TOSHIBA BiCD Integrated Circuit Silicon Monolithic
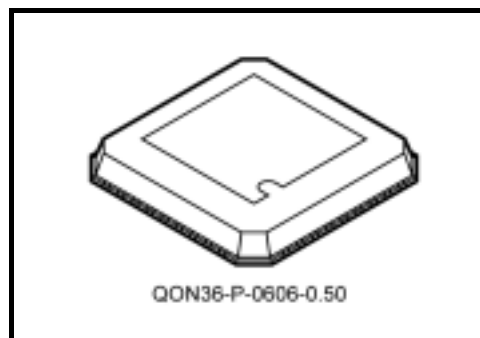
TB6607FLG

DC Motor Driver

The TB6607FLG is a driver IC for driving DC motors. Its employs LDMOS devices with low ON resistance for output drive transistors. The TB6607FLG incorporates two constant current-controlled H-bridge drivers and three voltage-controlled H-bridge drivers, making it ideal for controlling various lens actuators in digital still cameras. It supports three-wire serial data to control motors, thus reducing the number of lines for interfacing the control IC.

QON36-P-0606-0.50

Weight: 0.08 g (typ.)

Features

- Motor power supply voltage: $V_M \leq 6$ V (max)
- Control power supply voltage: $V_{CC} = 2.7$ to 6 V
- Output current: $I_{out} \leq 0.8$ A (max)
- P-/N-ch LDMOS complementary output transistors
- Output ON resistance: Ron (upper + lower) = 1.5 Ω (typ.)

[Constant current-controlled H-bridge drivers] ch. D, E
- High-speed PWM chopping control at around 100 kHz or higher (constant-current H-SW)

[Voltage-controlled H-bridge drivers] ch. A, B, C
- Three H-bridge drivers for direct PWM control

[Other Features]
- Two 6-bit DACs for setting reference value for constant-current limiter circuit
- Independent standby (Power save) feature
- Thermal shutdown (TSD) protective circuit (shut down output bias at internal junction temperature 170°C)
- Circuit for preventing malfunction at low voltage (shuts down internal circuits at UVLO: $V_{CC} \leq 2.2$ V (typ.)).
- Small QON-36 package (0.5-mm lead pitch)
- Supports Pb-free reflow mounting

The following conditions apply to solderability:
*Solderability
1. Use of Sn-37Pb solder bath
   *solder bath temperature = 230°C
   *dipping time = 5 seconds
   *number of times = once
   *use of R-type flux
2. Use of Sn-3.0Ag-0.5Cu solder bath
   *solder bath temperature = 245°C
   *dipping time = 5 seconds
   *number of times = once
   *use of R-type flux

Note: This product has a MOS structure and is sensitive to electrostatic discharge. When handling this product, ensure that the environment is protected against electrostatic discharge by using an earth strap, a conductive mat and an ionizer. Ensure also that the ambient temperature and relative humidity are maintained at reasonable levels.

Block Diagram
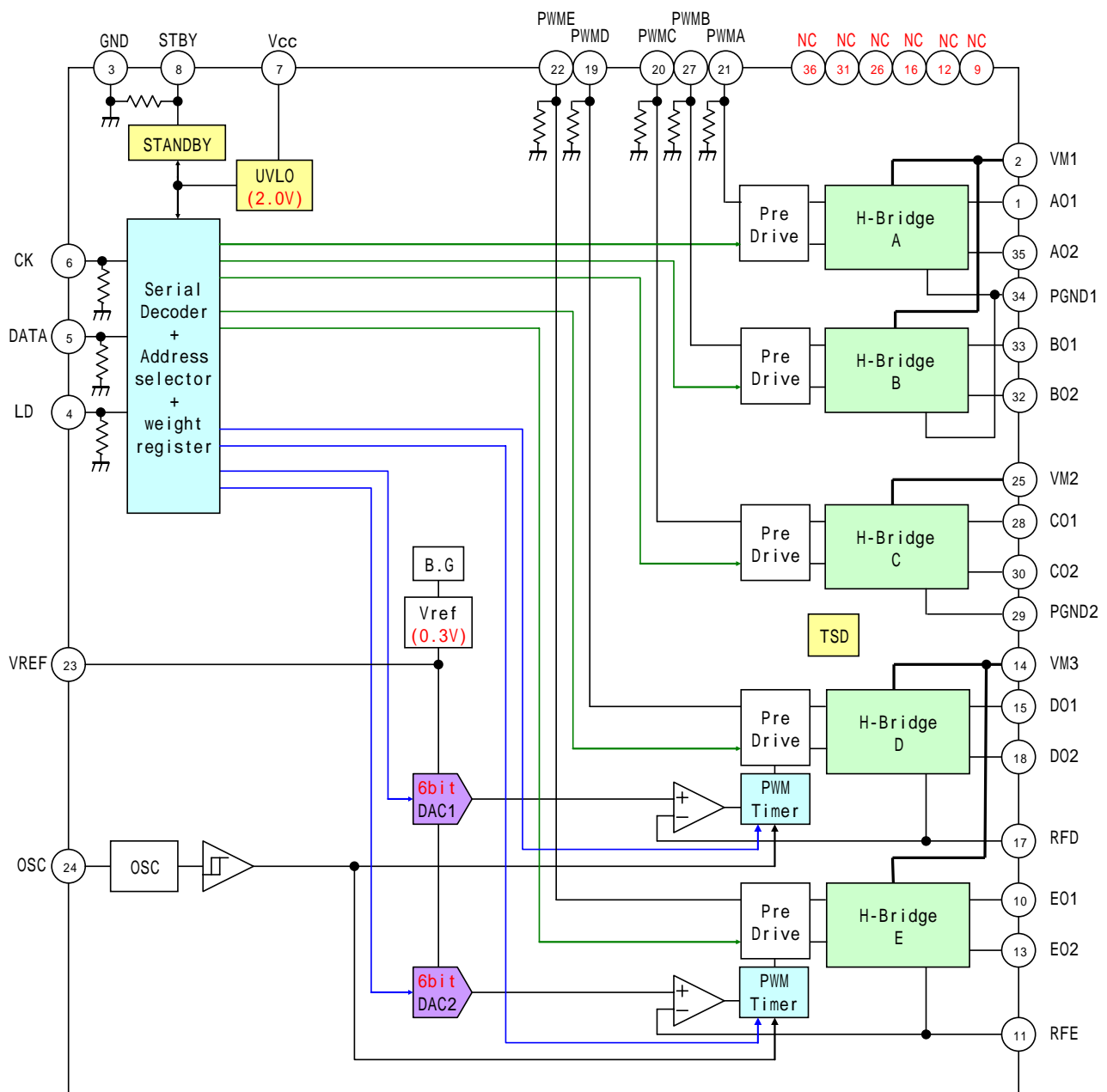
Pin Function

No.	Pin Name	I/O	Function
1	AO1	O	A ch Output pin 1
2	VM1	-	Motor Power Supply Voltage pin 1
3	GND	-	Ground pin
4	LD	I	Serial Data Load Signal input pin
5	DATA	I	Serial Data input pin
6	CK	I	Serial Clock input pin
7	Vcc	-	Power Supply Voltage pin
8	STBY	I	Standby (Power Save) Control Signal input pin
9	NC	-	Non-Connected pin
10	EO1	O	E ch Output pin 1
11	RFE	-	Current detect resistor connection pin (E ch)
12	NC	-	Non-Connected pin
13	EO2	O	E ch Output pin 2
14	VM3	-	Motor Power Supply Voltage pin 3
15	DO1	O	D ch Output pin 1
16	NC	-	Non-Connected pin
17	RFD	-	Current detect resistor connection pin (D ch)
18	DO2	O	D ch Output pin 2
19	PWMD	I	PWM Signal input pin (D ch)
20	PWMC	I	PWM Signal input pin (C ch)
21	PWMA	I	PWM Signal input pin (A ch)
22	PWME	I	PWM Signal input pin (E ch)
23	VREF	O	Reference Voltage (0.3V) output pin
24	OSC	-	External capacitor for OSC Circuit connection pin
25	VM2	-	Motor Power Supply Voltage pin 2
26	NC	-	Non-Connected pin
27	PWMB	I	PWM Signal input pin (B ch)
28	CO1	O	C ch Output pin 1
29	PGND2	-	Motor Ground pin 2
30	CO2	O	C ch Output pin 2
31	NC	-	Non-Connected pin
32	BO2	O	B ch Output pin 2
33	BO1	O	B ch Output pin 1
34	PGND1	-	Motor Ground pin 1
35	AO2	O	A ch Output pin 2
36	NC	-	Non-Connected pin

Absolute Maximum Ratings (Ta = 25°C)

Characteristics	Symbol	Rating	Unit	Remarks
Supply voltage	V_{CC}	6	V	V_{CC}
Motor supply voltage	V_M	6	V	V_M
Output pin voltage	V_{OUT}	−0.2 to 6	V	
Output current	I_{OUT}	0.8	A	
Input voltage	V_{IN}	−0.2 to 6	V	Each control input pin
Power dissipation	P_D	0.6	W	IC only
		1.04	W	* Note 1
Operating temperature	T_{opr}	−20 to 85	°C	
Storage temperature	T_{stg}	−55 to 150	°C	

* Note1. Mounted on Cu 40% grass epoxy single sided printed writing board (size: 50mm x 50mm x 1.6mm)

Operating Conditions (Ta = −20 to 85°C)

Characteristics	Symbol	Rating			Unit	Note
		Min	Typ.	Max		
Small signal supply voltage	V_{CC}	2.7	3	5.5	V	
Motor supply voltage	V_M	2.5	5	5.5	V	
Output current	I_{OUT}	—	—	600	mA	VM = 3 to 5.5V
		—	—	350		2.2V≤VM<3V
PWM frequency	f_{PWM}	—	—	500	kHz	
OSC oscillation frequency	f_{OSC}	—	—	1	MHz	

Operating Conditions 2: Serial Data Controller (Ta = −20 to 85°C)

Characteristics	Symbol	Rating		Unit
		Min	Max	
Low-level clock pulse width	t_{CKL}	200	—	ns
High-level clock pulse width	t_{CKH}	200	—	ns
Clock rise time	t_{Cr}	—	50	ns
Clock fall time	t_{Cf}	—	50	ns
Data setup time	t_{DCH}	30	—	ns
Data hold time	t_{CHD}	60	—	ns
Load setup time	t_{CHL}	200	—	ns
Load hold time	t_{LDC}	200	—	ns
PWM Synchronization time	t_{LDC2}	100	—	ns
High-level load pulse width	t_{LDH}	2	—	μs
CK (clock pulse) frequency	f_{CLK}	—	5	MHz
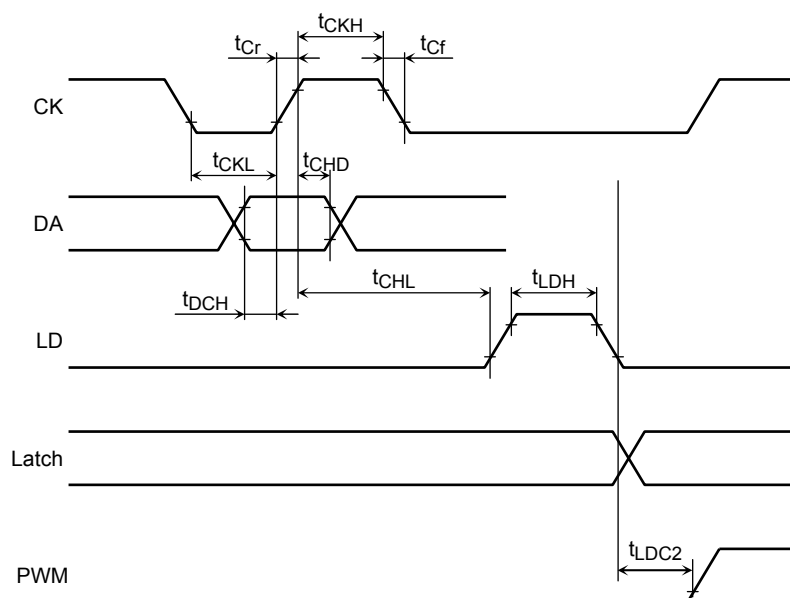
## Specifications and Operation of Each Circuit Block:

- Bridge output block:
  ### PWM control feature

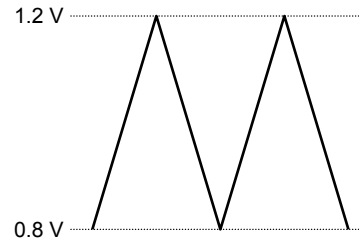 While PWM control is applied, normal operation t1, t5, and short brake t3 are repeated.
  (Dead time t2 and t4 are inserted to prevent pass-through current.)

| <PWM ON> t1 | <PWM ON → OFF> t2 | <PWM OFF> t3 |

| <PWM OFF → ON> t4 | <PWM ON> t5 |

Output voltage waveform (OUT1)
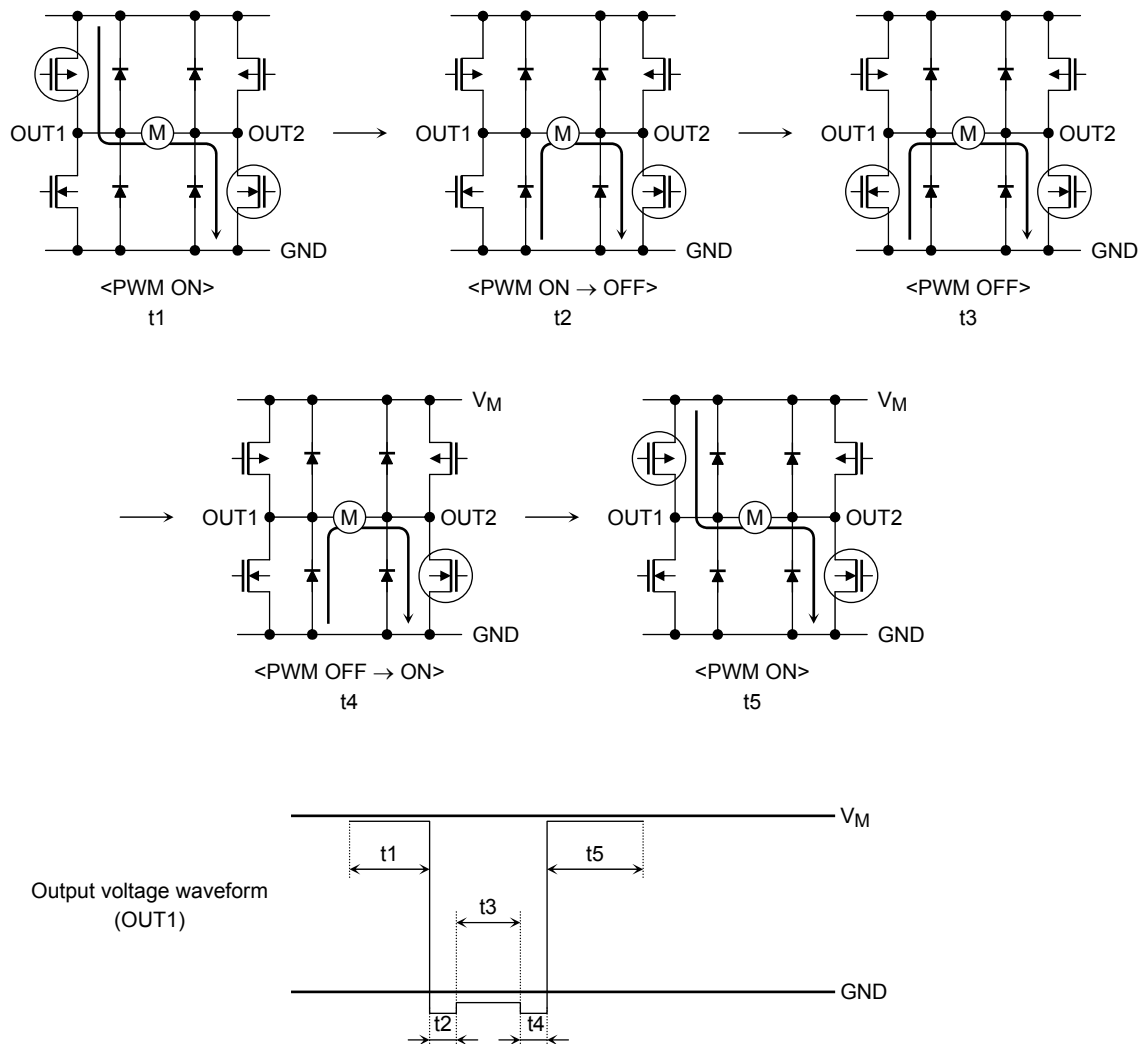
Operation of OSC oscillator: Charging and discharging external capacitor C_{OSC} cause OSC oscillation.
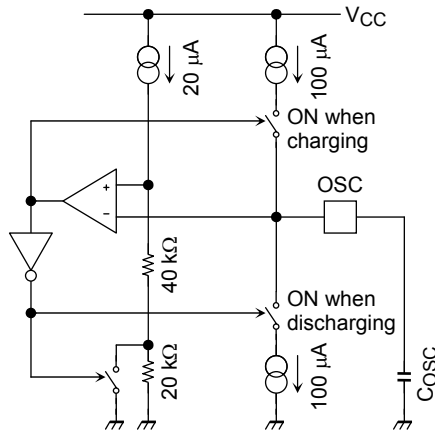
OSC block

V_{OSC} waveform

In the above circuit configuration, the voltage inclination, V_{OSC}, for charging (or discharging) external capacitor C_{OSC} is represented as follows:

$$V_{OSC} = \frac{1}{C_{OSC}} \int i\, dt$$

The following equations show relationships among t1 (time when V_{OSC} = 0.8 V), t2 (time when V_{OSC} = 1.2 V), and ΔV_{OSC} (variation in the V_{OSC} inclination):

$$\Delta V_{OSC} = I \times (t1 - t2)/C_{OSC}$$

$$\frac{1}{t1 - t2} = \frac{I}{\Delta V_{OSC} \cdot C_{OSC}}$$

The triangular oscillation frequency, f_{OSC}, represents a single period consisting of a pair of rising V_{OSC} inclination and falling inclination, so that the period is double the time between t1 and t2.

∴ Therefore, the relationship between C_{OSC} and f_{OSC} is shown by the following formula:

$$f_{OSC} = \frac{1}{2\,(t1 - t2)} = \frac{I}{2 \cdot \Delta V_{OSC} \cdot C_{OSC}}$$

With the above OSC block and V_{OSC} waveform, V_{OSC} = |1.2 V – 0.8 V| = 0.4 V, so that the value of f_{OSC} is determined from the following formula:

$$f_{OSC} = \frac{1}{2 \times 0.4/100\ \mu A \times C_{OSC}} = \frac{1}{6.957 \times 10^{3} \times C_{OSC}}$$

Example: The calculation shows f_{OSC} = 532 kHz when C_{OSC} = 270 pF and
f_{OSC} = 256 kHz when C_{OSC} = 560 pF.

In an actual application, however, the required capacitance may slightly differ from the theoretical value due to board pin capacitance and other factors. It is, therefore, recommended to determine the value of C_{OSC} experimentally.

- Constant-current bridge block (H-SW D, E): Description of PWM constant-current chopping

This product has a PWM control which applies chop-off-time-ratio-fixed method.
Chop off time internally counts driver CLK which is the external input. So, changing the chop off time is available by changing the driver CLK frequency or internal counts (3 or 5 counts).

Turning on the power (Chop on) causes current to flow into the load inductor. Once the voltage (VRF) generated with the external current detection resistor reaches the comparator reference voltage, Vlimit (current limit), the comparator starts operating (Chop off). After the output Hi-side transistor is turned off, counting for the chop-off time starts at the next rising edge of the internal clock, producing a chop-off time of clock cycles for five bits (reset at the rising edge for the 6th bit).
This chop-off time control creates a PWM signal to turn the output transistor on and off.
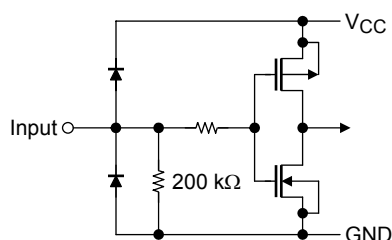
Conceptual diagram for constant PWM chopping operation (Example: Internal 5 counts.)
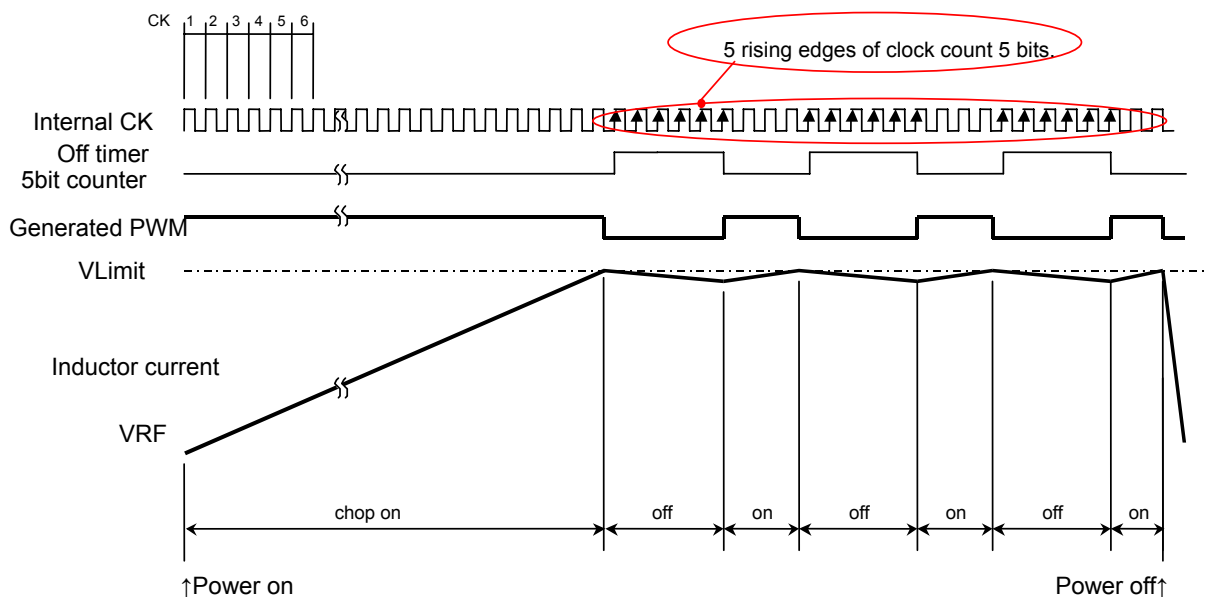
(The inductor current (IO peak) is limited by the value obtained from the expression IO = Vlimt/RNF.)
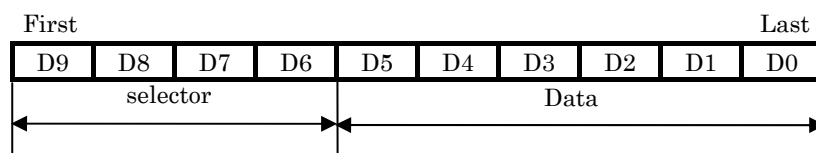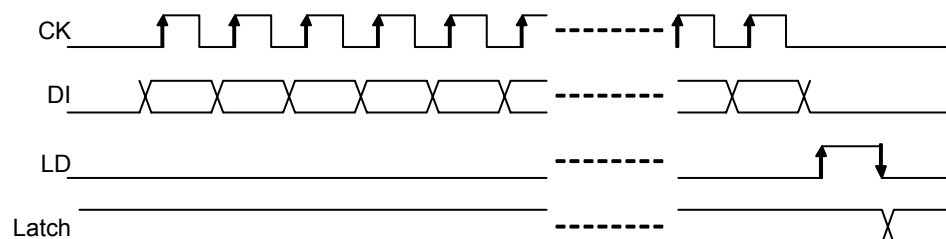
- Others

    Each input pin (CK, DATA, LD, PWMA to E, STBY) has a built-in pull-down resistor (approx. 200 kΩ)

Serial Data Specifications:

10 bit serial data (10 bit serial data format: MSB First)

First									Last
D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
selector				Data					

D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	Address
0	0	0	0	p2a	p2b	p1a	p1b	---	---	0
0	0	0	1	mod2	mod1	pm2	pm1	---	---	1
0	0	1	0	mod3	pm3	p3a	p3b	---	---	2
0	0	1	1	p5a	p5b	p4a	p4b	off5	off4	3
0	1	0	0	mod5	mod4	pm5	pm4	---	---	4
0	1	0	1	DA1(6bit) ch.D Current setting						5
0	1	1	0	DA2(6bit) ch.E Current setting						6

Chop off time setting (2 modes)

       off4   ch.D chop off count setting (0=5CLK / 1=3CLK)
       off5   ch.E chop off count setting (0=5CLK / 1=3CLK)

DA setting table: output of DA1, DA2 (6bit: 64step)

D5	D4	D3	D2	D1	D0	Value
0	0	0	0	0	0	0
0	0	0	0	0	1	1
0	0	0	0	1	0	2
0	0	0	0	1	1	3
0	0	0	1	0	0	4
1	1	1	1	0	1	61
1	1	1	1	1	0	62
1	1	1	1	1	1	63

Driver Function Table:

These are driver function tables for serial format pxa, pxb, modx, pmx.

modx=0 , pmx=0

pxa	pxb	IC terminal			mode
		PWMx	OutxA	OutxB	
0	0	X	Z	Z	Stop
0	1	L	L	L	Short brake
0	1	H	L	H	CCW
1	0	L	L	L	Short brake
1	0	H	H	L	CW
1	1	X	L	L	Short brake

modx=0 , pmx=1

pxa	pxb	IC terminal			mode
		PWMx	OutxA	OutxB	
0	0	X	Z	Z	Stop
0	1	L	L	H	CCW
0	1	H	L	L	Short brake
1	0	L	H	L	CW
1	0	H	L	L	Short brake
1	1	X	L	L	Short brake

modx=1 , pmx=X

pxa	pxb	IC terminal			mode
		PWMx	OutxA	OutxB	
0	X	X	Z	Z	Stop
1	0	L	H	L	CW
1	0	H	L	H	CCW
1	1	X	L	L	Short brake

X = don't care

Electrical Characteristics (V_{CC} = 3 V, V_M = 5 V, and Ta = 25°C unless otherwise specified)

Characteristics		Symbol	Test Condition	Min	Typ.	Max	Unit
Supply current		I_{CC}	All 5 channels in CW mode	—	1	2	mA
		$I_{CC\,(STB)}$	Standby mode (STBY=0V)	—	0.1	10	μA
		$I_{M\,(STB)}$		—	0	1	
Serial/standby /PWM input	Input voltage	V_{INH}		V_{CC} −0.8	—	V_{CC} + 0.2	V
		V_{INL}		−0.2	—	0.4	
	Input current	I_{INH}	V_{IH} = 3 V	5	15	25	μA
		I_{INL}	V_{IL} = 0 V	—	—	1	
Output saturation voltage (Ch. A to E)		$V_{sat\,(U+L)}$	I_O = 0.2 A	—	0.3	(0.4)	V
			I_O = 0.6 A	—	0.9	(1.2)	
Output leakage current (Ch. A to E)		$I_{L\,(U)}$	V_M = 6 V	—	—	1	μA
		$I_{L\,(L)}$		—	—	1	
Output diode forward voltage		$V_{F\,(U)}$	I_F = 0.6 A (Design value)	—	1	—	V
		$V_{F\,(L)}$		—	1	—	
Internal reference voltage		V_{ref}		(0.28)	0.305	(0.33)	V
6bit DAC	Nonlinearity error	LB	Ch. D,E	−3	—	3	LSB
	Differential linearity error	DLB		−2	—	2	
Oscillator	Oscillation frequency	f_{OSC}	C_{OSC}=270pF	(392)	560	(728)	kHz
Thermal shutdown circuit operating temperature		TSD	(Design value)	—	170	—	°C
Hysteresis temperature width for recovery from thermal shutdown		ΔTSD		—	20	—	

Example Application Circuit

Connect the noise absorption condensers C1,C2,C3,C4,C5,C6,C7,C8 to IC pins as near as possible.

 * Notes: Take enough care in designing output line, power line(Vcc, VM), and GND line to avoid short-circuit between outputs, VDD fault or GND fault which may cause the IC to break down.

Requests Concerning Use of QON

Outline Drawing of Package

(Upper surface)   (Lower surface)
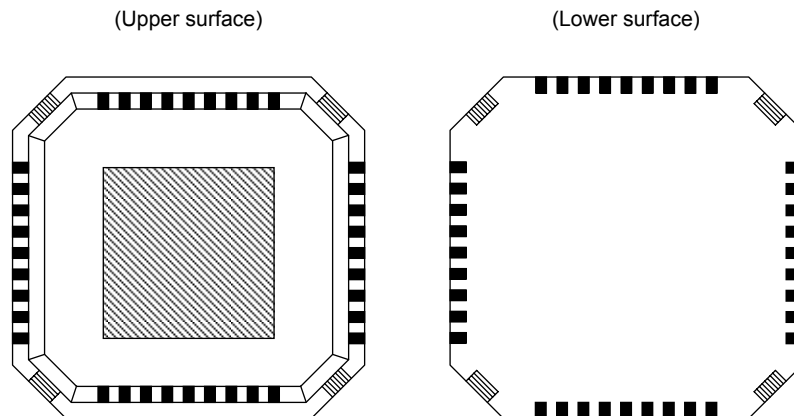
When using QON, please take into account the following items.

Caution

(1) Do not carry out soldering on the island section in the four corners of the package (the section shown on the lower surface drawing with diagonal lines) with the aim of increasing mechanical strength.

(2) The island section exposed on the package surface (the section shown on the upper surface drawing with diagonal lines) must be used as (Note) below while electrically insulated from outside.

Note: Ensure that the island section (the section shown on the lower surface drawing with diagonal lines) does not come into contact with solder from through-holes on the board layout.

- When mounting or soldering, take care to ensure that neither static electricity nor electrical overstress is applied to the IC (measures to prevent anti-static, leaks, etc.).
- When incorporating into a set, adopt a set design that does not apply voltage directly to the island section.

Top View Image
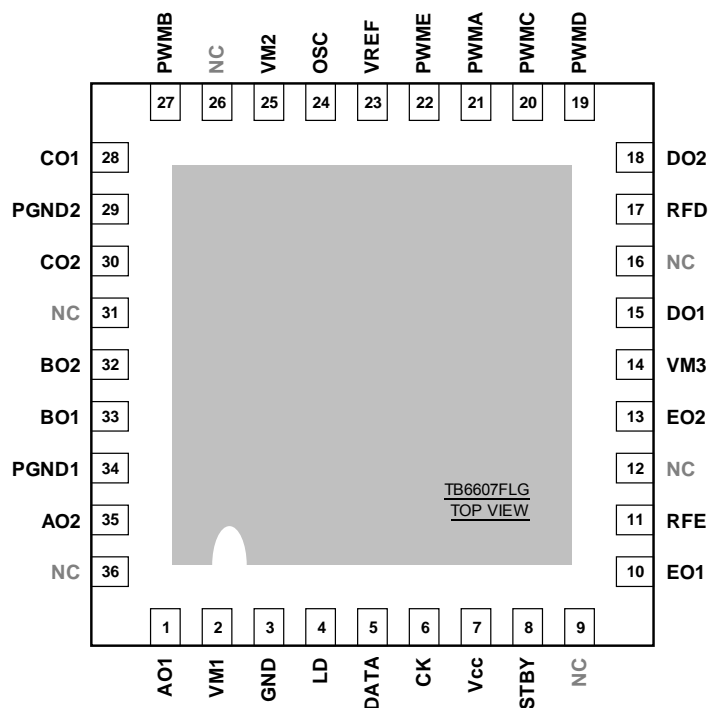
Package Dimensions

QON36-P-0606-0.50   Unit: mm

6.21±0.04

6.0±0.1

27   19

28   18

36   10

1   9

6.0±0.1

6.21±0.04

4-C0.61

1.0 TYP.

0.5

0.2 +0.05 −0.04 ⊕ 0.05 M

0.145 +0.055 −0.045

◿ 0.05

PartA

0.3±0.1

0.9MAX

0.8±0.05

0.3±0.1

Details of partA

(0.25)

(0.75)
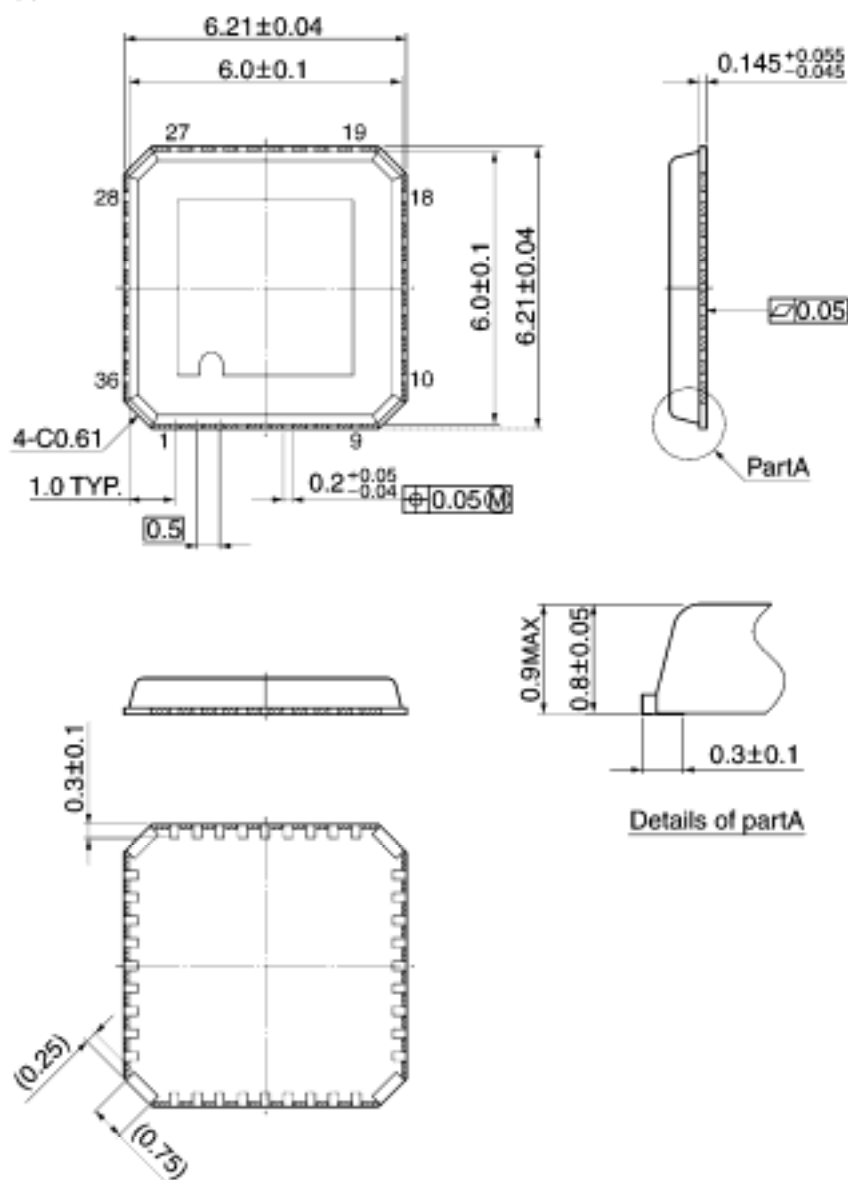
Note 1) The solder plating portion in four corners of tne package shall not be treated as an external terminal.

Note 2) Don`t carry out soldering to four corners of the package.

Note 3) ▨ area : Resin surface

Weight: 0.08 g (typ.)

Notes on Contents

1. Block Diagrams
Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purposes.

2. Equivalent Circuits
The equivalent circuit diagrams may be simplified or some parts of them may be omitted for explanatory purposes.

3. Timing Charts
Timing charts may be simplified for explanatory purposes.

4. Application Circuits
The application circuits shown in this document are provided for reference purposes only. Thorough evaluation is required, especially at the mass production design stage.
Toshiba does not grant any license to any industrial property rights by providing these examples of application circuits.

5. Test Circuits
Components in the test circuits are used only to obtain and confirm the device characteristics. These components and circuits are not guaranteed to prevent malfunction or failure from occurring in the application equipment.

IC Usage Considerations
Notes on handling of ICs

[1] The absolute maximum ratings of a semiconductor device are a set of ratings that must not be exceeded, even for a moment. Do not exceed any of these ratings.
Exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.

[2] Use an appropriate power supply fuse to ensure that a large current does not continuously flow in case of over current and/or IC failure. The IC will fully break down when used under conditions that exceed its absolute maximum ratings, when the wiring is routed improperly or when an abnormal pulse noise occurs from the wiring or load, causing a large current to continuously flow and the breakdown can lead smoke or ignition. To minimize the effects of the flow of a large current in case of breakdown, appropriate settings, such as fuse capacity, fusing time and insertion circuit location, are required.

[3] If your design includes an inductive load such as a motor coil, incorporate a protection circuit into the design to prevent device malfunction or breakdown caused by the current resulting from the inrush current at power ON or the negative current resulting from the back electromotive force at power OFF. IC breakdown may cause injury, smoke or ignition.
Use a stable power supply with ICs with built-in protection functions. If the power supply is unstable, the protection function may not operate, causing IC breakdown. IC breakdown may cause injury, smoke or ignition.

[4] Do not insert devices in the wrong orientation or incorrectly.
Make sure that the positive and negative terminals of power supplies are connected properly.
Otherwise, the current or power consumption may exceed the absolute maximum rating, and exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.
In addition, do not use any device that is applied the current with inserting in the wrong orientation or incorrectly even just one time.

Points to remember on handling of ICs

(1) Over current Protection Circuit

Over current protection circuits (referred to as current limiter circuits) do not necessarily protect ICs under all circumstances. If the Over current protection circuits operate against the over current, clear the over current status immediately.

Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the over current protection circuit to not operate properly or IC breakdown before operation. In addition, depending on the method of use and usage conditions, if over current continues to flow for a long time after operation, the IC may generate heat resulting in breakdown.

(2) Heat Radiation Design

In using an IC with large current flow such as power amp, regulator or driver, please design the device so that heat is appropriately radiated, not to exceed the specified junction temperature (T_J) at any time and condition. These ICs generate heat even during normal use. An inadequate IC heat radiation design can lead to decrease in IC life, deterioration of IC characteristics or IC breakdown. In addition, please design the device taking into considerate the effect of IC heat radiation with peripheral components.

(3) Back-EMF

When a motor rotates in the reverse direction, stops or slows down abruptly, a current flow back to the motor's power supply due to the effect of back-EMF. If the current sink capability of the power supply is small, the device's motor power supply and output pins might be exposed to conditions beyond maximum ratings. To avoid this problem, take the effect of back-EMF into consideration in system design.

RESTRICTIONS ON PRODUCT USE

2007/6/6