



Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of “Quality Parts,Customers Priority,Honest Operation,and Considerate Service”,our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip,ALPS,ROHM,Xilinx,Pulse,ON,Everlight and Freescale. Main products comprise IC,Modules,Potentiometer,IC Socket,Relay,Connector.Our parts cover such applications as commercial,industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!



Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832

Email & Skype: info@chipsmall.com Web: www.chipsmall.com

Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China



LED Drivers for LCD Backlights

White backlight LED Drivers for Small to Medium LCD Panels (Switching Regulator Type)



BD60910GU

No.11040EBT30

●Description

BD60910GU is maximum 8LED(minimum 4LED) serial LED driver with ALC (Auto Luminous Control) function.
Best match for mobile application that needs long battery life.

●Features

- 1) Boost DC/DC for LED back lighting
 - Drives maximum 8 to minimum 4 serial LEDs.
 - Integrated high voltage switching transistor
 - Soft start function.
 - Over voltage protection (Detect voltage is controllable)
 - Over current protection (2nd side)
 - VOUT short to GND protection
 - VOUT open protection.
- 2) Constant current driver for LED back lighting
 - Current step can be set in 7bit(0.2mA 128steps), and 8bit(0.1mA 256steps) in sloping.
 - Rise and fall time of sloping are set independently.
 - I_{out} max = 25.6mA
 - PWM brightness control by external input.
- 3) Auto Luminous Control (ALC)
 - Periodic ambient detection reduces sensor consumption current.
 - LED brightness can be controlled by 16steps ambient brightness level.
 - LED current for each ambient level is freely customizable.
 - SBIAS for sensor bias is integrated. (3.0V or 2.6V)
 - Photo Diode, Photo Transistor, Photo IC(Linear/ Logarithm) can be connected.
 - Automatic gain control built-in, so BH1600FVC can be connected directly.
- 4) Thermal shutdown (Auto-return type)
- 5) I²C BUS FS mode (max 400kHz) Write/Read
- 6) VCSP85H3(3.00mm x 3.00mm) Small Size CSP package

●Absolute Maximum Ratings (Ta=25 °C)

Parameter	Symbol	Ratings	Unit	Pins
Maximum voltage 1	VMAX1	7	V	except for VLED VOUT, SW
Maximum voltage 2	VMAX2	15	V	VLED
Maximum voltage 3	VMAX3	40	V	VOUT, SW
Power Dissipation	Pd	1250 ^{*1}	mW	
Operating Temperature Range	Topr	-40 ~ +85	°C	
Storage Temperature Range	Tstg	-55 ~ +150	°C	

*1) Power dissipation deleting is 10mW/ °C, when it's used in over 25 °C. It's deleting is on the board that is ROHM's standard.
Dissipation by LSI should not exceed tolerance level of Pd.

●Operating conditions (VBAT≥VIO, Ta=-40~85 °C)

Parameter	Symbol	Ratings	Unit
VBAT input voltage	VBAT	2.7~5.5	V
VIO pin voltage	VIO	1.65~3.3	V

●Electrical Characteristics (Unless otherwise specified, Ta=25°C, VBAT=3.6V, VIO=1.8V)

Parameter	Symbol	Limits			Unit	Condition
		Min.	Typ.	Max.		
【Circuit Current】						
VBAT Circuit current 1	IBAT1	-	0.1	1.0	μA	RESETB=0V, VIO=0V
VBAT Circuit current 2	IBAT2	-	0.5	3.0	μA	RESETB=0V, VIO=1.8V
VBAT Circuit current 3	IBAT3	-	3.5	5.0	mA	LED=ON, ILED=15mA setting Vo=24V
VBAT Circuit current 4	IBAT4	-	0.4	1.0	mA	Only ALC block ON ADCYC=0.52s setting Except sensor current
【LED Driver】						
LED current Step (Setup)	ILEDSTP1	128			Step	
LED current Step (At slope)	ILEDSTP2	256			Step	
LED Maximum current	IMAXWLED	-	25.6	-	mA	
LED current accuracy	IWLED	-7%	15	+7%	mA	ILED=15mA setting
【DC/DC】						
VLED pin feedback voltage	Vfb	-	0.3	-	V	
Over current protection	OCP	-	650	-	mA	
Oscillator frequency	fosc	0.8	1.0	1.2	MHz	
Over Voltage Protection detect voltage	OVP1	30	31	32	V	
	OVP2	-	27	-	V	
	OVP3	-	24	-	V	
	OVP4	-	21	-	V	
	OVP5	-	18	-	V	
Maximum Duty	Mduty	92.5	-	-	%	
VOUT open protection	OVO	-	0.7	1.4	V	

●Electrical Characteristics (Unless otherwise specified, Ta=25°C, VBAT=3.6V, VIO=1.8V)

Parameter	Symbol	Limits			Unit	Condition
		Min.	Typ.	Max.		
【I²C Input (SDA, SCL)】						
LOW level input voltage	VIL	-0.3	-	$0.25 \times VIO$	V	
HIGH level input voltage	VIH	$0.75 \times VIO$	-	$VBAT + 0.3$	V	
Hysteresis of Schmitt trigger input	Vhys	$0.05 \times VIO$	-	-	V	
LOW level output voltage (SDA) at 3mA sink current	VOL	0	-	0.3	V	
Input current each I/O pin	lin	-3	-	3	μA	Input voltage = $0.1 \times VIO \sim 0.9 \times VIO$
【RESETB】						
LOW level input voltage	VIL	-0.3	-	$0.25 \times VIO$	V	
HIGH level input voltage	VIH	$0.75 \times VIO$	-	$VBAT + 0.3$	V	
Input current each I/O pin	lin	-3	-	3	μA	Input voltage = $0.1 \times VIO \sim 0.9 \times VIO$

●Electrical Characteristics (Unless otherwise specified, Ta=25°C, VBAT=3.6V, VIO=1.8V)

Parameter	Symbol	Limits			Unit	Condition
		Min.	Typ.	Max.		
【ALC】						
SBIAS Output voltage	VoS	2.850	3.0	3.150	V	Io=200μA <Initial value>
		2.470	2.6	2.730	V	Io=200μA
SBIAS Output current	IoS	-	-	30	mA	Vo=3.0V
SSENS Input range	VISS	0	-	VoS x 255/256	V	
SBIAS Discharge resistor at OFF	ROFFS	-	1.0	1.5	kΩ	
ADC resolution	ADRES	8			bit	
ADC non-linearity error	ADINL	-3	-	+3	LSB	
ADC differential non-linearity error	ADDNL	-1	-	+1	LSB	
SSENS Input impedance	RSENS	1	-	-	MΩ	
【WPWMIN】						
L level input voltage	VILA	-0.3	-	0.3	V	
H level input voltage	VIHA	1.4	-	VBAT +0.3	V	
Input current	IinA	-	3.6	10	μA	Vin=1.8V
PWM input minimum High pulse width	PWpwm	50	-	-	μs	
【GC1, GC2】						
L level output voltage	VOLS	-	-	0.2	V	IOL=1mA
H level output voltage	VOHS	VoS -0.2	-	-	V	IOH=1mA

●Block Diagram / Application Circuit example

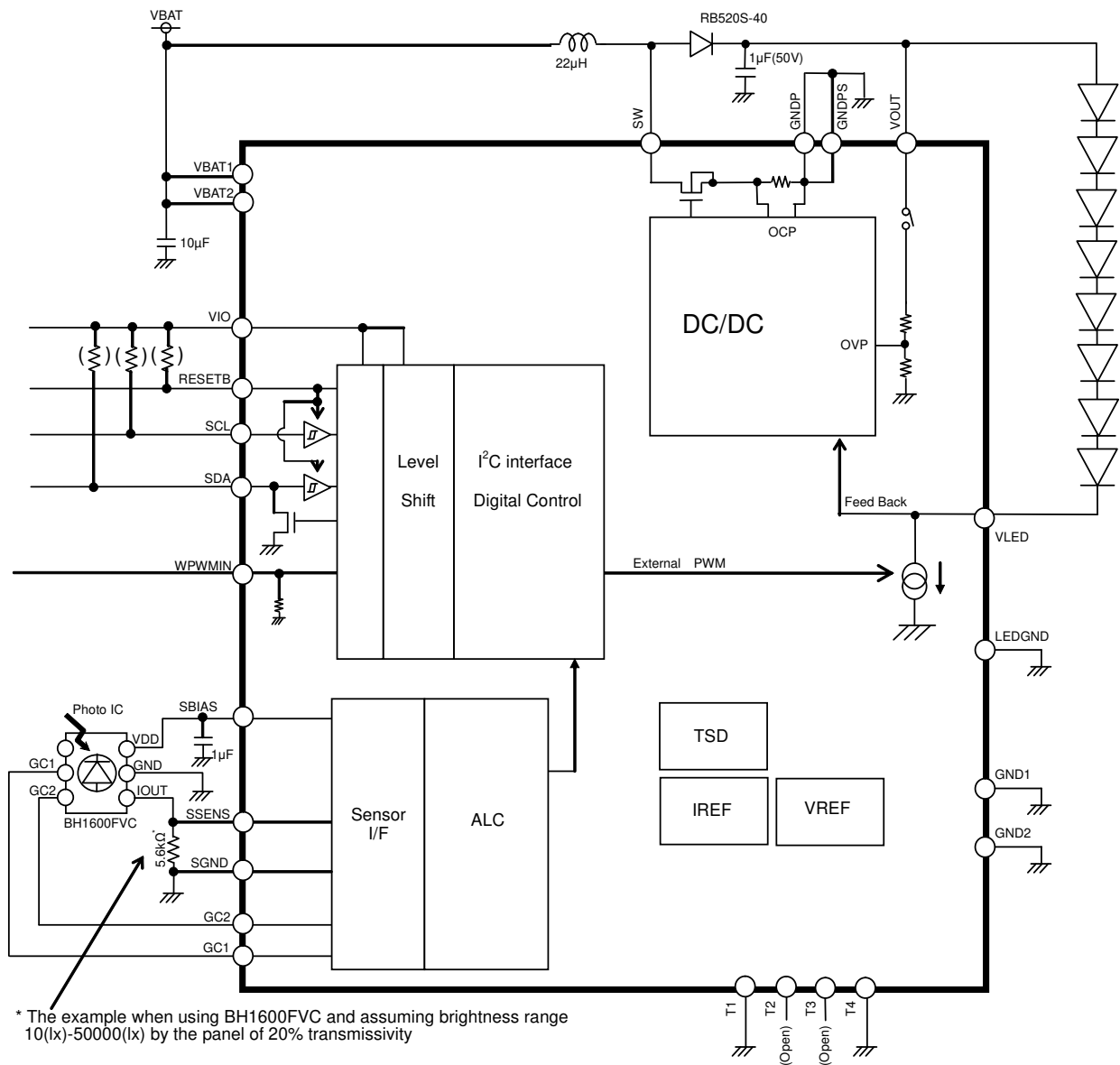


Fig.1 Block Diagram / Application Circuit example

●Pin Arrangement [Bottom View]

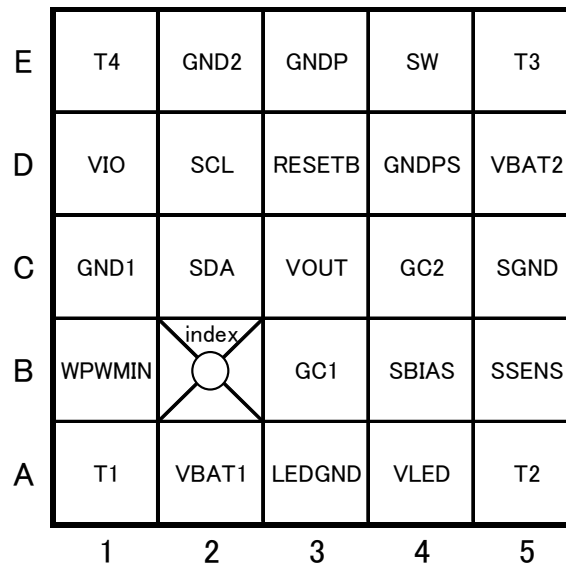
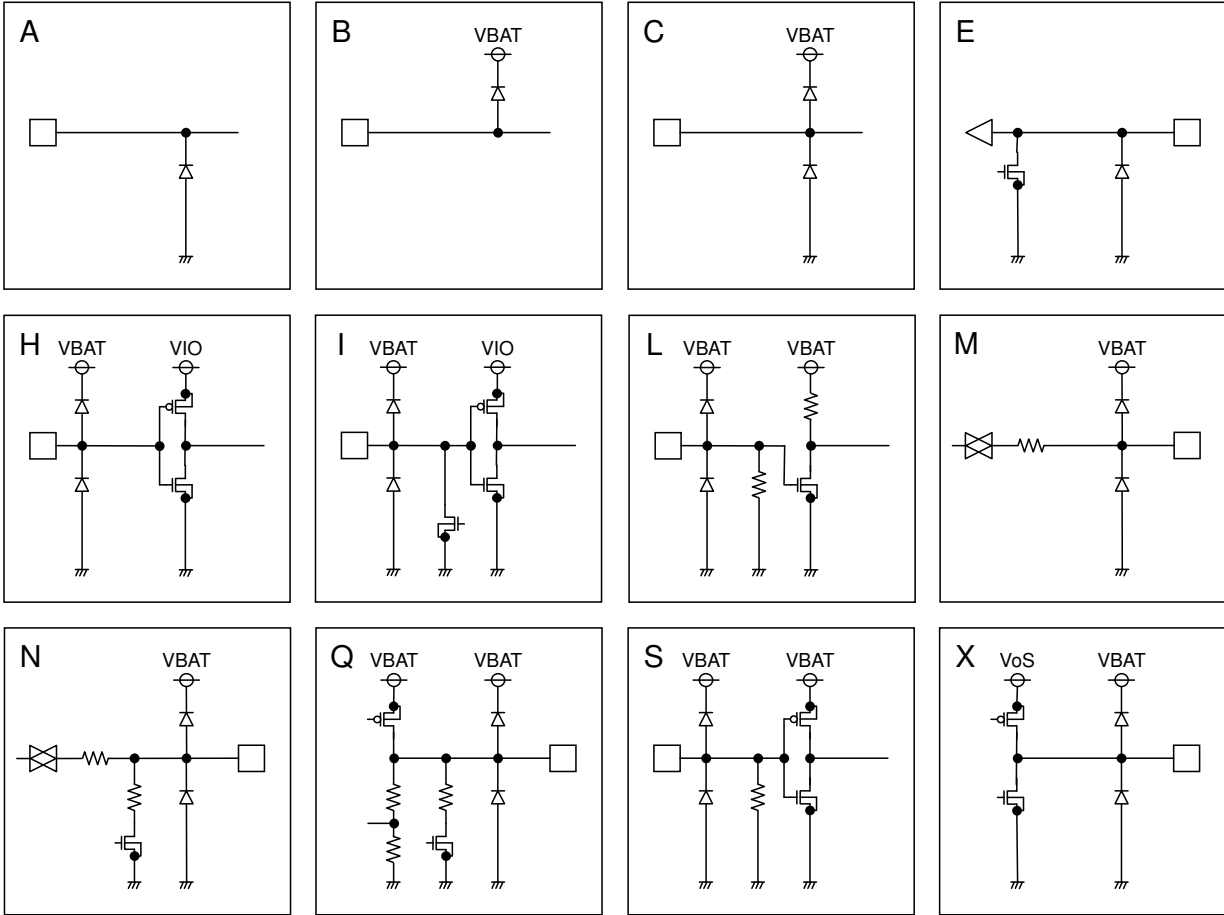


Fig.2 Pin Arrangement

●Pin Functions

No	Ball No.	Pin Name	I/O	ESD Diode		Functions	Equivalent Circuit
				For Power	For Ground		
1	A2	VBAT1	-	-	GND	Power supply	A
2	D5	VBAT2	-	-	GND	Power supply	A
3	D1	VIO	-	VBAT	GND	Power supply for I/O	C
4	C1	GND1	-	VBAT	-	Ground	B
5	E2	GND2	-	VBAT	-	Ground	B
6	A3	LEDGND	-	VBAT	-	Ground	B
7	E3	GNDP	-	VBAT	-	Ground	B
8	D4	GNDPS	-	VBAT	-	Ground	B
9	C5	SGND	-	VBAT	-	Ground	B
10	D3	RESETB	I	VBAT	GND	Reset input (L: reset, H: reset cancel)	H
11	C2	SDA	I/O	VBAT	GND	I ² C data input / output	I
12	D2	SCL	I	VBAT	GND	I ² C clock input	H
13	B1	WPWMIN	I	VBAT	GND	External PWM input	L
14	E4	SW	O	-	GND	DC/DC Switching port	A
15	C3	VOUT	O	-	GND	DC/DC output voltage monitor	A
16	A4	VLED	I	-	GND	LED cathode connection	E
17	B4	SBIAS	O	VBAT	GND	Bias output for the Ambient Light Sensor	Q
18	B5	SSENS	I	VBAT	GND	Ambient Light Sensor input	N
19	B3	GC1	O	VBAT	GND	Ambient Light Sensor gain control output 1	X
20	C4	GC2	O	VBAT	GND	Ambient Light Sensor gain control output 2	X
21	A1	T1	I	VBAT	GND	Test Input Pin (short to Ground)	S
22	A5	T2	O	VBAT	GND	Test Output Pin (Open)	M
23	E5	T3	O	VBAT	GND	Test Output Pin (Open)	N
24	E1	T4	I	VBAT	GND	Test Input Pin (short to Ground)	S

●Equivalent Circuit



● I²C BUS format

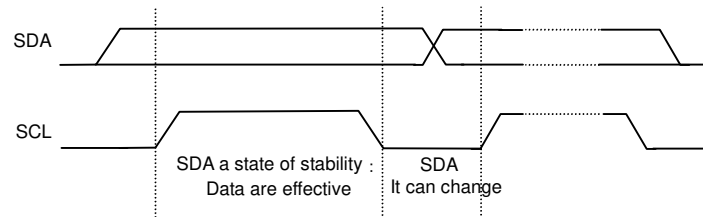
The writing/reading operation is based on the I²C slave standard.

- Slave address

A7	A6	A5	A4	A3	A2	A1	R/W
1	1	1	0	1	1	0	1/0

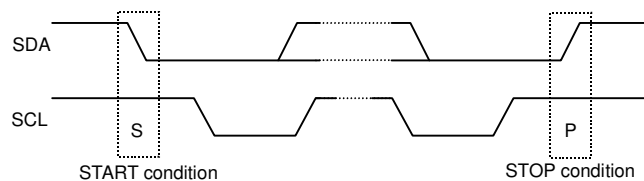
- Bit Transfer

SCL transfers 1-bit data during H. SCL cannot change signal of SDA during H at the time of bit transfer. If SDA changes while SCL is H, START conditions or STOP conditions will occur and it will be interpreted as a control signal.



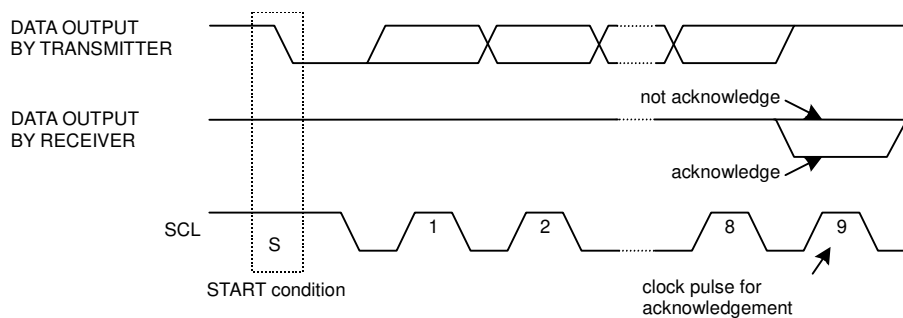
- START and STOP condition

When SDA and SCL are H, data is not transferred on the I²C- bus. This condition indicates, if SDA changes from H to L while SCL has been H, it will become START (S) conditions, and an access start, if SDA changes from L to H while SCL has been H, it will become STOP (P) conditions and an access end.



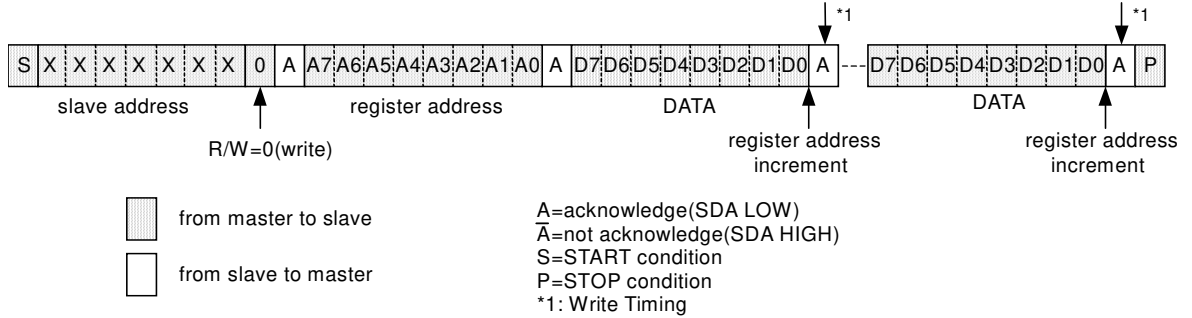
- Acknowledge

It transfers data 8 bits each after the occurrence of START condition. A transmitter opens SDA after transfer 8bits data, and a receiver returns the acknowledge signal by setting SDA to L.



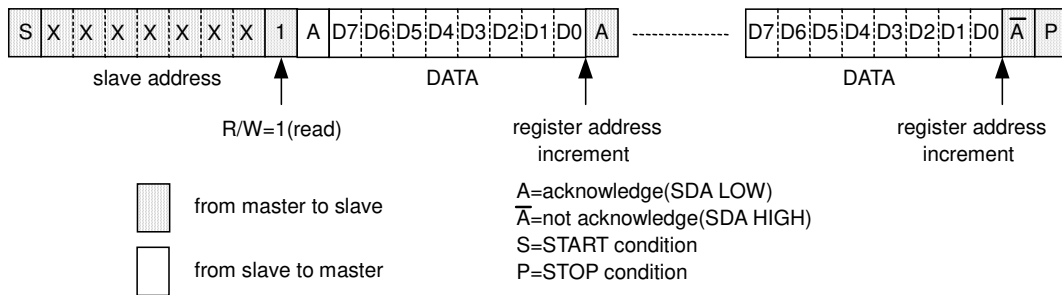
• Writing protocol

A register address is transferred by the next 1 byte that transferred the slave address and the write-in command. The 3rd byte writes data in the internal register written in by the 2nd byte, and after 4th byte or, the increment of register address is carried out automatically. However, when a register address turns into the last address, it is set to 00h by the next transmission. After the transmission end, the increment of the address is carried out.



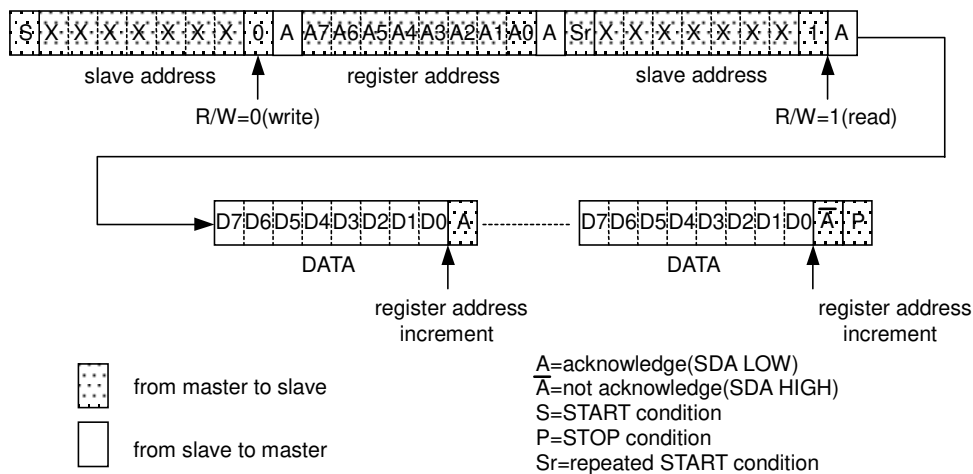
• Reading protocol

It reads from the next byte after writing a slave address and R/W bit. The register to read considers as the following address accessed at the end, and the data of the address that carried out the increment is read after it. If an address turns into the last address, the next byte will read out 00h. After the transmission end, the increment of the address is carried out.



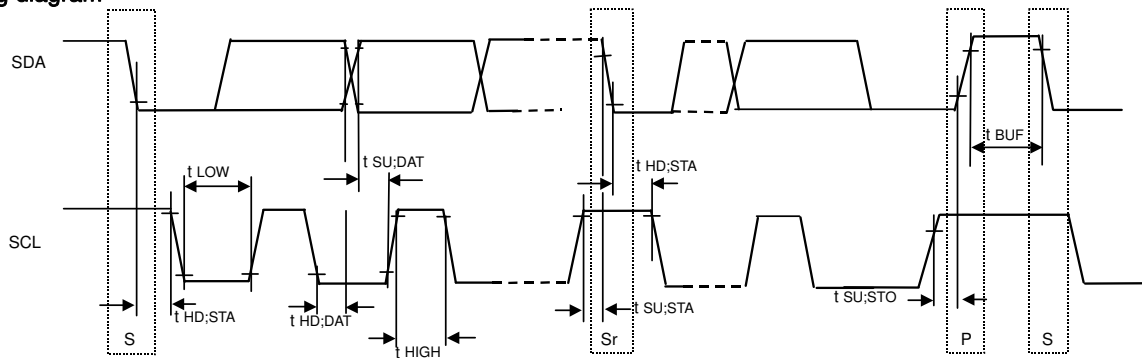
• Multiple reading protocols

After specifying an internal address, it reads by repeated START condition and changing the data transfer direction. The data of the address that carried out the increment is read after it. If an address turns into the last address, the next byte will read out 00h. After the transmission end, the increment of the address is carried out.



As for reading protocol and multiple reading protocols, please do \bar{A} (not acknowledge) after doing the final reading operation. It stops with read when ending by A(acknowledge), and SDA stops in the state of Low when the reading data of that time is 0. However, this state returns usually when SCL is moved, data is read, and \bar{A} (not acknowledge) is done.

●Timing diagram

●Electrical Characteristics(Unless otherwise specified, $T_a=25\text{ }^\circ\text{C}$, $V_{BAT}=3.6\text{V}$, $V_{IO}=1.8\text{V}$)

Parameter	Symbol	Standard-mode			Fast-mode			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
[I²C BUS format]								
SCL clock frequency	fSCL	0	-	100	0	-	400	kHz
LOW period of the SCL clock	tLOW	4.7	-	-	1.3	-	-	μs
HIGH period of the SCL clock	tHIGH	4.0	-	-	0.6	-	-	μs
Hold time (repeated) START condition After this period, the first clock is generated	tHD;STA	4.0	-	-	0.6	-	-	μs
Set-up time for a repeated START condition	tSU;STA	4.7	-	-	0.6	-	-	μs
Data hold time	tHD;DAT	0	-	3.45	0	-	0.9	μs
Data set-up time	tSU;DAT	250	-	-	100	-	-	ns
Set-up time for STOP condition	tSU;STO	4.0	-	-	0.6	-	-	μs
Bus free time between a STOP and START condition	tBUF	4.7	-	-	1.3	-	-	μs

● Register List

Input "0" for "-".

Address	W/R	Register data								Function
		D7	D6	D5	D4	D3	D2	D1	D0	
00h	W	-	-	-	-	-	-	-	SFTRST	Software Reset
01h	R/W	-	VOVP(2)	VOVP(1)	VOVP(0)	WPWMEN	ALCEN	LEDMD	LEDEN	LED, ALC, OVP Control
02h	-	-	-	-	-	-	-	-	-	-
03h	R/W	-	ILED(6)	ILED(5)	ILED(4)	ILED(3)	ILED(2)	ILED(1)	ILED(0)	LED Current Setting at non-ALC mode
04h	-	-	-	-	-	-	-	-	-	-
05h	-	-	-	-	-	-	-	-	-	-
06h	-	-	-	-	-	-	-	-	-	-
07h	-	-	-	-	-	-	-	-	-	-
08h	W	THL(3)	THL(2)	THL(1)	THL(0)	TLH(3)	TLH(2)	TLH(1)	TLH(0)	LED Current transition
09h	-	-	-	-	-	-	-	-	-	-
0Ah	-	-	-	-	-	-	-	-	-	-
0Bh	R/W	ADCYC(1)	ADCYC(0)	GAIN(1)	GAIN(0)	STYPE	VSB	MDCIR	SBIASON	ALC mode setting
0Ch	-	-	-	-	-	-	-	-	-	-
0Dh	R	-	-	-	-	AMB(3)	AMB(2)	AMB(1)	AMB(0)	Ambient level output
0Eh	W	-	IU0(6)	IU0(5)	IU0(4)	IU0(3)	IU0(2)	IU0(1)	IU0(0)	LED Current at Ambient level 0h
0Fh	W	-	IU1(6)	IU1(5)	IU1(4)	IU1(3)	IU1(2)	IU1(1)	IU1(0)	LED Current at Ambient level 1h
10h	W	-	IU2(6)	IU2(5)	IU2(4)	IU2(3)	IU2(2)	IU2(1)	IU2(0)	LED Current at Ambient level 2h
11h	W	-	IU3(6)	IU3(5)	IU3(4)	IU3(3)	IU3(2)	IU3(1)	IU3(0)	LED Current at Ambient level 3h
12h	W	-	IU4(6)	IU4(5)	IU4(4)	IU4(3)	IU4(2)	IU4(1)	IU4(0)	LED Current at Ambient level 4h
13h	W	-	IU5(6)	IU5(5)	IU5(4)	IU5(3)	IU5(2)	IU5(1)	IU5(0)	LED Current at Ambient level 5h
14h	W	-	IU6(6)	IU6(5)	IU6(4)	IU6(3)	IU6(2)	IU6(1)	IU6(0)	LED Current at Ambient level 6h
15h	W	-	IU7(6)	IU7(5)	IU7(4)	IU7(3)	IU7(2)	IU7(1)	IU7(0)	LED Current at Ambient level 7h
16h	W	-	IU8(6)	IU8(5)	IU8(4)	IU8(3)	IU8(2)	IU8(1)	IU8(0)	LED Current at Ambient level 8h
17h	W	-	IU9(6)	IU9(5)	IU9(4)	IU9(3)	IU9(2)	IU9(1)	IU9(0)	LED Current at Ambient level 9h
18h	W	-	IUA(6)	IUA(5)	IUA(4)	IUA(3)	IUA(2)	IUA(1)	IUA(0)	LED Current at Ambient level Ah
19h	W	-	IUB(6)	IUB(5)	IUB(4)	IUB(3)	IUB(2)	IUB(1)	IUB(0)	LED Current at Ambient level Bh
1Ah	W	-	IUC(6)	IUC(5)	IUC(4)	IUC(3)	IUC(2)	IUC(1)	IUC(0)	LED Current at Ambient level Ch
1Bh	W	-	IUD(6)	IUD(5)	IUD(4)	IUD(3)	IUD(2)	IUD(1)	IUD(0)	LED Current at Ambient level Dh
1Ch	W	-	IUE(6)	IUE(5)	IUE(4)	IUE(3)	IUE(2)	IUE(1)	IUE(0)	LED Current at Ambient level Eh
1Dh	W	-	IUF(6)	IUF(5)	IUF(4)	IUF(3)	IUF(2)	IUF(1)	IUF(0)	LED Current at Ambient level Fh

Prohibit to accessing the address that isn't mentioned.

The timing indicated by explanation of registers, is a value in case built-in OSC has Typ. frequency.(1MHz)

●Register Map

Address 00h < Software Reset >

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
00h	W	-	-	-	-	-	-	-	SFTRST
Initial Value	00h	-	-	-	-	-	-	-	0

Bit [7:1] : (Not used)

Bit0 : **SFTRST** Software Reset Command
 "0" : Reset cancel
 "1" : Reset (All register initializing)
 Refer to "Explanation 1" for detail.

Address 01h < LED, ALC Control >

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
01h	R/W	-	VOVP(2)	VOVP(1)	VOVP(0)	WPWMEN	ALCEN	LEDMD	LEDEN
Initial Value	00h	-	0	0	0	0	0	0	0

Bit7 : (Not used)

Bit [6:4] : **VOVP(2:0)** Over Voltage Protection detect voltage
 "000" : OVP=31V(typ) 8LED connection
 "001" : OVP=27V(typ) 7LED connection
 "010" : OVP=24V(typ) 6LED connection
 "011" : OVP=21V(typ) 5LED connection
 "100" : OVP=18V(typ) 4LED connection
 "101" : Don't use
 "110" : Don't use
 "111" : Don't use

Refer to "Explanation 4" for detail.

Bit3 : **WPWMEN** External PWM Input "WPWMIN" terminal Enable Control (Valid/Invalid)
 "0" : WPWMIN input invalid
 "1" : WPWMIN input valid
 Refer to "Explanation 5-(10)" for detail.

Bit2 : **ALCEN** ALC Function Control (ON/OFF)
 "0" : ALC function OFF
 "1" : ALC function ON
 Refer to "Explanation 5-(1)" for detail.

Bit1 : **LEDMD** LED Mode Select (ALC mode/Register mode)
 "0" : Register mode
 "1" : ALC mode
 Refer to "Explanation 5-(1)" for detail.

Bit0 : **LEDEN** LED Control (ON/OFF)
 "0" : LED OFF
 "1" : LED ON
 Refer to "Explanation 5-(1)" for detail.

Address 03h < LED Current Setting at Register mode >

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
03h	R/W	-	ILED(6)	ILED(5)	ILED(4)	ILED(3)	ILED(2)	ILED(1)	ILED(0)
Initial Value	00h	-	0	0	0	0	0	0	0

Bit7 : (Not used)

Bit [6:0] : ILED(6:0) LED Current Setting at Register mode

"0000000" : 0.2 mA	"1000000" : 13.0 mA
"0000001" : 0.4 mA	"1000001" : 13.2 mA
"0000010" : 0.6 mA	"1000010" : 13.4 mA
"0000011" : 0.8 mA	"1000011" : 13.6 mA
"0000100" : 1.0 mA	"1000100" : 13.8 mA
"0000101" : 1.2 mA	"1000101" : 14.0 mA
"0000110" : 1.4 mA	"1000110" : 14.2 mA
"0000111" : 1.6 mA	"1000111" : 14.4 mA
"0001000" : 1.8 mA	"1001000" : 14.6 mA
"0001001" : 2.0 mA	"1001001" : 14.8 mA
"0001010" : 2.2 mA	"1001010" : 15.0 mA
"0001011" : 2.4 mA	"1001011" : 15.2 mA
"0001100" : 2.6 mA	"1001100" : 15.4 mA
"0001101" : 2.8 mA	"1001101" : 15.6 mA
"0001110" : 3.0 mA	"1001110" : 15.8 mA
"0001111" : 3.2 mA	"1001111" : 16.0 mA
"0010000" : 3.4 mA	"1010000" : 16.2 mA
"0010001" : 3.6 mA	"1010001" : 16.4 mA
"0010010" : 3.8 mA	"1010010" : 16.6 mA
"0010011" : 4.0 mA	"1010011" : 16.8 mA
"0010100" : 4.2 mA	"1010100" : 17.0 mA
"0010101" : 4.4 mA	"1010101" : 17.2 mA
"0010110" : 4.6 mA	"1010110" : 17.4 mA
"0010111" : 4.8 mA	"1010111" : 17.6 mA
"0011000" : 5.0 mA	"1011000" : 17.8 mA
"0011001" : 5.2 mA	"1011001" : 18.0 mA
"0011010" : 5.4 mA	"1011010" : 18.2 mA
"0011011" : 5.6 mA	"1011011" : 18.4 mA
"0011100" : 5.8 mA	"1011100" : 18.6 mA
"0011101" : 6.0 mA	"1011101" : 18.8 mA
"0011110" : 6.2 mA	"1011110" : 19.0 mA
"0011111" : 6.4 mA	"1011111" : 19.2 mA
"0100000" : 6.6 mA	"1100000" : 19.4 mA
"0100001" : 6.8 mA	"1100001" : 19.6 mA
"0100010" : 7.0 mA	"1100010" : 19.8 mA
"0100011" : 7.2 mA	"1100011" : 20.0 mA
"0100100" : 7.4 mA	"1100100" : 20.2 mA
"0100101" : 7.6 mA	"1100101" : 20.4 mA
"0100110" : 7.8 mA	"1100110" : 20.6 mA
"0100111" : 8.0 mA	"1100111" : 20.8 mA
"0101000" : 8.2 mA	"1101000" : 21.0 mA
"0101001" : 8.4 mA	"1101001" : 21.2 mA
"0101010" : 8.6 mA	"1101010" : 21.4 mA
"0101011" : 8.8 mA	"1101011" : 21.6 mA
"0101100" : 9.0 mA	"1101100" : 21.8 mA
"0101101" : 9.2 mA	"1101101" : 22.0 mA
"0101110" : 9.4 mA	"1101110" : 22.2 mA
"0101111" : 9.6 mA	"1101111" : 22.4 mA
"0110000" : 9.8 mA	"1110000" : 22.6 mA
"0110001" : 10.0 mA	"1110001" : 22.8 mA
"0110010" : 10.2 mA	"1110010" : 23.0 mA
"0110011" : 10.4 mA	"1110011" : 23.2 mA
"0110100" : 10.6 mA	"1110100" : 23.4 mA
"0110101" : 10.8 mA	"1110101" : 23.6 mA
"0110110" : 11.0 mA	"1110110" : 23.8 mA
"0110111" : 11.2 mA	"1110111" : 24.0 mA
"0111000" : 11.4 mA	"1111000" : 24.2 mA
"0111001" : 11.6 mA	"1111001" : 24.4 mA
"0111010" : 11.8 mA	"1111010" : 24.6 mA
"0111011" : 12.0 mA	"1111011" : 24.8 mA
"0111100" : 12.2 mA	"1111100" : 25.0 mA
"0111101" : 12.4 mA	"1111101" : 25.2 mA
"0111110" : 12.6 mA	"1111110" : 25.4 mA
"0111111" : 12.8 mA	"1111111" : 25.6 mA

Address 08h < LED Current transition >

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
08h	W	THL(3)	THL(2)	THL(1)	THL(0)	TLH(3)	TLH(2)	TLH(1)	TLH(0)
Initial Value	C7h	1	1	0	0	0	1	1	1

Bit [7:4] : **THL(3:0)** LED current Down transition per 0.2mA step

"0000" :	0.256 ms
"0001" :	0.512 ms
"0010" :	1.024 ms
"0011" :	2.048 ms
"0100" :	4.096 ms
"0101" :	8.192 ms
"0110" :	16.38 ms
"0111" :	32.77 ms
"1000" :	65.54 ms
"1001" :	131.1 ms
"1010" :	196.6 ms
"1011" :	262.1 ms
"1100" :	327.7 ms (Initial value)
"1101" :	393.2 ms
"1110" :	458.8 ms
"1111" :	524.3 ms

Refer to "Explanation 5-(8)" for detail.

Bit [3:0] : **TLH(3:0)** LED current Up transition per 0.2mA step

"0000" :	0.256 ms
"0001" :	0.512 ms
"0010" :	1.024 ms
"0011" :	2.048 ms
"0100" :	4.096 ms
"0101" :	8.192 ms
"0110" :	16.38 ms
"0111" :	32.77 ms (Initial value)
"1000" :	65.54 ms
"1001" :	131.1 ms
"1010" :	196.6 ms
"1011" :	262.1 ms
"1100" :	327.7 ms
"1101" :	393.2 ms
"1110" :	458.8 ms
"1111" :	524.3 ms

Refer to "Explanation 5-(8)" for detail.

Address 0Bh < ALC mode setting >

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0Bh	R/W	ADCYC(1)	ADCYC(0)	GAIN(1)	GAIN(0)	STYPE	VSB	MDCIR	SBIASON
Initial Value	81h	1	0	0	0	0	0	0	1

Bit [7:6] : **ADCYC(1:0)** ADC Measurement Cycle

- "00" : 0.52 s
- "01" : 1.05 s
- "10" : 1.57 s (Initial value)
- "11" : 2.10 s

Refer to "Explanation 5-(4)" for detail.

Bit [5:4] : **GAIN(1:0)** Sensor Gain Switching Function Control

- "00" : Auto Change (Initial value)
- "01" : Manual High
- "10" : Manual Low
- "11" : Fixed

Refer to "Explanation 5-(3),5-(6)" for detail.

Bit3 : **STYPE** Ambient Light Sensor Type Select (Linear/Logarithm)

- "0" : For Linear Sensor (Initial value)
- "1" : For Log Sensor

Refer to "Explanation 5-(6)" for detail.

Bit2 : **VSB** SBIAS Output Voltage Control

- "0" : SBIAS output voltage 3.0V (Initial value)
- "1" : SBIAS output voltage 2.6V

Refer to "Explanation 5-(2)" for detail.

Bit1 : **MDCIR** LED Current Reset Select by Mode Change

- "0" : LED current non-reset at mode change (Initial value)
- "1" : LED current reset at mode change

Refer to "Explanation 5-(9)" for detail.

Bit0 : **SBIASON** SBIAS Control (ON/OFF)

- "0" : Measurement cycle synchronous
- "1" : Usually ON (at ALCEN=1) (Initial value)

Refer to "Explanation 5-(4)" for detail.

Address 0Dh < Ambient level (Read Only) >

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0Dh	R	-	-	-	-	AMB(3)	AMB(2)	AMB(1)	AMB(0)
Initial Value	-	-	-	-	-	-	-	-	-

Bit [7:4] : (Not used)

Bit [3:0] : **AMB(3:0)** Ambient Level

"0000" : 0h
 "0001" : 1h
 "0010" : 2h
 "0011" : 3h
 "0100" : 4h
 "0101" : 5h
 "0110" : 6h
 "0111" : 7h
 "1000" : 8h
 "1001" : 9h
 "1010" : Ah
 "1011" : Bh
 "1100" : Ch
 "1101" : Dh
 "1110" : Eh
 "1111" : Fh

The data can be read through I²C.
Refer to "Explanation 5-(6)" for detail.

Address 0Eh~1Dh < LED Current at Ambient level 0h~Fh >

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0Eh~1Dh	W	-	IU* (6)	IU* (5)	IU* (4)	IU* (3)	IU* (2)	IU* (1)	IU* (0)
Initial Value	-	Refer to "Explanation 5-(7)" for initial table							

"*" means 0~F.

Bit7 : (Not used)

Bit [6:0] : IU* (6:0) LED Current at Ambient Level for 0h~Fh

"0000000" : 0.2 mA	"1000000" : 13.0 mA
"0000001" : 0.4 mA	"1000001" : 13.2 mA
"0000010" : 0.6 mA	"1000010" : 13.4 mA
"0000011" : 0.8 mA	"1000011" : 13.6 mA
"0000100" : 1.0 mA	"1000100" : 13.8 mA
"0000101" : 1.2 mA	"1000101" : 14.0 mA
"0000110" : 1.4 mA	"1000110" : 14.2 mA
"0000111" : 1.6 mA	"1000111" : 14.4 mA
"0001000" : 1.8 mA	"1001000" : 14.6 mA
"0001001" : 2.0 mA	"1001001" : 14.8 mA
"0001010" : 2.2 mA	"1001010" : 15.0 mA
"0001011" : 2.4 mA	"1001011" : 15.2 mA
"0001100" : 2.6 mA	"1001100" : 15.4 mA
"0001101" : 2.8 mA	"1001101" : 15.6 mA
"0001110" : 3.0 mA	"1001110" : 15.8 mA
"0001111" : 3.2 mA	"1001111" : 16.0 mA
"0010000" : 3.4 mA	"1010000" : 16.2 mA
"0010001" : 3.6 mA	"1010001" : 16.4 mA
"0010010" : 3.8 mA	"1010010" : 16.6 mA
"0010011" : 4.0 mA	"1010011" : 16.8 mA
"0010100" : 4.2 mA	"1010100" : 17.0 mA
"0010101" : 4.4 mA	"1010101" : 17.2 mA
"0010110" : 4.6 mA	"1010110" : 17.4 mA
"0010111" : 4.8 mA	"1010111" : 17.6 mA
"0011000" : 5.0 mA	"1011000" : 17.8 mA
"0011001" : 5.2 mA	"1011001" : 18.0 mA
"0011010" : 5.4 mA	"1011010" : 18.2 mA
"0011011" : 5.6 mA	"1011011" : 18.4 mA
"0011100" : 5.8 mA	"1011100" : 18.6 mA
"0011101" : 6.0 mA	"1011101" : 18.8 mA
"0011110" : 6.2 mA	"1011110" : 19.0 mA
"0011111" : 6.4 mA	"1011111" : 19.2 mA
"0100000" : 6.6 mA	"1100000" : 19.4 mA
"0100001" : 6.8 mA	"1100001" : 19.6 mA
"0100010" : 7.0 mA	"1100010" : 19.8 mA
"0100011" : 7.2 mA	"1100011" : 20.0 mA
"0100100" : 7.4 mA	"1100100" : 20.2 mA
"0100101" : 7.6 mA	"1100101" : 20.4 mA
"0100110" : 7.8 mA	"1100110" : 20.6 mA
"0100111" : 8.0 mA	"1100111" : 20.8 mA
"0101000" : 8.2 mA	"1101000" : 21.0 mA
"0101001" : 8.4 mA	"1101001" : 21.2 mA
"0101010" : 8.6 mA	"1101010" : 21.4 mA
"0101011" : 8.8 mA	"1101011" : 21.6 mA
"0101100" : 9.0 mA	"1101100" : 21.8 mA
"0101101" : 9.2 mA	"1101101" : 22.0 mA
"0101110" : 9.4 mA	"1101110" : 22.2 mA
"0101111" : 9.6 mA	"1101111" : 22.4 mA
"0110000" : 9.8 mA	"1110000" : 22.6 mA
"0110001" : 10.0 mA	"1110001" : 22.8 mA
"0110010" : 10.2 mA	"1110010" : 23.0 mA
"0110011" : 10.4 mA	"1110011" : 23.2 mA
"0110100" : 10.6 mA	"1110100" : 23.4 mA
"0110101" : 10.8 mA	"1110101" : 23.6 mA
"0110110" : 11.0 mA	"1110110" : 23.8 mA
"0110111" : 11.2 mA	"1110111" : 24.0 mA
"0111000" : 11.4 mA	"1111000" : 24.2 mA
"0111001" : 11.6 mA	"1111001" : 24.4 mA
"0111010" : 11.8 mA	"1111010" : 24.6 mA
"0111011" : 12.0 mA	"1111011" : 24.8 mA
"0111100" : 12.2 mA	"1111100" : 25.0 mA
"0111101" : 12.4 mA	"1111101" : 25.2 mA
"0111110" : 12.6 mA	"1111110" : 25.4 mA
"0111111" : 12.8 mA	"1111111" : 25.6 mA

●Contents of “Explanation for operate”

1. Reset
 - (1) Software reset
 - (2) Hardware reset
 - (3) Reset sequence
2. Thermal shutdown
3. DC/DC for LED Driver
4. Protection function
 - (1) Over voltage protection
 - (2) Over current protection
 - (3) VOUT short to GND protection
 - (4) VOUT open protection
5. ALC (Auto Luminous Control) and LED Driver
 - (1) ALC ON/OFF
 - (2) I/V conversion
 - (3) Sensor Gain control
 - (4) A/D conversion
 - (5) Average filter
 - (6) Ambient level detection
 - (7) LED current assignment
 - (8) Slope process
 - (9) LED current reset at mode change
 - (10) Current adjustment (External PWM)
6. I/O
7. The unused terminal

●Explanation for operate

1. Reset

There are two kinds of reset, software reset and hardware reset.

(1) Software reset

- All the registers are initialized more than making a register (SFTRST) setup "1".
- The register of software resetting is an automatic return (Auto Return 0).

(2) Hardware reset

- RESETB pin "H" → "L" to shift hardware reset.
- Under hardware reset, all registers and output pins are initialized, and I²C access are stopped.
- RESETB pin "L" → "H" to release from hardware reset
- RESETB pin has delay circuit. It doesn't recognize as hardware reset in "L" period under 5μs.

(3) Reset Sequence

- When hardware reset was done during software reset, software reset is canceled when hardware reset is canceled. (Because the initial value of software reset is "0")

2. Thermal shutdown

Thermal shutdown function is effective in the following blocks.

DC/DC
LED Driver

A thermal shutdown function works in about 190°C.

Detection temperature has a hysteresis, and detection release temperature is about 170°C.
(Design reference value)

3. DC/DC for LED driver

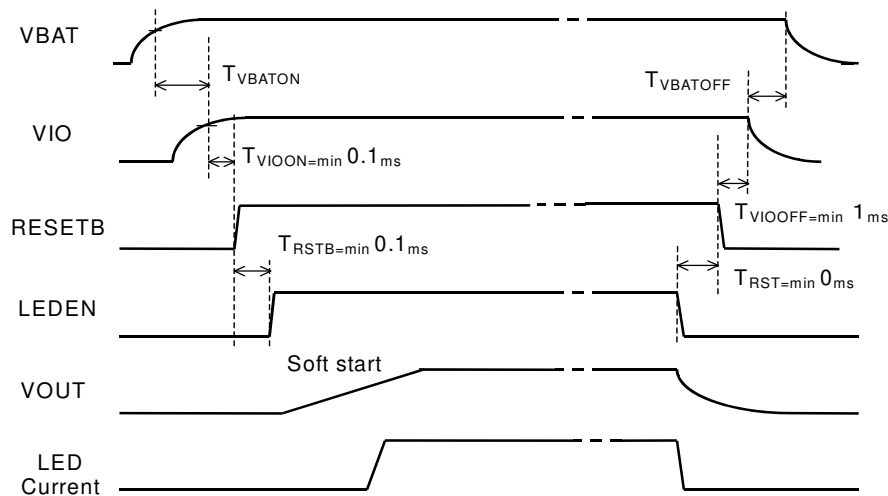
DC/DC block is designed for the power supply for LED driver.

Start

DC/DC circuit operates when LEDEN turns ON.

Soft start

Soft start function built-in to prevent rush current at start of the DC/DC.



4. Protection function

(1) Over voltage protection

Over Voltage Protection prevents the over-voltage of the VOUT terminal. If the VOUT voltage is over detect voltage, it stopping DC/DC switching. After stopping the switching, if VOUT is drop under un-detect voltage, the switching is re-start.

The OVP voltage can be changed by the register.

It is possible that an OVP voltage is set up suitably in accordance with the Vf and the number of LED that you use. Set it up toward an approximate goal of the following formula.

$$\text{OVP voltage} \geq (\text{LED number}) \times (\text{LED Vf max}) + 1 \text{ [V]}$$

(2) Over current protection

Switching Overcurrent detection is done by the resistance arranged under the switching Tr. If it detect over current level, it is stopping DC/DC switching. Switching begins again when a state of over-current is canceled.

(3) VOUT short to GND protection

The detection of a state of ground short of the VOUT terminal.

DC/DC switching does stop at the time of the detection. Switching begins again when a state of detection is canceled.

(4) VOUT open protection

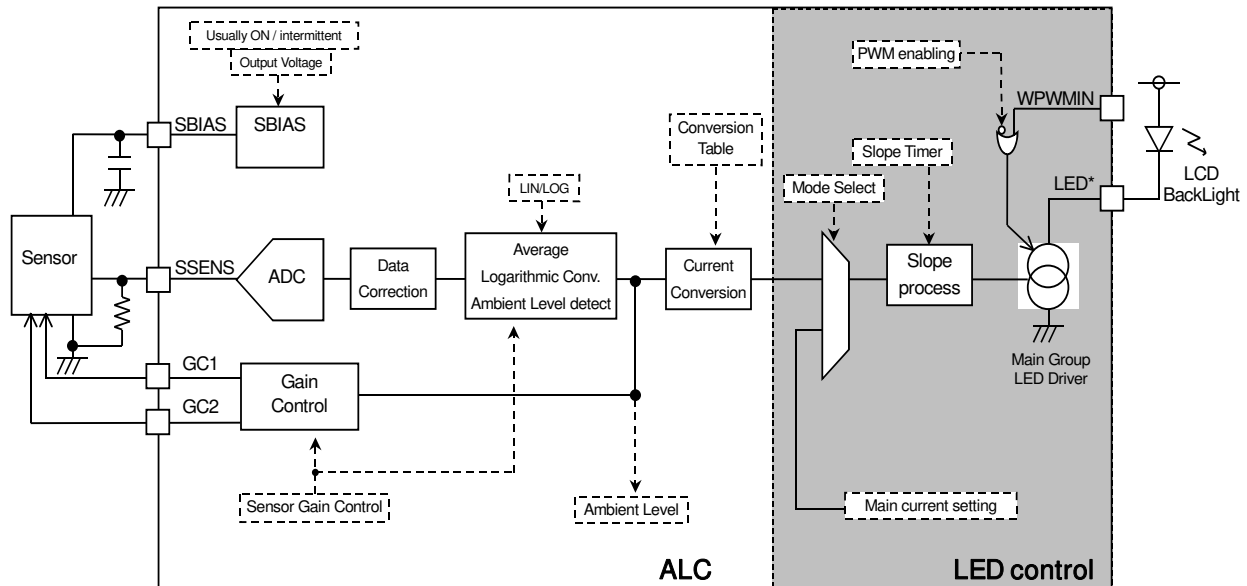
The detection of a state of Open of the VOUT terminal.

DC/DC switching does stop at the time of the detection. Switching begins again when a state of detection is canceled.

5. The explanation of ALC (Auto Luminous Control)

LCD backlight current adjustment is possible in the basis of ambient brightness by external sensor.

- Extensive selection of the ambient light sensors (Photo Diode, Photo Transistor, Photo IC(linear)) is possible by built-in adjustment feature of Sensor bias, ADC with average filter and logarithm conversion.
- Ambient brightness is changed into ambient level by digital data processing, and it can be read through I²C I/F.
- Register setting can customize a conversion to LED current. (Initial value is pre-set.)
- Natural dimming of LED driver is possible with the adjustment of the current transition speed.



* Wave form in this explanation just shows operation image, not shows absolute value precisely.

(1) Auto Luminous Control ON/OFF

- ALC block can be independent setting ON/OFF.
- It can use only to measure the Ambient level.
Register : ALCEN
Register : LEDEN
Register : LEDMD
- Refer to under about the associate ALC mode and LED current.

ALCEN	LEDEN	LEDMD	ALC	LED control	Mode	LED current
0	0	*	OFF (AMB(3:0)=0h)	OFF	OFF	OFF
0	1	0		ON	Resister mode	ILED(6:0)
0	1	1		ON		IU0(6:0) (* 1)
1	0	*	ON	OFF	ALC mode	OFF
1	1	0		ON		ILED(6:0)
1	1	1		ON		ALC mode (* 2)

(* 1) LED current is selected IU0(6:0), because of ALC is OFF, AMB(3:0)=0h.

(* 2) LED current is selected IU0(6:0)~IUF(6:0) corresponding to each ambient level.

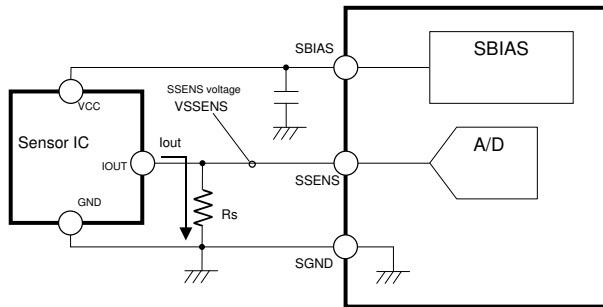
(2) I/V conversion

- The bias voltage and external resistance for the I-V conversion (R_s) are adjusted with adaptation of sensor characteristic
- The bias voltage is selectable by register setup.

Register : VSB

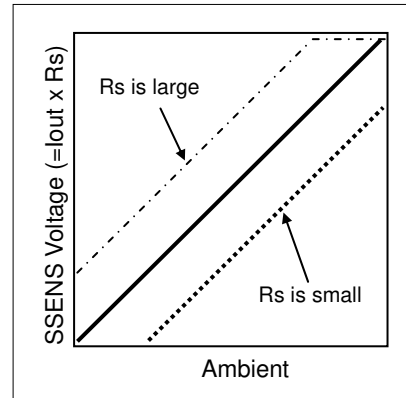
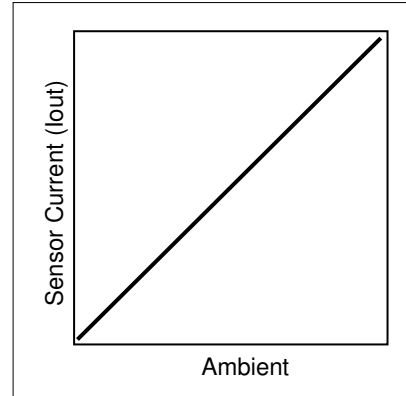
“0” : SBIAS output voltage 3.0V

“1” : SBIAS output voltage 2.6V



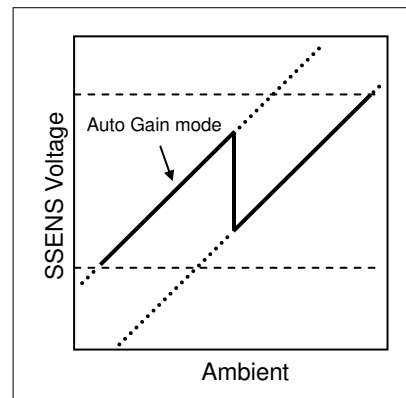
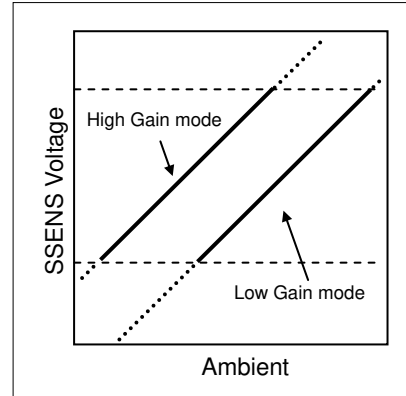
R_s : Sense resistance (A sensor output current is changed into the voltage value.)
 SBIAS : Bias power supply terminal for the sensor (3.0V / 2.6V by register setting)
 SSENS : Sense voltage input terminal

$$\text{SSENS Voltage} = I_{out} \times R_s$$



(3) Sensor Gain control

- Sensor gain switching function is built in to extend the dynamic range.
- It is controlled by register setup.
- When automatic gain control is off, the gain status can be set up in the manual.
Register : GAIN(1:0)
- GC1 and GC2 are outputted corresponding to each gain status.



	Example 1 (Use BH1600FVC)				Example 2				Example 3	
Application example										
	Resistor values are relative									
Operating mode	Auto	Manual		Auto	Manual		Fixed			
		High	Low		High	Low				
GAIN(1:0) setting	00	01	10	00	01	10	11			
Gain status	High Low	High	Low	High Low	High	Low	-			
GC1 output		L		L		L		L		
GC2 output	L		L		L		L		L	

: This means that it becomes High with A/D measurement cycle synchronously.

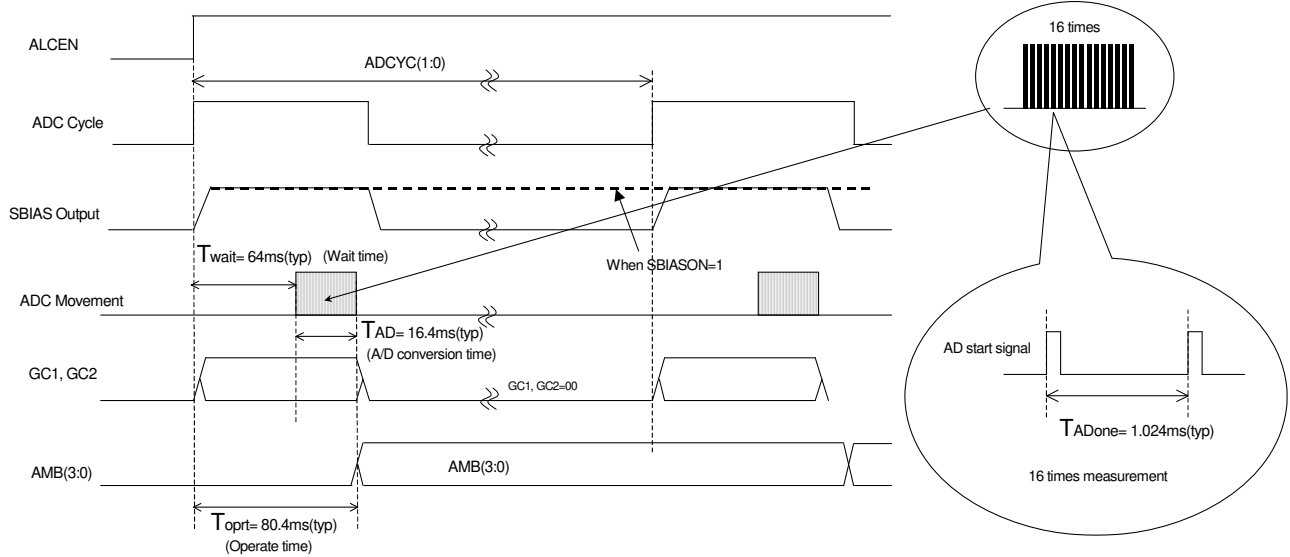
(*1) : Set up the relative ratio of the resistance in the difference in the brightness change of the High Gain mode and the Low Gain mode carefully.

(4) A/D conversion

- The detection of ambient data is done periodically for the low power.
- SBIAS and ADC are turned off except for the ambient measurement.
- The sensor current may be shut in this function, it can possible to decrease the current consumption.
- SBIAS pin and SSENS pin are pull-down in internal when there are OFF.
- SBIAS circuit has the two modes. (Usually ON mode or intermittent mode)

Register : ADCYC(1:0)

Register : SBIASON



(5) Average filter

- Average filter is built in to rid noise or flicker.
- 16 times averaging.

(6) Ambient level detection

- Averaged A/D value is converted to Ambient level corresponding to Gain control and sensor type.
- Ambient level is judged to rank of 16 steps by ambient data.
- The type of ambient light sensor can be chosen by register.
(Linear type sensor / Logarithm type sensor)

Register : STYPE

"0" : For Linear sensor

"1" : For Log sensor

- Ambient level is output through I²C.

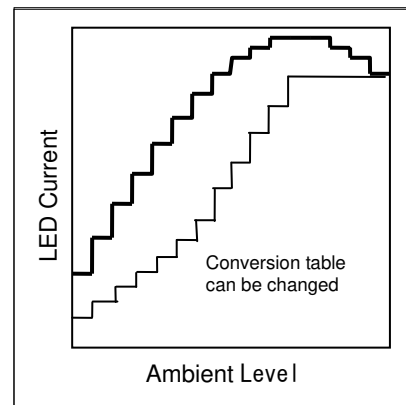
Register : AMB(3:0)

STYPE	0					1
GAIN(1:0)	00		10	01	11	XX
Gain Status	Auto Low	Auto High	Manual Low	Manual High	Fixed	Fixed
Ambient level	SSENS voltage					
0h	This area is not assigned.	VoS × 0 / 256	This area is not assigned.	VoS × 0 / 256	VoS × 0 / 256	VoS × 0 / 256 VoS × 17 / 256
1h		VoS × 1 / 256		VoS × 1 / 256	VoS × 1 / 256	VoS × 18 / 256 VoS × 26 / 256
2h		VoS × 2 / 256		VoS × 2 / 256	VoS × 2 / 256	VoS × 27 / 256 VoS × 36 / 256
3h		VoS × 3 / 256 VoS × 4 / 256		VoS × 3 / 256 VoS × 4 / 256	VoS × 3 / 256 VoS × 4 / 256	VoS × 37 / 256 VoS × 47 / 256
4h		VoS × 5 / 256 VoS × 7 / 256		VoS × 5 / 256 VoS × 6 / 256	VoS × 5 / 256 VoS × 7 / 256	VoS × 48 / 256 VoS × 59 / 256
5h	VoS × 0 / 256	VoS × 8 / 256 VoS × 12 / 256	VoS × 0 / 256	VoS × 8 / 256 VoS × 12 / 256	VoS × 7 / 256 VoS × 9 / 256	VoS × 60 / 256 VoS × 71 / 256
6h	VoS × 1 / 256	VoS × 13 / 256 VoS × 21 / 256	VoS × 1 / 256	VoS × 13 / 256 VoS × 21 / 256	VoS × 10 / 256 VoS × 13 / 256	VoS × 72 / 256 VoS × 83 / 256
7h	VoS × 2 / 256 VoS × 3 / 256	VoS × 22 / 256 VoS × 37 / 256	VoS × 2 / 256 VoS × 3 / 256	VoS × 22 / 256 VoS × 37 / 256	VoS × 14 / 256 VoS × 19 / 256	VoS × 84 / 256 VoS × 95 / 256
8h	VoS × 4 / 256 VoS × 6 / 256	VoS × 38 / 256 VoS × 65 / 256	VoS × 4 / 256 VoS × 6 / 256	VoS × 38 / 256 VoS × 65 / 256	VoS × 20 / 256 VoS × 27 / 256	VoS × 96 / 256 VoS × 107 / 256
9h	VoS × 7 / 256 VoS × 11 / 256	VoS × 66 / 256 VoS × 113 / 256	VoS × 7 / 256 VoS × 11 / 256	VoS × 66 / 256 VoS × 113 / 256	VoS × 28 / 256 VoS × 38 / 256	VoS × 108 / 256 VoS × 119 / 256
Ah	VoS × 12 / 256 VoS × 20 / 256	VoS × 114 / 256 VoS × 199 / 256	VoS × 12 / 256 VoS × 20 / 256	VoS × 114 / 256 VoS × 199 / 256	VoS × 39 / 256 VoS × 53 / 256	VoS × 120 / 256 VoS × 131 / 256
Bh	VoS × 21 / 256 VoS × 36 / 256	VoS × 200 / 256 VoS × 255 / 256	VoS × 21 / 256 VoS × 36 / 256	VoS × 200 / 256 VoS × 255 / 256	VoS × 54 / 256 VoS × 74 / 256	VoS × 132 / 256 VoS × 143 / 256
Ch	VoS × 37 / 256 VoS × 64 / 256	This area is not assigned.	VoS × 37 / 256 VoS × 64 / 256	This area is not assigned.	VoS × 75 / 256 VoS × 104 / 256	VoS × 144 / 256 VoS × 155 / 256
Dh	VoS × 65 / 256 VoS × 114 / 256		VoS × 65 / 256 VoS × 114 / 256		VoS × 105 / 256 VoS × 144 / 256	VoS × 156 / 256 VoS × 168 / 256
Eh	VoS × 115 / 256 VoS × 199 / 256		VoS × 115 / 256 VoS × 199 / 256		VoS × 145 / 256 VoS × 199 / 256	VoS × 169 / 256 VoS × 181 / 256
Fh	VoS × 200 / 256 VoS × 255 / 256		VoS × 200 / 256 VoS × 255 / 256		VoS × 200 / 256 VoS × 255 / 256	VoS × 182 / 256 VoS × 255 / 256

- In the Auto Gain control mode, sensor gain changes in gray-colored ambient level.

(7) LED current assignment

- LED current can be assigned as each of 16 steps of the ambient level.
- Register setting can customize a conversion to LED current. (Initial value is pre-set.)
Register : IU* (6:0)

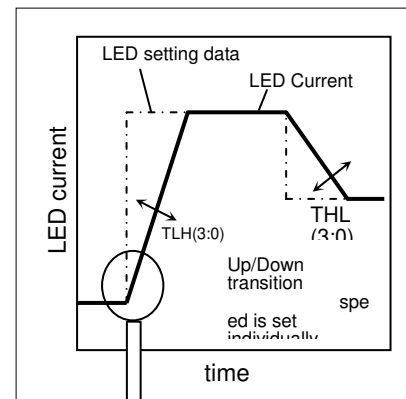
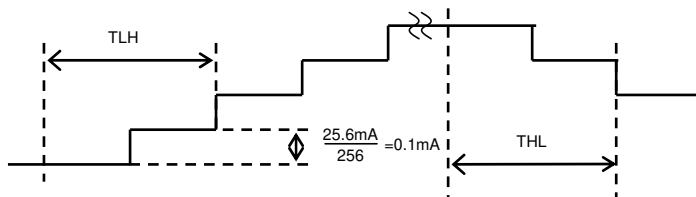


Conversion Table (initial value)

Ambient Level	Setting data	Current value	Ambient Level	Setting data	Current value
0h	11h	3.6mA	8h	48h	14.6mA
1h	13h	4.0mA	9h	56h	17.4mA
2h	15h	4.4mA	Ah	5Fh	19.2mA
3h	18h	5.0mA	Bh	63h	20.0mA
4h	1Eh	6.2mA	Ch	63h	20.0mA
5h	25h	7.6mA	Dh	63h	20.0mA
6h	2Fh	9.6mA	Eh	63h	20.0mA
7h	3Bh	12.0mA	Fh	63h	20.0mA

(8) Slope process

- Slope process is given to LED current to dim naturally.
- LED current changes in the 256Step gradation in sloping.
- Up(dark→bright),Down(bright→dark) LED current transition speed are set individually.
Register : THL(3:0)
Register : TLH(3:0)
- LED current changes as follows at the time as the slope.
TLH (THL) is setup of time of the current step 2/256.



Zoom

