{\circ}C/W$
TQFN3X3-16	TBD $^{\circ}C/W$
TQFN4X4-16	TBD $^{\circ}C/W$
Operating junction temperature (T_J)	-40 $^{\circ}C$ to 150 $^{\circ}C$
Storage Temperature (T_{stg})	-65 $^{\circ}C$ to 150 $^{\circ}C$
Reflow Temperature (soldering, 10sec)	260 $^{\circ}C$
ESD (HBM)	$\pm 2KV$
ESD (CDM)	$\pm 1KV$

Recommended Operating Conditions

Power supply voltage (V_M) ⁽¹⁾	2.7V to 10.8V
Logic level input voltage (V_I)	.0V to 5.5V
Motor RMS current (I_{RMS}) ⁽²⁾	
TSSOP-16 (FD)	.0 to 0.7A
TQFN3X3-16/TQFN4X4-16	.0 to 0.6A
Applied PWM signal to AIN1, AIN2, BIN1, or BIN2 (f_{PWM})	.0 to 200KHz
Operating ambient temperature (T_A)	-40 $^{\circ}C$ to 85 $^{\circ}C$

Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- (1) Note that when V_M is below 5V, $R_{DS(ON)}$ increases and maximum output current is reduced.
- (2) Power dissipation and thermal limits must be observed.

Electrical Characteristics

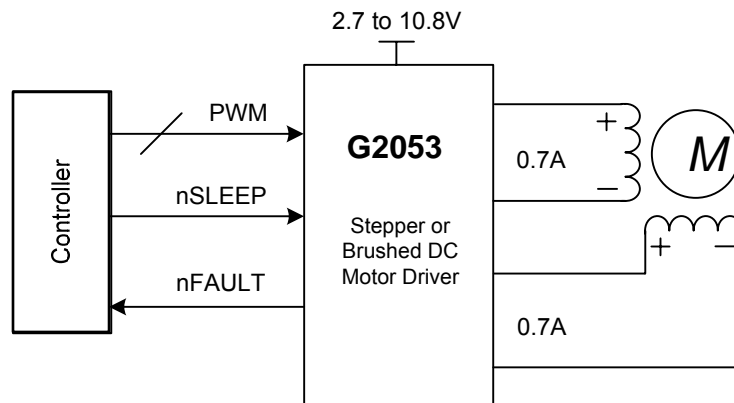
($T_A=25^{\circ}C$)

The device is not guaranteed to function outside its operating conditions. Parameters with MIN and/or MAX limits are 100% tested at +25 $^{\circ}C$, unless otherwise specified.

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
POWER SUPPLIES (V_M, VINT)						
V_M operating voltage	V_M		2.7	---	10.8	V
V_M operating supply current	I_{VM}	$V_M = 5V$, xINx low, nSLEEP high	---	1.7	3	mA
V_M sleep mode supply current	I_{VMQ}	$V_M = 5V$, nSLEEP low	---	1.6	2.7	μA
Sleep time	t_{SLEEP}	nSLEEP low to sleep mode	---	10	---	μs
Wake-up time	t_{WAKE}	nSLEEP high to output transition	---	155	---	μs
Turn-on time	t_{ON}	$V_M > V_{UVLO}$ to output transition	---	25	---	μs
Internal regulator voltage	V_{INT}	$V_M > V_{UVLO}$ to output transition	3	3.3	3.6	V
CONTROL INPUTS (AIN1, AIN2, BIN1, BIN2, nSLEEP)						
Input logic low voltage	V_{IL}	xINx	0	---	0.7	V
		nSLEEP	0	---	0.5	
Input logic high voltage	V_{IH}	xINx	2	---	5.5	V
		nSLEEP	2.5	---	5.5	
Input logic hysteresis	V_{HYS}		350	400	650	mV
Input logic low current	I_{IL}	$V_{IN} = 0V$	-1	---	1	μA
Input logic high current	I_{IH}	$V_{IN} = 5V$	---	---	50	μA
Pulldown resistance	R_{PD}	xINx	100	150	250	k Ω
		nSLEEP	380	500	750	
Input deglitch time	t_{DEG}		---	575	---	ns
Propagation delay INx to OUTx	t_{PROP}	$V_{IN} = 5V$	---	1.2	---	μs

Electrical Characteristics (Continued)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
CONTROL OUTPUTS (nFAULT)						
Output logic low voltage	V_{OL}	$I_O = 5\text{mA}$	---	---	0.5	V
Output logic high leakage	I_{OH}	$R_{PULLUP} = 1\text{k}\Omega$ to 5V	-1	---	1	μA
MOTOR DRIVER OUTPUTS (AOUT1, AOUT2, BOUT1, BOUT2)						
High-side FET on-resistance	$R_{DS(ON)}$	$V_M = 5\text{V}, I = 0.2\text{A}, T_A = 25^\circ\text{C}$	---	817	---	$\text{m}\Omega$
		$V_M = 2.7\text{V}, I = 0.2\text{A}, T_A = 25^\circ\text{C}$	---	1140	---	
Low-side FET on-resistance	$R_{DS(ON)}$	$V_M = 5\text{V}, I = 0.2\text{A}, T_A = 25^\circ\text{C}$	---	285	---	$\text{m}\Omega$
		$V_M = 2.7\text{V}, I = 0.2\text{A}, T_A = 25^\circ\text{C}$	---	382	---	
Off-state leakage current	I_{OFF}	$V_M = 5\text{V}$	-1	---	1	μA
Output rise time	t_{RISE}	$V_M = 5\text{V}; R_L = 16\Omega$ to GND	---	70	---	ns
Output fall time	t_{FALL}	$V_M = 5\text{V}; R_L = 16\Omega$ to VM	---	80	---	ns
Output dead time	t_{DEAD}	Internal dead time	---	450	---	ns
PWM CURRENT CONTROL (AISEN, BISEN)						
xISEN trip voltage	V_{TRIP}		160	200	240	mV
Current control constant off time	t_{OFF}	Internal PWM constant off time	---	20	---	μs
PROTECTION CIRCUITS						
V_M undervoltage lockout	V_{UVLO}	V_M falling; UVLO report	---	---	2.6	V
		V_M rising; UVLO recovery	---	---	2.7	
V_M undervoltage hysteresis	$V_{UVLO,HYS}$	Rising to falling threshold	---	90	---	mV
Overcurrent protection trip level	I_{OCP}		1	---	---	A
Overcurrent deglitch time	t_{DEG}		---	2.3	---	μs
Overcurrent protection period	t_{OCP}		---	1.4	---	ms
Thermal shutdown temperature	$T_{TSD}^{(1)}$	Die temperature, T_J	150	---	---	$^\circ\text{C}$
Thermal shutdown hysteresis	T_{HYS}	Die temperature, T_J	---	20	---	$^\circ\text{C}$



Pin Description

NAME	PIN		TYPE	FUNCTION	
	TSSOP	TQFN			
POWER AND GROUND					
GND	13	11	PWR	Device ground	Both the GND pin and device PowerPAD must be connected to ground
VINT	14	12	-	Internal regulator (3.3 V)	Internal supply voltage; bypass to GND with 2.2 μ F, 6.3V capacitor
V _M	12	10	PWR	Power supply	Connect to motor supply voltage; bypass to GND with a 10 μ F (minimum) capacitor rated for V _M
CONTROL					
AIN1	16	14	I	H-bridge A PWM input	Controls the state of AOUT1 and AOUT2; internal pulldown
AIN2	15	13			
BIN1	9	7	I	H-bridge B PWM input	Controls the state of BOUT1 and BOUT2; internal pulldown
BIN2	10	8			
nSLEEP	1	15	I	Sleep mode input	Logic high to enable device; logic low to enter low-power sleep mode; internal pulldown
STATUS					
nFAULT	8	6	OD	Fault indication pin	Pulled logic low with fault condition; open-drain output requires an external pullup
OUTPUT					
AISEN	3	1	O	Bridge A sense	Sense resistor to GND sets PWM current regulation level (see <i>PWM Motor Drivers</i>)
AOUT1	2	16	O	Bridge A output	Positive current is AOUT1 → AOUT2
AOUT2	4	2			
BISEN	6	4	O	Bridge B sense	Sense resistor to GND sets PWM current regulation level (see <i>PWM Motor Drivers</i>)
BOUT1	7	5	O	Bridge B output	Positive current is BOUT1 → BOUT2
BOUT2	5	3			

Detailed Description

Overview

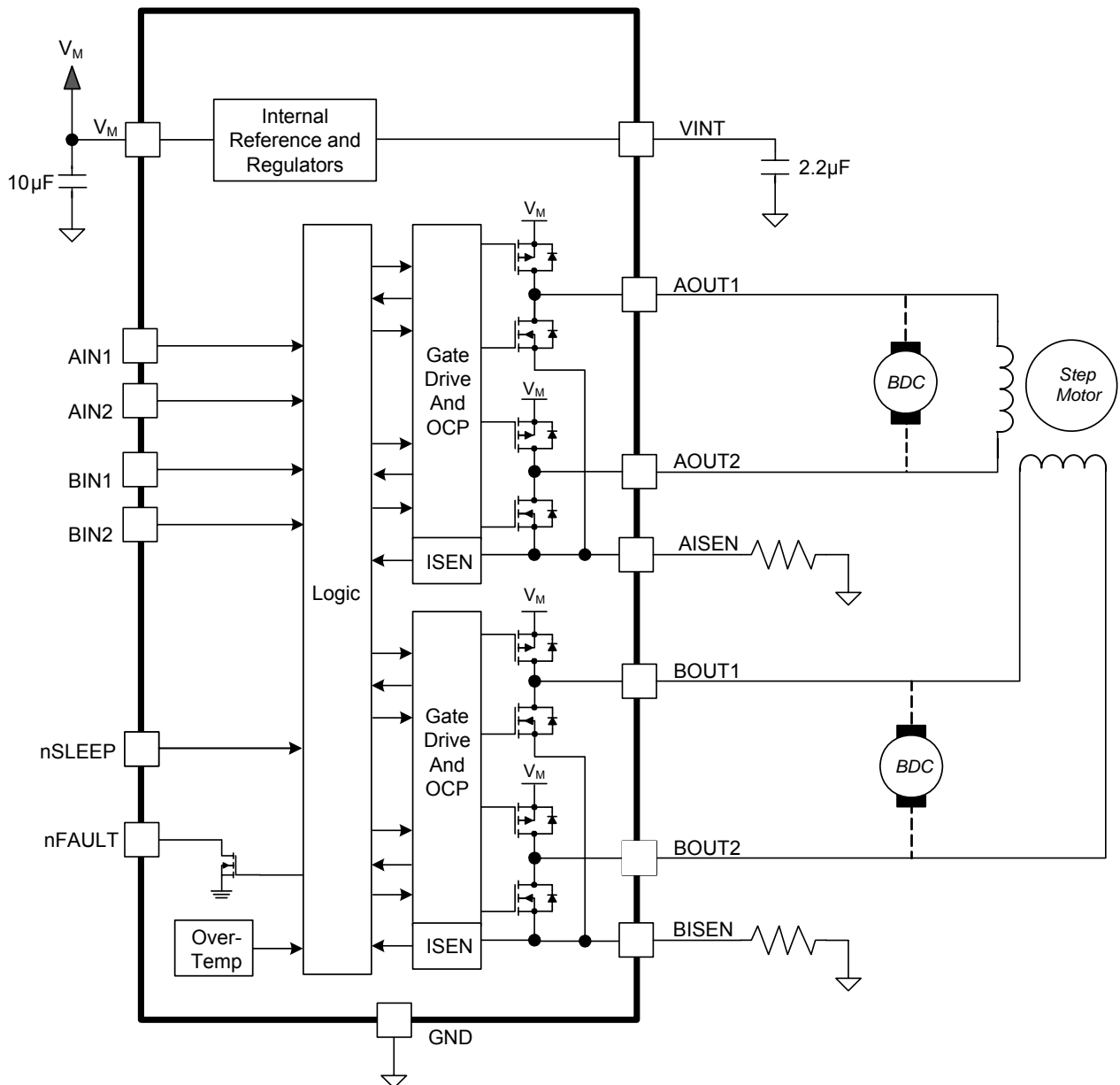
The G2053 device is an integrated motor driver solution for brushed DC or bipolar stepper motors. The device integrates two PMOS + NMOS H-bridges and current regulation circuitry. The G2053 can be powered with a supply voltage from 2.7 to 10.8V and can provide an output current up to 700mA RMS.

A simple PWM interface allows easy interfacing to the controller circuit.

The current regulation is a 20 μ s fixed off-time slow decay.

The device includes a low-power sleep mode, which lets the system save power when not driving the motor.

Functional Block Diagram



Feature Description

PWM Motor Drivers

The G2053 contains drivers for two full H-bridges. Figure 6 shows a block diagram of the circuitry.

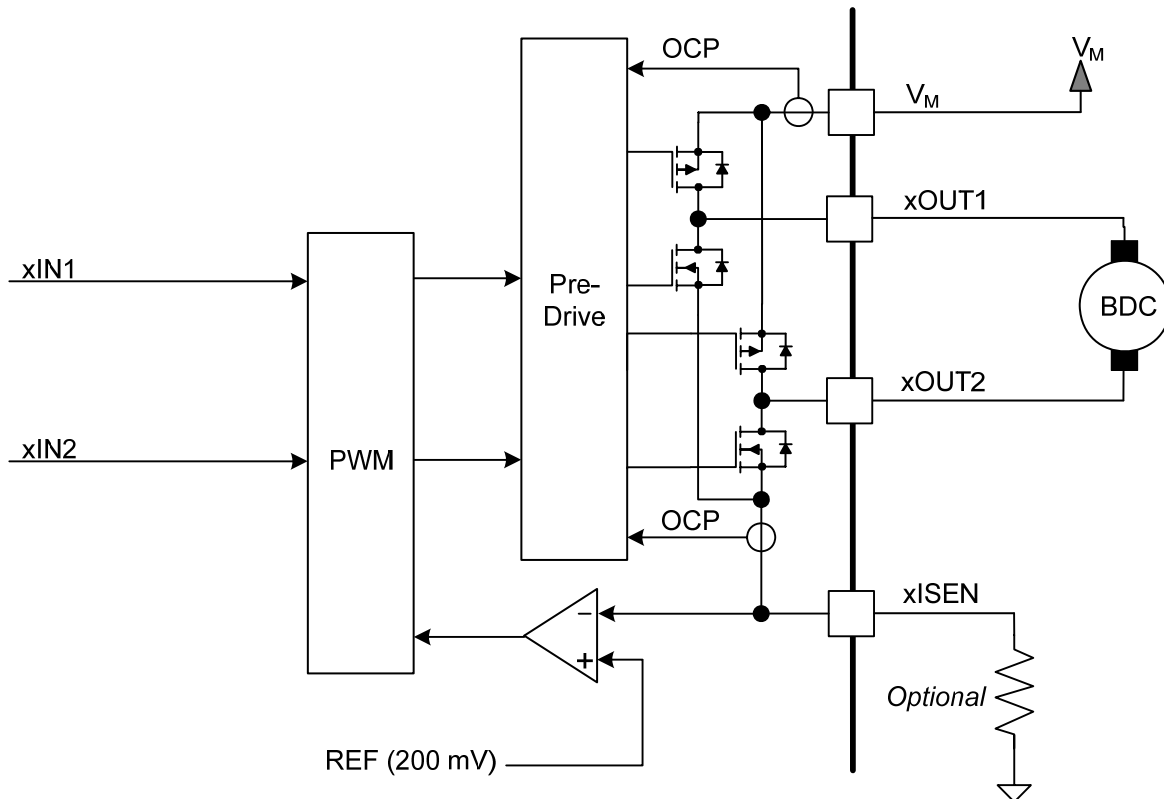


Figure 6. H-Bridge and Current-Chopping Circuitry

Bridge Control and Decay Modes

The AIN1 and AIN2 input pins control the state of the AOUT1 and AOUT2 outputs; similarly, the BIN1 and BIN2 input pins control the state of the BOUT1 and BOUT2 outputs (see Table 1).

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 inputs can also be used for PWM control of 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.

To externally pulse-width modulate the bridge in fast-decay mode, the PWM signal is applied to one xIN pin while the other is held low; to use slow-decay mode, one xIN pin is held high. See Table 2 for more information.

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 xIN. To disable the current control when applying external PWM, the xISEN pins should be connected directly to ground. Figure 7 show the current paths in different drive and decay modes.

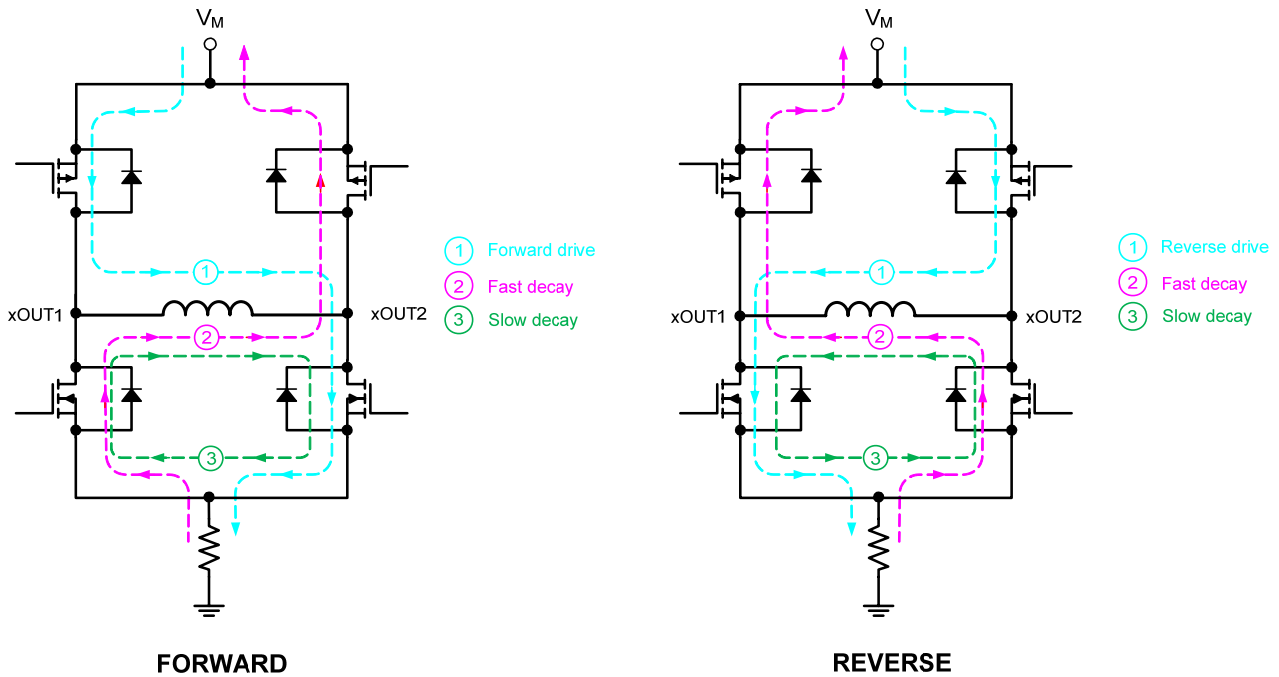


Figure 7. Drive and Decay Modes

Current Control

The current through the motor windings may be limited, or controlled, by a 20µs constant off-time 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 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 3.75µs.

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 200mV nominally. The chopping current is calculated as in Equation 1.

$$I_{CHOP} = \frac{200mV}{R_{XISEN}} \tag{1}$$

Example: If a 1Ω sense resistor is used, the chopping current will be 200 mV / 1Ω = 200mA.

Decay Mode

After the chopping current threshold is reached, the H-bridge switches to slow-decay mode. This state is held for t_{off} ($20\mu s$) until the next cycle to turn on the high-side MOSFETs.

Slow Decay

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 (typically $20\mu s$). After that, the high-side MOSFETs are enabled to increase the winding current again.

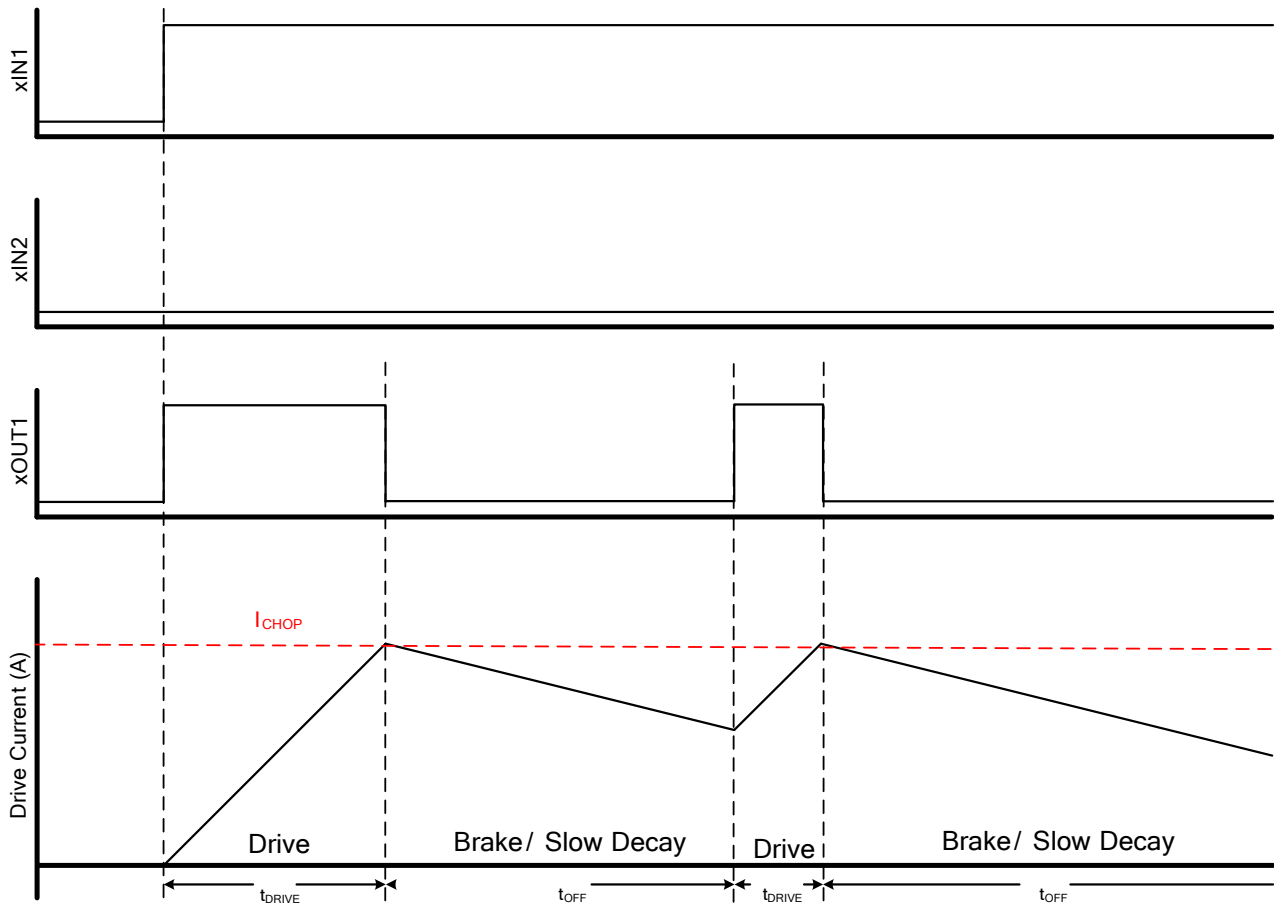


Figure 8. Current Chopping Operation

Sleep Mode

Driving nSLEEP low puts the device into a low-power sleep state. In this state, the H-bridges are disabled, all internal logic is reset, and all internal clocks are stopped. All inputs are ignored until nSLEEP returns inactive high. When returning from sleep mode, some time, t_{WAKE} , needs to pass before the motor driver becomes fully operational. To make the board design simple, the nSLEEP can be pulled up to the supply (V_M). GMT recommends to use a pullup resistor when this is done. This resistor limits the current to the input in case V_M is higher than 6.5V. Internally, the nSLEEP pin has a $500k\Omega$ resistor to GND. It also has a clamping Zener diode that clamps the voltage at the pin at 6.5V. Currents greater than $250\mu A$ can cause damage to the input structure. Therefore, GMT recommends a pullup resistor between 20 to $75k\Omega$.

Parallel Mode

The two H-bridges in the G2053 can be connected in parallel for double the current of a single H-bridge. The internal dead time in the G2053 prevents any risk of cross-conduction (shoot-through) between the two bridges due to timing differences between the two bridges. Figure 9 shows the connections.

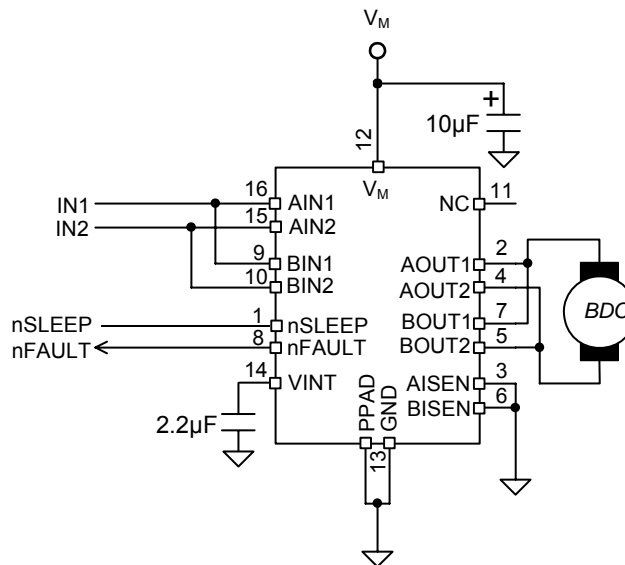


Figure 9. Parallel Mode Schematic

Protection Circuits

The G2053 is fully protected against overcurrent, overtemperature, and undervoltage events.

Overcurrent Protection (OCP)

An analog current limit (I_{OCP}) circuit on each FET limits the current through the FET by limiting the gate drive. If this analog current limit persists for longer than the OCP deglitch time (t_{DEG}), all FETs in the H-bridge are disabled and the nFAULT pin is driven low. The driver is re-enabled after the OCP retry period (t_{OCP}) has passed. nFAULT becomes high again after the retry time. If the fault condition is still present, the cycle repeats. If the fault is no longer present, normal operation resumes and nFAULT remains deasserted. Note that only the H-bridge in which the OCP is detected will be disabled while the other bridge functions normally.

Overcurrent conditions are detected independently on both high-side and low-side devices; a short to ground, supply, or across the motor winding all result in an overcurrent shutdown. Note that overcurrent protection does not use the current sense circuitry used for PWM current control, so it functions even without presence of the xISEN resistors.

Thermal Shutdown (TSD)

If the die temperature exceeds safe limits, all FETs in the H-bridge are disabled and the nFAULT pin is driven low. After the die temperature has fallen below the specified hysteresis (T_{HYS}), operation automatically resumes. The nFAULT pin is released after operation has resumed.

UVLO

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

Table 3. Device Protection

Fault	Condition	Error Report	H-Bridge	Internal Circuits	Recovery
V _M undervoltage (UVLO)	V _M < 2.6 V	None	Disabled	Disabled	V _M > 2.7 V
Overcurrent (OCP)	I _{OUT} > I _{OCP}	FAULTn	Disabled	Operating	OCP
Thermal Shutdown (TSD)	T _J > T _{TSD}	FAULTn	Disabled	Operating	T _J < T _{TSD} - T _{HYS}

Device Functional Modes

The G2053 is active unless the nSLEEP pin is brought logic low. In sleep mode, the H-bridge FETs are

disabled (Hi-Z). Note that t_{SLEEP} must elapse after a falling edge on the nSLEEP pin before the device is in sleep mode. The G2053 is brought out of sleep mode automatically if nSLEEP is brought logic high. Note that t_{WAKE} must elapse before the outputs change state after wake-up.

Table 4. Modes of Operation

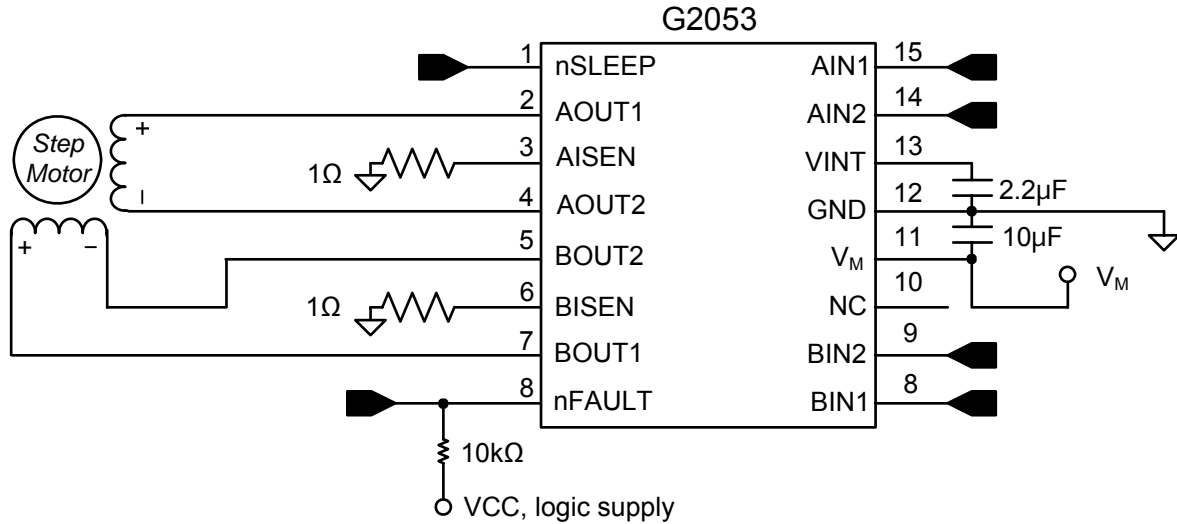
Fault	Condition	H-Bridge	Internal Circuits
Operating	nSLEEP pin high	Operating	Operating
Sleep mode	nSLEEP pin low	Disabled	Disabled
Fault encountered	Any fault condition met	Disabled	See Table 3

Application and Implementation

Application Information

The G2053 is used in stepper or brushed DC motor control. The following design procedure can be used to configure the G2053 in a bipolar stepper motor application.

Typical Application



Design Requirements

Table 5 gives design input parameters for system design.

Table 5. Design Parameters

Design Parameter	Reference	Example Value
Supply voltage	V_M	9 V
Motor winding resistance	R_L	12Ω/phase
Motor winding inductance	L_L	10 mH/phase
Motor full step angle	θ_{step}	1.8 °/step
Target stepping level	n_m	2 (half-stepping)
Target motor speed	v	120 rpm
Target chopping current	I_{CHOP}	200 mA
Sense resistor	R_{ISEN}	1Ω

Detailed Design Procedure

Stepper Motor Speed

The first step in configuring the G2053 requires the desired motor speed and stepping level. The G2053 can support full- and half-stepping modes using the PWM interface.

If the target motor speed is too high, the motor does not spin. Ensure that the motor can support the target speed.

For a desired motor speed (v), microstepping level (n_m), and motor full step angle (θ_{step}),

$$f_{step} (\text{step/s}) = \frac{v(\text{rpm}) \times n_m (\text{steps}) \times 360^\circ / \text{rot}}{Q_{step} (^\circ / \text{step}) \times 60\text{s} / \text{min}} \quad (2)$$

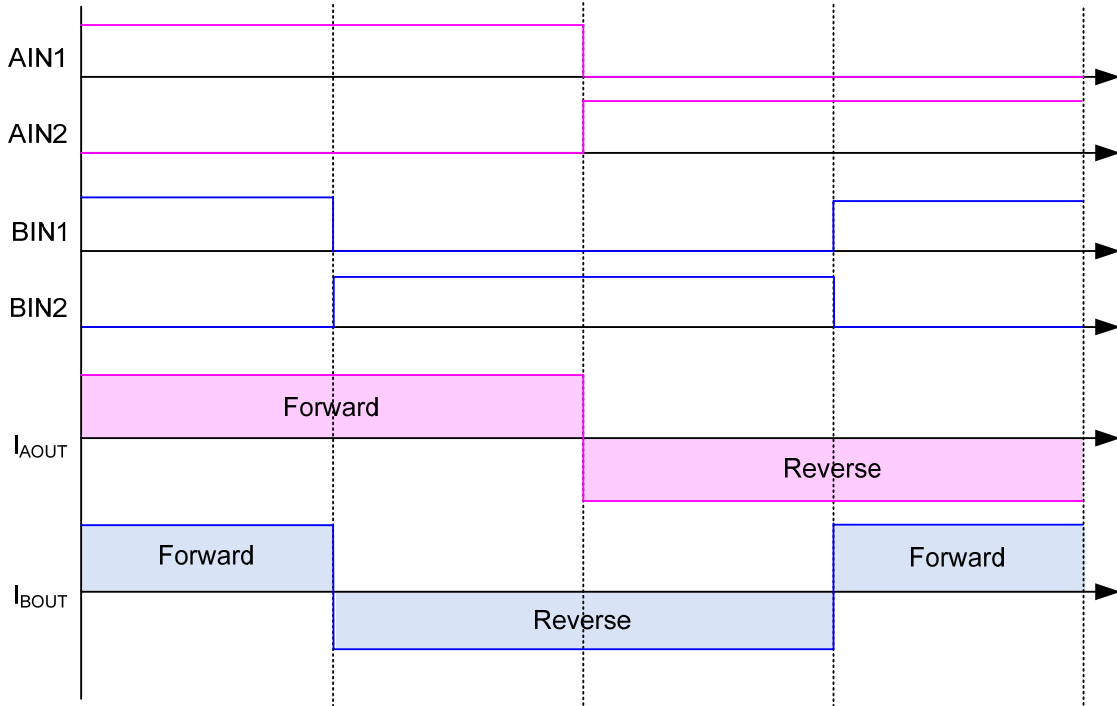


Figure 10. Full-Step Mode

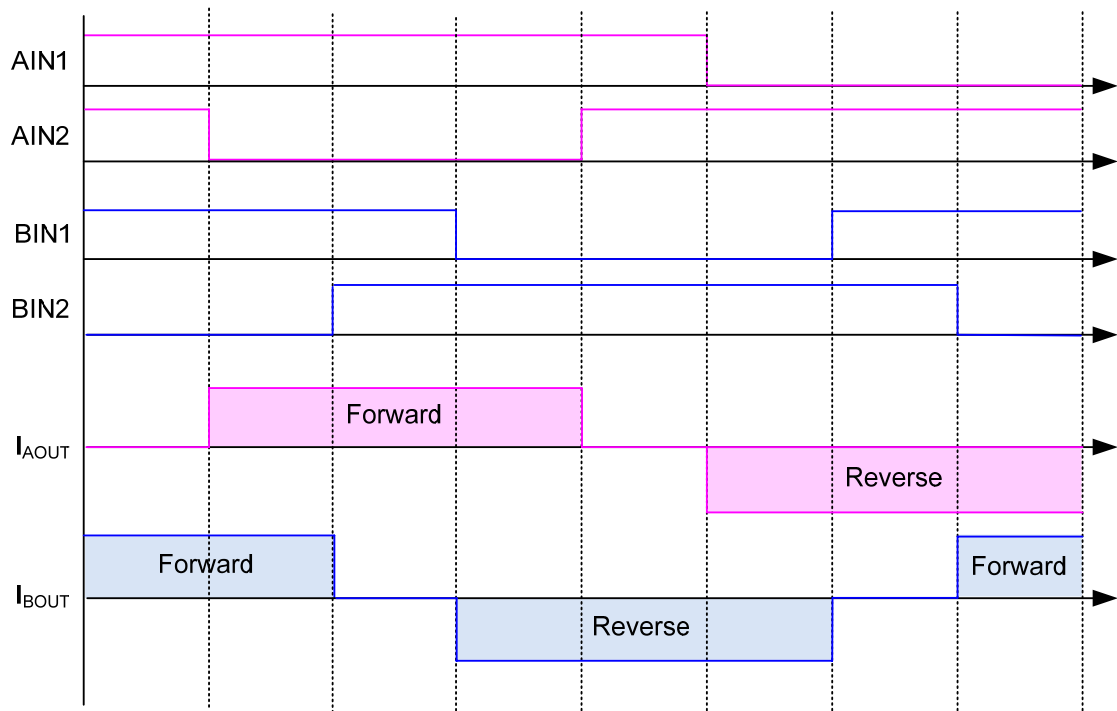


Figure 11. Half-Step Mode

Current Regulation

The chopping current (I_{CHOP}) is the maximum current driven through either winding. This quantity depends on the sense resistor value (R_{XISEN}).

$$I_{CHOP} = \frac{200mV}{R_{XISEN}} \quad (3)$$

I_{CHOP} is set by a comparator which compares the voltage across R_{XISEN} to a reference voltage. Note that I_{CHOP} must follow Equation 4 to avoid saturating the motor.

$$I_{FS} (A) < \frac{V_M (V)}{R_L (\Omega) + R_{DS(ON)} HS (\Omega) + R_{DS(ON)} LS (\Omega)} \quad (4)$$

Where

- V_M is the motor supply voltage.
- R_L is the motor winding resistance

Power Supply Recommendations

The G2053 is designed to operate from an input voltage supply (V_M) range between 2.7 to 10.8V. A 10 μ F ceramic capacitor rated for V_M must be placed as close to the G2053 as possible.

Sizing Bulk Capacitance for Motor Drive Systems

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

- Type of power supply
- Acceptable supply voltage ripple
- Parasitic inductance in the power supply wiring
- Type of motor (brushed DC, brushless DC, stepper)
- Motor startup current
- Motor braking method

The inductance between the power supply and motor drive system limits the rate current can change from the power supply. If the local bulk capacitance is too small, the system responds to excessive current demands or dumps from the motor with a change in voltage. Size the bulk capacitance to meet acceptable voltage ripple levels.

The data sheet generally provides a recommended value, but system-level testing is required to determine the appropriate-sized bulk capacitor.

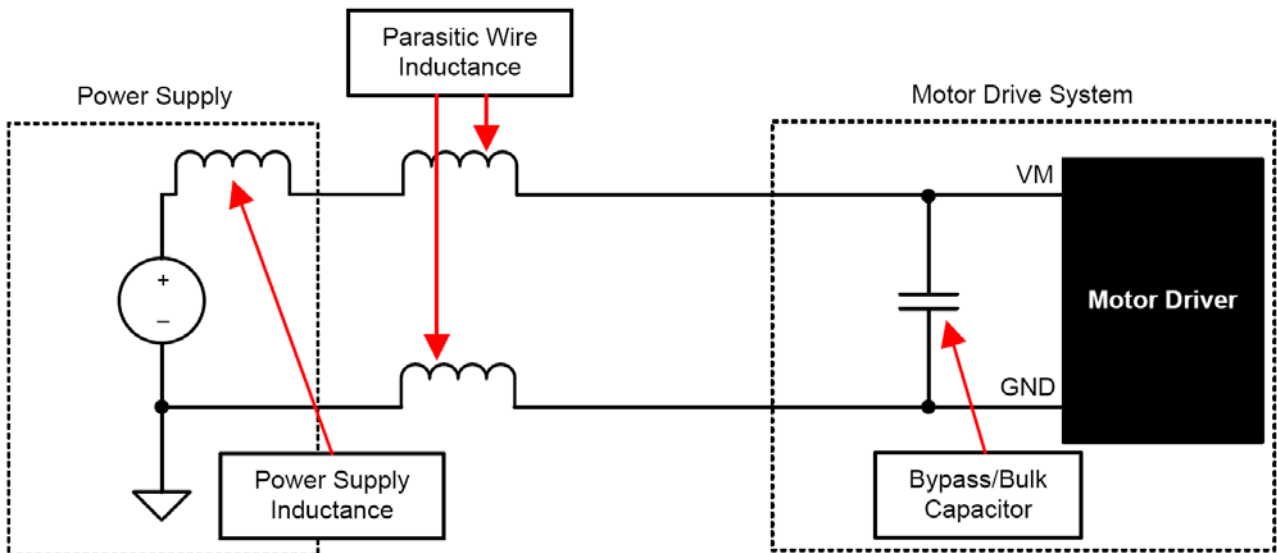


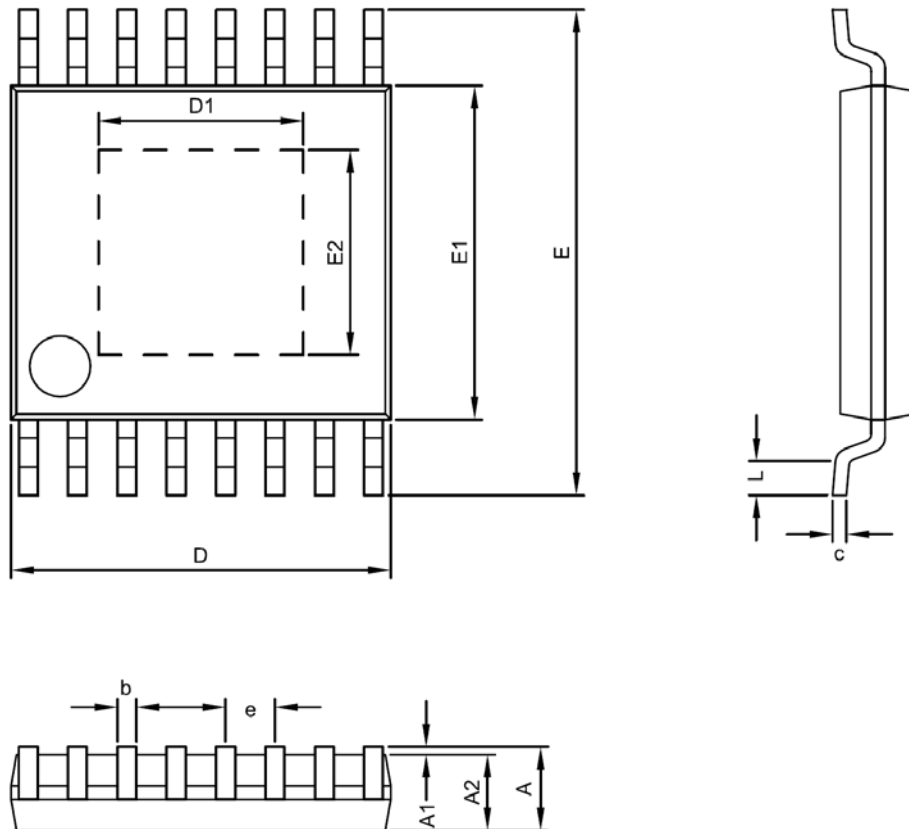
Figure 13. Setup of Motor Drive System With External Power Supply

Layout Guidelines

Bypass the V_M terminal to GND using a low-ESR ceramic bypass capacitor with a recommended value of $10\mu\text{F}$ rated for V_M . This capacitor should be placed as close to the V_M pin as possible with a thick trace or ground plane connection to the device GND pin and PowerPAD.

Bypass VINT to ground with a ceramic capacitor rated 6.3V. Place this bypassing capacitor as close to the pin as possible.

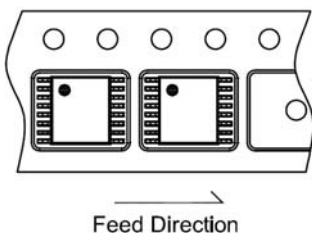
Package Information



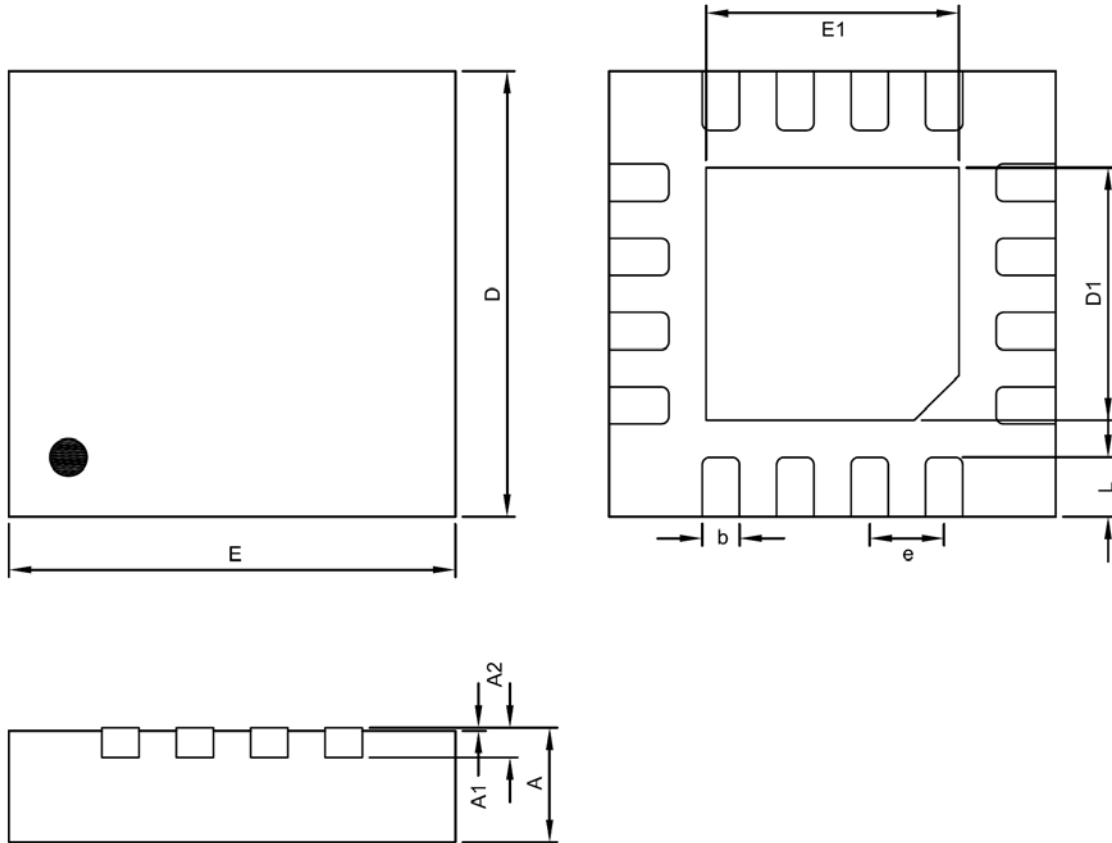
TSSOP-16 (FD) Package

Symbol	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	---	---	1.20	---	---	0.048
A1	0.00	---	0.15	0.000	---	0.006
A2	0.80	1.00	1.05	0.033	0.039	0.041
D	4.90	5.00	5.10	0.193	0.197	0.201
E	6.20	6.40	6.60	0.244	0.252	0.260
E1	4.30	4.40	4.50	0.169	0.173	0.177
D1	2.40	2.70	3.00	0.094	0.106	0.118
E2	2.40	2.70	3.00	0.094	0.106	0.118
c	0.09	---	0.20	0.004	---	0.008
b	0.19	0.22	0.30	0.008	0.009	0.012
e	0.65 BSC			0.026 BSC		
L	0.45	0.60	0.75	0.018	0.024	0.030

Taping Specification



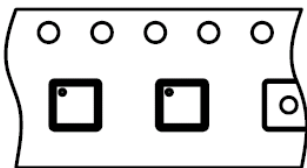
PACKAGE	Q'TY/BY REEL
TSSOP-16 (FD)	3,000 ea



TQFN3X3-16 Package

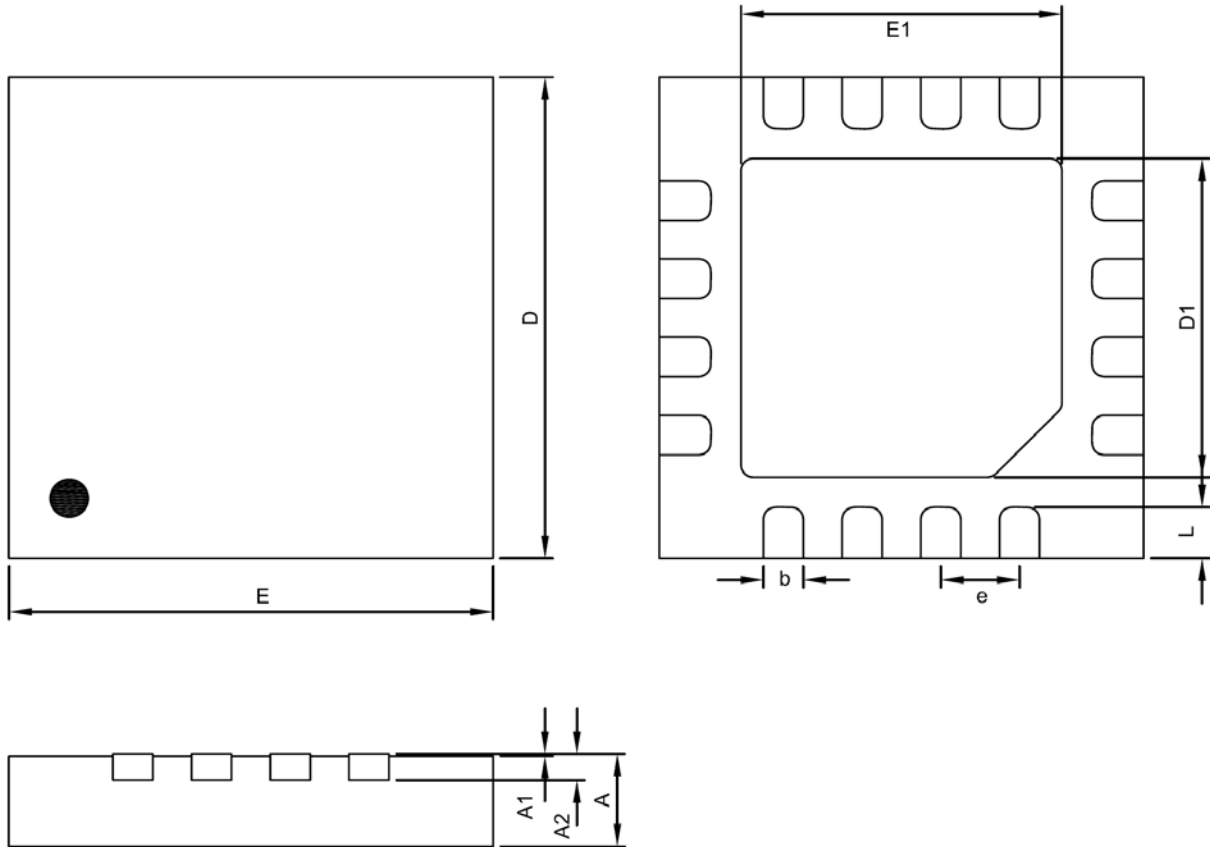
Symbol	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.0276	0.0295	0.0315
A1	0.00	---	0.05	0.0000	---	0.0020
A2	0.20 REF			0.0079 REF		
D	2.95	3.00	3.05	0.1161	0.1181	0.1201
E	2.95	3.00	3.05	0.1161	0.1181	0.1201
D1	1.60	1.70	1.80	0.0630	0.0669	0.0689
E1	1.60	1.70	1.80	0.0630	0.0669	0.0689
b	0.18	0.25	0.30	0.0071	0.0098	0.0118
e	0.50 BSC			0.0197 BSC		
L	0.35	0.40	0.45	0.0138	0.0157	0.0177

Taping Specification

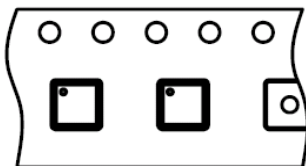


Feed Direction

PACKAGE	Q'TY/BY REEL
TQFN3X3-16	3,000 ea


TQFN4X4-16 Package

Symbol	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.0276	0.0295	0.0315
A1	0.00	---	0.05	0.0000	---	0.0020
A2	0.20 REF			0.0079 REF		
D	3.95	4.00	4.05	0.1555	0.1575	0.1594
E	3.95	4.00	4.05	0.1555	0.1575	0.1594
D1	2.50	2.60	2.70	0.0984	0.1024	0.1063
E1	2.50	2.60	2.70	0.0984	0.1024	0.1063
b	0.25	0.30	0.38	0.0098	0.0118	0.0150
e	0.65 BSC			0.0256 BSC		
L	0.30	0.40	0.45	0.0118	0.0157	0.0177

Taping Specification



Feed Direction

PACKAGE	Q'TY/BY REEL
TQFN4X4-16	3,000 ea

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