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SHARP

Reference

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To;

S P E C I F I C A T I O N S

Product Type 6 Segment LED Driver IC

IR2E53Y7

Model No.

※ This specifications contains 53 pages including the cover and appendix.
If you have any objections, please contact us before issuing purchasing order.

CUSTOMERS ACCEPTANCE

DATE :

BY :

PRESENTED

BY : H. Fujita

H. Fujita
Dept. General Manager

REVIEWED BY : H. Morikawa

PREPARED BY : A. Tokura

Engineering Dept. IV
Opto-Analog Devices Division
Electronic Components Group
SHARP Corporation

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● Please direct all queries regarding the products covered herein to a sales representative of the company.

Content

1. General Description

This IC incorporates LED driver for illumination with animated control.
This IC is equipped with 3-colum driver and 6 segment driver circuit. And This IC can controll 6-RGB LED or 18-single LED in maximum.
All LED brightness can continuously be changed with internal animation logic circuit.
This IC is equipped with charge pump DC/DC converter to drive LED.
This IC supports I^2C-Bus interface.
This product is optimum for use as the illumination LED driver IC for cellular phone and PDA applications, etc.

2. Features

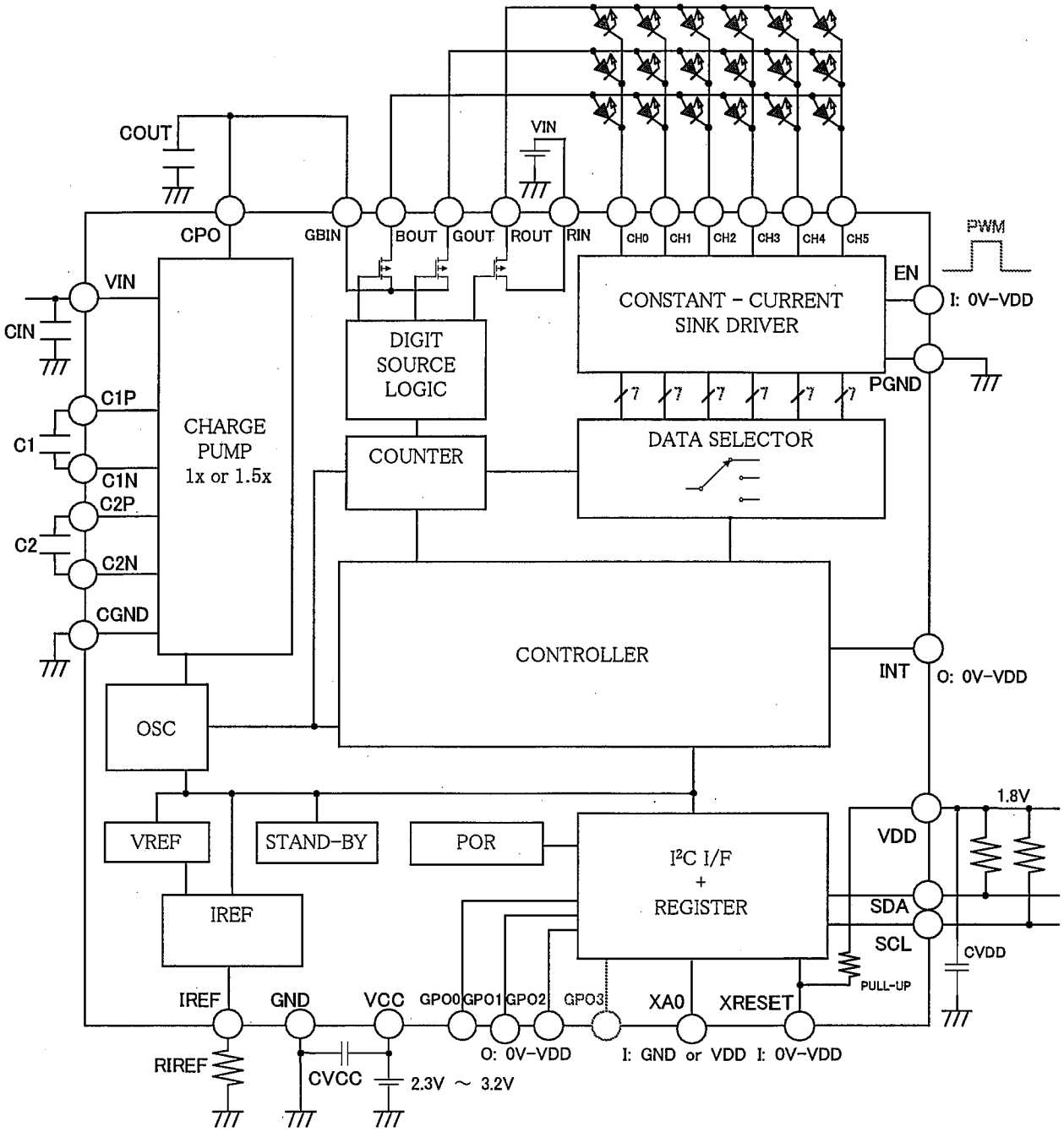
- Supply Voltage Range: VIN=3.0V to 4.5V, VCC=2.3V to 3.2V
- Supports I^2C-Bus interface
- Supports I^2C Extend address
- SCL pin and SDA pin are installed with noise filters.
- 6Ch Sink-type variable constant current driver for LED (maximum current 25.9mA)
- Control logic circuit for animated illumination embedded
- Output-enable circuit embedded
- 1x/1.5x Modes Charge Pump: Automatically Selected
- Voltage reference embedded
- Power-on-reset circuit embedded
- Soft-Start Limits Inrush Current
-

Radiation resistance designing:	No
Package:	35-pin WL-CSP package (3.57mm x 3.57mm)
Chip material and wafer board type:	P-type silicon substrate monolithic IC
Lead surface finish:	Lead-free
Process:	CMOS

3. Terminal name

Pin No	Pin name	Description
A1	U1A	Non-connect. This terminal is connected to pin No. F6 (U2F).
A2	VDD	Supply voltage for I/O buffer of I^2C, GPO and INT pin.
A3	IREF	Resistor connection terminal for reference current setting of LED drivers.
A4	XRESET	Hard reset terminal.
A5	SCL	I^2C clock input.
A6	GPO0	General purpose output.
B1	GBIN	Source terminal of column driver for ROUT and GOUT pin.
B2	GPO2	General purpose output.
B3	VCC	Power supply terminal.
B4	SDA	I^2C data Input/Output terminal.
B5	EN	Enable for all LED
B6	CH1	Constant current output terminal.
C1	GOUT	Column driver terminal to anode terminal of green LED
C2	INT	Interrupt output terminal.
C4	GPO3	General purpose output.
C5	CH0	Constant current output terminal.
C6	PGND	LED driver ground.
D1	RIN	Source terminal of column driver for ROUT pin.
D2	BOUT	Column driver terminal to anode terminal of blue LED
D3	GND	Ground terminal for control.
D4	XA0	I^2C address configuration input.
D5	CH2	Constant current output terminal.
D6	CH3	Constant current output terminal.
E1	VIN	Power supply terminal for charge pump.
E2	ROUT	Column driver terminal to anode terminal of red LED.
E3	C1N	Flying capacitor 1 negative connection.
E4	CH4	Constant current output terminal.
E5	CH5	Constant current output terminal.
E6	CGND	Ground terminal for charge pump.
F1	GPO1	General purpose output.
F2	C1P	Flying capacitor 1 positive connection.
F3	CPO	Output voltage terminal of charge pump.
F4	C2P	Flying capacitor 2 positive connection.
F5	C2N	Flying capacitor 2 negative connection.
F6	U2F	Non-connect. This terminal is connected to pin No. A1 (U1A).

4. Block Diagram



5. Pin Assignment

	1	2	3	4	5	6
A	U1A	VDD	IREF	XRESET	SCL	GPO0
B	GBIN	GPO2	VCC	SDA	EN	CH1
C	GOUT	INT		GPO3	CH0	PGND
D	RIN	BOUT	GND	XA0	CH2	CH3
E	VIN	ROUT	C1N	CH4	CH5	CGND
F	GPO1	C1P	CPO	C2P	C2N	U2F

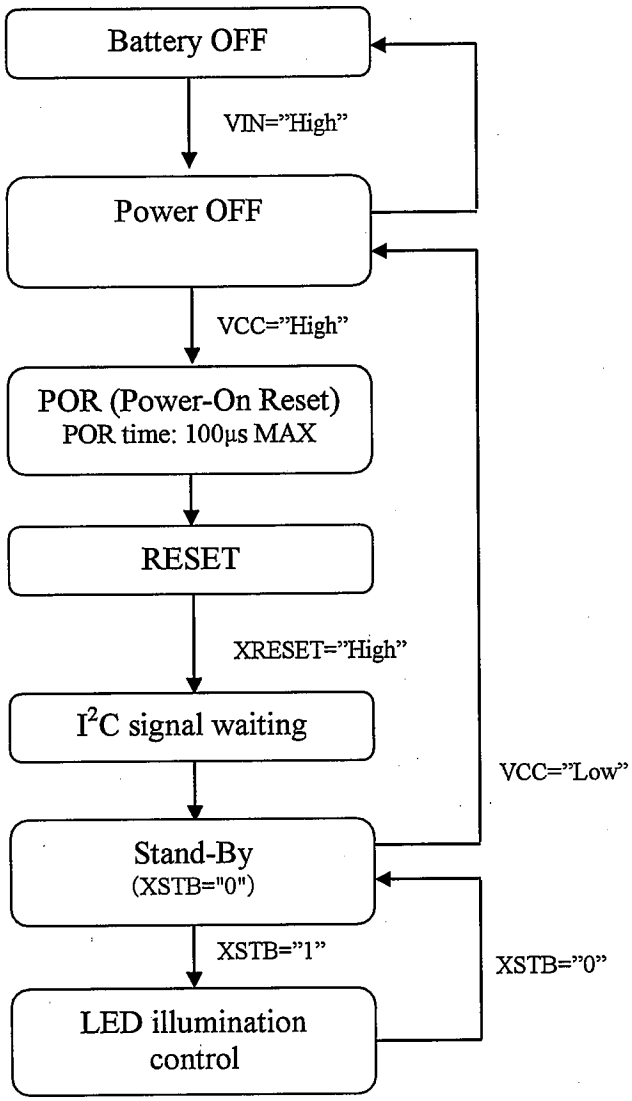
Note: Pins are located on the underside.

6. Peripheral Parts List

Type	Name	Maximum applied voltage(V)	Parts	Value
Smoothing capacitor	CVIN	6V	Temperature characteristICs code:B	1.0μF
Smoothing capacitor	CVCC	4.5V	Temperature characteristICs code:B	1.0μF
Smoothing capacitor	CVDD	3.3V	Temperature characteristICs code:B	1.0μF
Smoothing capacitor	COUT	8V	Temperature characteristICs code:B	2.2μF
Flying capacitor	C1	4.5V	Temperature characteristICs code:B	1.0μF
Flying capacitor	C2	4.5V	Temperature characteristICs code:B	1.0μF
Reference resistance	RIREF	-	Tolerance:±1%	13kΩ
Light-emitting diode	LED	-	GN1WA55320A	-

7. Function Operation

This IC is equipped with the LED driver circuit, the charge pump DC/DC converter that supply electricity to LED, I²C interface and general purpose outputs.
The operation of the IC can be set by the built-in register through the I²C interface.
I²C interface can use standby state or LED driver control mode.



7.1 Constant current driver

This IC is equipped with a sink-type variable constant current driver for LED.
This IC is connectable to 6-RGB LED or 18-single LED for illumination.
The maximum current of a constant current driver is the value set up by peripheral resistance. It is also possible to perform the ON/OFF control using the enable/disable pin (EN pin).
Connect driver terminal to VCC when LED is unconnected.

7.1.1 ON/OFF control of constant current driver

Constant current driver is also possible to perform the ON/OFF control using the EN pin.
EN pin can be disabled with the EXT_EN register.
The logic of EN pin can be reversed. with the EN_XEN register.

EN pin is an input terminal that controls ON/OFF of the Constant current driver.

Pin Name	Setting	Description(as EN_XEN=0)
EN	High	ON(output)
	Low	OFF(no output)

"EXT_EN" is a register that enables or disables the EN pin.

Symbol	Initial Value	Setting	Description
EXT_EN	0	1	EN pin enabled
		0	EN pin disabled

"EN_XEN" is a register that reverses the logic of EN pin.

Symbol	Initial Value	Setting	Description
EN_XEN	0	1	Constant current driver is enabled in terminal EN=H
		0	Constant current driver is enabled in terminal EN=L.

Truth tabe of the constant current driver pin

I^2C register			EN pin	Constant current driver
XSTB	EXT_EN	EN_XEN		
0	*	*	*	OFF
1	1	1	High	ON
1	1	1	Low	OFF
1	1	0	High	OFF
1	1	0	Low	ON
1	0	*	*	ON

Note: "*" indicates that the selection dose not matter.

7.1.2 Current setting of constant current driver

The output current from each driver can be varied to 16 steps. The variable range is 0 to 25.9mA with a step of about 1.8mA.

In the ANIME mode, the redundancy bit is added to achieve a smooth current change in the animated illumination, and it changes into 128 steps.

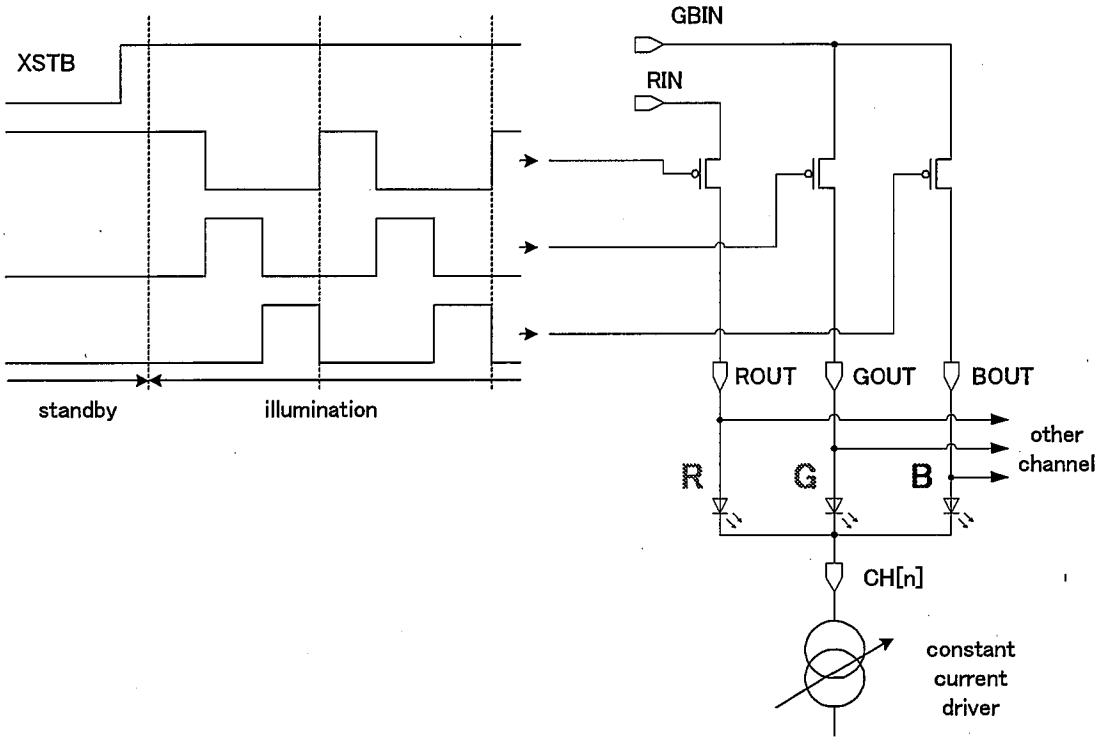
The starting point and the ending point of the animated illumination are set by 16 steps as well as the NORMAL mode and the BLINK mode.

CH[RGB][n][3:0] a register that sets the CH0,CH1,CH2,CH3,CH4 and CH5 pin current.

Symbol	Description	Setting			Inital Value	Value	Unit
		BINAA	DECCC	HEXXX			
CH[RGB][n][3:0]	Constant current driver output current	0000	0	00H	00H	0.0	mA
		0001	1	01H		1.9	
		0010	2	02H		3.6	
		0011	3	03H		5.4	
		0100	4	04H		7.1	
		0101	5	05H		8.8	
		0110	6	06H		10.5	
		0111	7	07H		12.2	
		1000	8	08H		13.9	
		1001	9	09H		15.6	
		1010	10	0AH		17.3	
		1011	11	0BH		19.0	
		1100	12	0CH		20.8	
		1101	13	0DH		22.5	
		1110	14	0EH		24.2	
		1111	15	0FH		25.9	

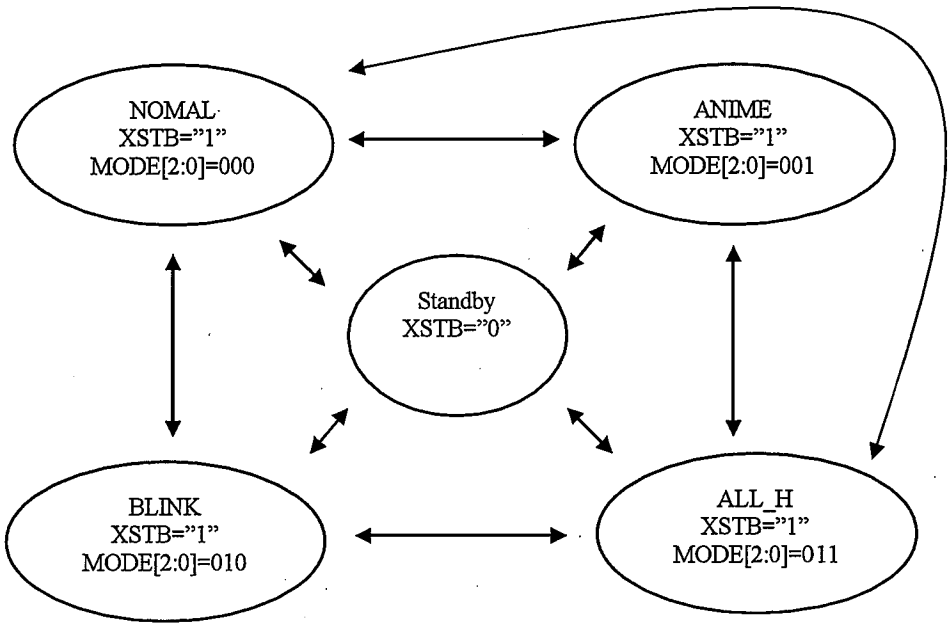
7.2 Column driver

Three column drivers are built into this IC. RGBLED for each one current driver or three single LED can be driven by timesharing by connecting the anode of LED with ROUT, GOUT, and BOUT. The column driver of ROUT is always turned on at the standby state.



7.3 Illumination mode select

This IC has 4 LED illumination mode, various illuminations can be displayed.
The illumination mode is selected from MODE[2:0] register.



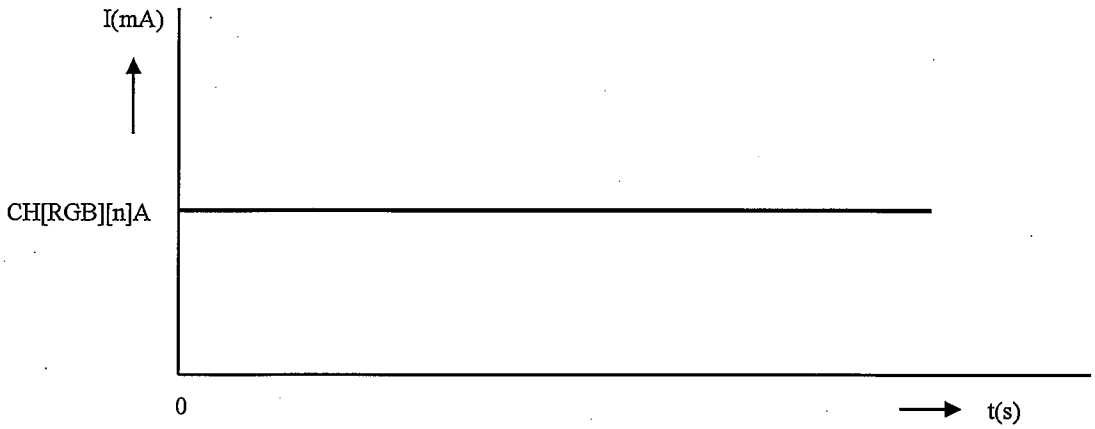
Note: The arrow is a mode that is possible to change.

MODE[2:0] a register that sets illumination mode. Do not set it from 100 to 111.

Symbol	Description	Setting			Initial Value	Value	Unit
		BIN	DEC	HEX			
MODE[2:0]	illumination mode	000	0	00H	00H	NOMAL	-
		001	1	01H		ANIME	
		010	2	02H		BLINK	
		011	3	03H		ALL_H	
		100	4	04H		inhibit	
		101	5	05H		inhibit	
		110	6	06H		inhibit	
		111	7	07H		inhibit	

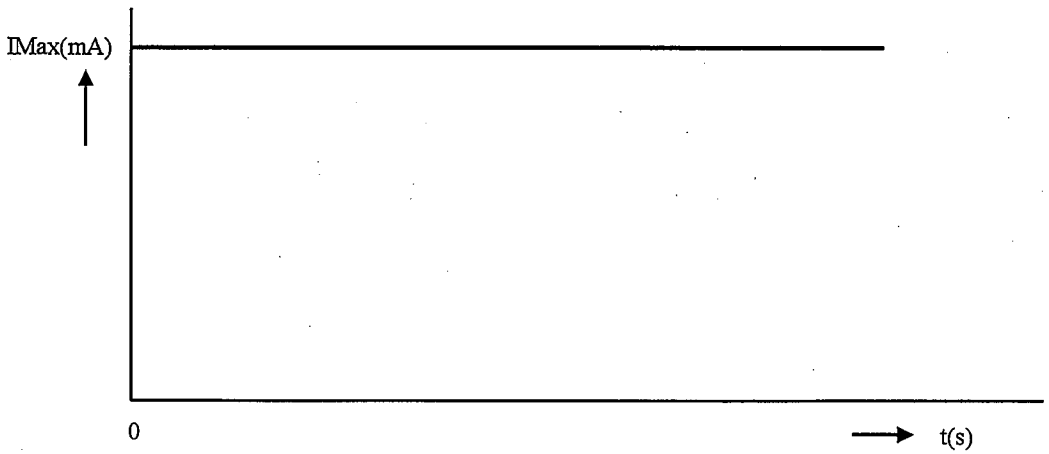
7.3.1 Normal mode

In Normal mode, current value written in CH[RGB][n]A register is outputted to the constant current driver.



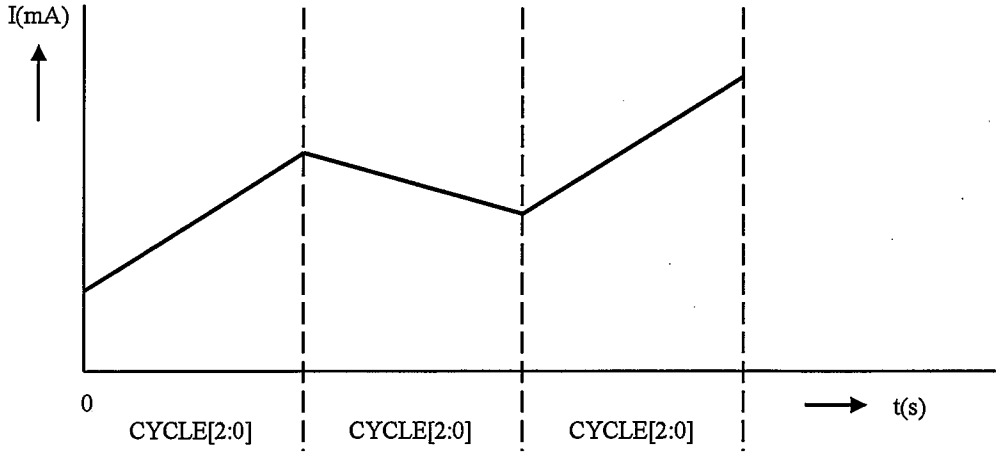
7.3.2 ALL_H mode

In ALL_H mode, MAX current value is output to all constant current driver.



7.3.3 ANIME mode

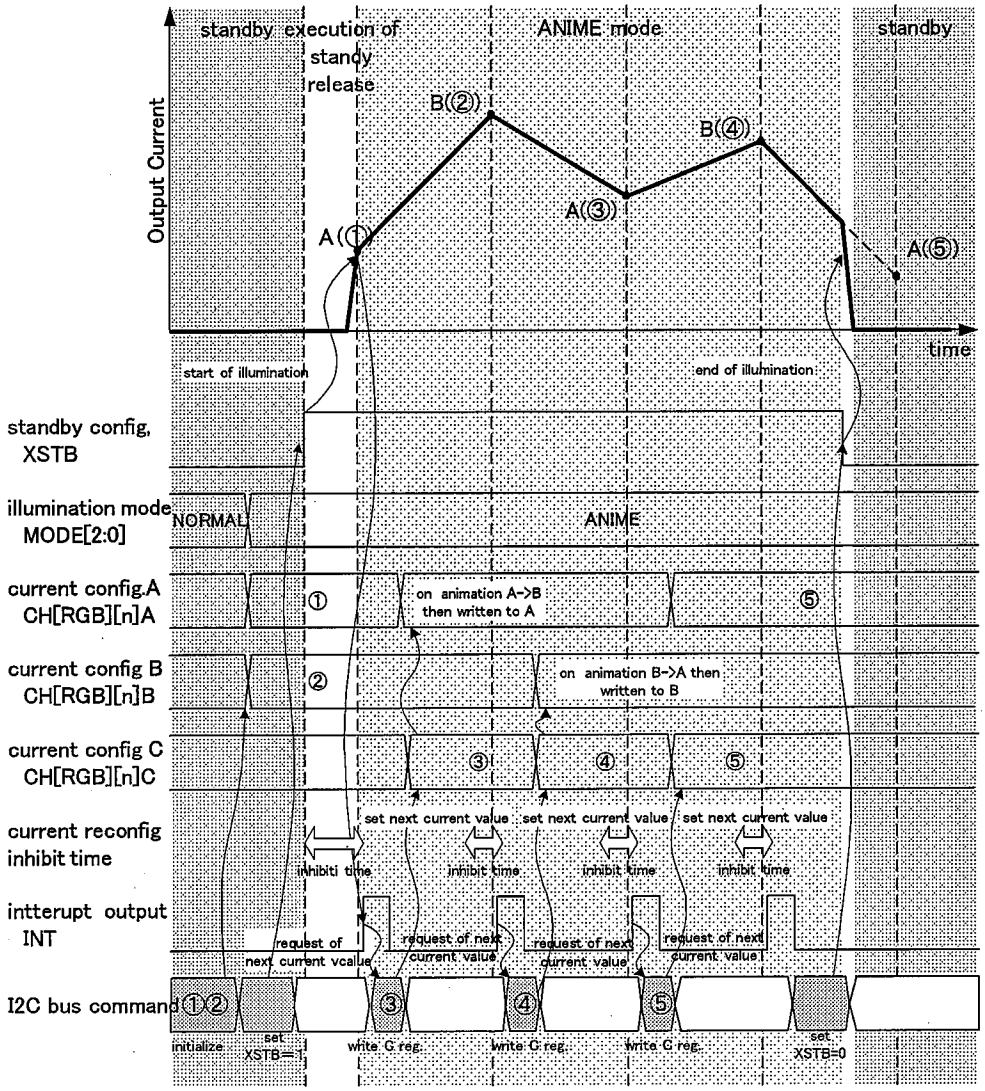
In ANIME mode, CH[RGB][n]A, CH[RGB][n]B, CH[RGB][n]A, and the current change gradually.
Timing to which the setting of the current of the driver is changed is time set with CYCLE[2:0].



CH[RGB][n]A1 → CH[RGB][n]B1 → CH[RGB][n]A2 → CH[RGB][n]B2

7.3.3.1 Basic operation on ANIME mode

In the ANIME mode, first of all, the current of the starting point and the following point is set to CH[RGB][n]A and CH[RGB][n]B. The current of the following respect is one by one set to CH[RGB][n]C register every cycle continuously set with CYCLE[3:0] register. The current in which LED is driven can be continuously changed by this operation.
When it becomes possible the setting of the following value, the INT signal is output, and this IC demands the setting from the host side.
The substance of CH[RGB][n]C register is either CH[RGB][n]A and CH[RGB][n]B. It is automatically allocated in the point of the next cycle while displaying it. Therefore, it is possible to set it consciously of a present display continuously.



7.3.3.2 ANIME mode Initialization

The following setting is necessary for the ANIME mode operation.

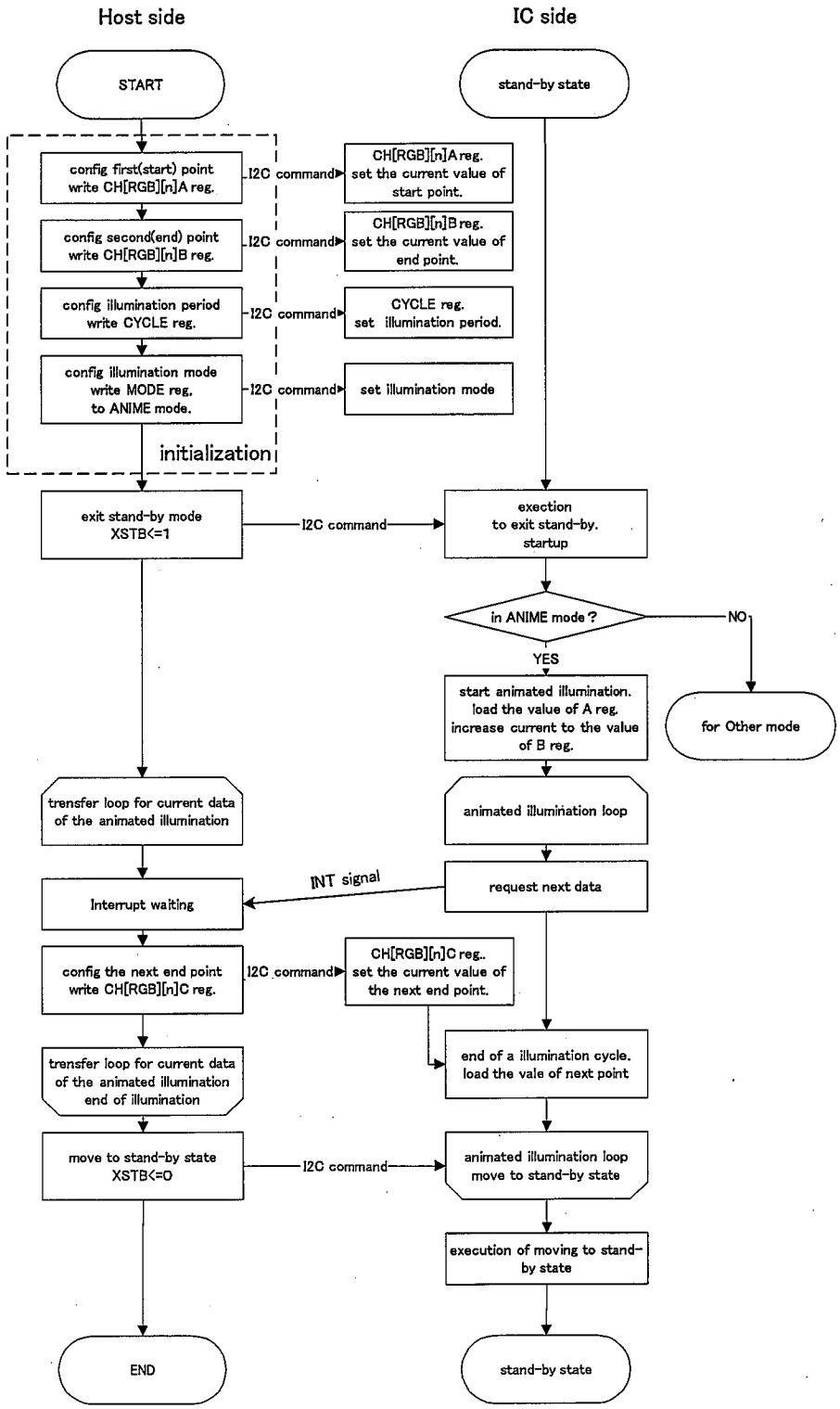
- MODE[2:0] Set ANIME mode [001].
- CYCLE[2:0] Set one illumination cycle period.
- CH[RGB][n]A Set the output current of the first illumination point.
- CH[RGB][n]B Set the output current of the second illumination point.
- XSTB This is the trigger to exit standby state. After the above-configuration is set, the standby is released when XSTB is assumed to be 1 and illumination is begun.

7.3.3.3 Animated Illumination Flow

The following setting is necessary to display animated illumination at each next data demand by the INT signal.

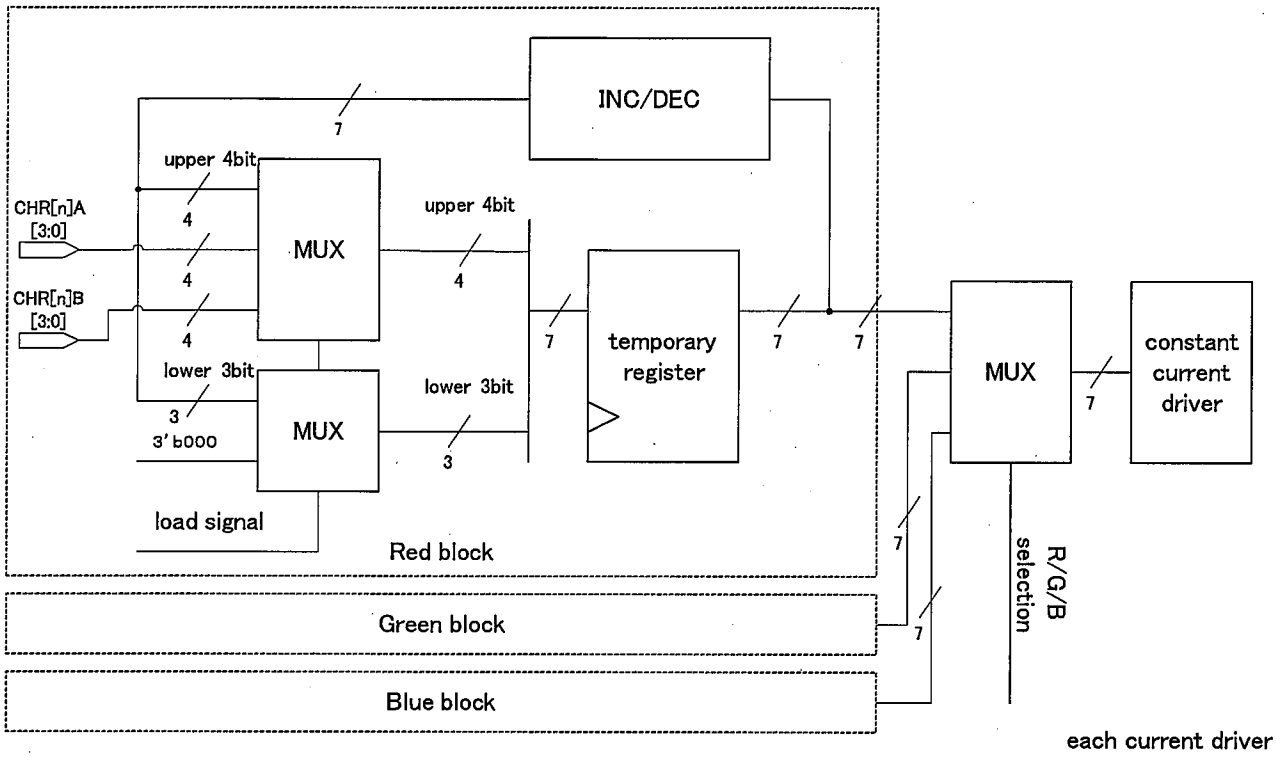
- CH[RGB][n]C set the output current value of the next end point of one display period

The example of the flow to one by one change the LED drive current by using the ANIME mode is shown as follows.



7.3.3.4 ANIME mode and Output Precision

In the ANIME mode, to achieve the illumination that changes smoothly, control logic circuit of animated illumination outputs current value by the redundancy bit addition and seven bit accuracy.



7.3.3.5 Limitations

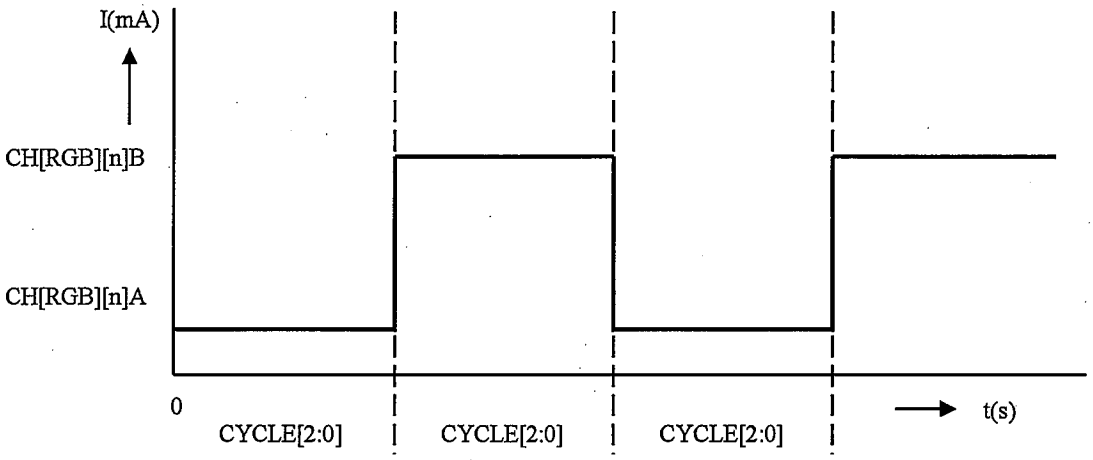
- Mode change under illumination
  The mode change between the ANIME mode and other modes under illumination is not recommended.
  Change in standby state.
  Behavior when the mode is changed in the illumination is as follows.

current mode	new mode	Behavior
ANIME,BLINK	NORMAL,ALL_H	Shift new mode immediately and output new value.
NORMAL,ALL_H	ANIME,BLINK	Start illumination from the CH[RGB][n]A value
ANIME	BLINK	The output at one CYCLE[1:0] period is not guaranteed from the change. The output returns to the normal performance at the next cycle.
BLINK	ANIME	

- Behavior when INT signal is output and CH[RGB][n]A, CH[RGB][n]B or CH[RGB][n]C are not replaced.
  The illumination is executed considering the previous value to be the following value when the CH[RGB][n]A, CH[RGB][n]B or CH[RGB][n]C register will not be updated in one illumination cycle after the INT signal is output.
- Setup/Hold time between INT signal and CH[RGB][n]A, CH[RGB][n]B and CH[RGB][n]C registers.
  It is necessary to keep to the time provided for according to the AC timing between the INT signal and the CH[RGB][n]A, CH[RGB][n]B and CH[RGB][n]C register.
  Do not update the CH[RGB][n]A, CH[RGB][n]B or CH[RGB][n]C register for the period from the standby release to positive edge of the first INT signal.
  When updating it outside timing, the SETUP/HOLD time cannot be defended, and the output might become irregular.

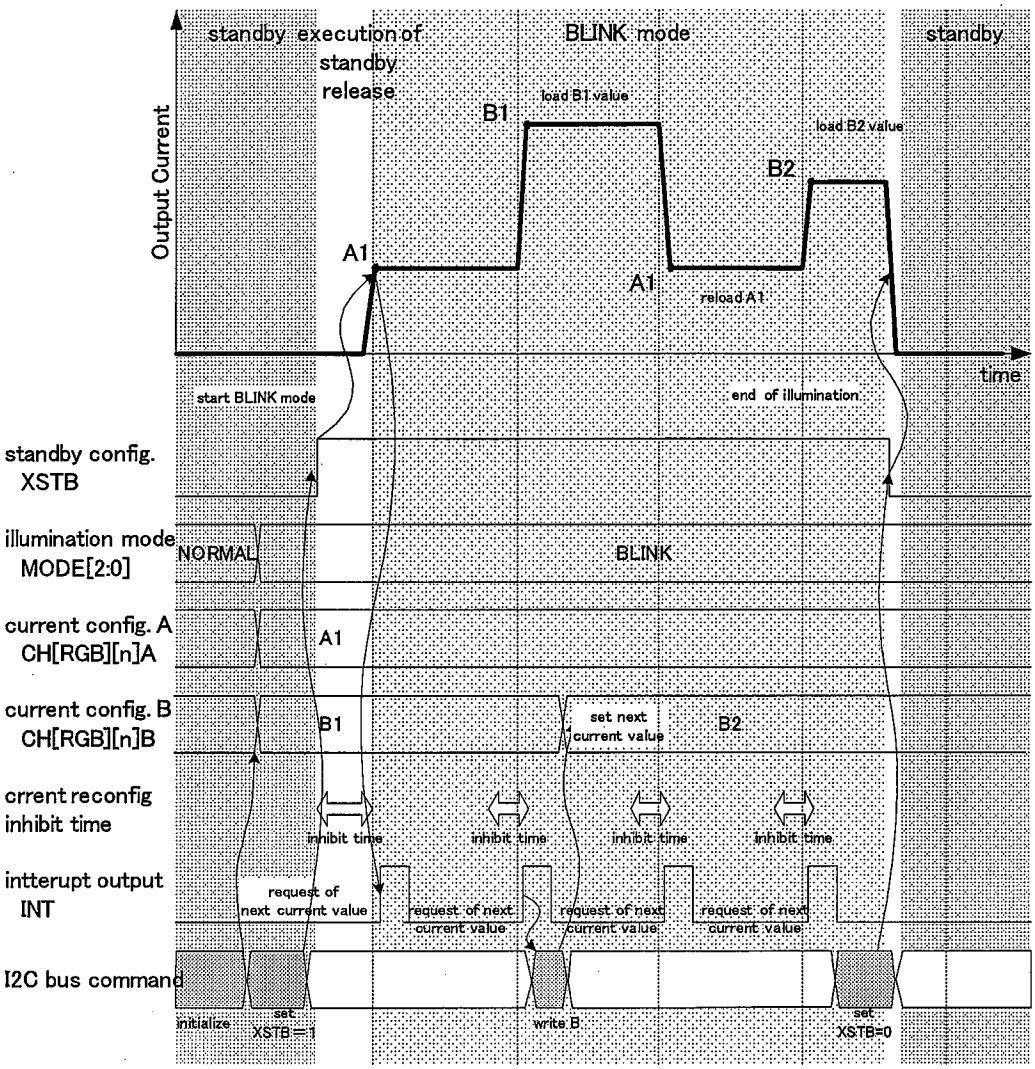
7.3.4 BLINK mode

In BLINK mode, CH[RGB][n]A and CH[RGB][n]B are alternately set to the constant current driver. Timing to which the setting of the current of the driver is changed is time set with CYCLE[2:0]



7.3.4.1 Basic operation on BLINK mode

As for the BLINK mode, it is the same as the ANIME mode not interpolating linearly.
The output current value is updated every CYCLE[2:0] cycle if the value is set at each positive-edge of the INT signal.
The CH[RGB][n]A value and the CH[RGB][n]B value are repeatedly output every CYCLE[2:0] period if the register value is fixed.



7.4 Setting of the frequency of the RGB column drivers

The frequency of RGB column drivers can be set by the matrix of DOSC[1:0] and OSC[2:0]. The combination of the settings is as follows.

However, the oscillation frequency of the charge pump changes, too, when OSC[2:0] is changed. The value of OSC[2] doesn't influence the frequency of RGB column drivers.

"DOSC[2:0]" is a register that sets the oscillator frequency of column driver.

Symbol	Description	Setting			Initial Value	the frequency at each value of OSC[2:0] register				Compared with frequency	Unit
		BIN	DEC	HEX		*00	*01	*10	*11		
DOSC[1:0]	the frequency of the RGB column divers	00	0	00H	00H	1146	1016	859	694	1	Hz
		01	1	01H		2292	2031	1719	1389	2	
		10	2	02H		859	762	645	521	0.75	
		11	3	03H		1719	1523	1289	1042	1.5	

Note: "*" indicates that the selection dose not matter.

7.5 Setting of the period of a cycle of illumination

The cycle used at the ANIME mode and the BLINK mode can be set by the CYCLE[2:0] register.

"CYCLE[2:0]" is a register that sets the period of a cycle of illumination

Symbol	Description	Setting			Initial Value	time	the period at each value of DOSC[1:0] register when OSC[2:0] register is *00(BIN)				Unit
		BIN	DEC	HEX			00	01	10	11	
CYCLE[2:0]	the period of illumination cycle	000	0	00H	00H	128/DOSC	0.112	0.056	0.149	0.074	sec
		001	1	01H		256/DOSC	0.223	0.112	0.298	0.149	
		010	2	02H		512/DOSC	0.447	0.223	0.596	0.298	
		011	3	03H		1024/DOSC	0.894	0.447	1.192	0.596	
		100	4	04H		2048/DOSC	1.787	0.894	2.383	1.192	
		101	5	05H		4096/DOSC	3.575	1.787	4.766	2.383	
		110	6	06H		8192/DOSC	7.149	3.575	9.533	4.766	
		111	7	07H		16384/DOSC	14.299	7.149	19.065	9.533	

Note1: The illumination cycle changes at the same time, too, when the frequency of the column drivers is changed by the OSC[1:0] register and the DOSC[1:0] register.

Note2: "*" indicates that the selection dose not matter.

7.6 Configuration of BLINKHD

After the value of the CH[RGB][n]A register is loaded, the BLINK operation is held when changing to the BLINK mode after the BLINKHD register is set to one. The skew is generated at the update time of each current value because the setting of the current value is updated in the NORMAL mode at the time of each writing the register. However, if BLINKHD is used, the setting of all current value can be updated at the same time.

°

Symbol	Initial Value	Setting	Description
BLINKHD	0	0	BLINK mode operation
		1	Hold after load the CH[RGB][n]A register value.

Concrete flow is as follows.

1. Release XSTB after set BLINKHD=1 and the BLINK mode.
2. Write the current value to CH[RGB][n]A register after wait time of release standby mode
3. Change to the NORMAL mode. The current setting is updated at the same time.
4. Change to the BLINK mode after wait time longer then 2*DOSC period.
5. Write the next current value to CH[RGB][n]A register after wait time longer then 2*DOSC period.
6. After arbitrary waiting time, go to 3.

※Please do not make it to the ANIME mode with BLINKHD set to 1. Operation when setting it is not guaranteed.

7.7 LED connected pin voltage monitoring and automatic select 1x or 1.5x charge pump mode

This IC monitors the voltage of all constant current driver pins. Charge pump boost ratio is selected automatically 1x mode in the minimum voltage is more than setting voltage, or 1.5x mode in the minimum voltage is less than setting voltage.

Charge and discharge cycle is 660 kHz (TYP.).

Oscillating frequency of charge pump can be changed by OSC[2:0] register.

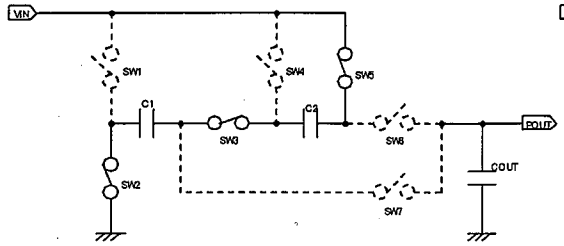


Fig.1 charge

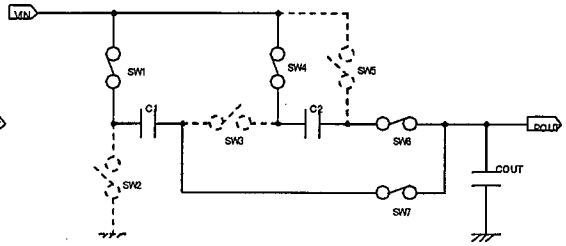


Fig.2 discharge

7.7.1 Oscillating frequency of charge pump

The register performs control of the oscillator frequency of charge pump.

Efficiency is optimized by changing the oscillation frequency of a charge pump.

When oscillation frequency is set up low, the efficiency of a charge pump increases, and output ripple becomes large.

When oscillation frequency is set up high, the efficiency of a charge pump falls, and output ripple becomes small.

When output ripple is large, the voltage monitoring function starts earlier than the case of output ripple is small, and changes 1x mode to 1.5x mode.

The adjustment of the oscillation frequency is effective to obtain the maximum efficiency.

Change OSC 2:0 register at the standby state.

"OSC[2:0]" is a register that sets the oscillator frequency of charge pump.

Symbol	Description	Setting			Initial Value	Value	Unit
		BIN	DEC	HEX			
OSC[2:0]	Oscillating frequency	000	0	00H	00H	660	kHz
		001	1	01H		585	
		010	2	02H		495	
		011	3	03H		400	
		100	4	04H		1320	
		101	5	05H		1170	
		110	6	06H		990	
		111	7	07H		800	