System LED Drivers for Mobile Phones

6 LEDs
LDO 4ch

BD6183GUL

No.10041EAT09

●Description

BD6183GUL is “Intelligent LED Driver” that is the most suitable for the cellular phone.
It has 3 - 6LED driver and output variable LDO4ch for LCD Backlight.
It can be developed widely from the high End model to the Low End model.
As it has charge pump circuit for DCDC, it is no need to use coils, and it contributes to small space.
VCSP50L3(3.15mm × 2.65mm 0.5mm pitch)
It adopts the very thin CSP package that is the most suitable for the slim phone.

●Features

1) Total 3 - 6LEDs driver for LCD Backlight
   - It has 4LEDs (it can select 4LED or 3LED) for exclusire use of Main and 2LEDs which can chose independent control or a main allotment by resister setting.
   - “Main Group” can be controlled by external PWM signal.
   - ON/ Off and a setup of LED current are possible at the time of the independent control by the independence.
2) Charge Pump DC/DC for LED driver
   - It has x1/x1.5/ x2 mode that will be selected automatically.
   - The most suitable voltage up magnification is controlled automatically by LED port voltage.
   - Soft start functions、Over voltage protection (Auto-return type)、Over current protection (Auto-return type) loading
3) 4ch Series Regulator (LDO)
   - LDOIt has selectable output voltage by the register.(16 steps)
     LDO1, LDO2, LDO3, LDO4 : Iomax=150mA
4) Thermal shutdown
5) I^2C BUS FS mode(max 400kHz)Compatibility

●Absolute Maximum Ratings (Ta=25 ℃)

Parameter	Symbol	Ratings	Unit
Maximum Voltage	VMAX	7	V
Power Dissipation	Pd	1340 note)	mW
Operating Temperature Range	Topr	-30 ~ +85	℃
Storage Temperature Range	Tstg	-55 ~ +150	℃

note) Power dissipation deleting is 10.72mW/ ℃ , when it’s used in over 25 ℃.
(It’s deleting is on the board that is ROHM’s standard)

●Operating Conditions (VBAT≥VIO, Ta=-30~85 ℃)

Parameter	Symbol	Limits	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℃, VBAT=3.6V, VIO=1.8V)

Parameter	Symbol	Limits			Unit	Conditions
		Min.	Typ.	Max.		
【Circuit Current】						
VBAT Circuit Current 1	IBAT1	-	0.1	3.0	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	-	61	65	mA	DC/DC x1 mode, Io=60mA VBAT=4.0V
VBAT Circuit Current 4	IBAT4	-	92	102	mA	DC/DC x1.5 mode, Io=60mA VBAT=3.6V
VBAT Circuit Current 5	IBAT5	-	123	140	mA	DC/DC x2 mode, Io=60mA VBAT=2.7V
VBAT Circuit Current 6	IBAT6	-	90	150	μA	LDO1,2=ON, I_{LDO}=0mA
VBAT Circuit Current 7	IBAT7	-	90	150	μA	LDO3,4=ON, I_{LDO}=0mA
【LED Driver】						
LED Current Step (Setup)	ILEDSTP1		128		Step	LED1~6
LED Current Step (At slope)	ILEDSTP2		256		Step	LED1~6
LED Maximum setup Current	IMAXWLED	-	25.6	-	mA	LED1~6
LED Current Accuracy	IWLED	-7%	15	+7%	mA	I_{LED}=15mA setting, VLED=1.0V
LED Current Matching	ILEDMT	-	-	4	%	Between LED1~6 at VLED=1.0V, ILED=15mA
LED OFF Leak Current	ILKLED	-	-	1.0	μA	VLED=4.5V
【DC/DC(Charge Pump)】						
Output Voltage	VoCP	-	Vf+0.2	Vf+0.25	V	Vf is forward direction of LED
Drive Ability	IOUT	-	-	150	mA	VBAT≥3.2V, VOUT=3.9V
Switching Frequency	fosc	0.8	1.0	1.2	MHz	
Over Voltage Protection Detect Voltage	OVP	-	5.6	-	V	
Over Current Protection Detect Current	OCP	-	250	375	mA	VOUT=0V

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

Parameter	Symbol	Limits			Unit	Conditions
		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	-	0.2	0.3	V	VBAT=2.5V, Io=150mA, 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	-	0.2	0.3	V	VBAT=2.5V, Io=150mA, 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	

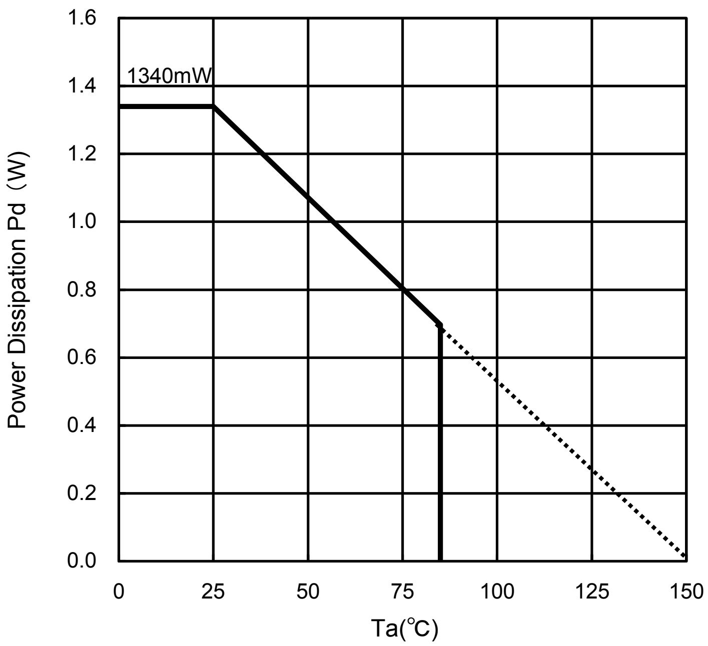
●Electrical Characteristics (Unless otherwise specified, Ta=25℃, VBAT=3.6V, VIO=1.8V)

Parameter	Symbol	Limits			Unit	Conditions
		Min.	Typ.	Max.		
【Regulator (LDO3)】						
Output Voltage	Vo3	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	Io3	-	-	150	mA	Vo=1.8V
Dropout Voltage	Vsat3	-	0.2	0.3	V	VBAT=2.5V, Io=150mA, Vo=2.8V
Load Stability	ΔVo31	-	10	60	mV	Io=1~150mA, Vo=1.8V
Input Voltage Stability	ΔVo32	-	10	60	mV	VBAT=3.4~4.5V, Io=50mA, Vo=1.8V
Ripple Rejection Ratio	RR3	-	65	-	dB	f=100Hz, Vin=200mVp-p, Vo=1.2V Io=50mA, BW=20Hz~20kHz
Short Circuit Current Limit	Ilim3	-	200	400	mA	Vo=0V
Discharge Resister at OFF	ROFF3	-	1.0	1.5	kΩ	
【Regulator (LDO4)】						
Output voltage	Vo4	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
		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 <Initial Voltage>
		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	Io4	-	-	150	mA	Vo=2.8V
Dropout Voltage	Vsat4	-	0.2	0.3	V	VBAT=2.5V, Io=150mA, Vo=2.8V
Load Stability	ΔVo41	-	10	60	mV	Io=1~150mA, Vo=2.8V
Input Voltage Stability	ΔVo42	-	10	60	mV	VBAT=3.4~4.5V, Io=50mA, Vo=2.8V
Ripple Rejection Ratio	RR4	-	65	-	dB	f=100Hz, Vin=200mVp-p, Vo=1.2V Io=50mA, BW=20Hz~20kHz
Short Circuit Current Limit	Ilim4	-	200	400	mA	Vo=0V
Discharge Resister at OFF	ROFF4	-	1.0	1.5	kΩ	

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

Parameter	Symbol	Limits			Unit	Conditions
		Min.	Typ.	Max.		
【SDA, SCL】(I^2C Interface)						
L Level Input Voltage	VILI	-0.3	-	0.25×VIO	V	
H Level Input Voltage	VIHI	0.75×VIO	-	VBAT+0.3	V	
Hysteresis of Schmitt trigger Input	VhysI	0.05 ×VIO	-	-	V	
L level Output Voltage	VOLI	0	-	0.3	V	SDA Pin, IOL=3 mA
Input Current	linI	-	-	1	μA	Input Voltage= 0.1×VIO ~ 0.9×VIO
【RESETB】(CMOS Input Pin)						
L Level Input Voltage	VILR	-0.3	-	0.25×VIO	V	
H Level Input Voltage	VIHR	0.75×VIO	-	VBAT+0.3	V	
Input Current	IinR	-	-	1	μA	Input Voltage = 0.1×VIO ~ 0.9×VIO
【WPWMIN】(NMOS Input Pin)						
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	Input Voltage = 1.8V
PWM Input Minimum High Pulse Width	PWmin	250	-	-	μs	WPWMIN Pin

●Power Dissipation (On the ROHM's standard board)



Information of the ROHM's standard board
Material : glass-epoxy
Size : 50mm × 58mm × 1.75mm(8th layer)
Wiring pattern figure Refer to after page.

Fig.1 Power Dissipation

●Block Diagram / Application Circuit Example 1

6LED + PWM

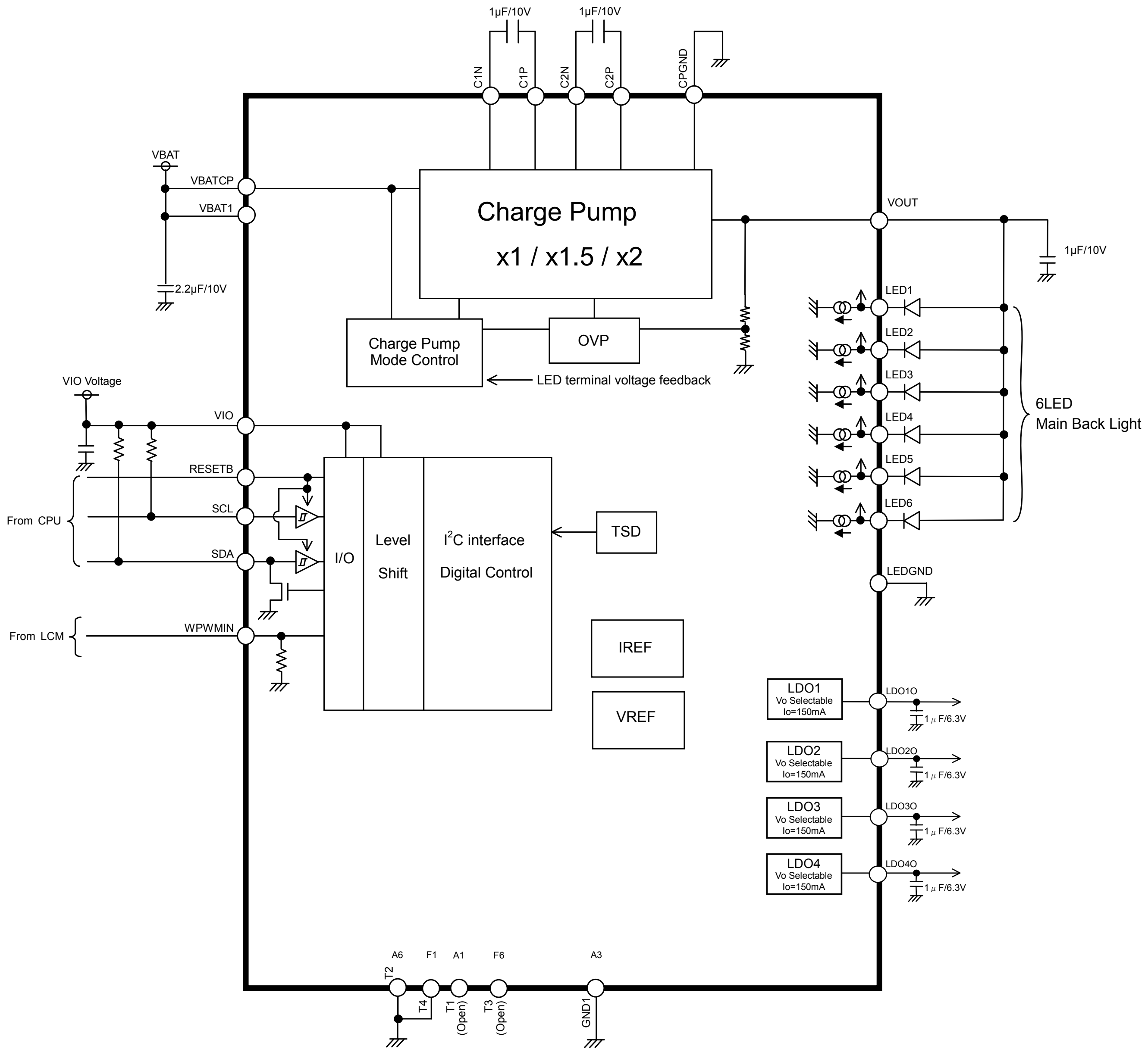


Fig.2 Block Diagram / Application Circuit Example 1

●Block Diagram / Application Circuit Example 2

5LED + PWM

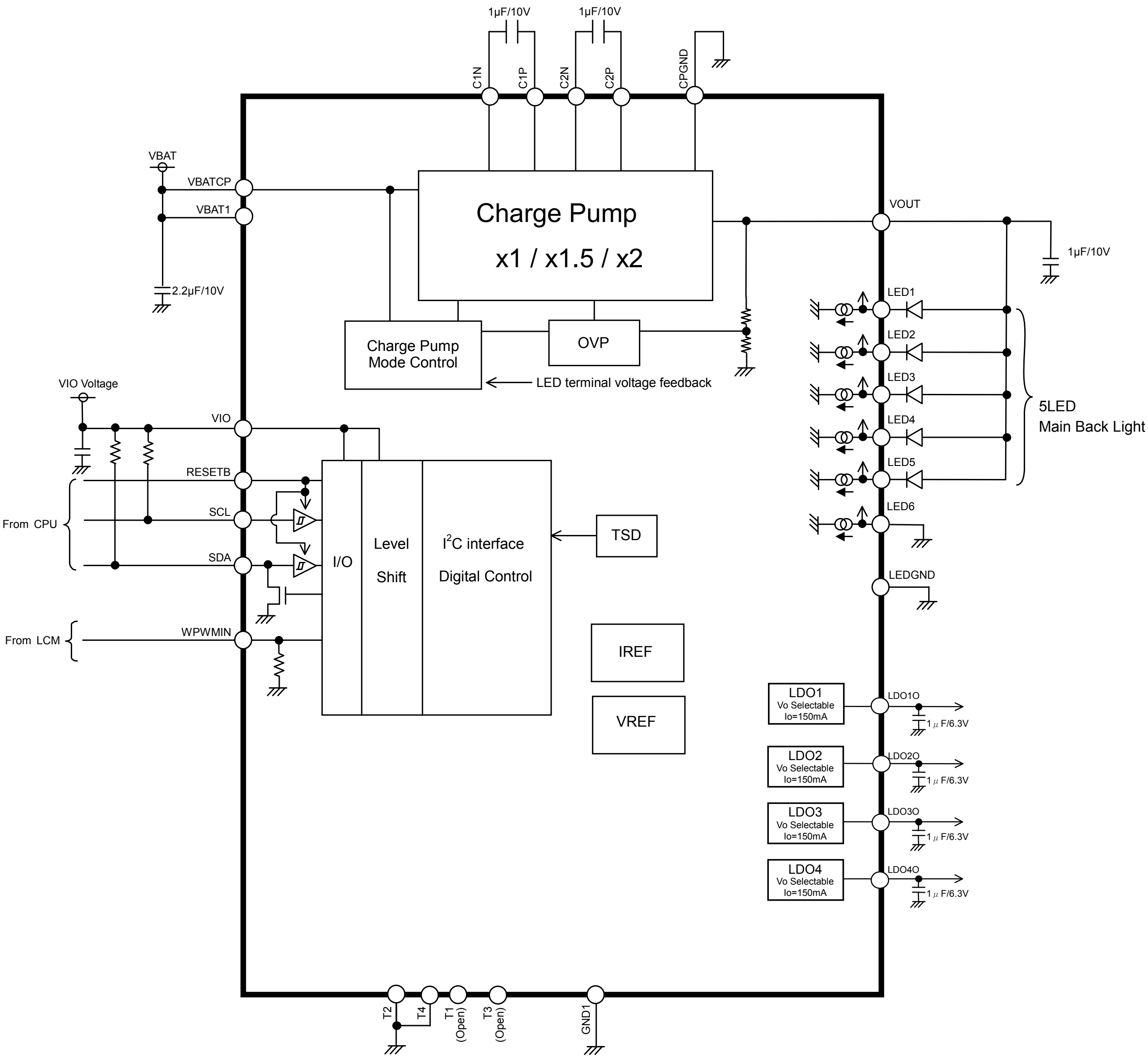


Fig.3 Block Diagram / Application Circuit Example 2

●Block Diagram / Application Circuit Example 3

4LED + 2LED + PWM

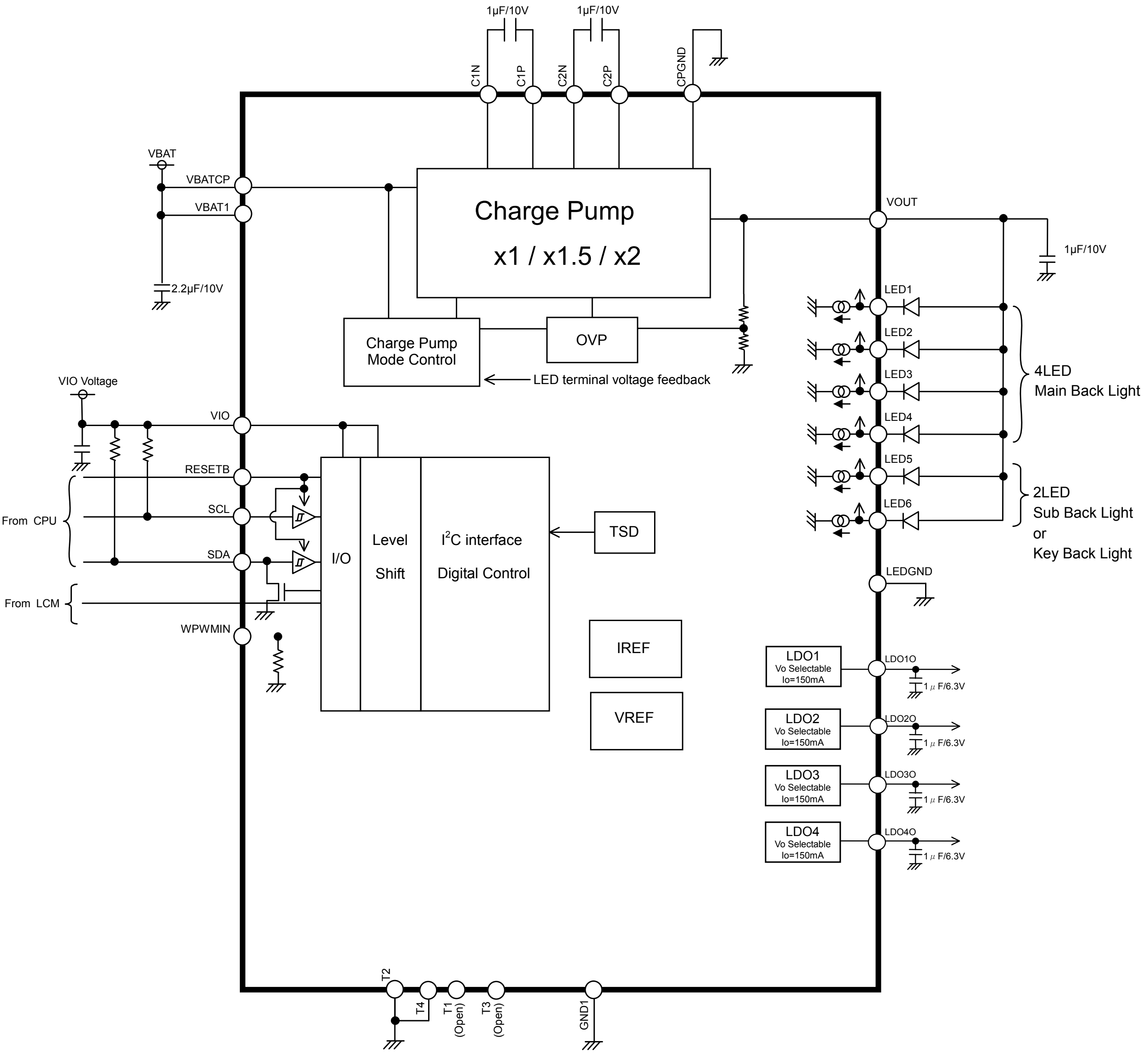


Fig.4 Block Diagram / Application Circuit Example 3

●Pin Arrangement ［Bottom View］

E	T4	LDO4O	VBAT1	LDO2O	LDO1O	T3
D	LED5	LED6	LDO3O	RESETB	VIO	SCL
C	LEDGND	LED4	WPWMIN	SDA	C2P	VOUT
B	LED2	LED3	index	C2N	C1P	VBATCP
A	T1	LED1	GND1	C1N	CPGND	T2
	1	2	3	4	5	6

Total 29 Ball

Fig.5 Pin Arrangement

●Package Outline

VCSP50L3 CSP small package
SIZE : 3.15mm x 2.65mm (A difference in public : X,Y Both ±0.05mm)
Height : 0.55mm max
A ball pitch : 0.5 mm

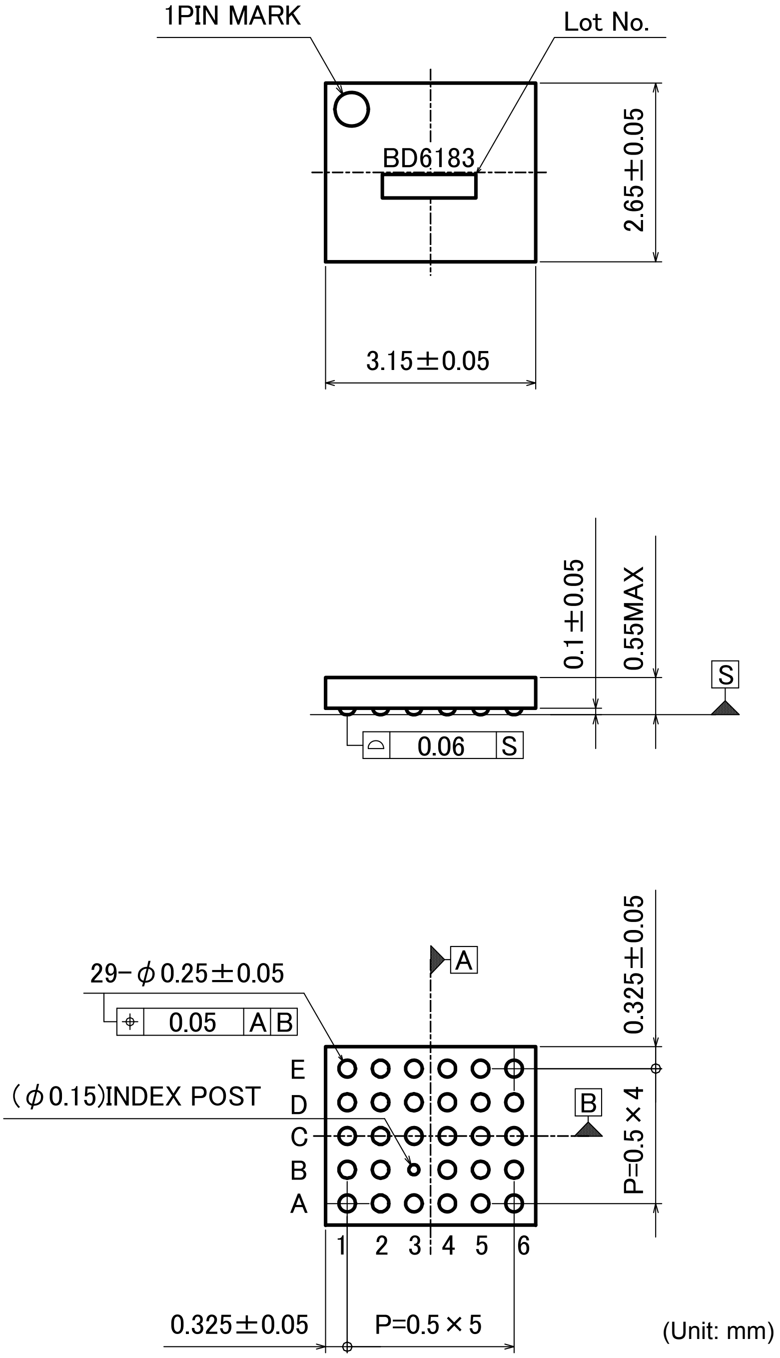


Fig.6 Package Outline

●Pin Functions

No	Ball No.	Pin Name	I/O	ESD Diode		Functions	Equivalent Circuit
				For Power	For Ground		
1	B6	VBATCP	-	-	GND	Battery is connected	A
2	E3	VBAT1	-	-	GND	Battery is connected	A
3	A1	T1	O	VBAT	GND	Test Output Pin(Open)	N
4	A6	T2	I	VBAT	GND	Test Input Pin (short to Ground)	S
5	E6	T3	O	VBAT	GND	Test Output Pin(Open)	M
6	E1	T4	I	VBAT	GND	Test Input Pin (short to Ground)	S
7	D5	VIO	-	VBAT	GND	I/O Power supply is connected	C
8	D4	RESETB	I	VBAT	GND	Reset input (L: reset, H: reset cancel)	H
9	C4	SDA	I/O	VBAT	GND	I^2C data input / output	I
10	D6	SCL	I	VBAT	GND	I^2C clock input	H
11	A5	CPGND	-	VBAT	-	Ground	B
12	A3	GND1	-	VBAT	-	Ground	B
13	C1	LEDGND	-	VBAT	-	Ground	B
14	A4	C1N	I/O	VBAT	GND	Charge Pump capacitor is connected	F
15	B5	C1P	I/O	-	GND	Charge Pump capacitor is connected	G
16	B4	C2N	I/O	VBAT	GND	Charge Pump capacitor is connected	F
17	C5	C2P	I/O	-	GND	Charge Pump capacitor is connected	G
18	C6	VOUT	O	-	GND	Charge Pump output pin	A
19	A2	LED1	I	-	GND	LED is connected 1 for LCD Back Light	E
20	B1	LED2	I	-	GND	LED is connected 2 for LCD Back Light	E
21	B2	LED3	I	-	GND	LED is connected 3 for LCD Back Light	E
22	C2	LED4	I	-	GND	LED is connected 4 for LCD Back Light	E
23	D1	LED5	I	-	GND	LED is connected 5 for LCD Back Light	E
24	D2	LED6	I	-	GND	LED is connected 6 for LCD Back Light	E
25	C3	WPWMIN	I	VBAT	GND	External PWM input for Back Light *	L
26	E5	LDO1O	O	VBAT	GND	LDO1 output pin	Q
27	E4	LDO2O	O	VBAT	GND	LDO2 output pin	Q
28	D3	LDO3O	O	VBAT	GND	LDO3 output pin	Q
29	E2	LDO4O	O	VBAT	GND	LDO4 output pin	Q

* A setup of a register is separately necessary to make it effective.

●Equivalent Circuit

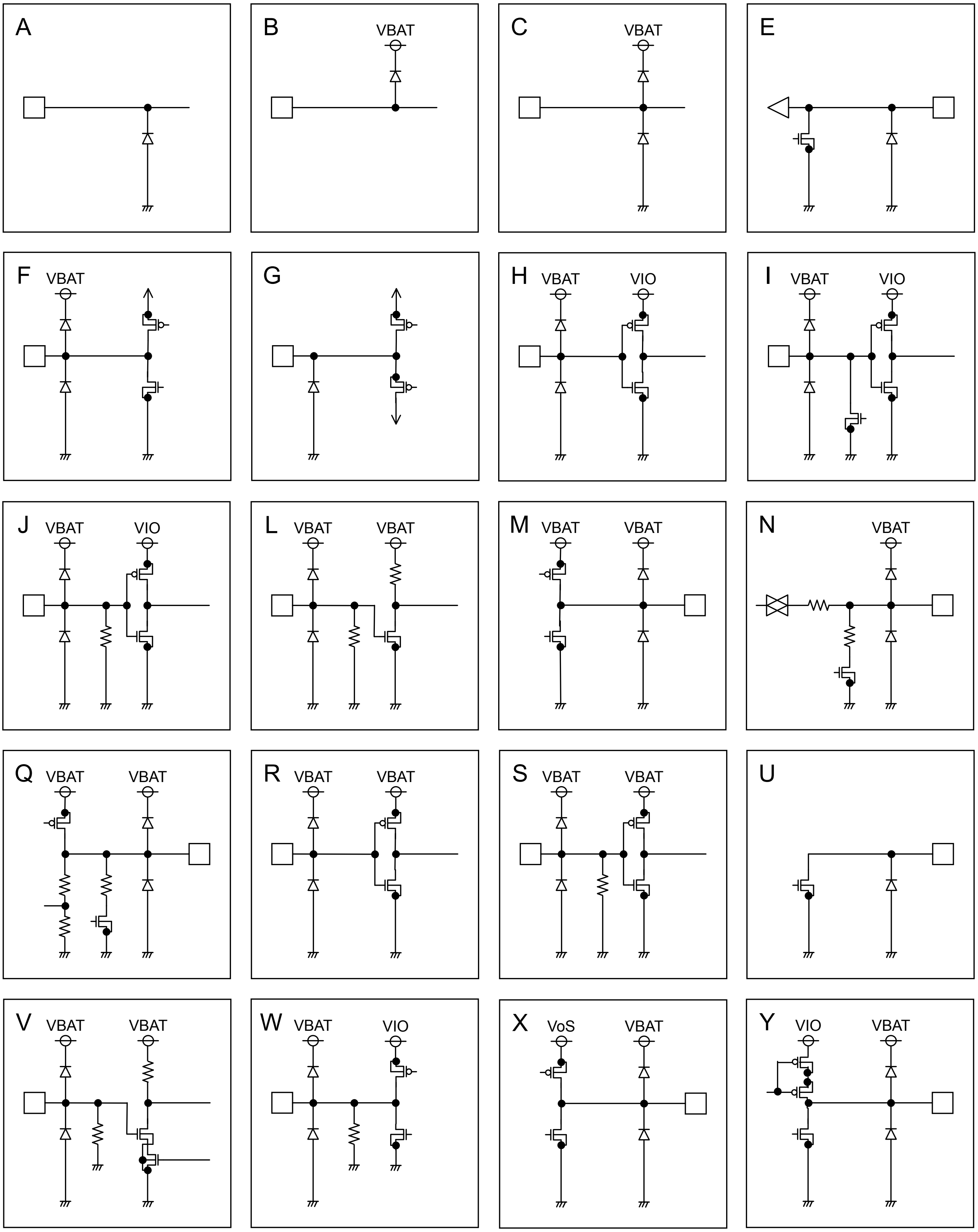


Fig.7 Equivalent Circuit

●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.

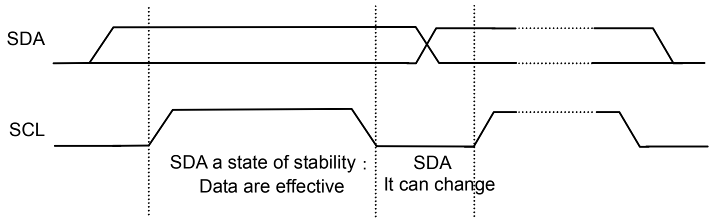


Fig.8

・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.

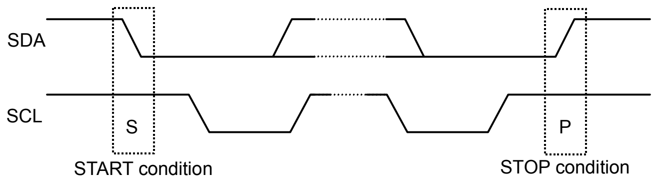


Fig.9

・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.

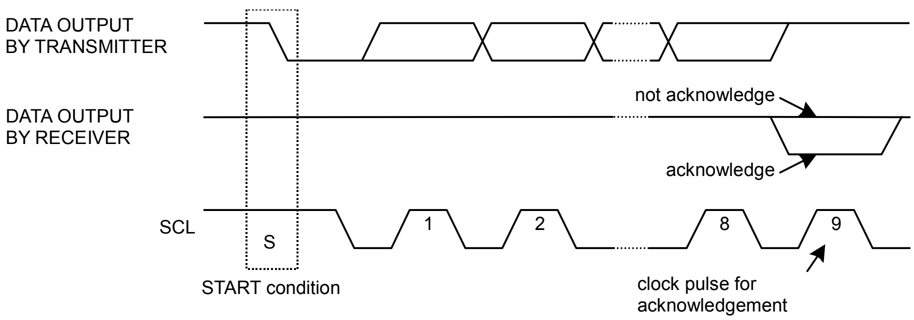


Fig.10

・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.

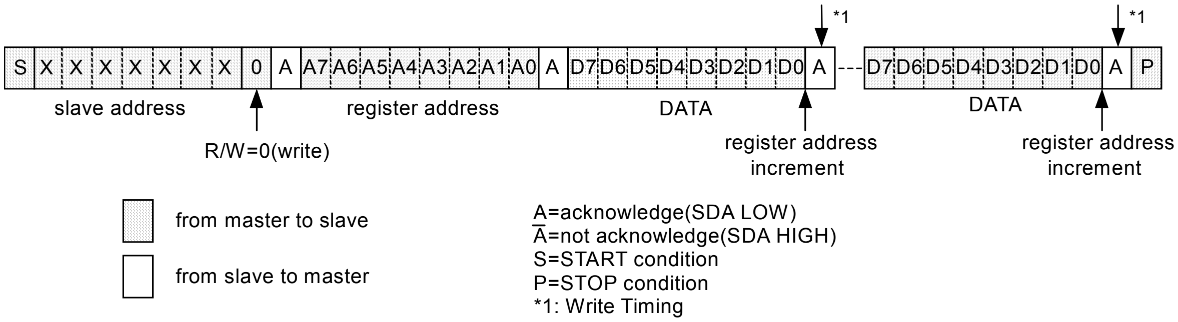


Fig.11

・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.

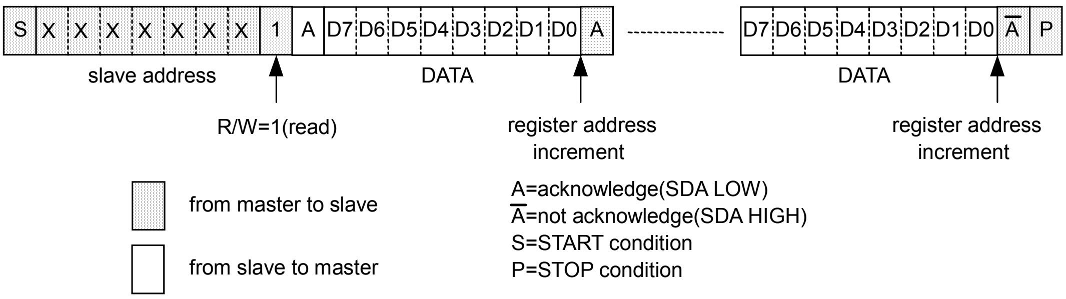


Fig.12

・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.

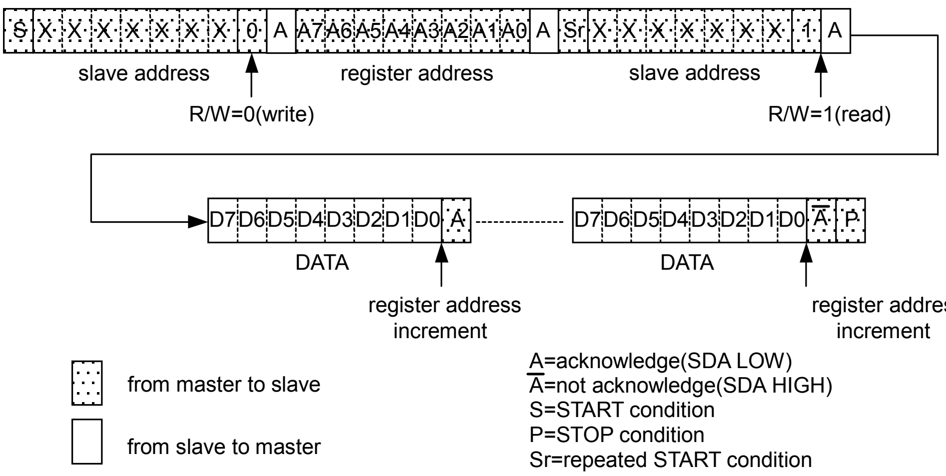


Fig.13

As for reading protocol and multiple reading protocols, please do $\overline{\text{A}}$ (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 $\overline{\text{A}}$(not acknowledge) is done.

●Timing Diagram

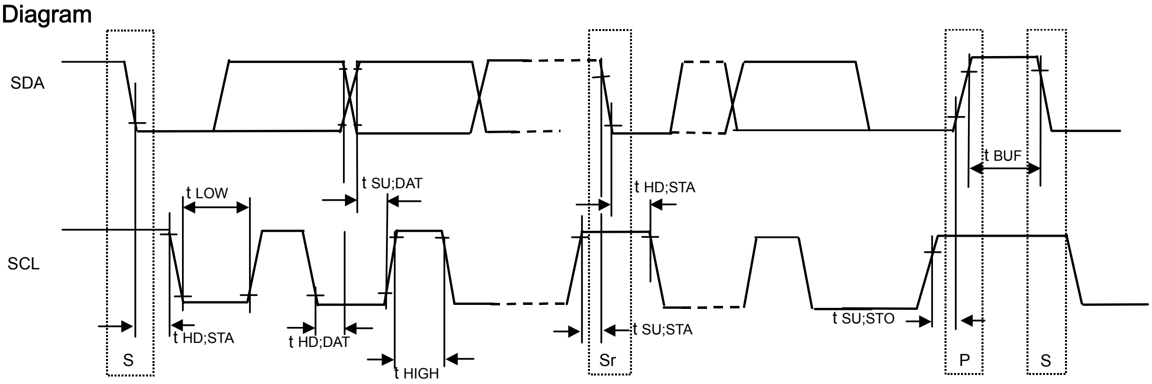


Fig.14 Timing Diagram

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

Parameter	Symbol	Standard-mode			Fast-mode			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
【I²C 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	-	-	-	-	W6MD	W5MD	W4MD	-	LED Pin function setting
02h	W	WPWMEN	-	-	-	W6EN	W5EN	-	MLEDEN	LED Power Control
03h	W	-	IMLED(6)	IMLED(5)	IMLED(4)	IMLED(3)	IMLED(2)	IMLED(1)	IMLED(0)	Main group current setting
04h	-	-	-	-	-	-	-	-	-	-
05h	W	-	IW5(6)	IW5(5)	IW5(4)	IW5(3)	IW5(2)	IW5(1)	IW5(0)	LED5 current setting
06h	W	-	IW6(6)	IW6(5)	IW6(4)	IW6(3)	IW6(2)	IW6(1)	IW6(0)	LED6 current setting
07h	-	-	-	-	-	-	-	-	-	-
08h	-	-	-	-	-	-	-	-	-	-
09h	W	THL (3)	THL (2)	THL (1)	THL (0)	TLH (3)	TLH (2)	TLH (1)	TLH (0)	Main Current transition
0Ah	-	-	-	-	-	-	-	-	-	-
0Bh	-	-	-	-	-	-	-	-	-	-
0Ch	-	-	-	-	-	-	-	-	-	-
0Dh	-	-	-	-	-	-	-	-	-	-
0Eh	-	-	-	-	-	-	-	-	-	-
0Fh	-	-	-	-	-	-	-	-	-	-
10h	-	-	-	-	-	-	-	-	-	-
11h	-	-	-	-	-	-	-	-	-	-
12h	-	-	-	-	-	-	-	-	-	-
13h	W	-	-	-	-	LDO4EN	LDO3EN	LDO2EN	LDO1EN	LDO Power Control
14h	W	LDO2VSEL3	LDO2VSEL2	LDO2VSEL1	LDO2VSEL0	LDO1VSEL3	LDO1VSEL2	LDO1VSEL1	LDO1VSEL0	LDO1 Vout Control LDO2 Vout Control
15h	W	LDO4VSEL3	LDO4VSEL2	LDO4VSEL1	LDO4VSEL0	LDO3VSEL3	LDO3VSEL2	LDO3VSEL1	LDO3VSEL0	LDO3 Vout Control LDO4 Vout Control

Input "0" for "-".
A free address has the possibility to assign it to the register for the test.
Access to the register for the test and the undefined register is prohibited.

●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
“0” : Reset cancel
“1” : Reset(All register initializing)
Refer to “Reset” for detail.

Address 01h < LED Pin function setting>

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
01h	W	-	-	-	-	W6MD	W5MD	W4MD	-
Initial Value	02h	-	-	-	-	0	0	1	-

Bit[7:4] : (Not used)

Bit3 : W6MD LED6 control setting (individual / Main group)
“0” : LED6 individual control (Initial Value)
“1” : LED6 Main group control
Refer to “LED Driver” for detail.

Bit2 : W5MD LED5 control setting (individual / Main group)
“0” : LED5 individual control (Initial Value)
“1” : LED5 Main group control
Refer to “LED Driver” for detail.

Bit1 : W4MD LED4 Control Board setting (unuse / use)
“0” : LED4 unuse
“1” : LED4 use (Main group Control) (Initial Value)
Refer to “LED Driver” for detail.

Bit0 : (Not used)

Set up a fixation in every design because it isn't presumed W*PW that it is changed dynamically.
And, do the setup of W*PW when each LED is Off.

Address 02h < LED Power Control>

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
02h	W	WPWMEN	-	-	-	W6EN	W5EN	-	MLEDEN
Initial Value	00h	0	-	-	-	0	0	-	0

Bit7 : WPWMEN External PWM Input “WPWMIN” terminal Enable Control (Valid/Invalid)
“0” : External PWM input invalid (Initial Value)
“1” : External PWM input valid
Refer to “●Current Adjustment”for detail.

Bit[6:4] : (Not used)

Bit3 : W6EN LED6 Control (ON/OFF)
“0” : LED6 OFF (Initial Value)
“1” : LED6 ON(individual control)
Refer to “LED Driver” for detail.

Bit2 : W5EN LED5 Control (ON/OFF)
“0” : LED5 OFF (Initial Value)
“1” : LED5 ON(individual control)
Refer to “LED Driver” for detail.

Bit1 : (Not used)

Bit0 : MLEDEN Main group LED Control (ON/OFF)
“0” : Main group OFF (Initial Value)
“1” : Main group ON
Refer to “●Slope process”for detail.

Address 03h < Main group LED Current setting(Normal 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

“0000000” :	0.2 mA (Initial Value)	“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 < LED5 Current setting(Independence control) >

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
05h	W	-	IW5(6)	IW5(5)	IW5(4)	IW5(3)	IW5(2)	IW5(1)	IW5(0)
Initial Value	00h	-	0	0	0	0	0	0	0

Bit7 : (Not used)

Bit[6:0] : IW5 (6:0) LED5 Current setting

"0000000" :	0.2 mA (Initial Value)	"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 06h < LED6 Current setting(Independence control) >

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
06h	W	-	IW6(6)	IW6(5)	IW6(4)	IW6(3)	IW6(2)	IW6(1)	IW6(0)
Initial Value	00h	-	0	0	0	0	0	0	0

Bit7 : (Not used)

Bit[6:0] : IW6 (6:0) LED6 Current setting

"0000000" :	0.2 mA (Initial Value)	"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 09h < Main Current slope time setting >

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
09h	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 "●Slope process"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 "●Slope process"for detail.

Address 13h <LDO Power Control>

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
13h	W/R	-	-	-	-	LDO4EN	LDO3EN	LDO2EN	LDO1EN
Initial Value	00h	-	-	-	-	0	0	0	0

Bit[7:4] : (Not used)

Bit3 : LDO4EN LDO4 control (ON/OFF)
"0" : LDO4 OFF (Initial Value)
"1" : LDO4 ON

Bit2 : LDO3EN LDO3 control (ON/OFF)
"0" : LDO3 OFF (Initial Value)
"1" : LDO3 ON

Bit1 : LDO2EN LDO2 control (ON/OFF)
"0" : LDO2 OFF (Initial Value)
"1" : LDO2 ON

Bit0 : LDO1EN LDO1 control (ON/OFF)
"0" : LDO1 OFF (Initial Value)
"1" : LDO1 ON

Address 14h < LDO1 Vout Control, LDO2 Vout Control >

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
14h	R/W	LDO2VSEL3	LDO2VSEL2	LDO2VSEL1	LDO2VSEL0	LDO1VSEL3	LDO1VSEL2	LDO1VSEL1	LDO1VSEL0
Initial Value	74h	0	1	1	1	0	1	0	0

Bit[7:4] : LDO2VSEL [3:0]
"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]
"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 15h < LDO3 Vout Control, LDO4 Vout Control >

Address	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
15h	R/W	LDO4VSEL3	LDO4VSEL2	LDO4VSEL1	LDO4VSEL0	LDO3VSEL3	LDO3VSEL2	LDO3VSEL1	LDO3VSEL0
Initial Value	A4h	1	0	1	0	0	1	0	0

Bit[7:4] : LDO4VSEL [3:0]
“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
“1000” : 2.60 V
“1001” : 2.70 V
“1010” : 2.80 V (Initial Value)
“1011” : 2.90 V
“1100” : 3.00 V
“1101” : 3.10 V
“1110” : 3.20 V
“1111” : 3.30 V

Bit[3:0] : LDO3VSEL [3:0]
“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

●Reset

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

(1) Software reset
- All the registers are initialized by SFTRST="1".
- SFTRST is an automatically returned to "0". (Auto Return 0).

(2) Hardware reset
- It shifts to hardware reset by changing RESETB pin “H” → “L”.
- The condition of all the registers under hardware reset pin is returned to the Initial Value, and it stops accepting all address.
- It’s possible to release from a state of hardware reset by changing RESETB pin “L” → “H”.
- 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”)

●VIODET

The decline of the VIO voltage is detected, and faulty operation inside the LSI is prevented by giving resetting to Levelsift block

Image Block Diagram

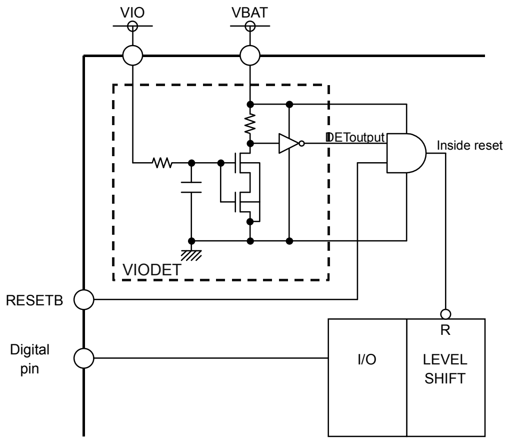


Fig.15

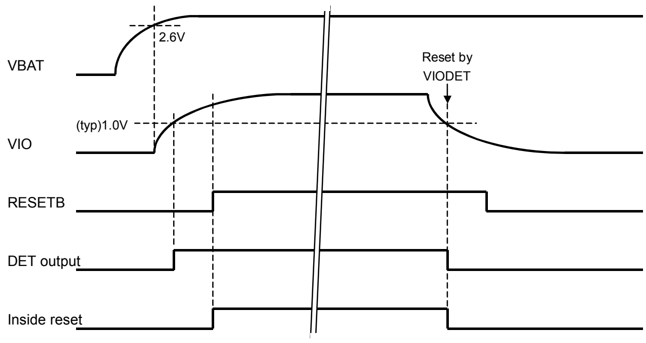


Fig.16

When the VIO voltage becomes more than typ1.0V(Vth of NMOS in the IC), VIODET is removed.
On the contrary, when VIO is as follows 1.0V, it takes reset.(The VBAT voltage being a prescribed movement range)

●Thermal Shut Down

A thermal shutdown function is effective in the following block.

DC/DC (Charge Pump)
LED Driver
LDO1, LDO2, LDO3, LDO4

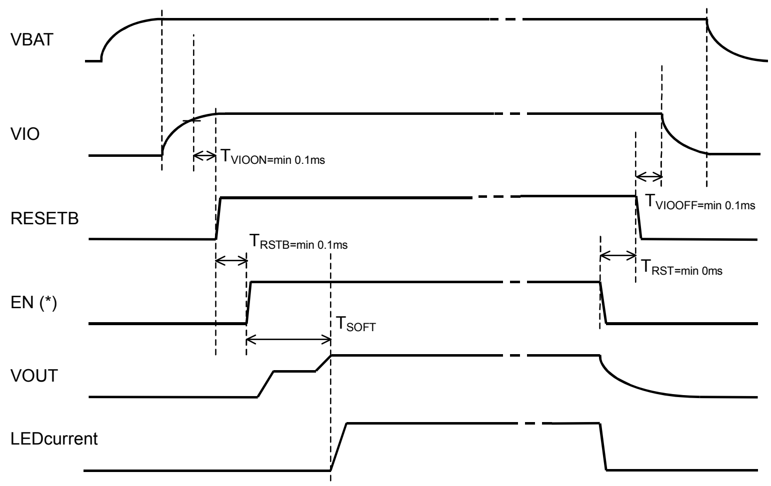
The thermal shutdown function is detection temperature that it works is about 195℃.
Detection temperature has a hysteresis, and detection release temperature is about 175 ℃.(Design reference value)

●DC/DC

Start

DC/DC circuit operates when any LED turns ON. (DCDCFON=0)
When the start of theDC/DC circuit is done, it has the soft start function to prevent a rush current.

Force of VBAT and VIO is to go as follows.



(*) An EN signal means the following in the upper figure.
EN = "MLEDEN" or "W∗EN"
(= LED The LED lighting control of a setup of connection VOUT)
But, as for Ta > T_{TSD} (typ : 195° C), a protection function functions, and an EN signal doesn't become effective.
T_{SOFT} changes by the capacitor connected to VOUT and inside OSC.
T_{SOFT} is Typ 200μs (when the output capacitor of VOUT =1.0μF).

Fig.17

Over Voltage protection / Over Current protection

DC/DC circuit output (VOUT) is equipped with the over-voltage protection and the over current protection function.
A VOUT over-voltage detection voltage is about 5.6V(typ). (VOUT at the time of rise in a voltage)
A detection voltage has a hysteresis, and a detection release voltage is about 5.4V (typ).
And, when VOUT output short to ground, input current of the battery terminal is limited by an over current protection function.

Mode transition

The transition of boosts multiple transits automatically by VBAT Voltage and the VOUT Pin Voltage.

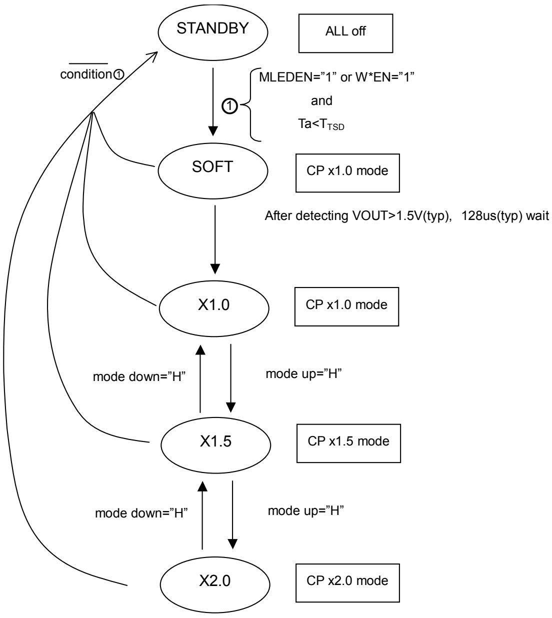


Fig.18

The mode transition of the charge pump works as follows.

＜x1.0→x1.5→x2.0 Mode transition＞

The transition of the mode is done when VOUT was compared with VBAT and the next condition was satisfied.

x1.0→x1.5 Mode transition
    VBAT ≤ VOUT + (Ron10×Iout)
    (LED Pin feedback: VOUT = Vf+0.2(Typ))
x1.5→x2.0 Mode transition
    VBAT×1.5 ≤ VOUT +(Ron15×Iout)
    (LED Pin feedback: VOUT = Vf+0.2(Typ))

Ron10: x1 Charge pump on resistance 1.4Ω (Typ)
Ron15: x1.5 Charge pump on resistance 8.5Ω (Typ)

＜x2.0→x1.5→x1.0 Mode transition＞

The transition of the mode is done when the ratio of VOUT and VBAT is detected and it exceeds a fixed voltage ratio.

x1.5→x1.0 Mode transition
    VBAT / VOUT =1.16(Design value)
x2.0→x1.5 Mode transition
    VBAT / VOUT =1.12(Design value)

●LED Driver

The LED driver of 6ch is constructed as the ground plan.
Equivalence control is possible with LED1 - 4(LED4 can choose use/un-use with a register W4MD.).
LED5, LED6 is controllable individually.
As for LED5, LED6, grouping setting to the main control is possible, and main control becomes effective for the main group in the allotment. LED5 and LED6 are setups of grouping to the main control.
When LED5 and LED6 are used by the individual control, a slope time setup (register THL and TLH) doesn't become effective.

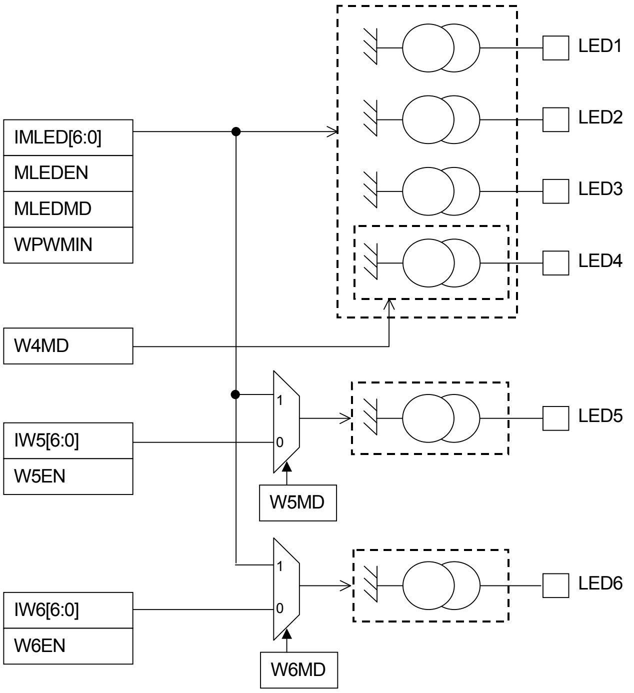


Fig.19

LED Composition which can be set up is the following.
The main, other1 and other2 are controllable to each.(Enable and current setting)

Main (PWM)	Other1	Other2
6LEDs	-	-
5LEDs	-	-
5LEDs	1LED	-
4LEDs	-	-
4LEDs	1 LED	-
4LEDs	2 LEDs	-
4LEDs	1 LED	1LED
3LEDs	-	-
3LEDs	1 LED	-
3LEDs	2 LEDs	-
3LEDs	1 LED	1LED

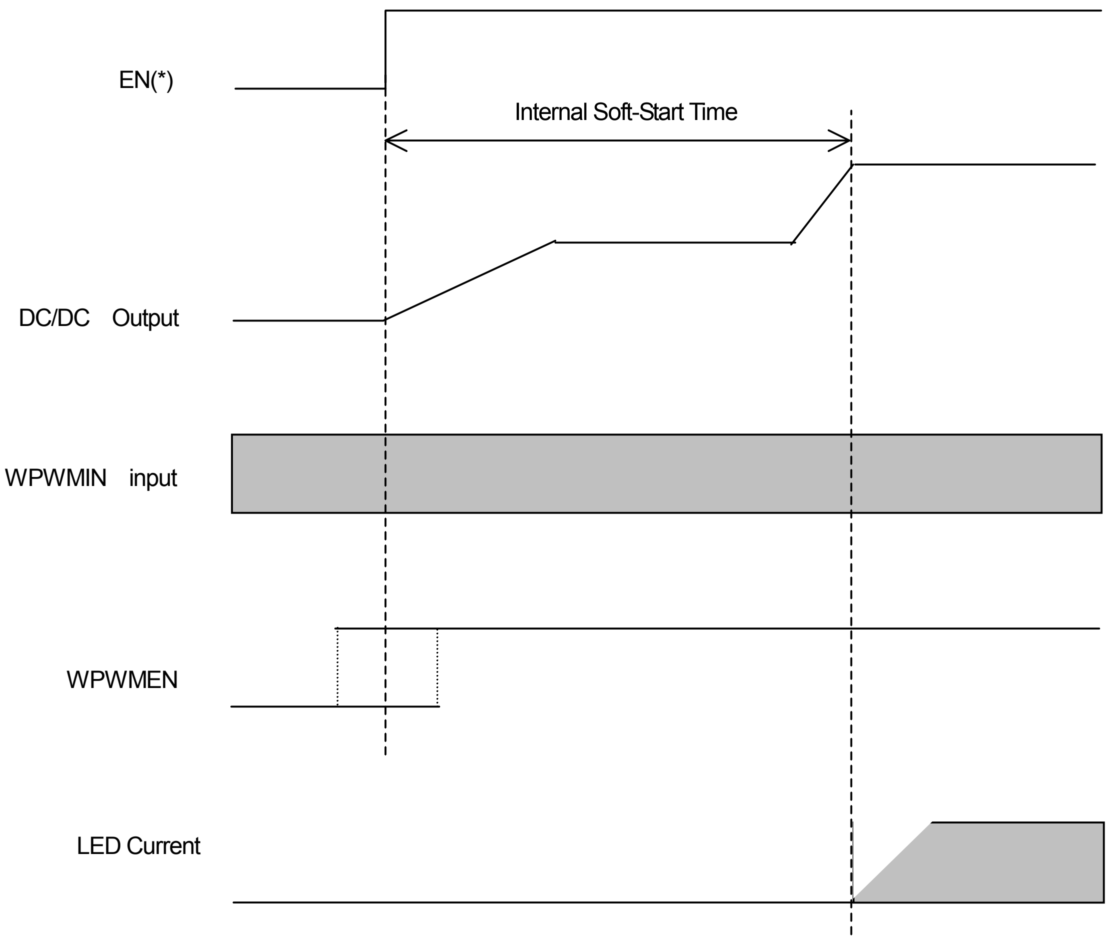
●Current Adjustment

・When the register setting permits it, PWM drive by the external terminal (WPWMIN) is possible.
Register: WPWMEN

・It is suitable for the intensity correction by external control, because PWM based on Main LED current of register setup.

WPWMEN(Register)	WPWMIN(External Pin)	Main group LED current
0	L	Normal operation
	H	Normal operation
1	L	Forced OFF
	H	Normal operation

"Normal operation " depends on the setup of each register.



EN(*) : it means "MLEDEN" or "W*EN".

It is possible to make it a WPWMIN input and WPWMEN=1 in front of EN(*).
A PWM drive becomes effective after the time of an LED current standup.

When rising during PWM operation, as for the standup time of a DC/DC output, only the rate of PWM Duty becomes late.
Appearance may be influenced when extremely late frequency and extremely low Duty are inputted.

Please secure 250 μs or more of H sections at the time of PWM pulse Force.

Fig.20

●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)
・Main LED current changes as follows at the time as the slope.
TLH (THL) is setup of time of the current step 2/256.

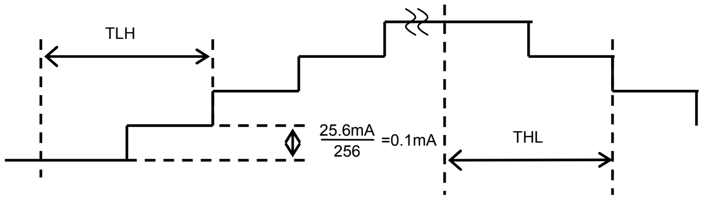
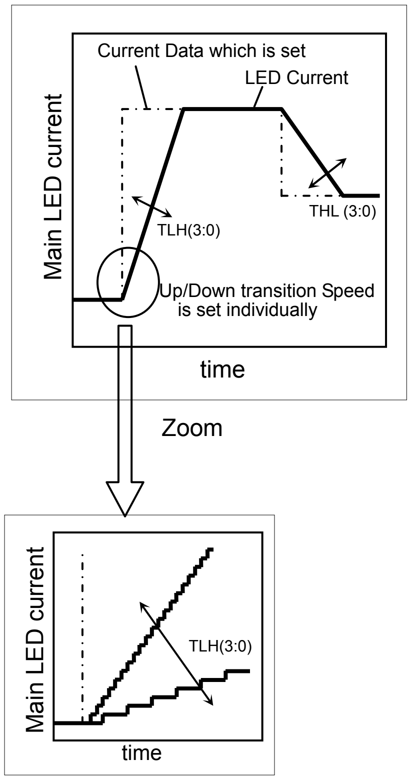


Fig.21



●I/O

When the RESETB pin is Low, the input buffers (SDA and SCL) are disabling for the Low consumption power.

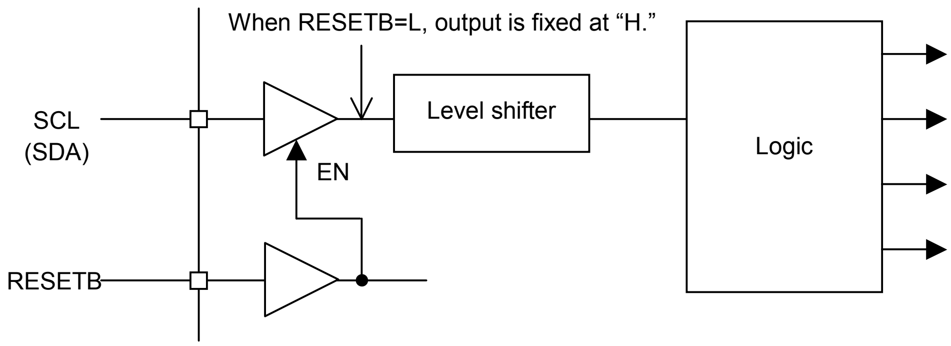


Fig.22

Special care should be taken because a current path may be formed via a terminal protection diode, depending on an I/O power-on sequence or an input level.

●About the Start of LDO1 ~ LDO4

It must start as follows.

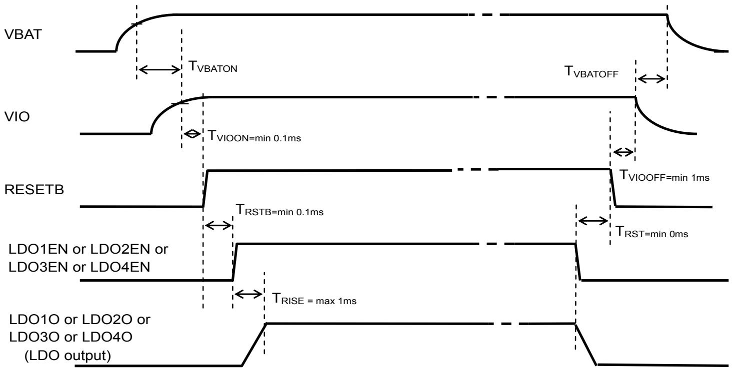


Fig.23

<Start Sequence>
VBAT ON (Enough rise up) → VIO ON (Enough rise up) → Reset release → LDO ON (Register access acceptable)

<End Sequence>
LDO OFF → Reset → VIO OFF (Enough fall down) → VBAT OFF

●About the pin management of the function that isn't used and test pins

Setting it as follows is recommended with the test pin and the pin which isn't used.
Set up pin referring to the “Equivalent circuit diagram” so that there may not be a problem under the actual use.

T2, T4	Short to GND because pin for test input
T1,T3	OPEN because pin for test output
Non-used LED Pin	Short to GND (Must) But, the setup of a register concerned with LED that isn’t used is prohibited.
WPWMIN	Short to ground (A Pull-Down resistance built-in terminal is contained, too.)

●Operation Settings (Flow Example)

Backlight: Fade-in/Fade-out

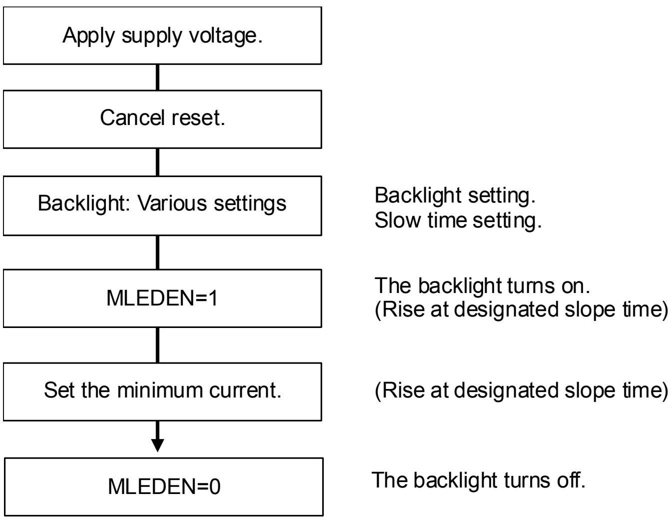
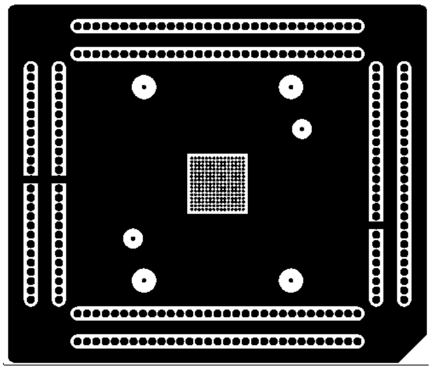
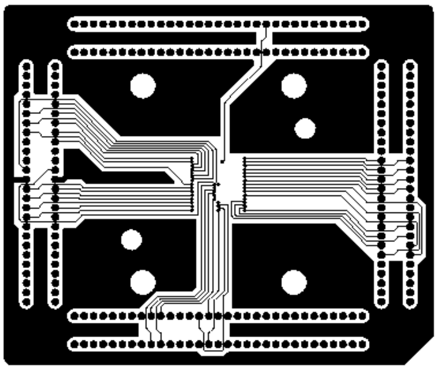
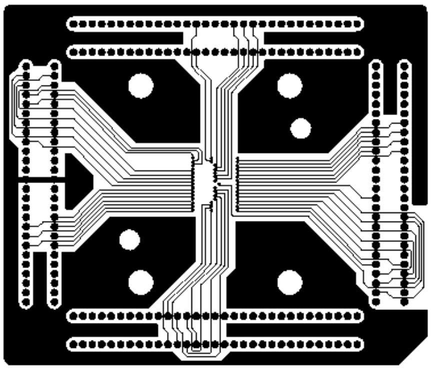


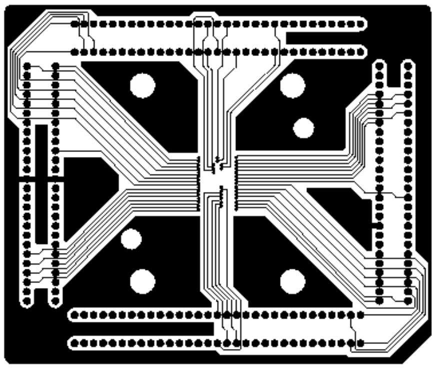
Fig.24

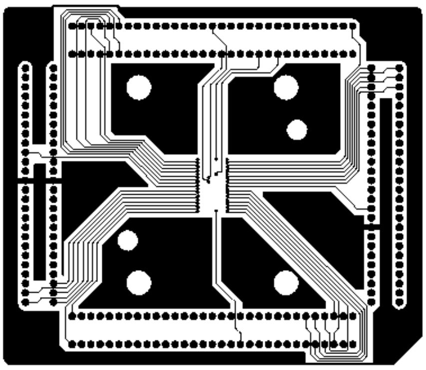
●PCB Pattern of the Power Dissipation Measuring Board

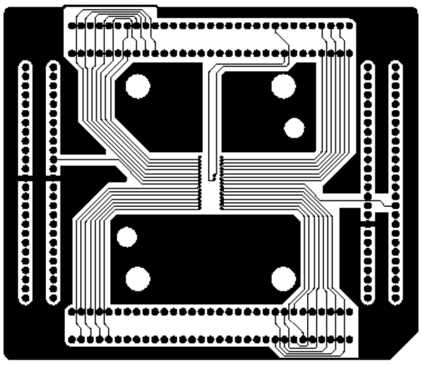

1st layer(component)

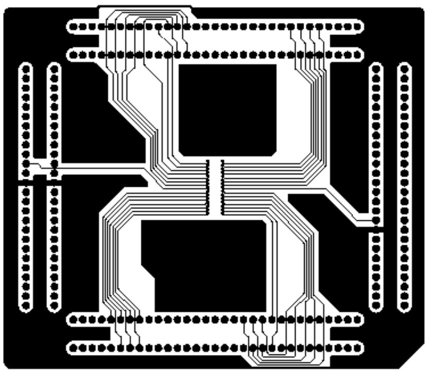

2nd layer


3rd layer


4th layer


5th layer


6th layer


7th layer

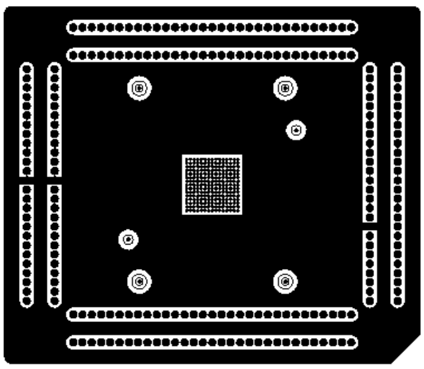

8th layer(solder)

Fig.25 PCB Pattern

●Notes for Use

(1) Absolute Maximum Ratings
An excess in the absolute maximum ratings, such as supply voltage, temperature range of operating conditions, etc., can break down devices, thus making impossible to identify breaking mode such as a short circuit or an open circuit. If any special mode exceeding the absolute maximum ratings is assumed, consideration should be given to take physical safety measures including the use of fuses, etc.

(2) Power supply and ground line
Design PCB pattern to provide low impedance for the wiring between the power supply and the ground lines. Pay attention to the interference by common impedance of layout pattern when there are plural power supplies and ground lines. Especially, when there are ground pattern for small signal and ground pattern for large current included the external circuits, please separate each ground pattern. Furthermore, for all power supply pins to ICs, mount a capacitor between the power supply and the ground pin. At the same time, in order to use a capacitor, thoroughly check to be sure the characteristics of the capacitor to be used present no problem including the occurrence of capacity dropout at a low temperature, thus determining the constant.

(3) Ground voltage
Make setting of the potential of the ground pin so that it will be maintained at the minimum in any operating state. Furthermore, check to be sure no pins are at a potential lower than the ground voltage including an actual electric transient.

(4) Short circuit between pins and erroneous mounting
In order to mount ICs on a set PCB, pay thorough attention to the direction and offset of the ICs. Erroneous mounting can break down the ICs. Furthermore, if a short circuit occurs due to foreign matters entering between pins or between the pin and the power supply or the ground pin, the ICs can break down.

(5) Operation in strong electromagnetic field
Be noted that using ICs in the strong electromagnetic field can malfunction them.

(6) Input pins
In terms of the construction of IC, parasitic elements are inevitably formed in relation to potential. The operation of the parasitic element can cause interference with circuit operation, thus resulting in a malfunction and then breakdown of the input pin. Therefore, pay thorough attention not to handle the input pins, such as to apply to the input pins a voltage lower than the ground respectively, so that any parasitic element will operate. Furthermore, do not apply a voltage to the input pins when no power supply voltage is applied to the IC. In addition, even if the power supply voltage is applied, apply to the input pins a voltage lower than the power supply voltage or within the guaranteed value of electrical characteristics.

(7) External capacitor
In order to use a ceramic capacitor as the external capacitor, determine the constant with consideration given to a degradation in the nominal capacitance due to DC bias and changes in the capacitance due to temperature, etc.

(8) Thermal Shut Down Circuit (TSD)
This LSI builds in a thermal shutdown circuit. When junction temperatures become detection temperature or higher, the thermal shutdown circuit operates and turns a switch OFF. The thermal shutdown circuit, which is aimed at isolating the LSI from thermal runaway as much as possible, is not aimed at the protection or guarantee of the LSI. Therefore, do not continuously use the LSI with this circuit operating or use the LSI assuming its operation.

(9) Thermal design
Perform thermal design in which there are adequate margins by taking into account the permissible dissipation (Pd) in actual states of use.

(10) LDO
Use each output of LDO by the independence. Don’t use under the condition that each output is short-circuited because it has the possibility that an operation becomes unstable.

(11) About the pin for the test, the un-use pin
Prevent a problem from being in the pin for the test and the un-use pin under the state of actual use. Please refer to a function manual and an application notebook. And, as for the pin that doesn't specially have an explanation, ask our company person in charge.

(12) About the rush current
For ICs with more than one power supply, it is possible that rush current may flow instantaneously due to the internal powering sequence and delays. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of wiring.

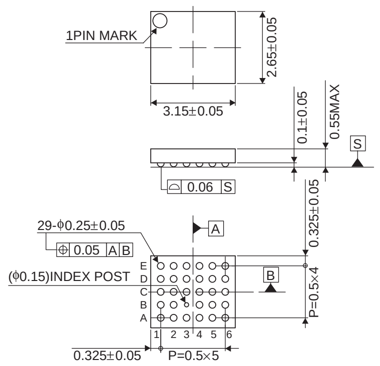
(13) About the function description or application note or more.
The function description and the application notebook are the design materials to design a set. So, the contents of the materials aren't always guaranteed. Please design application by having fully examination and evaluation include the external elements.

● Ordering Part Number

B	D		6	1	8	3		G	U	L	-	E	2

- B D: Part No.
- 6 1 8 3: Part No.
- G U L: Package
  GUL: VCSP50L3
- E 2: Packaging and forming specification
  E2: Embossed tape and reel

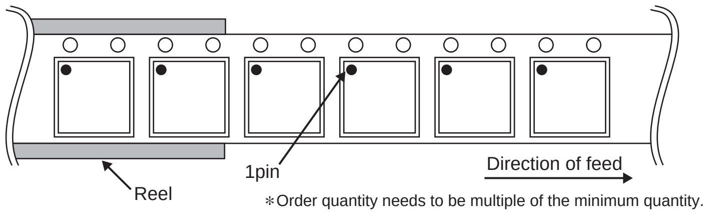
VCSP50L3(BD6183GUL)



(Unit : mm)

<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



∗Order quantity needs to be multiple of the minimum quantity.

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