



SANYO Semiconductors

DATA SHEET

An ON Semiconductor Company

LB11946 — Monolithic Digital IC PWM Current Control Stepping Motor Driver

Overview

The LB11946 is a stepping motor driver IC that implements PWM current control bipolar drive with a fixed off time. This IC features 15 current setting levels using a fixed VREF voltage and support for micro-stepping drive from 1-2 phase excitation drive to 4W1-2 phase excitation drive. This device is optimal for driving stepping motors such as those used for carriage drive and paper feed in printers.

Features

- PWM current control (with a fixed off time)
- Logic input serial-parallel converter (allows 1-2, W1-2, 2W1-2, and 4W1-2 phase excitation drive)
- Current attenuation switching function (with slow decay, fast decay, and mixed decay modes)
- Built-in upper and lower side diodes
- Simultaneous on state prevention function (through current prevention)
- Noise canceller function
- Thermal shutdown circuit
- Shutoff on low logic system voltage circuit
- Low-power mode control pin

Specifications

Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Motor supply voltage	V _{BB}		50	V
Peak output current	I _{O peak}	tw ≤ 20μS	1.2	A
Continuous output current	I _{O max}		1.0	A
Logic system supply voltage	V _{CC}		7.0	V
Logic input voltage range	V _{IN}		-0.3 to V _{CC}	V
Emitter output voltage	VE	V _{CC} = 5V specifications	1.0	V
		V _{CC} = 3.3V specifications	0.5	V
Allowable power dissipation	Pd max	Independent IC	3.0	W
Operating temperature	Topr		-25 to +85	°C
Storage temperature	Tstg		-55 to +150	°C

■ Any and all SANYO Semiconductor Co.,Ltd. products described or contained herein are, with regard to "standard application", intended for the use as general electronics equipment (home appliances, AV equipment, communication device, office equipment, industrial equipment etc.). The products mentioned herein shall not be intended for use for any "special application" (medical equipment whose purpose is to sustain life, aerospace instrument, nuclear control device, burning appliances, transportation machine, traffic signal system, safety equipment etc.) that shall require extremely high level of reliability and can directly threaten human lives in case of failure or malfunction of the product or may cause harm to human bodies, nor shall they grant any guarantee thereof. If you should intend to use our products for applications outside the standard applications of our customer who is considering such use and/or outside the scope of our intended standard applications, please consult with us prior to the intended use. If there is no consultation or inquiry before the intended use, our customer shall be solely responsible for the use.

■ Specifications of any and all SANYO Semiconductor Co.,Ltd. products described or contained herein stipulate the performance, characteristics, and functions of the described products in the independent state, and are not guarantees of the performance, characteristics, and functions of the described products as mounted in the customer's products or equipment. To verify symptoms and states that cannot be evaluated in an independent device, the customer should always evaluate and test devices mounted in the customer's products or equipment.

SANYO Semiconductor Co., Ltd.

www.semiconductor-sanyo.com/network

LB11946

Recommended Operating Conditions at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Motor supply voltage	V _{BB}		10 to 45	V
Logic system supply voltage	V _{CC}	V _{CC} = 5V specifications	4.5 to 5.5	V
		V _{CC} = 3.3V specifications	3.0 to 3.6	V
Reference voltage	V _{REF}	V _{CC} = 5V specifications	0.0 to 3.0	V
		V _{CC} = 3.3V specifications	0.0 to 1.0	V

Electrical Characteristics at Ta = 25°C, V_{CC} = 5V, V_{BB} = 42V, V_{REF} = 1.52V

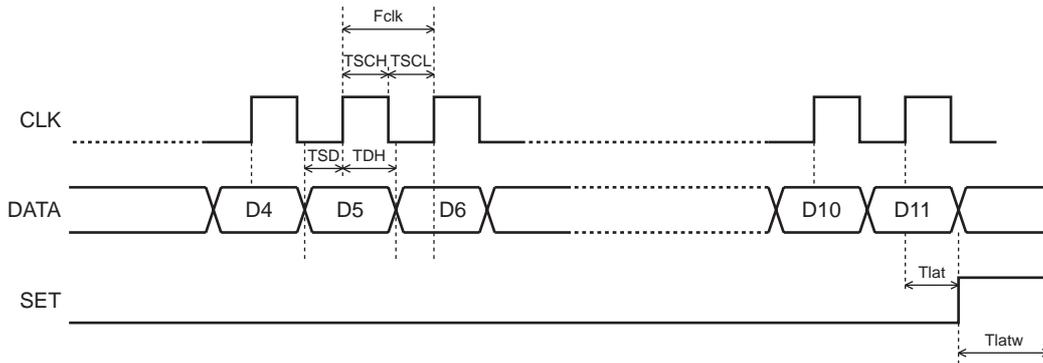
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Output Block						
Output stage supply current	I _{BB ON}		0.9	1.3	1.7	mA
	I _{BB OFF}		0.52	0.7	1.05	mA
Output saturation voltage	V _{O(sat) 1}	I _O = +0.5A (sink)		1.1	1.4	V
	V _{O(sat) 2}	I _O = +1.0A (sink)		1.4	1.7	V
	V _{O(sat) 3}	I _O = -0.5A (source)		1.9	2.2	V
	V _{O(sat) 4}	I _O = -1.0A (source)		2.2	2.5	V
Output leakage current	I _{O1} (leak)	V _O = V _{BB} (sink)			50	μA
	I _{O2} (leak)	V _O = 0V (source)	-50			μA
Output sustain voltage	V _{SUS}	L = 15mH, I _O = 1.0A, Design guarantee *	45			V
Logic Block						
Logic system supply current	I _{CC ON}	D0 = 1, D1 = 1, D2 = 1, D3 = 1 When these data values are set	24	35	46	mA
	I _{CC OFF1}	D0 = 0, D1 = 0, D2 = 0, D3 = 0	22	32	42	mA
	I _{CC OFF2}	ST = LOW		0.05	0.1	mA
Input voltage	V _{IH}		2			V
	V _{IL}				0.8	V
Input current	I _{IH}	V _{IH} = 2 V			35	μA
	I _{IL}	V _{IL} = 0.8 V	6			μA
Sense voltages	V _E	D0 = 1, D1 = 1, D2 = 1, D3 = 1 When these data values are set	0.470	0.50	0.525	V
		D0 = 1, D1 = 1, D2 = 1, D3 = 0	0.445	0.48	0.505	V
		D0 = 1, D1 = 1, D2 = 0, D3 = 1	0.425	0.46	0.485	V
		D0 = 1, D1 = 1, D2 = 0, D3 = 0	0.410	0.43	0.465	V
		D0 = 1, D1 = 0, D2 = 1, D3 = 1	0.385	0.41	0.435	V
		D0 = 1, D1 = 0, D2 = 1, D3 = 0	0.365	0.39	0.415	V
		D0 = 1, D1 = 0, D2 = 0, D3 = 1	0.345	0.37	0.385	V
		D0 = 1, D1 = 0, D2 = 0, D3 = 0	0.325	0.35	0.365	V
		D0 = 0, D1 = 1, D2 = 1, D3 = 1	0.280	0.30	0.325	V
		D0 = 0, D1 = 1, D2 = 1, D3 = 0	0.240	0.26	0.285	V
		D0 = 0, D1 = 1, D2 = 0, D3 = 1	0.195	0.22	0.235	V
		D0 = 0, D1 = 1, D2 = 0, D3 = 0	0.155	0.17	0.190	V
		D0 = 0, D1 = 0, D2 = 1, D3 = 1	0.115	0.13	0.145	V
		D0 = 0, D1 = 0, D2 = 1, D3 = 0	0.075	0.09	0.100	V
Reference current	I _{REF}	V _{REF} = 1.5V	-0.5			μA
CR pin current	I _{CR}	CR = 1.0V	-1.6	-1.2	-0.8	mA
MD pin current	I _{MD}	MD = 1.0V, CR = 4.0V	-5.0			μA
Logic system on voltage	V _{LSDON}		2.6	2.8	3.0	V
Logic system off voltage	V _{LSDOFF}		2.45	2.65	2.85	V
LVSD hysteresis	V _{LHIS}		0.03	0.15	0.35	V
Thermal shutdown temperature	T _s	Design guarantee *		170		°C

*Design guarantee: Design guarantee value, Do not measurement.

LB11946

AC Electrical Characteristics at $V_{CC} = 5V$

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Clock frequency	Fclk			200	550	kHz
Data setup time	TDS		0.9	2.5		μS
Data hold time	TDH		0.9	2.5		μS
Minimum clock high-level pulse width	TSCH		0.9	2.5		μS
Minimum clock low-level pulse width	TSCL		0.9	2.5		μS
SET pin stipulated time	Tlat		0.9	2.5		μS
SET pin signal pulse width	Tlatw		1.9	5.0		μS



LB11946

Electrical Characteristics at Ta = 25°C, VCC = 3.3V, VBB = 42V, VREF = 1.0V

(When measuring the sense voltage: VREF = 1.03V)

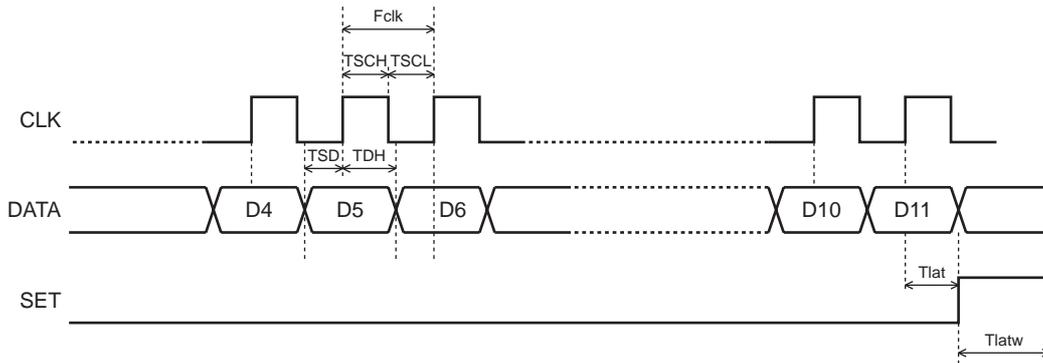
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Output Block						
Output stage supply current	I _{BB ON}		0.9	1.3	1.7	mA
	I _{BB OFF}		0.52	0.7	1.05	mA
Output saturation voltage	V _{O(sat) 1}	I _O = +0.5A (sink)		1.2	1.5	V
	V _{O(sat) 2}	I _O = +1.0A (sink)		1.5	1.8	V
	V _{O(sat) 3}	I _O = -0.5A (source)		2.0	2.3	V
	V _{O(sat) 4}	I _O = -1.0A (source)		2.3	2.6	V
Output leakage current	I _{O1 (leak)}	V _O = V _{BB} (sink)			50	μA
	I _{O2 (leak)}	V _O = 0V (source)	-50			μA
Output sustain voltage	V _{SUS}	L = 15mH I _O -1.5A, Design guarantee *	45			V
Logic Block						
Logic system supply current	I _{CC ON}	D0 = 1, D1 = 1, D2 = 1, D3 = 1 When these data values are set	21	30	39	mA
	I _{CC OFF1}	D0 = 0, D1 = 0, D2 = 0, D3 = 0	19	28	36.5	mA
	I _{CC OFF2}	ST = 0.8V		0.03	0.1	mA
Input voltage	V _{IH}		2			V
	V _{IL}				0.8	V
Input current	I _{IH}	V _{IH} = 2V			35	μA
	I _{IL}	V _{IL} = 0.8V	6			μA
Sense voltages	VE	D0 = 1, D1 = 1, D2 = 1, D3 = 1 VREF = 1.03V	0.303	0.330	0.356	V
		D0 = 1, D1 = 1, D2 = 1, D3 = 0 VREF = 1.03V	0.290	0.315	0.341	V
		D0 = 1, D1 = 1, D2 = 0, D3 = 1 VREF = 1.03V	0.276	0.300	0.324	V
		D0 = 1, D1 = 1, D2 = 0, D3 = 0 VREF = 1.03V	0.263	0.286	0.309	V
		D0 = 1, D1 = 0, D2 = 1, D3 = 1 VREF = 1.03V	0.250	0.272	0.294	V
		D0 = 1, D1 = 0, D2 = 1, D3 = 0 VREF = 1.03V	0.236	0.257	0.278	V
		D0 = 1, D1 = 0, D2 = 0, D3 = 1 VREF = 1.03V	0.223	0.243	0.263	V
		D0 = 1, D1 = 0, D2 = 0, D3 = 0 VREF = 1.03V	0.209	0.228	0.247	V
		D0 = 0, D1 = 1, D2 = 1, D3 = 1 VREF = 1.03V	0.183	0.200	0.217	V
		D0 = 0, D1 = 1, D2 = 1, D3 = 0 VREF = 1.03V	0.155	0.170	0.185	V
		D0 = 0, D1 = 1, D2 = 0, D3 = 1 VREF = 1.03V	0.128	0.143	0.158	V
		D0 = 0, D1 = 1, D2 = 0, D3 = 0 VREF = 1.03V	0.102	0.114	0.126	V
		D0 = 0, D1 = 0, D2 = 1, D3 = 1 VREF = 1.03V	0.074	0.085	0.096	V
		D0 = 0, D1 = 0, D2 = 1, D3 = 0 VREF = 1.03V	0.047	0.057	0.067	V
Reference current	I _{REF}	VREF = 1.0V	-0.5			μA
CR pin current	I _{CR}	CR = 1.0V	-0.91	-0.7	-0.49	mA
MD pin current	I _{MD}	MD = 1.0V, CR = 4.0V	-5.0			μA
LVSD voltage	V _{LSDON}		2.6	2.8	3.0	V
Logic system off voltage	V _{LSDOFF}		2.45	2.65	2.85	V
LVSD hysteresis	V _{LHIS}		0.03	0.15	0.35	V
Thermal shutdown temperature	T _s	Design guarantee *		170		°C

*Design guarantee: Design guarantee value, Do not measurement.

LB11946

AC Electrical Characteristics at $V_{CC} = 3.3V$

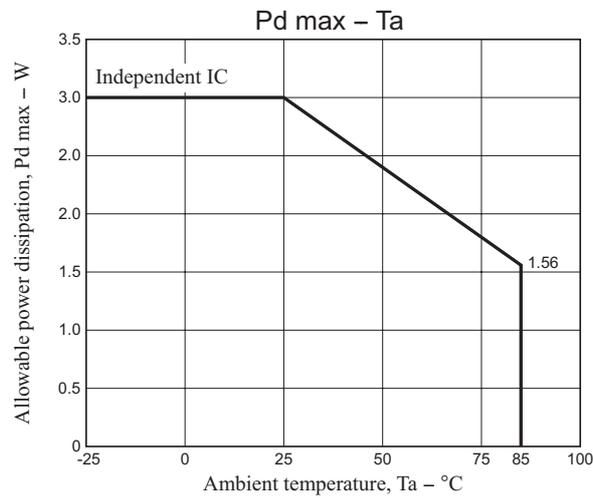
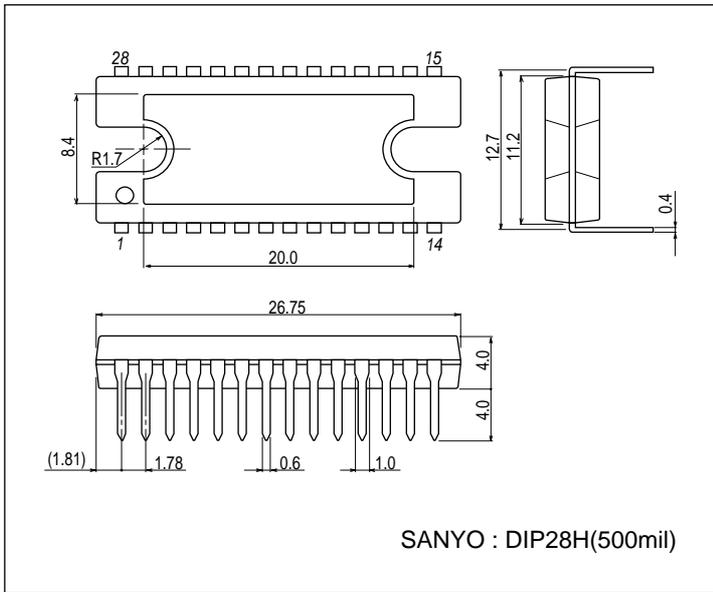
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Clock frequency	Fclk			200	550	kHz
Data setup time	TDS		0.9	2.5		μS
Data hold time	TDH		0.9	2.5		μS
Minimum clock high-level pulse width	TSCH		0.9	2.5		μS
Minimum clock low-level pulse width	TSCL		0.9	2.5		μS
SET pin stipulated time	Tlat		0.9	2.5		μS
SET pin signal pulse width	Tlatw		1.9	5.0		μS



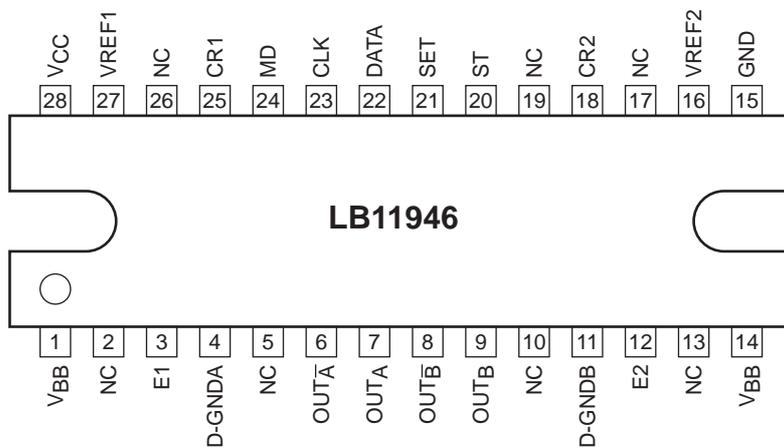
LB11946

Package Dimensions

unit : mm (typ)
3147C

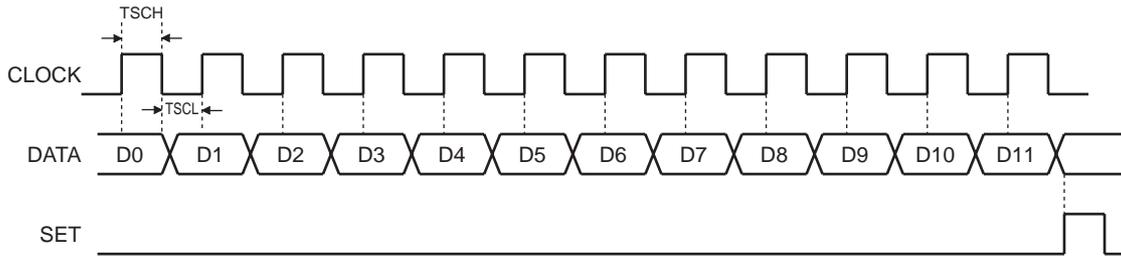


Pin Assignment



Note: The D-GNDA and D-GNDB pins are the anode sides of the lower side diodes

Timing Chart



Serially Transferred Data Definition

No.	IA4	IA3	IA2	IA1	DE1	PH1	IB4	IB3	IB2	IB1	DE2	PH2	Output mode				I/O ratio	DEC MODE
	D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	OUT _A	OUT _A [̄]	OUT _B	OUT _B [̄]		
0	1	1	1	1	1	1	1	1	1	1	1	1	H	L	H	L	100%	SLOW
1	1	1	1	0	1	1	1	1	1	0	1	1	H	L	H	L	96	SLOW
2	1	1	0	1	1	1	1	1	0	1	1	1	H	L	H	L	91	SLOW
3	1	1	0	0	1	1	1	1	0	0	1	1	H	L	H	L	87	SLOW
4	1	0	1	1	1	1	1	0	1	1	1	1	H	L	H	L	83	SLOW
5	1	0	1	0	1	1	1	0	1	0	1	1	H	L	H	L	78	SLOW
6	1	0	0	1	1	1	1	0	0	1	1	1	H	L	H	L	74	SLOW
7	1	0	0	0	1	1	1	0	0	0	1	1	H	L	H	L	70	SLOW
8	0	1	1	1	1	1	0	1	1	1	1	1	H	L	H	L	61	SLOW
9	0	1	1	0	1	1	0	1	1	0	1	1	H	L	H	L	52	SLOW
10	0	1	0	1	1	1	0	1	0	1	1	1	H	L	H	L	44	SLOW
11	0	1	0	0	1	1	0	1	0	0	1	1	H	L	H	L	35	SLOW
12	0	0	1	1	1	1	0	0	1	1	1	1	H	L	H	L	26	SLOW
13	0	0	1	0	1	1	0	0	1	0	1	1	H	L	H	L	17	SLOW
14	1	1	1	1	0	0	1	1	1	1	0	0	L	H	L	H	100	FAST
15	1	1	1	0	0	0	1	1	1	0	0	0	L	H	L	H	96	FAST
16	1	1	0	1	0	0	1	1	0	1	0	0	L	H	L	H	91	FAST
17	1	1	0	0	0	0	1	1	0	0	0	0	L	H	L	H	87	FAST
18	1	0	1	1	0	0	1	0	1	1	0	0	L	H	L	H	83	FAST
19	1	0	1	0	0	0	1	0	1	0	0	0	L	H	L	H	78	FAST
20	1	0	0	1	0	0	1	0	0	1	0	0	L	H	L	H	74	FAST
21	1	0	0	0	0	0	1	0	0	0	0	0	L	H	L	H	70	FAST
22	0	1	1	1	0	0	0	1	1	1	0	0	L	H	L	H	61	FAST
23	0	1	1	0	0	0	0	1	1	0	0	0	L	H	L	H	52	FAST
24	0	1	0	1	0	0	0	1	0	1	0	0	L	H	L	H	44	FAST
25	0	1	0	0	0	0	0	1	0	0	0	0	L	H	L	H	35	FAST
26	0	0	1	1	0	0	0	0	1	1	0	0	L	H	L	H	26	FAST
27	0	0	1	0	0	0	0	0	1	0	0	0	L	H	L	H	17	FAST
28	0	0	0	0	*	*	0	0	0	0	*	*	OFF	OFF	OFF	OFF	0	-

Note *: Either 0 or 1.

Note *1: In mixed decay mode, set D4 and D10 to 0 and set the MD pin to a level in the range 1.5 to 4.0V.

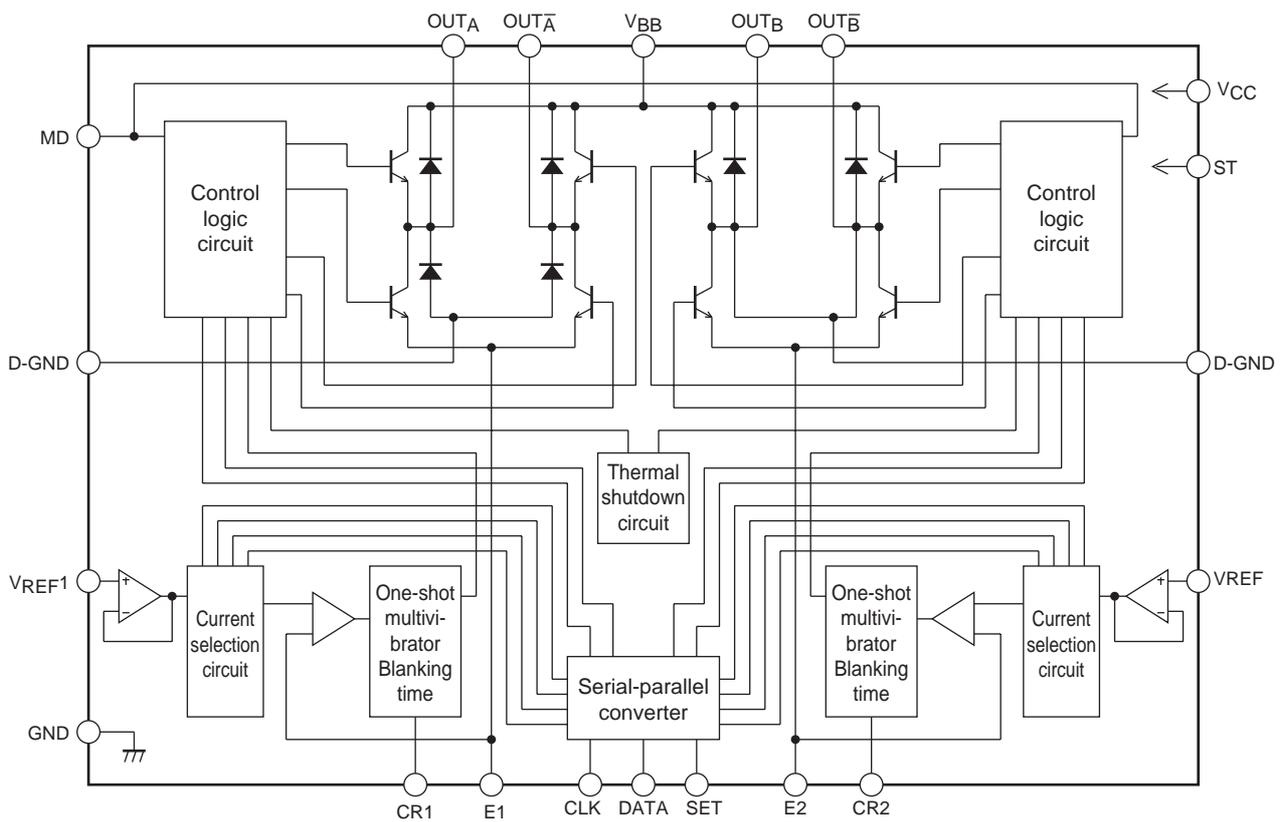
LB11946

Current Settings Truth Table * Items in parentheses are defined by the serial data.

IA4 (D0)	IA3 (D1)	IA2 (D2)	IA1 (D3)	Set current Iout	Current ratio (%)
1	1	1	1	$11.5/11.5 \times VREF/3.04RE = Iout$	100
1	1	1	0	$11.0/11.5 \times VREF/3.04RE = Iout$	95.65
1	1	0	1	$10.5/11.5 \times VREF/3.04RE = Iout$	91.30
1	1	0	0	$10.0/11.5 \times VREF/3.04RE = Iout$	86.95
1	0	1	1	$9.5/11.5 \times VREF/3.04RE = Iout$	82.61
1	0	1	0	$9.0/11.5 \times VREF/3.04RE = Iout$	78.26
1	0	0	1	$8.5/11.5 \times VREF/3.04RE = Iout$	73.91
1	0	0	0	$8.0/11.5 \times VREF/3.04RE = Iout$	69.56
0	1	1	1	$7.0/11.5 \times VREF/3.04RE = Iout$	60.87
0	1	1	0	$6.0/11.5 \times VREF/3.04RE = Iout$	52.17
0	1	0	1	$5.0/11.5 \times VREF/3.04RE = Iout$	43.48
0	1	0	0	$4.0/11.5 \times VREF/3.04RE = Iout$	34.78
0	0	1	1	$3.0/11.5 \times VREF/3.04RE = Iout$	26.08
0	0	1	0	$2.0/11.5 \times VREF/3.04RE = Iout$	17.39

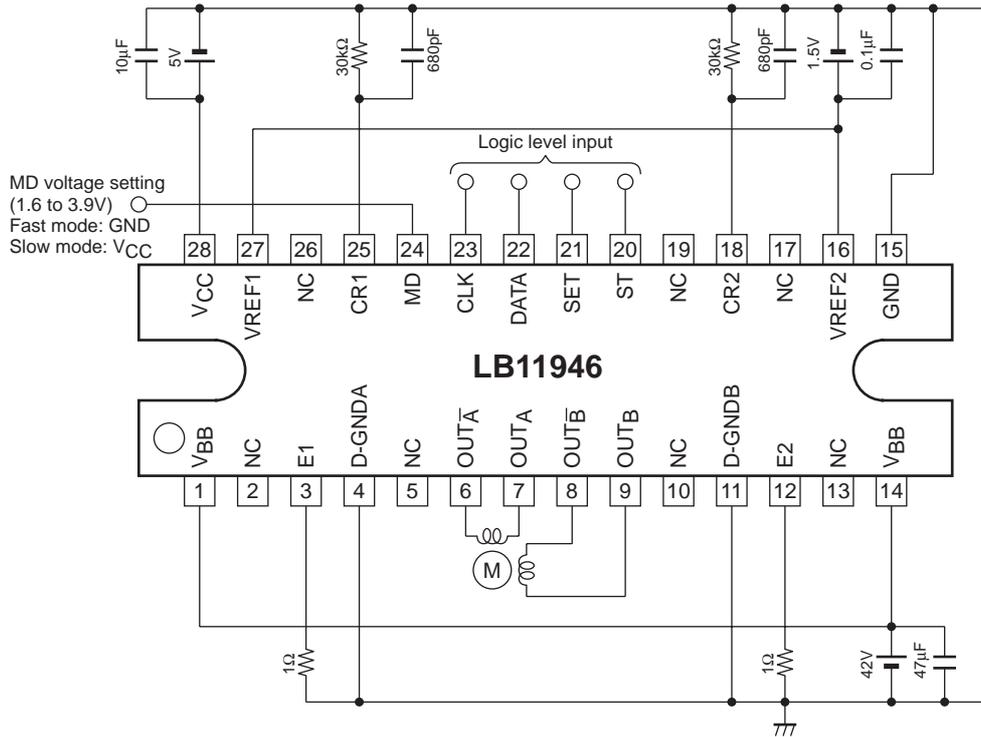
Note: The current ratios shown are calculated values.

Block Diagram

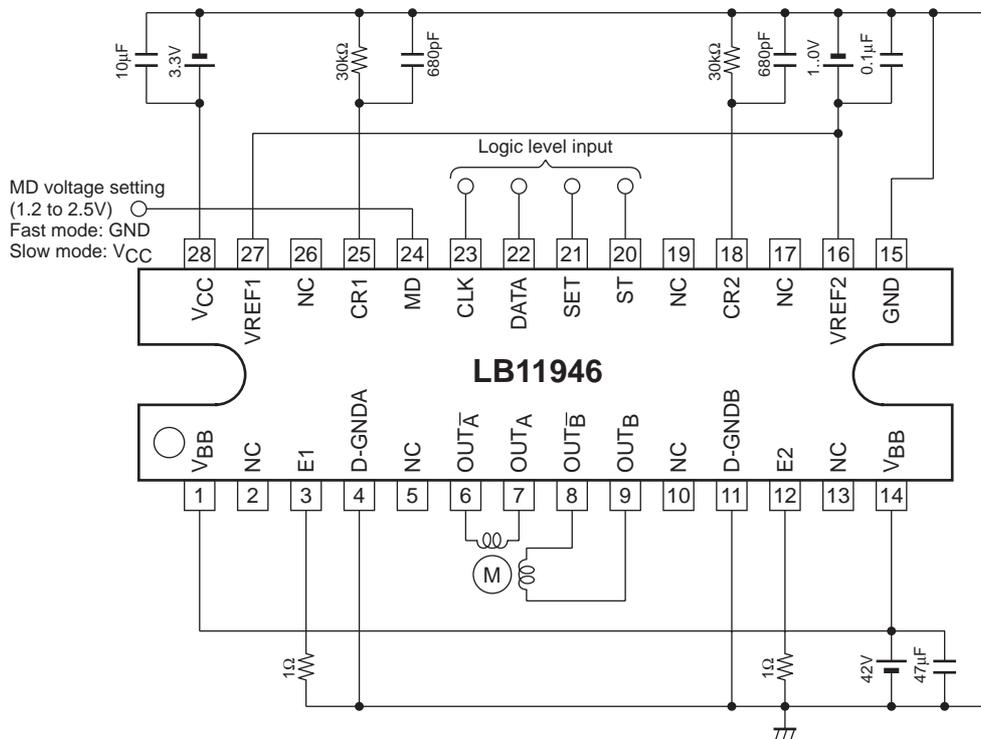


LB11946

Sample Application Circuit at $V_{CC} = 5V$



Sample Application Circuit at $V_{CC} = 3.3V$



SLOW DECAY Current Path

The reregenerative current at upper-side transistor switching operates

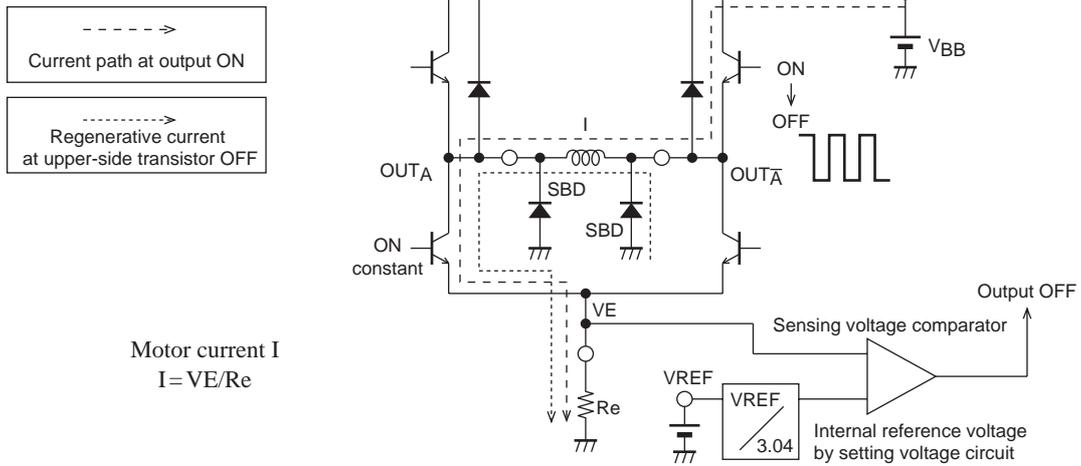


Fig.1

FAST DECAY Current Path

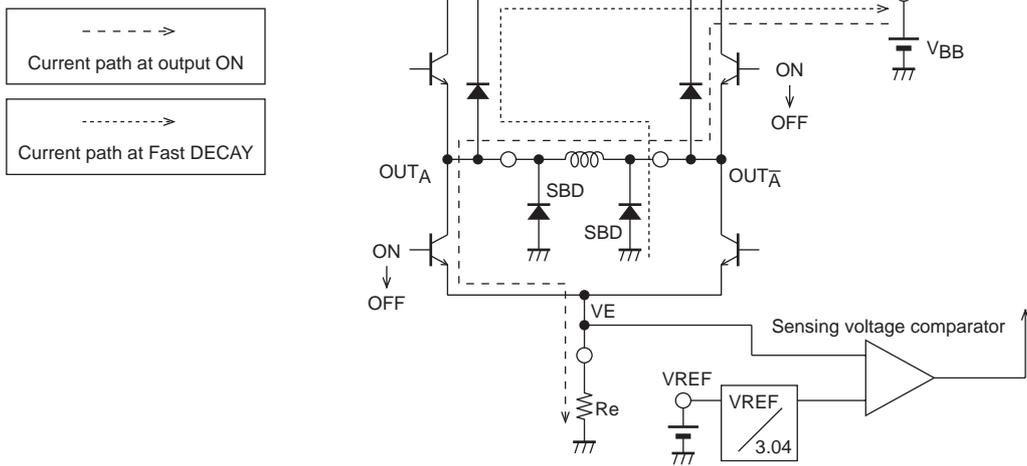


Fig.2

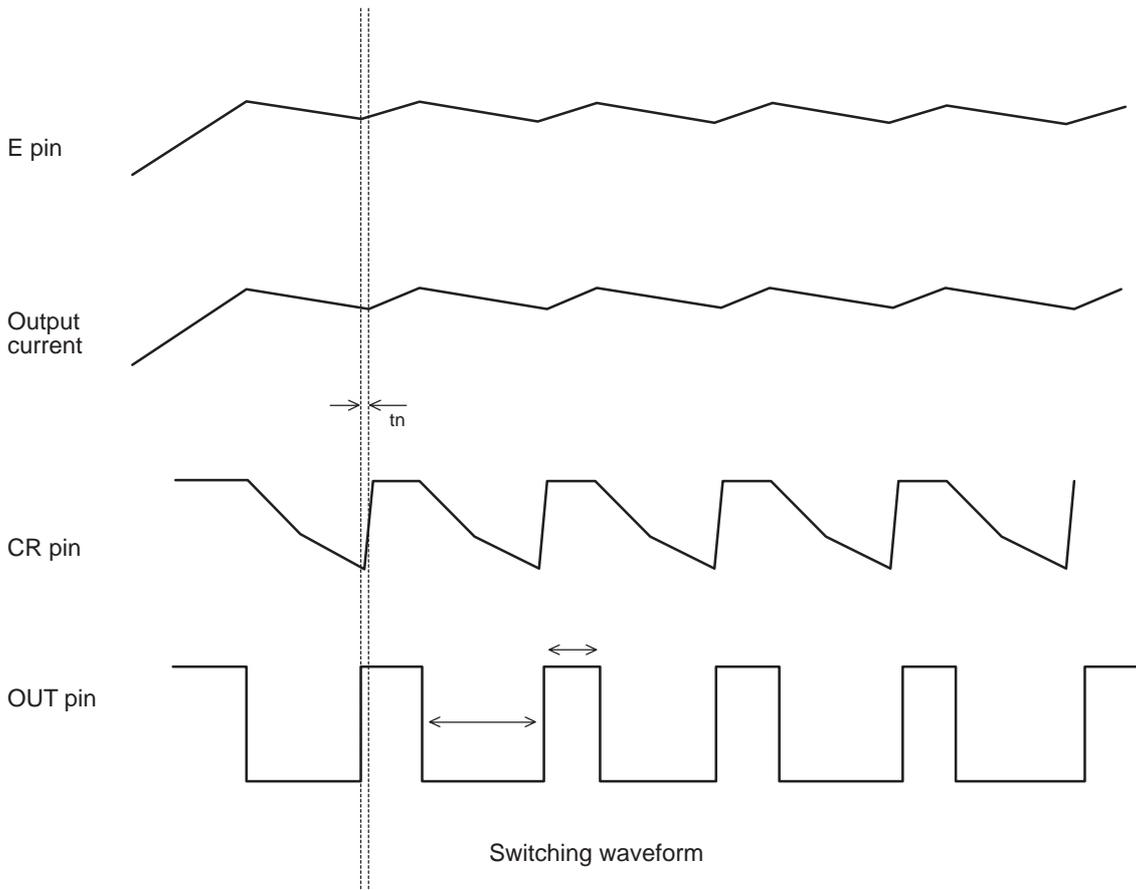
LB11946

Switching Time Chart at PWM operation

SLOW DECAY (Upper-side Chopping)

Serial transmission data (D4, D10) = High

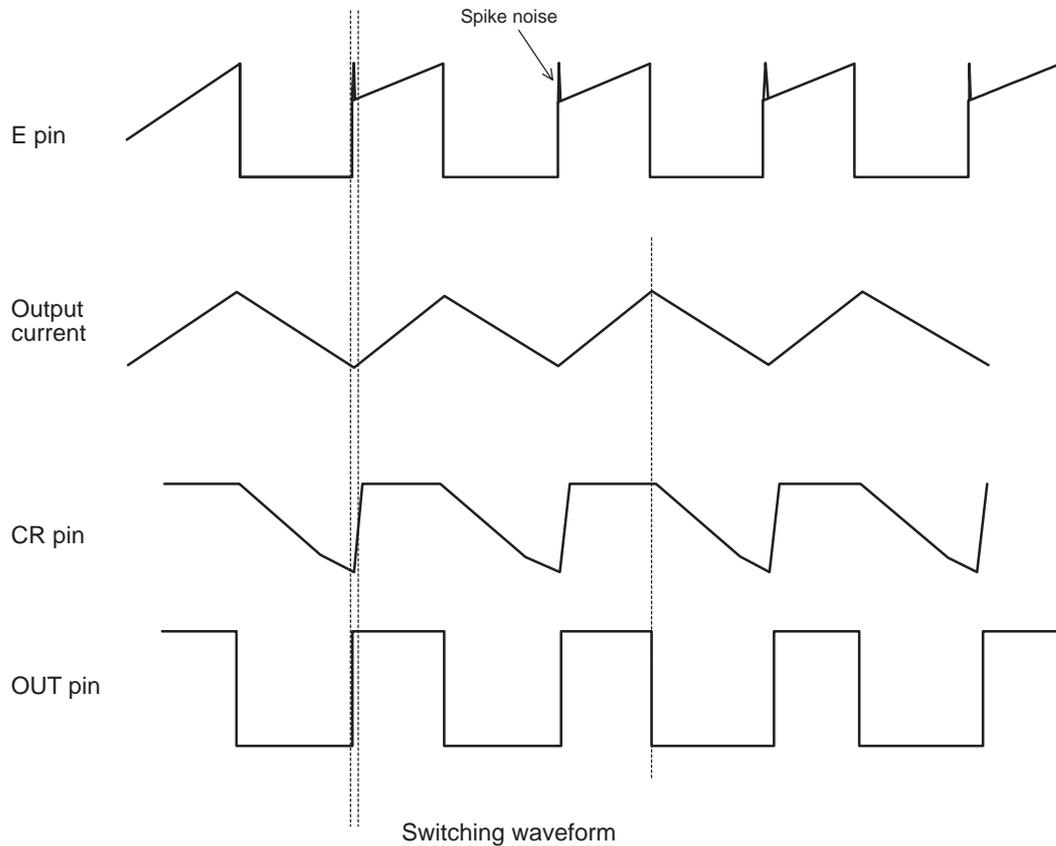
MD pin: Low setting



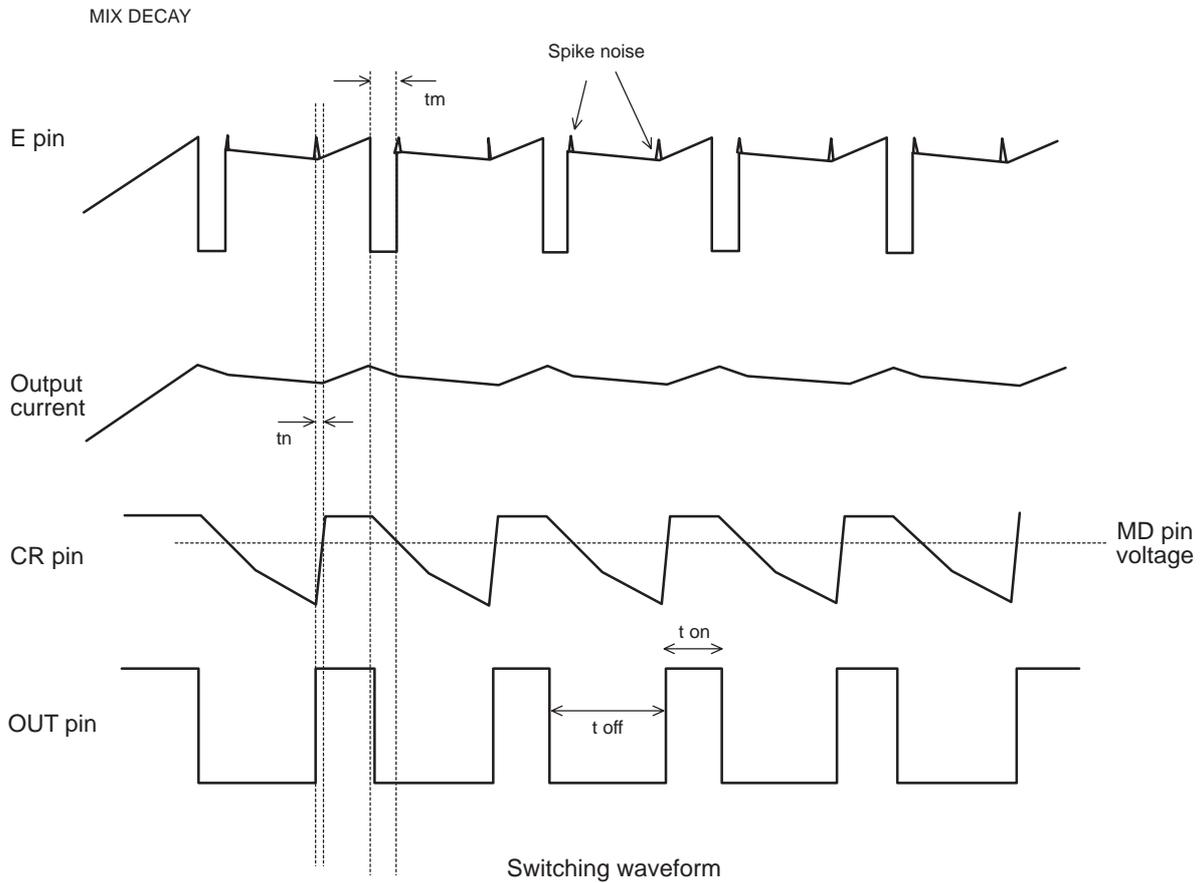
FAST DECAY

Serial transmission data (D4, D10) = Low

MD pin: Low setting



LB11946



MIX DECAY logic setting

serial transmission data (D4, D10) = Low

MD pin: 1.6V to 3.0V at $V_{CC} = 5V$ specification.

1.2V to 2.5V at $V_{CC} = 3.3V$ specification.

t_{on} : Output ON time

t_{off} : Output OFF time

t_m : FAST DECAY time at MIX DECAY mode

t_n : Noise cancel time

The following operation by comparison between CR voltage and MD pin voltage in turning off time.

CR voltage > MD pin voltage: both sides chopping

CR voltage < MD pin voltage: upper side chopping

Attached Documents

1. Switching Off Time and Noise Canceller Time Calculations

Notes on the CR Pin Setting (switching off time and noise canceller time)

The noise canceller time (Tn) and the switching off time (Toff) are set using the following formulas.

(1) When VCC is 5 V

Noise canceller time (Tn)

$$T_n \approx C \times R \times \ln \{ (1.5 - RI) / (4.0 - RI) \} [s]$$

CR pin charge current: 1.25mA

Switching off time (Toff)

$$T_{off} \approx -C \times R \times \ln (1.5/4.8) [s]$$

Component value ranges

R: 5.6kΩ to 100kΩ

C: 470pF to 2000pF

(2) When VCC is 3.3 V

Noise canceller time (Tn)

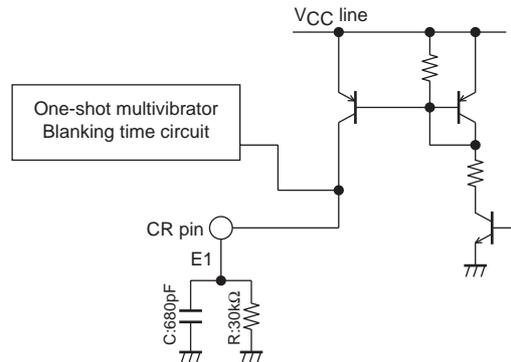
$$T_n \approx C \times R \times \ln \{ (1.06 - RI) / (2.66 - RI) \} [s]$$

CR pin charge current: 0.7 mA

Switching off time (Toff)

$$T_{off} \approx -C \times R \times \ln (1.06 / 3.1) [s]$$

CR Pin Internal Circuit Structure



2. Notes on the MD Pin

(1) If slow decay mode is set up by setting the D4 and D10 bits in the input serial data to 1, the MD pin must be shorted to ground.

(2) If fast decay mode is set up by setting the D4 and D10 bits in the input serial data to 0, mixed decay mode can be set with the MD pin.

When the VCC = 5V specifications are used the setting voltage range for mixed decay mode is 1.6 to 3.9V.

When the VCC = 3.3V specifications are used the setting voltage range for mixed decay mode is 1.2 to 2.5V.

If mixed decay mode will not be used with the fast decay mode setting, either:

(a) Short the MD pin to ground to select fast decay mode, or

(b) Short the MD pin to VCC to select slow decay mode.

Usage Notes

(1) Notes on the VREF pin

Since the VREF pin inputs the reference voltage used to set the current, applications must be designed so that noise does not occur at this pin.

(2) Notes on the ground pins

Since this IC switches large currents, care is required with respect to the ground pins.

The PCB pattern in sections where large currents flow must be designed with low impedances and must be kept separate from the small-signal system.

In particular, the ground terminals of the E1 and E2 pin sense resistors (R_e) and the external Schottky barrier diode ground terminals must be located as close as possible to the IC ground. The capacitors between V_{CC} and ground and between V_{BB} and ground must be as close as possible to the corresponding V_{CC} and V_{BB} pin in the pattern.

(3) Power on sequence

When turning the power systems on

$V_{CC} \rightarrow$ logic level inputs (CLK, DATA, SET, and ST) \rightarrow VREF \rightarrow V_{BB}

When turning the power systems off

$V_{BB} \rightarrow$ VREF logic level inputs (CLK, DATA, SET, and ST) \rightarrow V_{CC}

Note that if the power supply for the logic level inputs is on when the V_{CC} power supply is off, a bias with an unstable state will be applied due to the protection diodes at the V_{CC} pins, and this can cause incorrect operation.

- SANYO Semiconductor Co.,Ltd. assumes no responsibility for equipment failures that result from using products at values that exceed, even momentarily, rated values (such as maximum ratings, operating condition ranges, or other parameters) listed in products specifications of any and all SANYO Semiconductor Co.,Ltd. products described or contained herein.
- SANYO Semiconductor Co.,Ltd. strives to supply high-quality high-reliability products, however, any and all semiconductor products fail or malfunction with some probability. It is possible that these probabilistic failures or malfunction could give rise to accidents or events that could endanger human lives, trouble that could give rise to smoke or fire, or accidents that could cause damage to other property. When designing equipment, adopt safety measures so that these kinds of accidents or events cannot occur. Such measures include but are not limited to protective circuits and error prevention circuits for safe design, redundant design, and structural design.
- In the event that any or all SANYO Semiconductor Co.,Ltd. products described or contained herein are controlled under any of applicable local export control laws and regulations, such products may require the export license from the authorities concerned in accordance with the above law.
- No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying and recording, or any information storage or retrieval system, or otherwise, without the prior written consent of SANYO Semiconductor Co.,Ltd.
- Any and all information described or contained herein are subject to change without notice due to product/technology improvement, etc. When designing equipment, refer to the "Delivery Specification" for the SANYO Semiconductor Co.,Ltd. product that you intend to use.
- Information (including circuit diagrams and circuit parameters) herein is for example only; it is not guaranteed for volume production.
- Upon using the technical information or products described herein, neither warranty nor license shall be granted with regard to intellectual property rights or any other rights of SANYO Semiconductor Co.,Ltd. or any third party. SANYO Semiconductor Co.,Ltd. shall not be liable for any claim or suits with regard to a third party's intellectual property rights which has resulted from the use of the technical information and products mentioned above.

This catalog provides information as of February, 2009. Specifications and information herein are subject to change without notice.