Ordering number : EN7946A

LB11946

Monolithic Digital IC

PWM Current Control
Stepping Motor Driver

ON Semiconductor®

http://onsemi.com

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

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

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	VREF	V_{CC} = 5V specifications	0.0 to 3.0	V
		V_{CC} = 3.3V specifications	0.0 to 1.0	V

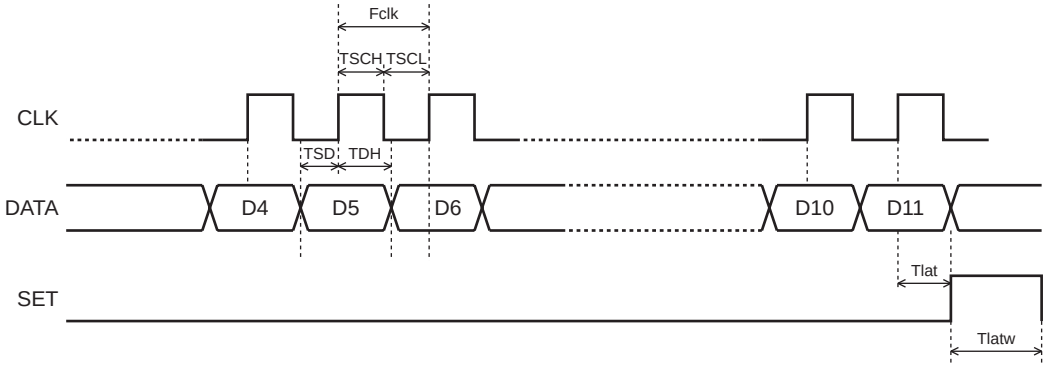
Electrical Characteristics at Ta = 25°C, V_{CC} = 5V, V_{BB} = 42V, VREF = 1.52V

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	VE	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}	VREF = 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_{LSD}ON		2.6	2.8	3.0	V
Logic system off voltage	V_{LSD}OFF		2.45	2.65	2.85	V
LVSD hysteresis	V_{LHIS}		0.03	0.15	0.35	V
Thermal shutdown temperature	Ts	Design guarantee *		170		°C

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

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



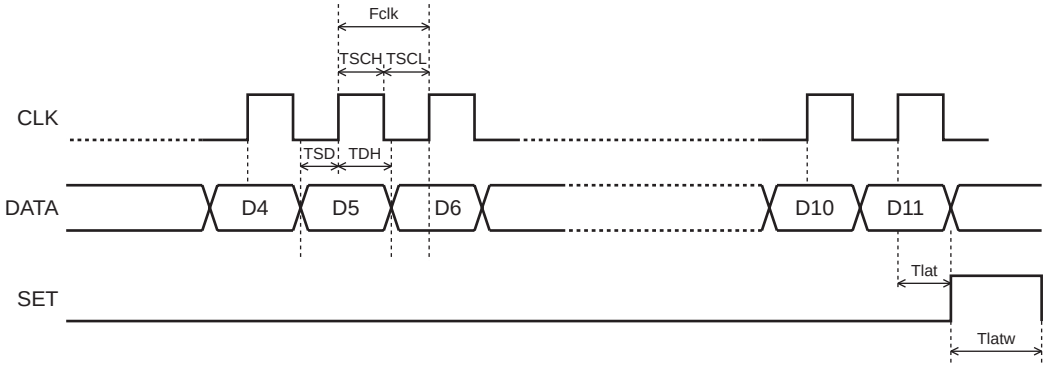
Electrical Characteristics at Ta = 25°C, V_{CC} = 3.3V, V_{BB} = 42V, VREF = 1.0V
(When measuring the sense voltage: VREF = 1.03V)

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_{LSD}ON		2.6	2.8	3.0	V
Logic system off voltage	V_{LSD}OFF		2.45	2.65	2.85	V
LVSD hysteresis	V_{LHIS}		0.03	0.15	0.35	V
Thermal shutdown temperature	Ts	Design guarantee *		170		°C

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

AC Electrical Characteristics at V_{CC} = 3.3V

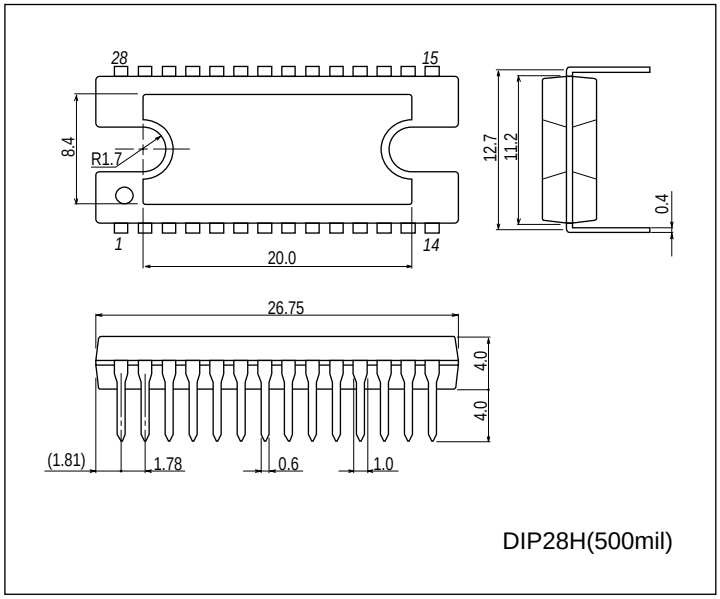
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Clock frequency	Fclk			200	550	kHz
Data setup time	TDS		0.9	2.5		µS
Data hold time	TDH		0.9	2.5		µS
Minimum clock high-level pulse width	TSCH		0.9	2.5		µS
Minimum clock low-level pulse width	TSCL		0.9	2.5		µS
SET pin stipulated time	Tlat		0.9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

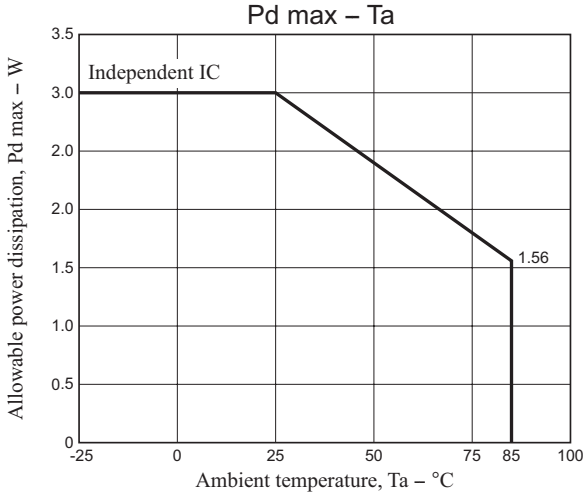


Package Dimensions

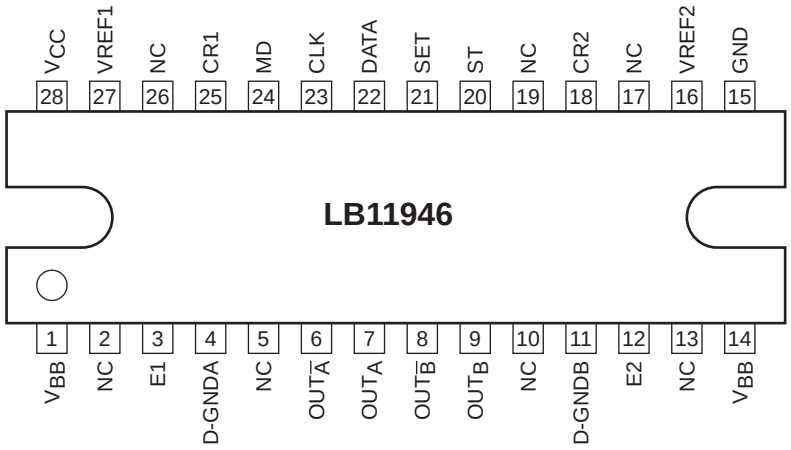
unit : mm (typ)

3147C



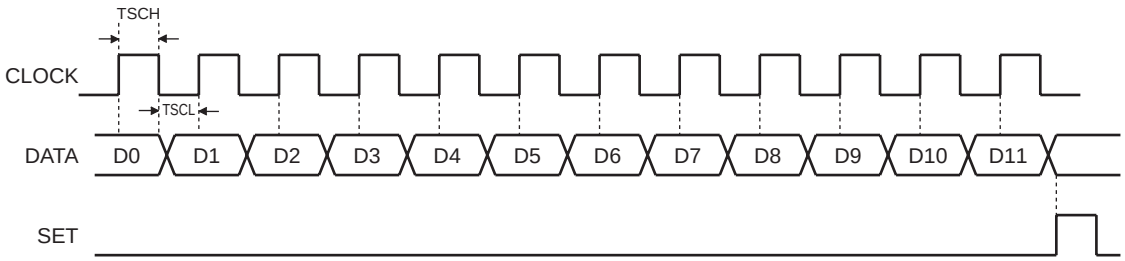


Pin Assignment



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	$OUT_{\overline{A}}$	OUT_B	$OUT_{\overline{B}}$		
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.

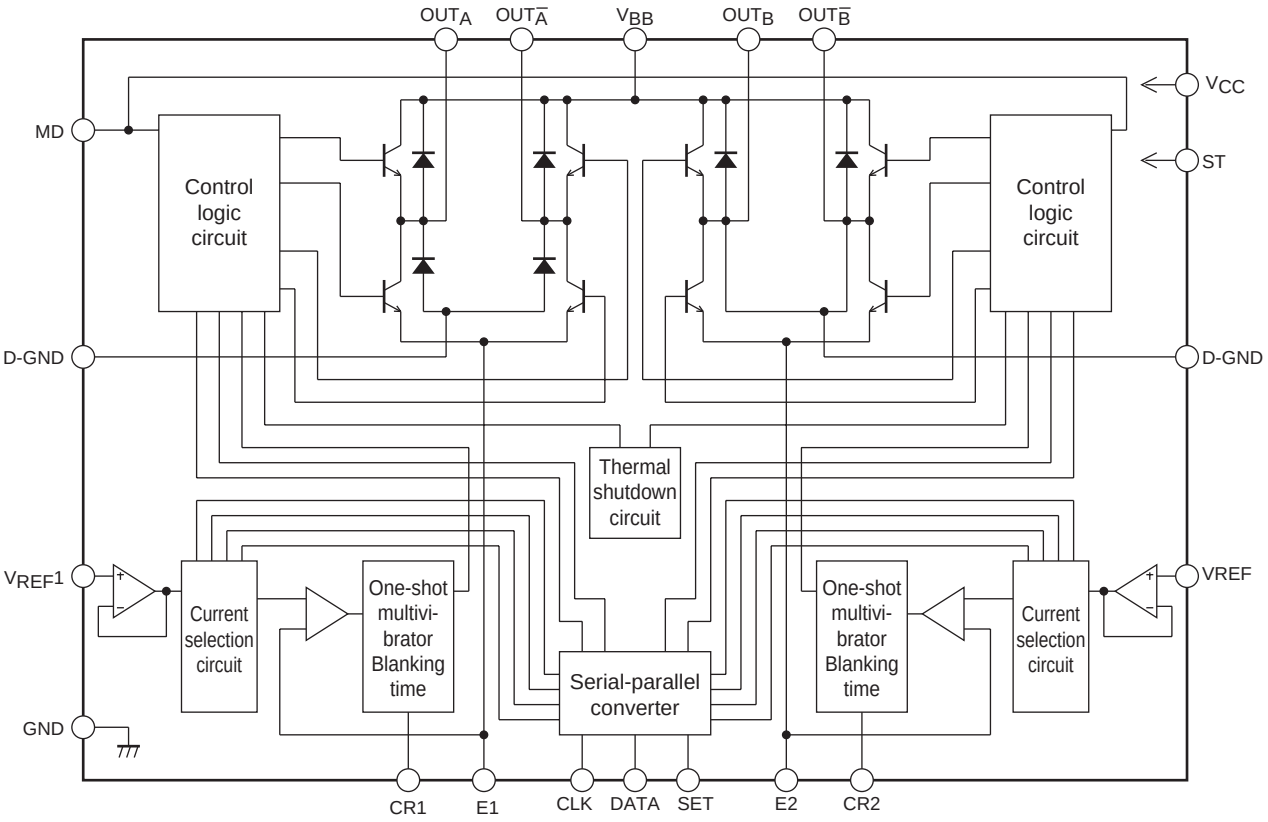
Note *1: In mixed decay mode, set D4 and D10 to 0 and set the MD pin to a level in the range 1.5 to 4.0V.

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

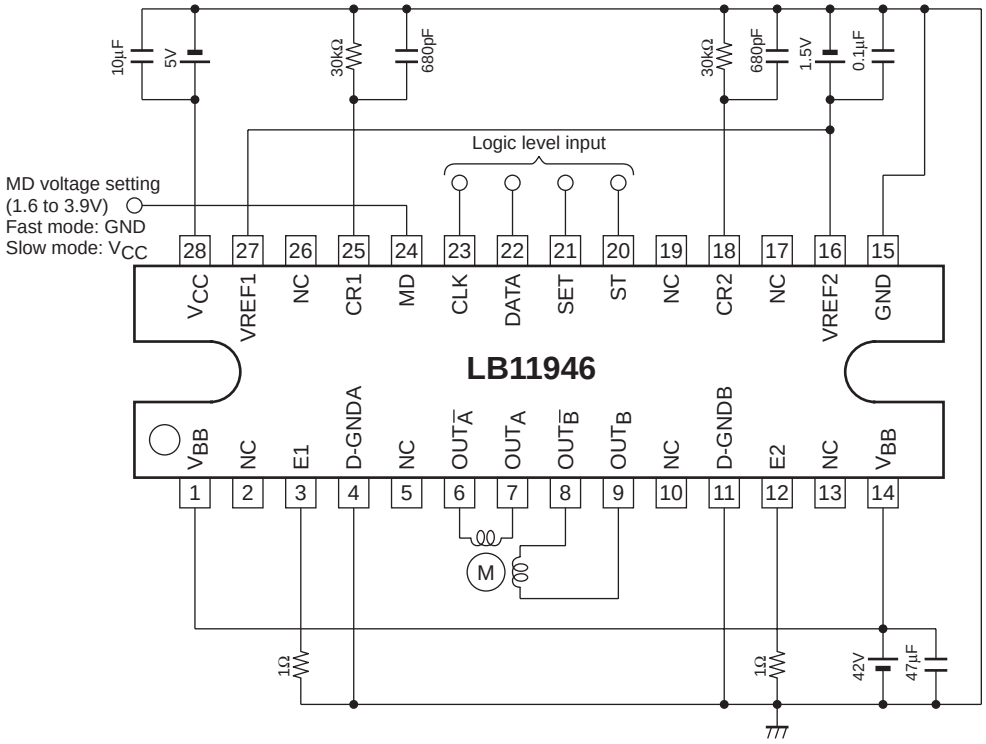
IA4 (D0)	IA3 (D1)	IA2 (D2)	IA1 (D3)	Set current Iout	Current ratio (%)
1	1	1	1	11.5/11.5 × VREF/3.04RE = Iout	100
1	1	1	0	11.0/11.5 × VREF/3.04RE = Iout	95.65
1	1	0	1	10.5/11.5 × VREF/3.04RE = Iout	91.30
1	1	0	0	10.0/11.5 × VREF/3.04RE = Iout	86.95
1	0	1	1	9.5/11.5 × VREF/3.04RE = Iout	82.61
1	0	1	0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

Note: The current ratios shown are calculated values.

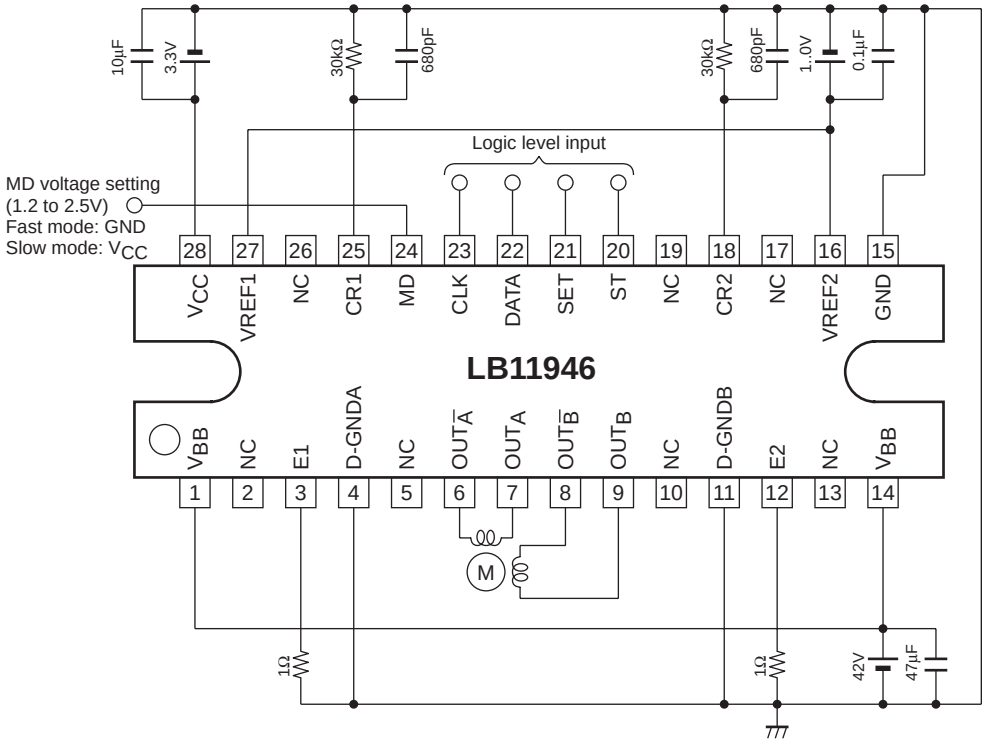
Block Diagram



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

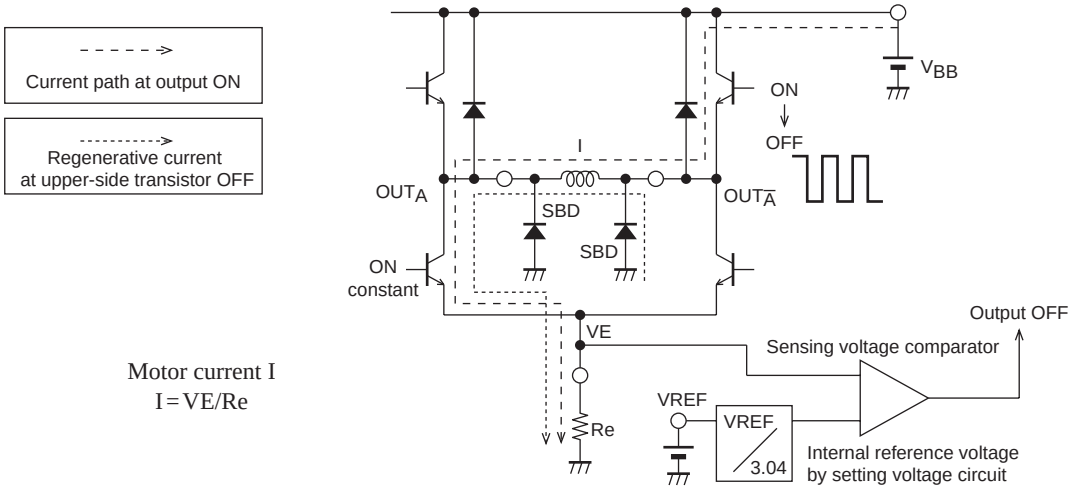


Fig.1

FAST DECAY Current Path

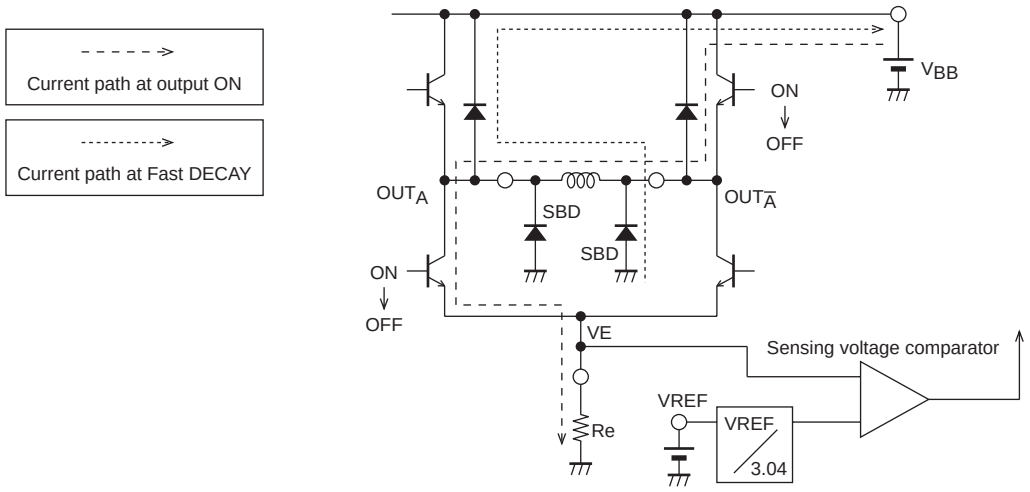
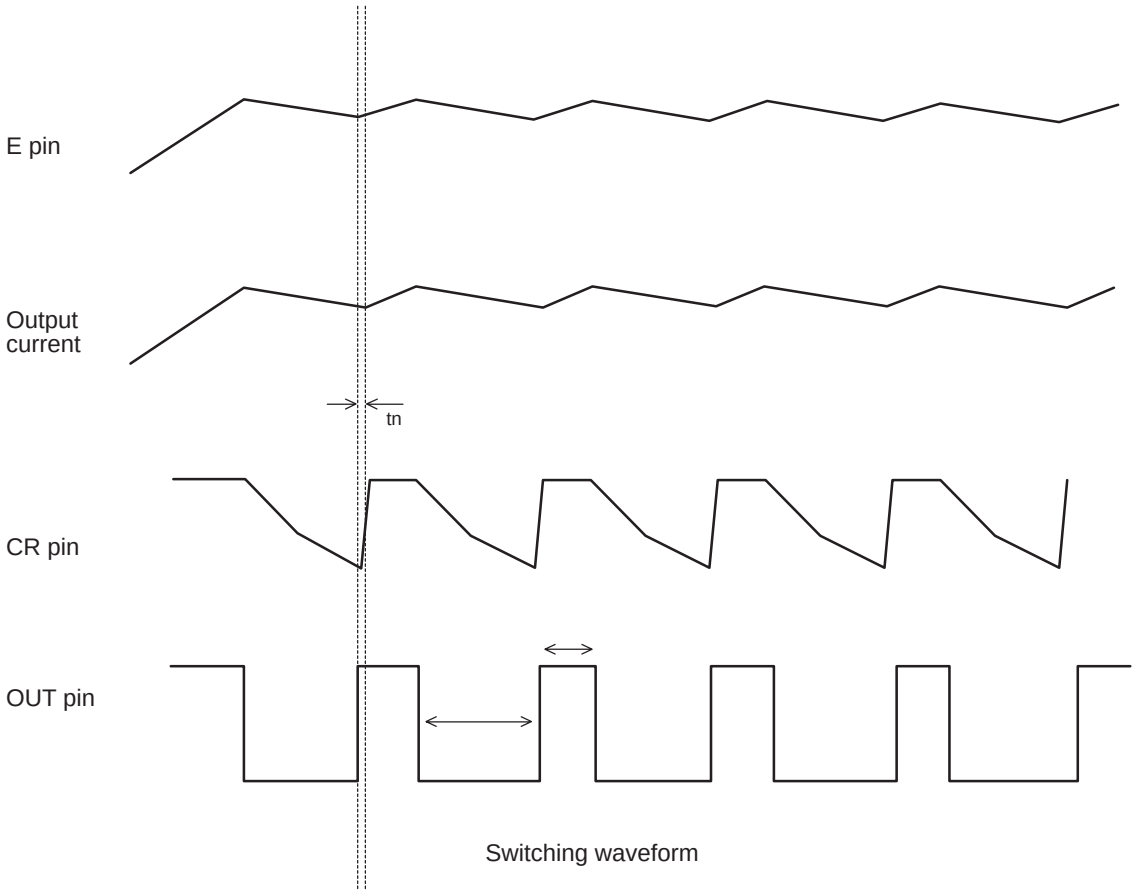


Fig.2

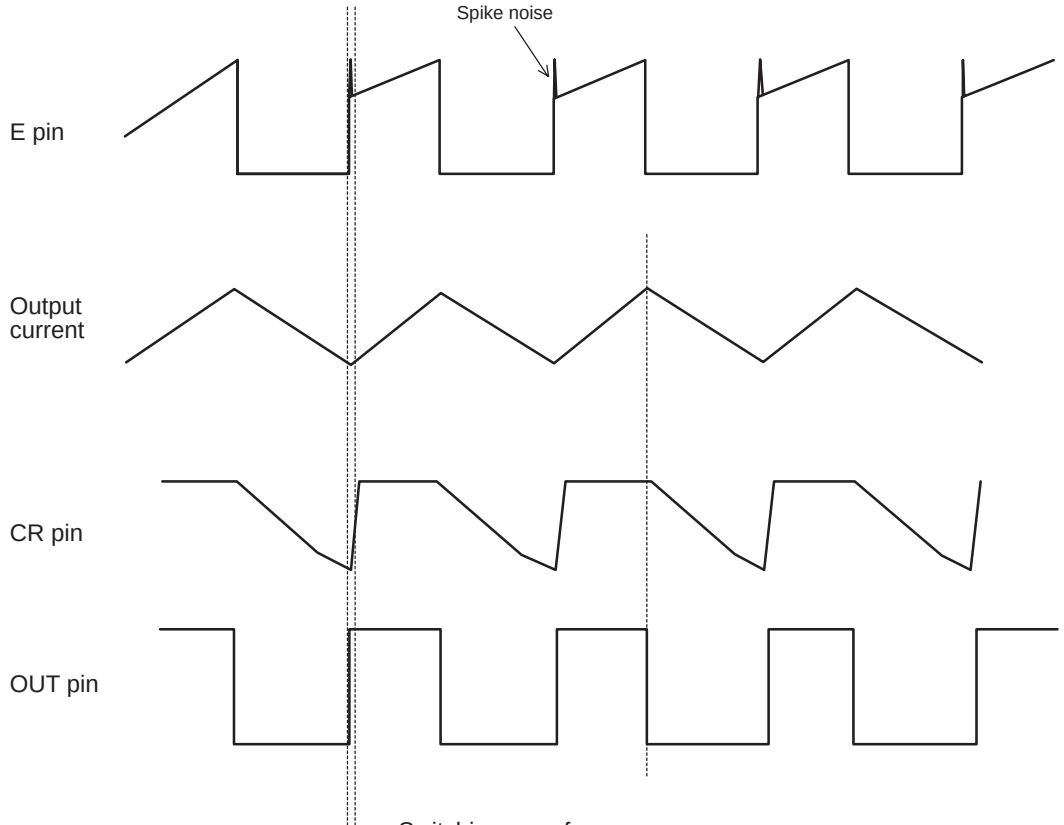
Switching Time Chart at PWM operation

SLOW DECAY (Upper-side Chopping) Serial transmission data (D4, D10) = High MD pin: Low setting

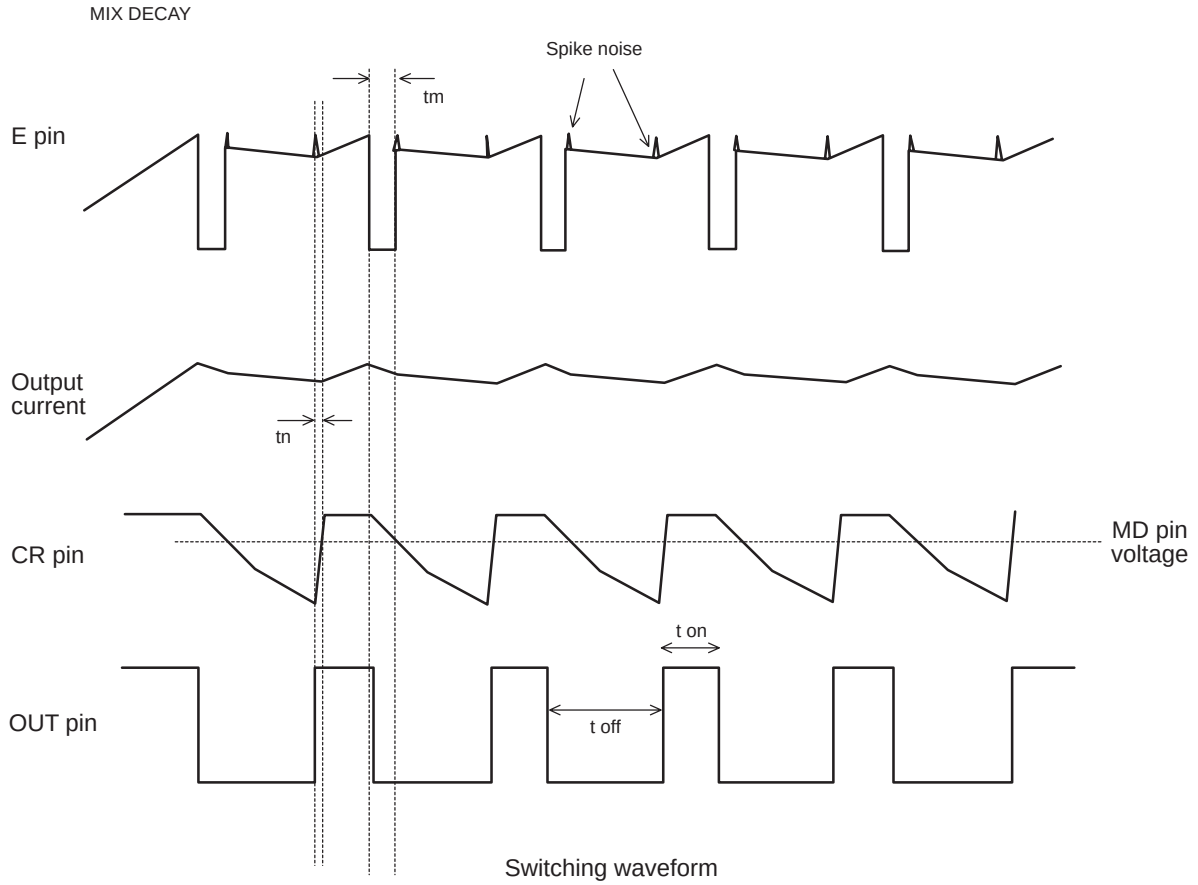


Switching waveform

FAST DECAY Serial transmission data (D4, D10) = Low MD pin: Low setting



Switching waveform



Switching waveform

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
tm: FAST DECAY time at MIX DECAY mode
tn: 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 V_{CC} is 5 V

Noise canceller time (Tn)

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

CR pin charge current: 1.25mA

Switching off time (Toff)

$Toff \approx -C \times R \times \ln (1.5/4.8)[s]$

Component value ranges
R: 5.6kΩ to 100kΩ
C: 470pF to 2000pF

(2) When V_{CC} is 3.3 V

Noise canceller time (Tn)

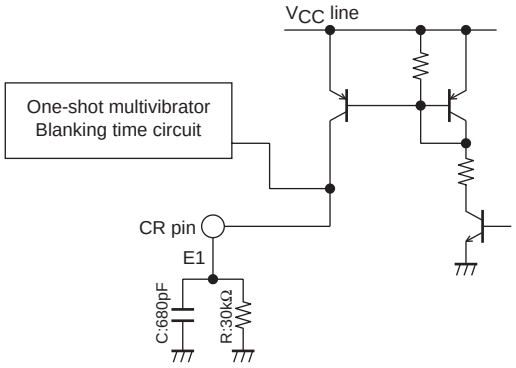
$Tn \approx C \times R \times \ln \{(1.06 - RI) / (2.66 - RI)\}[s]$

CR pin charge current: 0.7 mA

Switching off time (Toff)

$Toff \approx -C \times R \times \ln (1.06 / 3.1)[s]$

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 V_{CC} = 5V specifications are used the setting voltage range for mixed decay mode is 1.6 to 3.9V.
When the V_{CC} = 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 V_{CC} 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 (Re) 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.