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

Panasonic

AN32150B

http://www.semicon.panasonic.co.jp/en/

LED Driver LSI with Step-up Charge Pump Control Circuit

FEATURES

- 7 x 7 LED Matrix Driver
  (Total LED that can be driven = 49)
- Step-up charge pump DC/DC converter : 300 mA
- LDO : 2-ch.
- GPIO : 3-ch.
- GPO : 6-ch. (They are in common with LED driver terminals.)
- SPI interface / I²C interface selectable
- LED drivers (for backlight : 7-ch., for RGB : 3-ch., matrix LED driver : 7 × 7-ch.)
- LED brightness control function with an external illumination sensor
- 55pin Wafer Level Chip Size Package (WLCSP)

DESCRIPTION

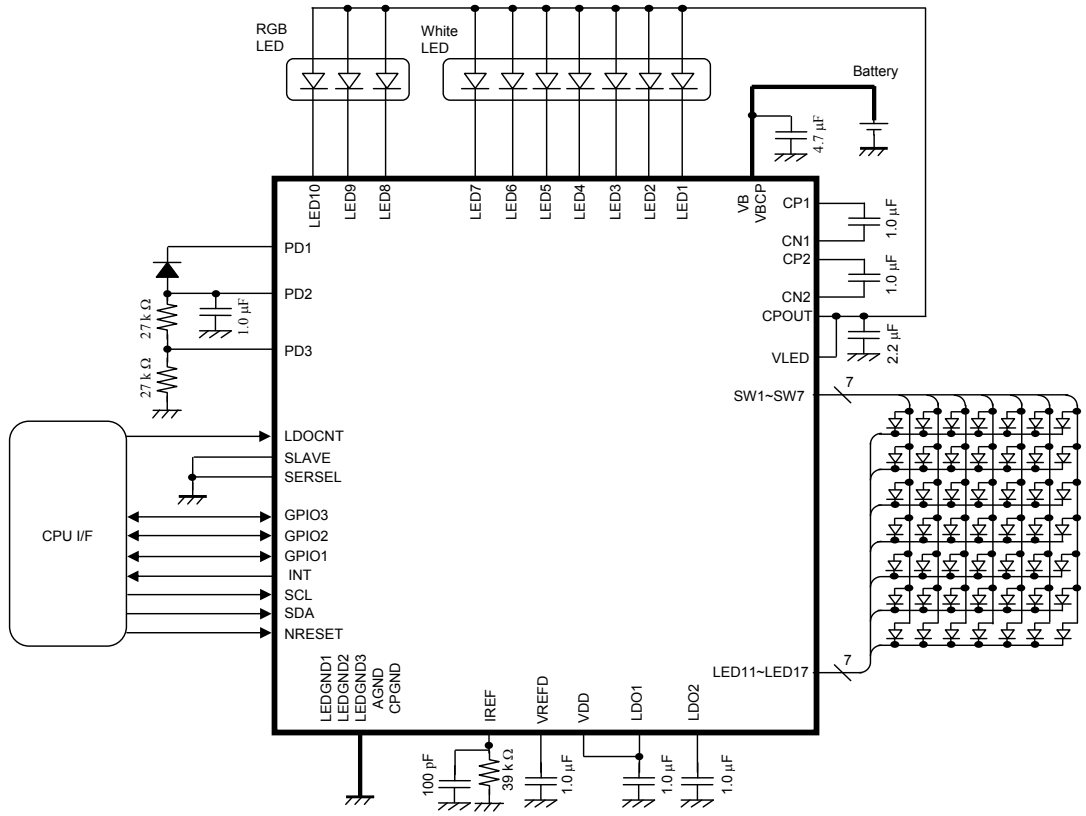
AN32150B is a LED driver and a light intensity controller. It can drive up to 7 channels of LCD backlight, 3 channels of RGB LEDs and 7 channels of LED matrix.

Voltage is supplied by a step-up charge pump DC/DC converter.

APPLICATIONS

- Mobile Phone
- Smart Phone
- PCs
- Game Consoles
- Home Appliances etc.

TYPICAL APPLICATION



Note)
The application circuit is an example. The operation of the mass production set is not guaranteed. Sufficient evaluation and verification is required in the design of the mass production set. The Customer is fully responsible for the incorporation of the above illustrated application circuit in the design of the equipment.

Established : 2011-05-30
Revised : 2013-04-16

CONTENTS

Established : 2011-05-30
Revised : 2013-04-16

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit	Note
Supply voltage	VB_{MAX}	6.0	V	*1
	$VLED_{MAX}$	6.5	V	*1
	VDD_{MAX}	4.3	V	*1
Operating ambience temperature	T_{opr}	– 30 to + 85	°C	*2
Operating junction temperature	T_j	– 30 to + 125	°C	*2
Storage temperature	T_{stg}	– 55 to + 125	°C	*2
Input Voltage Range	GPIO1, GPIO2, GPIO3, PD2, PD3, SERSEL, SLAVE, SCL, SDA	– 0.3 to 4.3	V	—
	NRESET, LDOCNT	– 0.3 to 6.0	V	—
Output Voltage Range	PD1	– 0.3 to 4.3	V	—
	LDO1, LDO2, INT	– 0.3 to 6.0	V	—
	SW1, SW2, SW3, SW4, SW5, SW6, SW7, LED1, LED2, LED3, LED4, LED5, LED6, LED7, LED8, LED9, LED10, LED11, LED12, LED13, LED14, LED15, LED16, LED17	– 0.3 to 6.5	V	—
ESD	HBM	1.0 to 1.5	kV	—

Note) This product may sustain permanent damage if subjected to conditions higher than the above stated absolute maximum rating. This rating is the maximum rating and device operating at this range is not guaranteeable as it is higher than our stated recommended operating range. When subjected under the absolute maximum rating for a long time, the reliability of the product may be affected.

*1: VB_{MAX} = VBCP = VB, VDD_{MAX} = VDD , $VLED_{MAX}$ = VLED
The values under the condition not exceeding the above absolute maximum ratings and the power dissipation.

*2: Except for the power dissipation, operating ambient temperature, and storage temperature, all ratings are for T_a = 25°C.

POWER DISSIPATION RATING

PACKAGE	θ_{JA}	P_D (Ta=25 °C)	P_D (Ta=85 °C)
55 pin Wafer Level Chip Size Package (WLCSP)	120.02 °C /W	0.833 W	0.333 W

Note) For the actual usage, please refer to the P_D-Ta characteristics diagram in the package specification, follow the power supply voltage, load and ambient temperature conditions to ensure that there is enough margin and the thermal design does not exceed the allowable value.

CAUTION

Although this LSI has built-in ESD protection circuit, it may still sustain permanent damage if not handled properly. Therefore, proper ESD precautions are recommended to avoid electrostatic damage to the MOS gates.

Established : 2011-05-30
Revised : 2013-04-16

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Min.	Typ.	Max.	Unit	Note
Supply voltage range	VB	3.1	3.6	4.6	V	*1
	VLED	3.1	4.5	5.8	V	*1
	VDD	1.7	1.85	3.2	V	*1
Input Voltage Range	GPIO1, GPIO2, GPIO3, PD2, PD3, SERSEL, SLAVE, SCL, SDA	– 0.3	—	VDD + 0.3	V	*2
	NRESET, LDOCNT	– 0.3	—	VB + 0.3	V	*2
Output Voltage Range	PD1	– 0.3	—	VDD + 0.3	V	*2
	LDO1, LDO2, INT	– 0.3	—	VB + 0.3	V	*2
	SW1, SW2, SW3, SW4, SW5, SW6, SW7, LED1, LED2, LED3, LED4, LED5, LED6, LED7, LED8, LED9, LED10, LED11, LED12, LED13, LED14, LED15, LED16, LED17	– 0.3	—	VLED + 0.3	V	*2

Note) *1: The values under the condition not exceeding the above absolute maximum ratings and the power dissipation.
Do not apply external currents and voltages to any pin not specifically mentioned.
Voltage values, unless otherwise specified, are with respect to GND. GND is voltage for AGND, CPGND, LEDGND1, LEDGND2 and LEDGND3.
VDD is voltage for VDD. VB is voltage for VB and VBCP. VLED is voltage for VLED.
*2: (VDD + 0.3) V must not exceed 4.3 V. (VB + 0.3) V must not exceed 6 V.
(VLED + 0.3) V must not exceed 6.5 V.

Established : 2011-05-30
Revised : 2013-04-16

ELECTRICAL CHARACTERISTICS

VB = VBCP = 3.6 V, VLED = 4.5 V, VDD = 1.85 V

Note) T_a = 25 °C ± 2 °C unless otherwise specified

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
Current consumption							
Current consumption (1) at OFF mode	ICC1	VB = 4.6 V LDOCNT = Low	—	0	1	μA	—
Current consumption (2) at LDO1 and LDO2 normal mode	ICC2	LDO1 to 2PS = [0] (LDO1, 2 normal mode) LDO1ON = [1] (LDO1 ON) VB = 4.6 V LDOCNT = High	—	130	300	μA	—
Current consumption (3) at LDO1 OFF mode, LDO2 power save mode	ICC3	LDO2 PS = [1] (LDO2 power save mode) LDO1ON = [0] (LDO1 OFF) VB = 4.6 V LDOCNT = High	—	10	25	μA	—
Current consumption (4) at VB through mode, LDO1 OFF mode, LDO2 power save mode	ICC4	LDO2 PS = [1] (LDO2 power save mode) LDO1ON = [0] (LDO1 OFF) VB = 4.6 V LDOCNT = High VB through mode I_{CPOUT} = 0 mA LED10ON = [1] (Current 0)	—	1.0	3.0	mA	—
Current consumption (5) at charge pump 1.5× (600 kHz operating) mode, LDO1 OFF mode, LDO2 power save mode	ICC5	LDO2 PS = [1] (LDO2 power save mode) LDO1ON = [0] (LDO1 OFF) VB = 3.1 V LDOCNT = High LED10ON = [1] (current 0) Charge Pump ON, 1.5×, 600 kHz operating mode I_{CPOUT} = 0 mA	—	2.0	5.0	mA	—

Established : 2011-05-30
Revised : 2013-04-16

ELECTRICAL CHARACTERISTICS (continued)

VB = VBCP = 3.6 V, VLED = 4.5 V, VDD = 1.85 V

Note) T_a = 25 °C ± 2 °C unless otherwise specified

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
Current consumption							
Current consumption (6) at charge pump 1.5× (1.2 MHz operating) mode, LDO1 OFF mode, LDO2 power save mode	ICC6	LDO2 PS = [1] (LDO2 power save mode) LDO1ON = [0] (LDO1 OFF) VB = 3.1 V LDOCNT = High LED10ON = [1] (current 0) Charge Pump ON, 1.5×, 1.2 MHz operating mode I_{CPOUT} = 0 mA	—	5.0	9.0	mA	—
Reference voltage							
Output voltage	VREF	VB = 3.1 V to 4.6 V	1.21	1.24	1.27	V	—
Voltage regulator (LDO1) normal mode Ioutmax = –100 mA							
Output voltage (1) 1.85 V mode	VL11	VB = 3.1 V to 4.6 V I_{LDO1} = –10 µA to –100 mA	1.79	1.85	1.91	V	—
Output voltage (2) 2.85 V mode	VL12	VB = 3.1 V to 4.6 V I_{LDO1} = –10 µA to –100 mA	2.76	2.85	2.94	V	—
Short circuit protection current (1) 1.85 V mode	IPT11	LDOCNT = High V_{LDO1} = 0 V	20	50	150	mA	—
Short circuit protection current (2) 2.85 V mode	IPT12	LDOCNT = High V_{LDO1} = 0 V	20	50	150	mA	—
Ripple rejection (1) 1.85 V mode	PSL11	VB = 3.6 V + 0.2 V[p-p] f = 1 kHz I_{LDO1} = –50 mA PSL11 = 20 log(acV_{LDO1} / 0.2)	—	–70	–60	dB	—
Ripple rejection (2) 1.85 V mode	PSL12	VB = 3.6 V + 0.2 V[p-p] f = 10 kHz I_{LDO1} = –50 mA PSL12 = 20 log(acV_{LDO1} / 0.2)	—	–60	–50	dB	—
Ripple rejection (3) 2.85 V mode	PSL13	VB = 3.6 V + 0.2 V[p-p] f = 1 kHz I_{LDO1} = –50 mA PSL13 = 20 log(acV_{LDO1} / 0.2)	—	–70	–60	dB	—
Ripple rejection (4) 2.85 V mode	PSL14	VB = 3.6 V + 0.2 V[p-p] f = 10 kHz I_{LDO1} = –50 mA PSL14 = 20 log(acV_{LDO1} / 0.2)	—	–60	–50	dB	—

Established : 2011-05-30
Revised : 2013-04-16

ELECTRICAL CHARACTERISTICS (continued)

VB = VBCP = 3.6 V, VLED = 4.5 V, VDD = 1.85 V

Note) T_a = 25 °C ± 2 °C unless otherwise specified

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
Voltage regulator (LDO1) power save mode : Ioutmax = – 15 mA (Ioutmax = – 5 mA at 2.85 V setting)							
Output voltage (1)	VLPS11	VB = 3.1 V to 4.6 V I_{LDO1} = – 10 µA to – 15 mA	1.79	1.85	1.91	V	—
Output voltage (2)	VLPS12	VB = 3.1 V to 4.6 V I_{LDO1} = – 10 µA to – 5 mA	2.76	2.85	2.94	V	—
Voltage regulator (LDO2) normal mode Ioutmax = – 100 mA							
Output voltage	VL2	VB = 3.1 V to 4.6 V I_{LDO2} = – 10 µA to – 100 mA	2.76	2.85	2.94	V	—
Short circuit protection current	IPT2	LDOCNT = High V_{LDO2} = 0 V	20	50	150	mA	—
Ripple rejection (1)	PSL21	VB = 3.6 V + 0.2 V[p-p] f = 1 kHz I_{LDO2} = – 50 mA PSL21 = 20 log(acV_{LDO2} / 0.2)	—	– 70	– 60	dB	—
Ripple rejection (2)	PSL22	VB = 3.6 V +0.2 V[p-p] f = 10 kHz I_{LDO2} = – 50 mA PSL22 = 20 log(acV_{LDO2} / 0.2)	—	– 60	– 50	dB	—
Voltage regulator (LDO2) power save mode Ioutmax = – 5 mA							
Output voltage	VLPS2	VB = 3.1 V to 4.6 V I_{LDO2} = – 10 µA to – 5 mA	2.76	2.85	2.94	V	—

Established : 2011-05-30
Revised : 2013-04-16

ELECTRICAL CHARACTERISTICS (continued)

VB = VBCP = 3.6 V, VLED = 4.5 V, VDD = 1.85 V

Note) T_a = 25 °C ± 2 °C unless otherwise specified

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
Charge pump DC/DC converter							
Oscillator frequency	FDC1	VB = 3.1 V to 4.6 V	1.92	2.40	2.88	MHz	—
VB through switch							
Resistance at switch ON	RVBS	VB = 4.5 V I_{CPOUT} = – 30 mA RVBS = (V_{VBCP} – V_{CPOUT}) / 30 mA	—	0.6	1	Ω	—
SCAN switch							
Resistance at switch ON	RSCAN	VLED = 4.5 V I_{SW1} to I_{SW7} = 20 mA RSCAN = V_{SW1} to V_{SW7} / 20 mA	—	1	2	Ω	—
Current regulator (LED1 to 7)							
Output current (1)	IBL1	At 31.750 mA setting V_{LED1} to V_{LED7} = 1 V IBL1 = I_{LED1} to I_{LED7}	30.132	31.718	33.304	mA	*1
Output current (2)	IBL2	At 1 mA setting V_{LED1} to V_{LED7} = 1 V IBL2 = I_{LED1} to I_{LED7}	0.948	0.998	1.048	mA	*1
Current step	IBSTEP	Minimum current step	0	125	250	μA	—
Off leak current	IBLOFF	OFF setting V_{LED1} to V_{LED7} = 4.5 V IBLOFF = I_{LED1} to I_{LED7}	—	—	1	μA	—
Error between channels	IBLCH	At 16 mA setting Current error between each channel and the median of LED1 to LED7	– 5	—	5	%	—

Note) *1 : Allowable value at the time when the recommended parts (ERJ2RHD393X) is connected to IREF.

Established : 2011-05-30
Revised : 2013-04-16

ELECTRICAL CHARACTERISTICS (continued)

VB = VBCP = 3.6 V, VLED = 4.5 V, VDD = 1.85 V

Note) T_a = 25 °C ± 2 °C unless otherwise specified

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
Current regulator (LED8 to 10)							
Output current (1)	IRGB1	At 31.750 mA setting V_{LED8} to V_{LED10} = 1 V IRGB1 = I_{LED8} to I_{LED10}	30.087	31.671	33.254	mA	*1
Output current (2)	IRGB2	At 1 mA setting V_{LED8} to V_{LED10} = 1 V IRGB2 = I_{LED8} to I_{LED10}	0.946	0.996	1.046	mA	*1
Current step	IRGBSTEP	Minimum current step	0	125	250	µA	—
Off leak current	IRGBOFF	OFF setting V_{LED8} to V_{LED10} = 4.5 V IRGBOFF = I_{LED8} to I_{LED10}	—	—	1	µA	—
Error between channels	IRGBCH	At 16 mA setting Current error between each channel and the median of LED8 to LED10	–5	—	5	%	—
Current regulator (LED11 to 17)							
Output current (1)	IMX1	At 1 mA setting V_{LED11} to V_{LED17} = 1 V IMX1 = I_{LED11} to I_{LED17}	0.943	0.993	1.043	mA	*1
Output current (2)	IMX2	At 2 mA setting V_{LED11} to V_{LED17} = 1 V IMX2 = I_{LED11} to I_{LED17}	1.891	1.990	2.090	mA	*1
Output current (3)	IMX3	At 4 mA setting V_{LED11} to V_{LED17} = 1 V IMX3 = I_{LED11} to I_{LED17}	3.768	3.966	4.164	mA	*1
Output current (4)	IMX4	At 8 mA setting V_{LED11} to V_{LED17} = 1 V IMX4 = = I_{LED11} to I_{LED17}	7.558	7.956	8.354	mA	*1
Output current (5)	IMX5	At 15 mA setting V_{LED11} to V_{LED17} = 1 V IMX5 = = I_{LED11} to I_{LED17}	14.172	14.918	15.663	mA	*1
Off leak current	IMXOFF	OFF setting V_{LED11} to V_{LED17} = 4.5 V IMXOFF = I_{LED11} to I_{LED17}	—	—	1	µA	—
Error between channels	IMXCH	At 15 mA setting Current error between each channel and the median of LED11 to LED17	– 5	—	5	%	—

Note) *1 : Allowable value at the time when the recommended parts (ERJ2RHD393X) is connected to IREF.

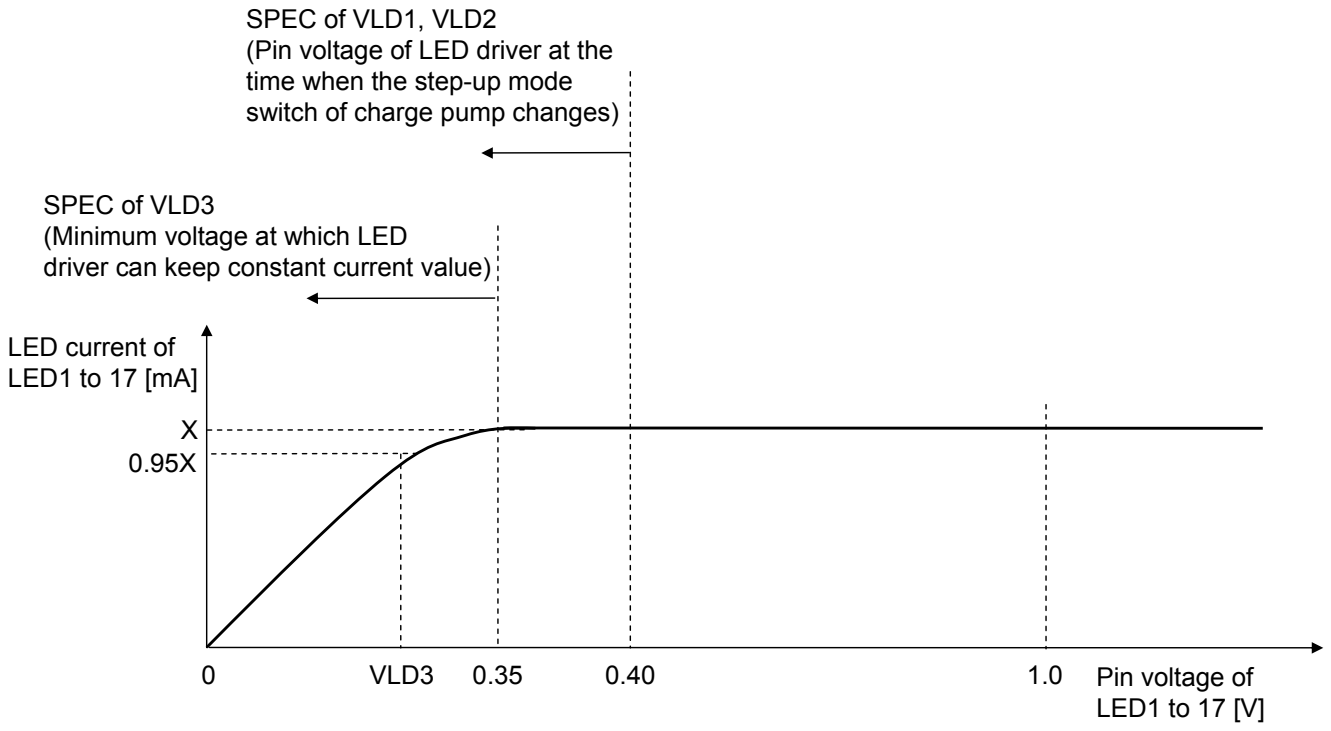
Established : 2011-05-30
Revised : 2013-04-16

ELECTRICAL CHARACTERISTICS (continued)

VB = VBCP = 3.6 V, VLED = 4.5 V, VDD = 1.85 V

Note) T_a = 25 °C ± 2 °C unless otherwise specified

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
Overvoltage detection							
Detection voltage	VOV	Charge pump DC/DC overvoltage detection	5.3	5.5	5.7	V	—
Step-up mode switch of charge pump							
Detection voltage (1)	VLD1	LED1 to LED7 pin voltage at the time when the step-up mode switch of charge pump changes	—	0.35	0.40	V	—
Detection voltage (2)	VLD2	LED8, 9 and 10 pin voltage at the time when the step-up mode switch of charge pump changes	—	0.35	0.40	V	—
Minimum voltage at which LED driver can keep constant current value							
Minimum voltage at which LED driver can keep constant current value	VLD3	95% LED current value at the time when LED1 to LED17 pin voltage is set to 1 V. Minimum value of LED1 to LED17 pin voltage	—	0.20	0.35	V	—



Established : 2011-05-30
Revised : 2013-04-16

ELECTRICAL CHARACTERISTICS (continued)

VB = VBCP = 3.6 V, VLED = 4.5 V, VDD = 1.85 V

Note) T_a = 25 °C ± 2 °C unless otherwise specified

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
GPIO I/F							
High-level input voltage range (1) at 1.85 V mode operation	VIH1	High-level recognition voltage of GPIO1 to 3. IOVSEL1 to 3 = [1] (Output voltage LDO1 level setting) LDO1VSEL = [0]	1.5	—	LDO1 + 0.3	V	—
Low-level input voltage range (1) at 1.85 V mode operation	VIL1	Low-level recognition voltage of GPIO1 to 3. IOVSEL1 to 3 = [1] (Output voltage LDO1 level setting) LDO1VSEL = [0]	– 0.3	—	0.4	V	—
High-level input voltage range (2) at 2.85 V mode operation	VIH2	High-level recognition voltage of GPIO1 to 3. LDO1VSEL = [1]	2.3	—	LDO1 + 0.3	V	—
Low-level input voltage range (2) at 2.85 V mode operation	VIL2	Low-level recognition voltage of GPIO1 to 3. LDO1VSEL = [1]	– 0.3	—	0.6	V	—
High-level input current	IIH1	V_{GPIO1} to V_{GPIO3} = 2.85 V IIH1 = I_{GPIO1} to I_{GPIO3}	—	0	1	µA	—
Low-level input current	IIL1	V_{GPIO1} to V_{GPIO3} = 0 V IIL1 = I_{GPIO1} to I_{GPIO3}	—	0	1	µA	—
High-level output voltage (1)	VOH1	V_{GPIO1} to V_{GPIO3} = – 2 mA IOVSEL1 to 3 = [0] (Output voltage LDO2 level setting)	LDO2 × 0.8	—	—	V	—
Low-level output voltage (1)	VOL1	I_{GPIO1} to I_{GPIO3} = 2 mA IOVSEL1 to 3 = [0] (Output voltage LDO2 level setting)	—	—	LDO2 × 0.2	V	—
High-level output voltage (2)	VOH2	I_{GPIO1} to I_{GPIO3} = – 2 mA IOVSEL1 to 3 = [1] (Output voltage LDO1 level setting)	LDO1 × 0.8	—	—	V	—
Low-level output voltage (2)	VOL2	I_{GPIO1} to I_{GPIO3} = 2 mA IOVSEL1 ~ 3 = [1] (Output voltage LDO1 level setting)	—	—	LDO1 × 0.2	V	—
Pull-down resistance	RPD	I_{GPIO1} to I_{GPIO3} = 5 µA RPD = V_{GPIO1} to V_{GPIO3} / 5 µA	60	110	210	kΩ	—

Established : 2011-05-30
Revised : 2013-04-16

ELECTRICAL CHARACTERISTICS (continued)

VB = VBCP = 3.6 V, VLED = 4.5 V, VDD = 1.85 V

Note) T_a = 25 °C ± 2 °C unless otherwise specified

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
LDOCNT							
High-level input voltage range	VIH3	High-level recognition voltage	1.6	—	VB + 0.3	V	—
Low-level input voltage range	VIL3	Low-level recognition voltage	– 0.3	—	0.4	V	—
High-level input current	IIH2	V_{LDOCNT} = 3.6 V	—	0	1	µA	—
Low-level input current	IIL2	V_{LDOCNT} = 0 V	—	0	1	µA	—
NRESET							
High-level input voltage range	VIH4	High-level recognition voltage	1.5	—	VB + 0.3	V	—
Low-level input voltage range	VIL4	Low-level recognition voltage	– 0.3	—	0.6	V	—
High-level input current	IIH3	V_{NRESET} = 3.6 V	—	0	1	µA	—
Low-level input current	IIL3	V_{NRESET} = 0 V	—	0	1	µA	—
INT							
ON resistance	RINTON	I_{INT} = 5 mA RINTON = V_{INT} / 5 mA	—	—	50	Ω	—

Established : 2011-05-30
Revised : 2013-04-16

ELECTRICAL CHARACTERISTICS (continued)

VB = VBCP = 3.6 V, VLED = 4.5 V, VDD = 1.85 V

Note) T_a = 25 °C ± 2 °C unless otherwise specified

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
I²C I/F							
High-level input voltage	VIH5	High-level recognition voltage of SDA, SCL	0.7 × VDD	—	VDD + 0.5, 3.2	V	*2
Low-level input voltage	VIL5	Low-level recognition voltage of SDA, SCL	– 0.5	—	0.3 × VDD	V	—
Low-level output voltage 1	VOL3	VDD > 2 V I_{SDA} = 3 mA	0	—	0.4	V	—
Low-level output voltage 2	VOL4	VDD < 2 V I_{SDA} = 3 mA	0	—	0.2 × VDD	V	—
Input current each I/O pin	Ii	V_{SDA}, V_{SCL} = 0.1 V to 2.88 V	– 10	0	10	μA	—
SCL clock frequency	f_{SCL}	—	0	—	400	kHz	—
Light Intensity Control							
PD1 pin ON resistance	RPD1ON	—	—	—	100	Ω	—
PD3 pin ON resistance	RPD3ON	—	—	—	50	Ω	—
A/D converted value (1)	AD1	V_{PD2} = VLPS2 / 256 Read value of the register, ADC_DATA[9:2]	—	1	5	LSB	—
A/D converted value (2)	AD2	V_{PD2} = VLPS2 × 128 / 256 Read value of the register, ADC_DATA[9:2]	124	128	132	LSB	—
A/D converted value (3)	AD3	V_{PD2} = VLPS2 × 255 / 256 Read value of the register, ADC_DATA[9:2]	251	255	—	LSB	—

Note) *2 : Maximum value of High-level input voltage range is the lower one of (VDD + 0.5 V) and 3.2 V.

Established : 2011-05-30
Revised : 2013-04-16

ELECTRICAL CHARACTERISTICS (continued)

VB = VBCP = 3.6 V, VLED = 4.5 V, VDD = 1.85 V

Note) T_a = 25 °C ± 2 °C unless otherwise specified

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
Current consumption							
Current consumption (1) at OFF mode	ICC1	VB = 3.1 V to 4.6 V LDOCNT = Low	—	0	—	μA	*3
Current consumption (2) at LDO1 and LDO2 normal mode	ICC2	LDO1 to 2PS = [0] (LDO1, 2 normal mode) LDO1ON = [1] (LDO1 ON) VB = 3.1 V to 4.6 V LDOCNT = High	—	130	—	μA	*3
Current consumption (3) at LDO1 OFF mode, LDO2 power save mode	ICC3	LDO2 PS = [1] (LDO2 power save mode) LDO1ON = [0] (LDO1 OFF) VB = 3.1 V to 4.6 V LDOCNT = High	—	10	—	μA	*3
Current consumption (4) at VB through mode, LDO1 OFF mode, LDO2 power save mode	ICC4	LDO2 PS = [1] (LDO2 power save mode) LDO1ON = [0] (LDO1 OFF) VB = 3.1 V to 4.6 V LDOCNT = High VB through mode I_{CPOUT} = 0 mA LED10ON = [1] (Current 0)	—	1.0	—	mA	*3

Note) *3 : Typical Design Value

Established : 2011-05-30
Revised : 2013-04-16

ELECTRICAL CHARACTERISTICS (continued)

VB = VBCP = 3.6 V, VLED = 4.5 V, VDD = 1.85 V

Note) T_a = 25 °C ± 2 °C unless otherwise specified

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
Voltage regulator (LDO1) power save mode loutmax = – 15 mA (loutmax = – 5 mA at 2.85 V setting)							
Ripple rejection (1) at power save mode	PSL11	1.85 V mode VB = 3.6 V + 0.2 V[p-p] f = 1 kHz I_{LDO1} = – 7.5 mA PSL11 = 20 log(acV_{LDO1} / 0.2)	—	– 40	—	dB	*3
Ripple rejection (2) at power save mode	PSL12	1.85 V mode VB = 3.6 V + 0.2 V[p-p] f = 10 kHz I_{LDO1} = – 7.5 mA PSL12 = 20 log(acV_{LDO1} / 0.2)	—	– 30	—	dB	*3
Voltage regulator (LDO2) power save mode loutmax = – 5 mA							
Ripple rejection (1) at power save mode	PSL21	VB = 3.6 V + 0.2 V[p-p] f = 1 kHz I_{LDO2} = – 2.5 mA PSL21 = 20 log(acV_{LDO2} / 0.2)	—	– 40	—	dB	*3
Ripple rejection (2) at power save mode	PSL22	VB = 3.6 V + 0.2 V[p-p] f = 10 kHz I_{LDO2} = – 2.5 mA PSL22 = 20 log(acV_{LDO2} / 0.2)	—	– 30	—	dB	*3

Note) *3 : Typical Design Value

Established : 2011-05-30
Revised : 2013-04-16

ELECTRICAL CHARACTERISTICS (continued)

VB = VBCP = 3.6 V, VLED = 4.5 V, VDD = 1.85 V

Note) T_a = 25 °C ± 2 °C unless otherwise specified

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
I²C I/F							
Hysteresis of Schmitt trigger input 1	Vhys1	V_{DD} > 2 V, Hysteresis voltage of SDA, SCL	0.05 × VDD	—	—	V	*4 *5
Hysteresis of Schmitt trigger input 2	Vhys2	V_{DD} < 2 V, Hysteresis voltage of SDA, SCL	0.1 × VDD	—	—	V	*4 *5
Output fall time from V_{IHmin} to V_{ILmax}	Tof	Bus capacitance : 10 pF to 400 pF $I_P \leq 6$ mA (V_{OLmax} = 0.6 V) I_P : Max. sink current	20 + 0.1 × C_b	—	250	ns	*4 *5
Pulse width of spikes which must be suppressed by the input filter	Tsp	—	0	—	50	ns	*4 *5
Capacitance for each I/O pin	Ci	—	—	—	10	pF	*4 *5

Note) *4 : The timing of Fast-mode Plus devices in I²C-bus is specified in Page.19. All values referred to V_{IHMIN} and V_{ILMAX} level.
*5 : These are values checked by design but not production tested.

Established : 2011-05-30
Revised : 2013-04-16

ELECTRICAL CHARACTERISTICS (continued)

VB = VBCP = 3.6 V, VLED = 4.5 V, VDD = 1.85 V

Note) T_a = 25 °C ± 2 °C unless otherwise specified

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
I²C I/F (continued)							
Hold time (repeated)	$t_{HD:STA}$	The first clock pulse is generated after $t_{HD:STA}$	0.6	—	—	µs	*4 *5
Low period of the SCL clock	t_{LOW}	—	1.3	—	—	µs	*4 *5
High period of the SCL clock	t_{HIGH}	—	0.6	—	—	µs	*4 *5
Set-up time for a repeat START condition	$t_{SU:STA}$	—	0.6	—	—	µs	*4 *5
Data hold time	$t_{HD:DAT}$	—	0	—	0.9	µs	*4 *5
Data set-up time	$t_{SU:DAT}$	—	100	—	—	ns	*4 *5
Rise time of both SDA and SCL signals	tr	—	20 + 0.1 × C_b	—	300	ns	*4 *5
Fall time of both SDA and SCL signals	t_f	—	20 + 0.1 × C_b	—	300	ns	*4 *5
Set-up time of STOP condition	$t_{SU:STO}$	—	0.6	—	—	µs	*4 *5
Bus free time between a STOP and START condition	t_{BUF}	—	1.3	—	—	µs	*4 *5
Capacitive load for each bus line	C_b	—	—	—	400	pF	*4 *5
Noise margin at the Low-level for each connected device	V_{aL}	—	0.1 × VDD	—	—	V	*4 *5
Noise margin at the High-level for each connected device	V_{aH}	—	0.2 × VDD	—	—	V	*4 *5

Note) *4 : The timing of Fast-mode Plus devices in I²C-bus is specified in Page.19. All values referred to V_{IHMIN} and V_{ILMAX} level.
*5 : These are values checked by design but not production tested.

Established : 2011-05-30
Revised : 2013-04-16

ELECTRICAL CHARACTERISTICS (continued)

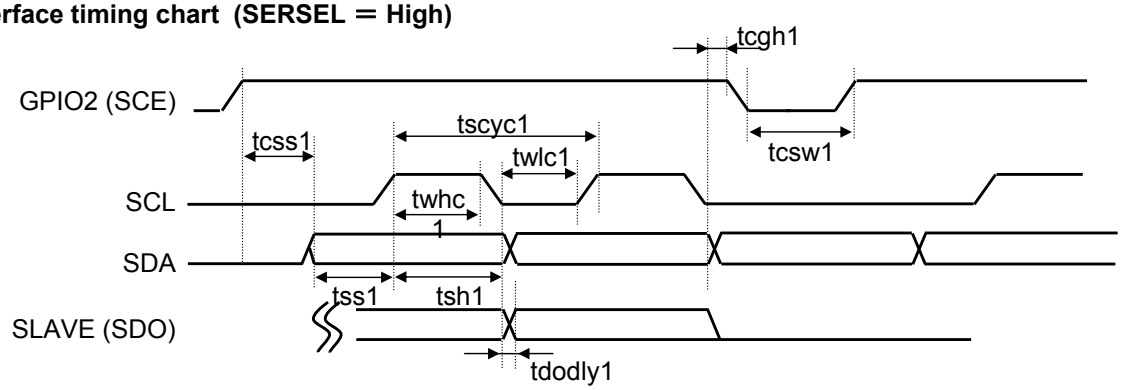
VB = VBCP = 3.6 V, VLED = 4.5 V, VDD = 1.85 V

Note) T_a = 25 °C ± 2 °C unless otherwise specified

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
SPI interface characteristics (VDD = 1.85 V ± 3%) Reception timing							
SCL cycle time	tscyc1	—	—	152	—	ns	*3
SCL cycle time High period	twhc1	—	—	70	—	ns	*3
SCL cycle time Low period	twlc1	—	—	70	—	ns	*3
Serial data setup time	tss1	—	—	62	—	ns	*3
Serial data hold time	tsh1	—	—	62	—	ns	*3
Transmitting and receiving interval	tcsw1	—	—	62	—	ns	*3
Chip enable setup time	tcss1	—	—	5	—	ns	*3
Chip enable hold time	tcgh1	—	—	5	—	ns	*3
SPI interface characteristics (VDD = 1.85 V ± 3%) Transmission timing							
SCL cycle time	tscyc1	—	—	152	—	ns	*3
SCL cycle time High period	twhc1	—	—	70	—	ns	*3
SCL cycle time Low period	twlc1	—	—	70	—	ns	*3
Serial data setup time	tss1	—	—	62	—	ns	*3
Serial data hold time	tsh1	—	—	62	—	ns	*3
Transmitting and receiving interval	tcsw1	—	—	62	—	ns	*3
Chip enable setup time	tcss1	—	—	5	—	ns	*3
Chip enable hold time	tcgh1	—	—	5	—	ns	*3
DC delay time	tdodly1	Only read mode	—	30	—	ns	*3

Note) *3 : Typical Design Value

SPI interface timing chart (SERSEL = High)

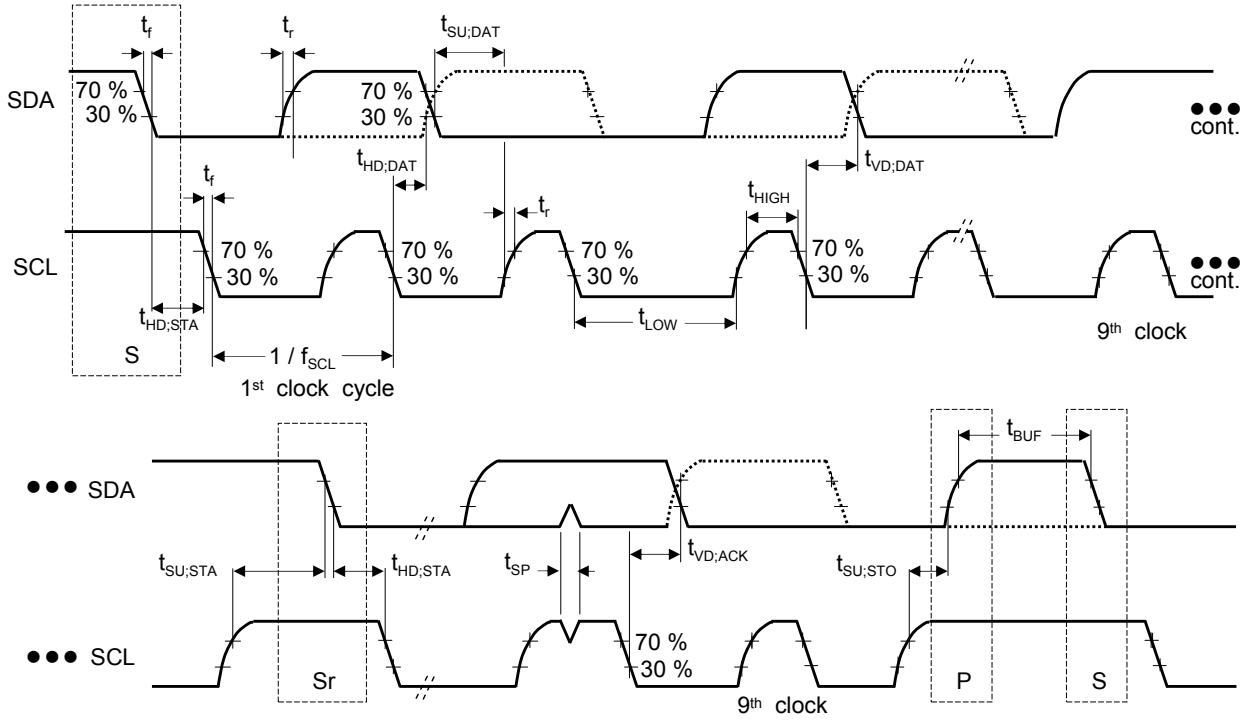


Established : 2011-05-30
Revised : 2013-04-16

ELECTRICAL CHARACTERISTICS (continued)

VB = VBCP = 3.6 V, VLED = 4.5 V, VDD = 1.85 V

Note) T_a = 25 °C ± 2 °C unless otherwise specified



V_{ILMAX} = 0.3 V_{DD}

V_{IHMIN} = 0.7 V_{DD}

S : START condition

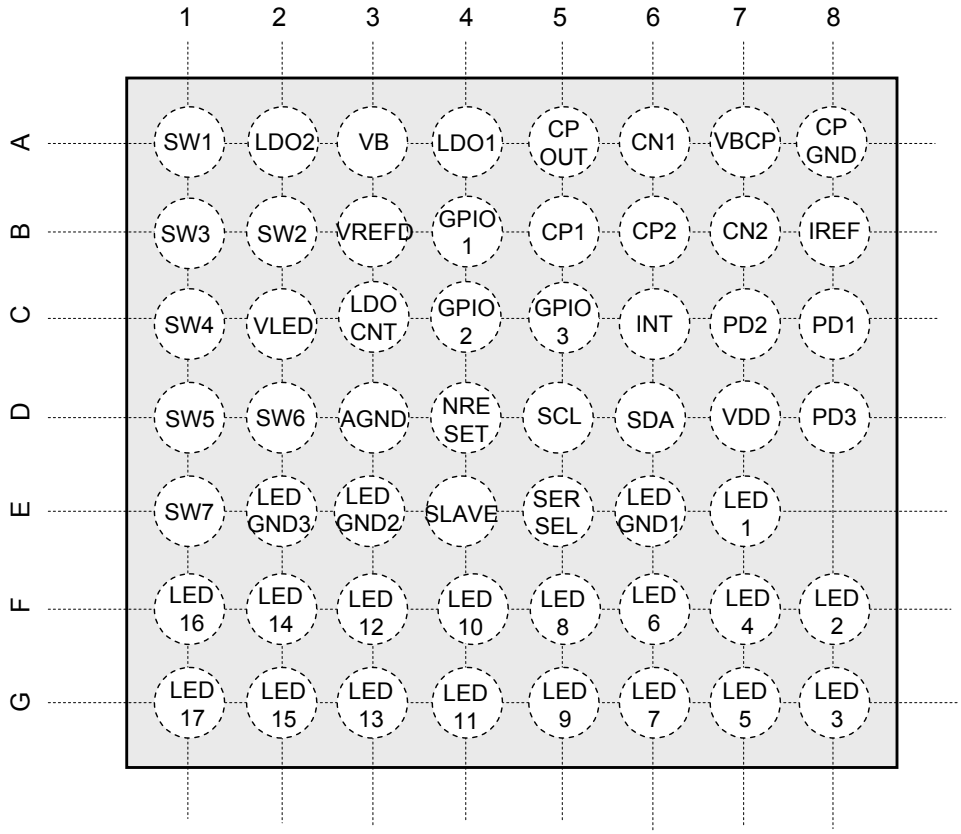
Sr : Repeat START condition

P : STOP condition

Established : 2 0 1-0 53 (
Revised : 2 0 1-0 41 (

PIN CONFIGURATION

TOP VIEW



Established : 2011-05-30
Revised : 2013-04-16

PIN FUNCTIONS

Pin No.	Pin name	Type	Description	Pin processing at unused
A1	SW1	Output	Control switch pin for matrix driver Connected to A column of matrix LED.	Open
A2	LDO2	Output	LDO2 (2.85 V) output pin	(Required pin)
A3	VB	Power supply	Power supply connection pin for BGR and LDO circuits	(Required pin)
A4	LDO1	Output	LDO1 (1.85 V / 2.85 V) output pin (Default : 1.85 V output)	(Required pin)
A5	CPOUT	Output	Charge pump output pin (Output pin for VB through SW)	Open
A6	CN1	Output	Capacitor connection pin for charge pump DC/DC converter	Open
A7	VBCP	Power supply	Power supply connection pin for charge pump DC/DC converter and for through switch	(Required pin)
A8	CPGND	Ground	GND for charge pump DC/DC converter	Connect to GND
B1	SW3	Output	Control switch pin for matrix driver Connected to C column of matrix LED.	Open
B2	SW2	Output	Control switch pin for matrix driver Connected to B column of matrix LED.	Open
B3	VREFD	Output	Capacitor connection pin for BGR circuit	(Required pin)
B4	GPIO1	Input / Output	GPIO input / output port pin (Default input mode with pull-down)	Recommended to connect to GND
B5	CP1	Output	Capacitor connection pin for charge pump DC/DC converter	Open
B6	CP2	Output	Capacitor connection pin for charge pump DC/DC converter	Open
B7	CN2	Output	Capacitor connection pin for charge pump DC/DC converter	Open
B8	IREF	Output	Resistor connection pin for constant current setup	(Required pin)
C1	SW4	Output	Control switch pin for matrix driver Connected to D column of matrix LED.	Open
C2	VLED	Power supply	Power supply for matrix driver Connected to the output of battery or step-up charge pump DC/DC converter.	Connect to VBAT or CPOUT (Open disabled)
C3	LDOCNT	Input	BGR circuit, ON/OFF control pin of LDO1 and LDO2	(Required pin)
C4	GPIO2	Input / Output	GPIO input / output port pin (Default input mode with pull-down) At SERSEL pin = High (SPI mode) : SCE pin	Recommended to connect to GND
C5	GPIO3	Input / Output	GPIO input / output port pin (Default input mode with pull-down)	Recommended to connect to GND
C6	INT	Output	Interrupt output pin	Open
C7	PD2	Input	Photo diode connection pin	Connect to GND
C8	PD1	Output	Photo diode connection pin	Open
D1	SW5	Output	Control switch pin for matrix driver Connected to E column of matrix LED.	Open
D2	SW6	Output	Control switch pin for matrix driver Connected to F column of matrix LED.	Open
D3	AGND	Ground	GND for analog block	Connect to GND
D4	NRESET	Input	Reset input pin	(Required pin)
D5	SCL	Input	SPI / I^2C interface common clock input pin	(Required pin)

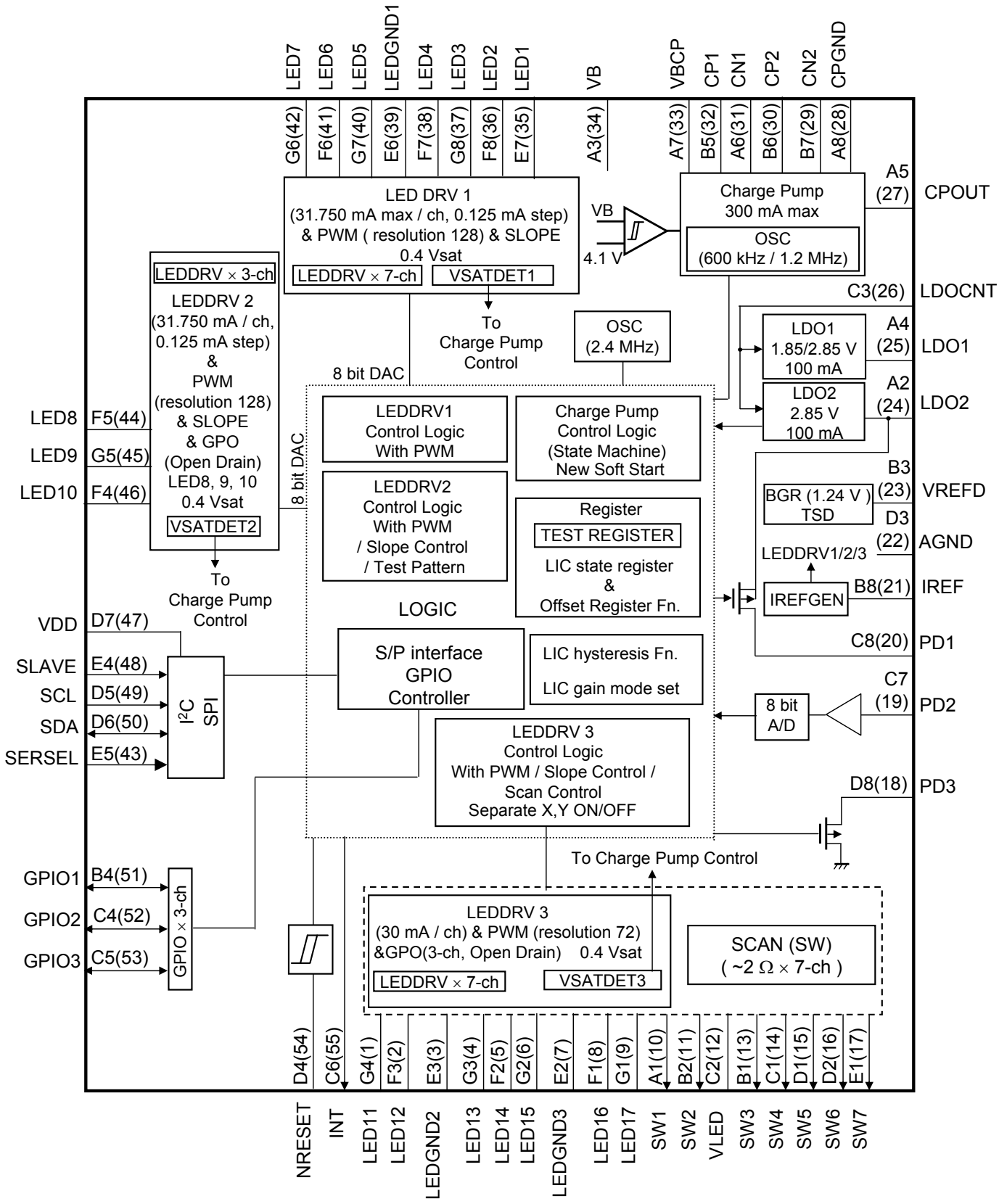
Established : 2011-05-30
Revised : 2013-04-16

PIN FUNCTIONS (continued)

Pin No.	Pin name	Type	Description	Pin processing at unused
D6	SDA	Input / Output	Data input / output pin for I²C interface At SERSEL pin = High (SPI mode) : Data input pin	(Required pin)
D7	VDD	Power supply	Power supply for I²C interface	(Required pin)
D8	PD3	Input	Detection resistor connection pin for photo diode adjustment	Open
E1	SW7	Output	Control switch pin for matrix driver Connected to G column of matrix LED.	Open
E2 E3	LEDGND3 LEDGND2	Ground	GND for matrix LED	Connect to GND
E4	SLAVE	Input / Output	Slave address selection pin for I²C interface At SERSEL pin = High (SPI mode) : SDO pin	(Required pin)
E5	SERSEL	Input	I²C / SPI interface selection pin	Connect to GND or VDD
E6	LEDGND1	Ground	GND for BL pin	Connect to GND
E7	LED1	Output	Constant current output pin for LED driver	Open
F1	LED16	Output	Constant current circuit, PWM control output pin Connected to the 6th row of matrix LED. And GPO (open drain) output pin	Open
F2	LED14	Output	Constant current circuit, PWM control output pin Connected to the 4th row of matrix LED.	Open
F3	LED12	Output	Constant current circuit, PWM control output pin Connected to the 2nd row of matrix LED.	Open
F4	LED10	Output	Constant current output pin for LED driver, and GPO (open drain) output pin	Open
F5	LED8	Output	Constant current output pin for LED driver, and GPO (open drain) output pin	Open
F6	LED6	Output	Constant current output pin for LED driver	Open
F7	LED4	Output	Constant current output pin for LED driver	Open
F8	LED2	Output	Constant current output pin for LED driver	Open
G1	LED17	Output	Constant current circuit, PWM control output pin Connected to the 7th row of matrix LED. And GPO (open drain) output pin	Open
G2	LED15	Output	Constant current circuit, PWM control output pin Connected to the 5th row of matrix LED. And GPO (open drain) output pin	Open
G3	LED13	Output	Constant current circuit, PWM control output pin Connected to the 3rd row of matrix LED.	Open
G4	LED11	Output	Constant current circuit, PWM control output pin Connected to the 1st row of matrix LED.	Open
G5	LED9	Output	Constant current output pin for LED driver, and GPO (open drain) output pin	Open
G6	LED7	Output	Constant current output pin for LED driver	Open
G7	LED5	Output	Constant current output pin for LED driver	Open
G8	LED3	Output	Constant current output pin for LED driver	Open

Established : 2011-05-30
Revised : 2013-04-16

FUNCTIONAL BLOCK DIAGRAM



Note) This block diagram is for explaining functions. Part of the block diagram may be omitted, or it may be simplified.

Established : 2011-05-30
Revised : 2013-04-16

OPERATION

1. Power-on / Power-off sequence

Description of each mode

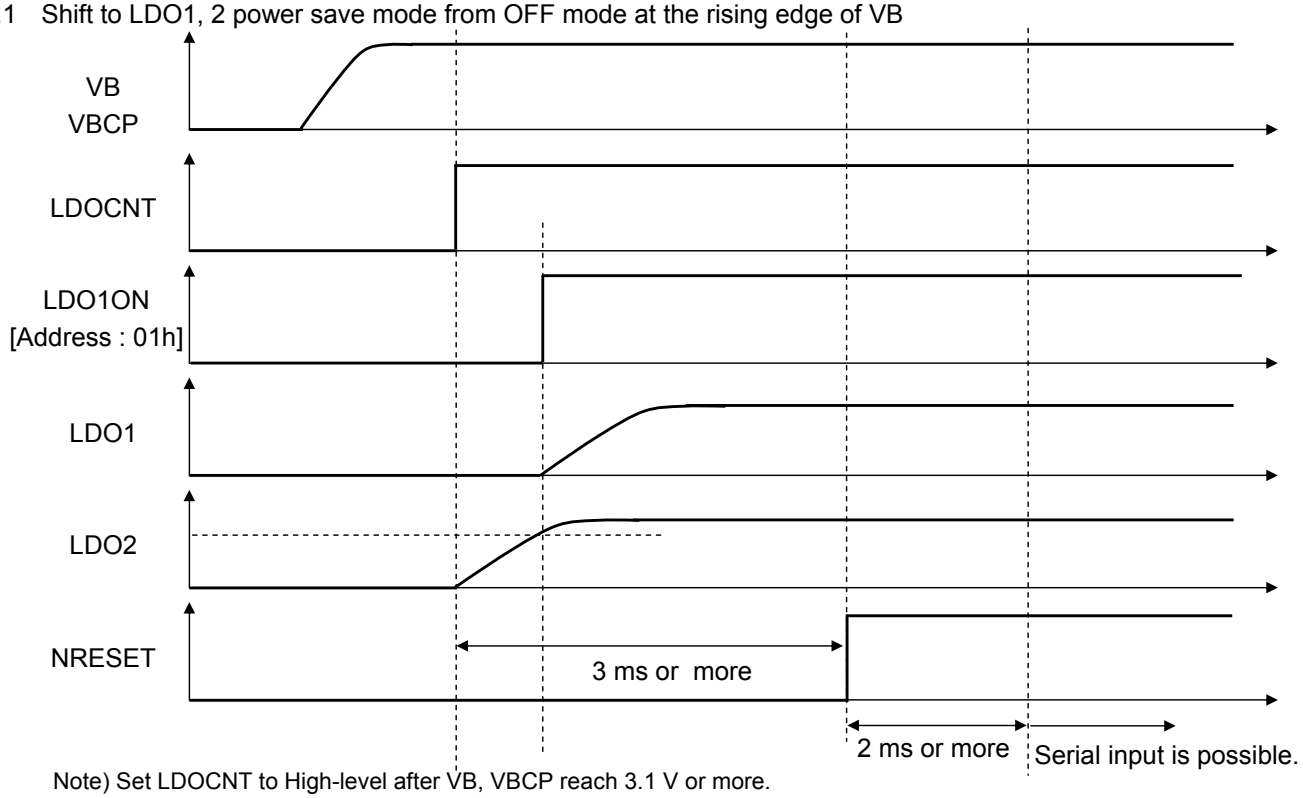
Mode	LDOCNT	LDO1ON	LDO2STB	LDO1PS	LDO2PS	Notes
OFF	Low	0	0	0	0	• The serial signal is not received at LDOCNT = Low. It is necessary to set LDOCNT to High for the return from OFF mode.
OFF ↓ Power save	Low ↓ High	1	0	1	1	• The serial signal can be received after 5 ms from LDOCNT = High. • The setting of registers is initialized after this LSI return from OFF mode. Then LDO1 and LDO2 operate in power save mode respectively.
Normal	High	0/1	0	0	0	• When NRESET is set to Low, the setting of registers is initialized. Then LDO1 and LDO2 operate in power save mode respectively. • The serial signal is turned LDO1 on or off. • LDO2 turns on at LDOCNT = High. • The serial signal is not received at NRESET = Low. • Low period of one or more internal clocks is required during NRESET = Low. • NRESET prohibits the input signal of those other than a rectangle wave. • When NRESET is set to Low, all the registers are set to the default value.
Normal / power save ↓ OFF	High ↓ Low	0	0	0/1 ↓ 0	0/1 ↓ 0	• The setting order to change into OFF mode is as follows. LDOCNT = Low → NRESET = Low, or NRESET = Low → LDOCNT = Low
Normal ↓ Power save	High	0/1	0	0/1	0/1	• LDO1, 2 can be individually shifted to power save mode by the serial signal. • It is possible to return from power save mode to normal mode with serial signal.
Power save ↓ Normal						
Normal / power save ↓ OFF(LDO1 only)	High ↓ Low	1	1	0/1	0/1	• When LDO1 output is used as power supply for I²C I/F and LDO1 is turned OFF by LDO1ON via serial interface, LDO1 cannot return to ON mode via serial interface. • When LDO1 output is used as power supply fro I²C I/F, write [1] in LDO2STB first. After that, LDOCNT changes from High to Low, and LDO1 only shifts to OFF mode.
OFF(LDO1 only) ↓ Normal / power save	Low ↓ High					• If LDOCNT is set to High from Low, this LSI can shift from standby to normal mode.

Established : 2011-05-30
Revised : 2013-04-16

OPERATION (continued)

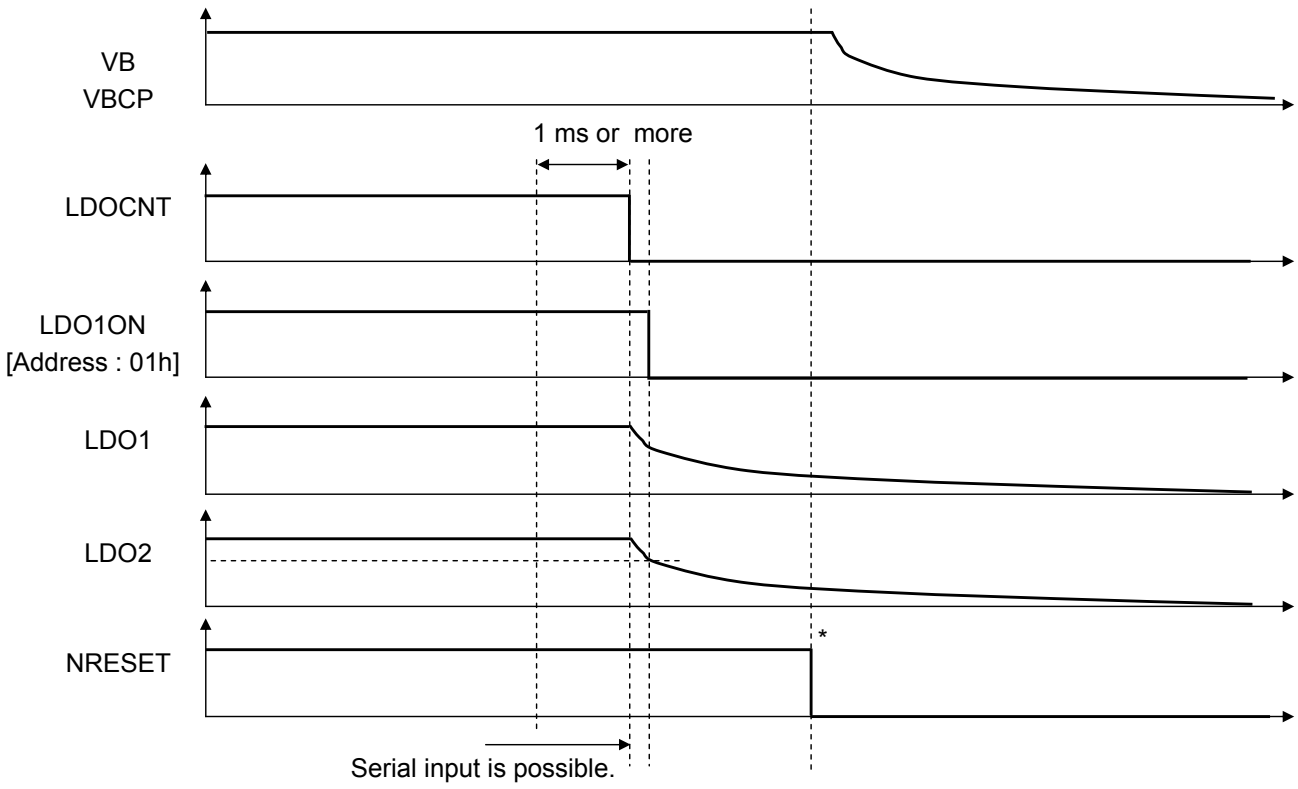
1. Power-on / Power-off sequence (continued)

1.1 Shift to LDO1, 2 power save mode from OFF mode at the rising edge of VB



Note) Set LDOCNT to High-level after VB, VBCP reach 3.1 V or more.
LDO1, LDO2 operate at power save mode after they just rise.

1.2 Shift to OFF mode from LDO1, 2 normal / power save mode



Note) * : There is no problem if NRESET falling timing is before or after LDOCNT falls.

Established : 2011-05-30
Revised : 2013-04-16