MP6637

5.5V, 1.3A Peak, Three-Phase, Sensorless BLDC Motor Driver with Integrated MOSFETs

DESCRIPTION

The MP6637 is a three-phase, sensorless, brushless DC (BLDC) motor driver with integrated power MOSFETs. The device features sinusoidal sensorless control for better efficiency and low vibration, with up to 1.3A of peak phase current. The input voltage (V_{CC}) ranges from 2.5V to 5.5V.

The MP6637 controls the motor speed through the pulse-width modulation (PWM) signal with a 1kHz to 100kHz PWM input frequency.

The MP6637 features rotational speed detection. The rotational speed is an open-drain output via the FG/RD pin.

Rich protection features include input over-voltage protection (OVP), under-voltage lockout (UVLO), locked-rotor protection, over-current protection (OCP), and thermal shutdown.

The MP6637 is available in an SOT583 package.

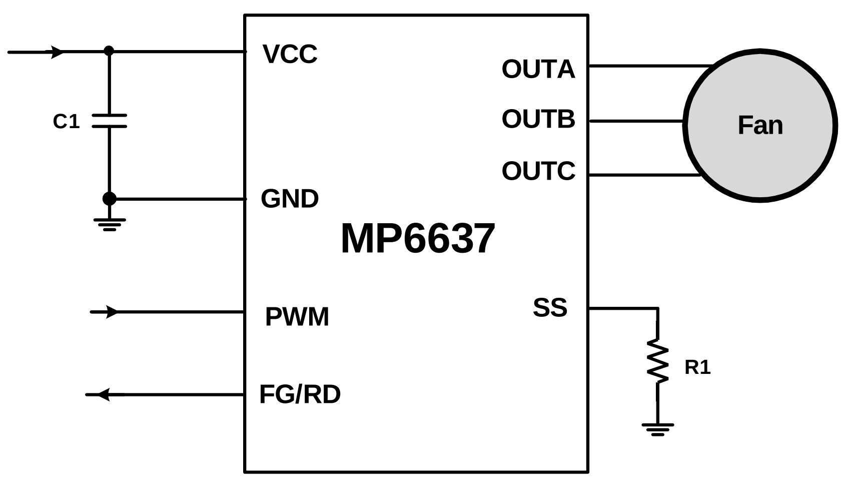
FEATURES

- 2.5V to 5.5V Operating Input Voltage (V_{CC}) Range
- Up to 1.3A of Peak Phase Current
- Sinusoidal Sensorless Control
- Integrated 350mΩ High-Side MOSFETs (HS-FETs) and Low-Side MOSFETS (LS-FETs)
- Supports 1kHz to 100kHz Pulse-Width Modulation (PWM) Input
- Power-Save Mode (PSM)
- 30kHz Switching Frequency (f_{SW})
- Current Limit
- Short-Circuit Protection (SCP)
- Over-Voltage Protection (OVP)
- Locked-Rotor Protection
- Selectable FG or RD Output
- Available in an SOT583 Package

APPLICATIONS

- Notebook Fans
- Gaming Fans
- General 3-Phase Fans

TYPICAL APPLICATION



ORDERING INFORMATION

Part Number*	Package	Top Marking	MSL Rating
MP6637GTL-xxxx**	SOT583	*See Below*	1

* For Tape & Reel, add suffix -Z (e.g. MP6637GTL-xxxx-Z).

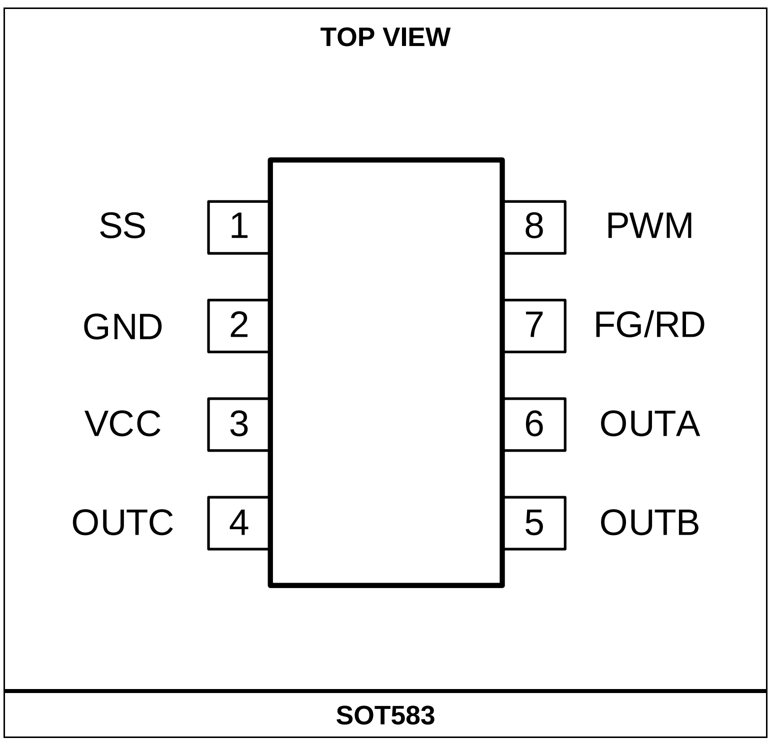
** "xxxx" is the configuration code identifier. The first four digits of the suffix (xxxx) can be a hexadecimal value between 0 and F. Work with an MPS FAE to create this unique number for non-default function options. The default code is "0000".

TOP MARKING

BZDY
LLL

BZD: Product code
Y: Year code
LLL: Lot number

PACKAGE REFERENCE



PIN FUNCTIONS

Pin #	Name	Description
1	SS	**Soft Start (SS).** To select SS parameters, connect a resistor to meet different load requirements.
2	GND	**Ground.**
3	VCC	**Input supply voltage.** Place a bypass capacitor as close to the VCC and GND pins as possible.
4	OUTC	**Phase C terminal.**
5	OUTB	**Phase B terminal.**
6	OUTA	**Phase A terminal.**
7	FG/RD	**Speed (FG) or rotor lock (RD) indication.** The FG/RD pin is an open-drain output that is pulled up externally.
8	PWM	**Speed control input.** Apply a pulse-width modulation (PWM) signal to the PWM pin. The PWM signal's duty cycle controls the motor speed. The PWM frequency is 1kHz to 100kHz.

ABSOLUTE MAXIMUM RATINGS (1)

All pins ....-0.3V to +6.5V
Junction temperature (T_J) ....150°C
Lead temperature ....260°C
Continuous power dissipation (T_A = 25°C) (2)
.... 0.96W
Supply voltage (V_{CC}) ....2.5V to 5.5V
Operating temperature............. -40°C to +125°C

ESD Ratings

Human body model (HBM) 4kV
Charged-device model (CDM) 2kV

Recommended Operating Conditions (3)

Supply voltage (V_{CC}) ....2.5V to 5.5V
Operating junction temp (T_J) .... -40°C to +125°C

Thermal Resistance (4) θ_{JA} θ_{JC}

SOT583 .... 130 ..... 60... °C/W

Notes:

1) Exceeding these ratings may damage the device.
2) The maximum allowable power dissipation is a function of the maximum junction temperature T_J (MAX), the junction-to-ambient thermal resistance θ_{JA}, and the ambient temperature T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P_D (MAX) = (T_J (MAX) - T_A) / θ_{JA}. Exceeding the maximum allowable power dissipation can produce an excessive die temperature, and may cause the regulator to go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.
3) The device is not guaranteed to function outside of its operating conditions.
4) Measured on a JESD51-7, 4-layer PCB.

ELECTRICAL CHARACTERISTICS

V_{IN} = 5V, T_J = -40°C to +125°C, unless otherwise noted.

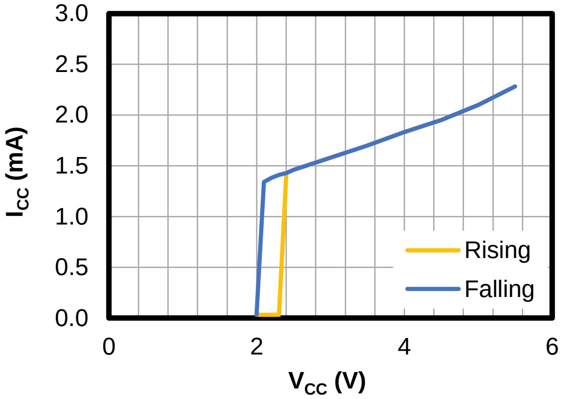
Parameters	Symbol	Condition	Min	Typ	Max	Units
Input under-voltage lockout (UVLO) rising threshold	V_{CC_UVLO}			2.3	2.4	V
Input UVLO hysteresis				0.23		V
Operating supply current	I_{CC}	No load		2.1	2.6	mA
Standby current	I_{ST}	PWM low		45	70	μA
Pulse-width modulation (PWM) input high voltage	V_{PWMH}		2		5.5	V
PWM input low voltage	V_{PWML}		0		0.8	V
PWM input internal pull-up resistance				40		kΩ
Soft start (SS) output current (I_{OUT})	I_{SS}			50		μA
Switching frequency	f_{SW}	T_J = 25°C	29.1	30	30.9	kHz
High-side MOSFET (HS-FET) on resistance	$R_{DS(ON)\_HS}$	I_{OUT} = 100mA		200		mΩ
Low-side MOSFET (LS-FET) on resistance	$R_{DS(ON)\_LS}$	I_{OUT} = 100mA		150		mΩ
Over-current protection (OCP) threshold	I_{OCP}	T_J = 25°C	1	1.3	1.6	A
Short-circuit protection (SCP) threshold	I_{SCP}			1.9		A
FG/RD output low-level voltage	V_{FG_L}	$I_{FG/RD}$ = 3mA		0.11	0.2	V
Rotor-lock off time	t_{RE}		4	4.4	4.8	sec
Input over-voltage protection (OVP) threshold	V_{OVP}		5.6	5.8	6	V
OVP hysteresis	V_{OVP_HYS}		0.4	0.44	0.48	V
Thermal shutdown threshold				150		°C
Thermal shutdown hysteresis				20		°C

TYPICAL CHARACTERISTICS

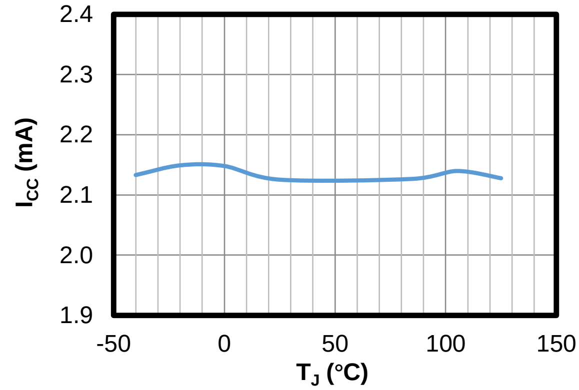
V_{CC} = 5V, T_J = -40°C to +125°C, unless otherwise noted.

Supply Current vs. Input Voltage

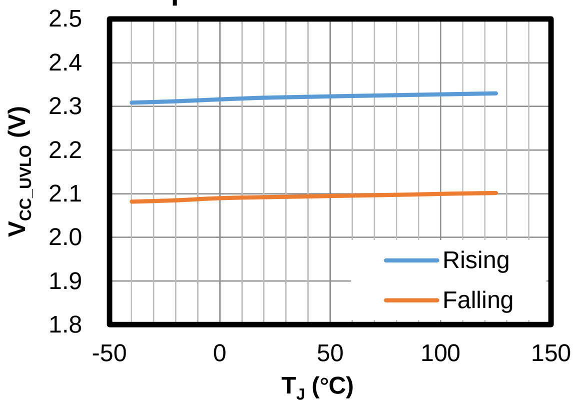
V_{CC} = 2V to 5.5V, no load, T_J = 25°C



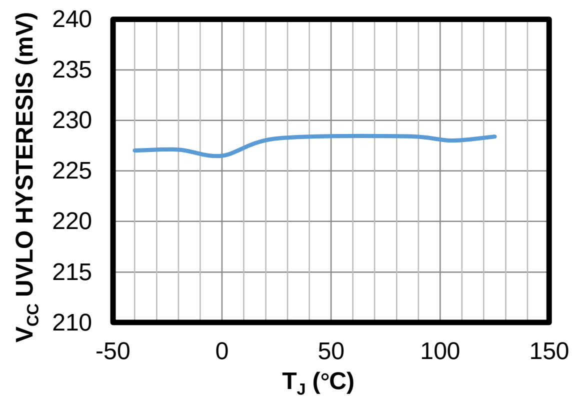
Supply Current vs. Junction Temperature



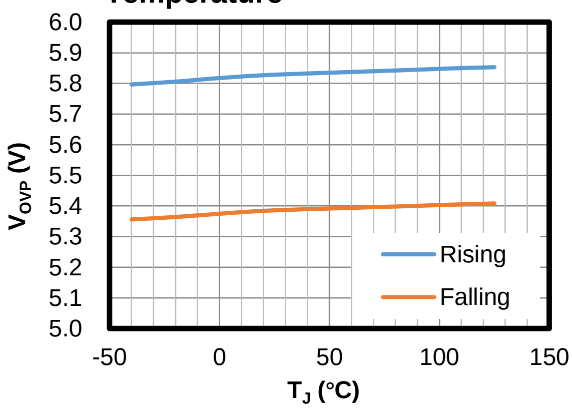
V_{CC} UVLO vs. Junction Temperature



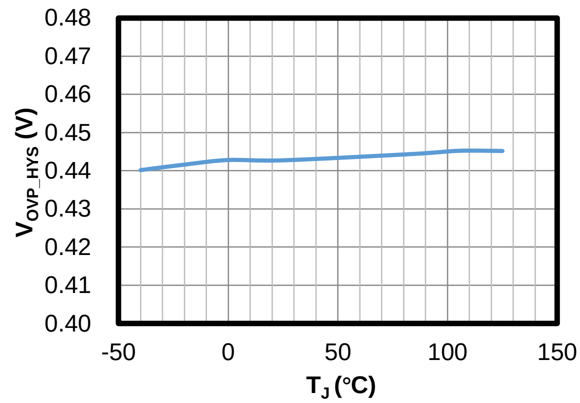
V_{CC} UVLO Hysteresis vs. Junction Temperature



OVP Threshold vs. Junction Temperature



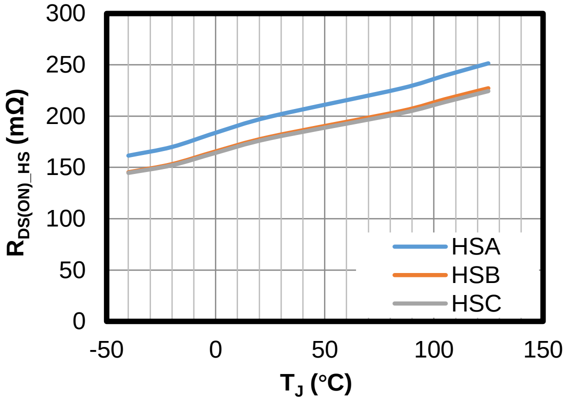
OVP Hysteresis vs. Junction Temperature



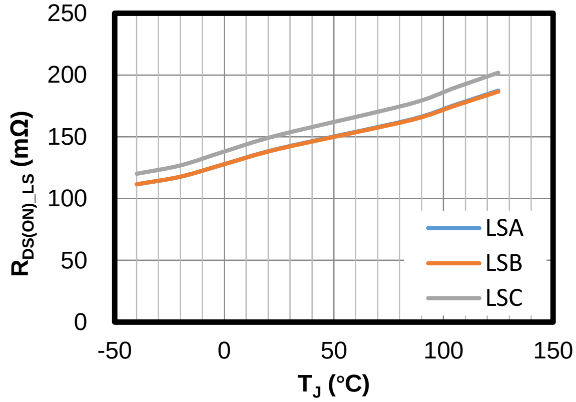
TYPICAL CHARACTERISTICS *(continued)*

V_{CC} = 5V, T_J = -40°C to +125°C, unless otherwise noted.

HS-FET On Resistance vs. Junction Temperature

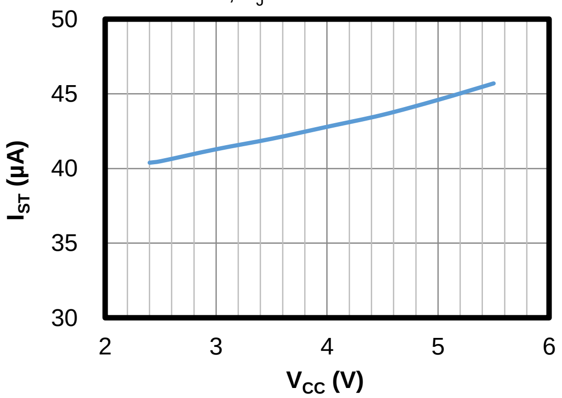


LS-FET On Resistance vs. Junction Temperature

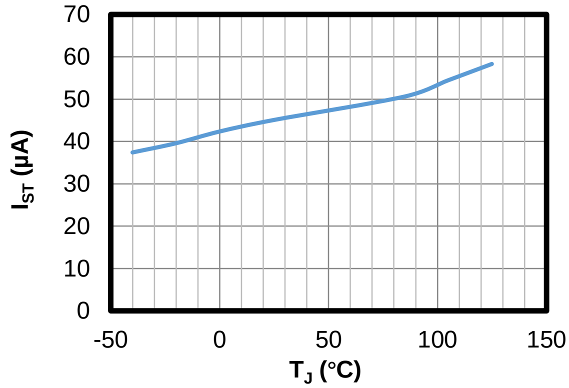


Standby Current vs. Input Supply Voltage

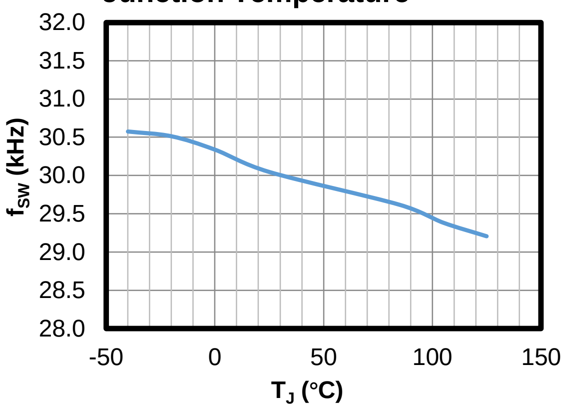
PWM = low, T_J = 25°C



Standby Current vs. Junction Temperature

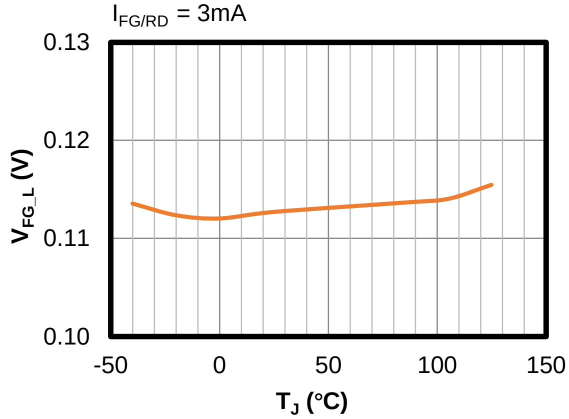


Switching Frequency vs. Junction Temperature



FG/RD Output Low Level vs. Junction Temperature

$I_{FG/RD}$ = 3mA

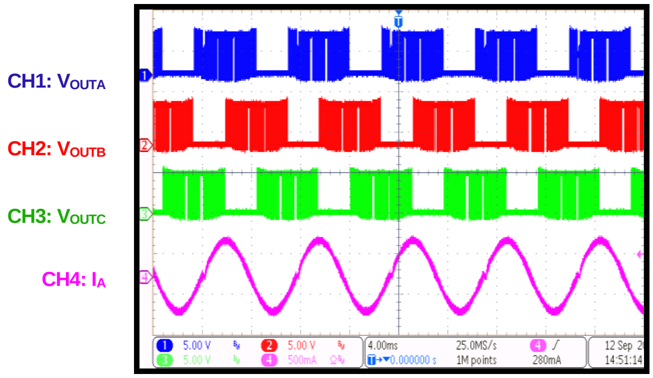


TYPICAL PERFORMANCE CHARACTERISTICS

Performance waveforms are tested on the evaluation board. SS pin floating, V_{IN} = 5V, f_{PWM} = 20kHz, T_A = 25°C, unless otherwise noted.

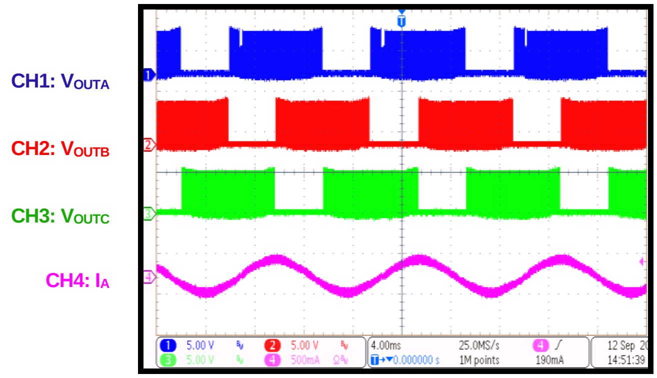
Steady State

Input PWM duty cycle = 100%



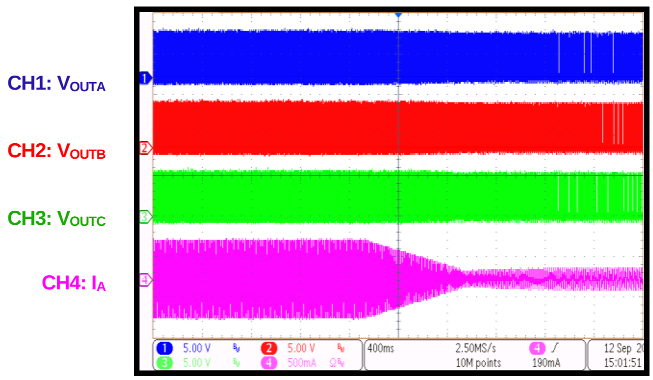
Steady State

Input PWM duty cycle = 50%



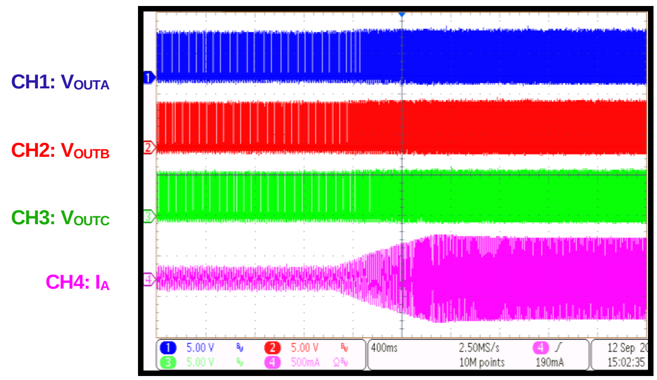
PWM Duty Transient Response

Input PWM duty cycle = 100% to 25%



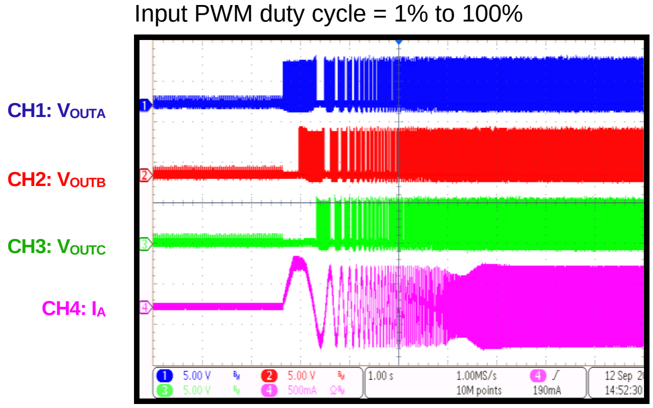
PWM Duty Transient Response

Input PWM duty cycle = 25% to 100%



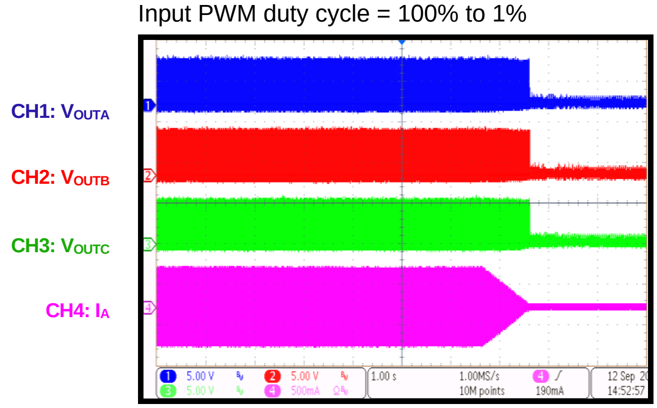
PWM On

Input PWM duty cycle = 1% to 100%



PWM Off

Input PWM duty cycle = 100% to 1%

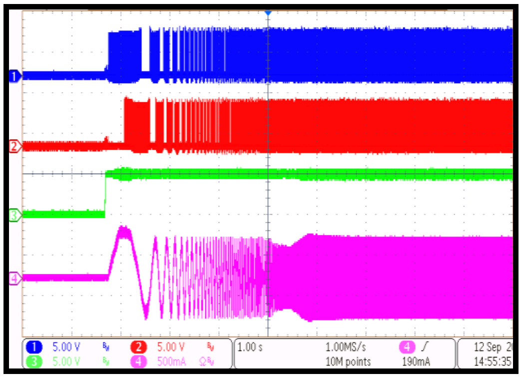


TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

Performance waveforms are tested on the evaluation board. SS pin floating, V_{IN} = 5V, f_{PWM} = 20kHz, T_A = 25°C, unless otherwise noted.

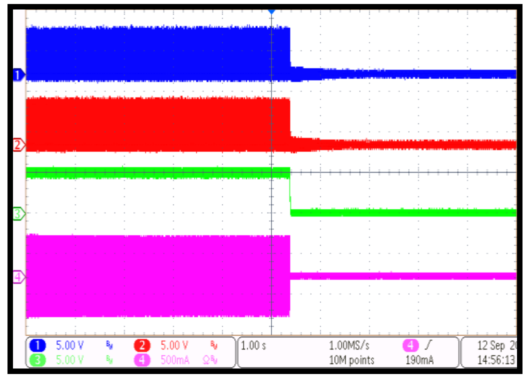
Start-Up

V_{CC} = 0V to 5V



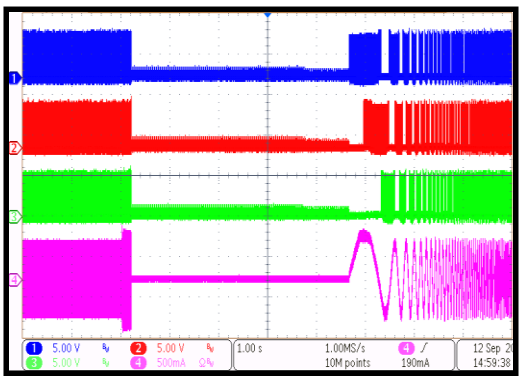
Shutdown

V_{CC} = 5V to 0V



Rotor Lock and Retry

Lock rotor, then release



FUNCTIONAL BLOCK DIAGRAM

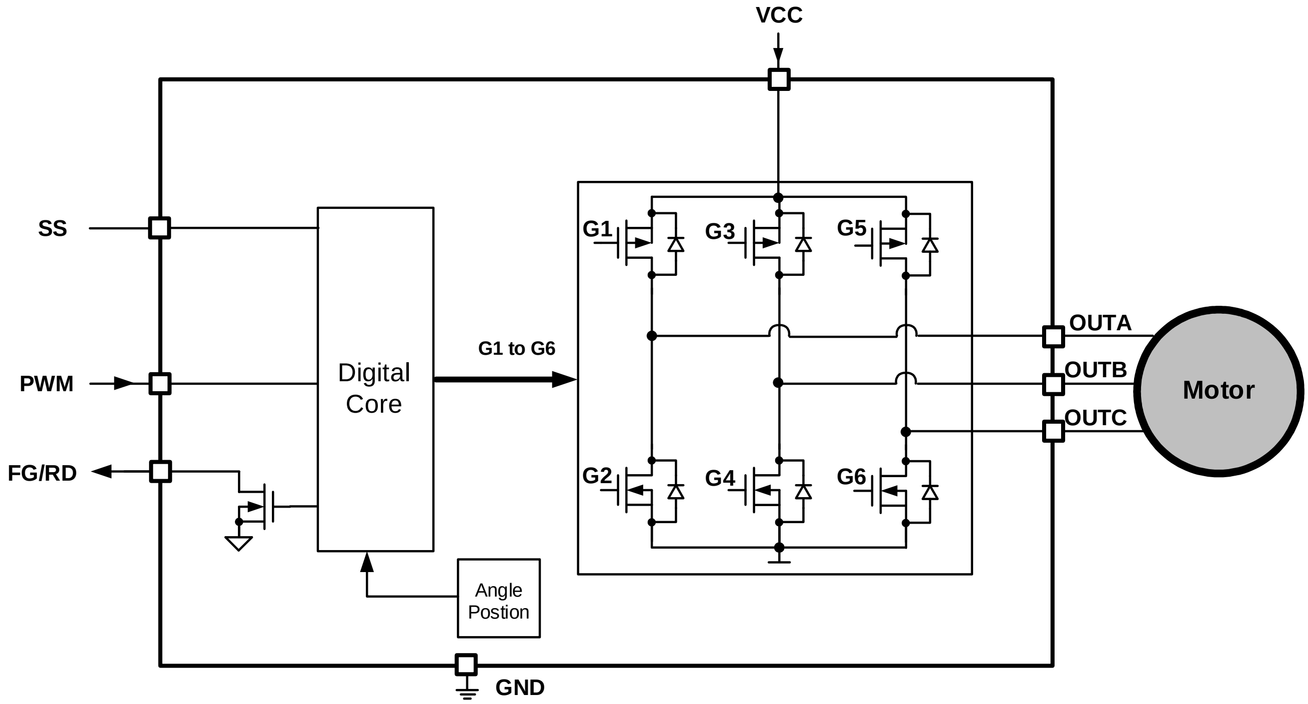


Figure 1: Functional Block Diagram

OPERATION

The MP6637 is a three-phase, sensorless, brushless DC (BLDC) motor driver with integrated power MOSFETs. It features sinusoidal sensorless control for better efficiency and low vibration, with up to 1.3A of peak phase current. The input voltage (V_{CC}) ranges from 2.5V to 5.5V.

Speed Control

The speed is controlled via the input pulse-width-modulation (PWM) signal applied on the PWM pin. The input PWM signal frequency ranges from 1kHz to 100kHz. The input duty cycle determines the output duty cycle.

Starting Duty

The starting duty cycle is configured via CURVE_WINDOW_PWM_DUTY (01h), bits[2:0]. If the input PWM duty cycle falls below the duty cycle set by these bits, the MP6637 stops switching. If the input PWM duty cycle exceeds DIN_MIN[2:0] + 1.2% (hysteresis), the MP6637 starts the output duty cycle and the motor starts rotating (see Figure 2). The default starting duty cycle is 12.5%.

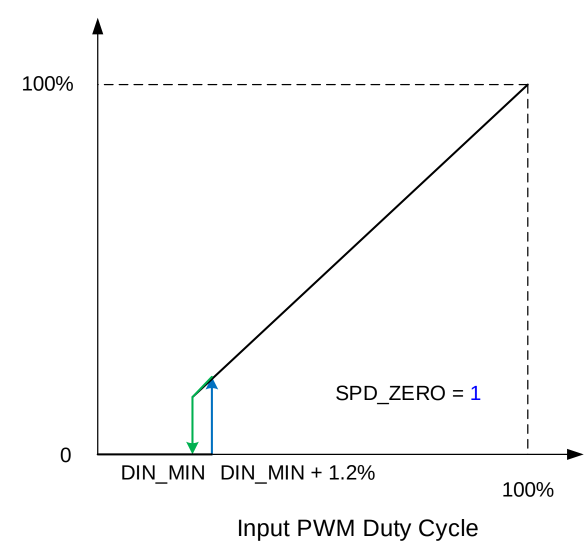


Figure 2: Starting Duty when SPD_ZERO = 1

When SPD_ZERO = 0, the MP6637 maintains the minimum speed when the input PWM duty cycle falls below the duty cycle set via CURVE_WINDOW_PWM_DUTY (01h), bits[2:0] (see Figure 3).

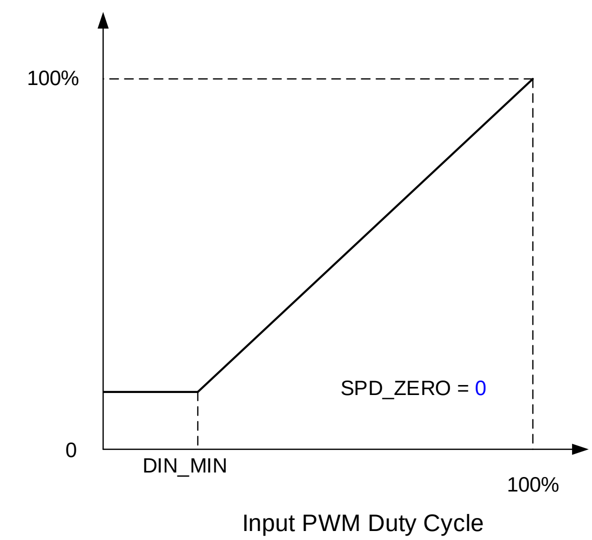


Figure 3: Minimum Speed when SPD_ZERO = 0

Open-Loop Acceleration Start-Up

After V_{CC} powers up, the MP6637 increases the driven vector's frequency to accelerate the motor. The acceleration slew rate is selected via register SOFT_START (00h), bits[3:2] or the SS pin. When the motor speed reaches the set threshold, the device enters sinusoidal sensorless control.

Soft Dynamic

After entering sinusoidal sensorless control, the MP6637's output duty cycle reaches its target smoothly depending on the soft-start time (t_{SS}). t_{SS} is configured via the SS pin or register SOFT_START (00h), bits[5:4].

Steady State

In steady-state operation, the device selects sensorless sinusoidal control. To obtain the motor position, the device detects the motor's back electromotive force (BEMF) zero-crossing, then drives the motor with a sinusoidal drive based on the rotor position.

Standby Mode

If V_{CC} exceeds the under-voltage lockout (UVLO) rising threshold and the PWM pin is pulled low, the MP6637 enters standby mode. The device exits standby mode when it detects the PWM input signal or the power is cycled.

Soft Start (SS) Selection

Connect a resistor between the SS and GND pins to select different open-loop acceleration start-up settings and t_{SS}. SS can be configured via SS resistor or internal register settings. If the SS resistor is not connected, the SS pin floats, then follows the settings set via the internal registers. Table 1 shows the start-up settings with different SS resistances.

Table 1: Start-Up Settings with Different SS Resistances

R_{SS}	OC_VF	VF_TAR	F_SLEW	T_SS
≤1kΩ	1/4 x I_{OCP}	20Hz	59Hz	2.2s
1.9kΩ	1/4 x I_{OCP}	39Hz	59Hz	2.2s
3kΩ	1/4 x I_{OCP}	78Hz	59Hz	2.2s
4.7kΩ	1/4 x I_{OCP}	20Hz	234Hz	1.1s
7.2kΩ	1/4 x I_{OCP}	39Hz	234Hz	1.1s
10kΩ	1/4 x I_{OCP}	78Hz	234Hz	1.1s
16kΩ	1/4 x I_{OCP}	78Hz	938Hz	1.1s
26kΩ	1/4 x I_{OCP}	156Hz	938Hz	1.1s
Float	Follow internal register setting, Below is the default register setting			
	1/2 x I_{OCP}	39Hz	59Hz	1.1s

OC_VF sets the current limit during open-loop acceleration. A higher value means a higher start-up torque.

VF_TAR sets the hand-off threshold speed from open-loop acceleration to sensorless sinusoid control. A higher value means open-loop acceleration lasts longer.

F_SLEW sets the frequency slew rate target during open-loop acceleration. A higher value provides a faster start-up and frequency increase rate.

T_SS sets t_{SS}. The time duration that outputs the duty cycle goes from 0% to 100%.

Rotor Speed (FG) and Rotor Lock Indication (RD)

The FG/RD pin is an open-drain output, and must be pulled up externally via an external resistor.

If FGRD = 0, the FG/RD pin is configured for speed indication (FG), and outputs 1 cycle during each electrical cycle.

If FGRD = 1, the FG/RD pin is configured for locked-rotor protection (RD). If locked-rotor protection is triggered, the FG/RD pin has a high output.

Protections

The MP6637 features rich protection features, such as short-circuit protection (SCP), over-voltage protection (OVP), UVLO, over-current protection (OCP), and over-temperature protection (OTP).

Short-Circuit Protection (SCP)

The MP6637 employs internal overload protection by detecting the current flowing through each MOSFET. If the current flowing through any MOSFET exceeds the protection threshold (typically 1.9A), all MOSFETs turn off immediately after a set blanking time. After a lock-retry time, the IC attempts to restart and resume normal operation.

Over-Current Protection (OCP)

During normal switching, if the current flowing through any MOSFET exceeds the threshold (typically 1.3A) after a set blanking time, the output duty cycle decreases to limit the load current.

Thermal Shutdown (TSD)

The MP6637 employs thermal monitoring. If the die temperature exceeds 150°C, all MOSFETs turn off. Once the die temperature drops to its low threshold (typically 130°C), the IC restarts and resumes normal operation.

Under-Voltage Lockout (UVLO)

If V_{CC} falls below the UVLO threshold, all device circuitries are disabled and the internal logic resets. Once V_{CC} exceeds the UVLO threshold again, the device restarts and resumes normal operation.

Locked-Rotor Protection (RD)

If RD protection triggers, the device turns off all MOSFETs. After a lock-retry time (typically 4.4s), the IC attempts to resume normal operation.

Over-Voltage Protection (OVP)

The MP6637 features input OVP. If V_{CC} exceeds the OVP threshold (typically 5.8V), all MOSFETs turn off. Once V_{CC} drops below 5.3V, the IC attempts to restart and resume normal operation. OVP can be disabled via register WINDOW_START_OVP_FGRD, bit[1].

REGISTER DESCRIPTION

Add	D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]
00h (OTP/REG)	OC_VF		T_SS		F_SLEW		F_TAR	
01h (OTP/REG	VOL	PWM_POL	WD_BLK	WD_ANG	SPD_ZERO	DIN_MIN[2:0]		
02h (OTP/REG)	WD_BLK_MD	QUICK_ST	BEMF_SAMP	RESERVED			OVP	FGRD

Note:

5) Ensure that V_{CC} = 6.5V when configuring OTP (one-time-program).

SOFT_START (00h)

The SOFT_START command configures the start-up parameters.

Bits	Access	Bit Name	Default	Description
7:6	R/W	OC_VF	10	Sets the current limit threshold during open-loop acceleration. 00: 1/4 x I_{OCP} 01: 1/4 x I_{OCP} 10: 1/2 x I_{OCP} 11: 1 x I_{OCP}
5:4	R/W	T_SS	11	Sets the soft-start time (t_{SS}). The time duration that outputs the duty cycle goes from 0% to 100%. 00: 8.7s 01: 4.4s 10: 2.2s 11: 1.1s
3:2	R/W	F_SLEW	01	Sets the frequency slew rate during open-loop acceleration. The start-up is faster with a higher value. 00: 15Hz 01: 59Hz 10: 234Hz 11: 938Hz
1:0	R/W	F_TAR	01	Sets the target electrical speed in open-loop acceleration. 00: 20Hz 01: 39Hz 10: 78Hz 11: 156Hz

CURVE_WINDOW_PWM_DUTY (01h)

The CURVE_WINDOW_PWM_DUTY command configures the starting duty cycle, PWM input polarity, detection window, and duty cycle limit.

Bits	Access	Bit Name	Default	Description
7	R/W	VOL	0	Sets the duty cycle limit during open-loop acceleration. 0: 87.5% 1: 50%
6	R/W	PWM_POL	0	Selects the PWM pin polarity. 0: Positive duty cycle 1: Negative duty cycle

5	R/W	WD_BLK	0	Selects the BEMF detection window blanking time. 0: 33µs 1: 100µs
4	R/W	WD_ANG	1	Selects the BEMF detection window. 0: 30° 1: 15°
3	R/W	SPD_ZERO	1	Enables zero speed. 0: Keeps the minimum speed when the input duty cycle is below the duty cycle set by DIN_MIN[2:0] 1: Stops when the input duty cycle is below the duty cycle set by DIN_MIN[2:0]
2:0	R/W	DIN_MIN[2:0]	010	Sets the starting duty cycle. 000: 6.25% 001: 9.375% 010: 12.5% (default) 011: 15.625% 100: 18.75% 101: 21.875% 110: 25% 111: 28.125%

WINDOW_START_OVP_FGRD (02h)

The WINDOW_START_OVP_FGRD command configures the BEMF window, quick start-up, over-voltage protection (OVP), and the FG/RD pin.

Bits	Access	Bit Name	Default	Description
7	R/W	WD_BLK_MD	0	Selects the BEMF blanking time mode. 0: Auto 1: Fixed time
6	R/W	QUICK_ST	0	Enables quick start-up. When QUICK_ST is set to 1, enables quick start-up with a faster alignment and open-loop acceleration. 0: Disabled 1: Enabled
5	R/W	BEMF_SAMP	0	Sets the BEMF detection activation. 0: During the BEMF detection window 1: At the end of the BEMF detection window
4:2	-	RESERVED	001	Reserved.
1	R/W	OVP	0	Enables input over-voltage protection (OVP). 0: OVP is enabled 1: OVP is disabled
0	R/W	FGRD	0	Selects the FG/RD pin output. 0: FG/RD pin outputs FG, 1 pulse in each electrical cycle 1: FG/RD pin outputs RD

APPLICATION INFORMATION

Selecting an Input Capacitor

Place an input capacitor (C_{IN}) as close to the VCC and GND pins as possible to maintain a stable input voltage (V_{CC}) and reduce noise at the input. C_{IN} must have a low impedance at f_{SW}.

Ceramic capacitors with X7R dielectrics are recommended for their low ESR characteristics. The effective capacitance decreases when the voltage across the ceramic capacitor increases. If the ceramic capacitor is biased with its voltage rating, the effective capacitance falls below 50%. Ensure that enough capacitance is applied.

Ensure the voltage rating of the ceramic capacitor is high enough to guarantee no over-voltage rating events.

Input Clamping TVS Diode

High-voltage spikes are caused by the energy stored in the motor charging back to the side of C_{IN}. To avoid these spikes, add a voltage-clamping transient voltage suppressor (TVS) diode or Zener diode. For a 5V application, a 6V/SOD-123 package TVS or Zener diode is sufficient.

Selecting an SS Resistor

The start-up setting can be configured via the internal registers or the SS resistor.

Float the SS pin if the internal registers are used for the start-up settings. Otherwise, the SS setting follows the SS resistor setting.

Different resistances set different start-up values to meet different application requirements. See Table 1 on page 11 for the selection of SS resistors.

FG Glitch during Start-Up

The FG/RD pin is an open-drain output. After UVLO, the FG/RD pin is pulled low. An FG glitch may occur during V_{CC} power-up.

To eliminate the FG signal glitch, a delay circuit is recommended. Combining C1 and R1 with the PNP transistor (Q1) generates a delay when the FG pin is pulled up (see Figure 4).

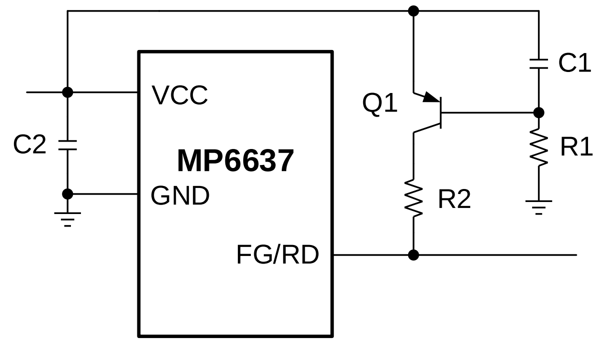


Figure 4: FG Glitch Delay Circuit

The delay circuit is active only when V_{CC} powers up.

The delay time changes with different C1 and R1 values for different applications. Typically, 1µF to 2.2µF for C1 and 100kΩ for R1 provides enough delay for most applications.

PCB Layout Guidelines

Efficient PCB layout is critical for stable operation and to avoid noise effects on the functions. For the best results, refer to Figure 5 and follow the guidelines below:

1. Place the input capacitor (C_{IN}) as close to the VCC and GND pins as possible to minimize the switching loop area. A small-sized ceramic capacitor (C1) is recommended to improve high-frequency noise performance.
2. If the SS resistor is applied, place the SS resistor close to the SS and GND pins. The SS resistor's ground loop trace keeps away from power loop trace.

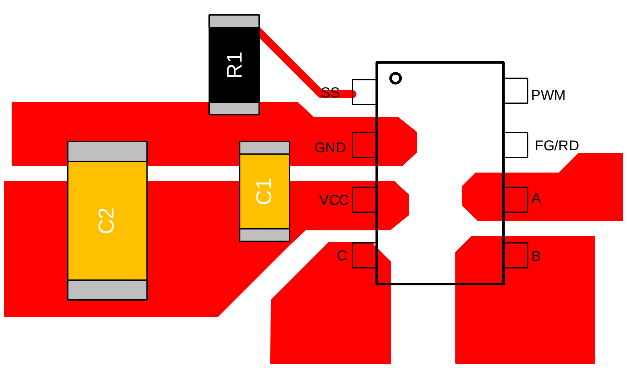


Figure 5: PCB Layout

TYPICAL APPLICATION CIRCUITS

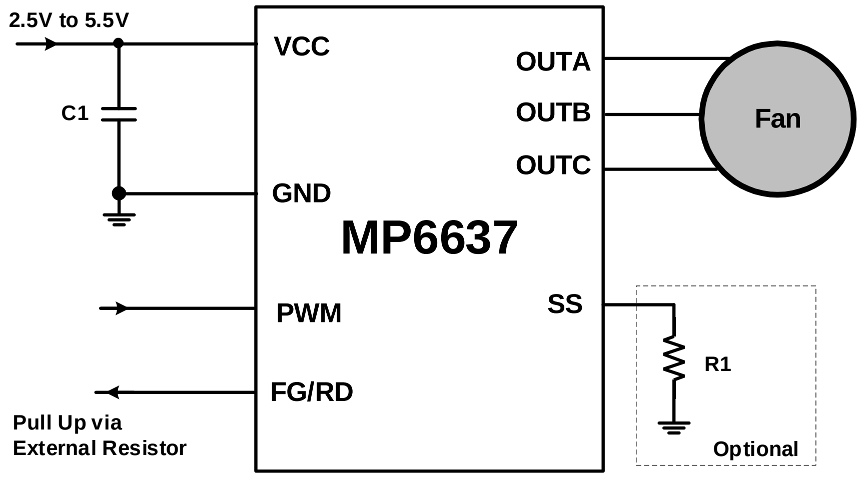


Figure 6: Typical Application Circuit

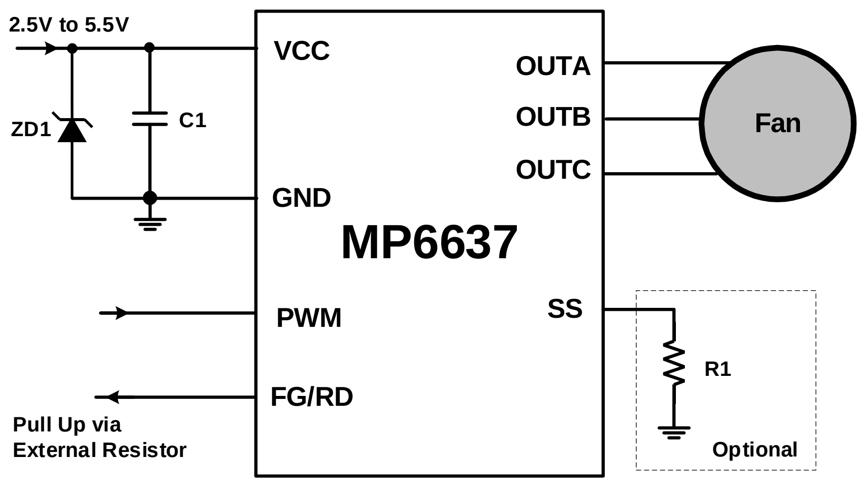
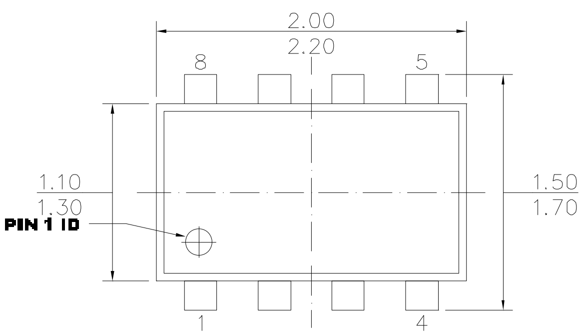


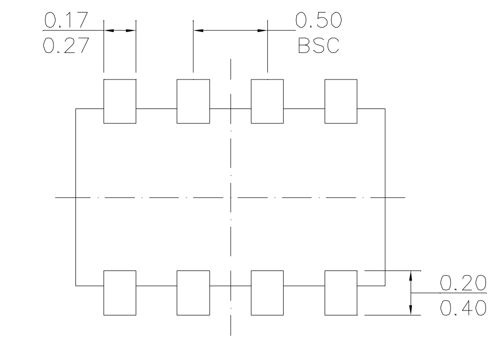
Figure 7: Typical Application Circuit with Input Clamping

PACKAGE INFORMATION

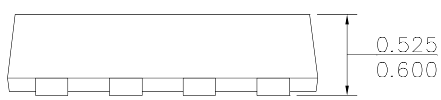
SOT583



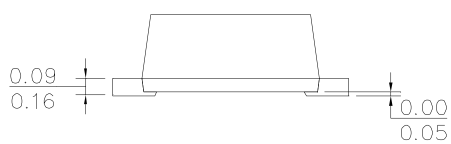
TOP VIEW



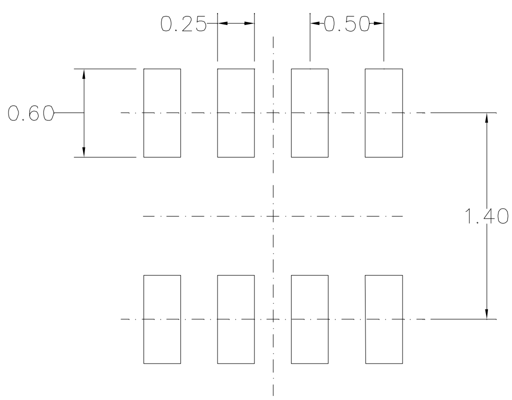
BOTTOM VIEW



FRONT VIEW



SIDE VIEW

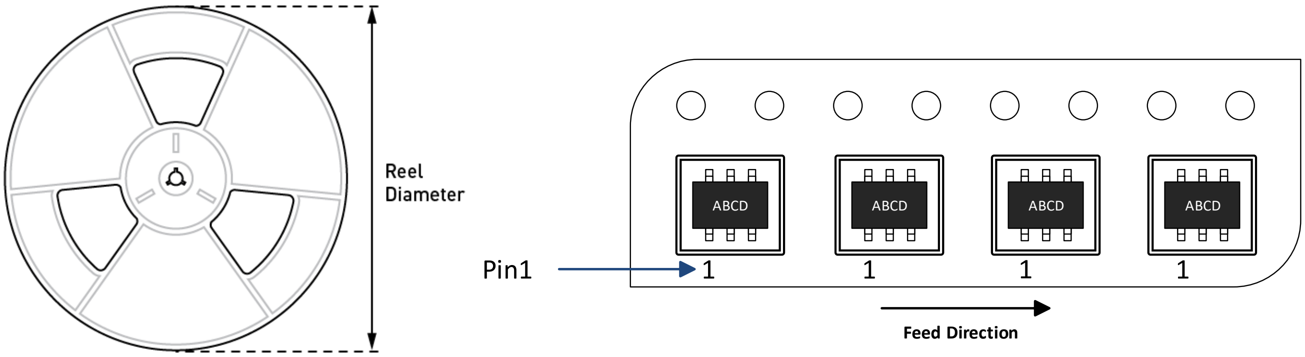


RECOMMENDED LAND PATTERN

NOTE:

1) ALL DIMENSIONS ARE IN MILLIMETERS.
2) PACKAGE WIDTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION.
3) LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.10 MILLIMETERS MAX.
4) DRAWING IS NOT TO SCALE.

CARRIER INFORMATION



Part Number	Package Description	Quantity/ Reel	Quantity/ Tube	Quantity/ Tray	Reel Diameter	Carrier Tape Width	Carrier Tape Pitch
MP6637GTL-xxxx-Z	SOT583	5000	N/A	N/A	7in	8mm	4mm

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	10/21/2024	Initial Release	-
1.1	7/14/2025	• Added maximum value of I_{CC}. • Added maximum value of V_{PWMH}. • Added minimum value of V_{PWML}. • Added test condition and minimum and maximum value of I_{OCP}. • Added typical value of V_{FG_L}. • Added minimum and maximum value of t_{RE}. • Added minimum and maximum value of V_{OVP}. • Added minimum and maximum value of V_{OVP_HYS}.	4