TOSHIBA BiCD Integrated Circuit Silicon Monolithic

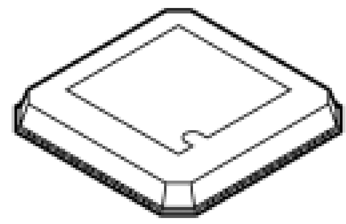
TB6596FLG

DC Motor Driver, Stepping Motor Driver

The TB6596FLG is a driver IC for driving DC motors. Its employs LDMOS devices with low ON resistance for output drive transistors.

The TB6596FLG incorporates one constant current-controlled H-bridge driver, four direct PWM operating H-bridge drivers, and one liner constant current-controlled H-bridge driver, making it ideal for controlling actuators of lenses in digital still cameras.

It supports three-wire serial data to control motors, thus reducing the number of lines for interfacing the control IC.



Weight: 0.08 g (typ.)

Features

- Motor power supply voltage: $V_M \leq 6$ V (max)
- Control power supply voltage: V_{CC} = 3 to 6 V
- Output current: $I_{out} \leq 0.8$ A (max.)
- Pch/Nch LDMOS P-/N-ch LDMOS complementary output transistors
- Output ON resistance: Ron (upper + lower) = 1.5Ω (typ.)

【DC Motor】ch.E

・High-speed PWM control at 100 kHz.

・ Serial setting can select two controls written below.

1. Speed is controlled by FLL speed discriminator, which compares FG signal and CLK, and the integrator. （Typical speed = 250 to 1750Hz, capable of setting them in 16 steps.）
2. H-bridge is controlled by normal direct PWM.

・Two Sw Tr. for power light encode diode.

【Stepping motor】ch.A/B or ch.C/D

・Four H-bridge drivers (ch.A/B,ch.C/D) which can control direct PWM.
（Capable of controlling two 2-phase-bipolar-stepping motors or four DC motors (max.).）

【Shutter driver】ch.F

・Constant current drivers which is a constant current liner control type.

・Controlling the step-up- rising current. It improves power dependence and reproduction of rising constant current.
（Controlling the internal CLK which is divided into 1 to 16. Step-up control with 32 steps in max..

【Others】

・ 6bit DAC 2ch（ch.E,F）for setting typical value of each constant current limiter.

・ Independent standby (Power save) feature.

・ Thermal shutdown (TSD: Shut down the output bias by detecting the internal junction at 170 degrees celsius.) protective circuit.

・ Circuit for preventing malfunction at low voltage (shut down internal circuit. （UVLO: Vcc = 2.2 V(typ.))

- Small QON-36 package (0.5-mm lead pitch)
- Supports Pb-free reflow mounting

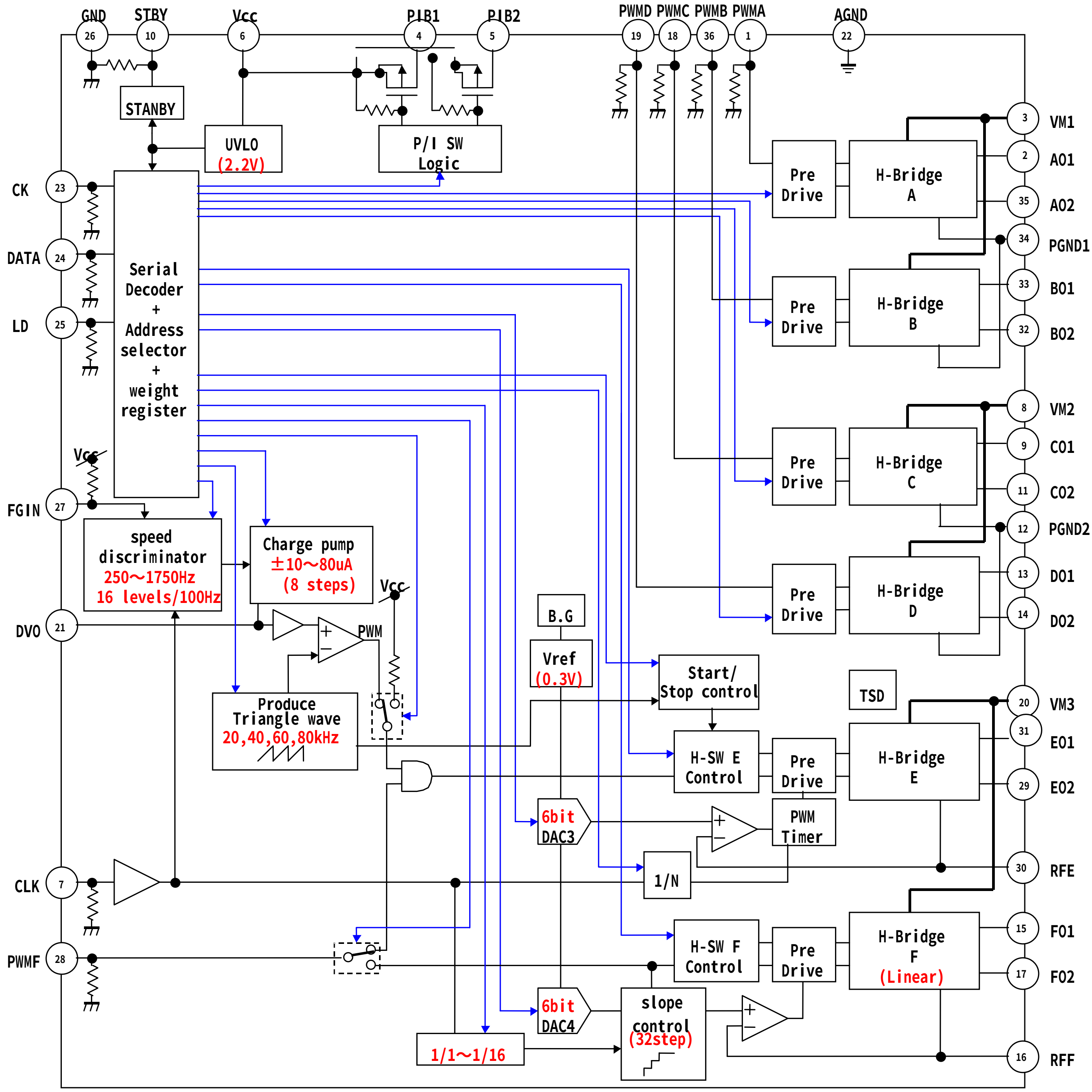
Note: This product has a MOS structure and is sensitive to electrostatic discharge. When handling this product, ensure that the environment is protected against electrostatic discharge by using an earth strap, a conductive mat and an ionizer. Ensure also that the ambient temperature and relative humidity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

About solderability, following conditions were confirmed.

(1) Use of Sn-37Pb solder bath
- Solder bath temperature = 230°C
- Dipping time = 5 seconds
- The 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
- The number of time = once
- Use of R-type flux

Block Diagram



Absolute Maximum Ratings (Ta = 25 ℃)

Characteristics		Symbol	Rating	Unit	Remarks
Supply voltage		V_{CC}	6	V	V_{CC}
Motror supply voltage		V_M	6	V	V_M
Output pin voltage		V_{OUT}	6	V	
Output current	H-SW	I_{OUT}	0.8	A	
	PI SW Tr.	ID	0.1	**A**	PIB1,PIB2
Input voltage		V_{IN}	−0.2~6	V	Each control input pin
Power dissipation		P_D	0.6	W	IC only
			1.04	W	Note.
Operating temperature		T_{opr}	−20~85	°C	
Strage temperature		T_{stg}	−55~150	°C	

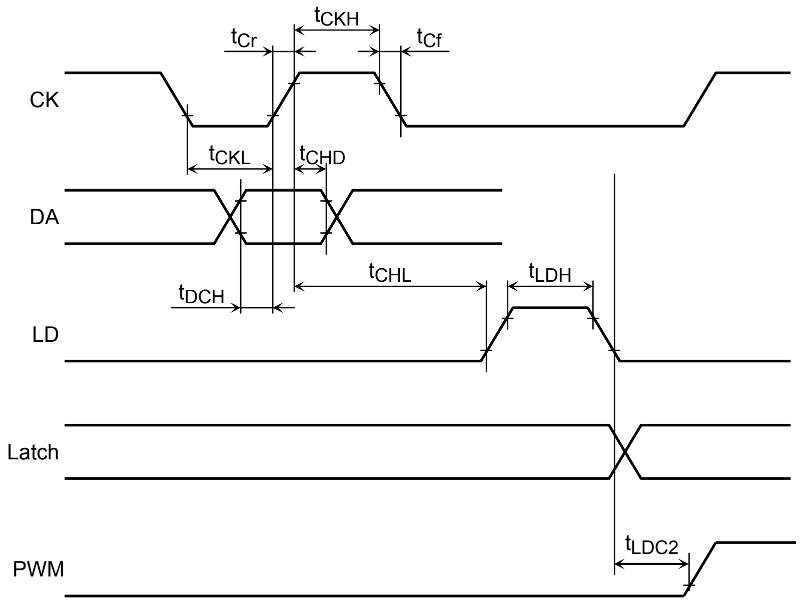
Note： 50mm×50mm×1.6mm, when one side is packaged by Glass epoxy including 40% Cu.

Operating Conditions (Ta = -20 ～ 85 ℃)

Characteristics		Symbol	Rating			Unit	Remarks
			Min.	Typ.	Max.		
Small signal supply voltage		V_{CC}	3	3.3	5.5	V	
Motor supply voltage		V_M	2.2	3.3	5.5	V	
Output current	H-SW	I_{OUT}	—	—	600	mA	VM=3～5.5V
			—	—	350		2.2V≦VM＜3V
	PI SW Tr.	ID	—	—	30		
PWM frequency (CH.A~E)		f_{PWM}	—	—	100	kHz	
CLK driver frequency		f_{CLK}	—	1	5	MHz	

Operating Conditions 2: Serial Data Contorller (Ta = –20~85°C)

Characteristics	Symbol	Rating Min.	Rating Max.	Unit
Low-level clock pulse width	t_{CKL}	200	—	ns
High-level clock pulse width	t_{CKH}	200	—	
Clock rise time	t_{Cr}	—	50	
Clock fall time	t_{Cf}	—	50	
Data setup time	t_{DCH}	30	—	
Data hold time	t_{CHD}	60	—	
Load setup time	t_{CHL}	200	—	
Load hold time	t_{LDC}	200	—	
PWM equivalent time	tLDC2	100	—	
High-level load pulse width	t_{LDH}	2	—	μs
CK (clock pulse) frequency	f_{CLK}	—	2.5	MHz



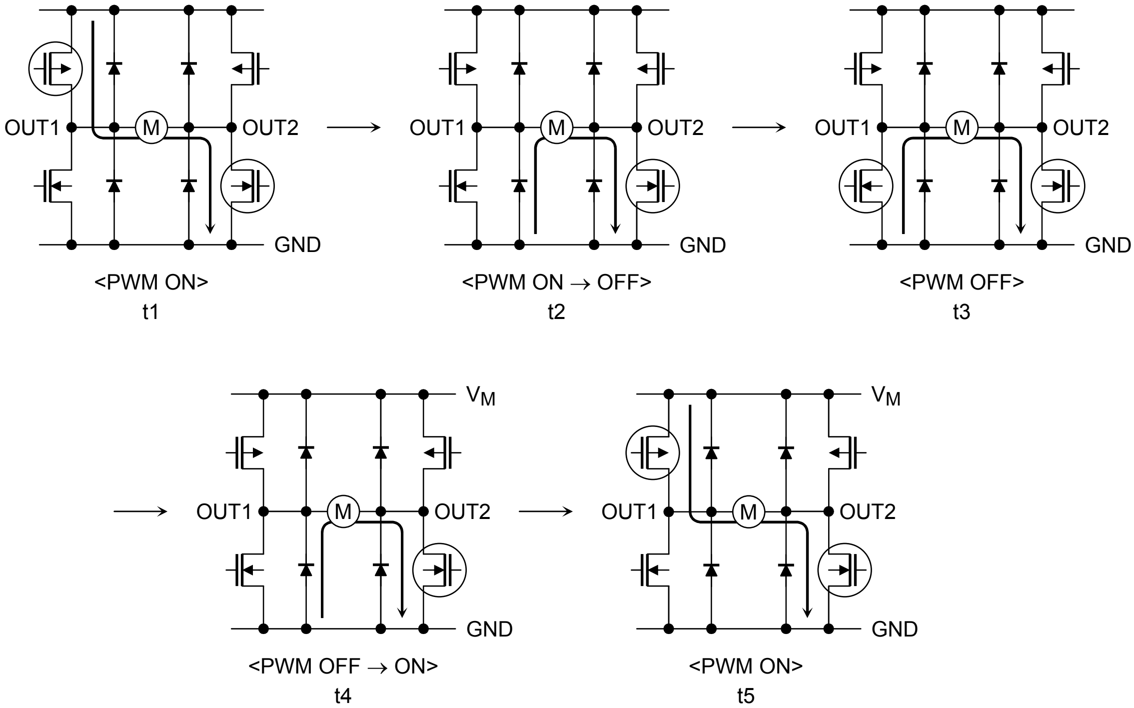
Specifications and Operation of Each Circuit Block:

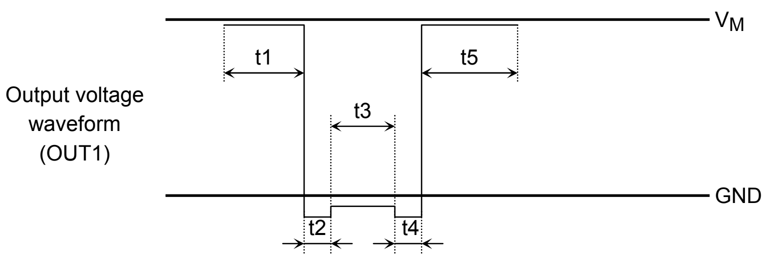
Bridge output block: ch.A～E basic operation

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.)





Constant-current Bridge Block (ch.E): Description of PWM Constant-current Chopping

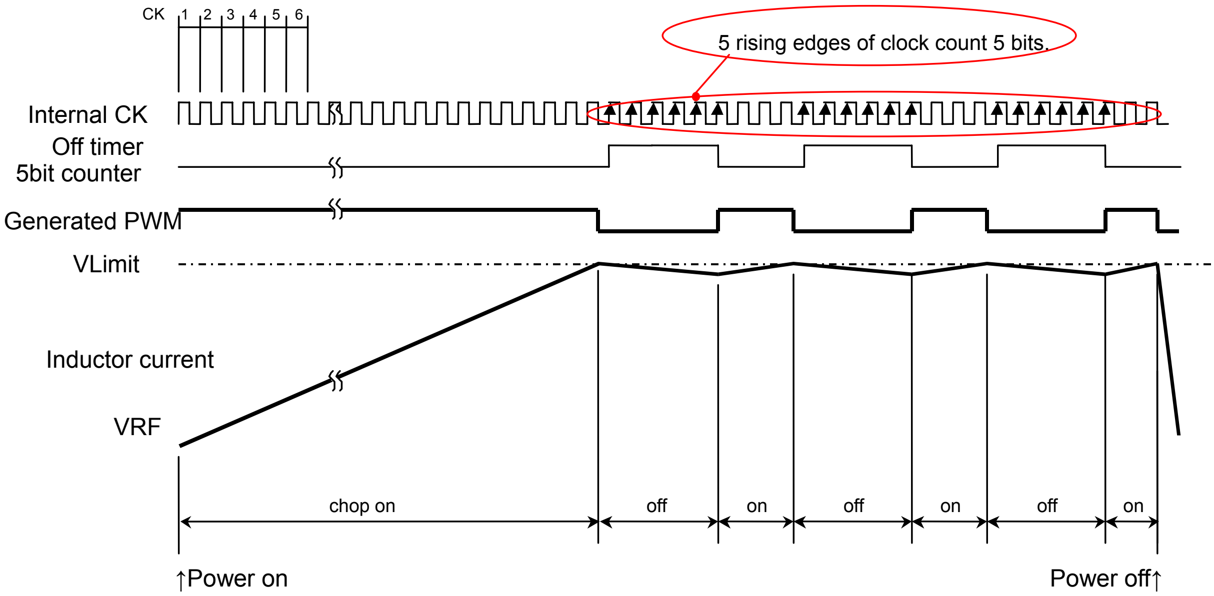
This product has a PWM control which applies chop-off-time-ratio-fixed method.

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.

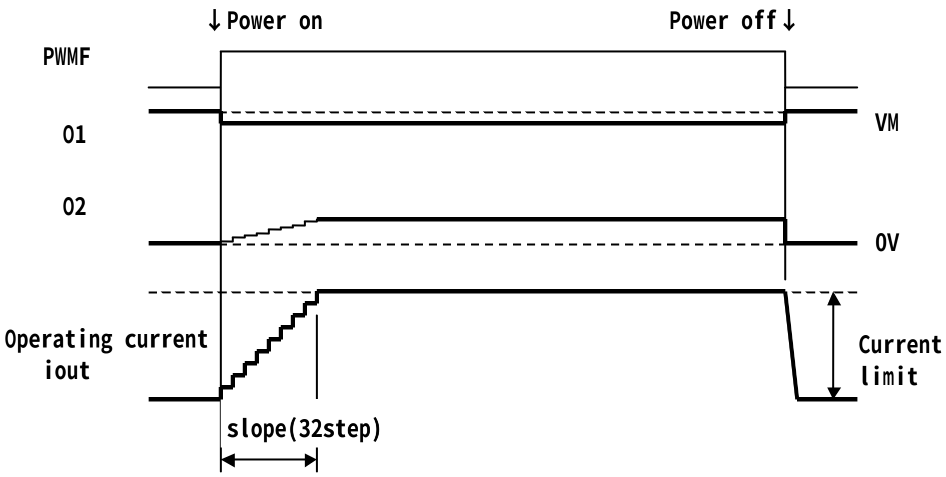
Conceptual diagram for constant PWM chopping operation (Example: Internal 5 counts.)

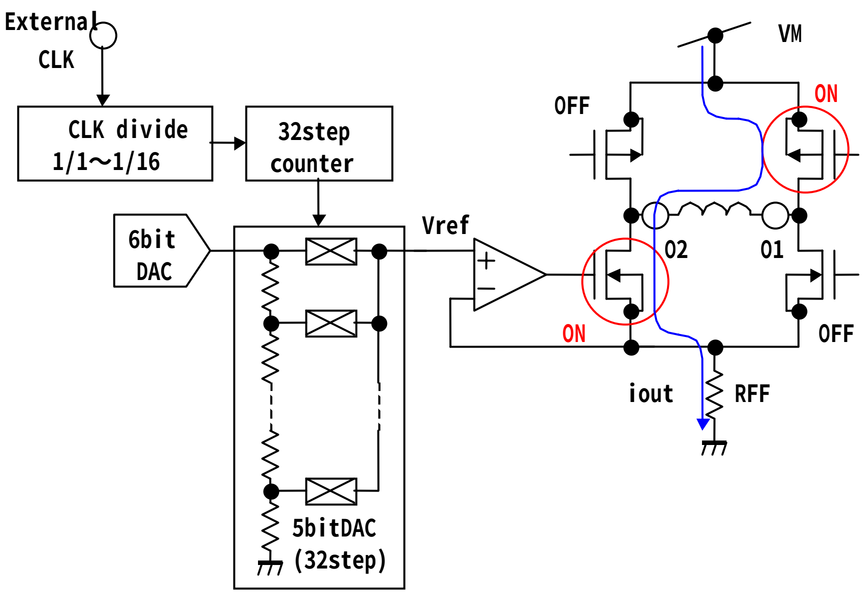


(The inductor current (IO peak) is limited by the value obtained from the expression IO = Vlimt/RNF.)

Liner Constant Current Bridge： ch.F

PWM pin is conductive at H level input and nonconductive at L level input. Constant current is controlled by changing the current into voltage by the external detection resistance REF, feed backing to sense Amp, forming negative feedback loop, and operating low side driver. Controlled current is set by Vref to sense Amp which is changeable by internal 6bit DAC: Max.=0.3V) .



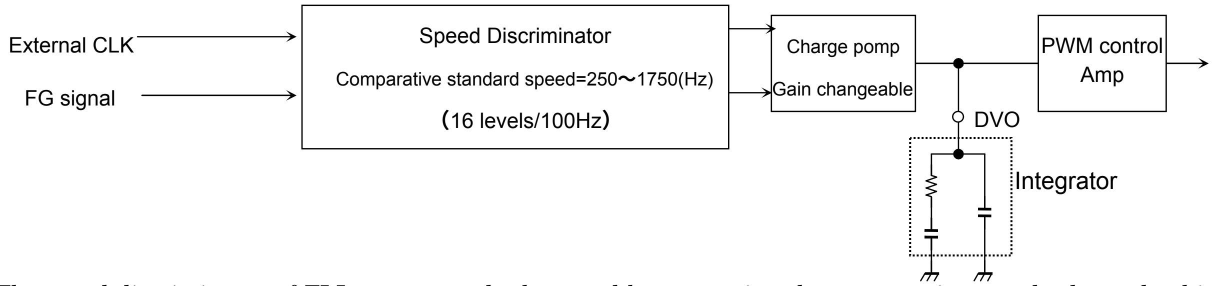


※Current rising slope control circuit：

Standard voltage of the comparator steps up to the current limit by 5 bit DAC (32 steps) to stabilize the reproduction of current rising. And it improves the dependence and reproduction of the power voltage when the coil time constant increases the current at power on.

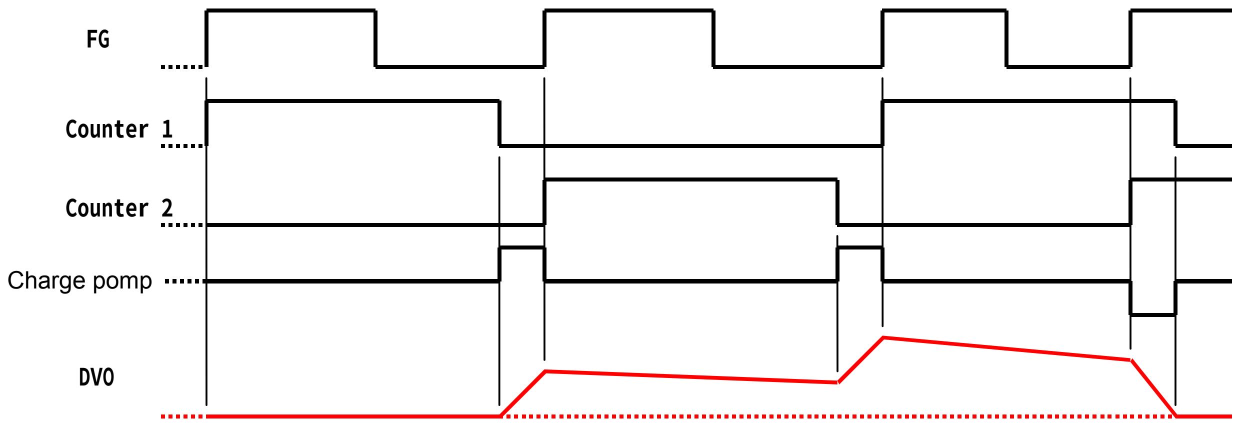
Stepping up speed is set by dividing the external CLK. It can select the 16 divided ratio (4 bit = 16 levels X 1/1 to 1/16) by serial data.

Speed Control：

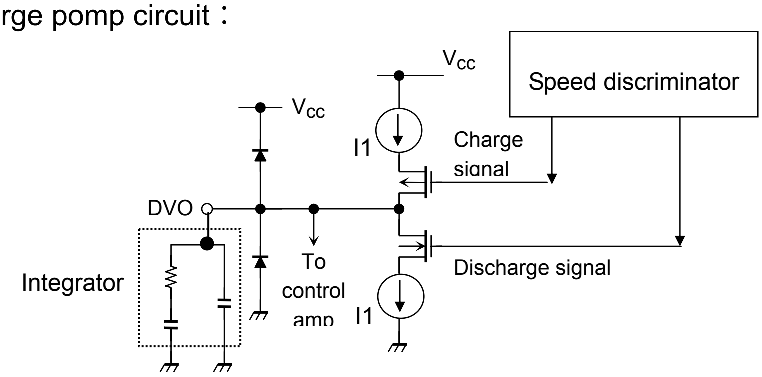


・The speed discriminator of FLL type controls the speed by comparing the comparative standard speed, which is produced from external CLK, and FG signal. And the motor speed becomes same to the standard speed.
・Speed discriminator has two counters and counts one cycle of FG signal by turns. And it outputs the gap with two signals (charge pulse / discharge pulse). After that, the integrator (set by external CR) and latter PWM control amp output signals.
・The comparative standard speed of speed discriminator is selectable in 16 levels from 250 to 1750 Hz per 100Hz. (It is selected by serial method.)
・The motor speed (N) is calculated in the equation written below.

N (rpm) ＝ fCLK(Hz)／CT × 60／Z
Z： FG pulse / round
CT： Speed discriminator count



Charge pomp circuit：



・High speed resolution is available because this circuit is constructed by CMOS transistors.
・The gain of speed discriminator makes possible the internal charge-discharge current to have 8 combinations.(± 10 to 80 uA) And the control gain controls it by charge pomp current and the external integrator.
・When the motor stops, this circuit is discharge mode(-50uA) and the charge of the external integrator becomes zero to reset the value of analog control.
・Just after the operating signal (PWME) input, the speed control loop dose not work because the motor stops and FG signal is not existence. And so, forced operation (100% Duty) is controlled in short time from the rising edge of PWME signal.

※Operating time is set at zero to 63 levels by serial command. (Unit: 6bit:2.048ms)

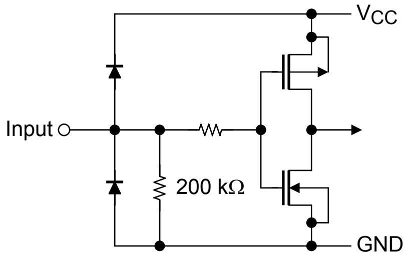
・Power off is controlled by the brake or the reverse and brake during the setting time from the falling edge of PWME signal.

※Reversing time is set at zero to 63 levels by serial command. (Unit:6bit:2.048ms)

Deal with Input Pin：

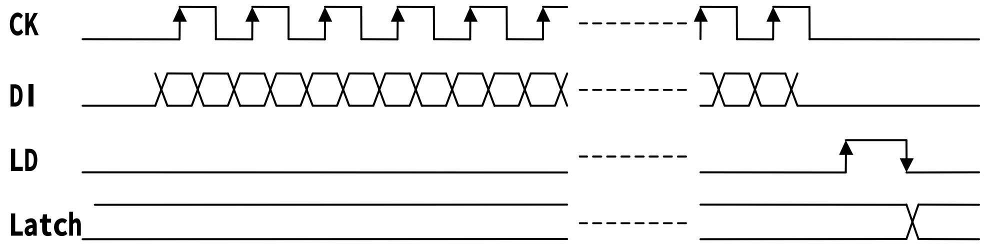
Each input pin (CK, DA, LD, PWME, PWMF, STBY,CLK) has pull-down resistance (approx. 200 kΩ), and FGIN pin has pull- up resistance (approx. 200kΩ) to Vcc.

CK,DI,LD,PWMA,B,C,D,PWMF,STBY,CLK



Serial Data Specifications

10bit serial data (10bit serial data format)



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

Each resister mode

D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	ｱﾄﾞﾚｽ
0	0	0	0	p2a	p2b	p1a	p1b	-	-	0
0	0	0	1	mod2	mod1	pm2	pm1	-	-	1
0	0	1	0	p4a	p4b	p3a	p3b	-	-	2
0	0	1	1	mod4	mod3	pm4	pm3	-	-	3
0	1	0	0	Reverse brake time set(0～127ms)						4
0	1	0	1	p5a	p5b	vc	pms	sw2	sw1	5
0	1	1	0	mod5	pm5	If5	Charge pomp set(3bit)			6
0	1	1	1	Aiming speed(4bit)				Career frequency		7
1	0	0	0	Forced starting time set(0～127ms)						8
1	0	0	1	DA5(6bit) ch.E current set						9
1	0	1	0	p6a	p6b	Rising constant current (4bit)				10
1	0	1	1	mod6	pm6	If6	-	-	-	11
1	1	0	0	DA6(6bit) ch.F current set						12
1	1	0	1	-	-	-	-	-	-	13
1	1	1	0	-	-	-	-	-	-	14
1	1	1	1	-	-	-	off	-	-	15

Ifx :Ch.E,F Current control with/without set (0=Without, 1=With)
Pms :Ch change of PMW input pin (0=ch.E, 1=ch.F)
Off :Chop off count set (0=5clk, 1=3clk)
Swx :Sw1,2 change (0=off, 1=on)
Vc :Ch.E control mode (0=Ext. PWM ctrl., 1=Internal FLL speed ctrl.)
Reverse brake :2.048ms×set time, brake reverse
Forced starting time:2.048ms×set time, Full conduction from power on
Charge pomp :Charge pomp(gain) set (8steps(10uA step) on ±10uA to 80uA: 3bit)
Career frequency :Triangle wave frequency set (2bit, 4steps=20k,40k,60k,80kHz)
Aiming speed :Aiming speed set (16steps(100Hz step) on 250Hz to 1750Hz: 4bit)
Rising constant current: Slope of rising ch.F constant current is controlled by changing the number of CLK. (0～15 CLK set : Stepping up DAC output per count.)

Driver Function Table

modx=0 pmx=0

pxa	pxb	PMx	OUTxA	OUTxB	Driving mode
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	PMx	OUTxA	OUTxB	Driving mode
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	PMx	OUTxA	OUTxB	Driving mode
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

※ Only Ch.E is available to set.（Reverse brake function）

・When short brake is selected, it is controlled in the following steps.

Reverse brake → Short brake

・The reverse brake time is set by the serial data.(Reverse brake time = 0 →Reverse brake dose not drive.)

・While the reverse brake is operating, operating mode cannot be change

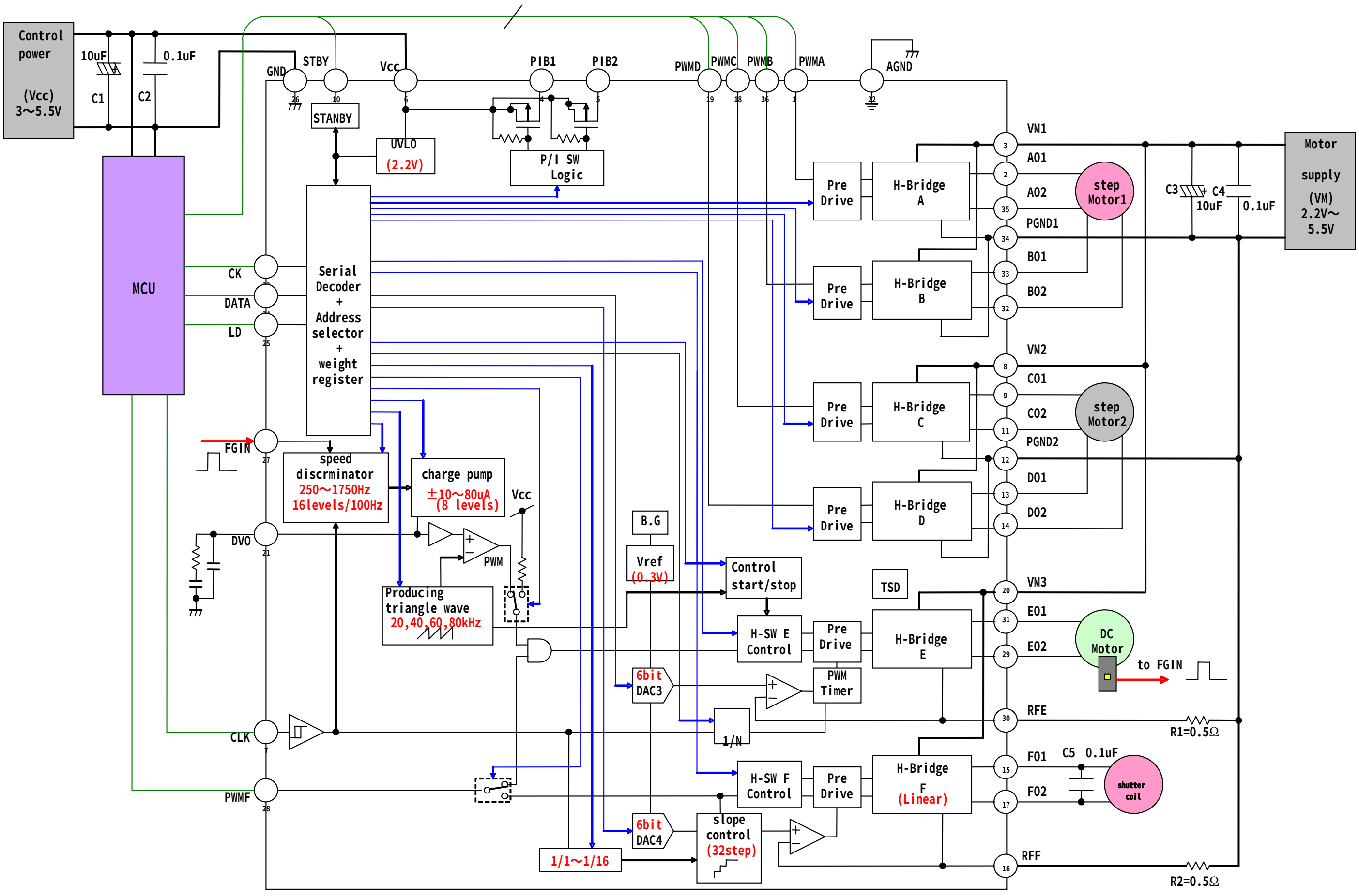
・When PMx changes during short brake operation at modx=0, it becomes conductive mode according to the pxa,pxb. input table.（Direct PWM control）

Electrical Characteristics (V_{CC} = 3.3 V, V_M = 5 V, Ta = 25°C) unless otherwise specified.)

Characteristics			Symbol	Test conditions	Min.	Typ.	Max.	Unit
Supply current			I_{CC}	All 6 channels in CW mode.	—	1	2.5	mA
			$I_{CC\,(STB)}$	Standby mode (STBY=0V)	—	0.1	10	μA
			$I_{M\,(STB)}$		—	0	1	
Serial /standby/ PWM,CLK 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	10	15	20	μA
			I_{INL}	V_{IL} = 0 V	—	—	1	
FG input	Input voltage		V_{INHFG}		Vcc -0.8	—	V_{CC} + 0.2	V
			V_{INLFG}		–0.2	—	0.4	
	Input current		I_{INSH}	V_{IH} = 3 V	—	—	1	μA
			I_{INSL}	V_{IL} = 0 V	-20	-15	-10	
Output saturation voltage（Ch.A～F）			$V_{sat\,(U+L)}$	I_O = 0.2 A	—	0.3	0.4	V
				I_O = 0.6 A	—	0.9	1.2	
Output leakege current（Ch.A～F）			$I_{L\,(U)}$	V_M = 6V	—	—	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	—	
Offset voltage for constant-current detection comparator			Comp ofs	RRF = 1 Ω, V_{ref} = 21Hex(約 103mV)	–15	—	15	mV
harge pomp	Charge current	Min.	ICHG Min	VDO=1V(Design value)	—	10	—	μA
		Max.	ICHG Max		—	80	—	
		Step	ICHG step		—	10	—	
	Discharge current	Min.	IDIS Min	VDO=2V(Design value)	—	-10	—	
		Max.	IDIS Max		—	-80	—	
		Step	IDIS step		—	-10	—	
6bit DAC	Nonlinearity error		LB	Ch.E,F	–3	—	3	LSB
	Differential linearity error		DLB		–2	—	2	
P/I SW Tr.	Output saturation voltage		Vsat	ID=20mA	—	—	0.1	V
	Outputleakage current		IDSS	VDS=6V	—	—	1	μA
Speed control	Minimum speed		FLL Min	(Design value)	—	250	—	Hz
	Maximum speed		FLL Max		—	1750	—	
	Speed step		FLL step		—	100	—	
Triangle wave career	Minimum speed		Ftig Min	(Design value)	—	17	—	kHz
	Maximum speed		Ftrig Max		—	68	—	
	Speed step		Ftrig step		—	17	—	
Start/Reverse	Minimum control time		Tmin	(Design value)	—	0	—	ms
	Maximum control time		Tmax		—	129	—	
	Control time step		T step		—	2.048	—	
Thermal shutdown circuit operating temperature			TSD	(Design value)	—	170	—	°C

Hysteresis temperature width for recovery from thermal shutdown	ΔTSD		—	20	—	

Application circuit

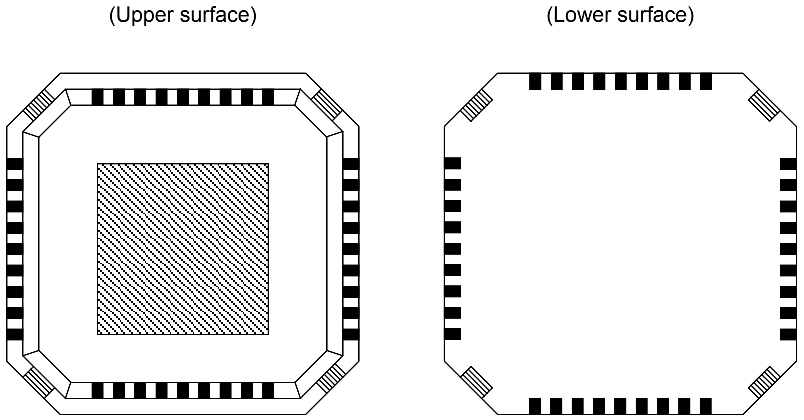


・Connect the noise absorption condensers（C1,C2,C3,C4）to IC pins as near as possible.
・Decide the constant C5 for avoiding oscillating Ch.F output by doing load experiment.

※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



When using QON, please take into account the following items.

Caution

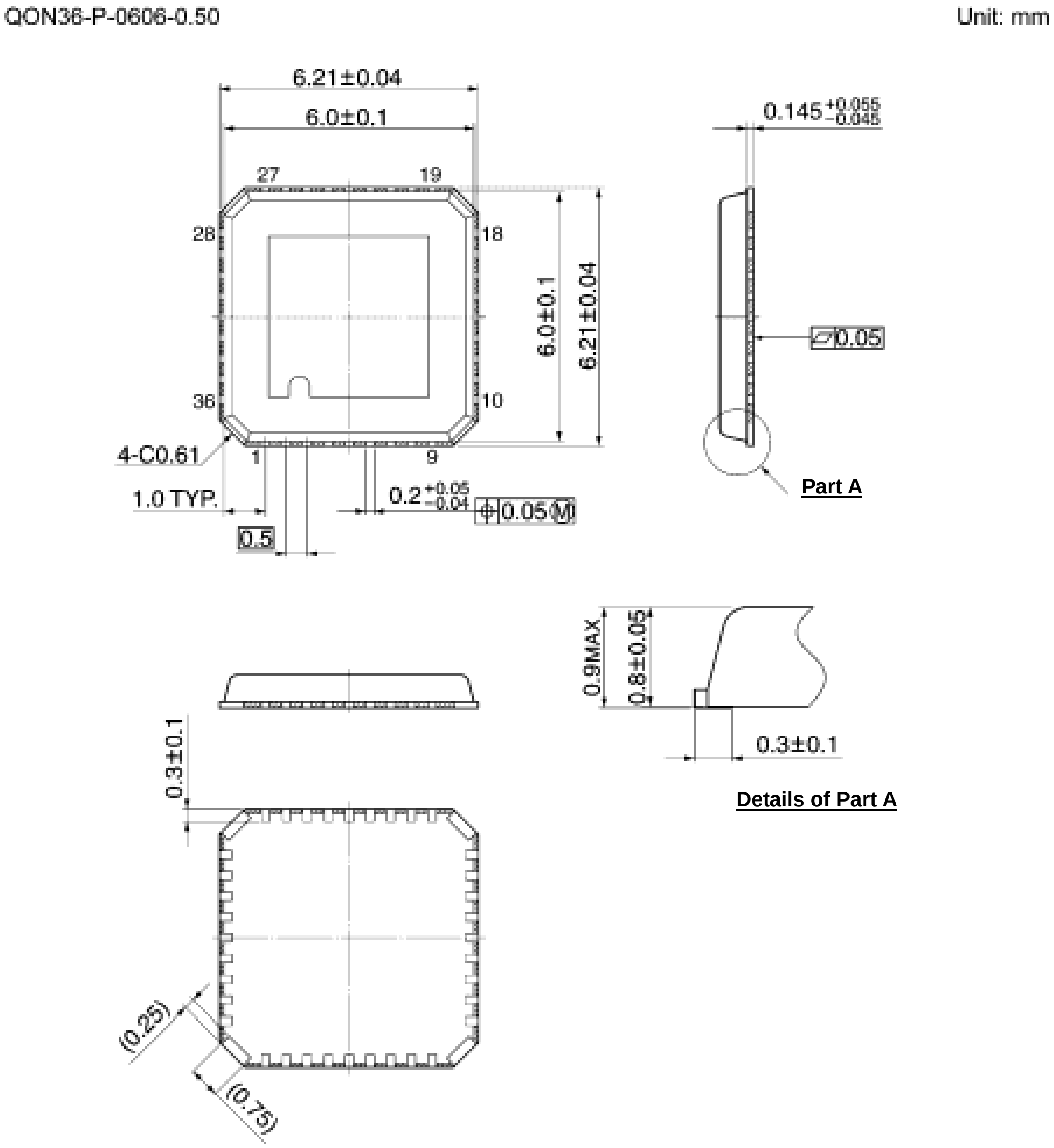
(1)Do not carry out soldering on the island section in the four corners of the package (the section shown on the lower surface drawing with diagonal lines) with the aim of increasing mechanical strength.

(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.

Package Dimensions



Note 1) The solder plating portion in four corners of the 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) Thermal Shutdown Circuit

Thermal shutdown circuits do not necessarily protect ICs under all circumstances. If the thermal shutdown circuits operate against the over temperature, clear the heat generation status immediately.

Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the thermal shutdown circuit to not operate properly or IC breakdown before operation.

(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

20070701-EN

- The information contained herein is subject to change without notice.
- TOSHIBA is continually working to improve the quality and reliability of its products. Nevertheless, semiconductor devices in general can malfunction or fail due to their inherent electrical sensitivity and vulnerability to physical stress. It is the responsibility of the buyer, when utilizing TOSHIBA products, to comply with the standards of safety in making a safe design for the entire system, and to avoid situations in which a malfunction or failure of such TOSHIBA products could cause loss of human life, bodily injury or damage to property.
  In developing your designs, please ensure that TOSHIBA products are used within specified operating ranges as set forth in the most recent TOSHIBA products specifications. Also, please keep in mind the precautions and conditions set forth in the "Handling Guide for Semiconductor Devices," or "TOSHIBA Semiconductor Reliability Handbook" etc.
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