Allowable Operating Ranges at Ta = 25°C

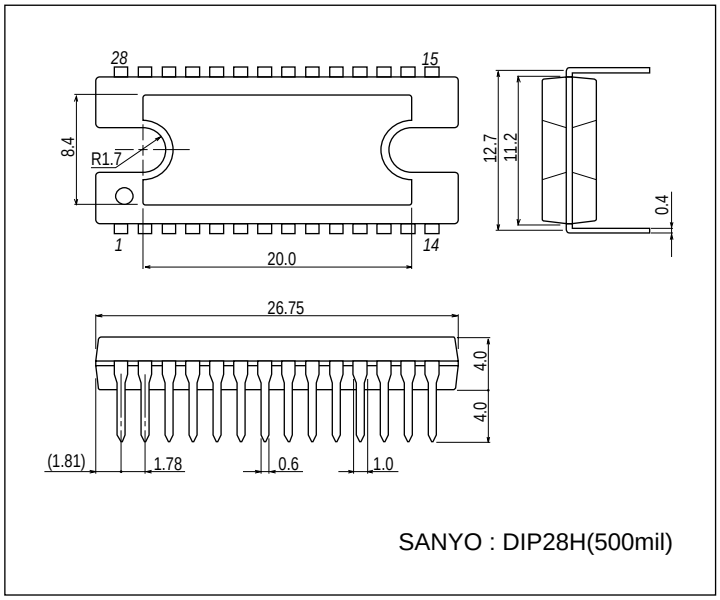
Parameter	Symbol	Conditions	Ratings	Unit
Motor supply voltage range	V_{BB}		10 to 45	V
Logic supply voltage	V_{CC}		4.75 to 5.25	V
Reference voltage range	V_{REF}		0.0 to 3.0	V

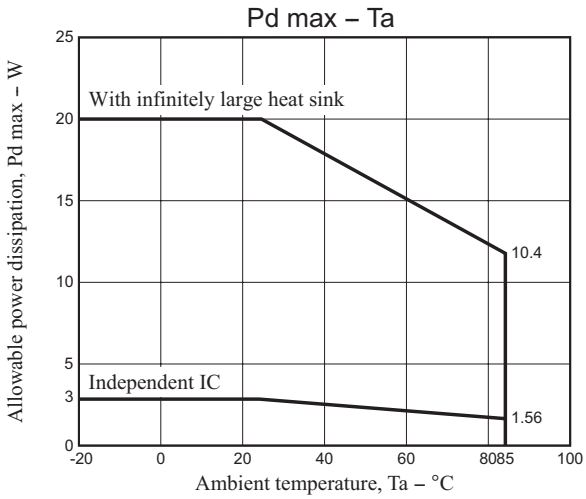
Electrical Characteristics at Ta = 25°C, V_{BB} = 45V, V_{CC} = 5V, V_{REF} = 1.52V

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Output Block						
Output stage supply voltage	I_{BB} ON		2.3	3.5	5.0	mA
	I_{BB} OFF		0.5	0.8	1.1	mA
Output saturation voltage	V_O(sat)1	I_O = +1.0A, sink		1.2	1.6	V
	V_O(sat)2	I_O = +1.5A, sink		1.5	1.9	V
	V_O(sat)3	I_O = -1.0A, source		1.9	2.2	V
	V_O(sat)4	I_O = -1.5A, source		2.2	2.4	V
Output leak current	I_O(leak)1	V_O = V_{BB}, sink			50	μA
	I_O(leak)2	V_O = 0V, source	-50			μA
Output sustain voltage	V_{SUS}	L = 15mH, I_O = 1.5A, Guaranteed design value *	45			V
Logic Block						
Logic supply voltage	I_{CC} ON	I_4 = 3.2V, I_3 = 3.2V, I_2 = 3.2V, I_1 = 3.2V	19.5	26	36.5	mA
	I_{CC} OFF	ENABLE = 3.2V	10.5	15	19.5	mA
Input voltage	V_{IH}		3.2			V
	V_{IL}				0.8	V
Input current	I_{IH}	V_{IH} = 3.2V			100	μA
	I_{IL}	V_{IL} = 0.8V	-10			μA
Sensing voltage	V_E	I_4 = 3.2V, I_3 = 3.2V, I_2 = 3.2V, I_1 = 3.2V	0.470	0.50	0.525	V
		I_4 = 3.2V, I_3 = 3.2V, I_2 = 3.2V, I_1 = 0.8V	0.445	0.48	0.505	V
		I_4 = 3.2V, I_3 = 3.2V, I_2 = 0.8V, I_1 = 3.2V	0.425	0.46	0.485	V
		I_4 = 3.2V, I_3 = 3.2V, I_2 = 0.8V, I_1 = 0.8V	0.410	0.43	0.465	V
		I_4 = 3.2V, I_3 = 0.8V, I_2 = 3.2V, I_1 = 3.2V	0.385	0.41	0.435	V
		I_4 = 3.2V, I_3 = 0.8V, I_2 = 3.2V, I_1 = 0.8V	0.365	0.39	0.415	V
		I_4 = 3.2V, I_3 = 0.8V, I_2 = 0.8V, I_1 = 3.2V	0.345	0.37	0.385	V
		I_4 = 3.2V, I_3 = 0.8V, I_2 = 0.8V, I_1 = 0.8V	0.325	0.35	0.365	V
		I_4 = 0.8V, I_3 = 3.2V, I_2 = 3.2V, I_1 = 3.2V	0.280	0.30	0.325	V
		I_4 = 0.8V, I_3 = 3.2V, I_2 = 3.2V, I_1 = 0.8V	0.240	0.26	0.285	V
		I_4 = 0.8V, I_3 = 3.2V, I_2 = 0.8V, I_1 = 3.2V	0.195	0.22	0.235	V
		I_4 = 0.8V, I_3 = 3.2V, I_2 = 0.8V, I_1 = 0.8V	0.155	0.17	0.190	V
		I_4 = 0.8V, I_3 = 0.8V, I_2 = 3.2V, I_1 = 3.2V	0.115	0.13	0.145	V
		I_4 = 0.8V, I_3 = 0.8V, I_2 = 3.2V, I_1 = 0.8V	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	-4.6		-1.0	mA
MD pin current	I_{MD}	MD = 1.0V, CR = 4.0V	-5.0			μA
DECAY pin current Low	I_{DECL}	V_{DEC} = 0.8V	-10			μA
DECAY pin current High	I_{DECH}	V_{DEC} = 3.2V			5	μA
Thermal shutdown temperature	TSD			170		°C
Logic ON voltage	$L_{VSD}1$		3.35	3.65	3.95	V
Logic OFF voltage	$L_{VSD}2$		3.20	3.50	3.80	V
LVSD hysteresis width	ΔL_{VSD}		0.065	0.15	0.23	V

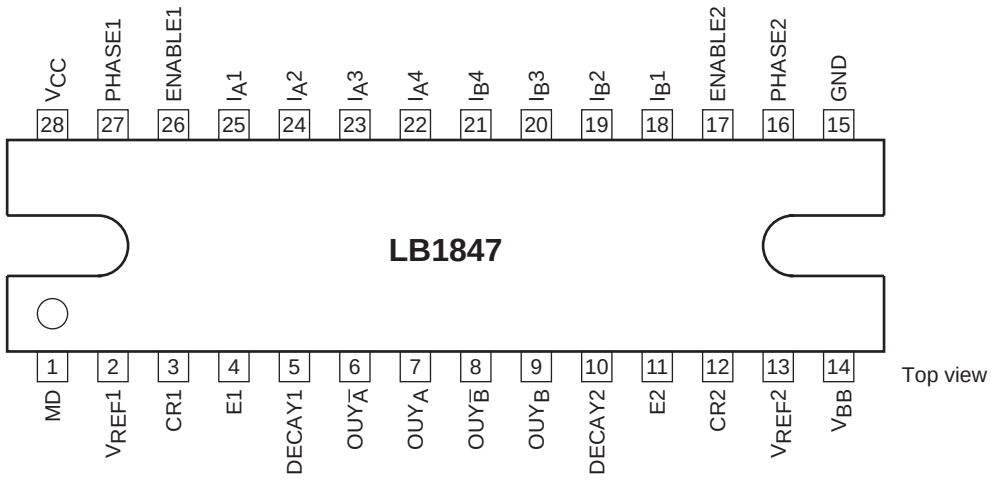
Package Dimensions

unit : mm (typ)
3147C

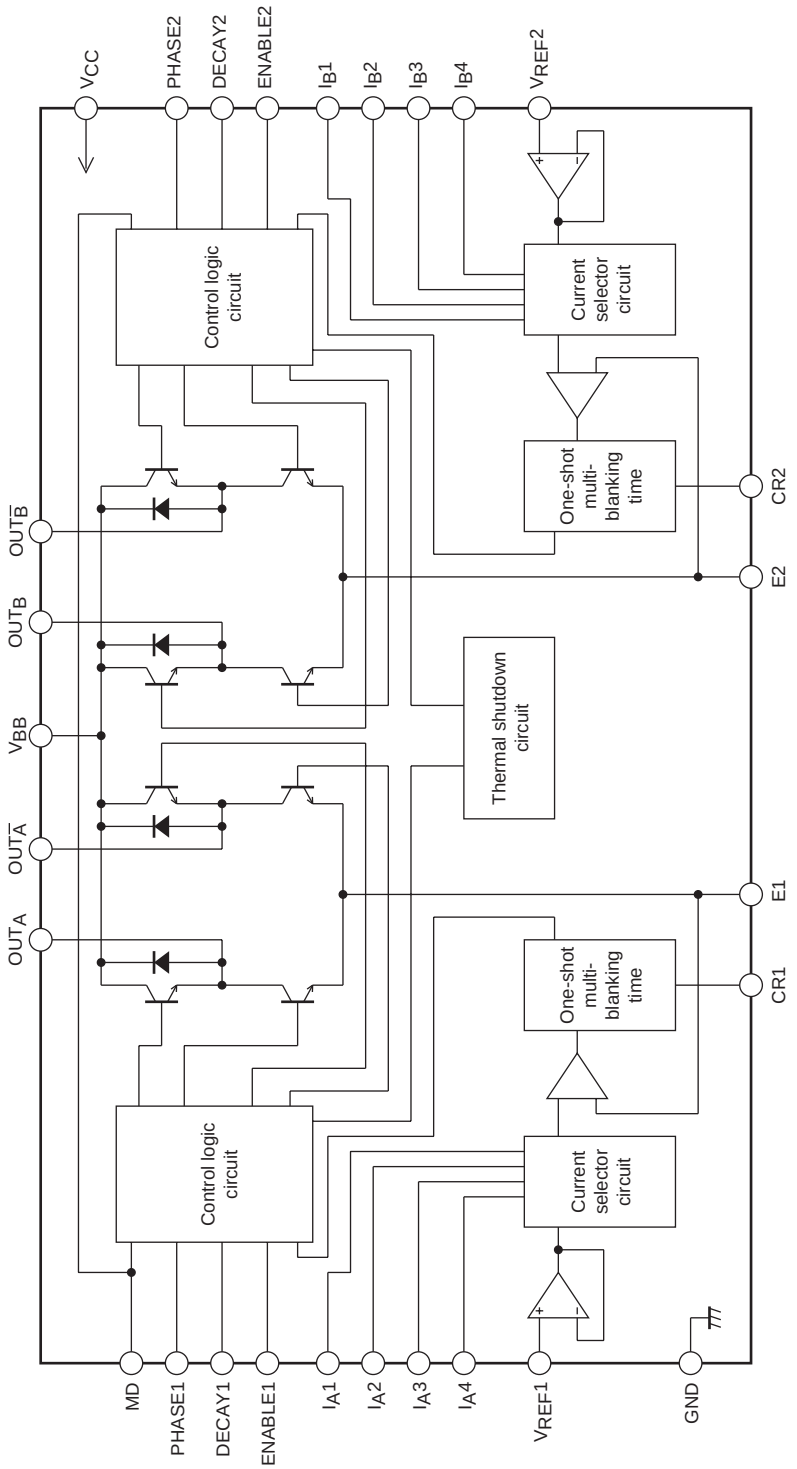




Pin Assignment



Block Diagram



Pin Function

Pin No.	Pin name	Function
1	MD	Sets the OFF time for FAST mode and SLOW mode in MIX DECAY. Setting input range: 4V to 1.5V.
2 13	$V_{REF}1$ $V_{REF}2$	Output set current reference supply pin. Setting voltage range: 0V to 3V.
3 12	CR1 CR2	Output OFF time setting pin for switching operation.
4 11	E1 E2	Pin for controlling the set current with sensing resistor RE.
5 10	DECAY1 DECAY2	SLOW mode/FAST mode selector pin. DECAY2 SLOW DECAY: H FAST DECAY: L
6 7 8 9	$OUT_{\overline{A}}$ OUT_A $OUT_{\overline{B}}$ OUT_B	Output pin.
14	V_{BB}	Output stage supply voltage pin.
15	GND	Ground pin.
27 16	PHASE1 PHASE2	Output phase selector input pin
26 17	ENABLE1 ENABLE2	Output ON/OFF setting input pin.
22,23 24,25 21,20 19,18	I_A4,I_A3 I_A2,I_A1 I_B4,I_B3 I_B2,I_B1	Output set current digital input pin. 15-stage voltage setting.
28	V_{CC}	Logic block supply voltage pin

Truth Table

PHASE	ENABLE	OUT_A	$OUT_{\overline{A}}$
H	L	H	L
L	L	L	H
–	H	OFF	OFF

Set Current Truth Table

I_A4	I_A3	I_A2	I_A1	Set current Iout	Current ratio
1	1	1	1	11.5/11.5 × V_{REF}/3.04RE = Iout	100
1	1	1	0	11.0/11.5 × V_{REF}/3.04RE = Iout	95.65
1	1	0	1	10.5/11.5 × V_{REF}/3.04RE = Iout	91.30
1	1	0	0	10.0/11.5 × V_{REF}/3.04RE = Iout	86.95
1	0	1	1	9.5/11.5 × V_{REF}/3.04RE = Iout	82.61
1	0	1	0	9.0/11.5 × V_{REF}/3.04RE = Iout	78.26
1	0	0	1	8.5/11.5 × V_{REF}/3.04RE = Iout	73.91
1	0	0	0	8.0/11.5 × V_{REF}/3.04RE = Iout	69.56
0	1	1	1	7.0/11.5 × V_{REF}/3.04RE = Iout	60.87
0	1	1	0	6.0/11.5 × V_{REF}/3.04RE = Iout	52.17
0	1	0	1	5.0/11.5 × V_{REF}/3.04RE = Iout	43.48
0	1	0	0	4.0/11.5 × V_{REF}/3.04RE = Iout	34.78
0	0	1	1	3.0/11.5 × V_{REF}/3.04RE = Iout	26.08
0	0	1	0	2.0/11.5 × V_{REF}/3.04RE = Iout	17.39

* Current ratio (%) is the calculated set current value.

Current Decay Switching Truth Table

Current decay mode	DECAY pin	MD pin	Output chopping
SLOW DECAY	H	L	Upper-side chopping
FAST DECAY	L	L	Dual-side chopping
MIX DECAY	L	4V to 1.5V input voltage setting	CR voltage > MD: dual-side chopping CR voltage < MD: upper-side chopping

Sequence Table

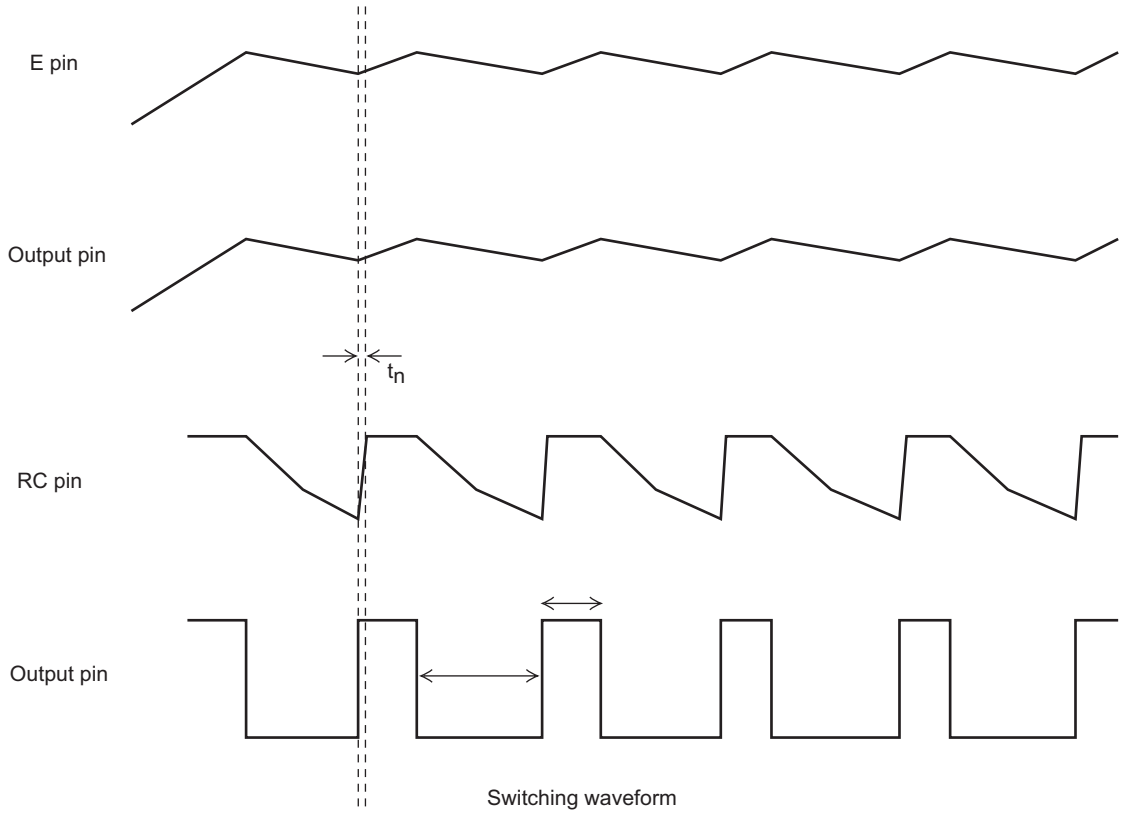
	Phase A							Phase B							Phase 1-2	Phase W1-2	Phase 2W1-2	Phase 4W1-2
No.	I_A4	I_A3	I_A2	I_A1	ENA1	PHA1	Iout	I_B4	I_B3	I_B2	I_B1	ENA2	PHA2	Iout				
0	1	1	1	1	0	0	100%	0	0	1	0	1	*	0%	○	○	○	○
1	1	1	1	1	0	0	100	0	0	1	0	0	0	17.39				○
2	1	1	1	1	0	0	100	0	0	1	1	0	0	26.08			○	○
3	1	1	1	0	0	0	95.65	0	1	0	0	0	0	34.78				○
4	1	1	0	1	0	0	91.30	0	1	0	1	0	0	43.48		○	○	○
5	1	1	0	0	0	0	86.95	0	1	1	0	0	0	52.17				○
6	1	0	1	1	0	0	82.61	0	1	1	1	0	0	60.87			○	○
7	1	0	1	0	0	0	78.26	1	0	0	0	0	0	69.56				○
8	1	0	0	1	0	0	73.91	1	0	0	1	0	0	73.91	○	○	○	○
9	1	0	0	0	0	0	69.56	1	0	1	0	0	0	78.26				○
10	0	1	1	1	0	0	60.87	1	0	1	1	0	0	82.61			○	○
11	0	1	1	0	0	0	52.17	1	1	0	0	0	0	86.95				○
12	0	1	0	1	0	0	43.48	1	1	0	1	0	0	91.30		○	○	○
13	0	1	0	0	0	0	34.78	1	1	1	0	0	0	95.65				○
14	0	0	1	1	0	0	26.08	1	1	1	1	0	0	100			○	○
15	0	0	1	0	0	0	17.39	1	1	1	1	0	0	100				○
16	0	0	0	1	1	*	0	1	1	1	1	0	0	100	○	○	○	○
17	0	0	1	0	0	1	17.39	1	1	1	1	0	0	100				○
18	0	0	1	1	0	1	26.08	1	1	1	1	0	0	100			○	○
19	0	1	0	0	0	1	34.78	1	1	1	0	0	0	95.65				○
20	0	1	0	1	0	1	43.48	1	1	0	1	0	0	91.30		○	○	○
21	0	1	1	0	0	1	52.17	1	1	0	0	0	0	86.95				○
22	0	1	1	1	0	1	60.87	1	0	1	1	0	0	82.61			○	○
23	1	0	0	0	0	1	69.56	1	0	1	0	0	0	78.26				○
24	1	0	0	1	0	1	73.91	1	0	0	1	0	0	73.91	○	○	○	○
25	1	0	1	0	0	1	78.26	1	0	0	0	0	0	69.56				○
26	1	0	1	1	0	1	82.61	0	1	1	1	0	0	60.87			○	○
27	1	1	0	0	0	1	86.95	0	1	1	0	0	0	52.17				○
28	1	1	0	1	0	1	91.30	0	1	0	1	0	0	43.48		○	○	○
29	1	1	1	0	0	1	95.65	0	1	0	0	0	0	34.78				○
30	1	1	1	1	0	1	100	0	0	1	1	0	0	26.08			○	○
31	1	1	1	1	0	1	100	0	0	1	0	0	0	17.39				○

* Don't care

Note: Iout percentage (%) is the calculated setting value.

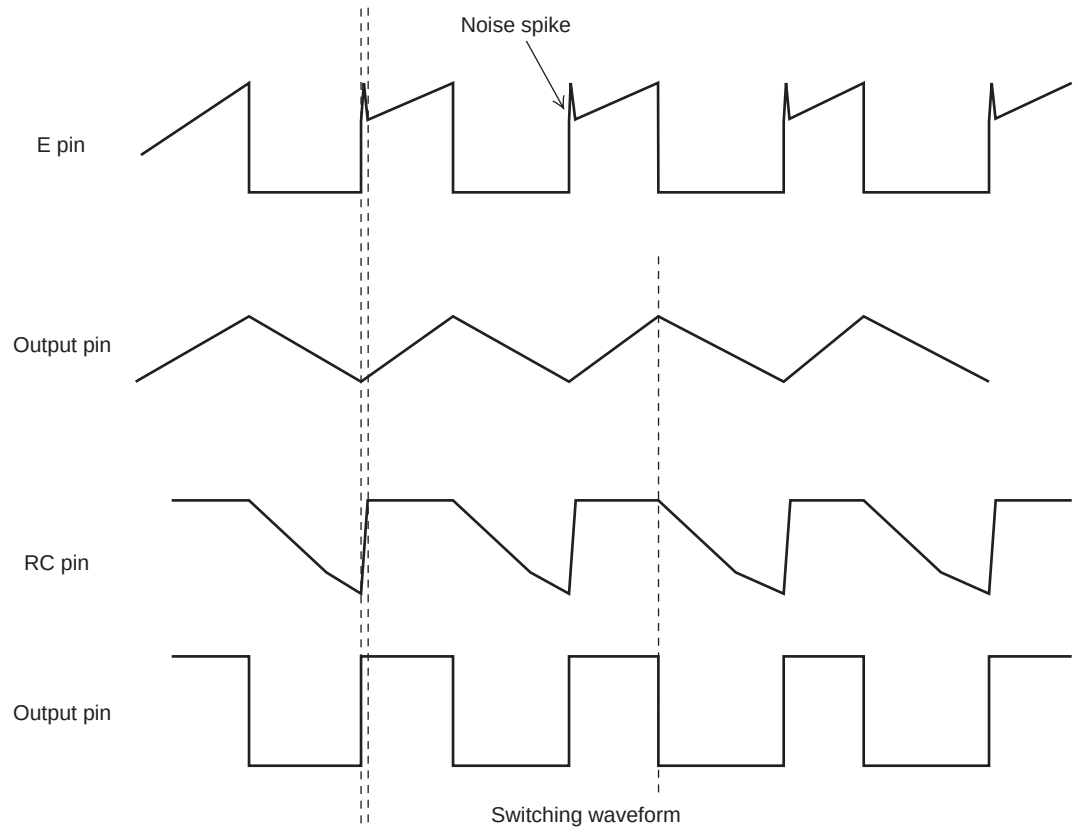
Switch Timing Chart During PWM Drive

SLOW DECAY (upper-side chopping)
DECAY pin: High MD pin: Low



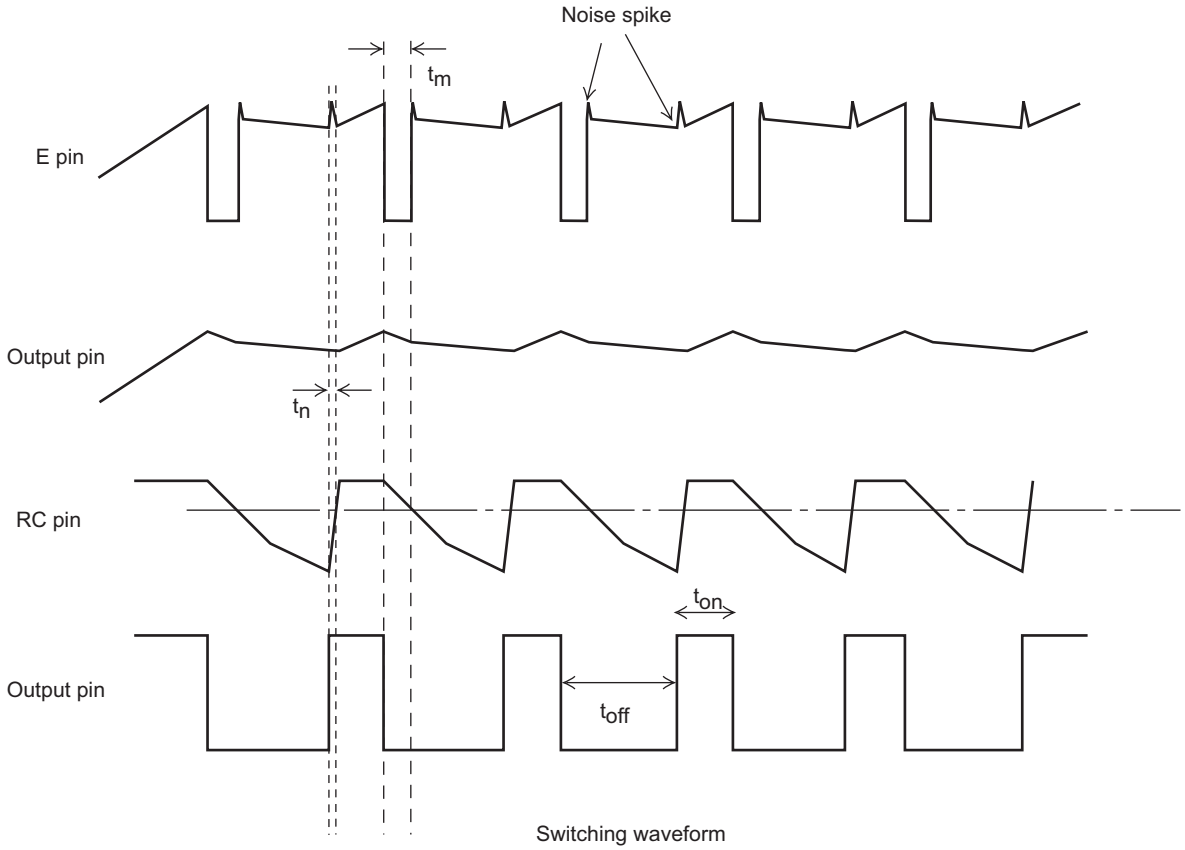
Switching waveform

FAST DECAY
DECAY pin: Low MD pin: Low



Switching waveform

MIX DECAY



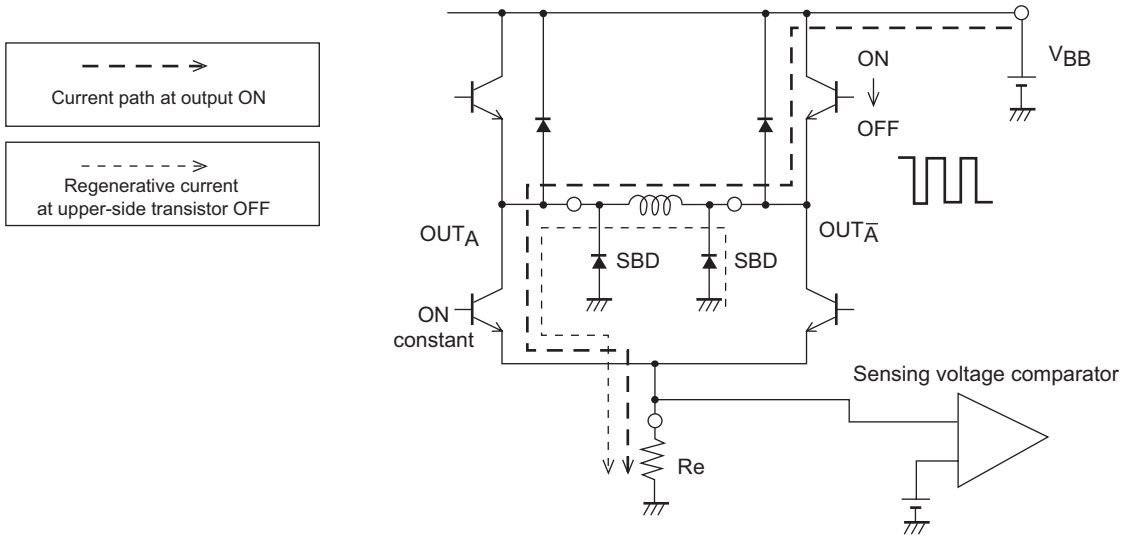
ton : Output ON time
toff : Output OFF time
tm : FAST DECAY time in MIX DECAY mode
tn : Noise cancelling time

MIX DECAY logic setting

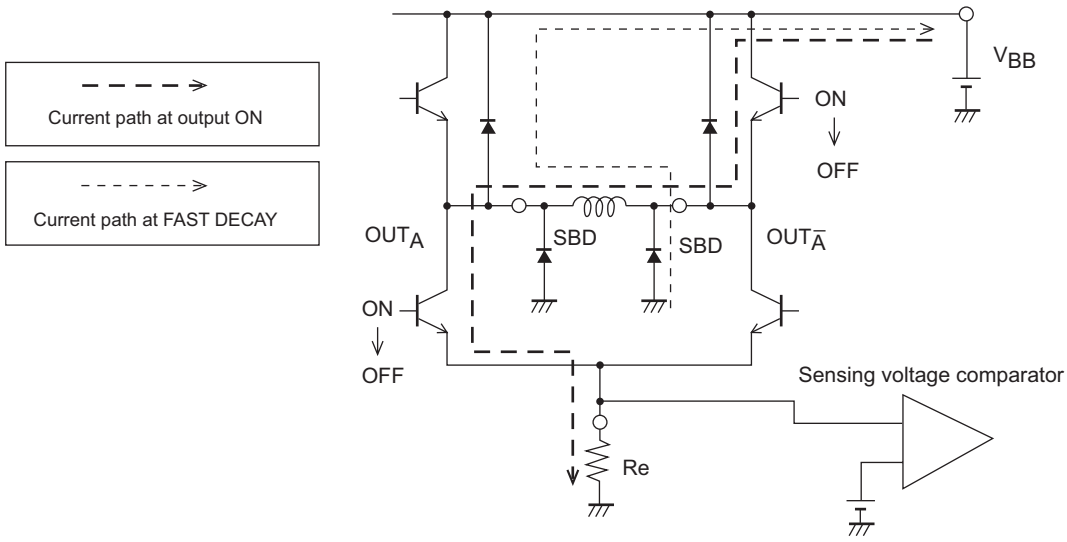
DECAY pin : L
MD pin : 1.5V to 4.0V voltage setting
CR voltage and MD pin voltage are compared to select dual-side chopping or upper-side chopping.
CR voltage > MD pin voltage: dual-side chopping
CR voltage < MD pin voltage: upper-side chopping

SLOW DECAY Current Path

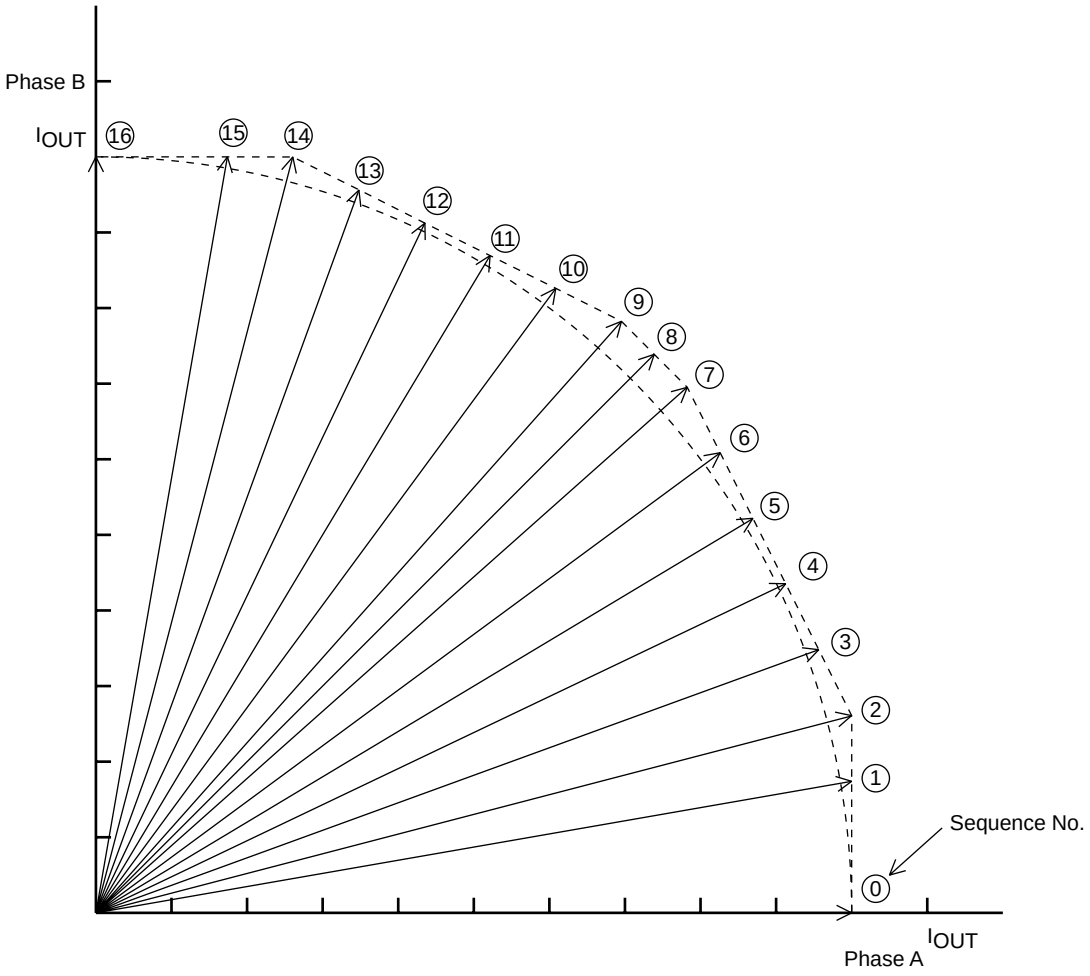
Regenerative current during upper-side transistor switching operation



FAST DECAY Current Path



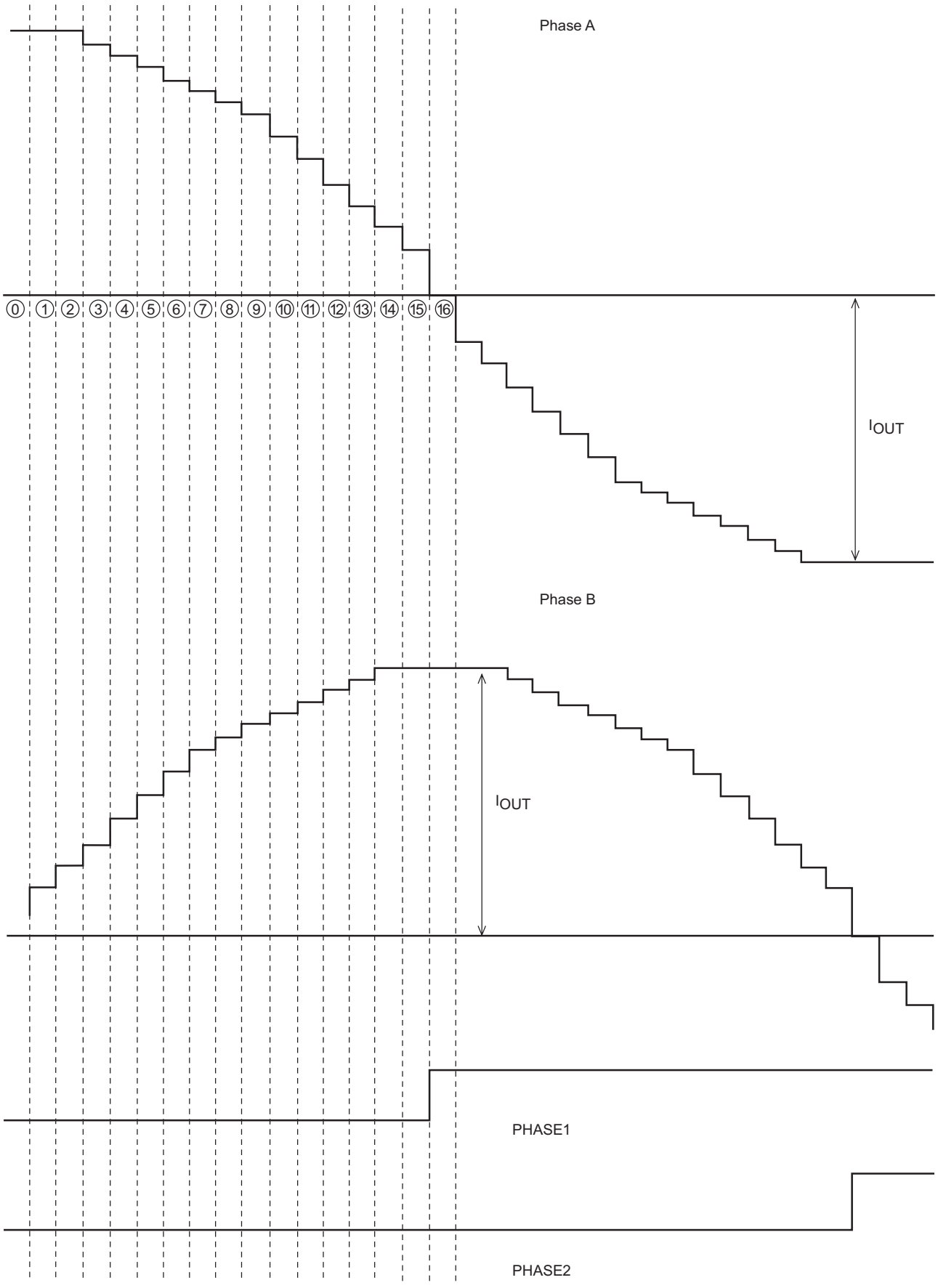
Composite Spectrum of Set Current (1 step normalized to 90°)



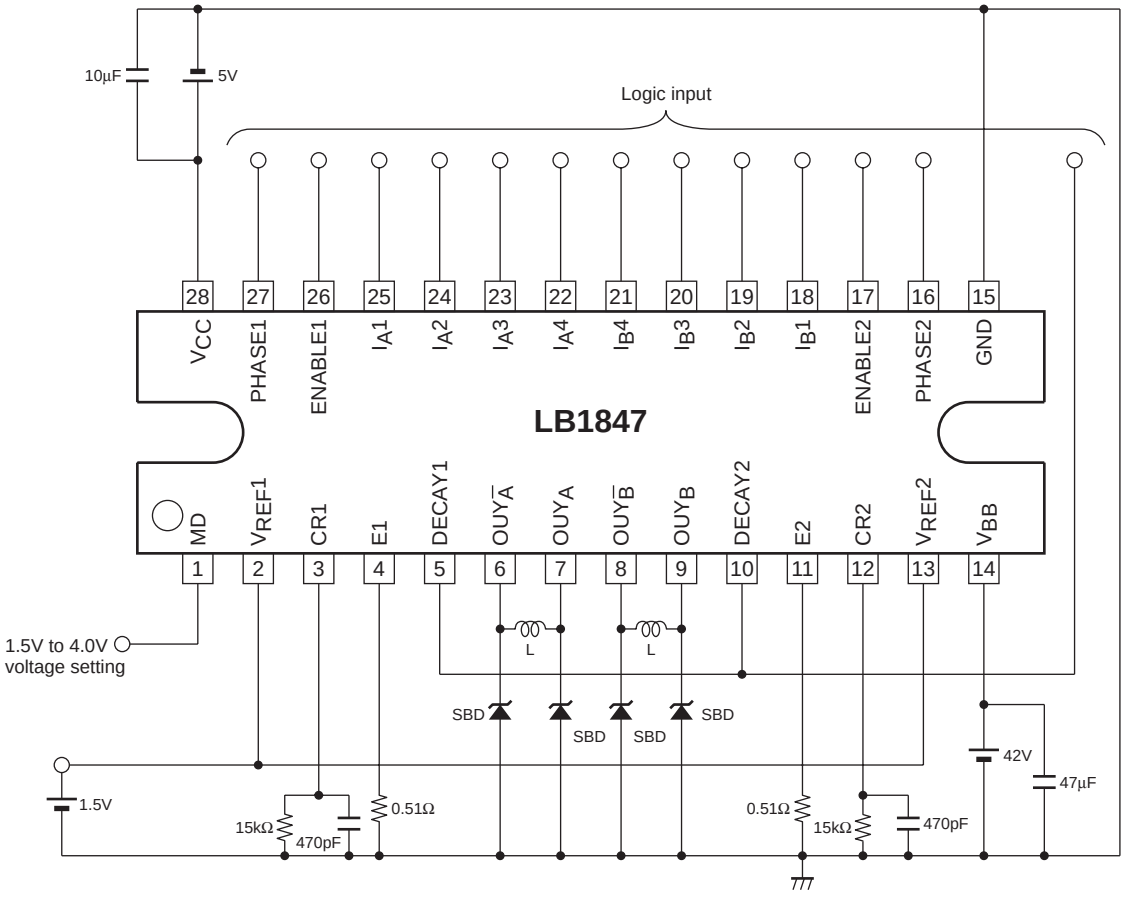
No.	θ	Rotation angle	Composite spectrum
0	θ_0	0°	100.0
1	θ_1	9.87°	101.5
2	θ_2	14.6°	103.35
3	θ_3	20.0°	101.78
4	θ_4	25.5°	101.12
5	θ_5	30.96°	101.4
6	θ_6	36.38°	102.61
7	θ_7	41.63°	104.7
8	θ_8	45.0°	104.5
9	θ_9	48.37°	104.7
10	θ_{10}	53.62°	102.61
11	θ_{11}	59.04°	101.4
12	θ_{12}	64.5°	101.12
13	θ_{13}	70.0°	101.78
14	θ_{14}	75.4°	103.35
15	θ_{15}	80.13°	101.5
16	θ_{16}	90.0°	100.0

* Rotation angle and composite spectrum are calculated values.

Set Current Waveform Model



Sample Application Circuit



Notes on Usage

1. External diodes
   Because this IC uses upper-side transistor switching in SLOW DECAY mode and dual-side transistor switching in FAST DECAY mode, it requires external diodes between the OUT pins and ground, for the regenerative current during switching OFF. Use Schottky barrier diodes with low VF.

2. VREF pin
   Because the VREF pin serves for input of the set current reference voltage, precautions against noise must be taken. The input voltage range is 0 to 3.0V.

3. GND pin
   The ground circuit for this IC must be designed so as to allow for high-current switching. Blocks where high current flows must use low-impedance patterns and must be removed from small-signal lines. Especially the ground connection for the sensing resistor RE at pin E, and the ground connection for the Schottky barrier diodes should be in close proximity to the IC ground.
   The capacitors between V_{CC} and ground, and V_{BB} and ground should be placed close to the V_{CC} and V_{BB} pins, respectively.

4. Simultaneous ON prevention function

This IC incorporates a circuit to prevent feed-through current when phase switching. For reference, the output ON and OFF delay times at PHASE and ENABLE switching are given below.

Reference Data * typical value

		Sink side	Source side
PHASE switching (Low → Hi)	ON delay time	1.9μs	2.2μs
	OFF deley time	0.8μs	1.8μs
PHASE switching (Hi → Low)	ON delay time	1.4μs	1.7μs
	OFF deley time	0.9μs	1.35μs
ENABLE switching	ON delay time	2.15μs	2.75μs
	OFF deley time	1.2μs	5.8μs

5. Noise canceler

This IC has a noise canceling function to prevent malfunction due to noise spikes generated when switching ON. The noise cancel time tn is determined by internal resistance of the CR pin and the constant of the externally connected CR components. The constant also determines the switching OFF time.
Figure 1 shows the internal configuration at the CR pin, and Figure 2 the CR pin constant setting range.

Equation when logic voltage V_{CC} = 5V
CR pin voltage E1 = $V_{CC} \times R / (R1 + R2 + R)$ [V]
Noise cancel time tn ≈ $(R1 + R2) \times C \times 1n \{(E1 - 1.5) / (E1 - 4.0)\}$ [s]
Switching OFF time toff ≈ $-R \times C \times 1n (1.5 / E1)$ [s]
Internal resistance at CR pin : R1 = 1kΩ, R2 = 300Ω (typ.)

*The CR constant setting range in Figure 2 on page 15 is given for reference. It applies to a switching OFF time in the range from 8 to 100μs. The switching time can also be made higher than 100 ms. However, a capacitor value of more than several thousand pF will result in longer noise canceling time, which can cause the output current to become higher than the set current. The longer switching OFF time results in higher output current ripple, causing a drop in average current and rotation efficiency. When keeping the switching OFF time within 100 ms, it is recommended to stay within the CR constant range shown in Figure 2.

Internal configuration at CR pin

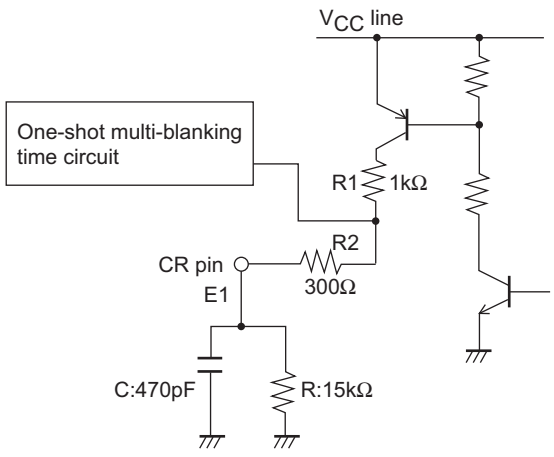


Figure 1

Switching OFF time and CR setting range
(t_{off} time : approx. 8 to 100µs)