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Panasonic

AN32055A

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

7 x 7 Dots Matrix LED Driver LSI with Step-up DC/DC Converter for White LED

FEATURES

- 7 x 7 LED Matrix Driver
  (Total LED that can be driven = 49)
- Built-in memory (ROM and RAM)
- Step-up DC/DC converter
- LDO : 2-ch
- GPIO : 2-ch
- GPI : 3-ch (3pins from GPI1 to GPI3 are in common with SPI2)
- GPO : 2-ch
- SPI Interface : 2-ch (SPI2 is only receiving. It is possible to control only address 05h by SPI2.)
- Driver for LED (Main LED : 4-ch, Sub LED : 2-ch, LED for Photo flash : 2-ch, RGB color unit : 1-ch)
- 80 pin Wafer level chip size package (WLCSP)

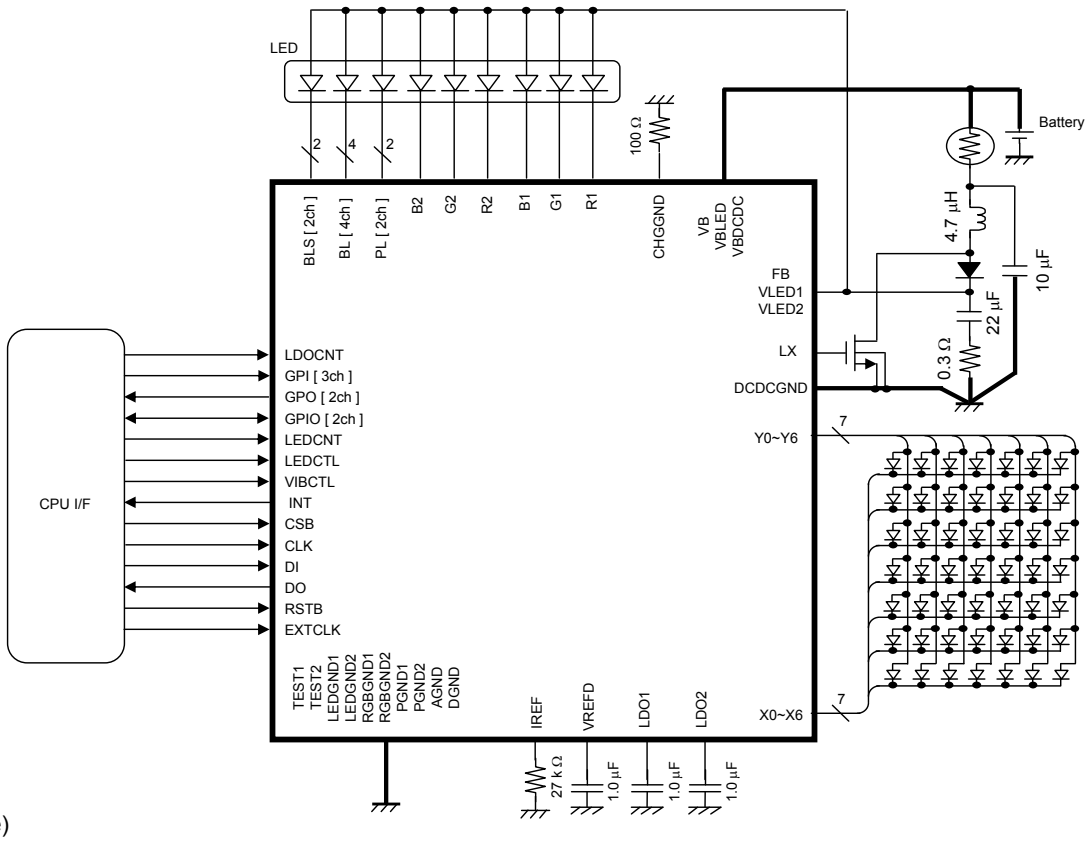
DESCRIPTION

AN32055A is a 6-ch LED driver for LCD backlights, and a driver for LED matrix.
They supply voltage by step-up 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.

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ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit	Note
Supply voltage	VB_{MAX}	6.0	V	*1
	$VLED_{MAX}$	6.5	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	LEDCTL, RSTB, CSB, CLK, DI, EXTCLK, VIBCTL, GPI1, GPI2, GPI3, GPIO1, GPIO2	– 0.3 to 3.4	V	—
	LEDCNT, LDOCNT, FB	– 0.3 to 6.0	V	—
Output Voltage Range	GPO1, GPO2, INT, DO	– 0.3 to 3.4	V	—
	LDO1, LDO2	– 0.3 to 6.0	V	—
	BL1, BL2, BL3, BL4, BLS1, BLS2, PL1, PL2, R1, G1, B1, R2, G2, B2, LDO1, LDO2, LX, X0, X1, X2, X3, X4, X5, X6, Y0, Y1, Y2, Y3, Y4, Y5, Y6	– 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} = VBDCDC = VBLED = VB, $VLED_{MAX}$ = VLED1 = VLED2. 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 Ta = 25°C.

POWER DISSIPATION RATING

PACKAGE	θ_{JA}	P_D (Ta=25 °C)	P_D (Ta=85 °C)
80 pin Wafer level chip size package (WLCSP)	119.4 °C /W	0.837 W	0.335 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. This value is based on the data LSI mount on PCB Grass Epoxy : 50 X 50 X 0.8 t (mm).

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.

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RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Min.	Typ.	Max.	Unit	Note
Supply voltage range	VB	3.1	3.7	4.6	V	*1
	VLED	3.1	5.0	5.6	V	*1
Input Voltage Range	LEDCTL, RSTB, CSB, CLK, DI, EXTCLK, VIBCTL, GPI1, GPI2, GPI3, GPIO1, GPIO2	– 0.3	—	3.0	V	—
	LEDCNT, LDOCNT, FB	– 0.3	—	VB + 0.3	V	*2
Output Voltage Range	GPO1, GPO2, INT, DO	– 0.3	—	3.0	V	—
	BL1, BL2, BL3, BL4, BLS1, BLS2, PL1, PL2, R1, G1, B1, R2, G2, B2, LDO1, LDO2, LX, X0, X1, X2, X3, X4, X5, X6, Y0, Y1, Y2, Y3, Y4, Y5, Y6	– 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, DGND, LEDGND1, LEDGND2, RGBGND1, RGBGND2, DCDCGND, PGND1 and PGND2.
VB is voltage for VBDCDC, VBLED and VB. VLED is voltage for VLED1 and VLED2.
*2: (VB + 0.3) V must not exceed 6 V. (VLED + 0.3) V must not exceed 6.5 V.

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ELECTRICAL CHARACTERISTICS

VB = VBDCDC = VBLED = 3.6 V, VLED1 = VLED2 = 4.9 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)	ICC1	At OFF mode LDOCNT = Low	—	0	1	μA	—
Current consumption (2)	ICC2	At Standby mode LDOCNT = Low LDO2 is active.	—	8	12	μA	—
Current consumption (3)	ICC3	LDOCNT = High LDO1 and LDO2 are active.	—	18	24	μA	—
Reference voltage							
Output voltage	VREF	I_{VREF} = 0 μA	1.21	1.24	1.27	V	—
Reference current							
Output voltage	VIREF	I_{IREF} = 0 μA	0.44	0.54	0.64	V	—
Voltage regulator (LDO1)							
Output voltage	VL1	I_{LDO1} = – 30 mA	1.79	1.85	1.91	V	—
Leakage Current when LDO1 turns off	IOFF1	LDOCNT = High REG18 = Low V_{LDO1} = 0 V, IOFF1 = I_{LDO1}	—	—	1	μA	—
Short circuit protection current	IPT1	LDOCNT = High REG18 = High V_{LDO1} = 0 V, IPT1 = I_{LDO1}	50	100	200	mA	—
Ripple rejection (1)	PSL11	VB = 3.6 V + 0.2 V[p-p] f = 1 kHz I_{LDO1} = – 15 mA PSL11 = 20log(acV_{LDO1} / 0.2)	—	– 45	– 40	dB	—
Ripple rejection (2)	PSL12	VB = 3.6 V + 0.2 V[p-p] f = 10 kHz I_{LDO1} = – 15 mA PSL12 = 20log(acV_{LDO1} / 0.2)	—	– 35	– 25	dB	—

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ELECTRICAL CHARACTERISTICS (continued)

VB = VBDCDC = VBLED = 3.6 V, VLED1 = VLED2 = 4.9 V

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

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
Voltage regulator (LDO2)							
Output voltage	VL2	I_{LDO2} = – 30 mA	2.76	2.85	2.94	V	—
Leakage Current when LDO2 turns off	IOFF2	LDOCNT = Low REG28 = Low V_{LDO2} = 0 V IOFF2 = I_{LDO2}	—	—	1	μA	—
Short circuit protection current	IPT2	LDOCNT = High V_{LDO2} = 0V IPT2 = I_{LDO2}	50	100	300	mA	—
Ripple rejection (1)	PSL21	VB = 3.6 V + 0.2 V[p-p] f = 1 kHz I_{LDO2} = – 15 mA PSL21 = 20log(acV_{LDO2} / 0.2)	—	– 35	– 30	dB	—
Ripple rejection (2)	PSL22	VB = 3.6 V + 0.2 V[p-p] f = 10 kHz I_{LDO2} = – 15 mA PSL22 = 20log(acV_{LDO2} / 0.2)	—	– 25	– 15	dB	—
Step-up DC/DC converter							
Output voltage (1)	VDC1	Mode 1 Iout = – 400 mA	4.62	4.89	5.16	V	—
Output voltage (2)	VDC2	Mode 2 Iout = – 400 mA	5.03	5.3	5.57	V	—
Oscillation frequency	FDC	OSCEN = [1] , DDSW = [1]	0.96	1.20	1.44	MHz	*1
Short detection delay time	TSCP	Time when INT is set to High from Low, after short detection.	3	13	30	ms	—
SCAN Switch							
Resistance at the Switch ON	RSCAN	$I_{Y0, Y1, Y2, Y3, Y4, Y5, Y6}$ = – 5 mA RSCAN = $V_{Y0, Y1, Y2, Y3, Y4, Y5, Y6}$ / 5 mA	—	2	4.8	Ω	—

*1: Make sure to set both bits of OSCEN and DDSW to [1].
During OSCEN = [1] , DDSW must be set to [1].

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ELECTRICAL CHARACTERISTICS (continued)

VB = VBDCDC = VBLED = 3.6 V, VLED1 = VLED2 = 4.9 V

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

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
Current generator (For backlights)							
Output current (1)	IBL1	At 1mA setup $V_{BL1, BL2, BL3, BL4}$ = 1 V IBLS1 = $I_{BL1, BL2, BL3, BL4}$	0.945	1.027	1.109	mA	*2
Output current (2)	IBL2	At 2 mA setup $V_{BL1, BL2, BL3, BL4}$ = 1 V IBLS2 = $I_{BL1, BL2, BL3, BL4}$	1.894	2.058	2.223	mA	*2
Output current (3)	IBL4	At 4 mA setup $V_{BL1, BL2, BL3, BL4}$ = 1 V IBLS4 = $I_{BL1, BL2, BL3, BL4}$	3.808	4.139	4.470	mA	*2
Output current (4)	IBL8	At 8 mA setup $V_{BL1, BL2, BL3, BL4}$ = 1 V IBLS8 = $I_{BL1, BL2, BL3, BL4}$	7.630	8.294	8.957	mA	*2
Output current (5)	IBL16	At 16 mA setup $V_{BL1, BL2, BL3, BL4}$ = 1 V IBLS16 = $I_{BL1, BL2, BL3, BL4}$	15.516	16.865	18.214	mA	*2
Leakage Current when BL1 ~ BL4 turn off	IBLOFF	At current OFF setup $V_{BL1, BL2, BL3, BL4}$ = 4.75 V IBLSOFF = $I_{BL1, BL2, BL3, BL4}$	—	—	1	μA	—
The error between channels	IBLCH	At 15 mA setup The average value of all channels, and the current error of each channel	– 5	—	5	%	—

*2: Values when recommended parts (ERJ2RHD273X) are used for IREF terminal.
The other current settings are combination of above items.

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ELECTRICAL CHARACTERISTICS (continued)

VB = VBDCDC = VBLED = 3.6 V, VLED1 = VLED2 = 4.9 V

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

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
Current generator (For sub backlights)							
Output current (1)	IBLS1	At 1mA setup $V_{BLS1, BLS2}$ = 1 V IBLS1 = $I_{BLS1, BLS2}$	0.949	1.032	1.114	mA	*2
Output current (2)	IBLS2	At 2 mA setup $V_{BLS1, BLS2}$ = 1 V IBLS2 = $I_{BLS1, BLS2}$	1.912	2.078	2.244	mA	*2
Output current (3)	IBLS4	At 4 mA setup $V_{BLS1, BLS2}$ = 1 V IBLS4 = $I_{BLS1, BLS2}$	3.818	4.149	4.480	mA	*2
Output current (4)	IBLS8	At 8 mA setup $V_{BLS1, BLS2}$ = 1 V IBLS8 = $I_{BLS1, BLS2}$	7.677	8.344	9.011	mA	*2
Output current (5)	IBLS16	At 16 mA setup $V_{BLS1, BLS2}$ = 1 V IBLS16 = $I_{BLS1, BLS2}$	15.331	16.665	17.998	mA	*2
Leak current at the time of OFF	IBLSOFF	At current OFF setup $V_{BLS1, BLS2}$ = 4.75 V IBLSOFF = $I_{BLS1, BLS2}$	—	—	1	μA	—
The error between channels	IBLSCH	At 15 mA setup The average value of all channels, and the current error of each channel	– 5	—	5	%	—

*2: Values when recommended parts (ERJ2RHD273X) are used for IREF terminal.
The other current settings are combination of above items.

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ELECTRICAL CHARACTERISTICS (continued)

VB = VBDCDC = VBLED = 3.6 V, VLED1 = VLED2 = 4.9 V

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

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
Current generator (For photo flashes)							
Output current (1)	IPL1	At 1mA setup $V_{PL1, PL2}$ = 1 V IPL1 = $I_{PL1, PL2}$	0.942	1.024	1.105	mA	*2
Output current (2)	IPL2	At 2 mA setup $V_{PL1, PL2}$ = 1 V IPL2 = $I_{PL1, PL2}$	1.887	2.051	2.215	mA	*2
Output current (3)	IPL4	At 4 mA setup $V_{PL1, PL2}$ = 1 V IPL4 = $I_{PL1, PL2}$	3.757	4.083	4.410	mA	*2
Output current (4)	IPL8	At 8 mA setup $V_{PL1, PL2}$ = 1 V IPL8 = $I_{PL1, PL2}$	7.526	8.180	8.835	mA	*2
Output current (5)	IPL16	At 16 mA setup $V_{PL1, PL2}$ = 1 V IPL16 = $I_{PL1, PL2}$	15.215	16.538	17.861	mA	*2
Output current (6)	IPL30	At 30mA setup $V_{PL1, PL2}$ = 1 V IPL30 = $I_{PL1, PL2}$	28.244	30.700	33.156	mA	*2
Leak current at the time of OFF	IPLOFF	At current OFF setup $V_{PL1, PL2}$ = 4.75 V IPLOFF = $I_{PL1, PL2}$	—	—	1	μA	—
The error between channels	IPLCH	At 15 mA setup The average value of all channels, and the current error of each channel	– 5	—	5	%	—

*2: Values when recommended parts (ERJ2RHD273X) are used for IREF terminal.
The other current settings are combination of above items.

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ELECTRICAL CHARACTERISTICS (continued)

VB = VBDCDC = VBLED = 3.6 V, VLED1 = VLED2 = 4.9 V

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

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
Current generator (For 7*7 dots matrix LED)							
Output current (1)	IMX1	At 1mA setup $V_{X0, X1, X2, X3, X4, X5, X6}$ = 1 V IMX1 = $I_{X0, X1, X2, X3, X4, X5, X6}$	0.920	1.000	1.080	mA	*2
Output current (2)	IMX2	At 2 mA setup $V_{X0, X1, X2, X3, X4, X5, X6}$ = 1 V IMX2 = $I_{X0, X1, X2, X3, X4, X5, X6}$	1.858	2.019	2.181	mA	*2
Output current (3)	IMX4	At 4 mA setup $V_{X0, X1, X2, X3, X4, X5, X6}$ = 1 V IMX4 = $I_{X0, X1, X2, X3, X4, X5, X6}$	3.742	4.068	4.393	mA	*2
Output current (4)	IMX8	At 8 mA setup $V_{X0, X1, X2, X3, X4, X5, X6}$ = 1 V IMX8 = $I_{X0, X1, X2, X3, X4, X5, X6}$	7.480	8.131	8.781	mA	*2
Output current (5)	IMX15	At 15 mA setup $V_{X0, X1, X2, X3, X4, X5, X6}$ = 1 V IMX15 = $I_{X0, X1, X2, X3, X4, X5, X6}$	14.220	15.456	16.693	mA	*2
Leak current at the time of OFF	IMXOFF	Current OFF setup $V_{X0, X1, X2, X3, X4, X5, X6}$ = 4.75 V IMXOFF = $I_{X0, X1, X2, X3, X4, X5, X6}$	—	—	1	μA	—
The error between channels	IMXCH	The average value of all channels, and the current error of each channel	– 5	—	5	%	—

*2: Values when recommended parts (ERJ2RHD273X) are used for IREF terminal. The other current settings are combination of above items.

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ELECTRICAL CHARACTERISTICS (continued)

VB = VBDCDC = VBLED = 3.6 V, VLED1 = VLED2 = 4.9 V

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

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
Current generator (For RGB color unit)							
Output current (1)	IRGB1	At 1mA setup $V_{R1, G1, B1}$ = 1 V	0.950	1.032	1.115	mA	*2
Output current (2)	IRGB2	At 2 mA setup $V_{R1, G1, B1}$ = 1 V	1.903	2.068	2.234	mA	*2
Output current (3)	IRGB4	At 4 mA setup $V_{R1, G1, B1}$ = 1 V	3.777	4.105	4.434	mA	*2
Output current (4)	IRGB8	At 8 mA setup $V_{R1, G1, B1}$ = 1 V	7.566	8.223	8.881	mA	*2
Leak current at the time of OFF	IRGBOFF	Current OFF setup $V_{R1, G1, B1, R2, G2, B2}$ = 4.75 V IRGBOFF = $I_{R1, G1, B1, R2, G2, B2}$	—	—	1	μA	—
The error between channels	IRGBCH	The average value of all channels, and the current error of each channel	– 5	—	5	%	—
Switch of Pch-MOS (VLED1)							
VBLED – VLED output impedance	RVLED	VBLED = 2.2 V V_{CHGGND} = 0 V I_{LED1} = – 10 mA RVLED = (2.2 V – V_{LED1}) / 10 mA	—	5	20	Ω	—
Switch of Nch-MOS (R1, R2, G2, B2)							
R1 output impedance	RR1	VB = 2.2 V V_{CHGGND} = 0 V I_{R1} = 5 mA RR1 = V_{R1} / 5 mA	—	10	50	Ω	—
R2 output impedance	RR2	Register : 19hD4 = High I_{R2} = 5 mA RR2 = V_{R2} / 5 mA	—	10	30	Ω	—
G2 output impedance	RG2	Register : 19hD3 = High I_{G2} = 5 mA RG2 = V_{G2} / 5 mA	—	10	30	Ω	—
B2 output impedance	RB2	Register : 19hD2 = High I_{B2} = 5 mA RB2 = V_{B2} / 5 mA	—	10	30	Ω	—

*2: Values when recommended parts (ERJ2RHD273X) are used for IREF terminal.
The other current settings are combination of above items.

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ELECTRICAL CHARACTERISTICS (continued)

VB = VBDCDC = VBLED = 3.6 V, VLED1 = VLED2 = 4.9 V

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

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
SPI I/F, LEDCTL, RSTB							
Input voltage range of High-level	VIH	High-level recognition voltage	1.4	—	LDO1 + 0.3	V	—
Input voltage range of Low-level	VIL	Low-level recognition voltage	– 0.3	—	0.4	V	—
Input current of High-level	IIH	$V_{LEDCTL, RSTB, CSB, CLK, DI}$ = 1.85 V IIH = $I_{LEDCTL, RSTB, CSB, CLK, DI}$	—	0	1	µA	—
Input current of Low-level	IIL	$V_{LEDCTL, RSTB, CSB, CLK, DI}$ = 0 V IIL = $I_{LEDCTL, RSTB, CSB, CLK, DI}$	—	0	1	µA	—
GPIO I/F, GPI I/F							
Input voltage range of High-level 1	VIH1	High-level recognition voltage (LDO1 mode)	1.4	—	LDO1 + 0.3	V	—
Input voltage range of High-level 1	VIH2	High-level recognition voltage (LDO2 mode)	2.1	—	LDO2 + 0.3	V	—
Input voltage range of Low-level	VIL	Low-level recognition voltage	– 0.3	—	0.4	V	—
Input current of High-level	IIH	$V_{GPI1, GPI2, GPI3, GPIO1, GPIO2}$ = 2.85 V IIH = $I_{GPI1, GPI2, GPI3, GPIO1, GPIO2}$	—	0	1	µA	—
Input current of Low-level	IIL	$V_{GPI1, GPI2, GPI3, GPIO1, GPIO2}$ = 0 V IIL = $I_{GPI1, GPI2, GPI3, GPIO1, GPIO2}$	—	0	1	µA	—
GPIO I/F, GPO I/F, INT							
Output voltage of High-level (1)	VOH1	$I_{GPO1, GPO2, GPIO1, GPIO2, INT}$ = – 2 mA VDDSEL = LDO2	LDO2 × 0.8	—	—	V	—
Output voltage of Low-level (1)	VOL1	$I_{GPO1, GPO2, GPIO1, GPIO2, INT}$ = 2 mA VDDSEL = LDO2 ($I_{GPO1, GPO2, GPIO1, GPIO2, INT}$ = 0.5 mA)	—	—	LDO2 ×0.2 (0.15)	V	—
Output voltage of High-level (2)	VOL2	$I_{GPO1, GPO2, GPIO1, GPIO2, INT}$ = – 2 mA VDDSEL = LDO1	LDO1 × 0.8	—	—	V	—
Output voltage of Low-level (2)	VOL2	$I_{GPO1, GPO2, GPIO1, GPIO2, INT}$ = 2 mA VDDSEL = LDO1 ($I_{GPO1, GPO2, GPIO1, GPIO2, INT}$ = 0.5 mA)	—	—	LDO1 ×0.3 (0.15)	V	—

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ELECTRICAL CHARACTERISTICS (continued)

VB = VBDCDC = VBLED = 3.6 V, VLED1 = VLED2 = 4.9 V

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

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
LDOCNT, LEDCNT							
Input voltage range of High-level	VIH	High-level recognition voltage	VB × 0.7	—	VB + 0.3	V	—
Input voltage range of Low-level	VIL	Low-level recognition voltage	– 0.3	—	0.4	V	—
Input current of High-level	IIH	$V_{LDOCNT, LEDCNT}$ = 3.6 V IIH = $I_{LDOCNT, LEDCNT}$	—	0	1	µA	—
Input current of Low-level	IIL	$V_{LDOCNT, LEDCNT}$ = 0 V IIL = $I_{LDOCNT, LEDCNT}$	—	0	1	µA	—
VIBCTL							
Input voltage range of High-level	VIH	High-level recognition voltage	2.1	—	3.3	V	—
Input voltage range of Low-level	VIL	Low-level recognition voltage	– 0.3	—	0.4	V	—
Input current of High-level	IIH	V_{VIBCTL} = 3.0 V IIH = I_{VIBCTL}	—	0	1	V	—
Input current of Low-level	IIL	V_{VIBCTL} = 0 V IIL = I_{VIBCTL}	—	0	1	µA	—
DO							
Output voltage of High-level	VOH3	I_{DO} = – 2 mA	LDO1 × 0.8	—	—	V	—
Output voltage of Low-level	VOL3	I_{DO} = 2 mA	—	—	LDO1 × 0.2	V	—
TEST1, TEST2, GPI1, GPI2, GPI3							
Pull-down resistance	RPD	$I_{TEST1, TEST2, GPI1, GPI2, GPI3}$ = 5 µA RPD = $V_{TEST1, TEST2, GPI1, GPI2, GPI3}$ / 5 µA	70k	100k	130k	Ω	—
GPIO1, GPIO2							
Pull-up resistance	RPU	$I_{GPIO1, GPIO2}$ = 0 µA RPU1 = $V_{GPIO1, GPIO2}$ $I_{GPIO1, GPIO2}$ = – 5 µA RPU = (RPU1 – $V_{GPIO1, GPIO2}$) / 5 µA	70k	100k	130k	Ω	—

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ELECTRICAL CHARACTERISTICS (continued)

VB = VBDCDC = VBLED = 3.6 V, VLED1 = VLED2 = 4.9 V

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

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
DC/DC converter automatic control part							
Detection voltage	VMON	Voltage which DC/DC converter turns on when the voltage of BL1, BL2, BL3, BL4, BLS1, and BLS2 terminal falls	0.36	0.40	0.44	V	—
Current consumption of DC/DC converter part							
DC/DC control current (1)	IDC1	Current when DC/DC converter is active.	—	1.2	3.0	mA	—
DC/DC control current (2)	IDC2	Current when DC/DC converter is inactive and the automatic control circuit is operating	—	0.7	1.4	mA	—

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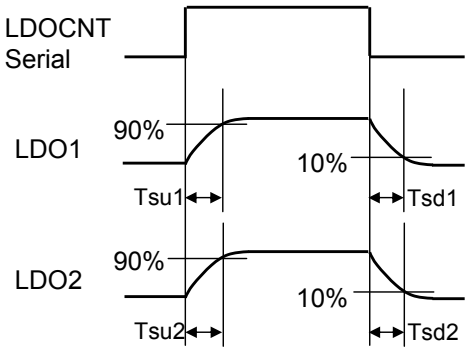
ELECTRICAL CHARACTERISTICS (continued)

VB = VBDCDC = VBLED = 3.6 V, VLED1 = VLED2 = 4.9 V

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

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
Voltage regulator (LDO1)							
Rise time	Tsu1	Time until output voltage reaches to 0 V to 90 %	—	250	—	µs	*3 *4
Fall time	Tsd1	Time until output voltage reaches to 10 %	—	5	—	ms	*3 *4
Load transient response (1)	Vtr11	I_{LDO1} = – 50 µA → – 15 mA (1 µs)	—	70	—	mV	*4
Load transient response (2)	Vtr12	I_{LDO1} = – 15 mA → – 50 µA (1 µs)	—	70	—	mV	*4
Output capacity range	Cldo1	—	—	1.0	—	µF	*4
Output capacity ESR tolerance level	Resr1	—	—	0.05	—	Ω	*4
Maximum output current	Imax1	—	—	15	—	mA	*5
Voltage regulator (LDO2)							
Rise time	Tsu2	Time until output voltage reaches to 0 V to 90 %	—	250	—	µs	*3 *4
Fall time	Tsd2	Time until output voltage reaches to 10 %	—	5	—	ms	*3 *4
Load transient response (1)	Vtr21	I_{LDO2} = – 50 µA → – 15 mA (1 µs)	—	70	—	mV	*4
Load transient response (2)	Vtr22	I_{LDO2} = – 15 mA → – 50 µA (1 µs)	—	70	—	mV	*4
Output capacity range	Cldo2	—	—	1.0	—	µF	*4
Output capacity ESR tolerance level	Resr2	—	—	0.05	—	Ω	*4
Maximum output current	Imax2	—	—	15	—	mA	*5

Note) *3 : Rise time and Fall time are defined as below.
*4 : Typical Design Value



*5 : This IC consumes each 5mA maximum from LDO1 and LDO2 for the internal circuit.
When it is used to supply external components, it must be used within 25mA load current.

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ELECTRICAL CHARACTERISTICS (continued)

VB = VBDCDC = VBLED = 3.6 V, VLED1 = VLED2 = 4.9 V

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

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
Step-up DC/DC converter							
Rise time	Tsu11	Time until output voltage reaches to 90 % from battery voltage	—	1	—	ms	*4 *6
Fall time	Tsd11	Time until output voltage reaches to 3.8 V from 4.9 V $I_{DCDCOUT}$ = 0 mA	—	1	—	s	*4 *6
Load transient response (1)	Vtrdc1	$I_{DCDCOUT}$ = – 50 μA → – 400 mA (1 μs)	—	1	—	V	*4
Load transient response (2)	Vtrdc2	$I_{DCDCOUT}$ = – 400 mA → – 50 μA (1 μs)	—	1	—	V	*4
Output capacity range	Cdc1	—	—	22	—	μF	*4
Output capacity ESR tolerance level	Resr1	—	—	0.30	—	Ω	*4
Excess voltage detection voltage	VOVP	VLED voltage which detects excess voltage	—	6.2	—	V	*4
Delay time of Excess voltage detection voltage	TOVP	Time after excess voltage is detected until INT is set to High from Low	—	12.75	—	ms	*4
Delay time of Constant voltage circuit monitor	TMON	Time after the voltage of BL1 to 4 / BLS1 to 2 goes under 0.4 V until it detects coincidence 3 times and DC/DC converter operates.	—	2.0	—	ms	*4
TSD (Thermal shutdown circuit)							
Detection temperature	Tdet	Temperature which LDO1, LDO2, DC/DC, Constant current circuit, Matrix SW and RGB turns off.	—	160	—	°C	*4 *7
Return temperature	Tsd11	Returning temperature	—	110	—	°C	*4 *8

Note) *4 : Typical Design Value
*6, *7, *8 : Refer to the next page

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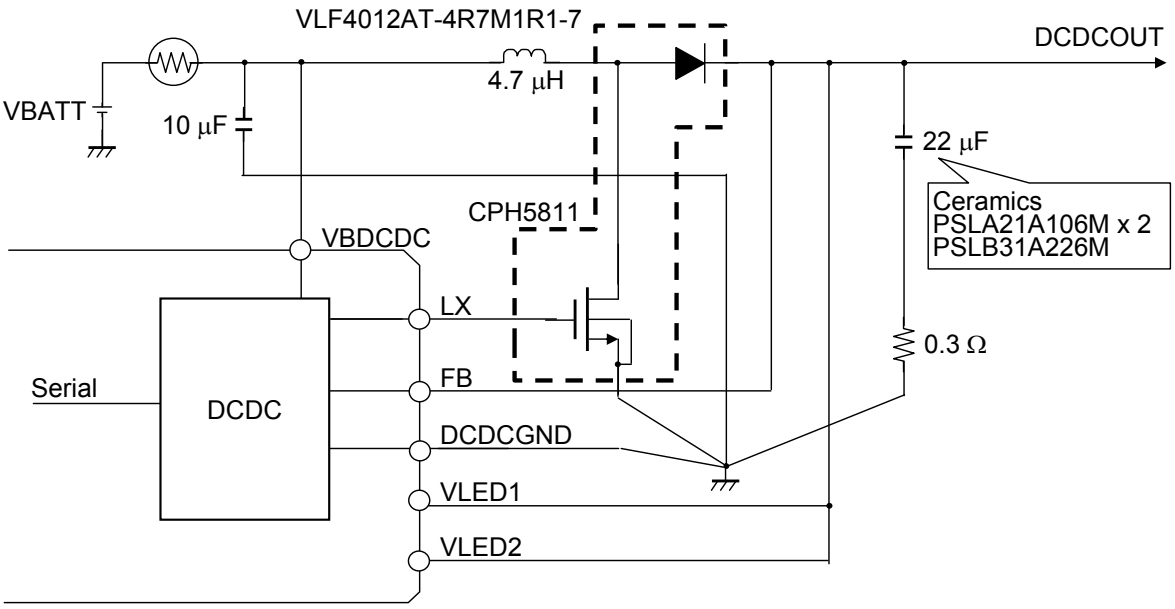
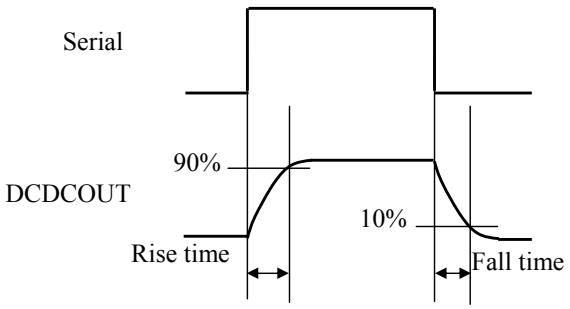
ELECTRICAL CHARACTERISTICS (continued)

VB = VBDCDC = VBLED = 3.6 V, VLED1 = VLED2 = 4.9 V

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

Note) *6 :





*7: LDO1, LDO2, DC/DC converter, Constant current circuit, and Matrix SW and RGB are turned off when TSD is High. When TSD is High, the register is set as 14hD 1 = 1. However, data can be read only when the register is read immediately after INT occurs since internal regulator is turned off.

*8: Only LDO1 and LDO2 return after ON state of TSD. A logic part will be in Reset state.

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ELECTRICAL CHARACTERISTICS (continued)

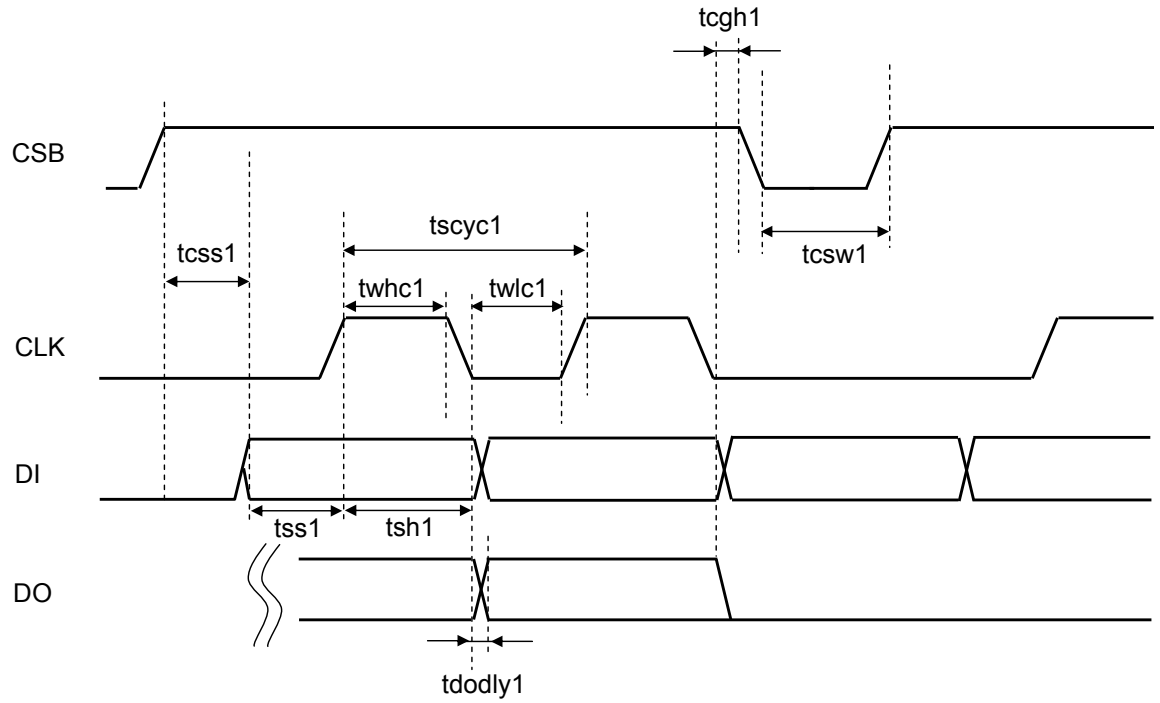
VB = VBDCDC = VBLED = 3.6 V, VLED1 = VLED2 = 4.9 V

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

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
Microcomputer interface characteristic (Vdd = 1.85 V ± 3%)							
CLK cycle time	tscyc1	—	—	125	—	ns	*4
CLK cycle time High period	twhc1	—	—	60	—	ns	*4
CLK cycle time Low period	twlc1	—	—	60	—	ns	*4
Serial-data setup time	tss1	—	—	62	—	ns	*4
Serial-data hold time	tsh1	—	—	62	—	ns	*4
Transceiver interval	tcsw1	—	—	62	—	ns	*4
Chip enable setup time	tcss1	—	—	5	—	ns	*4
Chip enable hold time	tcgh1	—	—	5	—	ns	*4
DC delay time	tdodly1	Only READ	—	25	—	ns	*4

Note) *4 : Typical Design Value

Microcomputer interface Timing chart



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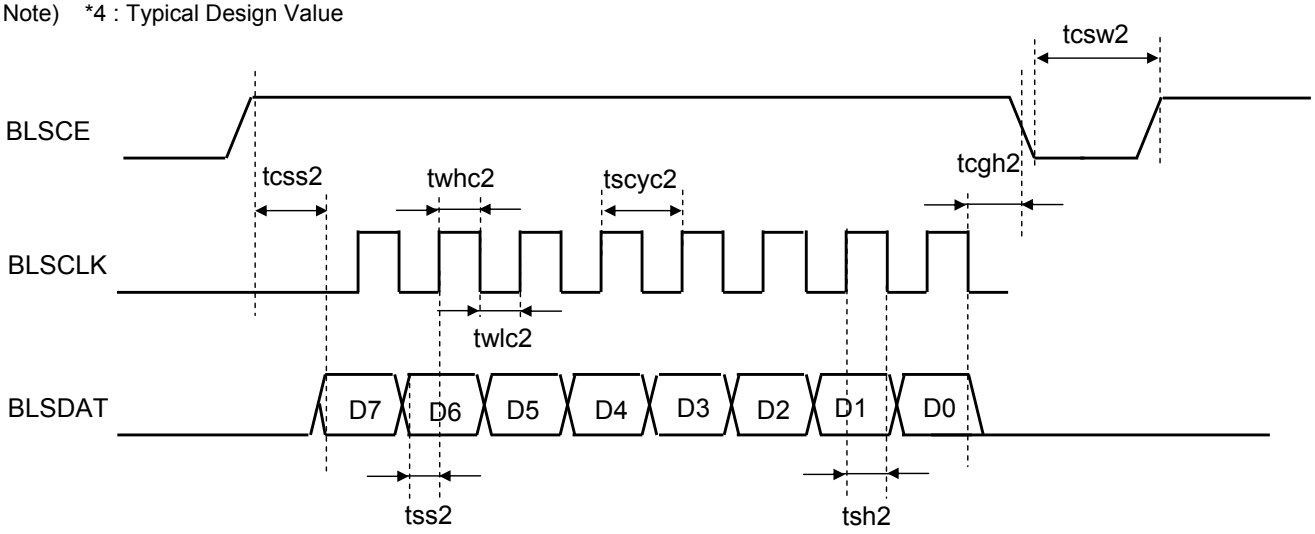
ELECTRICAL CHARACTERISTICS (continued)

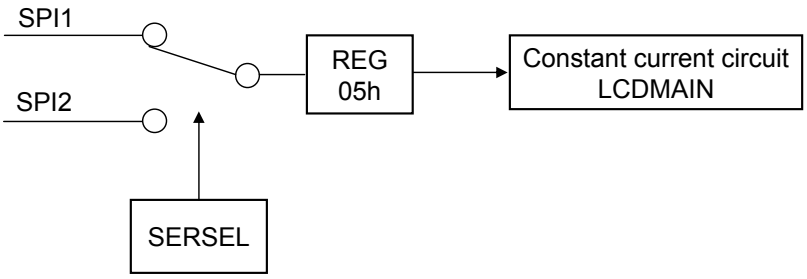
VB = VBDCDC = VBLED = 3.6 V, VLED1 = VLED2 = 4.9 V

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

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
SPI2 format Microcomputer interface characteristic (Vdd = 1.85 V ± 3%)							
BLSCLK cycle time	tscyc2	—	—	125	—	ns	*4
BLSCLK cycle time High period	twhc2	—	—	60	—	ns	*4
BLSCLK cycle time Low period	Twlc2	—	—	60	—	ns	*4
Serial-data setup time	tss2	—	—	62	—	ns	*4
Serial-data hold time	tsh2	—	—	62	—	ns	*4
Transceiver interval	tcsw2	—	—	62	—	ns	*4
BLSCE setup time	tcss2	—	—	5	—	ns	*4
BLSCE hold time	tcgh2	—	—	5	—	ns	*4

Note) *4 : Typical Design Value





SERSEL	GPI1 terminal	GPI2 terminal	GPI3 terminal	Operation
0	GPI1 operation	GPI2 operation	GPI3 operation	GPIO operation
1	BLSCE operation	BLSCLK operation	BLSDAT operation	SPI2 operation

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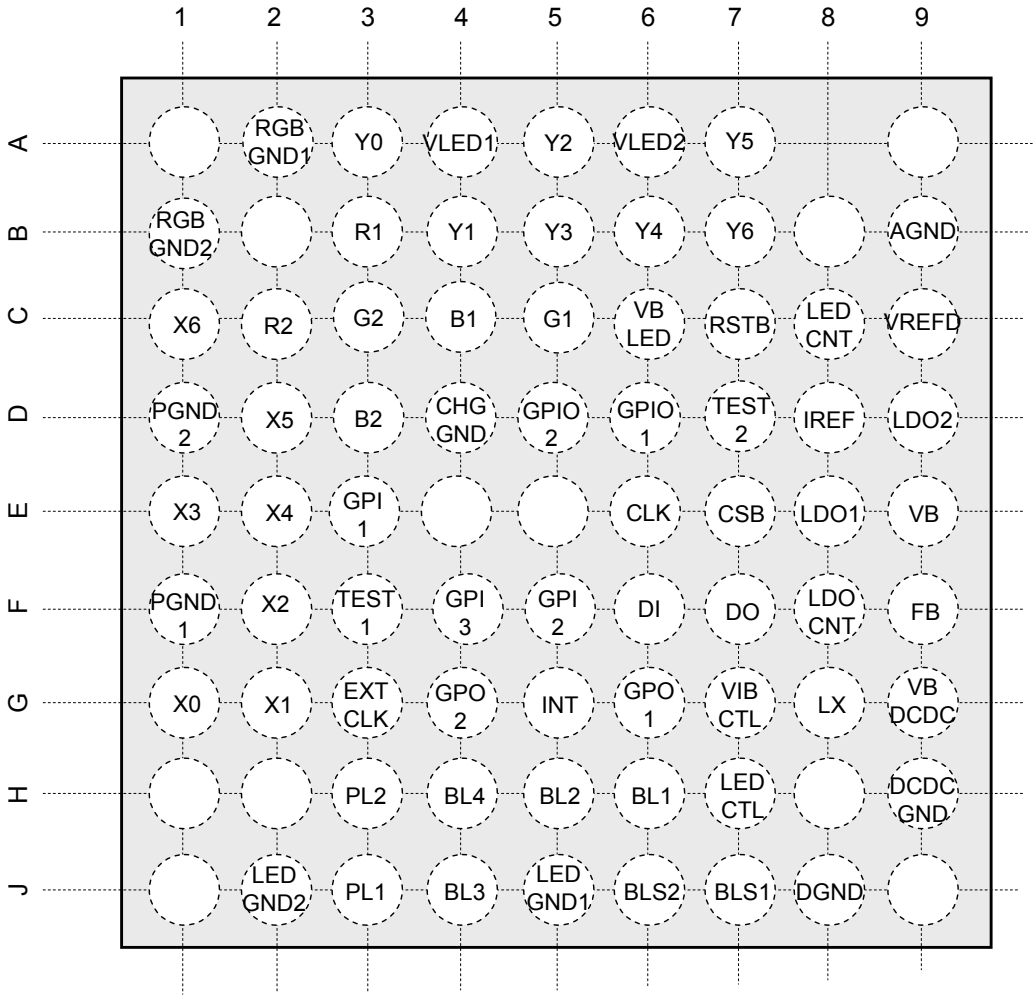
PIN CONFIGURATION

Top View



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PIN FUNCTIONS

Pin No.	Pin name	Type	Description
G1(1)	X0	Output	Constant current circuit. The output terminal of PWM control. It connects with the 1st Row of matrix LED.
G2(2)	X1	Output	Constant current circuit. The output terminal of PWM control. It connects with the 2nd Row of matrix LED.
F2(3)	X2	Output	Constant current circuit. The output terminal of PWM control. It connects with the 3rd Row of matrix LED.
E1(4)	X3	Output	Constant current circuit. The output terminal of PWM control. It connects with the 4th Row of matrix LED.
F1(5) D1(6)	PGND1 PGND2	Ground	The GND terminal for matrix LED
E2(7)	X4	Output	Constant current circuit. The output terminal of PWM control. It connects with the 5th Row of matrix LED.
D2(8)	X5	Output	Constant current circuit. The output terminal of PWM control. It connects with the 6th Row of matrix LED.
C1(9)	X6	Output	Constant current circuit. The output terminal of PWM control. It connects with the 7th Row of matrix LED.
A3(10)	Y0	Output	Constant current circuit. The output terminal of PWM control. It connects with the A Column of matrix LED.
B4(11)	Y1	Output	Constant current circuit. The output terminal of PWM control. It connects with the B Column of matrix LED.
A5(12)	Y2	Output	Constant current circuit. The output terminal of PWM control. It connects with the C Column of matrix LED.
B5(13)	Y3	Output	Constant current circuit. The output terminal of PWM control. It connects with the D Column of matrix LED.
A4(14) A6(15)	VLED1 VLED2	Power supply	The power supply's connect terminal for matrix LED. Connect with the output of battery or step-up DC/DC converter.
B6(16)	Y4	Output	Constant current circuit. The output terminal of PWM control. It connects with the E Column of matrix LED.
A7(17)	Y5	Output	Constant current circuit. The output terminal of PWM control. It connects with the F Column of matrix LED.
B7(18)	Y6	Output	Constant current circuit. The output terminal of PWM control. It connects with the G Column of matrix LED.

PIN FUNCTIONS (Continued)

Pin No.	Pin name	Type	Description
F9(19)	FB	Input	The feedback terminal for step-up DC/DC converter.
H9(20)	DCDCGND	Ground	The GND terminal for step-up DC/DC converter.
G8(21)	LX	Output	The terminal for External Nch-type MOS-Tr Gate driver.
G9(22)	VBDCDC	Power supply	The power supply's connect terminal for step-up DC/DC converter.
B3(23)	R1	Output	LED contact terminal. Control by LEDCNT terminal is also possible.
C5(24)	G1	Output	LED contact terminal.
C4(25)	B1	Output	LED contact terminal.
A2(26) B1(27)	RGBGND1 RGBGND2	Ground	The GND terminal for RGB terminal.
C2(28)	R2	Output	General-purpose output terminal.(Nch-MOS Open Drain)
C3(29)	G2	Output	General-purpose output terminal.(Nch-MOS Open Drain)
D3(30)	B2	Output	General-purpose output terminal.(Nch-MOS Open Drain)
D4(31)	CHGGND	Output	The resistance contact terminal for charge LED.(Connect current restriction resistance between this terminal and GND terminal.)
C6(32)	VBLED	Power supply	Battery voltage's connect terminal. This terminal supplies Power supply to R1 terminal and R2 terminal.
C8(33)	LEDCNT	Input	ON/OFF control terminal of LED connected to R1 terminal and R2 terminal.
D9(34)	LDO2	Output	LDO2 (2.85 V) output terminal.
E9(35)	VB	Power supply	The power supply's connect terminal for BGR circuit and LDO circuit.
E8(36)	LDO1	Output	LDO1 (1.85 V) output terminal.
F8(37)	LDOCNT	Input	ON/OFF control terminal of LDO1 and LDO2.
C9(38)	VREFD	Output	BGR circuit output terminal.
D8(39)	IREF	Output	The resistance connect terminal for constant current value setup.

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PIN FUNCTIONS (Continued)

Pin No.	Pin name	Type	Description
J3(40)	PL1	Output	The constant current output terminal for LED driver. (0 to 61 mA) This terminal is driven with the same current value as PL2 terminal.
H3(41)	PL2	Output	The constant current output terminal for LED driver. (0 to 61 mA) This terminal is driven with the same current value as PL1 terminal.
J5(42) J2(43)	LEDGND1 LEDGND2	Ground	The GND terminal for constant current circuits for LED driver.
H6(44)	BL1	Output	The constant current output terminal for LED driver. (0 to 31 mA) This terminal is driven with the same current value as BL2, BL3 and BL4 terminal.
H5(45)	BL2	Output	The constant current output terminal for LED driver. (0 to 31 mA) This terminal is driven with the same current value as BL1, BL3 and BL4 terminal.
J4(46)	BL3	Output	The constant current output terminal for LED driver. (0 to 31 mA) This terminal is driven with the same current value as BL1, BL2 and BL4 terminal.
H4(47)	BL4	Output	The constant current output terminal for LED driver. (0 to 31 mA) This terminal is driven with the same current value as BL1, BL2 and BL3 terminal.
J7(48)	BLS1	Output	The constant current output terminal for LED driver. (0 to 31 mA) This terminal is driven with the same current value as BLS2 terminal.
J6(49)	BLS2	Output	The constant current output terminal for LED driver. (0 to 31 mA) This terminal is driven with the same current value as BLS1 terminal.
B9(50)	AGND	Ground	The GND terminal for Analog circuitry.
G5(51)	INT	Output	Interrupt output terminal.
F3(52)	TEST1	Input	Test terminal.
D7(53)	TEST2	Input	Test terminal.
E7(54)	CSB	Input	Chip-enable terminal for SPI1 interface.
E6(55)	CLK	Input	Clock input terminal for SPI1 interface.
F6(56)	DI	Input	Data input terminal for SPI1 interface.
F7(57)	DO	Output	Data output terminal for SPI1 interface.
C7(58)	RSTB	Input	Reset input terminal

PIN FUNCTIONS (Continued)

Pin No.	Pin name	Type	Description
G3(59)	EXTCLK	Input	External clock input terminal. (It can operate by the clock frequency of a maximum of 1.44 MHz.)
J8(60)	DGND	Ground	The GND terminal for Logic circuitry.
E3(61)	GPI1	Input	GPI input port terminal. (Chip-enable terminal for SPI2 interface.)
F5(62)	GPI2	Input	GPI input port terminal. (Clock input terminal for SPI2 interface.)
F4(63)	GPI3	Input	GPI input port terminal. (Data input terminal for SPI2 interface.)
G6(64)	GPO1	Output	GPO output port terminal.
G4(65)	GPO2	Output	GPO output port terminal.
D6(66)	GPIO1	Input / Output	GPIO input/output port terminal.
D5(67)	GPIO2	Input / Output	GPIO input/output port terminal.
H7(68)	LEDCTL	Input	LED's lighting ON/OFF control terminal. (It is based on register 0Ah.)
G7(69)	VIBCTL	Input	LED's lighting ON/OFF control terminal. (It is based on register 09h.)

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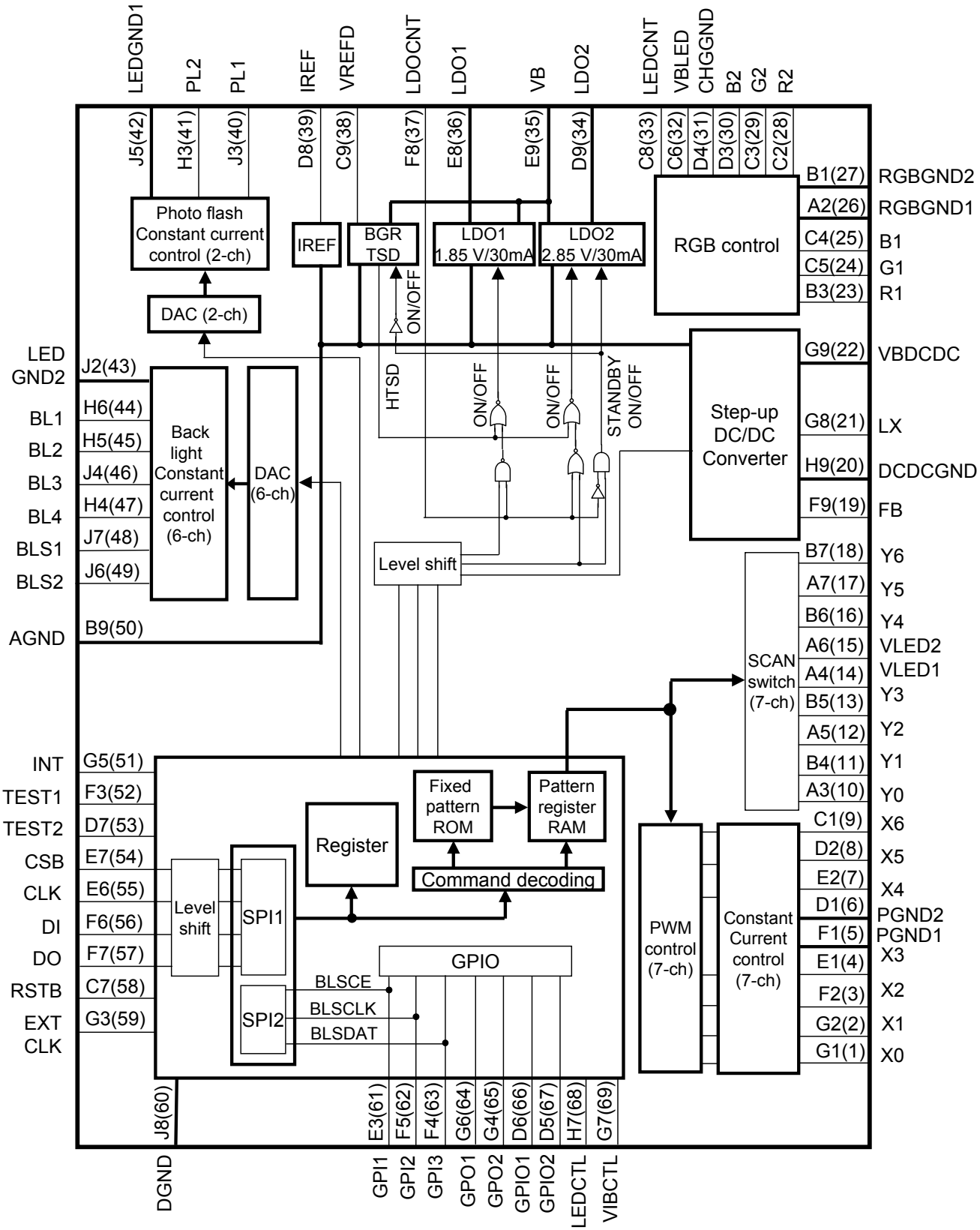
FUNCTIONAL BLOCK DIAGRAM



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

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