Application Circuits of TPD4204F and TB6634FNG Sine-Wave Control Type of BLDC Motor Driver

Reference Guide

RD018-RGUIDE-02

TOSHIBA ELECTRONIC DEVICES & STORAGE CORPORATION

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0. Introduction

Incorporating 250- to 600-V switching devices, Toshiba's intelligent power devices (IPDs) can directly drive a brushless DC (BLDC) motor. Toshiba offers various IPDs that meet a wide range of requirements, including a motor's output power, the control method (square wave vs sine wave), and the AC input voltage of the application. Toshiba provides a reference design for each type of application to help you create the optimal design. Table 0.1 lists the reference designs for different applications and motors. Consult an appropriate reference design.

Table 0.1 Reference designs for high-voltage IPDs

Motor output	≤ 30 W	≤ 30 W	≤ 60W	≤ 60W
Quiet operation	N/R	N/R	Required	Required
Commutation	Square-wave	Square-wave	Sine-wave	Sine-wave
AC input voltage	100-127 V	100-240 V For countries or regions with unstable power distribution	100-240 V For countries or regions with unstable power distribution	100-240 V For countries or regions with stable power distribution
Recommended IPD	TPD4151F (250 V / 1 A)	TPD4152F (600 V / 0.7A)	TPD4204F (600 V / 2.5A)	TPD4206F (500 V / 2.5A)
Recommended PWM controller	N/R	N/R	TB6634FNG	TB6634FNG
Reference design	Click Here	Click Here	Click Here	Click Here
Reference Guide	RD020-RGUIDE-02	RD017-RGUIDE-02	This document	RD019-RGUIDE-02

For Toshiba's high-voltage IPDs → Click Here

1. Overview

A motor is a generic name of machine designed to convert electric energy into mechanical energy. When an electric current flows through a motor's coil, magnetic fields are produced. The rotor of the motor spins as magnets in the rotor are attracted and repelled by the magnetic fields. The direction of motor rotation can be changed by controlling the direction of the electric current.

In line with the low power consumption requirement of home appliances and increasing vehicle electrification, the importance of motors is growing dramatically. There are various kinds of motors. For example, brushed direct-current (DC) motors are commonly used in automotive applications, toy trains and so on. Nowadays, brushed DC motors are the most widely used due to their excellent controllability, high efficiency, ease of size reduction, and low price. Stepping motors, which are also in widespread use, are characterized by their high accuracy. For example, industrial precision machines require high positioning accuracy, which is enabled by stepping motors. In addition, stepping motors ensure repeatability of movement. The stepping motors found in air-conditioner louvers also feature long service life and quiet operation.

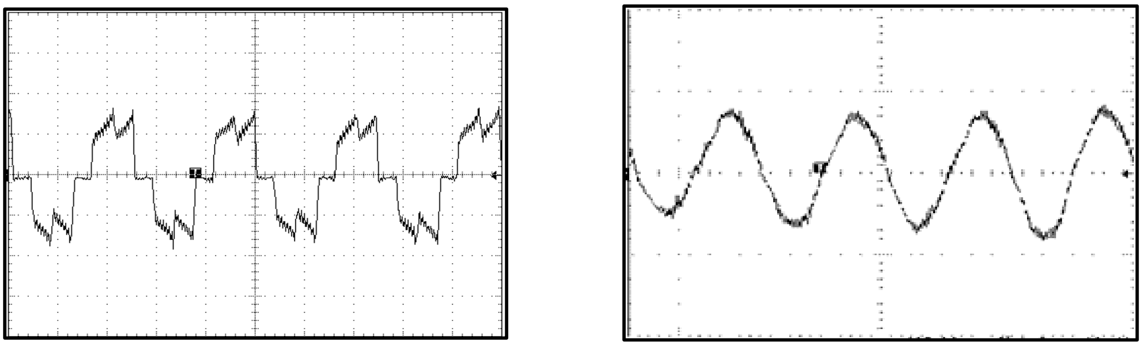
Brushed DC motors use brushes to send electric currents to coils. A motor's rotor has several coils, and a commutator is attached on the motor shaft. The commutator is a rotating electrical switch that reverses the current direction in the rotor coils periodically. The commutator is connected to the coils rotating inside magnetic fields. As a coil rotates, it makes contact with one brush on the power supply side. At this point, the commutator reverses the direction of current through the coil. The commutation sequence is controlled to produce an even torque.

In contrast, BLDC motors do not use any brush (i.e., mechanical contactor) or commutator to change the current direction. Instead, BLDC motors rely on sensors and electronic circuits (collectively called a "driver"). Current commutation using an electronic motor driver was enabled by the progress of semiconductor devices. Being similar in the principle of operation, brushed and BLDC motors have almost the same current-to-torque and voltage-to-rpm relationships. However, as the structure of BLDC motors is similar to that of alternating-current (AC) motors, BLDC motors provide the combined advantages of both DC and AC motors. BLDC motors are small, provide high output power, generate no internal spark or noise due to brushes, have a long service life being free from mechanical wear, and exhibit low energy loss. Therefore, BLDC motors are widely used for various applications including computers and home appliances. Table 1.1 compares various types of motors.

Table 1.1 Comparison of various types of motors

	Brushed DC motors	BLDC motors	Stepping motors	AC motors
Efficiency	60 to 80%	≥80%	60 to 70%	40 to 80%
Size	Small	Small	Medium	Large
Electronic circuit	N/R	Required	Required	N/R
Service life	Short	Long	Long	Long
Brushes	Y	N	N	N
Applications	Toys, small home appliances	Air conditioners, washing machines, small home appliances	Robots, small home appliances, industrial precision machines	Washing machines, electric fans, vacuum cleaners

As described above, BLDC motors can operate at high efficiency due to low energy conversion loss. In recent years, manufacturers of home appliances and other consumer products have been under pressure to further reduce their power consumption, driving the widespread use of efficient BLDC motors. For example, a three-phase BLDC motor is commutated using six switching devices. There are two major control techniques for three-phase BLDC motors: 120-degree square-wave control and 180-degree sine-wave control. A square-wave control technique generates square motor winding currents in such a manner as to energize each phase winding for 120 electrical degrees whereas a sine-wave control technique controls sine-wave currents to energize each phase winding for 180 electrical degrees. Figure 1.1 shows examples of phase currents for square- and sine-wave control.



(A) Square-wave control **(b) Sine-wave control**

Figure 1.1 Phase current examples

Table 1.2 summarizes the characteristics of 120-degree square-wave control and 180-degree sine-wave control.

Table 1.2 Characteristics of square-wave and sine-wave commutation

	Square-wave (120-degree) control	Sine-wave (180-degree) control
Noise/vibration	Moderate	Low
Efficiency	Moderate	Excellent
Ease of design	Simple control, small board area	Complicated control, large board area
Other	Configurable only with an IPD	Composed of a PWM controller and an IPD

The TPD4204F incorporates a level-shifting high-side driver, a low-side driver, and output power MOSFETs. The TPD4204F can directly drive a BLDC motor with an output power of 60 W or less using control signals from a PWM controller IC. The TPD4204F provides thermal shutdown, overcurrent protection, and undervoltage protection, which force its outputs to be shut down via an external signal in the event of a potentially damaging condition. These protection features help reduce design resource of peripheral circuits, reduce the system size, and improve the safety and reliability of an entire system. In countries or regions where AC mains electricity is unstable, the mains voltage could instantaneously shoot up to 450 V. In such areas, the TPD4206F rated at 500 V cannot be used for motor applications with a 200 VAC input. To address the needs for these applications, the TPD4204F incorporates output MOSFETs with the maximum rated voltage of 600 V. Housed in the small SSOP30 surface-mount package, the TPD4204F helps reduce the size and thickness of a motor control board, providing greater flexibility in incorporating the board into a motor casing and thereby reducing the size of the motor assembly.

The TB6634FNG is a sine-wave PWM controller for BLDC motors. The TPD4204F and TB6634FNG can be used in combination to realize sine-wave control for BLDC motors. The TB6634FNG incorporates a lead angle control function that can be internally configured automatically or externally programmed. Lead angle control makes it possible to drive a BLDC motor with high efficiency. In addition, the TB6634FNG provides a voltage regulator, a current limiter, and an undervoltage protection circuit, simplifying the design of a peripheral circuit.

To help reduce the power consumption of and obtain the best performance from a motor application, this reference guide describes application circuits and design considerations for sine-wave BLDC control using the TPD4204F and TB6634FNG.

For details of the TPD4204F and TB6634FNG, see the datasheets.

To download the datasheet for the TPD4204F → Click Here

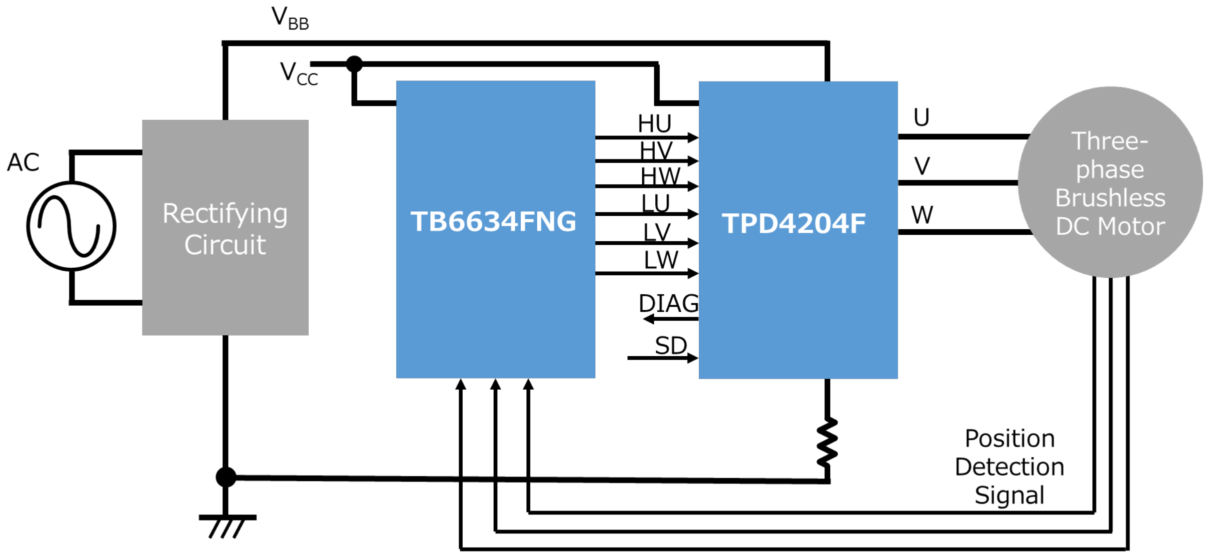
To download the datasheet for the TB6634FNG → Click Here

Target applications

Applications using a motor with an output power of 60W or less (motor control in inverter systems)

- Air conditioners (indoor and outdoor unit fans)
- Air purifier fans
- Washing machine pumps

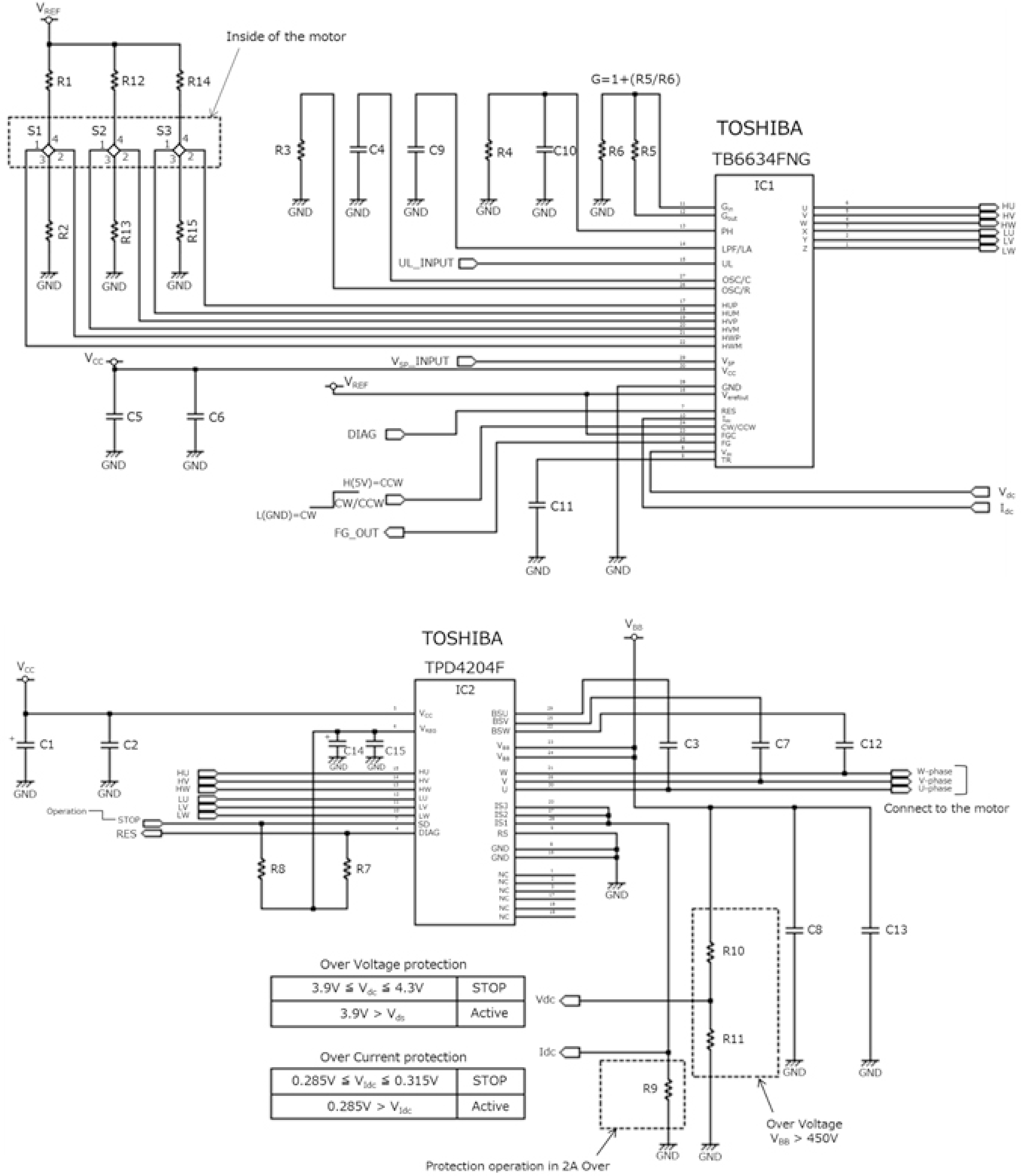
Circuit example



2. Application circuit example and the bill of materials

2.1. Application circuit example

Figure 2.1 shows an application circuit for motor control using the TPD4204F and TB6634FNG. (The assumption is that the overcurrent protection function available with the TB6634FNG is used.)



Over Voltage protection	
3.9V ≦ V_{dc} ≦ 4.3V	STOP
3.9V > V_{dc}	Active

Over Current protection	
0.285V ≦ V_{Idc} ≦ 0.315V	STOP
0.285V > V_{Idc}	Active

Figure 2.1 Application circuit for controlling a BLDC motor

2.2. Bill of materials

Table 2.1 Bill of materials (Figure 2.1)

No.	Ref.	Qty	Value	Part Number	Manufacturer	Description	Packaging	Typical Dimensions in mm (inches)
1	IC1	1	-	TB6634FNG	TOSHIBA	-	SSOP30	10.2 x 7.6
2	IC2	1	-	TPD4204F	TOSHIBA	-	SSOP30	20.0 x 14.2
3	R1,R2,R12, R13,R14,R15	6	300 Ω	-	-	100 mW ± 5%	-	1.6 x 0.8 (0603)
4	R3, R6	2	10 kΩ	-	-	100 mW ± 0.5%	-	1.6 x 0.8 (0603)
5	R4, R5	2	100 kΩ	-	-	100 mW ± 0.5%	-	1.6 x 0.8 (0603)
6	R7	1	5.1 kΩ	-	-	100 mW ± 1%	-	1.6 x 0.8 (0603)
7	R8	1	10 kΩ			100 mW ± 1%		1.6 x 0.8 (0603)
8	R9	1	140 mΩ	SL1TTER	KOA	1 W, ±1%	-	6.3 x 3.1 (2512)
9	R10	1	2 MΩ	-	-	1 W ± 5%	-	6.3 x 3.1 (2512)
10	R11	1	17.4 kΩ	-	-	250 mW ± 1%	-	2.0 x 1.2 (0805)
11	C1	1	10 µF			Chemical, 25 V, ±10%	-	2.0 x 1.2 (0805)
12	C2	1	0.1 µF			Ceramic, 25 V, ±10%		2.0 x 1.2 (0805)
12	C3, C7, C12	3	2.2 µF	-	-	Ceramic, 25 V, ±10%	-	2.0 x 1.2 (0805)
13	C4	1	330 pF	-	-	Ceramic, 25 V, ±5%	-	1.6 x 0.8 (0603)
14	C5	1	10 µF	-	-	Ceramic, 25 V, ±20%	-	2.0 x 1.2 (0805)
15	C6, C9, C10, C11	4	100 nF	-	-	Ceramic, 25 V, ±10%	-	1.6 x 0.8 (0603)
16	C8, C13	2	1 µF	ECQE6105KF	Panasonic	Polypropylene Film, 650 V, ±10 %	DIP	-
17	C14	1	1 µF			Chemical, 25 V, ±10%		2.0 x 1.2 (0805)
18	C15	1	1000 pF			Ceramic, 25 V, ±10%		2.0 x 1.2 (0805)
19	S1, S2, S3	3	-	HW-101A	ASK	Hall Sensor	4SOP	-

3. Control method

3.1. Motor startup

Upon startup, the TPD4204F drives a BLDC motor with a square wave according to the rotor position signals. When the frequency of the position signals indicates a rotation speed of 1 Hz, the TPD4204F estimates the rotor position based on the position signals, produces a carrier signal, and compares the carrier signal with a triangular wave to generate a sine-wave PWM signal. Figure 3.1 shows a simplified waveform at motor startup.

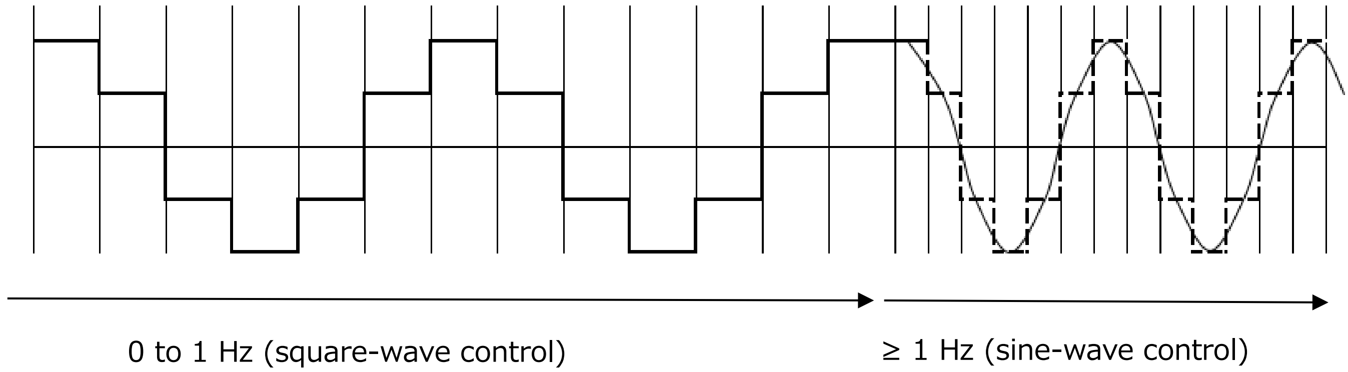


Figure 3.1 At motor startup

Figure 3.2 shows a timing chart for motor control. The TPD4204F senses the rotor position based on the signals from Hall sensors. The FG output pin of the TB6634FNG indicates the motor rpm.

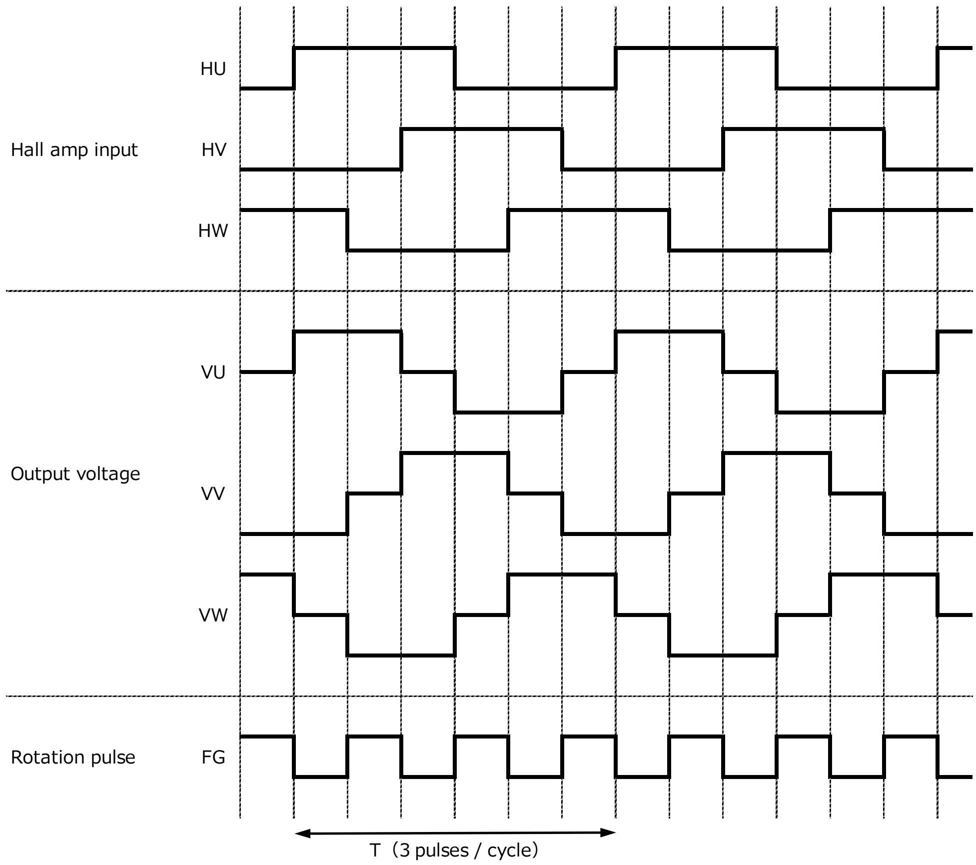


Figure 3.2 Timing chart

3.2. Calculating the rpm of a motor

The revolutions per minute (rpm) of a motor can be calculated by measuring the period of an output rotation pulse shown in Figure 3.2.

$$\mathrm{RS} = 60 \times 2 \times \frac{F}{P}$$

where:

RS: Motor rotation speed (rpm)
T/3: Rotation pulse period
P: Number of motor poles
F: Frequency (= 1/T)

Calculation example: When the frequency of the output rotation pulse for an eight-pole motor is measured to be 300 Hz

$$\mathrm{RS} = 60 \times 2 \times \frac{\frac{300}{3}}{8} = 1500\mathrm{rpm}$$

3.3. Controlling the rpm of a motor

The motor rpm can be controlled via the DC voltage applied to the V_{SP} pin of the TB6634FNG. Figure 3.3 shows the relationship between the V_{SP} voltage and the PWM duty cycle. The TB6634FNG allows the motor rpm to be controlled when V_{SP} is in the voltage range of (3).

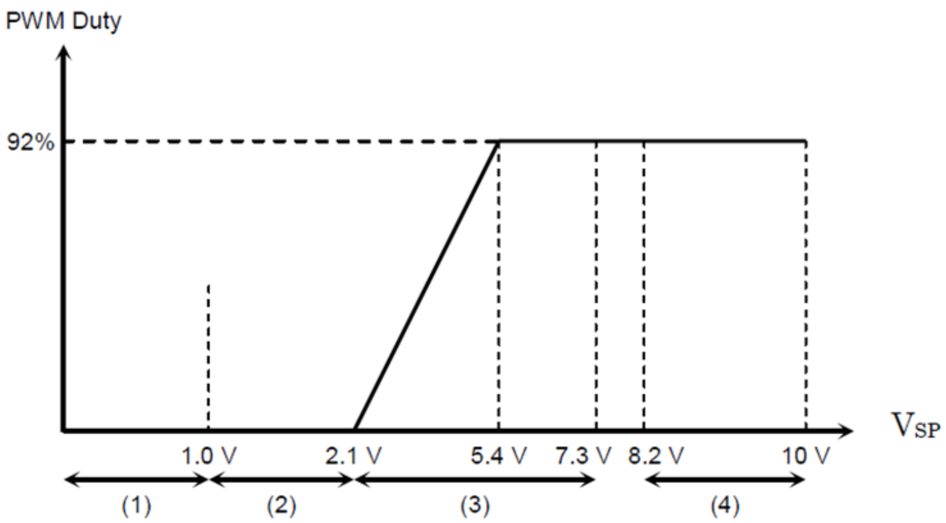


Figure 3.3 Controlling the motor rpm via the V_{sp} voltage

(1) Voltage command input: When $V_{SP} \leq 1.0$ V
The commutation outputs are disabled. (Gate protection is activated.)

(2) Voltage command input: When 1.0 V < V_{SP} ≤ 2.1 V

The low-side MOSFETs turn on at a fixed carrier frequency. (The “on” duty cycle is roughly 8%.) (Refresh)

(3) Voltage command input: When 2.1 V < V_{SP} ≤ 7.3 V

During sine-wave control, the commutation signals directly appear externally. The PWM duty cycle is approximated as follows:

$$\text{PWM Duty}(\%) = 27.9 \times V_{SP} - 58.5 \; (2.1V \leqq V_{SP} \leqq 5.4V)$$

During square-wave control, the low-side MOSFETs are forced on at a fixed carrier frequency. (The “on” duty cycle is roughly 8%.)

(4) Voltage command input: When 8.2 V < V_{SP} ≤ 10 V (test mode)

The TB6634FNG operates in sine-wave mode with zero lead angle. However, the TB6634FNG operates in square-wave mode when a reverse rotation is detected.

The TB6634FNG switches from square-wave mode to sine-wave mode at a V_{SP} of 7.9 V (typical).

The output “on” duty cycle is kept as when 5.4 V (typical) ≤ V_{SP} and is calculated as (carrier frequency) × 92%.

Example: When the maximum speed of a loaded motor is 1000 rpm

The maximum PWM duty cycle is 92%. Therefore, the motor speed is 1000 rpm when the PWM duty cycle is 92%.

The PWM pulse width can be adjusted via the voltage applied to the V_{SP} pin. When V_{SP} = 3 V, the PWM duty cycle is roughly 25.2%, which gives a motor speed of about 252 rpm.

* If the acurate motor rpm is needed, it should be measured since there is some error depending on the motor characteristics.

3.4. Hall sensors and Hall ICs

The rotor position in a motor is detected using Hall sensors, a Hall IC, or a linear Hall IC, all of which are based on the Hall effect. When a magnetic field is applied perpendicular to a current flowing in an electrical conductor, a voltage difference is produced across the conductor, transverse to the current flow. This phenomenon is called the Hall effect. Hall sensors, Hall ICs, and linear Hall ICs are non-contact sensors that vary their output voltage in response to a magnetic field according to the Hall effect. It is important to select the sensors that best suit your application needs.

The next section describes the designing of motor drivers using Hall sensors and a Hall IC in detail.

3.4.1. Using Hall sensors

There are various types of Hall sensors with different characteristics. Examine their specifications to select the optimal one. Hall sensors could burn up at high temperature, depending on their temperature characteristics. Generally, Hall bias resistors are added as shown in Figure 3.4 for burn-out protection. Appropriate Hall bias resistors must be selected so that the maximum input current to the Hall sensor (I_{inA}) falls within its safe operating area, an example of which is shown in Figure 3.5. Generally, R_A on the power supply side and R_B on the GND side should have the same value.

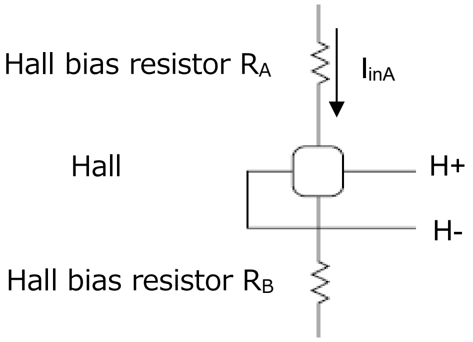


Figure 3.4 Hall bias resistors

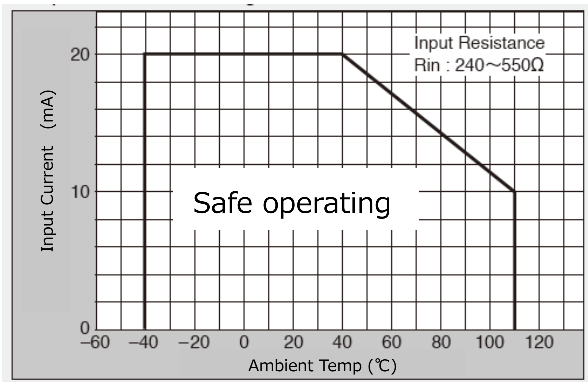


Figure 3.5 Temperature characteristics of a Hall sensor (HW101A)

Calculating the Hall sensor bias current

The following exemplifies how to calculate the Hall sensor bias current for the HW-101A from Asahi Kasei Corporation.

- Design conditions
  The power supply from the V_{refout} pin of the TB6634FNG is used for the HW-101A.
  Operating temperature range: -40 to 110°C
  R_A and R_B have a tolerance of ±5%.

The safe operating area shown in Figure 3.4 indicates that, at 110°C, the maximum current that provides the best performance is 10 mA. Therefore, we are going to use the center value, 5 mA, for this design example.

The values of the Hall bias resistors R_A and R_B can be calculated as follows:

$$R_A + R_B + R_{in} = \frac{V_{REG}}{I_{inA}}$$

where:

R_A, R_B: Hall bias resistors
R_{in}: Input resistance of the Hall sensor (see Figure 3.6)
I_{inA}: Input current to the Hall sensor
V_{refout}: Regulator output of the TB6634FNG

Hence, ($R_A + R_B + R_{in}$) is calculated to be 1000 Ω.

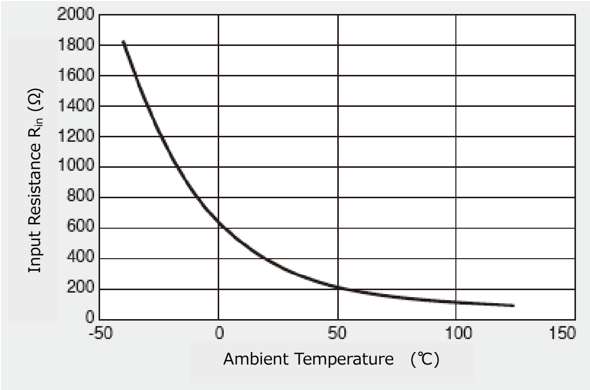


Figure 3.6 R_{in} vs temperature curve of the HW-101A

It is recommended to set the bias voltage across R_A and R_B to $\frac{V_{REG}}{2}$ when a motor is de-energized. Under this condition, R_A=R_B. Hence,

$$2R+R_{in} = 1000\ \Omega$$
$$R_{in\_Max} = 500\ \Omega$$
$$2R = 1000-500 = 500\ \Omega$$
$$R = 500/2 = 250\ \Omega$$

Here, let's use the resistors of E24 series, considering availability. Therefore, R = 300 Ω. Next, it is necessary to determine whether the HW-101A operates inside its safe operating area with R = 300 Ω, referring to the HW-101A datasheet. The I_{inA} value becomes maximum when R_{in} is 100 Ω at 110°C (Figure 3.5), R_A and R_B are minimum, and V_{REG} is maximum. Hence:

$$I_{inA} = \frac{5.5}{285\ \times 2 + 100} = 8.2mA$$

Therefore, the HW-101A falls inside the safe operating area over the temperature range from -40°C to 110°C.

* Modify the design according to the temperature range in which the HW-101A is used and perform verification with actual hardware. The above calculation is intended merely as an example.

3.4.2. Using a Hall IC

In addition to Hall sensors, the TPD4204F allows the use of a Hall IC. When the Hall IC has an open-collector (or open-drain) output, pullup resistors must be added, as shown in Figure 3.7. In this case, the Hall amplifier inputs can be derived from the output of the voltage regulator (V_{refout}) incorporated in the TB6634FNG. Figure 3.8 shows an example of the V_{refout} characteristics. Since the maximum Hall-amp common-mode input voltage of the TB6634FNG is specified as 3.5 V, the maximum amplitude must be less than 3.5 V. The reference voltage should be one-half of the input voltage to ensure that the Hall IC output is read correctly.

The pullup resistors are unnecessary when the Hall IC has a push-pull output.

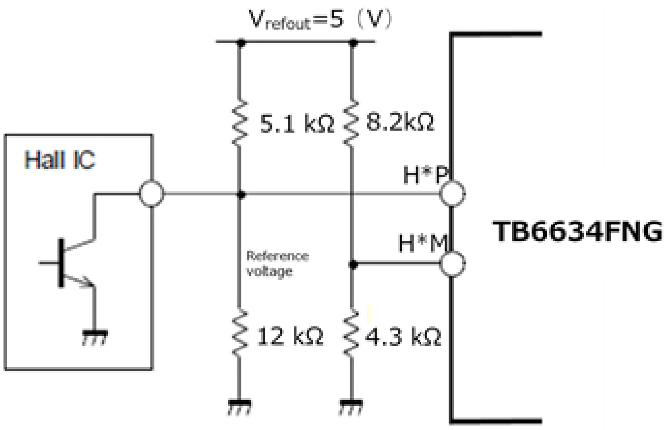


Figure 3.7 Voltage conversion circuit

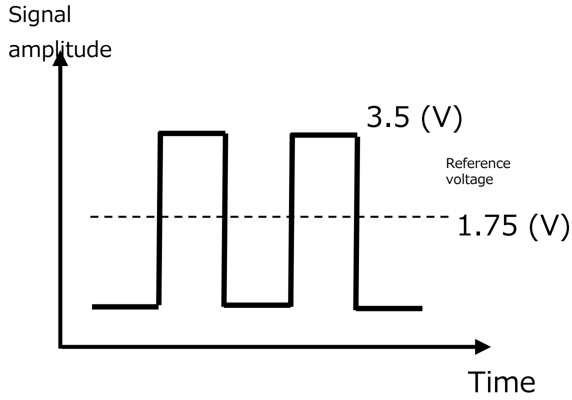


Figure 3.8 Example of output characteristics

3.5. Lead angle control

The TB6634FNG provides lead angle control that helps improve the motor efficiency. The application circuit shown in the previous section automatically adjusts the lead angle according to the output current (i.e., motor rpm). Figure 3.9 shows the relationship between the output current (i.e., motor rpm) and the lead angle. The output current increases as the motor rpm increases. The peak-hold circuit of the TB6634FNG holds the output at the peak according to the current value from the I_{dc} pin and feeds it to a filter to obtain the LPA/LA voltage level. The lead angle is determined from the LPF/LA value as shown in Table 3.1. It is necessary to correct the lead angle according to the motor and load conditions in order to improve the motor efficiency. The lead angle should be determined through a hardware test.

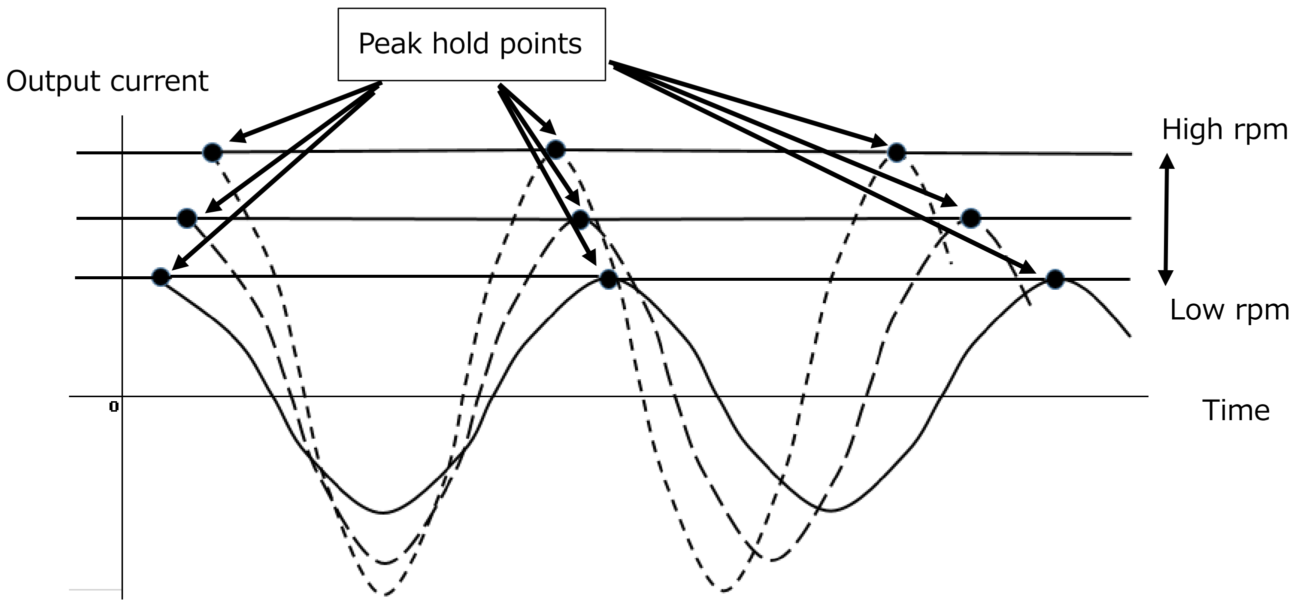


Figure 3.9 Output current (rpm) vs. auto lead angle control

Table 3.1 LPA/LA lead angles

Step	LPF/LA (V)	Lead angle (°)	Step	LPF/LA (V)	Lead angle (°)	Step	LPF/LA (V)	Lead angle (°)
0	0.000	0.000	11	1.719	20.625	22	3.438	41.250
1	0.156	1.875	12	1.875	22.500	23	3.594	43.125
2	0.313	3.750	13	2.031	24.375	24	3.750	45.000
3	0.469	5.625	14	2.188	26.250	25	3.906	46.875
4	0.625	7.500	15	2.344	28.125	26	4.063	48.750
5	0.781	9.375	16	2.500	30.000	27	4.219	50.625
6	0.938	11.250	17	2.656	31.875	28	4.375	52.500
7	1.094	13.125	18	2.813	33.750	29	4.531	54.375
8	1.250	15.000	19	2.969	35.625	30	4.688	56.250
9	1.406	16.875	20	3.125	37.500	31	4.844	58.125
10	1.563	18.750	21	3.281	39.375	32	5.000	58.125

4. Design considerations

- The absolute maximum ratings of a semiconductor device are a set of ratings that must not be exceeded, even instantaneously. None of the absolute maximum ratings must be exceeded. Exposure to conditions exceeding the absolute maximum ratings may damage or degrade a device, or cause personal injury due to explosion or ignition.

- Use an appropriate power supply fuse to ensure that an excessive current does not continuously flow in the event of an overcurrent or an IC failure. The IC may be permanently damaged if it is used under conditions exceeding its absolute maximum ratings or if it is wired incorrectly or exposed to abnormal pulse noise induced by wires and a load. An excessive current, if left to flow continuously, might cause smoke or fire. The capacity, fusing time, and location of a fuse should be considered to minimize the impact of an excessive current flowing into or out of the IC in the event of self-damage.

- For applications with a motor coil or other inductive load, add a protection circuit to prevent malfunction or destruction of the device due to an inrush current at power-on or a negative current generated by back-EMF at power-off. IC destruction might cause personal injury, smoke, or fire. Use a regulated power supply for ICs with protection features. If the power supply is unstable, the protection features might not work properly, leading to IC destruction and causing personal injury, smoke, or fire.

- Avoid using ICs in the wrong orientation or using the wrong ICs. Also avoid a reverse power supply connection. A current or power consumption exceeding the absolute maximum ratings may damage or degrade a device, or cause personal injury due to explosion or ignition. Do not apply a current to a device that is inserted in the wrong orientation or incorrectly. Do not use any device if a current is applied in such a manner even once.

- Control the input signal when the V_{CC} voltage is stable. (The order of V_{BB} and V_{CC} is insignificant.) When V_{CC} and V_{BB} are powered down, the IC might be permanently damaged if the V_{BB} line is disconnected by a relay or other means while the motor is running because this blocks a current recirculation path to V_{BB}.

- If a motor is allowed to stop or slow to low rpm quickly, a current recirculates to the motor power supply due to the effect of a motor’s back-EMF. This might cause a rise in supply voltage. Therefore, care should be exercised in reducing the motor speed. It is advisable to reduce the motor speed slowly so as not to damage power devices due to a rise in supply voltage. Experiment with your application to determine the rate of deceleration.

- Noise might be superimposed on the position input signals due to GND bounces or imbalances among output signals. If the position input signals have noise, add a capacitor between them to prevent malfunction.

5. Product overview

5.1. TPD4204F

5.1.1. Overview

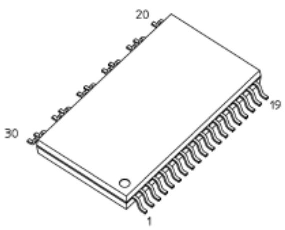
The TPD4204F in the 30-pin SSOP package is a high-voltage BLDC motor driver with 600-V power MOSFETs that supports current sensing using three shunt resistors. The TPD4204F incorporates a level-shifting high-side driver, a low-side driver, a thermal shutdown circuit, an undervoltage protection circuit, an overcurrent protection circuit, an output shutdown (SD) function, and output power MOSFETs. The TPD4204F provides direct variable-speed control of a BLDC motor based on control signals from a microcontroller.

Overview

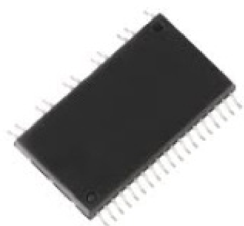
- Isolates high-voltage, high-current pins and control pins on the opposite sides of the package
- Supports current sensing using three shunt resistors
- A bootstrap circuit, eliminates the need for a power supply for the high-side driver
- Incorporates bootstrap diodes
- Ideal for sine-wave commutation due to a dead time that can be set to as short as 1.4 μs
- Incorporates a three-phase bridge composed of power MOSFETs
- Incorporates overcurrent protection, thermal shutdown, output shutdown (SD), and undervoltage protection functions
- Incorporates a 7-V regulator (typical)
- Package: SSOP30 (20.2 mm x 14.5 mm x 2.2 mm (maximum))

5.1.2. External view and pin assignment

External view



Product photo



Marking (top view)

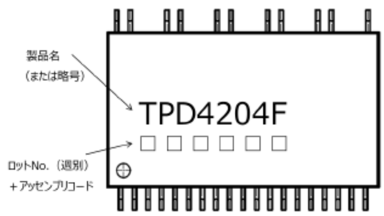


Figure 5.1 External view and marking of the TPD4204F

5.1.3. Internal block diagram

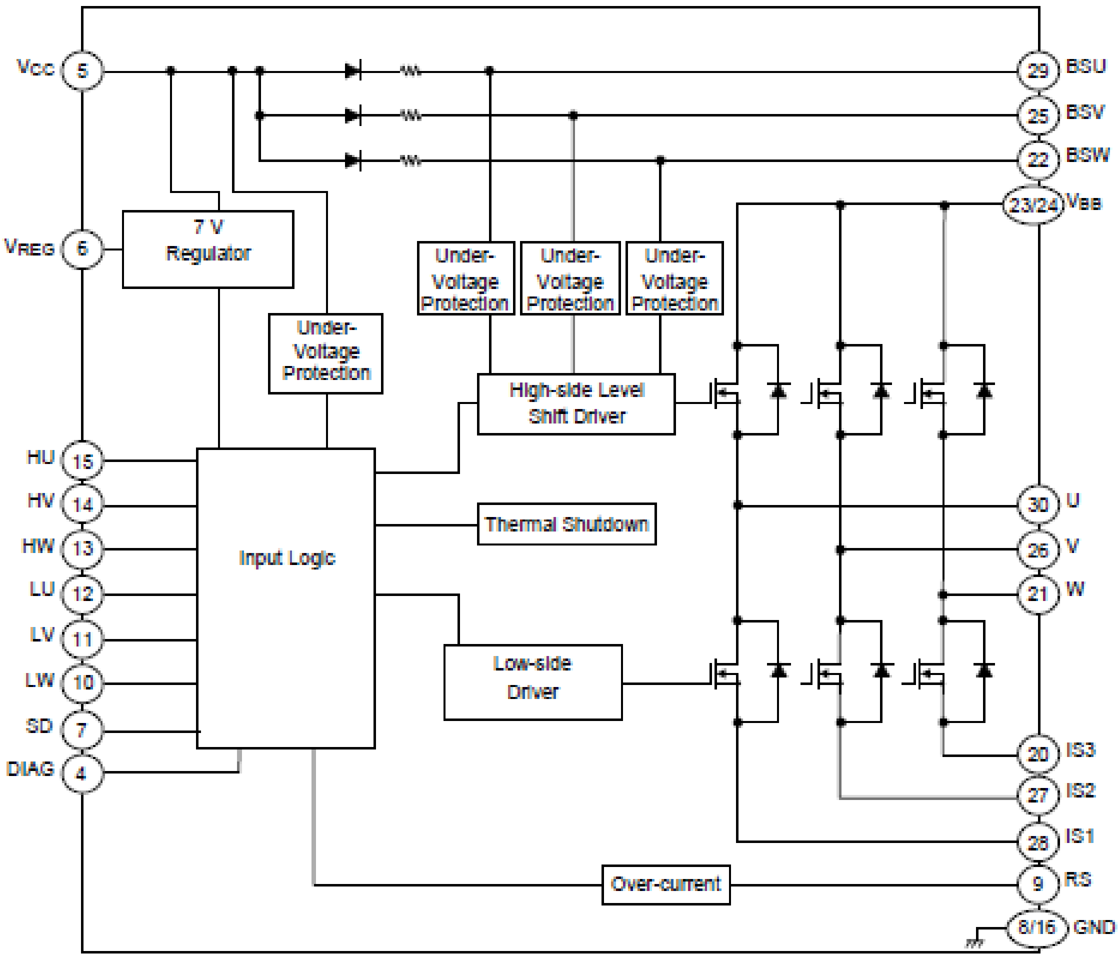


Figure 5.2. Internal block diagram of the TPD4204F

5.1.4. Pin description

Table 5.1. Pins of the TPD4204F

Pin no.	Symbol	Description
1	NC	No-connect pin, which is not connected to the internal chip
2	NC	No-connect pin, which is not connected to the internal chip
3	NC	No-connect pin, which is not connected to the internal chip
4	DIAG	Open-drain diagnostic output. Connect a pullup resistor to the DIAG pin. The DIAG output is set to on in the event of a faulty condition.
5	V_{CC}	Control power supply pin. 15 V (typ.)
6	V_{REG}	7-V regulator output pin
7	SD	External protection input (Active-Low, no hysteresis)
8	GND	Ground pin
9	RS	Overcurrent detection pin
10	LW	Control pin for the low-side Phase-W MOSFET. The MOSFET turns off when LW ≤ 1.5 V and turns on when LW ≥ 2.5 V.
11	LV	Control pin for the low-side Phase-V MOSFET. The MOSFET turns off when LV ≤ 1.5 V and turns on when LV ≥ 2.5 V.
12	LU	Control pin for the low-side Phase-U MOSFET. The MOSFET turns off when LU ≤ 1.5 V and turns on when LU ≥ 2.5 V.
13	HW	Control pin for the high-side Phase-W MOSFET. The MOSFET turns off when HW ≤ 1.5 V and turns on when HW ≥ 2.5 V.
14	HV	Control pin for the high-side Phase-V MOSFET. The MOSFET turns off when HV ≤ 1.5 V and turns on when HV ≥ 2.5 V.
15	HU	Control pin for the high-side Phase-U MOSFET. The MOSFET turns off when HU ≤ 1.5 V and turns on when HU ≥ 2.5 V.
16	GND	Ground pin
17	NC	No-connect pin, which is not connected to the internal chip
18	NC	No-connect pin, which is not connected to the internal chip
19	NC	No-connect pin, which is not connected to the internal chip
20	IS3	Source pin for the Phase-W MOSFET
21	W	Phase-W output pin
22	BSW	Phase-W bootstrap capacitor connection pin
23	V_{BB}	High-voltage power supply pin
24	V_{BB}	High-voltage power supply pin
25	BSV	Phase-V bootstrap capacitor connection pin
26	V	Phase-V output pin
27	IS2	Source pin for the Phase-V MOSFET
28	IS1	Source pin for the Phase-U MOSFET
29	BSU	Phase-U bootstrap capacitor connection pin
30	U	Phase-U output pin

5.2. TB6634FNG

5.2.1. Overview

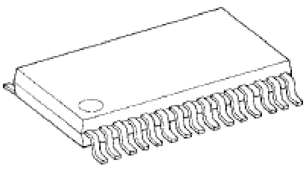
The TB6634FNG is a sine-wave PWM controller that provides lead angle control to help improve the motor efficiency. The TB6634FNG provides a current limit control input pin and a motor supply voltage detection function.

Overview

- Sine-wave PWM drive
- Incorporates a triangle wave generator (carrier frequency = f_{OSC}/252 Hz)
- Lead angle control (32 steps between 0° and 58°)
- External lead angle setting and internal auto lead angle setting
- Current limit control input pin
- Incorporates a voltage regulator (V_{refout} = 5 V (typical), 30 mA (maximum))
- Operating voltage range: V_{CC} = 6 to 16.5 V
- Motor lock detection
- Motor supply voltage detection
- Package: SSOP30 (10.2 mm x 7.9 mm x 1.6 mm (maximum))

5.2.2. External view and pin assignment

External view



Product photo

Figure 5.3 External view of the TB6634FNG

5.2.3. Internal block diagram

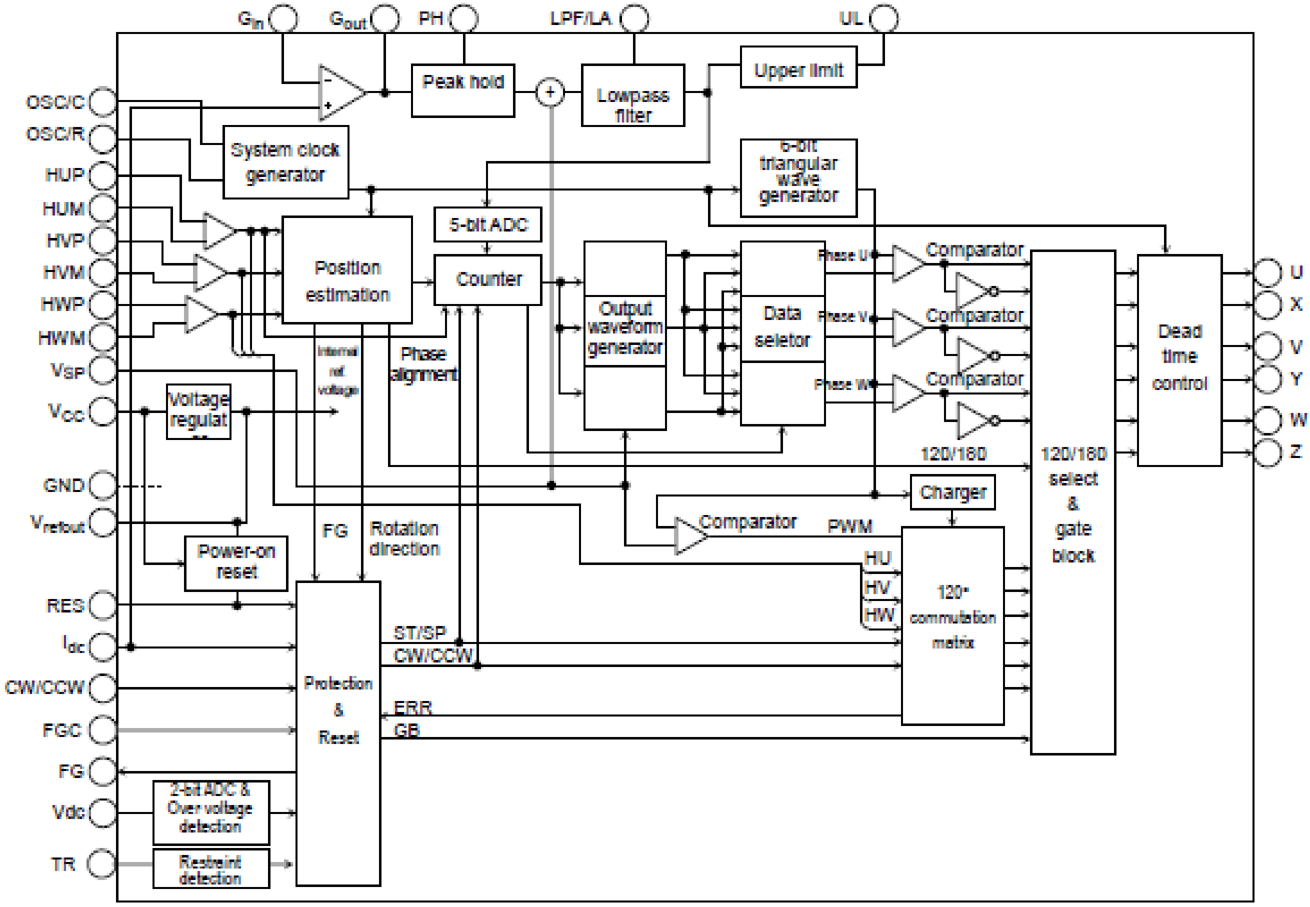


Figure 5.4. Internal block diagram of the TB6634FNG

5.2.4. Pin description

Table 5.2. Pins of the TB6634FNG

Pin no.	Symbol	Description
1	Z	Commutation signal Z (Low-side Phase W)
2	Y	Commutation signal Y (Low-side Phase V)
3	X	Commutation signal X (Low-side Phase U)
4	W	Commutation signal W (High-side Phase W)
5	V	Commutation signal V (High-side Phase V)
6	U	Commutation signal U (High-side Phase U)
7	RES	Fault detection input H: Runs the motor L: Stops the motor The RES input has an internal pulldown resistor.
8	V_{dc}	Motor supply voltage detection
9	TR	Motor lock detection
10	I_{dc}	Current limit control input
11	G_{in}	Gain setting
12	G_{out}	Gain setting
13	PH	Peak hold
14	LPF/LA	Lowpass filter/lead angle setting
15	UL	Upper lead angle limit
16	V_{refout}	Reference voltage output
17	HUP	Position signal input U
18	HUM	Position signal input U
19	HVP	Position signal input V
20	HVM	Position signal input V
21	HWP	Position signal input W
22	HWM	Position signal input W
23	FGC	FG output signal selection input
24	CW/CCW	Clockwise/counterclockwise rotation input
25	FG	FG signal output
26	OSC/R	Oscillator resistor
27	OSC/C	Oscillator capacitor
28	GND	Ground pin
29	V_{SP}	Voltage command input
30	V_{CC}	Supply voltage

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