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LED Drivers for LCD Backlights

Mulitifunction Backlight LED Driver for Small LCD Panels (Charge Pump Type)

BD6095GUL,BD6095GU

No.11040EAT31

●Description

BD6095GUL/BD6095GU is “Intelligent LED Driver” that is the most suitable for the cellular phone.
It has many functions that are needed to "the upper side" of the cellular phone.
It has ALC function, that is “Low Power Consumption System” realized.
It has “Contents Adaptive Interface” (External PWM control), that is “Low Power Consumption System” realized.
It adopts the very thin CSP package that is the most suitable for the slim phone.

●Features

1) Total 5LEDs driver for LCD Backlight
   It can set maximum 25.6mA /ch by 128steps (Current DAC) for LCD Display.
   3LEDs(LED1~LED3) are same controlled.
   Another 2LEDs(LED4~5) can be independent controlled. (Enable and Current setting)
   2LEDs(LED4~5) can be attributed to “Main Group”.
   “Main Group” can be controlled by Auto Luminous Control (ALC) system.
   “Main Group” can be controlled by external PWM signal.
2) 1LED driver for Flash/Torch
   It can set maximum 120mA for Flash LED Driver.
   It has Flash mode and Torch mode, there can be changed by external pin or register.
3) **A**uto **L**uminous **C**ontrol (ALC)
   Main backlight can be controlled by ambient brightness.
   Photo Diode, Photo Transistor, Photo IC(Linear/Logarithm) can be connected.
   Bias source for ambient light sensor, gain and offset adjustment are built in.
   LED driver current as ambient level can be customized.
4) 2ch Series Regulator (LDO)
   It has selectable output voltage by the register.
   LDO1,LDO2 : Iomax=150mA
5) Charge Pump DC/DC for LED driver
   It has x1/x1.33/x1.5/x2 mode that will be selected automatically.
   Soft start functions
   Over voltage protection (Auto-return type)
   Over current protection (Auto-return type)
6) Thermal shutdown (Auto-return type)
7) I^2C BUS FS mode (max 400kHz)
8) VCSP50L3 (3.75mm^2, 0.55mmt max) Small and thin CSP package (BD6095GUL)
9) VCSP85H3 (3.75mm^2, 1.0mmt max) Small and thin CSP package (BD6095GU)

*This chip is not designed to protect itself against radioactive rays.
*This material may be changed on its way to designing.
*This material is not the official specification.

●Absolute Maximum Ratings (Ta=25 °C)

Parameter	Symbol	Ratings	Unit
Maximum voltage	VMAX	7	V
Power Dissipation	Pd	1500	mW
Operating Temperature Range	Topr	-35 ~ +85	°C
Storage Temperature Range	Tstg	-55 ~ +150	°C

note)Power dissipation deleting is 12.0mW/°C, when it’s used in over 25°C. (It’s deleting is on the board that is ROHM’s standard)

●Operating conditions (VBAT≥VIO, Ta=-35~85°C)

Parameter	Symbol	Ratrings	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	-	90	150	μA	LDO1=LDO2=ON, I_{LDO}=0mA Other blocks=OFF
VBAT Circuit current 4	IBAT4	-	61	65	mA	DC/DC x1mode, I_{LED}=60mA VBAT=3.7V, LED Vf=3.0V
VBAT Circuit current 5	IBAT5	-	83	94	mA	DC/DC x1.33mode, I_{LED}=60mA VBAT=3.1V, LED Vf=3.0V
VBAT Circuit current 6	IBAT6	-	93	104	mA	DC/DC x1.5mode, I_{LED}=60mA VBAT=2.9V, LED Vf=3.5V
VBAT Circuit current 7	IBAT7	-	124	136	mA	DC/DC x2mode, I_{LED}=60mA VBAT=3.2V, LED Vf=4.0V
VBAT Circuit current 8	IBAT8	-	0.25	1.0	mA	Only ALC block ON ADCYC=0.5s setting Except sensor current
【LED Driver】						
LED current Step (Setup)	ILEDSTP1		128		Step	LED1~5
LED current Step (At slope)	ILEDSTP2		256		Step	LED1~5
LED current Step (Flash)	ILEDSTPFL		32		Step	LEDFL
White LED Maximum setup current	IMAXWLED	-	25.6	-	mA	LED1~5
Flash LED Maximum setup current	IMAXFLED	-	120	-	mA	LEDFL
LED1~5 current accuracy	IWLED	-7%	15	+7%	mA	I_{LED}=15mA setting at VLED=1.0V
Flash LED current accuracy	IFLED	-7%	60	+7%	mA	I_{LED}=60mA setting at VLED=1.0V
LED current Matching	ILEDMT	-	-	4	%	Between LED1~5 at VLED=1.0V
LED OFF Leak current	ILKLED	-	-	1.0	μA	VLED=4.5V
【DC/DC（Charge Pump)】						
Maximum Output voltage	VoCP	4.65	5.1	5.55	V	
Current Load	IOUT	-	-	250	mA	VBAT≥3.2V, VOUT=4V
Oscillator frequency	fosc	0.8	1.0	1.2	MHz	
Over Voltage Protection detect voltage	OVP	-	-	6.0	V	
Short Circuit current limit	Ilim	-	125	250	mA	VOUT=0V
【I^2C Input (SDA, SCL)】						
LOW level input voltage	VIL	-0.3	-	0.25 × VIO	V	
HIGH level input voltage	VIH	0.75 × VIO	-	VBAT +0.3	V	
Hysteresis of Schmitt trigger input	Vhys	0.05 × VIO	-	-	V	
LOW level output voltage (SDA) at 3mA sink current	VOL	0	-	0.3	V	
Input current each I/O pin	Iin	-3	-	3	μA	Input voltage = 0.1×VIO~0.9×VIO
【RESETB】						
LOW level input voltage	VIL	-0.3	-	0.25 × VIO	V	
HIGH level input voltage	VIH	0.75 × VIO	-	VBAT +0.3	V	
Input current each I/O pin	Iin	-3	-	3	μA	Input voltage = 0.1×VIO~0.9×VIO

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

Parameter	Symbol	Limits			Unit	Condition
		Min.	Typ.	Max.		
【Regulator (LDO1)】						
Output voltage	Vo1	1.164	1.20	1.236	V	Io=50mA
		1.261	1.30	1.339	V	Io=50mA
		1.455	1.50	1.545	V	Io=50mA
		1.552	1.60	1.648	V	Io=50mA
		1.746	1.80	1.854	V	Io=50mA <Initial Voltage>
		2.134	2.20	2.266	V	Io=50mA
		2.328	2.40	2.472	V	Io=50mA
		2.425	2.50	2.575	V	Io=50mA
		2.522	2.60	2.678	V	Io=50mA
		2.619	2.70	2.781	V	Io=50mA
		2.716	2.80	2.884	V	Io=50mA
		2.813	2.90	2.987	V	Io=50mA
		2.910	3.00	3.090	V	Io=50mA
		3.007	3.10	3.193	V	Io=50mA
		3.104	3.20	3.296	V	Io=50mA
		3.201	3.30	3.399	V	Io=50mA
Output Current	Io1	-	-	150	mA	Vo=1.8V
Dropout Voltage	Vsat1	-	0.05	0.1	V	VBAT=2.5V, Io=50mA, Vo=2.8V
Load stability	ΔVo11	-	10	60	mV	Io=1~150mA, Vo=1.8V
Input voltage stability	ΔVo12	-	10	60	mV	VBAT=3.4~4.5V, Io=50mA, Vo=1.8V
Ripple Rejection Ratio	RR1	-	65	-	dB	f=100Hz, Vin=200mVp-p, Vo=1.2V Io=50mA, BW=20Hz~20kHz
Short circuit current limit	Ilim1	-	200	400	mA	Vo=0V
Discharge resister at OFF	ROFF1	-	1.0	1.5	kΩ	
【Regulator (LDO2)】						
Output voltage	Vo2	1.164	1.20	1.236	V	Io=50mA
		1.261	1.30	1.339	V	Io=50mA
		1.455	1.50	1.545	V	Io=50mA
		1.552	1.60	1.648	V	Io=50mA
		1.746	1.80	1.854	V	Io=50mA
		2.134	2.20	2.266	V	Io=50mA
		2.328	2.40	2.472	V	Io=50mA
		2.425	2.50	2.575	V	Io=50mA <Initial Voltage>
		2.522	2.60	2.678	V	Io=50mA
		2.619	2.70	2.781	V	Io=50mA
		2.716	2.80	2.884	V	Io=50mA
		2.813	2.90	2.987	V	Io=50mA
		2.910	3.00	3.090	V	Io=50mA
		3.007	3.10	3.193	V	Io=50mA
		3.104	3.20	3.296	V	Io=50mA
		3.201	3.30	3.399	V	Io=50mA
Output Current	Io2	-	-	150	mA	Vo=2.5V
Dropout Voltage	Vsat2	-	0.05	0.1	V	VBAT=2.5V, Io=50mA, Vo=2.8V
Load stability	Δvo21	-	10	60	mV	Io=1~150mA, Vo=2.5V
Input voltage stability	Δvo22	-	10	60	mV	VBAT=3.4~4.5V, Io=50mA, Vo=2.5V
Ripple Rejection Ratio	RR2	-	65	-	dB	f=100Hz, Vin=200mVp-p, Vo=1.2V Io=50mA, BW=20Hz~20kHz
Short circuit current limit	Ilim2	-	200	400	mA	Vo=0V
Discharge resister at OFF	ROFF2	-	1.0	1.5	kΩ	

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

Parameter	Symbol	Limits			Unit	Condition
		Min.	Typ.	Max.		
【Sensor Interface】						
SBIAS Output voltage	VoS	2.850	3.0	3.150	V	Io=200μA <Initial Voltage>
		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 resister 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	RSSENS	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	80	-	-	μs	
【GC1, GC2】						
L level output voltage	VOLS	-	-	0.2	V	IOL=1mA
H level output voltage	VOHS	VoS -0.2	-	-	V	IOH=1mA
【FLASHCNT】						
L level input voltage	VILF	-0.3	-	0.3	V	
H level input voltage	VIHF	1.4	-	VBAT +0.3	V	
Input current	IinF	-	3.6	10	μA	Vin=1.8V

●Block Diagram / Application Circuit example

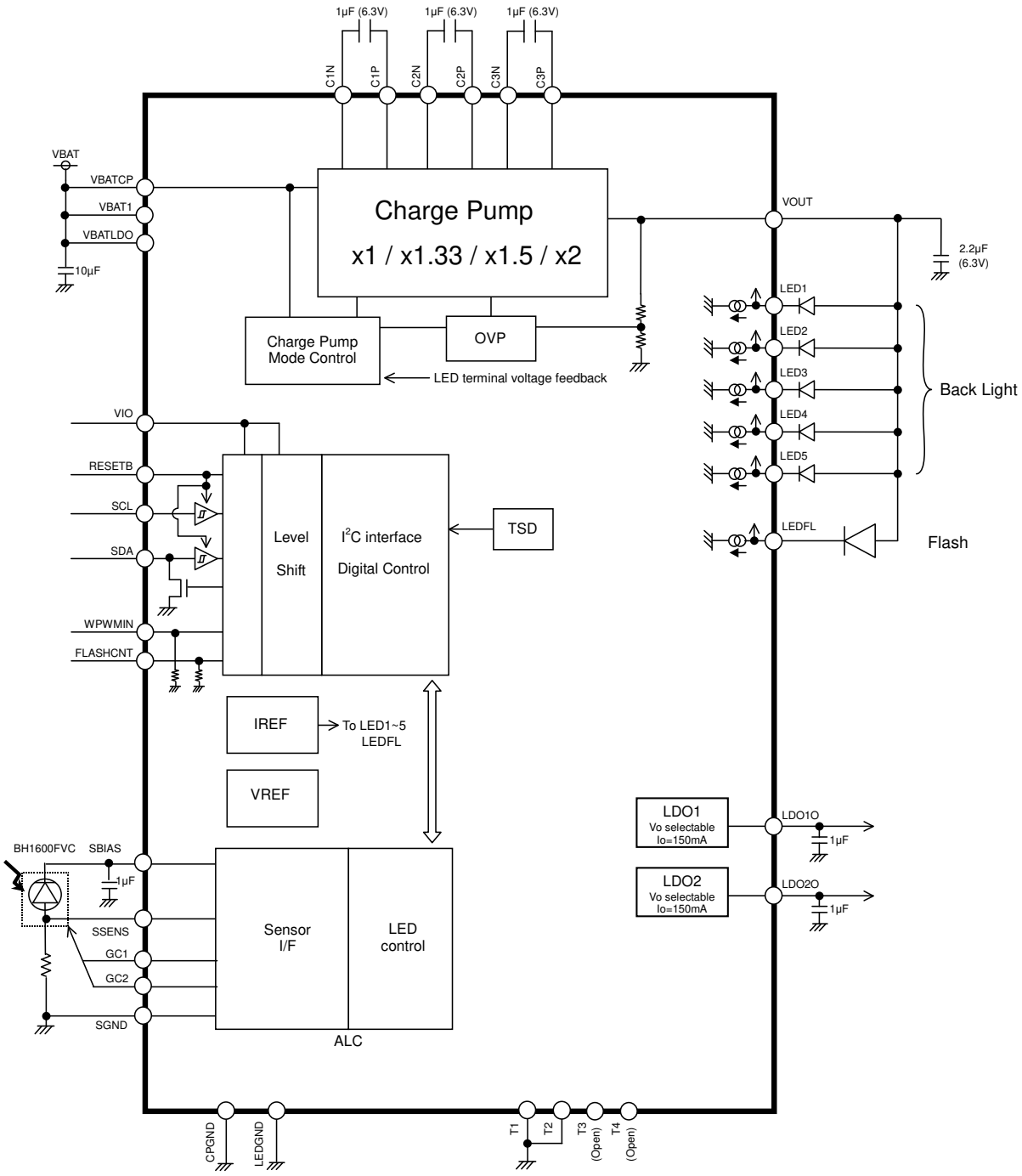
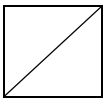


Fig.1 Block Diagram / Application Circuit example

●Pin Arrangement ［Bottom View］

	1	2	3	4	5	6
F	T4	LDO1O	SSENS	VBAT1	SBIAS	T3
E	VBATLDO	LDO2O	GC2	GC1	SGND	VIO
D	WPWMIN	LED1	FLASHCNT	SDA	SCL	C1N
C	LED3	LED2		RESETB	C1P	C2N
B	LED4	LED5	LEDGND	VOUT	VBATCP	C2P
A	T1	LEDFL	CPGND	C3N	C3P	T2


Index

Total: 35 balls

●Package

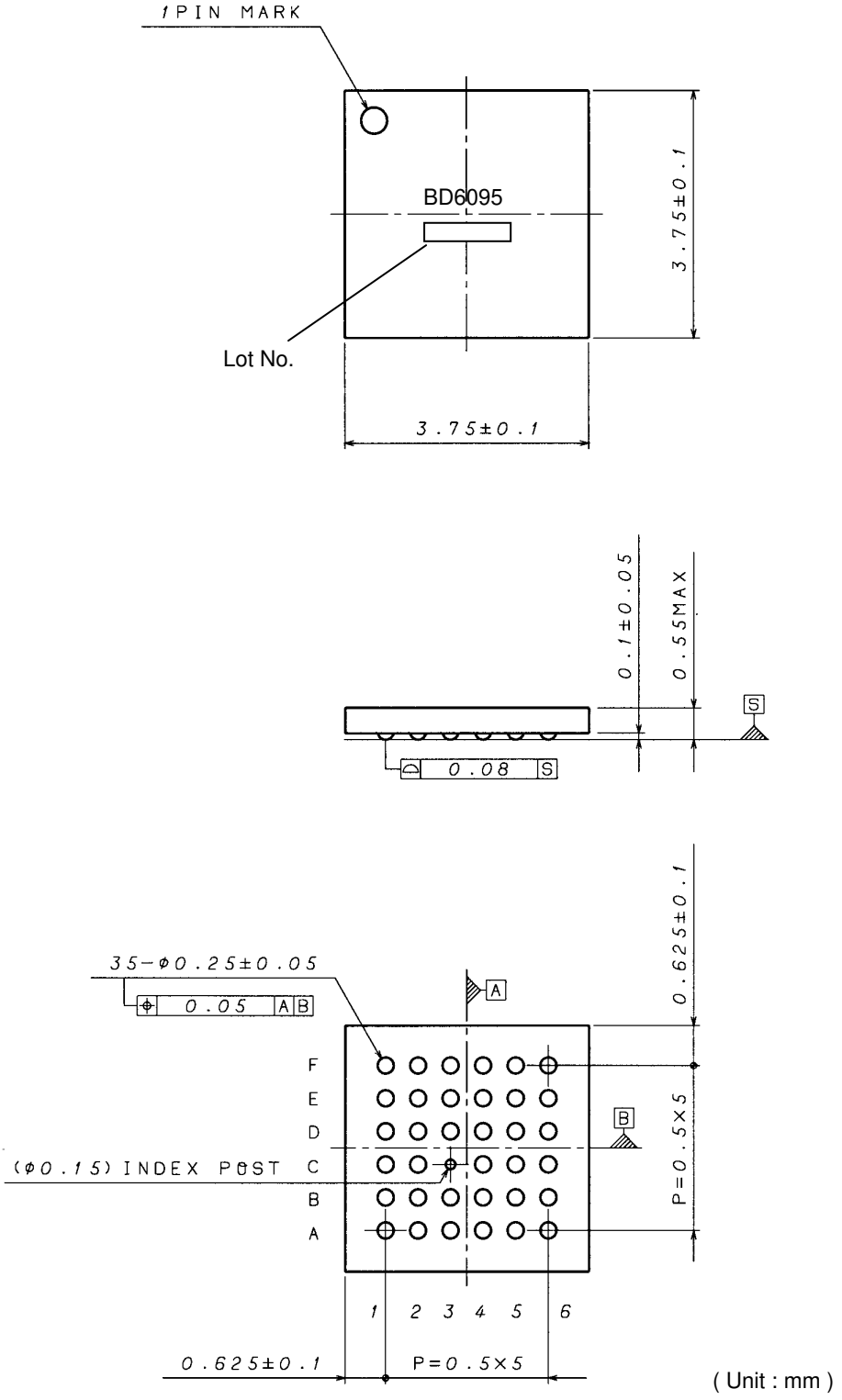
●BD6095GUL

VCSP50L3

SIZE : 3.75mm

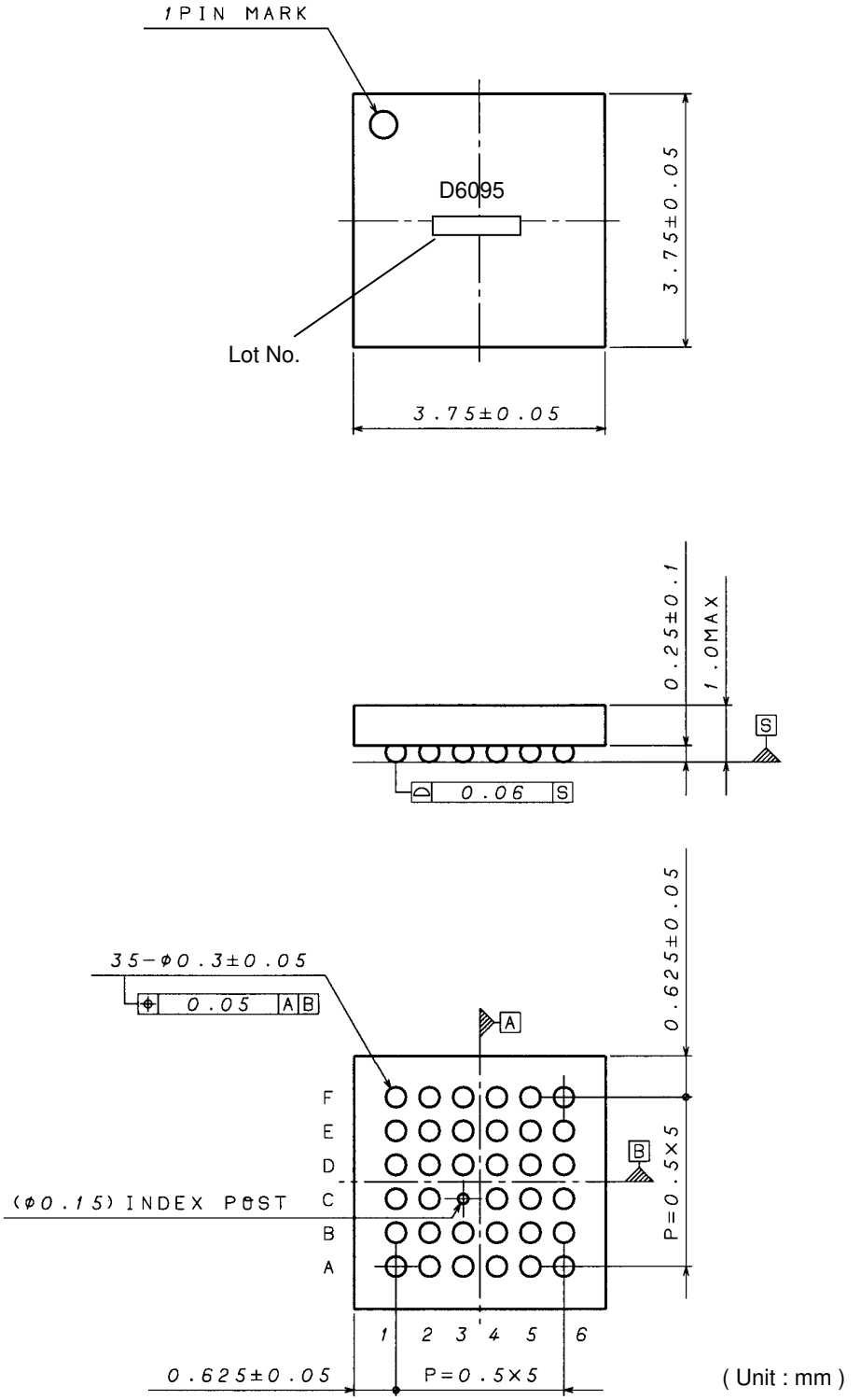
A ball pitch : 0.5mm

Height : 0.55mm max



(Unit : mm)

●BD6095GU
VCSP85H3
SIZE : 3.75mm
A ball pitch : 0.5mm
Height : 1.0mm max



(Unit : mm)

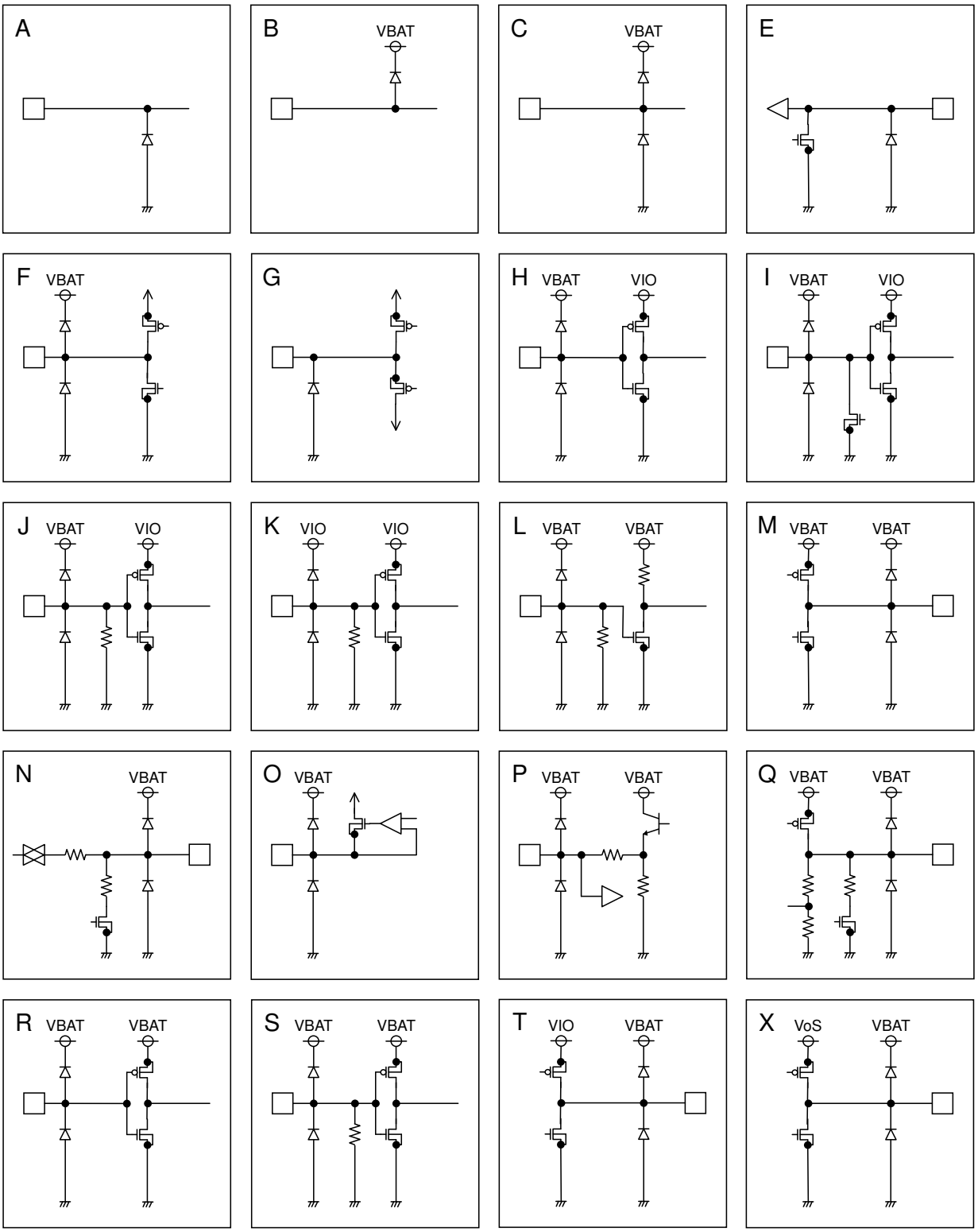
●Pin Functions

No	Ball No.	Pin Name	I/O	ESD Diode		Functions	Equivalent Circuit
				For Power	For Ground		
1	B5	VBATCP	-	-	GND	Power supply for charge pump	A
2	F4	VBAT1	-	-	GND	Power supply	A
3	E1	VBATLDO	-	-	GND	Power supply for LDO	A
4	A1	T1	I	VBAT	GND	Test Input Pin (short to Ground)	S
5	A6	T2	I	VBAT	GND	Test Input Pin (short to Ground)	S
6	F6	T3	O	VBAT	GND	Test Output Pin (Open)	M
7	F1	T4	O	VBAT	GND	Test Output Pin (Open)	N
8	E6	VIO	-	VBAT	GND	Power supply for I/O and Digital	C
9	C4	RESETB	I	VBAT	GND	Reset input (L: reset, H: reset cancel)	H
10	D4	SDA	I/O	VBAT	GND	I^2C data input / output	I
11	D5	SCL	I	VBAT	GND	I^2C clock input	H
12	A3	CPGND	-	VBAT	-	Ground	B
13	B3	LEDGND	-	VBAT	-	Ground	B
14	D6	C1N	I/O	VBAT	GND	Charge Pump capacitor is connected	F
15	C5	C1P	I/O	-	GND	Charge Pump capacitor is connected	G
16	C6	C2N	I/O	VBAT	GND	Charge Pump capacitor is connected	F
17	B6	C2P	I/O	-	GND	Charge Pump capacitor is connected	G
18	A4	C3N	I/O	VBAT	GND	Charge Pump capacitor is connected	F
19	A5	C3P	I/O	-	GND	Charge Pump capacitor is connected	G
20	B4	VOUT	O	-	GND	Charge Pump output pin	A
21	F2	LDO1O	O	VBAT	GND	LDO1 output pin	Q
22	E2	LDO2O	O	VBAT	GND	LDO2 output pin	Q
23	D2	LED1	I	-	GND	LED cathode connection 1	E
24	C2	LED2	I	-	GND	LED cathode connection 2	E
25	C1	LED3	I	-	GND	LED cathode connection 3	E
26	B1	LED4	I	-	GND	LED cathode connection 4	E
27	B2	LED5	I	-	GND	LED cathode connection 5	E
28	A2	LEDFL	I	-	GND	LED cathode connection for Flash	E
29	F5	SBIAS	O	VBAT	GND	Bias output for the Ambient Light Sensor	Q
30	F3	SSENS	I	VBAT	GND	Ambient Light Sensor input	N
31	E4	GC1	O	VBAT	GND	Ambient Light Sensor gain control output 1	X
32	E3	GC2	O	VBAT	GND	Ambient Light Sensor gain control output 2	X
33	E5	SGND	-	VBAT	-	Ground	B
34	D1	WPWMIN	I	VBAT	GND	External PWM input for Back Light	L
35	D3	FLASHCNT	I	VBAT	GND	External enable for Flash	L

※ The LED terminal that isn't used is to short-circuit to the ground. But, the setup of a register concerned with LED that isn't used is prohibited.

Total: 35 Pin

●Equivalent Circuit



●I²C BUS format

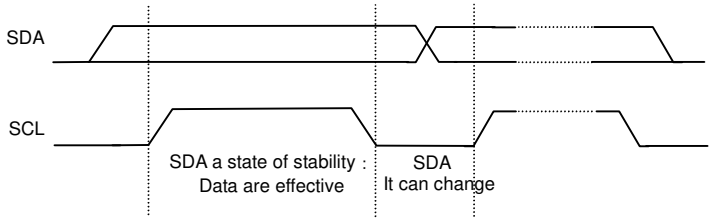
The writing/reading operation is based on the I²C slave standard.

・Slave address

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

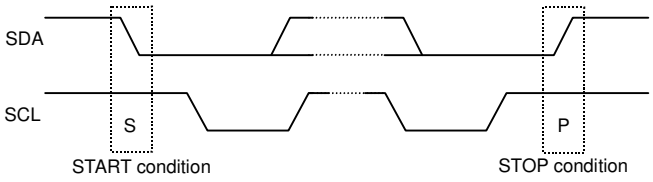
・Bit Transfer

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.



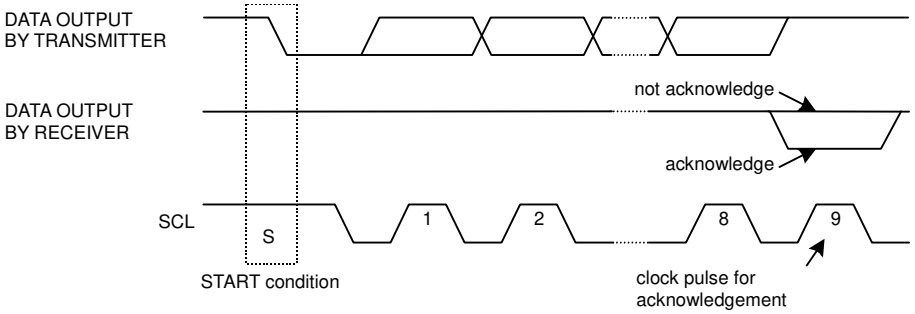
・START and STOP condition

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.



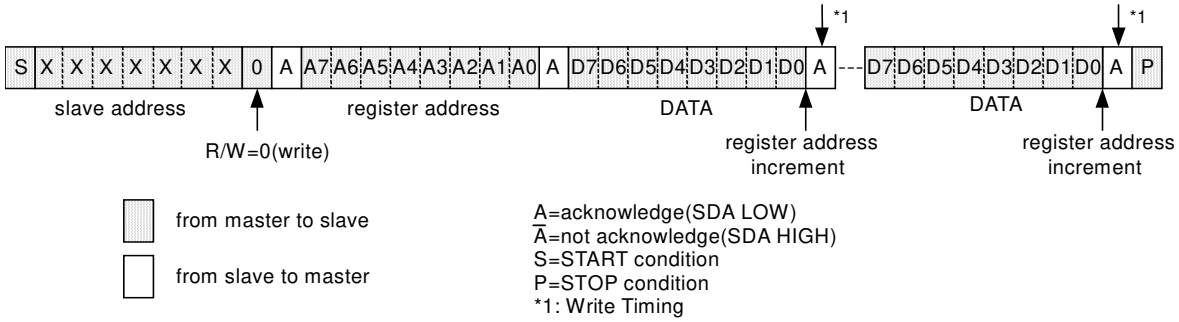
・Acknowledge

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.



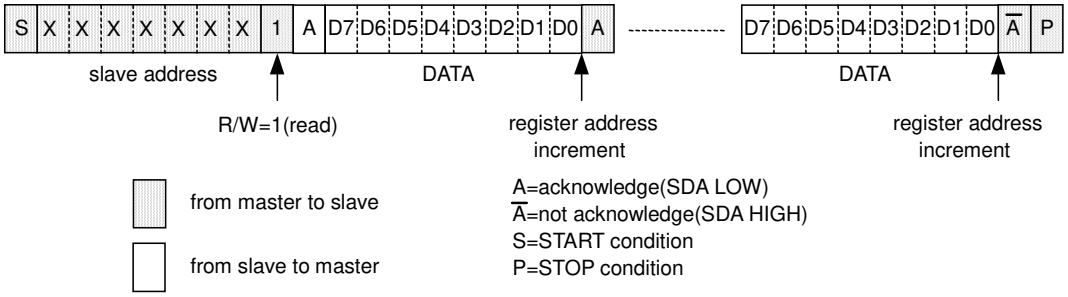
・Writing protocol

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.



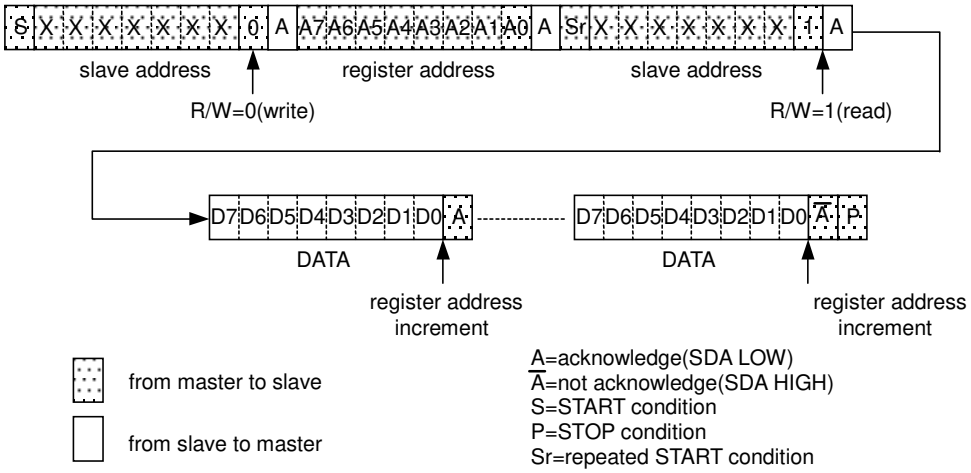
・Reading protocol

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.



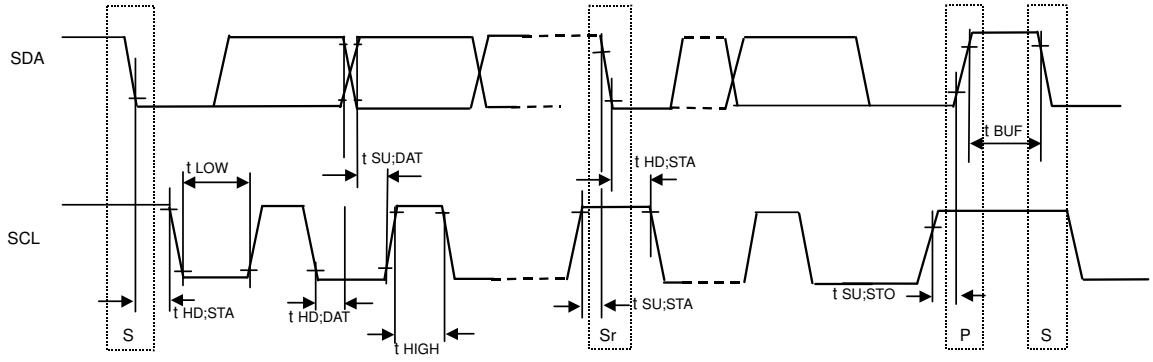
・Multiple reading protocols

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 Ā(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 A(not acknowledge) is done.

●Timing diagram



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

Parameter	Symbol	Standard-mode			Fast-mode			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
【I^2C BUS format】								
SCL clock frequency	f_{SCL}	0	-	100	0	-	400	kHz
LOW period of the SCL clock	t_{LOW}	4.7	-	-	1.3	-	-	μs
HIGH period of the SCL clock	t_{HIGH}	4.0	-	-	0.6	-	-	μs
Hold time (repeated) START condition After this period, the first clock is generated	$t_{HD;STA}$	4.0	-	-	0.6	-	-	μs
Set-up time for a repeated START condition	$t_{SU;STA}$	4.7	-	-	0.6	-	-	μs
Data hold time	$t_{HD;DAT}$	0	-	3.45	0	-	0.9	μs
Data set-up time	$t_{SU;DAT}$	250	-	-	100	-	-	ns
Set-up time for STOP condition	$t_{SU;STO}$	4.0	-	-	0.6	-	-	μs
Bus free time between a STOP and START condition	t_{BUF}	4.7	-	-	1.3	-	-	μs

●Register List

Address	W/R	Register data								Function
		D7	D6	D5	D4	D3	D2	D1	D0	
00h	W	-	-	-	-	-	-	-	SFTRST	Software Reset
01h	W	-	LED5MD(1)	LED5MD(0)	LED4MD	-	WPWMEN	ALCEN	MLEDMD	LED, ALC Control
02h	W	FLASHEN	TORCHEN	SLEDEN	MLEDEN	-	-	LDO2EN	LDO1EN	Power Control
03h	W	-	IMLED(6)	IMLED(5)	IMLED(4)	IMLED(3)	IMLED(2)	IMLED(1)	IMLED(0)	“Main Group” LED Current Setting at non-ALC mode
04h	W	-	ISLED(6)	ISLED(5)	ISLED(4)	ISLED(3)	ISLED(2)	ISLED(1)	ISLED(0)	“Sub Group” LED Current Setting
05h	W	-	-	-	IFTLED(4)	IFTLED(3)	IFTLED(2)	IFTLED(1)	IFTLED(0)	Flash LED “Torch mode” Current Setting
06h	W	-	-	-	IFFLED(4)	IFFLED(3)	IFFLED(2)	IFFLED(1)	IFFLED(0)	Flash LED “Flash mode” Current Setting
07h	W	LDO2VSEL(3)	LDO2VSEL(2)	LDO2VSEL(1)	LDO2VSEL(0)	LDO1VSEL(3)	LDO1VSEL(2)	LDO1VSEL(1)	LDO1VSEL(0)	LDO1, LDO2 Vout Setting
08h	W	THL(3)	THL(2)	THL(1)	THL(0)	TLH(3)	TLH(2)	TLH(1)	TLH(0)	Main Current transition
09h	-	-	-	-	-	-	-	-	-	-
0Ah	-	-	-	-	-	-	-	-	-	-
0Bh	W	ADCYC(1)	ADCYC(0)	GAIN(1)	GAIN(0)	STYPE	VSB	MDCIR	SBIASON	ALC mode setting
0Ch	W	SOFS(3)	SOFS(2)	SOFS(1)	SOFS(0)	SGAIN(3)	SGAIN(2)	SGAIN(1)	SGAIN(0)	ADC Data adjustment
0Dh	R	-	-	-	-	AMB(3)	AMB(2)	AMB(1)	AMB(0)	Ambient level
0Eh	W	-	IU0(6)	IU0(5)	IU0(4)	IU0(3)	IU0(2)	IU0(1)	IU0(0)	Main Current at Ambient level 0h
0Fh	W	-	IU1(6)	IU1(5)	IU1(4)	IU1(3)	IU1(2)	IU1(1)	IU1(0)	Main Current at Ambient level 1h
10h	W	-	IU2(6)	IU2(5)	IU2(4)	IU2(3)	IU2(2)	IU2(1)	IU2(0)	Main Current at Ambient level 2h
11h	W	-	IU3(6)	IU3(5)	IU3(4)	IU3(3)	IU3(2)	IU3(1)	IU3(0)	Main Current at Ambient level 3h
12h	W	-	IU4(6)	IU4(5)	IU4(4)	IU4(3)	IU4(2)	IU4(1)	IU4(0)	Main Current at Ambient level 4h
13h	W	-	IU5(6)	IU5(5)	IU5(4)	IU5(3)	IU5(2)	IU5(1)	IU5(0)	Main Current at Ambient level 5h
14h	W	-	IU6(6)	IU6(5)	IU6(4)	IU6(3)	IU6(2)	IU6(1)	IU6(0)	Main Current at Ambient level 6h
15h	W	-	IU7(6)	IU7(5)	IU7(4)	IU7(3)	IU7(2)	IU7(1)	IU7(0)	Main Current at Ambient level 7h
16h	W	-	IU8(6)	IU8(5)	IU8(4)	IU8(3)	IU8(2)	IU8(1)	IU8(0)	Main Current at Ambient level 8h
17h	W	-	IU9(6)	IU9(5)	IU9(4)	IU9(3)	IU9(2)	IU9(1)	IU9(0)	Main Current at Ambient level 9h
18h	W	-	IUA(6)	IUA(5)	IUA(4)	IUA(3)	IUA(2)	IUA(1)	IUA(0)	Main Current at Ambient level Ah
19h	W	-	IUB(6)	IUB(5)	IUB(4)	IUB(3)	IUB(2)	IUB(1)	IUB(0)	Main Current at Ambient level Bh
1Ah	W	-	IUC(6)	IUC(5)	IUC(4)	IUC(3)	IUC(2)	IUC(1)	IUC(0)	Main Current at Ambient level Ch
1Bh	W	-	IUD(6)	IUD(5)	IUD(4)	IUD(3)	IUD(2)	IUD(1)	IUD(0)	Main Current at Ambient level Dh
1Ch	W	-	IUE(6)	IUE(5)	IUE(4)	IUE(3)	IUE(2)	IUE(1)	IUE(0)	Main Current at Ambient level Eh
1Dh	W	-	IUF(6)	IUF(5)	IUF(4)	IUF(3)	IUF(2)	IUF(1)	IUF(0)	Main Current at Ambient level Fh

Input "0” for "-".
Prohibit to accessing the address that isn’t mentioned.
The time indicated by register explanation is the TYP time made by dividing of the built-in OSC.

●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 "The explanation of Reset" for detail.

Address 01h < LED, ALC Control >

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
01h	W	-	LED5MD(1)	LED5MD(0)	LED4MD	-	WPWMEN	ALCEN	MLEDMD
Initial Value	00h	-	0	0	0	-	0	0	0

Bit7 : (Not used)

Bit [6:5] : **LED5MD(1:0)** LED5 Group Select (Main/Sub/OFF)
"00" : LED5 OFF
"01" : reserved
"10" : LED5 "Sub Group"
"11" : LED5 "Main Group"
Refer to "The explanation of LED Driver" for detail.

Bit4 : **LED4MD** LED4 Group Select (Main/Sub)
"0" : LED4 "Sub Group"
"1" : LED4 "Main Group"
Refer to "The explanation of LED Driver" for detail.

Bit3 : (Not used)

Bit2 : **WPWMEN** External PWM Input "WPWMIN" terminal Enable Control (Valid/Invalid)
"0" : WPWMIN input invalid
"1" : WPWMIN input valid
Refer to "(11) Current Adjustment" of "The explanation of ALC" for detail.

Bit1 : **ALCEN** ALC Function Control (ON/OFF)
"0" : ALC function OFF
"1" : ALC function ON
Refer to "(1) Auto Luminous Control ON/OFF" of "The explanation of ALC" for detail.

Bit0 : **MLEDMD** "Main Group" LED Mode Select (Non ALC / with ALC)
"0" : Non ALC mode
"1" : ALC mode
Refer to "(1) Auto Luminous Control ON/OFF" of "The explanation of ALC" for detail.

Address 02h < Power Control >

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
02h	W	FLASHEN	TORCHEN	SLEDEN	MLEDEN	-	-	LDO2EN	LDO1EN
Initial Value	00h	0	0	0	0	-	-	0	0

Bit [7:6] : **FLASHEN**, **TORCHEN** LEDFL Control (Flash ON / Torch ON / OFF)

		(At FLASHCNT=L)	(At FLASHCNT=H)	"FLASHCNT" means external pin.
"00" :	LEDFL:	OFF,	Flash mode ON	
"01" :	LEDFL:	Torch mode ON,	Flash mode ON	
"10" :	LEDFL:	Flash mode ON,	Flash mode ON	
"11" :	reserved			

For Torch/Flash, refer to "Flash LED Current Setting" (address 05h, 06h)
At FLASHCNT=H, even if RESETB=L, the Flash mode becomes ON, and LED is turned on.
But, the setup of LED current becomes the minimum setting in this case.
(Because the setting of LED current is reset at the time of RESETB=L.)
Refer to "The explanation of LED Driver" for detail.

Bit5 : **SLEDEN** Sub Group LED Control (ON/OFF)
"0" : "Sub Group" LED OFF
"1" : "Sub Group" LED ON

Bit4 : **MLEDEN** Main Group LED Control (ON/OFF)
"0" : "Main Group" LED OFF
"1" : "Main Group" LED ON

Bit [3:2] : (Not used)

Bit1 : **LDO2EN** LDO2 Control (ON/OFF)
"0" : LDO2 OFF
"1" : LDO2 ON

Bit0 : **LDO1EN** LDO1 Control (ON/OFF)
"0" : LDO1 OFF
"1" : LDO1 ON

Address 03h < “Main Group” LED Current Setting at non-ALC mode >

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

Bit7 : (Not used)

Bit [6:0] : **IMLED(6:0)** Main Group LED Current Setting at non-ALC 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 04h < “Sub Group” LED Current Setting >

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
04h	W	-	ISLED(6)	ISLED(5)	ISLED(4)	ISLED(3)	ISLED(2)	ISLED(1)	ISLED(0)
Initial Value	00h	-	0	0	0	0	0	0	0

Bit7 : (Not used)

Bit [6:0] : **ISLED(6:0)** Sub Group LED Current Setting

“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 05h < Flash LED “Torch mode” Current Setting >

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
05h	W	-	-	-	IFTLED(4)	IFTLED(3)	IFTLED(2)	IFTLED(1)	IFTLED(0)
Initial Value	00h	-	-	-	0	0	0	0	0

Bit [7:5] : (Not used)

Bit [4:0] : **IFTLED(4:0)** “Torch mode” of LEDFL Current Setting

“00000” : 3.75 mA (Initial value)
“00001” : 7.50 mA
“00010” : 11.25 mA
“00011” : 15.00 mA
“00100” : 18.75 mA
“00101” : 22.50 mA
“00110” : 26.25 mA
“00111” : 30.00 mA
“01000” : 33.75 mA
“01001” : 37.50 mA
“01010” : 41.25 mA
“01011” : 45.00 mA
“01100” : 48.75 mA
“01101” : 52.50 mA
“01110” : 56.25 mA
“01111” : 60.00 mA
“10000” : 63.75 mA
“10001” : 67.50 mA
“10010” : 71.25 mA
“10011” : 75.00 mA
“10100” : 78.75 mA
“10101” : 82.50 mA
“10110” : 86.25 mA
“10111” : 90.00 mA
“11000” : 93.75 mA
“11001” : 97.50 mA
“11010” : 101.25 mA
“11011” : 105.00 mA
“11100” : 108.75 mA
“11101” : 112.50 mA
“11110” : 116.25 mA
“11111” : 120.00 mA

* LED Current : 120 x 1/32 mA Step (=3.75 mA Step)

Address 06h < Flash LED “Flash mode” Current Setting >

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
06h	W	-	-	-	IFFLED(4)	IFFLED(3)	IFFLED(2)	IFFLED(1)	IFFLED(0)
Initial Value	00h	-	-	-	0	0	0	0	0

Bit [7:5] : (Not used)

Bit [4:0] : **IFFLED(4:0)** “Flash mode” of LEDFL Current Setting

“00000” : 3.75 mA (Initial value)
“00001” : 7.50 mA
“00010” : 11.25 mA
“00011” : 15.00 mA
“00100” : 18.75 mA
“00101” : 22.50 mA
“00110” : 26.25 mA
“00111” : 30.00 mA
“01000” : 33.75 mA
“01001” : 37.50 mA
“01010” : 41.25 mA
“01011” : 45.00 mA
“01100” : 48.75 mA
“01101” : 52.50 mA
“01110” : 56.25 mA
“01111” : 60.00 mA
“10000” : 63.75 mA
“10001” : 67.50 mA
“10010” : 71.25 mA
“10011” : 75.00 mA
“10100” : 78.75 mA
“10101” : 82.50 mA
“10110” : 86.25 mA
“10111” : 90.00 mA
“11000” : 93.75 mA
“11001” : 97.50 mA
“11010” : 101.25 mA
“11011” : 105.00 mA
“11100” : 108.75 mA
“11101” : 112.50 mA
“11110” : 116.25 mA
“11111” : 120.00 mA

* LED Current : 120 x 1/32 mA Step (=3.75 mA Step)

Address 07h < LDO1 Vout Control, LDO2 Vout Control >

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
07h	W	LDO2VSEL(3)	LDO2VSEL(2)	LDO2VSEL(1)	LDO2VSEL(0)	LDO1VSEL(3)	LDO1VSEL(2)	LDO1VSEL(1)	LDO1VSEL(0)
Initial Value	74h	0	1	1	1	0	1	0	0

Bit [7:4] : **LDO2VSEL(3:0)** LDO2 Output Voltage Control

"0000" : 1.20 V
"0001" : 1.30 V
"0010" : 1.50 V
"0011" : 1.60 V
"0100" : 1.80 V
"0101" : 2.20 V
"0110" : 2.40 V
"0111" : 2.50 V (Initial value)
"1000" : 2.60 V
"1001" : 2.70 V
"1010" : 2.80 V
"1011" : 2.90 V
"1100" : 3.00 V
"1101" : 3.10 V
"1110" : 3.20 V
"1111" : 3.30 V

Bit [3:0] : **LDO1VSEL(3:0)** LDO1 Output Voltage Control

"0000" : 1.20 V
"0001" : 1.30 V
"0010" : 1.50 V
"0011" : 1.60 V
"0100" : 1.80 V (Initial value)
"0101" : 2.20 V
"0110" : 2.40 V
"0111" : 2.50 V
"1000" : 2.60 V
"1001" : 2.70 V
"1010" : 2.80 V
"1011" : 2.90 V
"1100" : 3.00 V
"1101" : 3.10 V
"1110" : 3.20 V
"1111" : 3.30 V

Address 08h < Main 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)** Main 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

Setting time is counted based on the switching frequency of Charge Pump.
The above value becomes the value of the Typ (1MHz) time.
Refer to "(9) Slope Process" of "The explanation of ALC" for detail.

Bit [3:0] : **TLH(3:0)** Main 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

Setting time is counted based on the switching frequency of Charge Pump.
The above value becomes the value of the Typ (1MHz) time.
Refer to "(9) Slope Process" of "The explanation of ALC" for detail.

Address 0Bh < ALC mode setting >

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0Bh	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 "(4) A/D conversion" of "The explanation of ALC" for detail.

Bit [5:4] : **GAIN(1:0)** Sensor Gain Switching Function Control (This is effective only at STYPE="0".)
"00" : Auto Change (Initial value)
"01" : High
"10" : Low
"11" : Fixed
Refer to "(3) Gain control" of "The explanation of ALC" for detail.

Bit3 : **STYPE** Ambient Light Sensor Type Select (Linear/Logarithm)
"0" : For Linear sensor (Initial value)
"1" : For Log sensor
Refer to "(7) Ambient level detection" of "The explanation of ALC" for detail.

Bit2 : **VSB** SBIAS Output Voltage Control
"0" : SBIAS output voltage 3.0V (Initial value)
"1" : SBIAS output voltage 2.6V
Refer to "(2) I/V conversion" of "The explanation of ALC" for detail.

Bit1 : **MDCIR** LED Current Reset Select by Mode Change
"0" : LED current non-reset when mode change (Initial value)
"1" : LED current reset when mode change
Refer to "(10) LED current reset when mode change" of "The explanation of ALC" for detail.

Bit0 : **SBIASON** SBIAS Control (ON/OFF)
"0" : Measurement cycle synchronous
"1" : Usually ON (at ALCEN=1) (Initial value)
Refer to "(4) A/D conversion" of "The explanation of ALC" for detail.

Address 0Ch < ADC Data adjustment >

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0Ch	W	SOFS(3)	SOFS(2)	SOFS(1)	SOFS(0)	SGAIN(3)	SGAIN(2)	SGAIN(1)	SGAIN(0)
Initial Value	00h	0	0	0	0	0	0	0	0

Bit [7:4] : **SOFS(3:0)** AD Data Offset Adjustment

"1000" : -8 LSB
"1001" : -7 LSB
"1010" : -6 LSB
"1011" : -5 LSB
"1100" : -4 LSB
"1101" : -3 LSB
"1110" : -2 LSB
"1111" : -1 LSB
"0000" : non-adjust
"0001" : +1 LSB
"0010" : +2 LSB
"0011" : +3 LSB
"0100" : +4 LSB
"0101" : +5 LSB
"0110" : +6 LSB
"0111" : +7 LSB

Offset adjust is performed to ADC data.
Refer to "(5) ADC data Gain/offset adjustment" of "The explanation of ALC" for detail.

Bit [3:0] : **SGAIN(3:0)** AD Data Gain Adjustment

"1000" : reserved
"1001" : reserved
"1010" : -37.50%
"1011" : -31.25%
"1100" : -25.00%
"1101" : -18.75%
"1110" : -12.50%
"1111" : -6.25%
"0000" : non-adjust
"0001" : +6.25%
"0010" : +12.50%
"0011" : +18.75%
"0100" : +25.00%
"0101" : +31.25%
"0110" : +37.50%
"0111" : reserved

Gain adjust is performed to ADC data.
The data after adjustment are round off by 8-bit data.
Refer to "(5) ADC data Gain/offset adjustment" of "The explanation of ALC" 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 I^2C.
Refer to "(7) Ambient level detection" of "The explanation of ALC" for detail.