TB6559FG Usage Considerations

TB6559FG is a single H- bridge driver for DC brush motor. Direct PWM drive and constant current drive can be selected.

1. Power Supply

(1) Operation Power Supply Voltage

Characteristic	Symbol	Operating Voltage Range	Unit
Supply voltage	V_{CC}	10 to 30	V

Though absolute maximum rating is 50 V, the operation supply voltage should be set to 27 V or less.

(2) Power On/Shut Down

In powering on and shutting down, SB should be set to low level (standby mode) to avoid the error in supplying V_{CC}.

2. Output Current

Absolute maximum rating is 2.5 A (peak). It must not be exceeded, even for a moment. Average tolerant current is limited by total dissipation. Pay attention not to exceed the dissipation in using the IC.

3. Control Input

(1) IN1 and IN2 Signal Input

Output mode can be chosen by IN1 or IN2 input.
Input signal of 3 V line can control the IC when $V_{IN\ (H)}$ is 2 V and $V_{IN\ (L)}$ is 0.8 V.
Pull down resistance of 100 kΩ (typ.) is included.

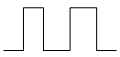
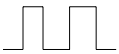
(2) Standby Input

All output transistors are off by setting SB pin to low level (standby mode).
Input signal of 3 V line can control the IC when $V_{IN\ (H)}$ is 2 V and $V_{IN\ (L)}$ is 0.8 V.
Pull down resistance of 100 kΩ (typ.) is included. It moves to standby mode when input is open.

(3) V_{ref} Input

Control of constant current PWM or direct PWM mode can be chosen by inputting V_{ref}.
In control of constant current PWM mode, the constant current value is determined by the input voltage.
Input is high impedance because of the based input of the transistor.
(V_{ref} = 5 V in input. Input current = 1 μA)

Input/Output Function

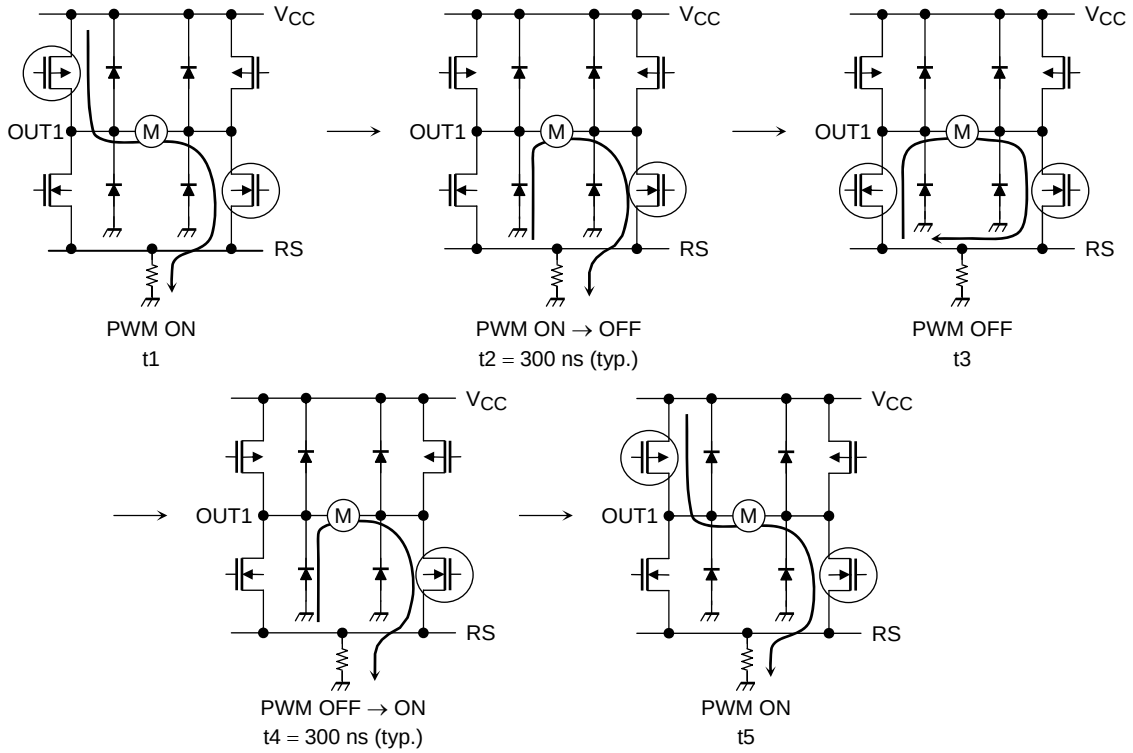
	Input					Output			
	V_{ref}	IN1	IN2	SB	PWM/OSC	IO (100%) (typ.)	OUT1	OUT2	Mode
Constant current PWM mode	0 to 3 V	H	**H**	H	Condenser	—	L	L	Short break
		L	H	H	Condenser	$\frac{Vref}{6 \cdot RS}$	L L	Constant current chopping 	CCW Short break
		H	**L**	H	Condenser	$\frac{Vref}{6 \cdot RS}$	Constant current chopping 	L L	CCW Short break
		L	L	H	Condenser	—	OFF: Hi-Z		Stop
		X	X	L	Condenser	—	OFF: Hi-Z		Standby
Direct PWM mode	4.5 V to V_{REG}	H	**H**	H	H L		L	L	Short break
		L	H	H	H L		L L	H L	CCW Short break
		H	**L**	H	H L		H L	L L	CW Short break
		L	L	H	H L		OFF: Hi-Z		Stop
		X	X	L	H L		OFF: Hi-Z		Standby

4. PWM Operation

When constant current control and PWM control are provided, normal operation and short brake operation are repeated.

If the upper and lower power transistors in the output circuit were ON at the same time, a penetrating current would be produced. To prevent this current from being produced, a dead time of 300 ns (design target value) is provided in the IC when either of the transistors changes from ON to OFF, or vice versa.

Therefore, PWM control by synchronous rectification is enabled without an OFF time being inserted by external input. Note that a dead time is also provided in the IC at the time of transition between CW and CCW or between CW (CCW) and short brake mode, thereby eliminating the need for an OFF time.



4.1 Control of Constant Current PWM

It moves to the control of constant current PWM mode when V_{ref} is 0 to 3 V.

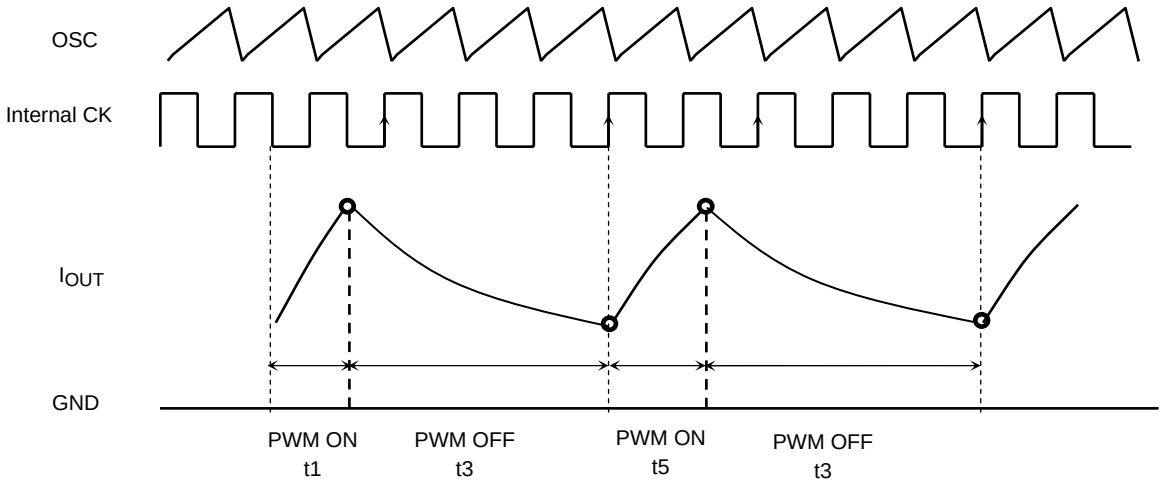
PWM OFF (t3) is determined by the clock frequency which is generated internally by the oscillation of OSC pin.

PWM is off after Iout reaches the reference value and PWM is on when 4th internal clock rises.

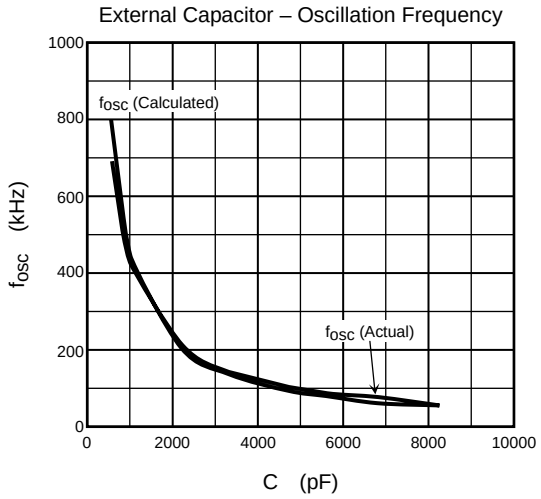
On time changes depending on the load condition (L and R constant numbers of the motor) and the reference current. So, set the off time (value of external capacitor) to provide the PWM frequency the audio frequency (15 kHz) or more.

Oscillation frequency of OSC is approximated by the formula below.

$$f_{osc} = 1/(0.523 \times (C_{osc} \times 3700 + C_{osc} \times 600)$$



Actual measurement value and calculated value of the external capacitor and the oscillation frequency are shown below.(Calculated value is the reference value produced in the center.)



Setting Motor Current in the Constant Current Drive

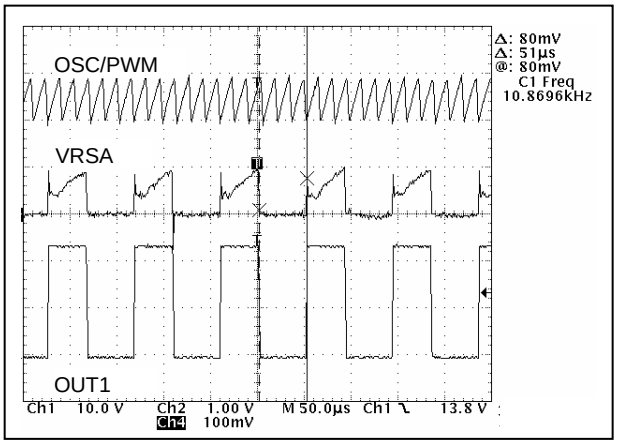
Motor current is set by V_{ref} and current detection resistance (Rs).

$$I_{O\ (peak)} = V_{ref} \times 1/6 \times 1/Rs\ [A]$$

Average current is the reference value or less because this circuit applies peak current detection method

Average current changes because current ripple changes depending on the time constant of the coil, PWM frequency, and so on. So, determine the most appropriate value for design.

Example: Waveform in constant current drive



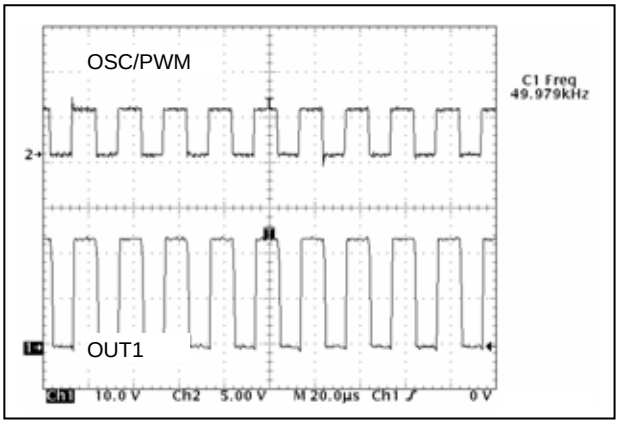
<Conditions>
V_{CC} = 24 V
V_{ref} = 0.5 V
C_{osc} = Motor load
RSA = 1 Ω
Ambient temperature

4.2 Control of Direct PWM

It moves to control of direct PWM mode when V_{ref} is 4.5 V to V_{reg}.

Upper output FET turns on or off with synchronizing to PWM signal inputted by OSC and PWM pins.

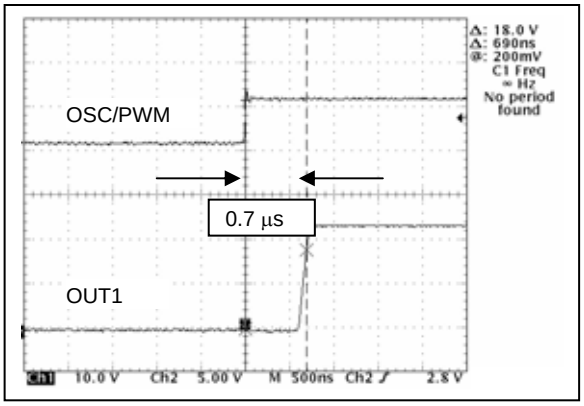
Setting externally is unnecessary because the dead time is generated internally.

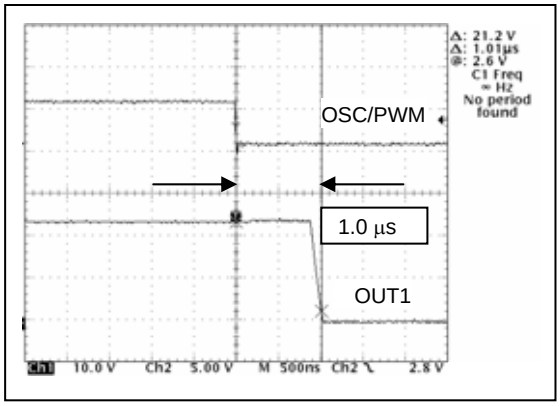


<Conditions>
V_{CC} = 24 V
V_{ref} = 5 V
OSC/PWM input: 0/5 V. 50 kHz
Motor load
Ambient temperature

OSC/PWM Input/Output

Reference data of response of OSC/PWM between input and drive output is shown below.





<Conditions>
V_{CC} = 24 V
V_{ref} = 5 V (control of direct PWM mode)
OSC/PWM input: 0/5 V, 50 kHz
Output: No load
Ambient temperature

5. Protect Circuit

This IC includes the functions below but it does not necessarily protect ICs under all circumstances.

Be sure to use the IC within the rating. If a short circuit takes place between output pins or if an output pin is connected to the voltage source or ground, a heavy current temporarily flows though the IC. It might destroy the IC.

(1) Over Current Protection Circuit

It monitors the current flowing in 4 output transistors. If one ore more of the current exceeds the reference current (5.0 A typ.), all outputs turn off. They recover at 50 μs (typ.).

Over current detection value has the variation of 4 A to 6 A.

(2) Thermal Shutdown Circuit

All outputs turn off when junction temperature exceeds 160°C (typ).

It has also temperature hysteresis of 40°C (typ). They recover when junction temperature decreases to 120°C.

6. Detection Signal Output for Abnormal State

The signal outputs from Alert pin when thermal shutdown circuit and over current detection circuit drive.

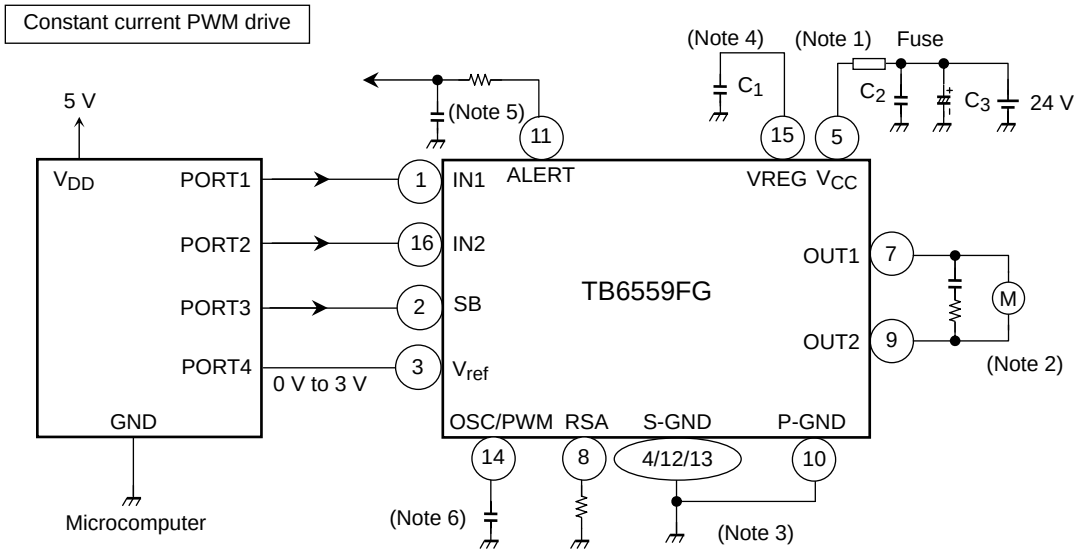
Normal: L output

Abnormal detection: H output

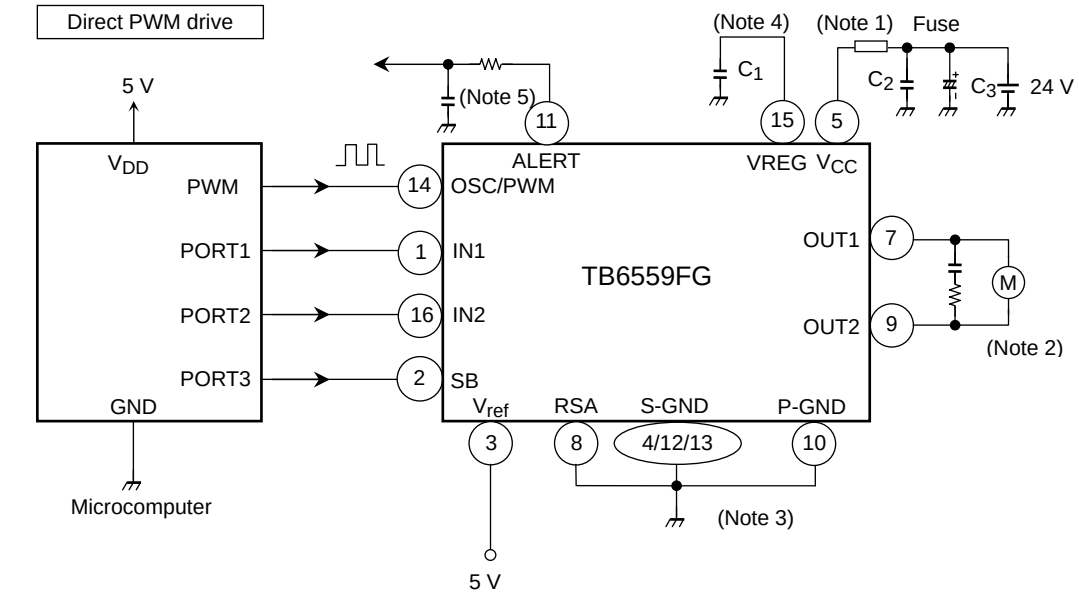
Output is CMOS output.

7. Application Circuit

(1) Constant Current PWM Drive



(2) Direct PWM Drive



Note 1: Capacitor for Supply Pin
Connect the capacitor between V_{CC} and GND as near the IC as possible.

Recommended Value

Characteristic	Recommended Value	Remarks
V_{CC} – GND	50 μF to 100 μF	Electrolytic condenser
	0.001 μF to 1 μF	Ceramic condenser

Note 2: Capacitor Between Outputs and Resistance
Connect them in reducing the brush noise of the motor. In this case, limit the current by the resistance because it moves to the short circuit mode momentarily in conduction when capacitor is not charged.

Note 3: GND
Connect it when S-GND and P-GND are arranged near IC with taking enough rooms.

Note 4: Capacitor for V_{reg} Pin
Connect the capacitor between V_{reg} and GND as near the IC as possible.

Recommended Value

Characteristic	Recommended Value	Remarks
V_{reg} – GND	0.1 μF to 1 μF	Ceramic condenser

Note 5: FIN
FIN is connected to the bed of the IC. So, radiation is effective when GND pattern of the FIN boarded part is layout largely and the metallic layer is applied. In case of multi-layer substrate, more improvement is possible when the same layout is provided on the backside with the through hole.

Note 6: Capacitor for OSC/PWM Pin

Recommended Value

Characteristic	Recommended Value	Remarks
OSC/PWM – GND	820 pF to 4700 pF	Ceramic condenser

8. Calculation of Power Dissipation

Power dissipation is calculated by the formula below.

PWM Duty = 100%

$$P = V_{CC} \times I_{CC} + I_O^2 \times Ron\ (upper + down)$$

When the ambient temperature is high, the dissipation becomes low. Design the radiation taking enough margin by applying Pd−Ta property data.

The relation between ambient temperature and junction temperature is calculated by the formula below. Be sure to set the junction temperature 150°C or less.

$$Tj = P \times R_{th\ (j\text{-}a)} + Ta$$

*: $R_{th\ (j\text{-}a)}$: Heat resistance between junction and ambient temperature

*: Ta: Ambient temperature

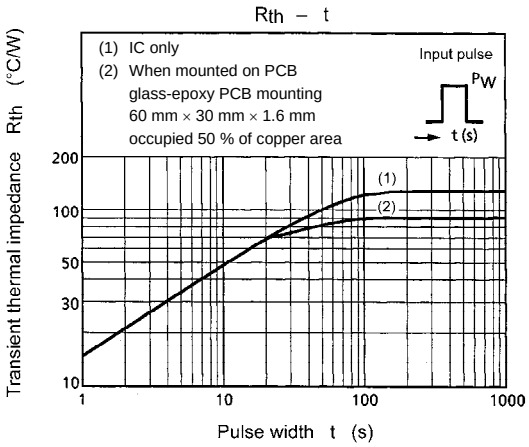
Pay attention that $R_{th(j\text{-}a)}$ depends on the usage circumstances (ex. mounted board).

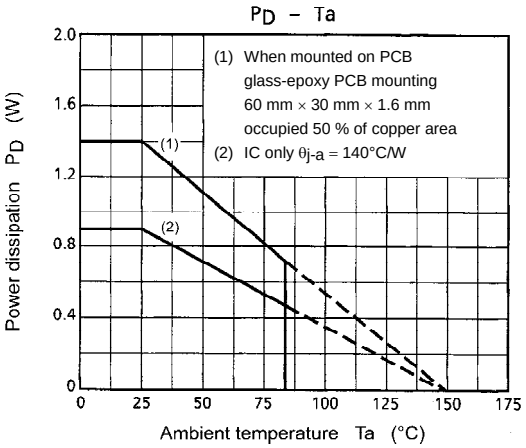
(Reference data of transient heat resistance in boarding only IC or constant conditioned IC is shown below.)

PWM Drive

It can be calculated easily by the formula below. (switching loss is generated actually.)

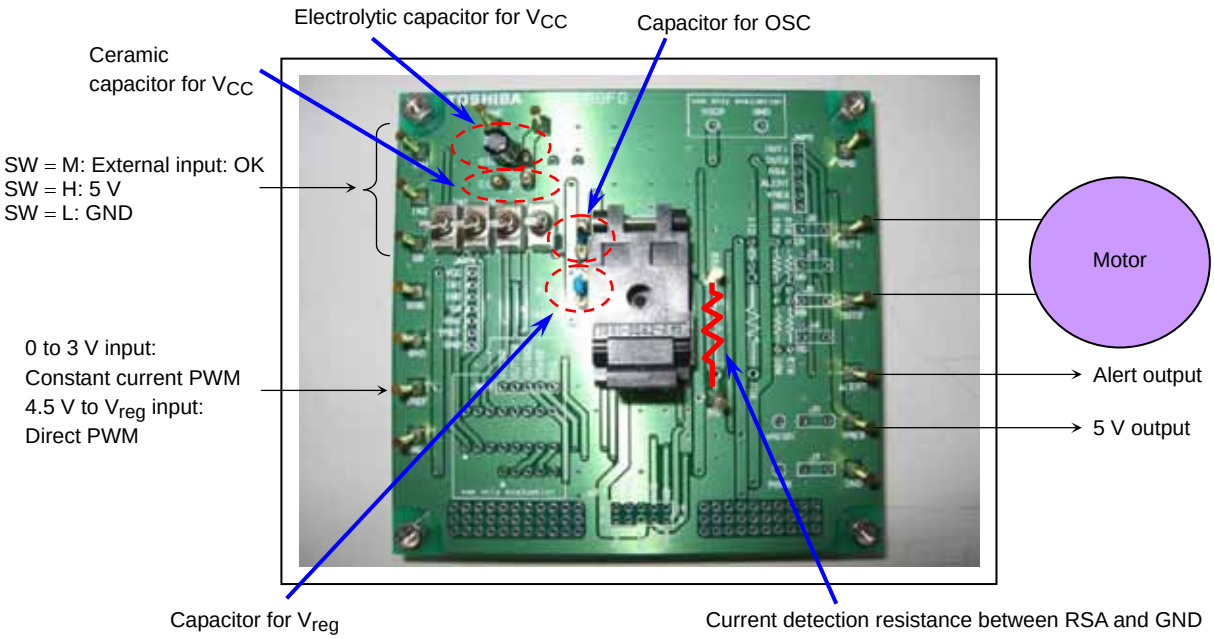
$$P = V_{CC} \times I_{CC} + I_O^2 \times Ron\ (upper + down) \times duty$$





9. Evaluation Board

The evaluation board below is prepared. (socket type)



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