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LV5223GR

Bi-CMOS IC

LED Driver

Overview

The LV5223GR is 9ch LED driver IC for the cell phones with built-in charge pump circuit.

Features

- LED driver ×9 channels (3-color 1, 3-color 2, GPO (LED) ×3, 9 channels in total) and on-chip charge pump circuit.
- Each LED driver current level can be adjusted independently over the serial bus.
- Ring tone and 3-color LEDs (3-color 1, 3-color 2) synchronization function.
- Gradation function (3-color 1, 3-color 2, in total 6 channels only)
- RLED2 and GLED2 support strobe mode.
- Miniature package

Function

- Charge pump circuit ((2 times step up) Output voltage: 5V)
- LED driver 3-color LED ×2 + GPO (LED) LED driver ×3
 - Channel 1 LED current can be switched indecently in 5-bit units (0.5 to 16mA)
 - Ring tone synchronization function (forced activation with SCTL: H)
 - Gradation function
 - Channel 1 LED current can be switched indecently in 5-bit units (0.5 to 16mA)
 - Ring tone synchronization function (forced activation with SCTL: H)
 - Gradation function
 - Only RLED2 and GLED2 support strobe mode; LED current output (2.8mA to 44.8mA) (FCTL=high)
- GPO1 (LED3), GPO2 (LED4), GPO3 (LED5) when GPO1 to GPO3 are used as the LED driver
- GPO output ×3

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Specifications

Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	V _{CC} max		5	V
Maximum voltage	V _I max	LED pins, charge pump pin	6	V
Maximum output current	I _O max 1	RLED1, GLED1, BLED1 and BLED2 pins	40	mA
	I _O max 2	RLED2 and GLED2 pins	50	mA
Allowable power dissipation	P _d max	* Mounted on a circuit board	800	mW
Operating temperature	T _{opr}		-30 to +80	°C
Storage temperature	T _{stg}		-40 to +125	°C

* Specified board: 40mm × 50mm × 0.8mm, glass epoxy board. (2S2P (4-layer board))

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

Operating Conditions at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage 1	V _{BAT}		3.0 to 5.0	V
Supply voltage 2	V _{DD}		1.65 to V _{BAT}	V

Electrical Characteristics at Ta = 25°C, V_{CC} = 5.0V

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Consumption current						
Consumption current	I _{CC1}	V _{BAT} +V _{DD} consumption current RESET:L (when reset)		0	5	μA
	I _{CC2}	V _{BAT} +V _{DD} consumption current RESET:H in serial default		0.5	5.0	μA
	I _{CC3}	V _{BAT} +V _{DD} consumption current charge pump: ON		4		mA
Oscillator block						
Oscillator frequency	Fosc			500		kHz
Charge pump block						
Output voltage	V _{O1}	I _O =30mA	4.8	5.0	5.2	V
Maximum current	I _{O1}	V _{BAT} =3.3V, V _{O1} >4.3V	200			mA
Soft start time	TSS	TSS=1/Fosc × 400 *1		800		μs
LED driver block						
Minimum output current value 1	I _{MIN1}	3-color 1, 2 LED driver FCTL=L Serial data=#00 V _O =0.5V	0.2	0.5	1.0	mA
Maximum output current value 1	I _{MAX1}	3-color 1, 2 LED driver FCTL=L Serial data=#FF V _O =0.5V	15	16	17	mA
Minimum output current value 2	I _{MIN2}	RLED2, GLED2 pin LED driver FCTL=H Serial data=#00 V _O =0.5V	1.8	2.8	3.8	mA
Maximum output current value 2	I _{MAX2}	RLED2, GLED2 pin LED driver FCTL=H Serial data=#FF V _O =0.5V	42.0	44.8	47.6	mA
ON resistance	RON1	GPO1(LED3), GPO2(LED4), GPO3(LED5) pins When LED driver ON I _L =-40mA		5		Ω
Non-linearity error	LE1	3-color 1, 2 LED driver V _O =0.5V *2	-2		2	LSB
Differential linearity error	DLE1	3-color 1, 2 LED driver V _O =0.5V *3	-2		2	LSB
Maximum output current	ΔIL1	3-color LED driver 1, 2 FCTL=L Maximum current setting V _O =0.35V	-10			%
	ΔIL2	RLED2, GLED2 pin LED driver FCTL=H Maximum current setting V _O =0.45V	-10			%
Leakage current	IL1	3-color LED driver 1, 2 & GPO(LED) × 3 LED driver: OFF V _O =5V			1	μA
Control circuit block						
H level 1	V _{INH1}	Input H level SCTL	1.3			V
L level 1	V _{INL1}	Input L level SCTL	0		0.45	V
H level 2	V _{INH2}	Input H level FCTL	1.3			V
L level 2	V _{INL2}	Input L level FCTL	0		0.45	V
H level 3	V _{INH3}	Input H level serial signal input pin	V _{DD} × 0.8			V

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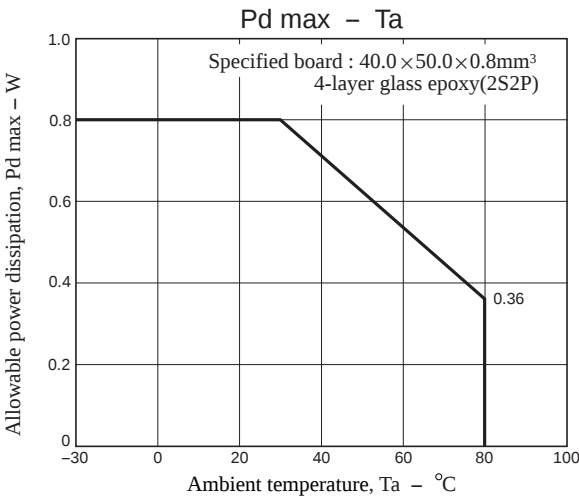
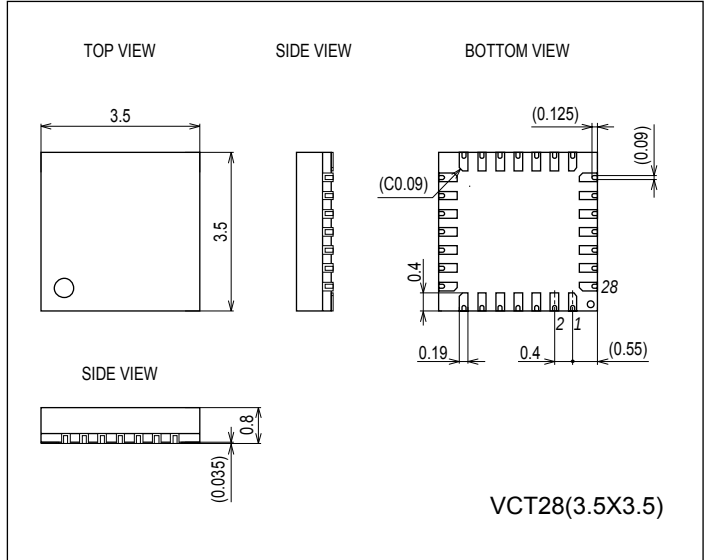
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
L level 3	V _{INL3}	Input L level serial signal input pin	0		V _{DD} × 0.2	V
H level 4	V _{INH4}	Input H level RESET	1.5			V
L level 4	V _{INL4}	Input L level RESET	0		0.3	V
H level 5	V _{HO5}	Output H level GPO1 GPO2 GPO3 I _L =1mA When output mode is set to buffer	V _{DD} − 0.3			V
L level 5	V _{LO5}	Output L level GPO1 GPO2 GPO3 I _L =−1mA When output mode is set to buffer	0		0.3	V

- *1. Soft start time: Interval from the time the charge pump is started until the time the charge pump output voltage reaches 5V.
- *2. Non-linearity error: The difference between the actual and ideal current values.
- *3. Differential linearity error: The difference between the actual and ideal increment when one low-order bi value is added.
- Note) The LED current can be charged by changing the value of RT.
- (Example: When RT = 10kΩ, V_O>0.945V and RGB1&2 LED current is set to 14.5mA, the RGB1&2 current can be set to flow at 14.5mA × 27kΩ / 10 kΩ = 39.15mA)
- (When the value of RT has been reduced, adjust the oscillation frequency by increasing the value of CT.)

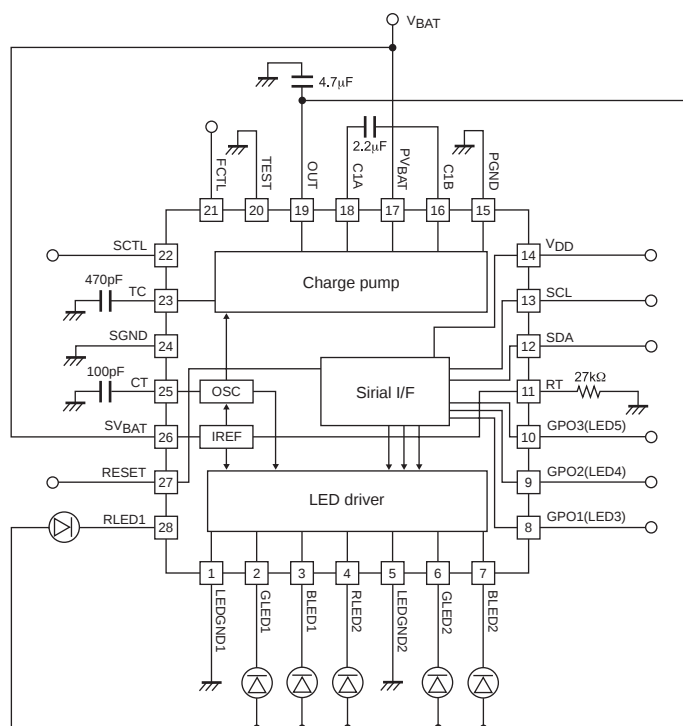
Package Dimensions

unit : mm (typ)

3357



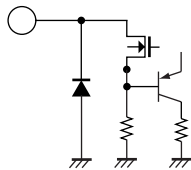
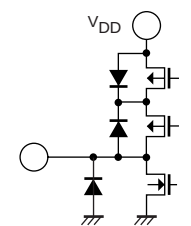
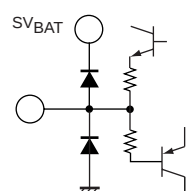
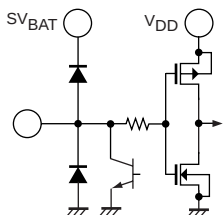
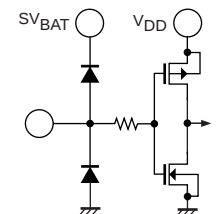
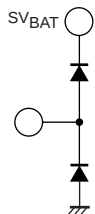
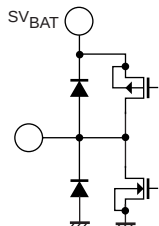
Block Diagram & Pin arrangement drawing



Pin Descriptions

Pin No.	Pin name	Description	Protection diode vs. V _{BAT}	Protection diode vs. GND
1	LEDGND1	GND pin1 for LED driver		
2	GLED1	GLED1 driver output pin		○
3	BLED1	BLED1 driver output pin		○
4	RLED2	RLED2 driver output pin		○
5	LEDGND2	GND pin2 for LED driver		
6	GLED2	GLED2 driver output pin		○
7	BLED2	BLED2 driver output pin		○
8	GPO1(LED3)	GPO1 output & LED3 driver output pin		○
9	GPO2(LED4)	GPO2 output & LED4 driver output pin		○
10	GPO3(LED5)	GPO3 output & LED5 driver output pin		○
11	RT	Standard current setting resistance connection pin	○	○
12	SDA	Serial data signal input pin	○	○
13	SCL	Serial clock signal input pin	○	○
14	V _{DD}	Power supply pin	○	○
15	PGND	GND pin for Charge pump		
16	C1B	Flying capacitor connection pin B for charge pump	○	○
17	PV _{BAT}	Power supply for charge pump		
18	C1A	Flying capacitor connection pin A for charge pump		○
19	OUT	Output pin for charge pump		○
20	TEST	TEST pin	○	○
21	FCTL	Strobe mode pin	○	○
22	SCTL	3-color1 & 3-color2 LED driver external synchronous signal input pin	○	○
23	TC	Charge pump phase amends pin	○	○
24	SGND	GND pin for analog circuit		
25	CT	Setting of frequency of oscillator capacity connection pin	○	○
26	SV _{BAT}	Supply voltage for analog circuit		
27	RESET	RESET signal input pin	○	○
28	RLED1	RLED1 driver output pin		○

Pin Functions

Pin No.	Pin Name	Pin function	Equivalent Circuit
1	LEDGND1	GND pin1 for LED driver	
2	GLED1	LED driver pin for RGB1 and RGB2. Feedback is applied so that the current flowing to the output transistor becomes the set current level. When $R_T=27k\Omega$, the driver output current levels can be independently adjusted from approx. 0.5mA to 16mA in 0.5mA steps by serial setting. In the strobe mode, the current levels can be independently adjusted from 2.8mA to 44.8mA in 2.8mA steps for the RLED2 and GLED2 pins only.	
3	BLED1		
4	RLED2		
6	GLED2		
7	BLED2		
28	RLED1		
5	LEDGND2	GND pin2 for LED driver	
8	GPO1(LED3)	GPO output/LED driver shared pin. Output can be set to current sink by serial setting or VDD or GND voltage can be output.	
9	GPO2(LED4)		
10	GPO3(LED5)		
11	RT	Reference current setting resistor connection pin. The reference current is generated by connecting an external resistor to GND. The pin voltage is approximately 0.65V. By changing this current level, the oscillation frequency and LED driver current (3-color 1 and 3-color 2 only) can be changed.	
12	SDA	Serial data signal input pin	
13	SCL	Serial clock signal input pin	
14	VDD	Power supply pin	
15	PGND	GND pin for Charge pump	
16	C1B	Charge pump flying capacitor connection pin B This pin is connected to the clock driver side of the charge pump.	

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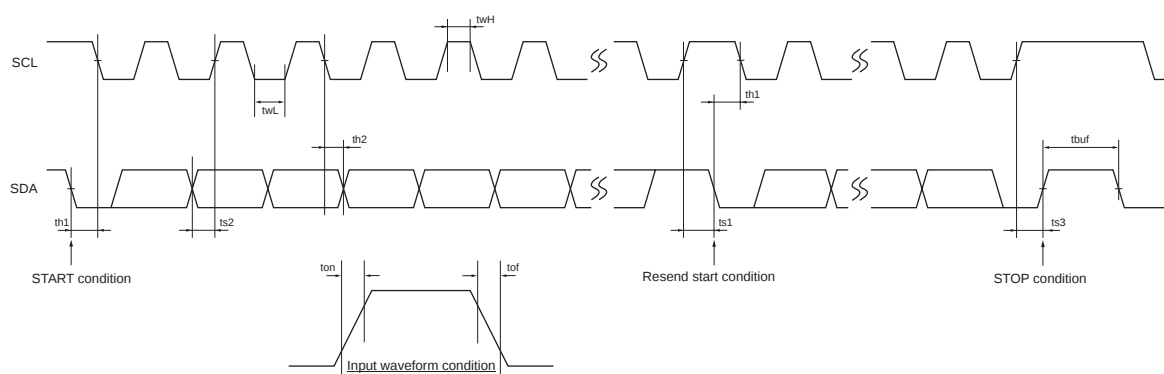
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Pin No.	Pin Name	Pin function	Equivalent Circuit
17	PV _{BAT}	Power supply for charge pump	
18	C1A	Charge pump flying capacitor connection pin A This pin is connected to the charge transfer driver side of the charge pump.	
19	OUT	Output pin for charge pump	
20	TEST	Test pin. This must always be connected to GND.	
21 22	FCTL SCTL	FCTL: Strobe mode pin. SCTL: 3-color 1 and 3-color 2 LED driver external sync signal input pin. When this pin is not going to be used, it must be connected to GND without fail.	
23	TC	Charge pump phase compensation pin. Stable operation of the charge pump is provided by connecting a capacitor to this pin.	
24	SGND	GND pin for analog circuit	
25	CT	Oscillator frequency setting capacitor connection pin. The oscillation frequency can be changed by changing the capacitance of the capacitor.	
26	SV _{BAT}	Supply voltage for analog circuit	
27	RESET	RESET signal input pin. Reset state at L.	

Serial Bus Communication Specifications

1) I²C serial transfer timing conditions



Standard mode

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
SCL clock frequency	fsc1	SCL clock frequency	0	-	100	kHz
Data setup time	ts1	SCL setup time relative to the fall of SDA	4.7	-	-	μs
	ts2	SDA setup time relative to the rise of SCL	250	-	-	ns
	ts3	SCL setup time relative to the rise of SDA	4.0	-	-	μs
Data hold time	th1	SCL hold time relative to the fall of SDA	4.0	-	-	μs
	th2	SDA hold time relative to the fall of SCL	0	-	3.45	μs
Pulse width	twL	SCL pulse width for the L period	4.7	-	-	μs
	twH	SCL pulse width for the H period	4.0	-	-	μs
Input waveform conditions	ton	SCL and SDA (input) rise time	-	-	1000	ns
	tof	SCL and SDA (input) fall time	-	-	300	ns
Bus free time	tbuf	Time between STOP condition and START condition	4.7	-	-	μs

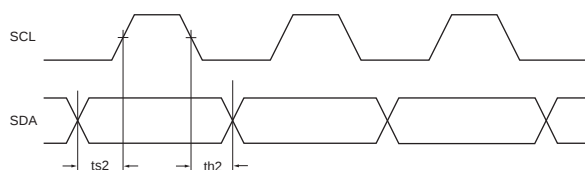
High-speed mode

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
SCL clock frequency	fsc1	SCL clock frequency	0	-	400	kHz
Data setup time	ts1	SCL setup time relative to the fall of SDA	0.6	-	-	μs
	ts2	SDA setup time relative to the rise of SCL	100	-	-	ns
	ts3	SCL setup time relative to the rise of SDA	0.6	-	-	μs
Data hold time	th1	SCL hold time relative to the fall of SDA	0.6	-	-	μs
	th2	SDA hold time relative to the fall of SCL	0	-	0.9	μs
Pulse width	twL	SCL pulse width for the L period	1.3	-	-	μs
	twH	SCL pulse width for the H period	0.6	-	-	μs
Input waveform conditions	ton	SCL and SDA (input) rise time	-	-	300	ns
	tof	SCL and SDA (input) fall time	-	-	300	ns
Bus free time	tbuf	Time between STOP and START conditions	1.3	-	-	μs

2) I²C bus transfer method

Start and stop conditions

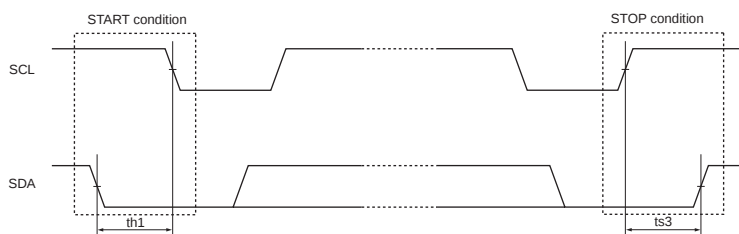
During data transfer operation using the I²C bus, SDA must basically be kept in constant state while SCL is "H" as shown below.



When data is not being transferred, both SCL and SDA are set in the "H" state.

When SCL=SDA is "H," the start condition is established when SDA is changed from "H" to "L," and access is started.

When SCL is "H," the stop condition is established when SDA is changed from "L" to "H," and access is ended.



Data transfer and acknowledgement response

After the start condition has been established, the data is transferred one byte (8 bits) at a time.

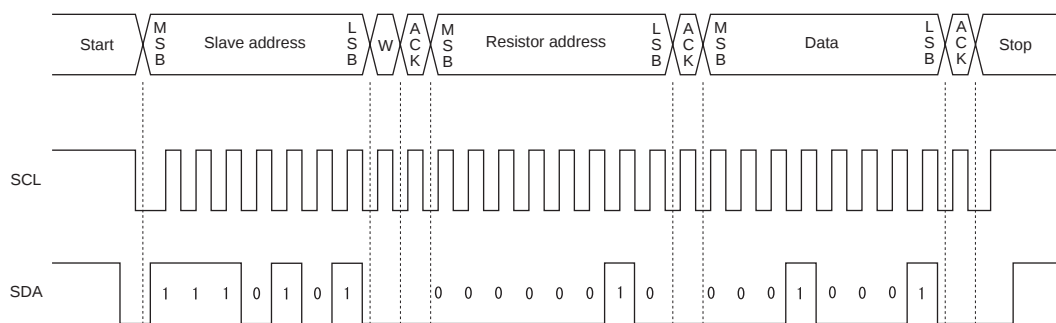
Any number of bytes of data can be transferred continuously.

Each time the 8-bit data is transferred, the ACK signal is sent from the receive side to the send side. The ACK signal is issued when SDA on the send side is released and SDA on the receive side is set to "L" immediately after fall of the clock pulse at the SCL eighth bit of data transfer to "L."

When the next 1-byte transfer is left in the receive state after sending the ACK signal from the receive side, the receive side releases SDA at the fall of the SCL ninth clock.

In the I²C bus, there is no CE signal. In its place, a 7-bit slave address is assigned to each device, and the first byte of transfer is assigned to the command (R/W) representing the 7-bit address and subsequent transfer direction. Note that only write is valid in this IC. The 7-bit address is transferred sequentially starting with MSB, and the eighth bit is set to "L" which indicates a write.

In the LV5223GP the slave address is specified as "1110101"



Serial mode setting

	ADDRESS : 00h							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	B2SW	G2SW	R2SW	B1SW	G1SW	R1SW	CPSW	STBY
default	0	0	0	0	0	0	0	0

D0	STBY
0	Standby
1	Active

STBY setting

*Default

LED operation enabled by releasing STBY (LED can be operated by another power supply)

D1	CPSW
0	OFF
1	ON

Charge pump ON/OFF setting

*Default

D2	R1SW
0	OFF
1	ON

RLED1 output setting

*Default

D3	G1SW
0	OFF
1	ON

GLED1 output setting

*Default

D4	B1SW
0	OFF
1	ON

BLED1 output setting

*Default

D5	R2SW
0	OFF
1	ON

RLED2 output setting

*Default

D6	G2SW
0	OFF
1	ON

GLED2 output setting

*Default

D7	B2SW
0	OFF
1	ON

BLED2 output setting

*Default

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	ADDRESS : 01h							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	SCTEN1	-	-	R1[4]	R1[3]	R1[2]	R1[1]	R1[0]
default	0	0	0	0	0	0	0	0

D4	D3	D2	D1	D0	current value (mA)
0	0	0	0	0	0.5
0	0	0	0	1	1.0
0	0	0	1	0	1.5
0	0	0	1	1	2.0
0	0	1	0	0	2.5
0	0	1	0	1	3.0
0	0	1	1	0	3.5
0	0	1	1	1	4.0
0	1	0	0	0	4.5
0	1	0	0	1	5.0
0	1	0	1	0	5.5
0	1	0	1	1	6.0
0	1	1	0	0	6.5
0	1	1	0	1	7.0
0	1	1	1	0	7.5
0	1	1	1	1	8.0
1	0	0	0	0	8.5
1	0	0	0	1	9.0
1	0	0	1	0	9.5
1	0	0	1	1	10.0
1	0	1	0	0	10.5
1	0	1	0	1	11.0
1	0	1	1	0	11.5
1	0	1	1	1	12.0
1	1	0	0	0	12.5
1	1	0	0	1	13.0
1	1	0	1	0	13.5
1	1	0	1	1	14.0
1	1	1	0	0	14.5
1	1	1	0	1	15.0
1	1	1	1	0	15.5
1	1	1	1	1	16.0

RLED1 current value setting

*Default

D7	SCTEN1
0	RGB1 SCTL valid
1	RGB1 SCTL non valid

RGB1 SCTL signal enable

*Default

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	ADDRESS : 02h							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	-	-	-	G1[4]	G1[3]	G1[2]	G1[1]	G1[0]
default	0	0	0	0	0	0	0	0

D4	D3	D2	D1	D0	current value (mA)
0	0	0	0	0	0.5
0	0	0	0	1	1.0
0	0	0	1	0	1.5
0	0	0	1	1	2.0
0	0	1	0	0	2.5
0	0	1	0	1	3.0
0	0	1	1	0	3.5
0	0	1	1	1	4.0
0	1	0	0	0	4.5
0	1	0	0	1	5.0
0	1	0	1	0	5.5
0	1	0	1	1	6.0
0	1	1	0	0	6.5
0	1	1	0	1	7.0
0	1	1	1	0	7.5
0	1	1	1	1	8.0
1	0	0	0	0	8.5
1	0	0	0	1	9.0
1	0	0	1	0	9.5
1	0	0	1	1	10.0
1	0	1	0	0	10.5
1	0	1	0	1	11.0
1	0	1	1	0	11.5
1	0	1	1	1	12.0
1	1	0	0	0	12.5
1	1	0	0	1	13.0
1	1	0	1	0	13.5
1	1	0	1	1	14.0
1	1	1	0	0	14.5
1	1	1	0	1	15.0
1	1	1	1	0	15.5
1	1	1	1	1	16.0

GLED1 current value setting

*Default

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	ADDRESS : 03h							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	-	-	-	B1[4]	B1[3]	B1[2]	B1[1]	B1[0]
default	0	0	0	0	0	0	0	0

D4	D3	D2	D1	D0	current value (mA)
0	0	0	0	0	0.5
0	0	0	0	1	1.0
0	0	0	1	0	1.5
0	0	0	1	1	2.0
0	0	1	0	0	2.5
0	0	1	0	1	3.0
0	0	1	1	0	3.5
0	0	1	1	1	4.0
0	1	0	0	0	4.5
0	1	0	0	1	5.0
0	1	0	1	0	5.5
0	1	0	1	1	6.0
0	1	1	0	0	6.5
0	1	1	0	1	7.0
0	1	1	1	0	7.5
0	1	1	1	1	8.0
1	0	0	0	0	8.5
1	0	0	0	1	9.0
1	0	0	1	0	9.5
1	0	0	1	1	10.0
1	0	1	0	0	10.5
1	0	1	0	1	11.0
1	0	1	1	0	11.5
1	0	1	1	1	12.0
1	1	0	0	0	12.5
1	1	0	0	1	13.0
1	1	0	1	0	13.5
1	1	0	1	1	14.0
1	1	1	0	0	14.5
1	1	1	0	1	15.0
1	1	1	1	0	15.5
1	1	1	1	1	16.0

BLED1 current value setting

*Default

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	ADDRESS : 04h							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	SCTEN2	-	-	R2[4]	R2[3]	R2[2]	R2[1]	R2[0]
default	0	0	0	0	0	0	0	0

D4	D3	D2	D1	D0	current value (mA)
0	0	0	0	0	0.5
0	0	0	0	1	1.0
0	0	0	1	0	1.5
0	0	0	1	1	2.0
0	0	1	0	0	2.5
0	0	1	0	1	3.0
0	0	1	1	0	3.5
0	0	1	1	1	4.0
0	1	0	0	0	4.5
0	1	0	0	1	5.0
0	1	0	1	0	5.5
0	1	0	1	1	6.0
0	1	1	0	0	6.5
0	1	1	0	1	7.0
0	1	1	1	0	7.5
0	1	1	1	1	8.0
1	0	0	0	0	8.5
1	0	0	0	1	9.0
1	0	0	1	0	9.5
1	0	0	1	1	10.0
1	0	1	0	0	10.5
1	0	1	0	1	11.0
1	0	1	1	0	11.5
1	0	1	1	1	12.0
1	1	0	0	0	12.5
1	1	0	0	1	13.0
1	1	0	1	0	13.5
1	1	0	1	1	14.0
1	1	1	0	0	14.5
1	1	1	0	1	15.0
1	1	1	1	0	15.5
1	1	1	1	1	16.0

RLED2 current value setting

*Default

D7	SCTEN2
0	RGB2 SCTL valid
1	RGB2 SCTL non valid

RGB2 SCTL signal enable

*Default

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	ADDRESS : 05h							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	-	-	-	G2[4]	G2[3]	G2[2]	G2[1]	G2[0]
default	0	0	0	0	0	0	0	0

D4	D3	D2	D1	D0	current value (mA)
0	0	0	0	0	0.5
0	0	0	0	1	1.0
0	0	0	1	0	1.5
0	0	0	1	1	2.0
0	0	1	0	0	2.5
0	0	1	0	1	3.0
0	0	1	1	0	3.5
0	0	1	1	1	4.0
0	1	0	0	0	4.5
0	1	0	0	1	5.0
0	1	0	1	0	5.5
0	1	0	1	1	6.0
0	1	1	0	0	6.5
0	1	1	0	1	7.0
0	1	1	1	0	7.5
0	1	1	1	1	8.0
1	0	0	0	0	8.5
1	0	0	0	1	9.0
1	0	0	1	0	9.5
1	0	0	1	1	10.0
1	0	1	0	0	10.5
1	0	1	0	1	11.0
1	0	1	1	0	11.5
1	0	1	1	1	12.0
1	1	0	0	0	12.5
1	1	0	0	1	13.0
1	1	0	1	0	13.5
1	1	0	1	1	14.0
1	1	1	0	0	14.5
1	1	1	0	1	15.0
1	1	1	1	0	15.5
1	1	1	1	1	16.0

GLED2 current value setting

*Default

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	ADDRESS : 06h							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	-	-	-	B2[4]	B2[3]	B2[2]	B2[1]	B2[0]
default	0	0	0	0	0	0	0	0

D4	D3	D2	D1	D0	current value (mA)
0	0	0	0	0	0.5
0	0	0	0	1	1.0
0	0	0	1	0	1.5
0	0	0	1	1	2.0
0	0	1	0	0	2.5
0	0	1	0	1	3.0
0	0	1	1	0	3.5
0	0	1	1	1	4.0
0	1	0	0	0	4.5
0	1	0	0	1	5.0
0	1	0	1	0	5.5
0	1	0	1	1	6.0
0	1	1	0	0	6.5
0	1	1	0	1	7.0
0	1	1	1	0	7.5
0	1	1	1	1	8.0
1	0	0	0	0	8.5
1	0	0	0	1	9.0
1	0	0	1	0	9.5
1	0	0	1	1	10.0
1	0	1	0	0	10.5
1	0	1	0	1	11.0
1	0	1	1	0	11.5
1	0	1	1	1	12.0
1	1	0	0	0	12.5
1	1	0	0	1	13.0
1	1	0	1	0	13.5
1	1	0	1	1	14.0
1	1	1	0	0	14.5
1	1	1	0	1	15.0
1	1	1	1	0	15.5
1	1	1	1	1	16.0

BLED2 current value setting

*Default

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	ADDRESS : 07h							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	-	-	FOUT1[2]	FOUT1[1]	FOUT1[0]	FIN1[2]	FIN1[1]	FIN1[0]
default	0	0	0	0	0	0	0	0

D2	D1	D0	FIN1
0	0	0	No slope
0	0	1	Slope 1/32
0	1	0	1/16
0	1	1	1/8
1	0	0	1/4
1	0	1	1/2
1	1	0	3/4
1	1	1	Max slope

RGB1 FIN slope setting

*Default

Max. slope is 1/2 of automatic ON/OFF period of RGB1

D5	D4	D3	FOUT1
0	0	0	No slope
0	0	1	Slope 1/32
0	1	0	1/16
0	1	1	1/8
1	0	0	1/4
1	0	1	1/2
1	1	0	3/4
1	1	1	Max slope

RGB1 FOUT slope setting

*Default

Max. slope is 1/2 of automatic ON/OFF period of RGB1

	ADDRESS : 08h							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	-	-	FOUT2[2]	FOUT2[1]	FOUT2[0]	FIN2[2]	FIN2[1]	FIN2[0]
default	0	0	0	0	0	0	0	0

D2	D1	D0	FIN2
0	0	0	No slope
0	0	1	Slope 1/32
0	1	0	1/16
0	1	1	1/8
1	0	0	1/4
1	0	1	1/2
1	1	0	3/4
1	1	1	Max slope

RGB2 FIN slope setting

*Default

Max. slope is 1/2 of automatic ON/OFF period of RGB2

D5	D4	D3	FOUT2
0	0	0	No slope
0	0	1	Slope 1/32
0	1	0	1/16
0	1	1	1/8
1	0	0	1/4
1	0	1	1/2
1	1	0	3/4
1	1	1	Max slope

RGB2 FOUT slope setting

*Default

Max. slope is 1/2 of automatic ON/OFF period of RGB2

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	ADDRESS : 09h							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	-	-	SYNC	GR1M1	GRON1	AT1[2]	AT1[1]	AT1[0]
default	0	0	0	0	0	0	0	0

D2	D1	D0	AT1
0	0	0	0.262sec
0	0	1	0.524sec
0	1	0	1.049sec
0	1	1	2.097sec
1	0	0	4.194sec
1	0	1	8.389sec
1	1	×	-

RGB1 automatic ON/OFF function setting

*Default

D3	GRON1
0	OFF
1	ON

RGB1 automatic ON/OFF function setting

*Default

D4	GR1M1
0	OFF
1	ON

RGB1 is executed one time of the gradation.

*Default

D5	SYNC
0	OFF
1	ON

Automatic operation ON/OFF cycle and the gradation.

execution setting of RGB2 are done as well as RGB1

*Default

	ADDRESS : 0ah							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	-	-	-	GR1M2	GRON2	AT2[2]	AT2[1]	AT2[0]
default	0	0	0	0	0	0	0	0

D2	D1	D0	AT2
0	0	0	0.262sec
0	0	1	0.524sec
0	1	0	1.049sec
0	1	1	2.097sec
1	0	0	4.194sec
1	0	1	8.389sec
1	1	×	-

RGB2 automatic ON/OFF function setting

*Default

D3	GRON1
0	OFF
1	ON

RGB2 automatic ON/OFF function setting

*Default

D4	GR1M1
0	OFF
1	ON

RGB2 is executed one time of the gradation.

*Default

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	ADDRESS : 0bh							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	-	-	R1Aoff[5]	R1Aoff[4]	R1Aoff[3]	R1Aoff[2]	R1Aoff[1]	R1Aoff[0]
default	0	0	0	0	0	0	0	0

D5-0 RLED1 automatic OFF position setting (default: ALL0)

	ADDRESS : 0ch							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	-	-	R1Aon[5]	R1Aon[4]	R1Aon[3]	R1Aon[2]	R1Aon[1]	R1Aon[0]
default	0	0	0	0	0	0	0	0

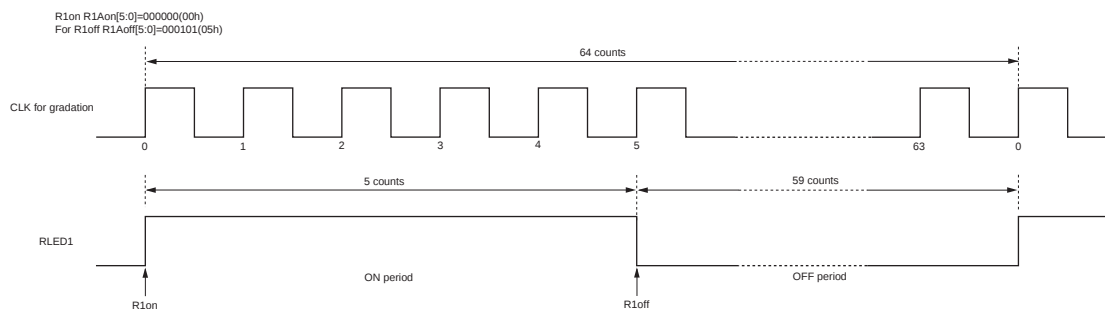
D5-0 RLED1 automatic OFF position setting (default: ALL0)

When R1Aon=R1Aoff, all the periods off.

LED control output waveform (RLED1). Same for GLED1, BLED1, GLED2, GLED2 and BLED2

When D5 to D0 ALL0: Clock 0 rise position.

When D5 to D0 ALL1: Clock 63 rise position.



	ADDRESS : 0dh							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	-	-	G1Aoff[5]	G1Aoff[4]	G1Aoff[3]	G1Aoff[2]	G1Aoff[1]	G1Aoff[0]
default	0	0	0	0	0	0	0	0

D5-0 GLED1 automatic OFF position setting (default: ALL0)

	ADDRESS : 0eh							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	-	-	G1Aon[5]	G1Aon[4]	G1Aon[3]	G1Aon[2]	G1Aon[1]	G1Aon[0]
default	0	0	0	0	0	0	0	0

D5-0 GLED1 automatic OFF position setting (default: ALL0)

When G1Aon=G1Aoff, all the periods off.

	ADDRESS : 0fh							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	-	-	B1Aoff[5]	B1Aoff[4]	B1Aoff[3]	B1Aoff[2]	B1Aoff[1]	B1Aoff[0]
default	0	0	0	0	0	0	0	0

D5-0 BLED1 automatic OFF position setting (default: ALL0)

	ADDRESS : 10h							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	-	-	B1Aon[5]	B1Aon[4]	B1Aon[3]	B1Aon[2]	B1Aon[1]	B1Aon[0]
default	0	0	0	0	0	0	0	0

D5-0 BLED1 automatic OFF position setting (default: ALL0)

When B1Aon=B1Aoff, all the periods off.

	ADDRESS : 11h							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	-	-	R2Aoff[5]	R2Aoff[4]	R2Aoff[3]	R2Aoff[2]	R2Aoff[1]	R2Aoff[0]
default	0	0	0	0	0	0	0	0

D5-0 RLED2 automatic OFF position setting (default: ALL0)

	ADDRESS : 12h							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	-	-	R2Aon[5]	R2Aon[4]	R2Aon[3]	R2Aon[2]	R2Aon[1]	R2Aon[0]
default	0	0	0	0	0	0	0	0

D5-0 RLED2 automatic OFF position setting (default: ALL0)

When R2Aon=R2Aoff, all the periods off.

	ADDRESS : 13h							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	-	-	G2Aoff[5]	G2Aoff[4]	G2Aoff[3]	G2Aoff[2]	G2Aoff[1]	G2Aoff[0]
default	0	0	0	0	0	0	0	0

D5-0 GLED2 automatic OFF position setting (default: ALL0)

	ADDRESS : 14h							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	-	-	G2Aon[5]	G2Aon[4]	G2Aon[3]	G2Aon[2]	G2Aon[1]	G2Aon[0]
default	0	0	0	0	0	0	0	0

D5-0 GLED2 automatic OFF position setting (default: ALL0)

When G2Aon=G2Aoff, all the periods off.

	ADDRESS : 15h							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	-	-	B2Aoff[5]	B2Aoff[4]	B2Aoff[3]	B2Aoff[2]	B2Aoff[1]	B2Aoff[0]
default	0	0	0	0	0	0	0	0

D5-0 BLED2 automatic OFF position setting (default: ALL0)

	ADDRESS : 16h							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	-	-	B2Aon[5]	B2Aon[4]	B2Aon[3]	B2Aon[2]	B2Aon[1]	B2Aon[0]
default	0	0	0	0	0	0	0	0

D5-0 BLED2 automatic OFF position setting (default: ALL0)

When B2Aon=B2Aoff, all the periods off.

	ADDRESS : 17h							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	GTO3EN	GPO2EN	GPO1EN	-	-	GPO3	GPO2	GPO1
default	0	0	0	0	0	0	0	0

D0	GPO1
0	GPO1 (LED3) output: Open when GPO1EN=0, low when GPO1EN=1
1	GPO1 (LED3) output: LED-Drv ON when GPO1EN=0, high when GPO1EN=1

GPO1(LED3) output setting
*Default

D1	GPO2
0	GPO2 (LED4) output: Open when GPO2EN=0, low when GPO2EN=1
1	GPO2 (LED4) output: LED-Drv ON when GPO2EN=0, high when GPO2EN=1

GPO2(LED4) output setting
*Default

D2	GPO3
0	GPO3 (LED5) output: Open when GPO3EN=0, low when GPO3EN=1
1	GPO3 (LED5) output: LED-Drv ON when GPO3EN=0, high when GPO3EN=1

GPO3(LED5) output setting
*Default

D5	GPO1EN
0	When GPO1 (LED3) output is used as LED-Drv
1	When GPO1 (LED3) output is used as GPO

GPO1(LED3) output
Setting for using GPO or LED-Drv
*Default

D6	GPO2EN
0	When GPO2 (LED4) output is used as LED-Drv
1	When GPO2 (LED4) output is used as GPO

GPO2(LED4) output
Setting for using GPO or LED-Drv
*Default

D7	GPO3EN
0	When GPO3 (LED5) output is used as LED-Drv
1	When GPO3 (LED5) output is used as GPO

GPO3(LED5) output
Setting for using GPO or LED-Drv
*Default

*GPO1EN must be set to 1 without fail when the GPO1 (LED3) pin is to be used as GPO.

When GPO1EN is set to 1, do not apply a voltage higher than the V_{DD} voltage to the GPO1 (LED3) pin.

The same applies to the GPO2 (LED4) and GPO3 (LED5) pins.

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	ADDRESS : 18h							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	FCTENR2	-	-	-	FCTR2[3]	FCTR2[2]	FCTR2[1]	FCTR2[0]
default	0	0	0	0	0	0	0	0

D3	D2	D1	D0	Current value(mA)
0	0	0	0	2.8
0	0	0	1	5.6
0	0	1	0	8.4
0	0	1	1	11.2
0	1	0	0	14.0
0	1	0	1	16.8
0	1	1	0	19.6
0	1	1	1	22.4
1	0	0	0	25.2
1	0	0	1	28.0
1	0	1	0	30.8
1	0	1	1	33.6
1	1	0	0	36.4
1	1	0	1	39.2
1	1	1	0	42.0
1	1	1	1	44.8

Strobe mode: RLED2 current level established when FCTL is high.

*Default

D7	FCTENR2
0	FCTL non valid
1	FCTL valid

RLED2 FCTL signal enable

*Default

	ADDRESS : 19h							
	D7	D6	D5	D4	D3	D2	D1	D0
resister name	FCTENG2	-	-	-	FCTG2[3]	FCTG2[2]	FCTG2[1]	FCTG2[0]
default	0	0	0	0	0	0	0	0

D3	D2	D1	D0	Current value(mA)
0	0	0	0	2.8
0	0	0	1	5.6
0	0	1	0	8.4
0	0	1	1	11.2
0	1	0	0	14.0
0	1	0	1	16.8
0	1	1	0	19.6
0	1	1	1	22.4
1	0	0	0	25.2
1	0	0	1	28.0
1	0	1	0	30.8
1	0	1	1	33.6
1	1	0	0	36.4
1	1	0	1	39.2
1	1	1	0	42.0
1	1	1	1	44.8

Strobe mode: GLED2 current level established when FCTL is high.

*Default

D7	FCTENG2
0	FCTL non valid
1	FCTL valid

GLED2 FCTL signal enable

*Default

Precautions for serial transmission and usage note

- * ON operation of the charge pump must be performed when the LED is off.
- * Do not turn ON the LED for 800 μ s typ. (soft start time) after the charge pump has been turned on.
- * When the fade operation of LED is performed, turn off the charge pump after the fade-out has been completed.
- * Gradation level must be selected without fail when gradation is OFF.
- * When the charge pump is operating, use the LED driver in such a way that the total current flowing to the LEDs.
- * Even in the strobe mode (FCTL=H), the gradation operation is performed for RLED2 and GLED2 when RLED2 and GLED2 are set to gradation ON.
- * Even in the strobe mode (FCTL=H), current flows to RLED2 and GLED2 in synchronization with the SCTL signal when SCTL is valid.
- * When the LED pins are not to be used
When LEDs are not connected to the LED pins, connect the LED driver pins to VBAT or GND.
- * Precaution when using the SCTL pin or FCTL pin
When the SCTL pin or FCTL pin is set to high, current flows to the SCTL or FCTL input circuit.
(This is also true in the STBY or reset mode.)
When the pin is not going to be used, it must be set to low without fail.
- * By default, the GP01 (LED3) pin is left open.
When the GP01 (LED3) pin is to be set high by default, connect a pull-up resistor to the pin.
Conversely, when the GP01 (LED3) pin is to be set low by default, connect a pull-down resistor to the pin.
Connect pull-up or pull-down resistors to the GP02 (LED4) and GP03 (LED5) pins as well in the same way.

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LV5223GR serial map

- Table upper row: Register name Table the lower: Default value

	Register address								data							
	A7	A6	A5	A4	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0
00h	0	0	0	0	0	0	0	0	B2SW	G2SW	R2SW	B1SW	G1SW	R1SW	CPSW	STBY
									0	0	0	0	0	0	0	0
01h	0	0	0	0	0	0	0	1	SCTEN1	×	×	R1[4:0]				
									0	0	0	0	0	0	0	0
02h	0	0	0	0	0	0	1	0	×	×	×	G1[4:0]				
									0	0	0	0	0	0	0	0
03h	0	0	0	0	0	0	1	1	×	×	×	B1[4:0]				
									0	0	0	0	0	0	0	0
04h	0	0	0	0	0	1	0	0	×	×	×	R2[4:0]				
									0	0	0	0	0	0	0	0
05h	0	0	0	0	0	1	0	1	×	×	×	G2[4:0]				
									0	0	0	0	0	0	0	0
06h	0	0	0	0	0	1	1	0	×	×	×	B2[4:0]				
									0	0	0	0	0	0	0	0
07h	0	0	0	0	0	1	1	1	×	×	FOUT1[2:0]			FIN1[2:0]		
									0	0	0	0	0	0	0	0
08h	0	0	0	0	1	0	0	0	×	×	FOUT2[2:0]			FIN2[2:0]		
									0	0	0	0	0	0	0	0
09h	0	0	0	0	1	0	0	1	×	×	SYNC	GR1M1	GRON1	AT1[2:0]		
									0	0	0	0	0	0	0	0
0ah	0	0	0	0	1	0	1	0	×	×	×	GR1M2	GRON2	AT2[2:0]		
									0	0	0	0	0	0	0	0
0bh	0	0	0	0	1	0	1	1	×	×	R1Aoff[5:0]					
									0	0	0	0	0	0	0	0
0ch	0	0	0	0	1	1	0	0	×	×	R1Aon[5:0]					
									0	0	0	0	0	0	0	0
0dh	0	0	0	0	1	1	0	1	×	×	G1Aoff[5:0]					
									0	0	0	0	0	0	0	0
0eh	0	0	0	0	1	1	1	0	×	×	G1Aon[5:0]					
									0	0	0	0	0	0	0	0
0fh	0	0	0	0	1	1	1	1	×	×	B1Aoff[5:0]					
									0	0	0	0	0	0	0	0
10h	0	0	0	1	0	0	0	0	×	×	B1Aon[5:0]					
									0	0	0	0	0	0	0	0
11h	0	0	0	1	0	0	0	1	×	×	R2Aoff[5:0]					
									0	0	0	0	0	0	0	0
12h	0	0	0	1	0	0	1	0	×	×	R2Aon[5:0]					
									0	0	0	0	0	0	0	0
13h	0	0	0	1	0	0	1	1	×	×	G2Aoff[5:0]					
									0	0	0	0	0	0	0	0
14h	0	0	0	1	0	1	0	0	×	×	G2Aon[5:0]					
									0	0	0	0	0	0	0	0
15h	0	0	0	1	0	1	0	1	×	×	B2Aoff[5:0]					
									0	0	0	0	0	0	0	0
16h	0	0	0	1	0	1	1	0	×	×	B2Aon[5:0]					
									0	0	0	0	0	0	0	0
17h	0	0	0	1	0	1	1	1	GPO3EN	GPO2EN	GPO1EN	×	×	GPO3	GPO2	GPO1
									0	0	0	0	0	0	0	0
18h	0	0	0	1	1	0	0	0	FCTENR2	×	×	×	FCTR2[3:0]			
									0	0	0	0	0	0	0	0
19h	0	0	0	1	1	0	0	1	FCTENG2	×	×	×				
									0	0	0	0	0	0	0	0
	Register address								Data							

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