Ordering number : ENN7982

SANYO Semiconductors
DATA SHEET

LB8653T LB8653FN

Monolithic Digital IC
DSC Motor Driver

Features

- An actuator driver for single focus digital camera is implemented on a single chip.
  - (1) Supports a constant voltage for the AF H-bridge×2 : a stepping motor (STM) ×1.
    - Constant voltage drive.
    - Enables 1-phase, 1-2 phase and 2-phase excitation.
    - VC1 and VC2 allow the constant voltage for each channel to be set independently.
  - (2) Supports a constant current for the shutter H-bridge×1 : a voice coil motor (VCM) ×1.
    - Constant current drive.
    - A fast charge/discharge circuit allows for stabilization of response speed for the continuous drive mode.
    - Allows offsetting of the constant current rising waveform with an external CR.
      (The external CR is not required when an offset is not performed.)
      → Prevent current rising variation of coil caused by supply voltage fluctuation.
    - Implements regenerative brake logic.
  - (3) Supports a constant voltage for the iris H-bridge×1 : a voice coil motor (VCM) ×1.
    - Constant voltage drive.
    - VC4 allows the independent constant voltage to be set.

[Actuator applications]

	Focus	Shutter	Iris
Applications	STM	VCM	VCM

SANYO Semiconductor Co., Ltd.
TOKYO OFFICE Tokyo Bldg., 1-10, 1 Chome, Ueno, Taito-ku, TOKYO, 110-8534 JAPAN

- Enables simultaneous operation of both focus and iris.

	Focus	Shutter	Iris
When "MD1" is not used. (Requires 4 input ports.)	Not enable the simultaneous operation.		
When "MD1" is used. (Requires 5 input ports.)	○		○

- Parallel control with 4 or 5 input ports.
- Two power supply systems.
- Supports low voltage drive (2.2Vmin).
- Low saturation output (Vsat = 0.3Vtyp at I_O = 300mA).
- Current dissipation in stand-by state is 0 (zero).
- Built-in overheat protection circuit.
- Small and thin package. TSSOP24 (225mil) for LB8653T and VQFN44 (6.0×6.0) for LB8653FN.

Specifications

Absolute Maximum Ratings at Ta = 25°C [LB8653FN : Preliminary]

Parameter	Symbol	Conditions	Ratings	Unit
Maximum power supply voltage	VB max		-0.3 to 10.5	V
	V_{CC} max		-0.3 to 10.5	
Maximum applied output voltage	V_{OUT} max	OUT1, 2, 3, 4, 5, 6	-0.3 to VB+VF	V
		OUT7, 8	-0.3 to V_{CC}+VF	
Maximum output current	I_{OUT} max	OUT1, 2, 3, 4, 5, 6	600	mA
		OUT7, 8	800	
Maximum applied input voltage	V_{IN} max	MD1, MD2, MD3, IN1, IN2	-0.3 to 10.5	V
Allowable power dissipation	Pd max	Standard PWB mounting (*1) [LB8653T]	0.8	W
		Standard PWB mounting (*2) [LB8653FN]	1.9	
Operating temperature	Topr		-20 to +80	°C
Storage temperature	Tstg		-55 to +150	°C

(*1) Standard PWB: 76.1mm × 114.3mm × 1.6mm glass epoxy resin
(*2) Standard PWB: 30mm × 50mm × 0.8mm glass epoxy resin 4-layer PWB

Recommended Operating Range at Ta = 25°C [LB8653FN : Preliminary]

Parameter	Symbol	Conditions	Ratings	Unit
Voltage for guarantee of function	VB opr		2.2 to 10	V
	V_{CC} opr		2.2 to 10	
Constant-voltage setting range	V_{OUT}		0 to VB	V
Constant-current setting range	I_{OUT}		50 to 500	mA
Constant-voltage setting input range	VVC	VC1, VC2, VC3	0.1 to VB	V
Constant-current setting input range	VIC	IC	0.1 to 1.0	V
Input pin "H" voltage	$V_{IN}H$	MD1, MD2, MD3, IN1, IN2	1.8 to 10	V
Input pin "L" voltage	$V_{IN}L$		-0.3 to 0.4	V

Electrical Characteristics at Ta = 25°C, VB = V_{CC} = 3V [LB8653FN : Preliminary]

Parameter	Symbol	Conditions	Ratings min	Ratings typ	Ratings max	Unit	Remarks
Current dissipation in stand-by state	ISTB	VB = V_{CC} = 10V MD1/MD2/MD3/IN1/IN2 = L/L/L/L/L		0.1	1.0	μA	1
VB system operation current dissipation	IB1	MD1/MD2/MD3/IN1/IN2 = L/L/L/L/H, L/L/L/H/L, L/L/L/H/H		3.7	5.0	mA	2
	IB2	MD1/MD2/MD3/IN1/IN2 = L/L/H/*/*		5.3	7.0		
	IB3	MD1/MD2/MD3/IN1/IN2 = L/H/L/*/*		6.9	9.0		
	IB4	MD1/MD2/MD3/IN1/IN2 = L/H/H/*/*		5.3	7.0		
	IB5	MD1/MD2/MD3/IN1/IN2 = H/*/L/*/*		8.5	12.0		
	IB6	MD1/MD2/MD3/IN1/IN2 = H/*/H/*/*		6.9	9.0		

Continued on next page.

Continued from preceding page.

Parameter	Symbol	Conditions	Ratings min	Ratings typ	Ratings max	Unit	Remarks
V_{CC} system operation current dissipation	$I_{CC}1$	MD1/MD2/MD3/IN1/IN2 = L/L/L/L/H, L/L/L/H/L, L/L/L/H/H		15	20	mA	3
	$I_{CC}2$	One or more of MD1, MD2 and MD3 is "H".		0.1	1.0	μA	
[Constant-voltage driver] (OUT1, OUT2, OUT3, OUT4, OUT5, OUT6)							
Output constant-voltage	V_O1	VC1 or VC2 or VC3 = 0.3V	1.53	1.58	1.63	V	4
	V_O2	VC1 or VC2 or VC3 = VREF×0.3 (partial resistance)	1.48	1.58	1.68		
Output saturation voltage 1	VSAT1	VB = 3.0V, I_O = 200mA		0.3	0.45	V	5
[Constant-current driver] (OUT7, OUT8)							
Output constant-current	I_O	V_{CC} = 3.0V, between IM and GND : 1.0Ω, IC = VREF/5	188	200	212	mA	6
Output constant-current/voltage variation	IOLIN	V_{CC} = 3V to 5V (V_{CC} = 4V typ), I_O = 200mA	-1	0	+1	%	7
Output saturation voltage 2	VSAT2	V_{CC} = 3.0V, I_O = 300mA		0.3	0.45	V	8
IC output saturation voltage	VSAT3	V_{CC} = 3.0V, I_O = 1mA		0.12	0.2	V	9
[Reference voltage circuit] (VREF)							
VREF output constant-voltage	VREF	IREF = -1mA	0.95	1.00	1.05	V	10
[Input circuit] (MD1, MD2, MD3, IN1, IN2)							
Control pin input current	$I_{IN}H$	V_{IN} = 5.0V		60	90	μA	11
	$I_{IN}L$	V_{IN} = 0V			0	μA	12
[Others]							
Overheat protection detection temperature	TTSD	*Design guarantee	160	180	200	°C	13

* Temperature characteristics of design guaranteed, however individual unit testing is not performed.

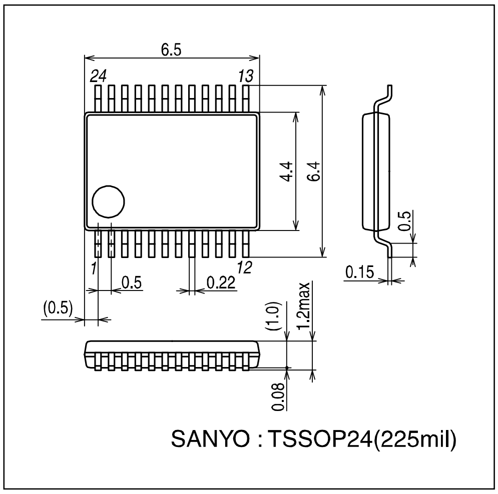
[Remarks]

1) Specifies the IC standby leak current.
2) Specifies the current dissipated at the pin VB in each mode.
   (Specifies the maximum value for each condition.)
3) Specifies the current dissipated at the pin V_{CC} in each mode.
   (Specifies the maximum value for each condition.)
4) Specifies the output voltage when constant voltage is output from pins OUT1 to OUT 6.
5) Specifies the output transistor (upper and lower) saturation voltage at pins OUT1 to OUT6.
6) Specifies the output current when constant voltage is output from pins OUT7 and OUT8.
7) Specifies the output voltage variation caused by supply voltage fluctuation when constant current is output from pins OUT7 and OUT8.
8) Specifies the output transistor (upper and lower) saturation voltage at pins OUT7 to OUT8.
9) Specifies the saturation voltage of the IC pin discharge transistor.
10) Specifies the output voltage at VREF.
11) Specifies the input current when the voltage input at pins MD1 to MD3 and IN1 and IN2 is "H".
12) Specifies the input current when the voltage input at pins MD1 to MD3 and IN1 and IN2 is "L".
13) Specifies the overheat protection circuit detection temperature. (design guaranteed)

Package Dimensions

unit : mm

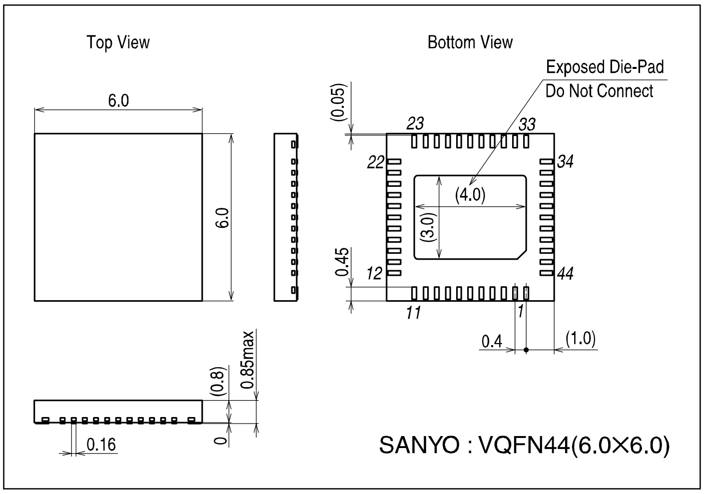
3260A [LB8653T]



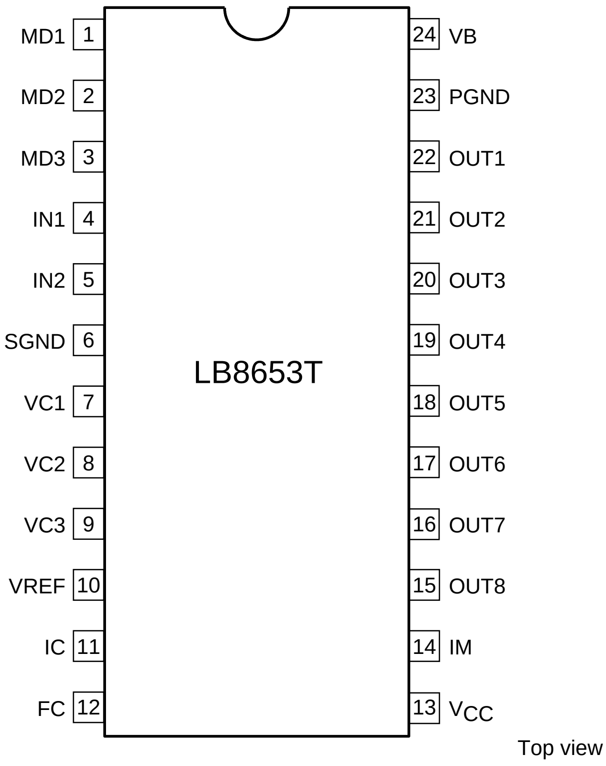
Package Dimensions

unit : mm

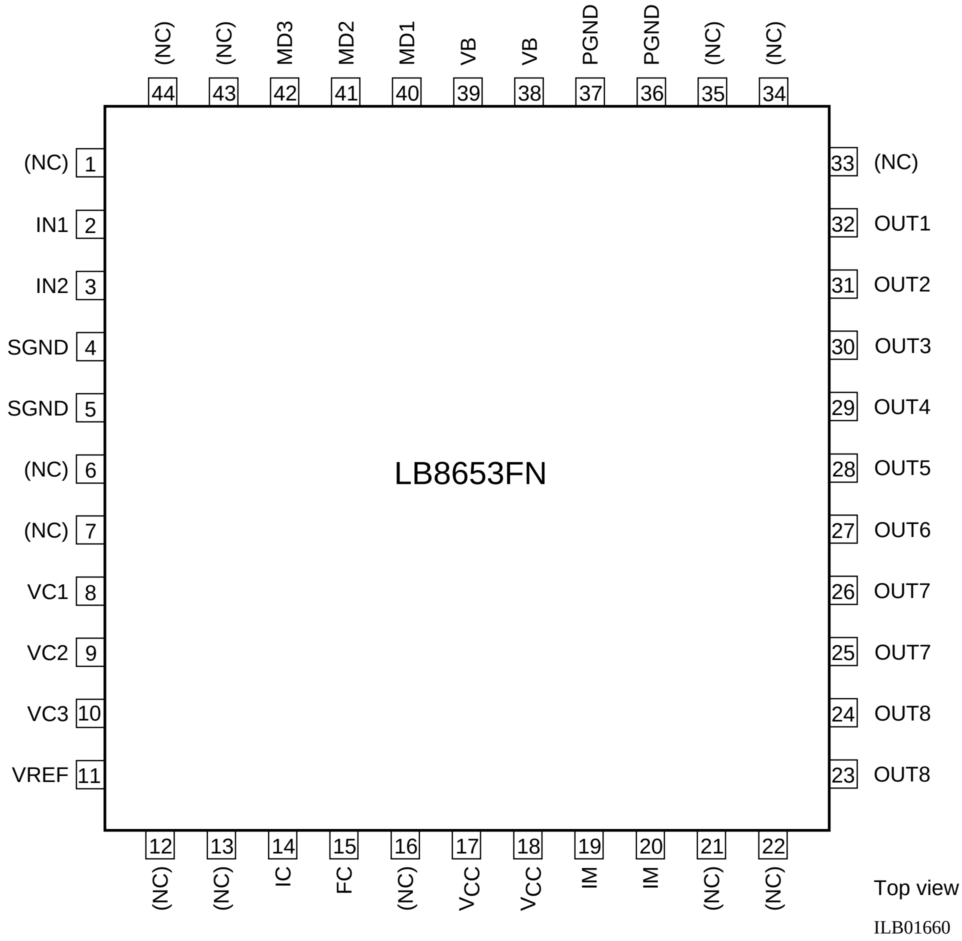
3293 [LB8653FN]



Pin Assignment



ILB01659



Pin Description

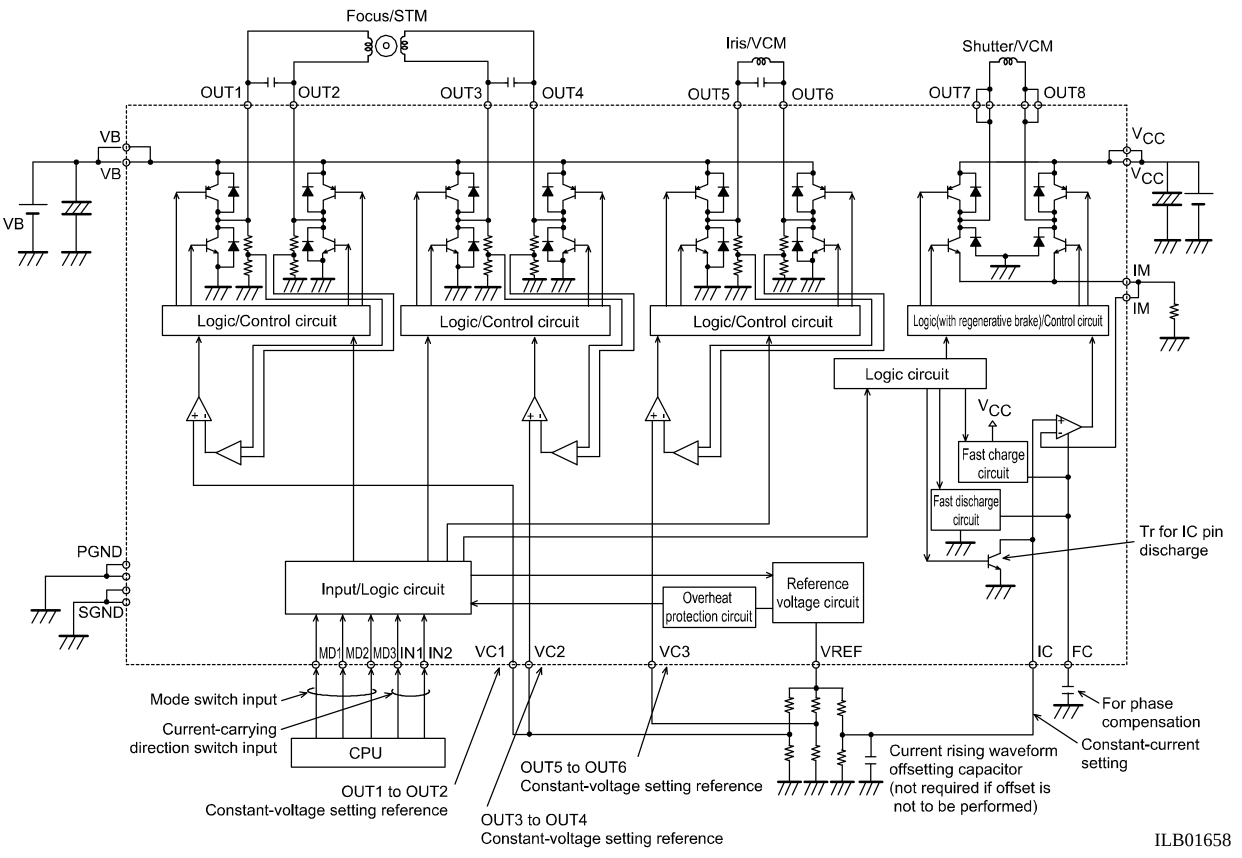
Pin number		Pin name	Description	Protection diode			
				Upper side		Lower side	
LB8653T	LB8653FN			VB	V_{CC}	PGND	SGND
24	38, 39	VB	Battery power supply				
13	17, 18	V_{CC}	ditto				
23	36, 37	PGND	Power system GND				
6	4, 5	SGND	Control system GND				
14	19	IM	OUT7 and OUT8 current detection pin				
	20	IM	OUT7 and OUT8 current detection feedback pin				
22	32	OUT1	Motor drive output	○		○	
21	31	OUT2	ditto	○		○	
20	30	OUT3	ditto	○		○	
19	29	OUT4	ditto	○		○	
18	28	OUT5	ditto	○		○	
17	27	OUT6	ditto	○		○	
16	25, 26	OUT7	ditto		○	○	
15	23, 24	OUT8	ditto		○	○	

Continued on next page.

Continued from preceding page.

Pin number		Pin name	Description	Protection diode			
				Upper side		Lower side	
LB8653T	LB8653FN			VB	V_{CC}	PGND	SGND
1	40	MD1	Control signal input				○
2	41	MD2	ditto				○
3	42	MD3	ditto				○
4	2	IN1	ditto				○
5	3	IN2	ditto				○
10	11	VREF	Reference voltage output				○
7	8	VC1	Constant-voltage setting reference input				○
8	9	VC2	ditto				○
9	10	VC3	ditto				○
12	15	FC	Phase compensation pin				○
11	14	IC	Constant-current setting reference input				○

Block Diagram



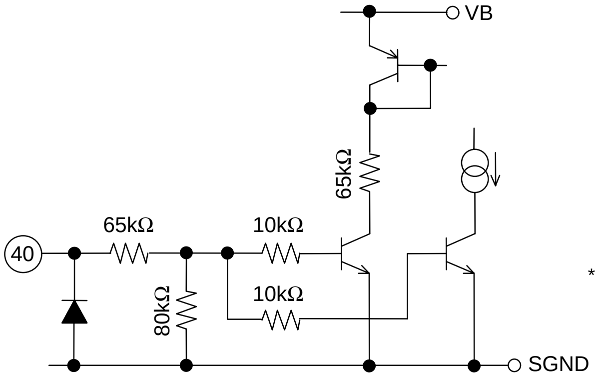
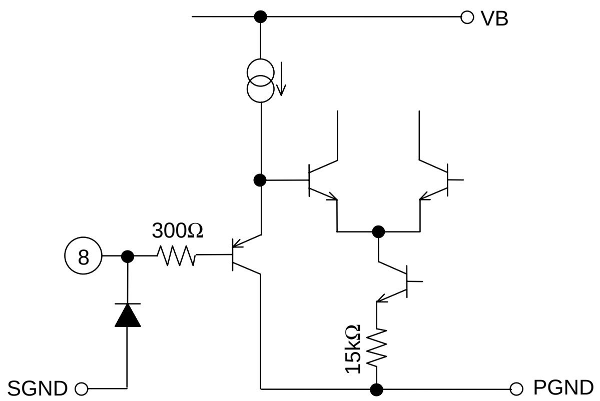
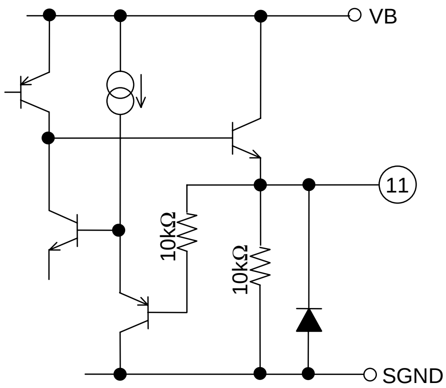
Note1 : When the input voltage to the IC pin is set with the resistor dividing reference voltage such as VREF, make sure not to use “VC1”, “VC2” and “VC3”, together with the voltage-dividing resisters.
(In any mode other than shutter mode, the IC pin discharge transistor inside the IC pin switches to ON.)

Note2 : The above block diagram applies to LB8653FN. For the LB8653T, a single pin is provided for VB, V_{CC}, PGND, SGND, OUT7 and OUT8 respectively.

Truth Table

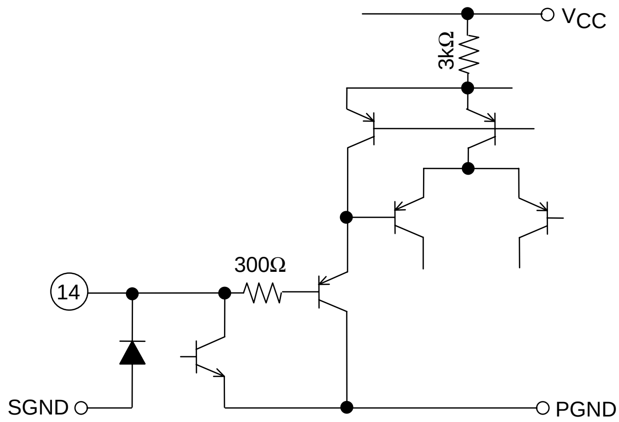
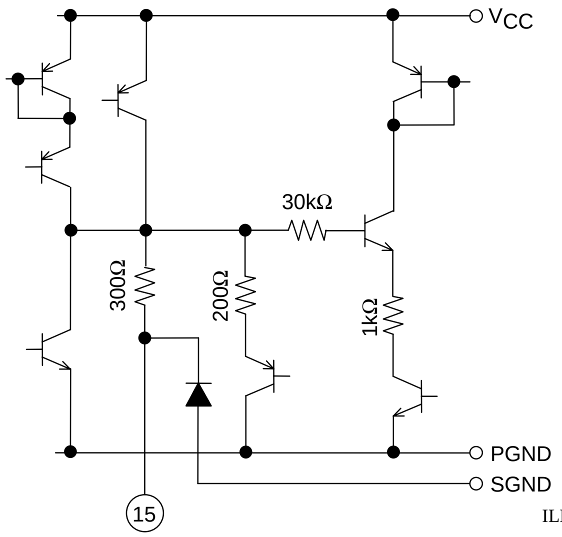
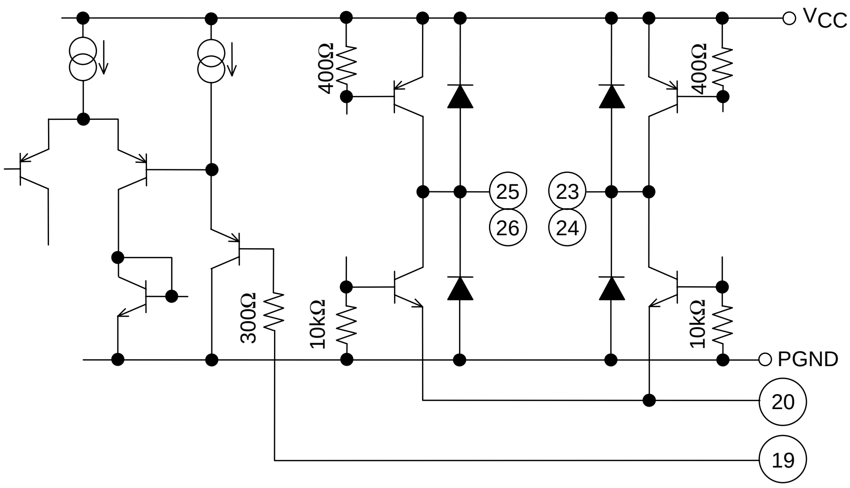
Input					Output								VREF	IC PIN discharging	Mode	
MD1	MD2	MD3	IN1	IN2	OUT1	OUT2	OUT3	OUT4	OUT5	OUT6	OUT7	OUT8				
L	L	L	L	L							-	-	OFF	OFF	Stand-by	Shutter
			L	H							L	H	ON		Close	
			H	L							H	L			Open	
			H	H							-	H			Regeneration	
		H	L	L					-	-				ON	Iris	
			L	H					L	H						
			H	L					H	L						
			H	H					-	-						
	H	L	L	L	L	H	H	L							AF only (2-phase excitation)	
			L	H	L	H	L	H								
			H	L	H	L	H	L								
			H	H	H	L	L	H								
		H	L	L	-	-	H	L							AF only (1-phase excitation)	
			L	H	L	H	-	-								
			H	L	H	L	-	-								
			H	H	-	-	L	H								
H	L	L	L	L	L	H	H	L	L	H					AF and iris(1) (2-phase excitation)	
			L	H	L	H	L	H								
			H	L	H	L	H	L								
			H	H	H	L	L	H								
		H	L	L	-	-	H	L							AF and iris (1) (1-phase excitation)	
			L	H	L	H	-	-								
			H	L	H	L	-	-								
			H	H	-	-	L	H								
	H	L	L	L	L	H	H	L	H	L					AF and iris (2) (2-phase excitation)	
			L	H	L	H	L	H								
			H	L	H	L	H	L								
			H	H	H	L	L	H								
		H	L	L	-	-	H	L							AF and iris (2) (1-phase excitation)	
			L	H	L	H	-	-								
			H	L	H	L	-	-								
			H	H	-	-	L	H								

Internal Equivalent Circuit Diagram (Pin number in the figure applies to LB8653FN)

Pin number		Pin name	Internal equivalent circuit diagram
LB8653T	LB8653FN		
1 2 3 4 5	40 41 42 2 3	MD1 MD2 MD3 IN1 IN2	 ILB01661 * The same for pins 41, 42, 2 and 3.
7 8 9	8 9 10	VC1 VC2 VC3	 ILB01662 * The same for pins 9, 10.
10	11	VREF	 ILB01663

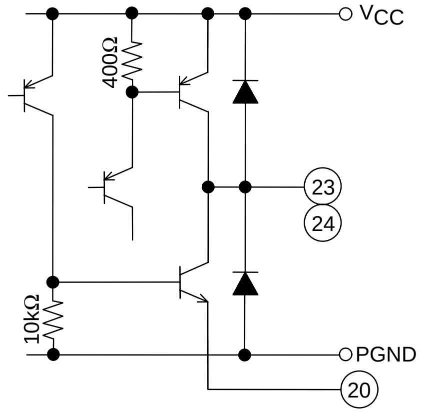
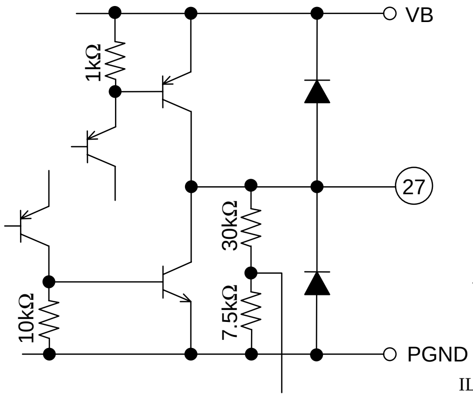
Continued on next page.

Continued from preceding page.

Pin number		Pin name	Internal equivalent circuit diagram
LB8653T	LB8653FN		
11	14	IC	 ILB01664
12	15	FC	 ILB01665
14	19 20	IM	 ILB01666

Continued on next page.

Continued from preceding page.

Pin number		Pin name	Internal equivalent circuit diagram
LB8653T	LB8653FN		
15 16	23 24 25 26	OUT8 OUT7	 * The same for pins 25, 26. ILB01667
17 18 19 20 21 22	27 28 29 30 31 32	OUT6 OUT5 OUT4 OUT3 OUT2 OUT1	 * The same for pins 28 to 32. ILB01668

Application Design Notes

(1) Constant-voltage setting for OUT1 to OUT6
"H" output voltage for OUT1 and OUT2 can be set by the VC1 pin input voltage.
The setting formula is as follows:

(OUT1/2 output voltage) = (VC1 input voltage) $\times$5.27

Correspondingly, OUT3 and OUT4 can be set by VC2, and OUT5 and OUT6 can be set by VC3.
The setting formula is as follows:

(OUT3/4 output voltage) = (VC2 input voltage) $\times$5.27
(OUT5/6 output voltage) = (VC3 input voltage) $\times$5.27

In addition, if the right side setting of the above formula exceeds the supply voltage (VB), the output voltage is saturated.

(2) Output pin oscillation prevention capacitor for OUT1 to OUT6 constant-voltage control.
For constant-voltage control of OUT1 to OUT6, a capacitor must be placed between OUT pins in order to prevent oscillation.
Test capacitor values between 0.01µF to 0.1µF and choose a value that does not cause output oscillation problems.
However, for the saturated drive, no oscillation prevention capacitor is necessary.

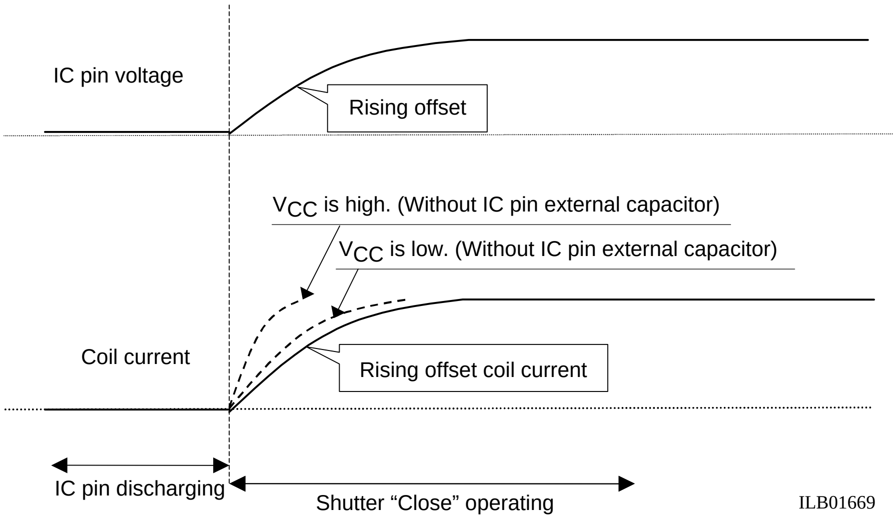
(3) Constant-current setting between OUT7 and OUT8
Constant-current setting between OUT7 and OUT8 depends on the IC pin input voltage and IM pin connection resistance (current detection resistor).
As shown in the block diagram, the output current is controlled so that the IC pin input voltage can be equal to the voltage generated on the current detection resistor which is connected between IM and GND.
The formula for output current is as follows:

(Output current) = (IC input pin voltage) $\div$ (current detection resistance)

In addition, since the constant-current control block is connected to PGND inside the IC, when the voltage is supplied to the IC pin with partial resistance, GND side of the resistor must be connected to PGND.

(4) Fast charge/discharge circuit for the FC pin
In order to support high speed shutter control (sequential shutter), a built-in fast charge/fast discharge circuit is implemented in the shutter control block (OUT7, OUT8).

(5) Constant-current rising offset function



The rising waveform of the coil current can be offset by having the external CR network give a slope to the rising waveform of the voltage input to the IC pin and setting a greater coil time constant to make the slope more gradual. This ensures stable shutter operation under severe power voltage fluctuations.

Note : When offsetting the rising waveform of the coil current using the IC pin, assume the VB1 voltage that could be obtained in the absence of the capacitor to the IC pin as the supposed minimum voltage and observe and confirm the rising waveform of the coil current that flows at that voltage, then determine the capacitance of the capacitor so as to yield a time constant value that is greater than the one that could produce the waveform generated at the supposed minimum voltage.

The rising waveform offsetting capacitor is unnecessary if the power voltage supplied is stable or in similar cases in which the rising waveform offsetting function is not required.

(6) FC pin phase compensation capacitor

The capacitor connected to the FC pin is used for phase compensation of constant-current control between OUT9 and OUT10.

Test capacitor values between 0.0015μF to 0.033μF and choose a value that does not cause output oscillation problems.

(In particular, when a large-inductance coil is used, it is necessary to provide a margin to a capacity value.)

Moreover, since the constant-current control block is connected to PGND inside the IC, GND side of the FC pin capacitor must be connected to PGND.

(Cautions for FC pin capacitor setting)

For the capacitor value setting, set the value by which the output does not oscillate, observing an output voltage waveform.

In circuit, the FC pin is connected to the output part of the constant-current control amplifier, and an output transistor drives because the potential of the FC pin rises.

That is, since the initial state of the FC pin influences the output-drive timing, the potential of the FC pin is discharged (fast discharge circuit) inside the IC to a certain level before the shutter is ON, and the potential of the FC pin is charged (fast charge circuit) inside the IC to a certain level when a shutter is ON, so that the state of the FC pin during shutter driving can always be constant on this IC. This allows constant input/output delay time.

However, since the time involved in charge/discharge in the above-mentioned circuit will be long if the capacitor value setting is too large, the amount of variation in charge/discharge delay time will increase with the variation of capacitor value (absolute value variation and temperature characteristic).

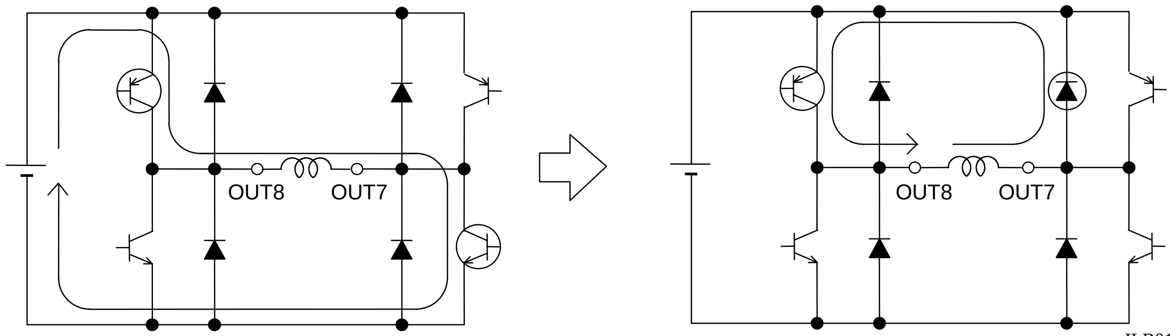
Moreover, as another negative effect of setting a large value to the capacitor, it is considered that the rising inclination of coil current is moderate. Although the rising inclination of coil current originally depends on L component of the coil, if a large value is set to a capacitor and the capacitor time constant increases, the rising inclination of coil current depends on the value of the capacitor.

For the reasons mentioned above, especially in the applications in which a high-speed shutter drive is required, both the value by which output does not oscillate and as small a value as possible (0.0015μF to 0.033μF) must be set to a capacitor which is connected to the FC pin.

(7) Shutter drive "Regeneration" mode

The "Regeneration" (MD1/MD2/MD3/IN1/IN2 = L/L/L/H/H) in shutter mode is used to slow the coil current decay. This mode makes coil current regenerative (Slow-Decay) within the output H-bridge by switching from "Close" (MD1/MD2/MD3/IN1/IN2 = L/L/L/L/H). (Refer to the following figure.)

(1) "Close" (MD1/2/3/IN1/2 = L/L/L/L/H) (2) "Regeneration" (MD1/2/3/IN1/2 = L/L/L/H/H)

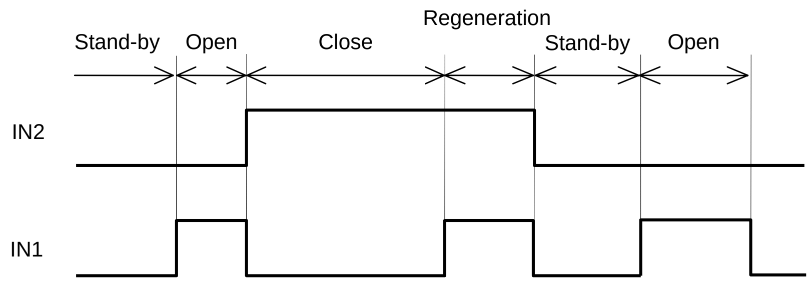


ILB01670

When shutter control is switched from "Stand-by" to "Close" ("Open"), the current rises to the target constant-current value from the state of output current 0 (zero). However, the output of the constant-current control amplifier inside the IC is in the full drive state during the above-mentioned "Regeneration" state. Therefore, when it is switched from "Regeneration" to "Close" ("Open"), the current falls to the target constant-current value from the state of full drive output.

For that reason, to switch the shutter drive to "Close" ("Open") from "Regeneration" by constant-current control, it must be switched to "Stand-by" once before switching to "Close" ("Open").

The example of drive sequence is shown in the figure below.



ILB01671

(8) GND wiring and each power supply line capacitor

Connect PGND and SGND near the IC and set a capacitor to the part nearest the power supply pin for each power supply.

This catalog provides information as of June, 2004. Specifications and information herein are subject to change without notice.