S6AL211 Series

ASSP
4ch. LED Driver IC for Intelligent Lighting

Data Sheet (Full Production)

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S6AL211 Series

ASSP
4ch. LED Driver IC for Intelligent Lighting

Data Sheet (Full Production)

1. Description

S6AL211 series provide an intelligent LED driver solution for commercial lighting, residential lighting, illumination lighting, and so on. There are possible to the light dimming and tune colors control of 4ch. LED strings. This device can be dimming and toning for 4ch. LEDs. The dimming and color control is corresponded to communication interfaces and sensors. Through it can use for not only the general lighting but also office, shop and residence lighting control systems. Moreover, S6AL211 series integrate a 3V-LDO regulator circuit for supplying the power to the peripheral circuits. It contributes to the BOM cost reduction. S6AL211 series can offer the best solution according to your usage.

2. Features

- Control of up to 4 channels LED strings (such as Red, Green, Blue, White or White×4 etc.)
- Input voltage range VIN: DC 24V (Absolute Maximum rating: 35V)
- Output power range: 72W (1A / 18V at LED Vf 3.6V(typ)×5 / 1ch.)
- LED brightness control method: LED current control and LED ON/OFF PWM control
- LED constant current control method: Based on Buck DC/DC converter
- High efficiency > 94% (Dimming type B,C at 4ch. 100% brightness, Typ-sample)
- Communication interfaces: DALI, External module of Bluetooth® (UART)
- Integrates 3V-LDO regulator circuit for supplying the power to the peripheral circuits
- Protection functions
  - Output signal of IC protection status
  - Low input voltage protection
  - Output over current protection , etc.
- Small package: LQFP48 (7.0 mm × 7.0 mm × 1.7 mm [Max])

3. Applications

- Commercial lightings such as office, shop and so on
- Residential lighting such as down-light, ceiling-light
- Street light, Sensor light
- Illumination

etc.

- Supported to the standards:
  Japanese Electrical Appliances and Materials Safety Law (PSE)
  Japanese lamp industrial standard (JEL)

Publication Number S6AL211_DS405-00022 Revision 3.0 Issue Date June 12, 2015

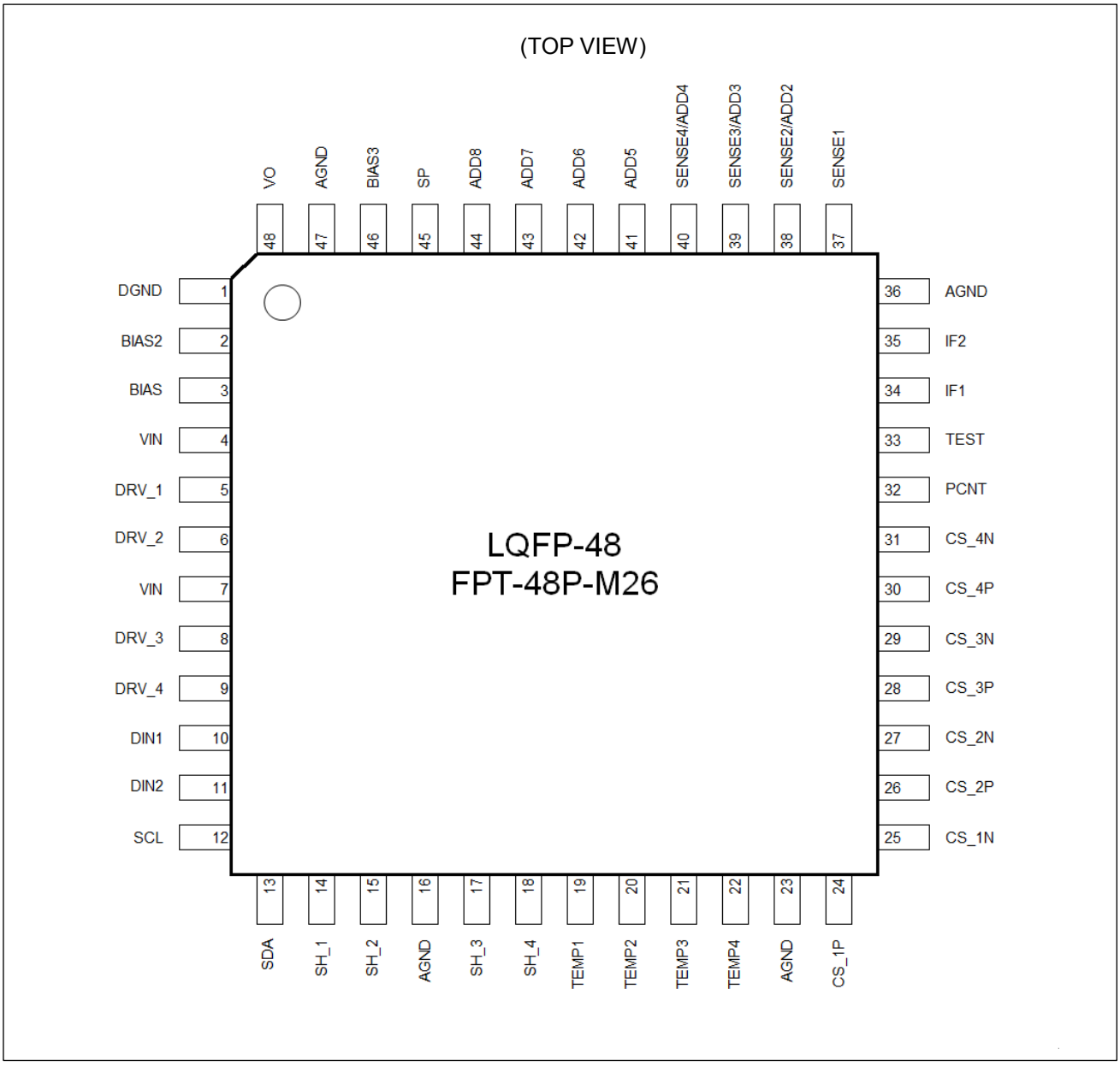
Table of Contents

Figures

Tables

4. Pin Assignment

Figure 4-1 Pin Assignment



5. Pin Descriptions

Table 5-1 Pin Descriptions

Pin No.	Pin Name	I/O	Description	
1	DGND	-	Ground pin	
2	BIAS2	O	By-pass capacitor connection Pin (Do not connect external load)	
3	BIAS	O	By-pass capacitor connection Pin (Do not connect external load)	
4	VIN	-	Power supply input Pin	
5	DRV_1	O	Gate driver output for external switching FET Pin 1 (for current control)	
6	DRV_2	O	Gate driver output for external switching FET Pin 2 (for current control)	
7	VIN	-	Power supply input Pin	
8	DRV_3	O	Gate driver output for external switching FET Pin 3 (for current control)	
9	DRV_4	O	Gate driver output for external switching FET Pin 4 (for current control)	
10	DIN1	I	Mode setting Pin 1 Usually, please connect to VO pin. If you use the interface, please refer to the hardware manual of each IC. S6AL211A21 hardware manual, S6AL211A31 hardware manual	
11	DIN2	I	Unused Pin Please connect to GND level.	
12	SCL	I/O	I^2C bus Clock I/O Pin	Please connect to VO pin if you do not use the interface.
13	SDA	I/O	I^2C bus Data I/O Pin	
14	SH_1	O	Gate driver output for external switching FET Pin 1 (for PWM dimming control)	
15	SH_2	O	Gate driver output for external switching FET Pin 2 (for PWM dimming control)	
16	AGND	-	Ground pin	
17	SH_3	O	Gate driver output for external switching FET Pin 3 (for PWM dimming control)	
18	SH_4	O	Gate driver output for external switching FET Pin 4 (for PWM dimming control)	
19	TEMP1	I	Temperature sensor connection Pin 1	
20	TEMP2	I	Temperature sensor connection Pin 2	
21	TEMP3	I	Temperature sensor connection Pin 3	
22	TEMP4	I	Temperature sensor connection Pin 4	
23	AGND	-	Ground pin	
24	CS_1P	I	LED current sense Pin 1 (High side)	
25	CS_1N	I	LED current sense Pin 1 (Low side)	
26	CS_2P	I	LED current sense Pin 2 (High side)	
27	CS_2N	I	LED current sense Pin 2 (Low side)	
28	CS_3P	I	LED current sense Pin 3 (High side)	
29	CS_3N	I	LED current sense Pin 3 (Low side)	
30	CS_4P	I	LED current sense Pin 4 (High side)	
31	CS_4N	I	LED current sense Pin 4 (Low side)	
32	PCNT	O	IC status output Pin	
33	TEST	I	Exclusive use of the Test Please connect to BIAS3 Pin.	
34	IF1	I	Communication interface (DALI/UART) data input Pin Please connect to VO pin if you do not use the interface.	
35	IF2	O	Communication interface (DALI/UART) data output Pin	
36	AGND	-	Ground pin	
37	SENSE1	I	Unused Pin Please connect to GND level.	

Pin No.	Pin Name	I/O	Description	
38	SENSE2/ADD2	I	Unused Pin Please connect to GND level.	
39	SENSE3/ADD3	I	Analog sensor connection Pin	Please connect to GND level if you do not use the function.
40	SENSE4/ADD4	I	Digital sensor connection Pin	
41	ADD5	I	DALI interface diagnosis circuit connection Pin − 0: Fault detection input value − 1: Normal mode In case of DALI products when IC does not connect the external diagnosis circuit, please connect to VO pin. In case of products other than there, please connect to GND level.	
42	ADD6	I	DALI Physical Selection setting Pin − 0: Normal mode − 1: Physical Selection mode Please connect to GND level if you do not use the function.	
43	ADD7	I	Unused Pin Please connect to GND level.	
44	ADD8	I	Unused Pin Please connect to GND level.	
45	SP	I	Exclusive use of the Test Please connect to BIAS3 Pin.	
46	BIAS3	O	By-pass capacitor connection Pin (Do not connect external load)	
47	AGND	-	Ground pin	
48	VO	O	3V LDO output Pin	

6. Block Diagram

6.1 Simplified System Block Diagram

There are the examples of the simplified system block diagram according to application.

Figure 6-1 Simplified System Block Diagram Example 1

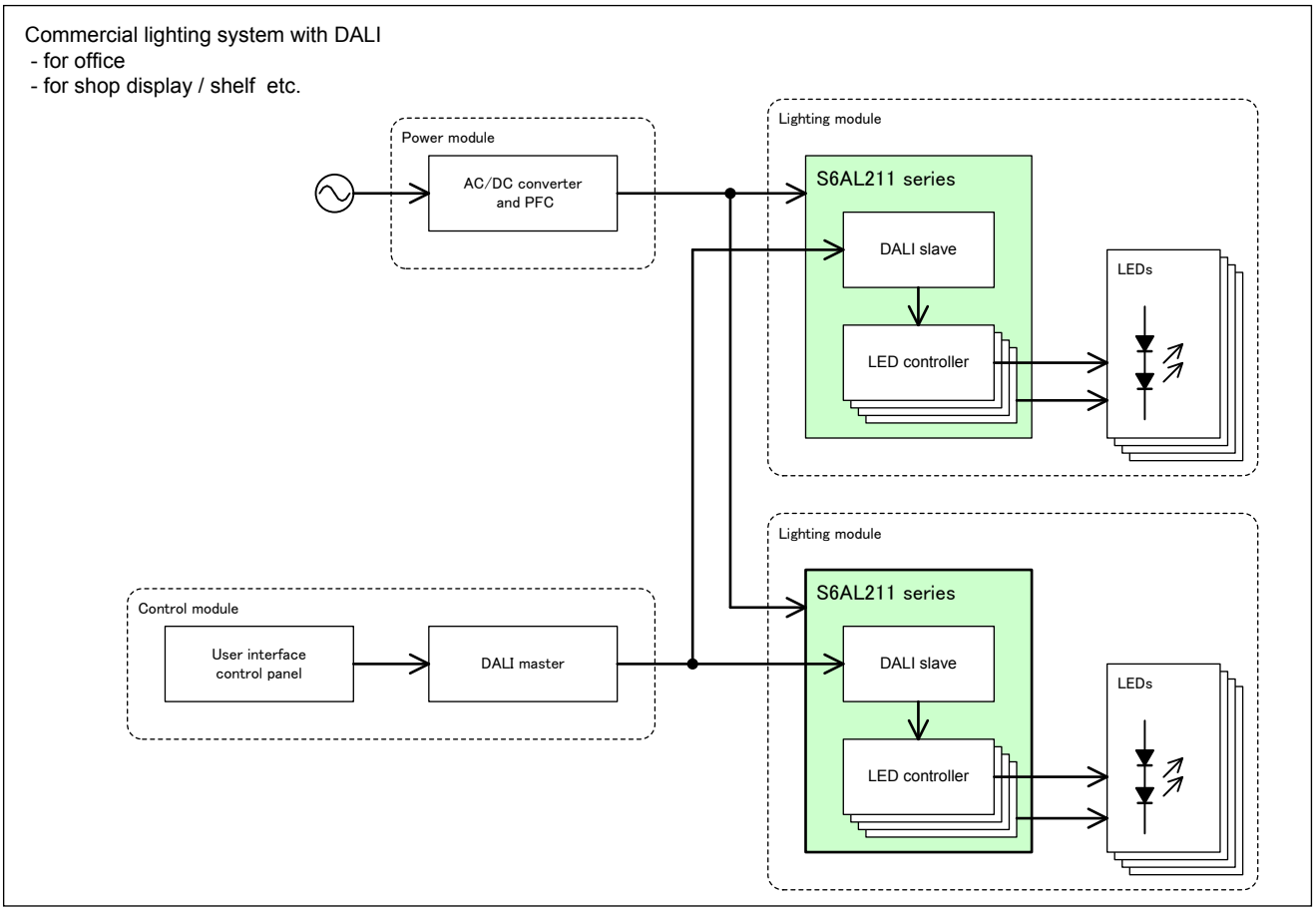


Figure 6-2 Simplified System Block Diagram Example 2

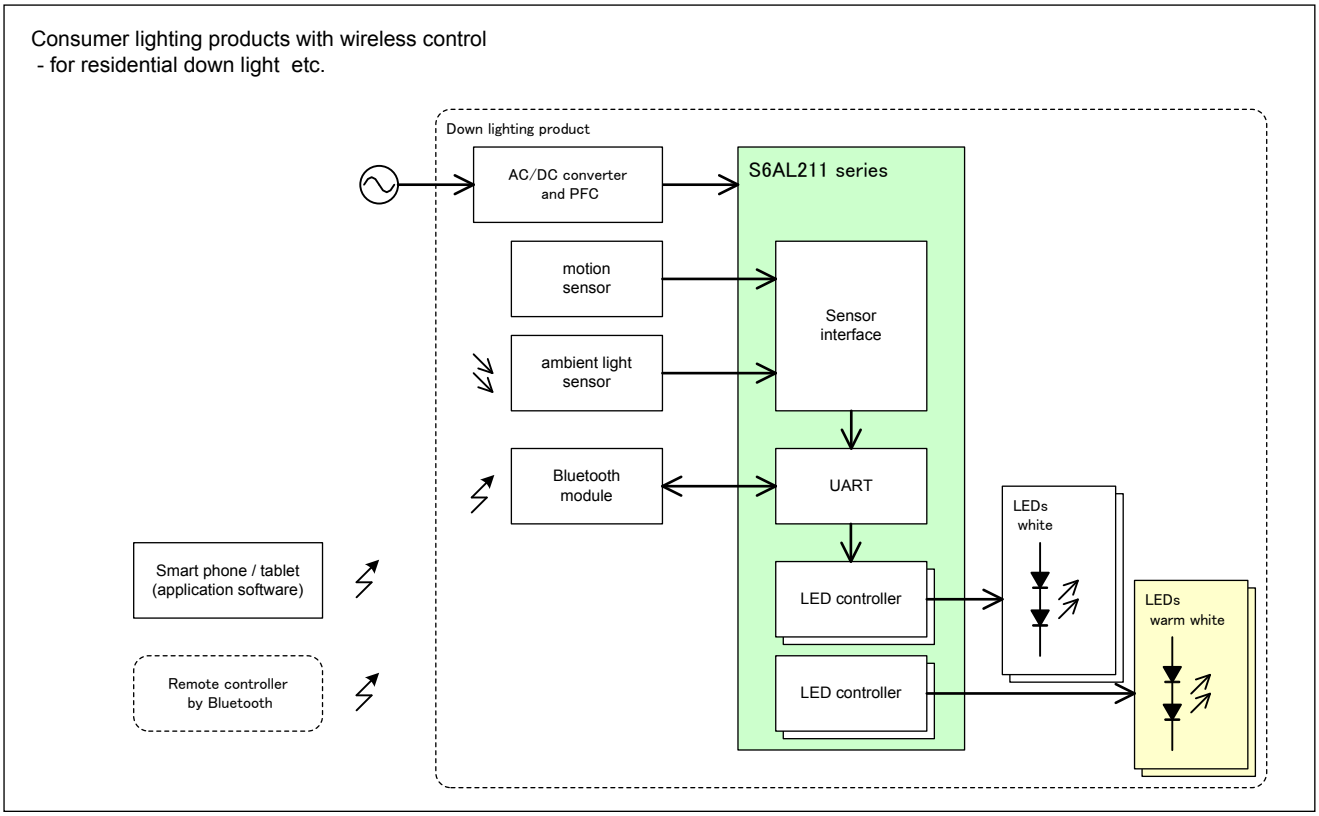
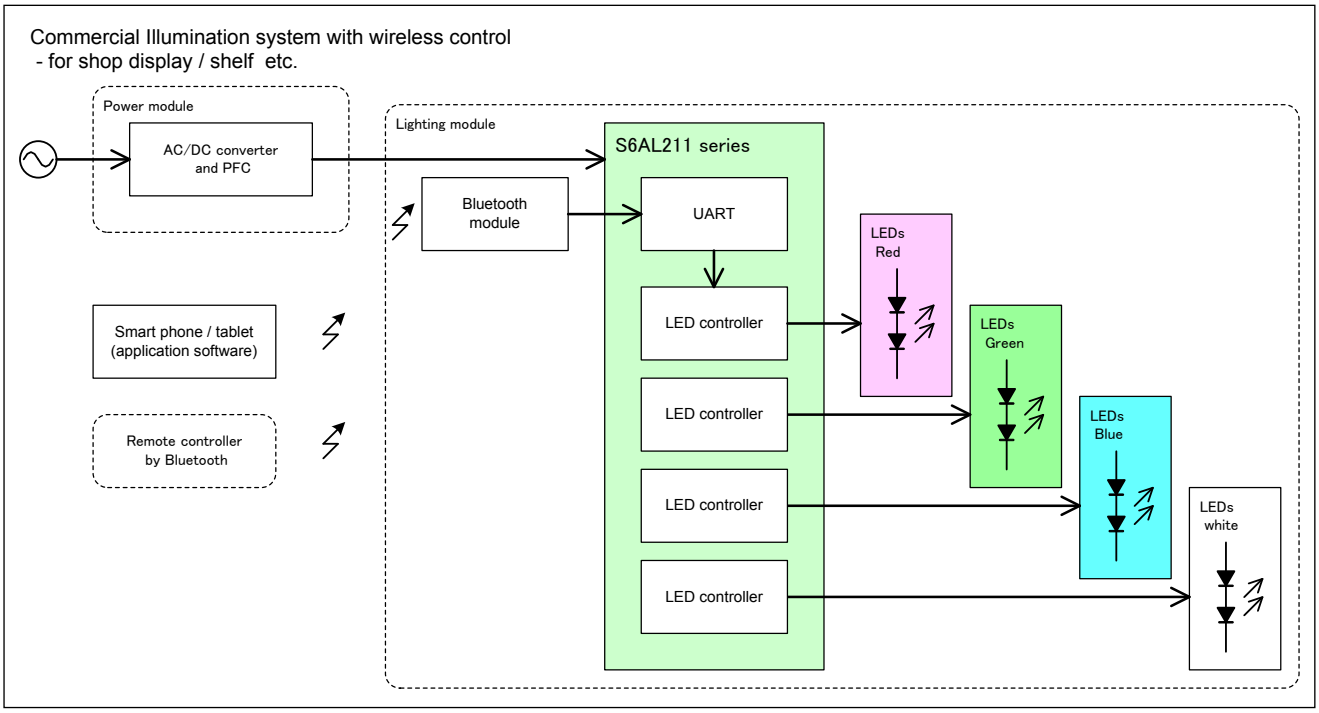
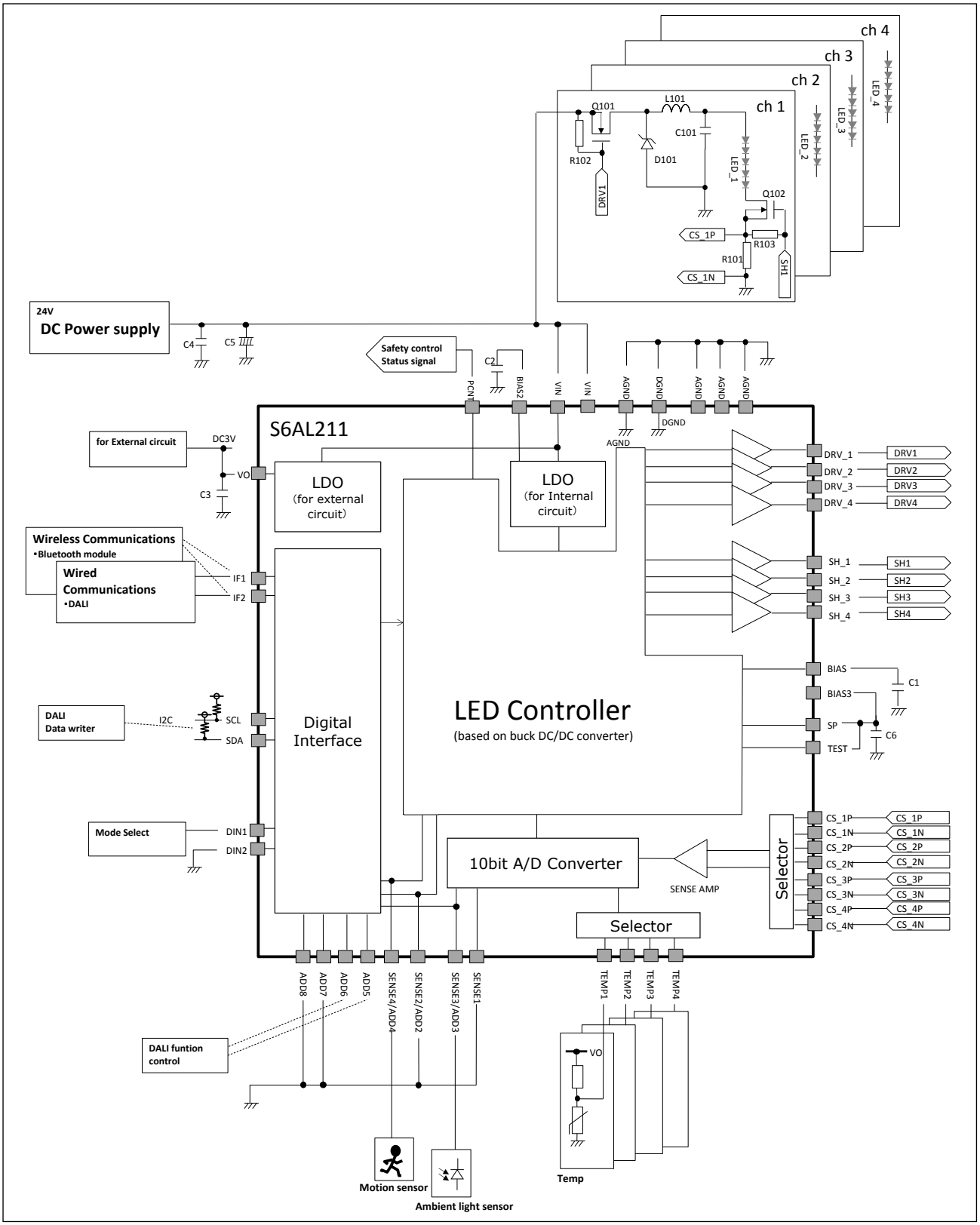


Figure 6-3 Simplified System Block Diagram Example 3



6.2 Block Diagram

Figure 6-4 Block Diagram



7. Absolute Maximum Ratings

Table 7-1 Absolute Maximum Ratings

Parameter	Symbol	Conditions	Rating		Unit
			Min	Max	
Power supply voltage	VIN	VIN pin	-0.3	+35.0	V
Input voltage	VI	Input pins other than SENSE1	-0.3	+6.0	V
	VHVI	SENSE1 Pin	-0.3	+35.0	V
Output Voltage	VO1	BIAS2,BIAS3,VO,PCNT,IF2 Pin	-0.3	+6.0	V
	VO2	BIAS pin	-0.3	+2.5	V
	VO3	SH_1 to SH_4 pin	-0.3	+6.5	V
	VHVO	DRV_1 to DRV_4 pin	-0.3	+35.0	V
Output current	IOH	H level maximum output current Output pins other than VO	-15.0	-	mA
	IOL	L level maximum output current Output pins other than VO	-	+15.0	mA
	IVO	VO Pin	-	+60.0	mA
Power dissipation	PD	Ta ≤ +25°C	-	1780(*1)	mW
Junction Temperature	TJ	-	-40	+125	°C
Storage temperature	TSTG	-	-55	+125	°C
ESD voltage	VESDH	Human Body Model	-2000	+2000	V
	VESDM	Machine Model	-200	+200	V
	VESDC	Charged Device Model	-1000	+1000	V

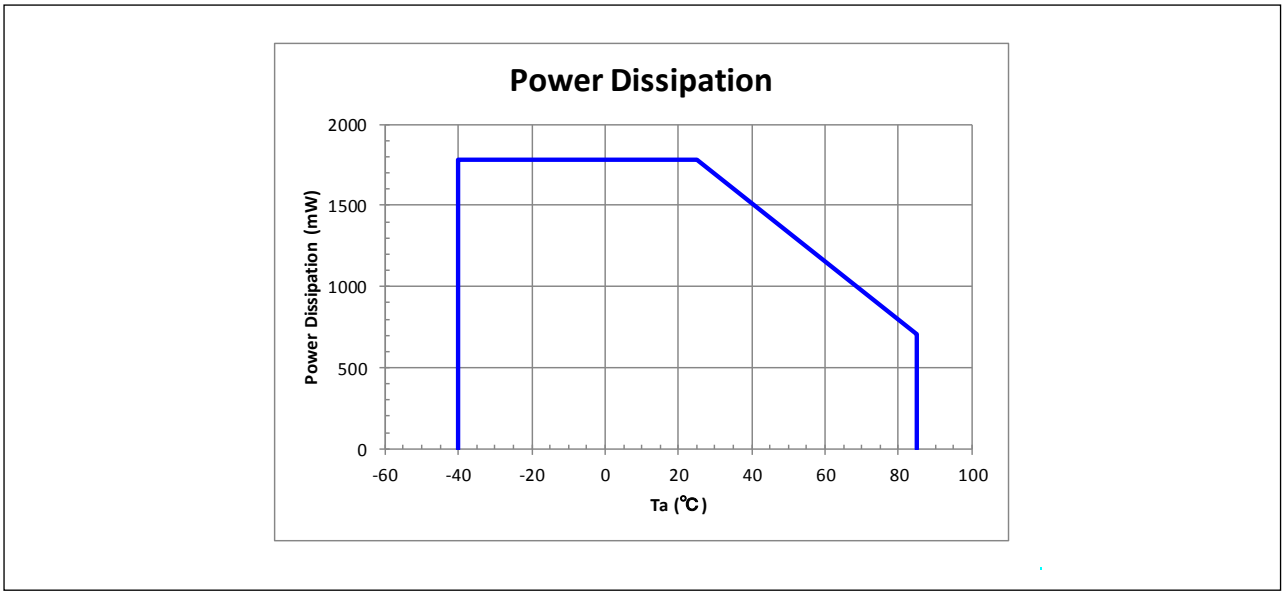
*1: The value when using two layers PCB.

Reference: θja (wind speed 0m/s) +56°C/W

Warning:

1. Semiconductor devices may be permanently damaged by application of stress (including, without limitation, voltage, current or temperature) in excess of absolute maximum ratings. Do not exceed any of these ratings.

Figure 7-1 Graph of Power Dissipation – Operating Ambient Temperature



8. Recommended Operating Conditions

Table 8-1 Recommended Operating Conditions

Parameter	Symbol	Conditions	Value			Unit	Remarks
			Min	Typ	Max		
Power supply voltage	VIN	VIN pin	22	24	26	V	24V power supply operation
Bypass capacitor	C1	BIAS Pin to DGND Pin	0.022	-	1.0	µF	
	C2	BIAS2 Pin to AGND Pin	-	4.7	-	µF	
	C3	BIAS3 Pin to AGND Pin	-	4.7	-	µF	
	C4	VO Pin to AGND Pin	-	4.7	-	µF	
	CVIN	VIN Pin to AGND Pin	100 µF//100 pF			-	Parallel connection
Operating ambient temperature	Ta	-	-40	+25	+85	°C	

Warning:

1. *The recommended operating conditions are required in order to ensure the normal operation of the semiconductor device. All of the device's electrical characteristics are warranted when the device is operated under these conditions.*
2. *Any use of semiconductor devices will be under their recommended operating condition.*
3. *Operation under any conditions other than these conditions may adversely affect reliability of device and could result in device failure.*
4. *No warranty is made with respect to any use, operating conditions or combinations not represented on this data sheet. If you are considering application under any conditions other than listed herein, please contact sales representatives beforehand.*

9. Electrical Characteristics

9.1 Power Supply Current

Table 9-1 Power Supply Current

(Ta = +25°C, VIN = 24V)

Parameter	Symbol	Pin Name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
Operating current	IVIN	VIN	VIN=24V, VO=No load	-	15	25	mA	Normal operation
Standby current	IVINS	VIN	VIN=24V, VO=No load	-	300	450	μA	Other than DALI communication products
				-	540	810	μA	DALI communication products

9.2 Common Parameter

Table 9-2 Common Parameter

(Ta = +25°C, VIN = 24V)

Parameter	Symbol	Pin Name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
High Level Input voltage	VIH1	TEST, ADD2 to 8, DIN1, DIN2, SP	-	2.1	-	5.8	V	
	VIH2	IF1, SCL, SDA	-	2.4	-	5.8	V	
Low Level Input voltage	VIL1	TEST, ADD2 to 8, DIN1, DIN2, SP	-	DGND-0.3	-	0.9	V	
	VIL2	IF1, SCL, SDA	-	DGND-0.3	-	0.6	V	
Open Drain Output Applied Voltage	VD	SCL, SDA	-	DGND-0.3	-	5.8	V	
High Level Output Voltage	VOH1	IF2	IOH = -4 mA	2.4	-	-	V	
	VOH2	PCNT	IOH = -8 mA	4.4	-	-	V	
	VOHD	DRV_1, DRV_2, DRV_3, DRV_4	IOH = 0 mA, VIN = 24V	-	24.0	-	V	
	VOHS	SH_1, SH_2, SH_3, SH_4	IOH = 0 mA, VIN = 24V	-	5.5	-	V	
Low Level Output Voltage	VOL1	IF2 ,SCL,SDA	IOL = 4 mA	-	-	0.4	V	
	VOL2	PCNT	IOL = 8 mA	-	-	0.4	V	
	VOLD	DRV_1, DRV_2, DRV_3, DRV_4	IOL = 0 mA, VIN = 24V	-	18.5	-	V	
	VOLS	SH_1, SH_2, SH_3, SH_4	IOL = 0 mA, VIN = 24V	-	0.0	-	V	
Input Leak Current (Hi-Z Output Current)	ILEAK	ALL Pins Exceptional Pin: VIN, VO, AGND, DGND, BIAS, BIAS2, BIAS3, SP	0V < VI < 5.0V	-1	-	+1	μA	
Pull-up Resistance	RPUD	DRV_1, DRV_2, DRV_3, DRV_4	-	-	1	-	MΩ	
	RPUS	SP	-	-	50	-	kΩ	
Power-on Time	TVR	VIN	VIN × 0.1 to VIN × 0.9	1	-	8	ms	(*1)

Parameter	Symbol	Pin Name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
Input Capacitance	CIN	ALL Pins Exceptional Pin : VIN, VO, AGND, DGND, BIAS, BIAS2, BIAS3	-	-	5	15	pF	

*1: When the ramp up of power-supply-voltage at the power-on exceeds the maximum time, IC may enter the protection mode and stops safety.

9.3 Power Supply Protection

Table 9-3 Power Supply Protection

(Ta = +25°C, VIN = 24V)

Parameter	Symbol	Pin Name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
Input Low Voltage Protection Detection Voltage	VUVLO	VIN	VIN = 24V	20.4	21.0	21.6	V	
Input Over Voltage Protection Detection Voltage	VOVP	VIN	VIN = 24V	26.4	27.0	27.6	V	
Input Under Voltage Shutdown Threshold Voltage : enter (VIN Decreasing)	VLSDI	VIN	-	8.4	8.8	9.2	V	IC Shutdown
Input Under Voltage Shutdown Threshold Voltage : release (VIN Increasing)	VRSDI	VIN	-	-	-	10.2	V	

9.4 Internal Temperature Protection

Table 9-4 Internal Temperature Protection

(Ta = +25°C, VIN = 24V)

Parameter	Symbol	Pin Name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
Internal Over Temperature Protection Detection Temperature	TOTPI	-	TJ	-	110	-	°C	Design Standard Value
Internal Over Temperature Shutdown Threshold Temperature :enter	TLSDI	-	TJ	-	150	-	°C	IC Shutdown Design Standard Value
Internal Over Temperature Shutdown Threshold Temperature :release	TRSDI	-	TJ	-	100	-	°C	Design Standard Value

9.5 LDO

Table 9-5 LDO

(Ta = +25°C, VIN = 24V)

Parameter	Symbol	Pin Name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
Output Voltage	VOUT3	VO	VIN = 22 to 26V	2.85	3.00	3.15	V	
Maximum Output Current	IO3	VO	-	-	-	60	mA	VO Over Current Protection
Line Regulation	VLINE3	VO	VIN = 22->26V, IO3 = 20 mA, C4 = 4.7 µF	-	-	20	mV	
Load Regulation	VLOAD3	VO	VIN = 24V, IO3 = 1 mA to IOmax, C4 = 4.7 µF	-	-	20	mV	
Power Supply Rejection Ratio	PSRR3	VO	f = 50Hz to 1 kHz, IO3 = 1 mA, C4 = 4.7 µF	-	60	-	dB	
			f = 1 kHz to 200 kHz, IO3 = 1 mA, C4 = 4.7 µF	-	45	-	dB	
Over Current Limit	ILIM3	VO	VOUT3 = 2.64V	86	-	118	mA	Fold back current limiting characteristic
Rise Time	TSTART3	VO	VIN = 24V, IO3 = 0 mA, C4 = 4.7 µF, VOUT3 = 90% From Release of Input Under Voltage Shutdown To Reach the output voltage	-	3.0	-	ms	

9.6 Current Detection

Table 9-6 Current Detection

(Ta = +25°C, VIN = 24V)

Parameter	Symbol	Pin Name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
Analog Input voltage	VDAI	CS_1P, CS_1N, CS_2P, CS_2N, CS_3P, CS_3N, CS_4P, CS_4N	-	0.0	-	0.4	V	
Input Impedance	RDAI	CS_1P, CS_1N, CS_2P, CS_2N, CS_3P, CS_3N, CS_4P, CS_4N	at CS_xP - CS_xN Voltage = 0.2V	-	228	-	kΩ	
External Sense Resister	-	-	LED current:350 mA	-	0.51	-	Ω	E24 series ±1%
			LED current:1A	-	0.20	-	Ω	
Output Over Current Protection Detection Voltage	VOCP1	CS_xP - CS_xN	LED current:350 mA	0.260	0.267	0.275	V	Peak voltage in measurement period
	VOCP2	CS_xP - CS_xN	LED current:1A	0.291	0.300	0.308	V	
Output Short Circuit Protection Detection Voltage	VSCP1	CS_xP - CS_xN	LED current:350 mA	0.260	0.267	0.275	V	Average voltage in measurement period
	VSCP2	CS_xP - CS_xN	LED current:1A	0.291	0.300	0.308	V	

9.7 Gate Driver for Switching FET

Table 9-7 Current Detection

(Ta = +25°C, VIN = 24V)

Parameter	Symbol	Pin Name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
Switching Frequency	fSWD	DRV_1, DRV_2, DRV_3, DRV_4	-	-	33.3	-	kHz	Dimming Type B, C
Rise Time	TRDRV		External Load = 1 nF	-	-	200	ns	Design Standard Value
Fall Time	TFDRV			-	-	200	ns	
Output ON Resistance	RDHON		High side VIN = 24V, Iout = -45 mA	-	45	-	Ω	Design Standard Value
	RDLON		Low side VIN = 24V, Iout = 45 mA	-	12	-	Ω	
Switching Frequency	fSWS	SH_1, SH_2, SH_3, SH_4	-	-	0.53	-	kHz	Dimming Type C
Rise Time	TRSH		External Load = 1 nF	-	-	200	ns	Design Standard Value
Fall Time	TFSH			-	-	200	ns	
Output ON Resistance	RSHON		High side VIN = 24V, Iout = -45 mA	-	13	-	Ω	Design Standard Value
	RSLON		Low side VIN = 24V, Iout = 45 mA	-	14	-	Ω	

9.8 Constant Current Control

Table 9-8 Constant Current Control

(Ta = +25°C, VIN = 24V)

Parameter	Symbol	Pin Name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
Power ON to Initial Setting Current Operation Time	TPOLC	-	Power Supply > 0.9 × VIN, Initial Setting Brightness = 100%	-	-	0.3	s	(*3), (*4)
Standby restoration to Initial Setting Current Operation Time	TSOLC	-	Initial Setting Brightness = 100%	-	-	0.3	s	(*4)
Current Accuracy	-	CS_1P, CS_1N, CS_2P, CS_2N, CS_3P, CS_3N, CS_4P, CS_4N	LED current:1A	-4.6	-	+4.6	%	Dimming Type B, C (*2)
Output Current Ripple (*1)	-	-	LED current:1A	-	-	0.4	-	Dimming Type B, C
			LED current:less than 1A	-	-	1.3	-	

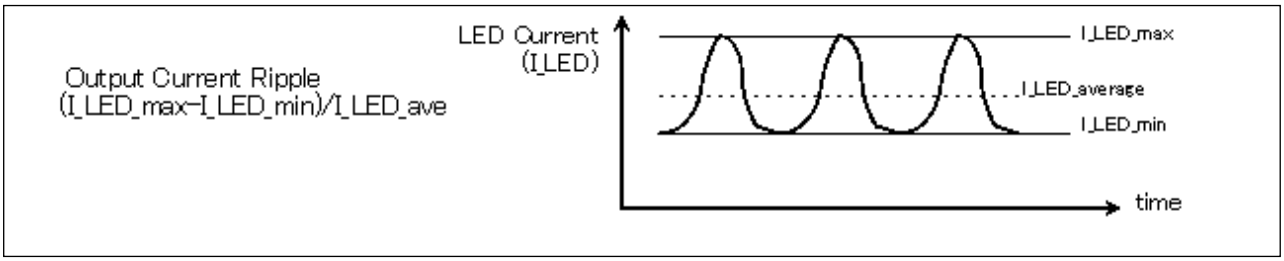
*1: Please refer to Figure 9-1 for output current ripple.

*2: Include effect of sense resistor accuracy (as ±1%)

*3: When DALI, Not include 0.6s of waiting time for the Power Level command.

*4: When do not use the Fade function

Figure 9-1 Formula of Output Current Ripple



9.9 Analog Input (TEMPx, SENSE1, SENSE3 Pins)

Table 9-9 Analog Input (TEMPx, SENSE1, SENSE3 Pins)

(Ta = +25°C, VIN = 24V)

Parameter	Symbol	Pin Name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
External Impedance	ROTI	TEMP1, TEMP2, TEMP3, TEMP4	VTEMPx ≤ 2.0V (External Over Temperature Protection Detection Voltage)	(*1)	-	40	kΩ	(*3)
	RS3I	SENSE3	-	(*2)	-	40	kΩ	(*4)
TEMPx Input Voltage	VIOT	TEMP1, TEMP2, TEMP3, TEMP4	-	0.0	-	VOUT3 +0.3	V	
External Over Temperature Protection Detection Voltage	VDOT	TEMP1, TEMP2, TEMP3, TEMP4	-	-	1.50	-	V	(*5)
SENSE3 Input Voltage	VIS3	SENSE3	-	0.0	-	VOUT3 +0.3	V	

*1: Please use the LDO output (Pin VO) to the temperature sensor (thermistor). It is necessary to arrange a current limit resister, in order to do not exceed the maximum power dissipation.

*2: In case of power to the Ambient light sensor (Photo Transistor) from the LDO output (Pin VO), it is necessary to arrange a current limit resister, in order to do not exceed the maximum power dissipation.

*3: If the series resistance of temperature sensor is large, please arrange the stabilizing capacitor about 0.1 µF in between TEMPx and GND.

*4: If the series resistance of Ambient light sensor is large, please arrange the stabilizing capacitor about 0.1 µF in between SENSE3 and GND.

*5: In the application circuit example, External Over Temperature Protection Detection Temperature: Correspond to 90°C

9.10 SENSE4 Trigger Input

Table 9-10 SENSE4 Trigger Input

(Ta = +25°C, VIN = 24V)

Parameter	Symbol	Pin Name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
Effective High Level Pulse Width	TVSP4	SENSE4	-	0.3	-	-	s	Design Standard Value
Ineffective Time from Power-on	TENS4	SENSE4	-	-	-	30	s	Design Standard Value (*1)

*1: SENSE4 ignore from sensor output signal for Ineffective Time after Power-on, because it is stabilization waiting condition of the sensor output signal.

9.11 Asynchronous Communication Interface Timing

Table 9-11 Asynchronous Communication Interface Timing

(Ta = +25°C, VIN = 24V)

Parameter	Symbol	Pin Name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
Baud rate	TBRT	IF1, IF2	DALI	1080	1200	1320	bps	
			UART	-	115.2	-	kbps	

9.12 I²C Bus Interface Timing

Table 9-12 I²C Bus Interface Timing

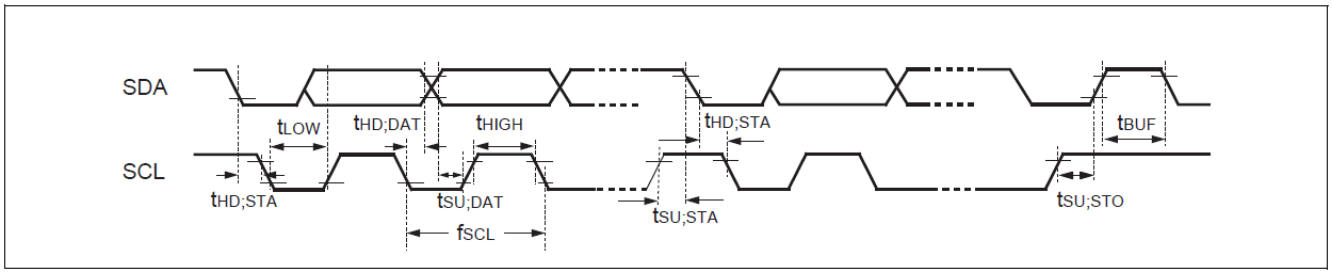
(Ta = +25°C, VIN = 24V)

Parameter	Symbol	Pin Name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
SCL Clock Frequency	f_{SCL}	SCL	-	0	-	75	kHz	Slave Operation
(Replicate) Hold Time of Start Conditions SDA↓ to SCL↓	$t_{HD;STA}$	SCL, SDA	R = 1.7 kΩ, C = 400 pF (*1) Pull-up to: 2.85 to 5.50V	4.0	-	-	µs	
SCL Clock Low Level Width	t_{LOW}	SCL		4.7	-	-	µs	
SCL Clock High Level Width	t_{HIGH}	SCL		4.0	-	-	µs	
(Replicate) Setup Time of Start Condition SCL↑ to SDA↓	$t_{SU;STA}$	SCL, SDA		4.7	-	-	µs	
Data Hold Time SCL↓ to SDA↑or↓	$t_{HD;DAT}$	SCL, SDA		0	-	3.45 (*2)	µs	
Data Setup Time SDA↑or↓ to SCL↑	$t_{SU;DAT}$	SCL, SDA		0.25	-	-	µs	
Setup Time of Stop condition SCL↑ to SDA↑	$t_{SU;STO}$	SCL, SDA		4	-	-	µs	
Bus-free Time between Stop and Start conditions	t_{BUF}	SCL, SDA		4.7	-	-	µs	

*1: R,C is the resistance and capacitance of SCL, SDA line.

*2: Maximum Value of $T_{HD;DAT}$, Applies only when the device is not extended "L" period of the SCL signal(T_{LOW}).

Figure 9-2 I²C Bus Interface Timing



9.13 DALI Setting Data Retention

Table 9-13 DALI Setting Data Retention

(Ta = +25°C, VIN = 24V)

Parameter	Symbol	Pin Name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
DALI Setting Data Retention Period	-	-	Number of Rewrites : ≤ 1000	20	-	-	year	
			Number of Rewrites : 1001≤, and ≤ 10000	15	-	-		
			Number of Rewrites : 10001≤, and ≤ 100000	10	-	-		
From store command to Power off	-	-	-	5	-	-	s	

10. Description of Functions

10.1 Dimming Function

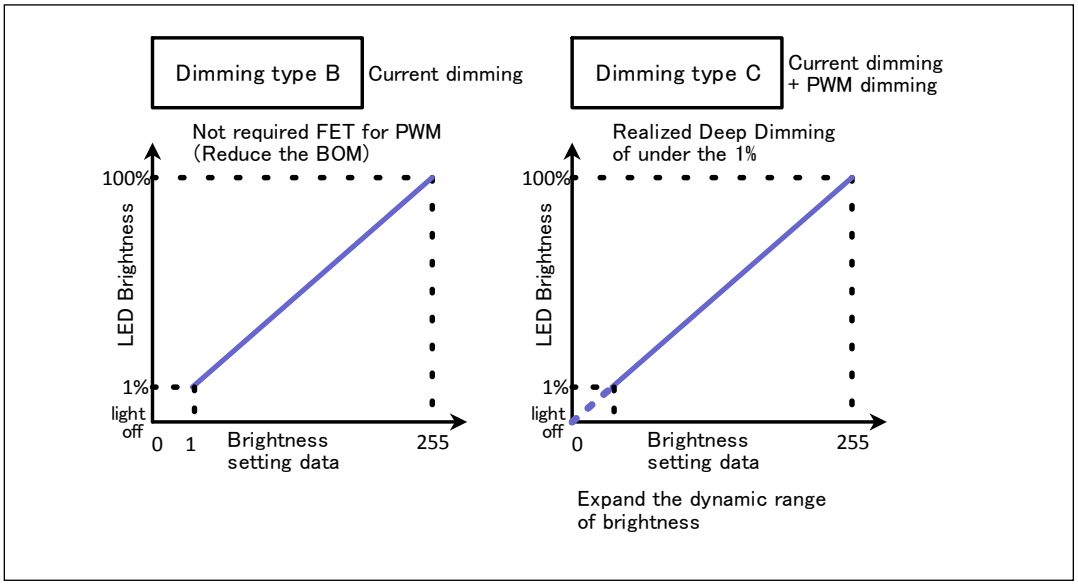
S6AL211 series are integrated with 4channels LED-lighting dimming circuits.

The change in the brightness of the LED, the combination of current dimming (i.e. change the LED current) and the PWM dimming (i.e. change the turning on and off time of the LED) is possible. As a result, you can choose the best dimming type for your application.

Dimming Type B:
It is a dimming method that controls the LED current by brightness setting data. By the LED continuously lighted, flicker-free application can be realized. In addition, FET of the PWM dimming is not required for reduce the BOM.

Dimming Type C:
By adding the PWM dimming to the current dimming, providing deep dimming that expands the dynamic range of brightness. It can output a brightness of less than 1% by the PWM dimming.

Figure 10-1 Dimming Type



Brightness of the LED, you can change the setting through the following equipment.

- Setting from the communication module (DALI, UART (Bluetooth module))
- Motion sensor

UART (Bluetooth module) is possible to set 4 separate channels. Therefore it is possible to toning and dimming for RBGW.

10.2 Constant Current Control

S6AL211 series are integrated with 4ch. constant current control circuit. It based on the step-down (Buck) DC / DC converter.

DC / DC converter generates VOUT voltage from VIN voltage by controlling the ON / OFF duty of external switching FET (Pch.) which connected to DRV_n terminal.

The LED current (ILED) of lighting LED depend on the VF-IF characteristics of the LED. The ILED value is converted into voltage by the detection resistor Rs, and is feedback to the control circuit from CS_n terminal. A control circuit compares and controls the ILED current coincided with the target current value by changing output voltage VOUT.

In the case of only current control (Dimming type B), external PWM FET (Nch.) is not necessary.

Figure 10-2 Constant Current Control and PWM Dimming Circuit

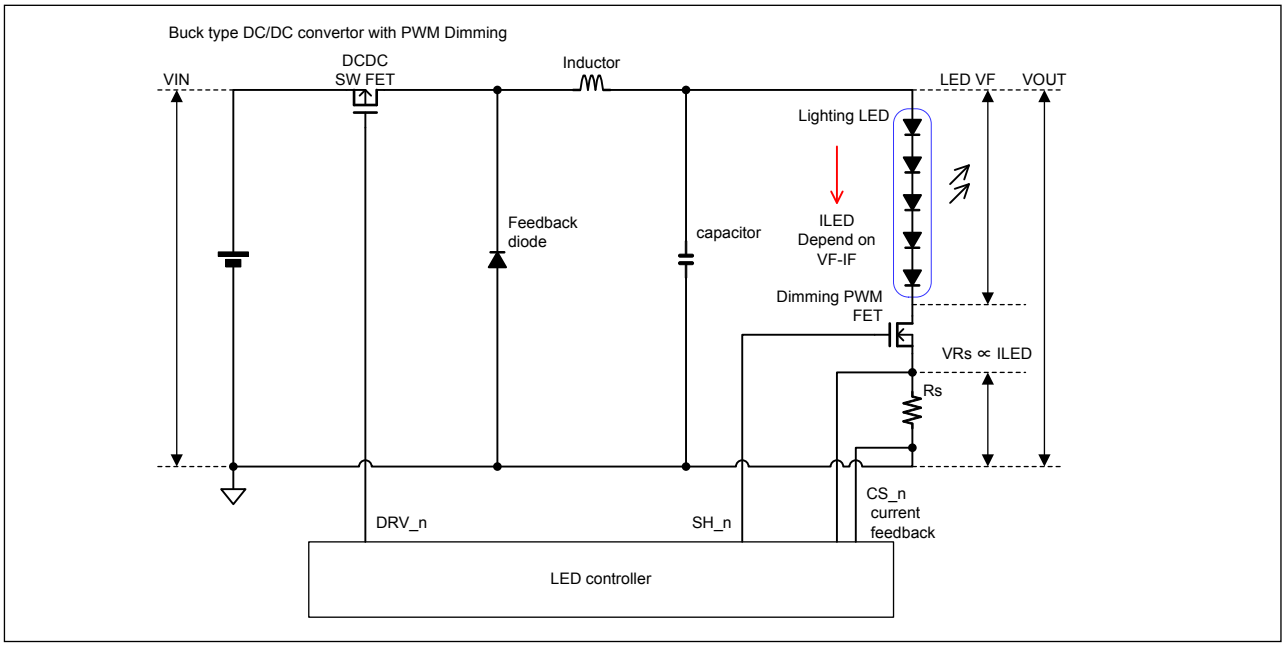
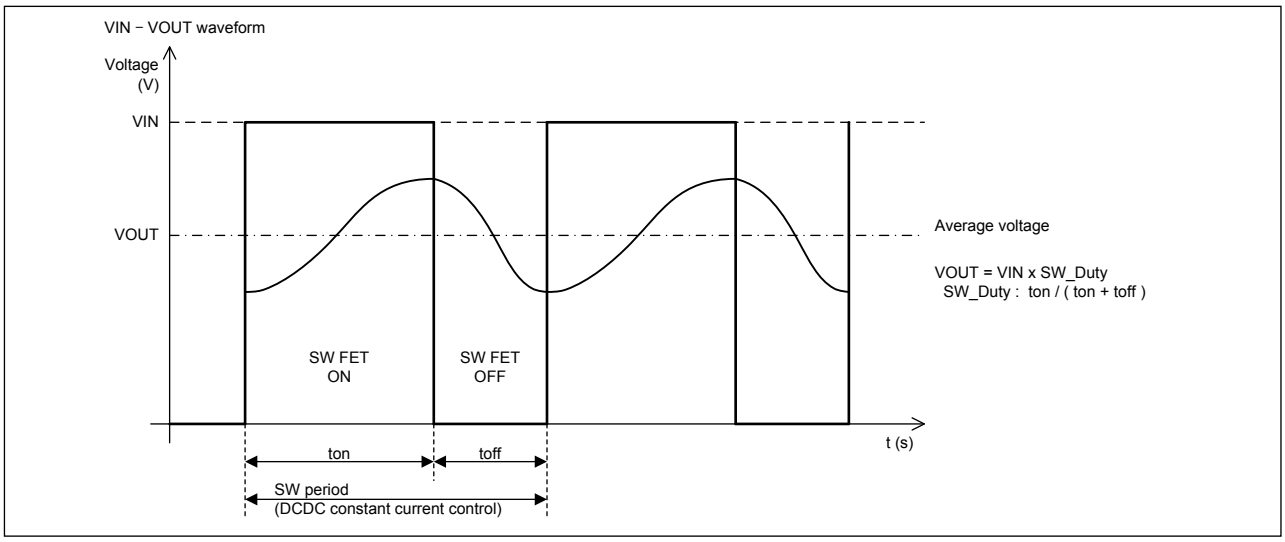
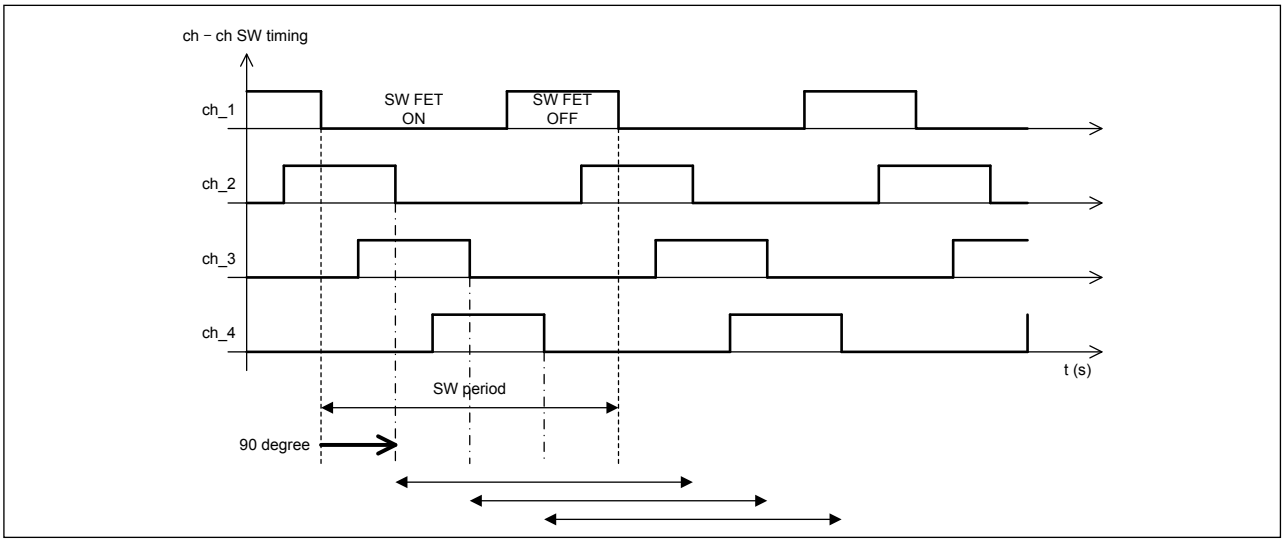


Figure 10-3 Waveform of Constant Current Control



The constant current control circuit shifts the phase of ON timing of each 4ch. external FET to 90 degrees. Therefore, it reduces the switching noise of the circuits.

Figure 10-4 Waveform of ch. - ch. Switching Timing

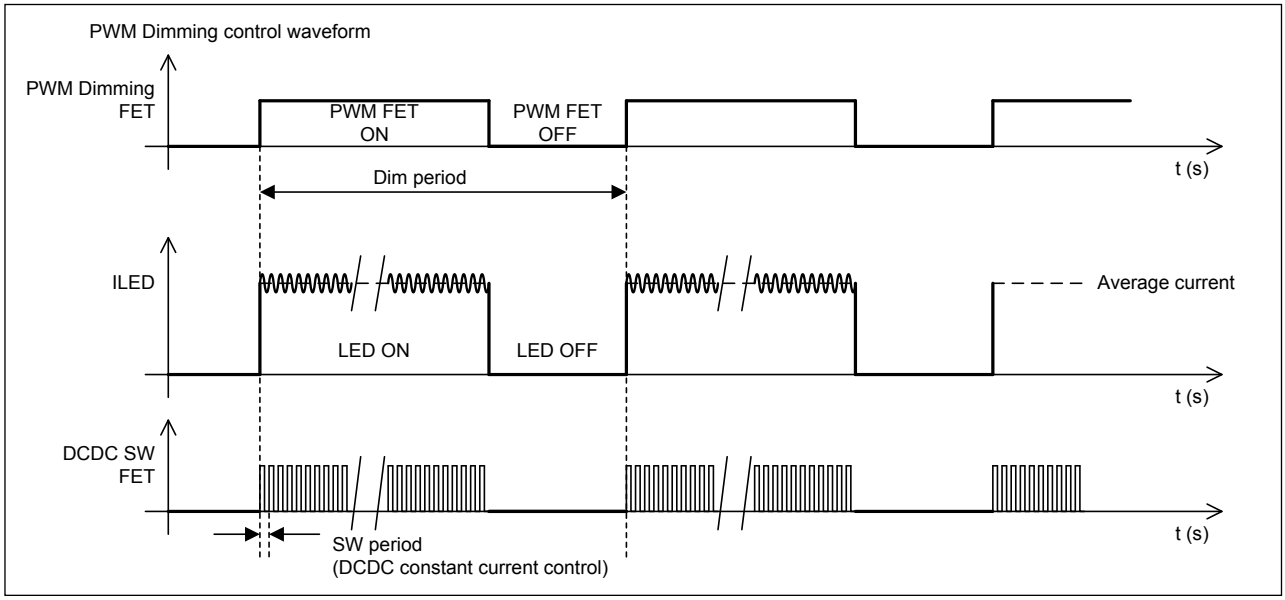


10.3 PWM Dimming Control

PWM dimming performs dimming by constant LED-ON brightness based on fixed current value by the constant current control circuit, according to change the ON / OFF duty of the LED shunt SW of the external.

ON / OFF duty value of the shunt SW according to the value which is set by the communication or the dimmer.

Figure 10-5 Waveform of PWM Dimming Control



10.4 Current Dimming Control

Current dimming performs dimming that according to the value set by the communication or the dimmer to change the current flowing to the constant current control circuit.

10.5 Protection Function

S6AL211 series are integrated with various protection functions. Protection function has 10 protection functions and 4 protection states.

When the protection factor (i.e. Measurement target in for protection) in each protection function exceeds protection conditions (i.e. Detection value and number of detected), it moves to a protection mode. In the protection mode, function of reduce the lighting or lights off, and function of IC operation stop are performed. As a result, the LED circuit and the power supply circuit are protected safely.

<Note>

- *In addition, we have implemented safety considerations by being integrated with various protection functions. However, to prevent smoke or ignition if circuit is failure such as broken the external FET or the IC, should mount the protection circuit or fuse at the power supply circuit.*

10.5.1 Protection States

S6AL211 series have the following 4 protection states.

Dimming Protection, Lights out Protection-1, Lights out Protection-2 and Lights out Protection-3

Reducing LED output current and Keeping lighting-ON to eliminate the protection conditions

Dimming Protection : Lights down operation which reduce the LED output current of 10% from 100% brightness

- “Protection release wait time” is assigned by the Protection States. When during “Protection release wait time” ignores request of brightness increase from communication interfaces (UART and sensor input) (Request of brightness reduce or lights-off are enabled). (*1)
- If the protection condition is detected again during “Protection release wait time”, adds the Lights down operation. It reduces the LED output current of 10% from 100% brightness. In addition, it resets the “Protection release wait time”.
- If lights out (LED output current is zero) as a result of the Dimming Protection, IC moves to the Lights out Protection-2 state.
- When the protection condition is not detected again during “Protection release wait time”, IC moves to the Normal state. And reduced brightness by the Lights down operation is maintained until received the new brightness from communication interface.

Lighting-OFF, if the circuit behavior is abnormal or the protection condition is not eliminated by Dimming Protection

■ Lights out Protection-1: Lights out operation

- After Lights out and “Restart wait time”, IC is initialized for return from the protection state and restarted lighting operation (auto restart). (*2)
- When IC receives communication from communication interface (DALI and UART) during “Restart wait time”, IC is initialized and restarted immediately. (*2)

■ Lights out Protection-2: Lights out operation

- It does not restart automatically. (latch off)
- When IC receives communication from communication interface (DALI and UART), IC is initialized and restarted. (*2)

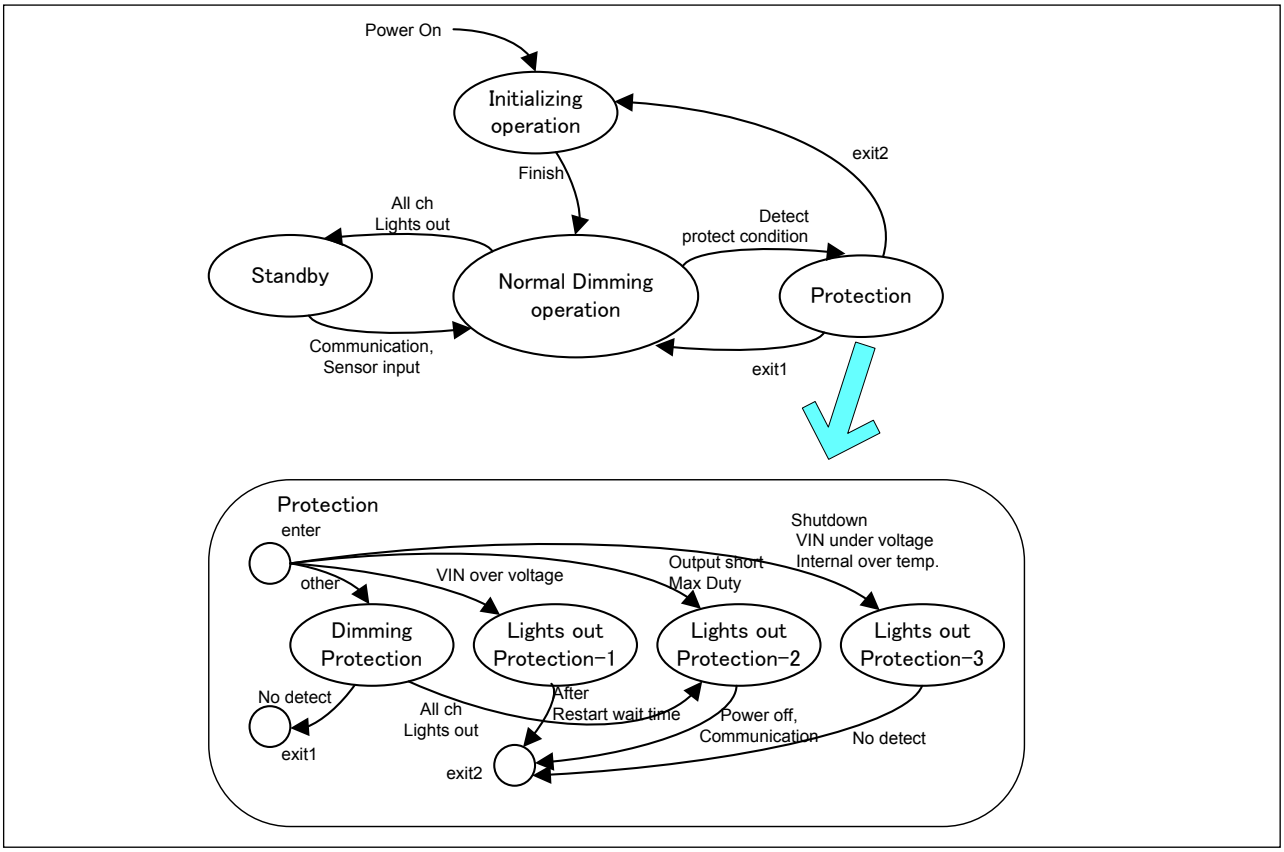
■ Lights out Protection-3: Lights out and Shutdown of IC operation

- IC maintains the protection (Shutdown) state until eliminated of the protection conditions.
- To avoid the failure operation, IC stops functions other than protection and moves to the shutdown.
- When eliminated of the protection conditions, IC is initialized and restarted (auto restart). (*2)

*1: When DALI products, during “Protection release wait time” of Dimming Protection, received brightness set to memory and do not change the brightness. After “Protection release wait time”, changes to the brightness that stored value.

*2: When DALI products, restart to “POWER ON LEVEL”.

Figure 10-6 State flow



10.5.2 Protection Function

Table 10-1 Protection Function

Function	Detect Pin	DRV_1 to 4 SH_1 to 4 (*1)	PCNT (*7)	Protection Conditions	Protection release Condition	State
Initializing operation	-	DRV_x = “H”, SH_x = “L” Stop Switching (All channels)	L	-	-	Initializing operation
Normal Dimming operation	-	Switching	L	-	-	Normal Dimming operation
Output Over Current Protection (*2)	CS_xP, CS_xN	Switching (All channels) − Output current -10% − Disable output current increase	L	CS_xx ≥ set value (*3)	CS_xx < set value (*3) − Enable output current increase	Dimming Protection
Output Short Circuit Protection (*2)	CS_xP, CS_xN	DRV_x = “H”, SH_x = “L” Stop Switching (All channels)	H (*7)	CS_xx ≥ set value (*3)	Re-power supply-on or Receive communication	Lights out Protection-2
Max Duty Protection (*2)	-	DRV_x = “H”, SH_x = “L” Stop Switching (All channels)	H (*7)	(DRV_x Duty) ≥ 98%	Re-power supply-on or Receive communication	Lights out Protection-2
Input Over Voltage Protection	VIN	DRV_x = “H”, SH_x = “L” Stop Switching (All channels)	H (*7)	VIN ≥ set value (*4)	After “Restart wait time” VIN < set value (*4)	Lights out Protection-1
Input Low Voltage Protection	VIN	Switching (All channels) − Output current -10% − Disable output current increase	L	VIN ≤ set value (*4)	VIN > set value (*4) − Enable output current increase	Dimming Protection
Input Under Voltage Shutdown	VIN	DRV_x = “H”, SH_x = “L” Stop Switching (All channels)	X (*6)	VIN ≤ 8.8V	VIN ≥ 9.6V	Lights out Protection-3
External Over Temperature Protection (*2)	TEMPx	Switching (All channels) − Output current -10% − Disable output current increase	L	TEMPx ≤ 1.5V (*5)	TEMPx > 1.5V (*5) − Enable output current increase	Dimming Protection
Internal Over Temperature Protection	IC Internal Temperature	Switching (All channels) − Output current -10% − Disable output current increase	L	Internal Temperature ≥ 110°C	Internal Temperature < 110°C − Enable output current increase	Dimming Protection
Internal Over Temperature Shutdown	IC Internal Temperature	DRV_x = “H”, SH_x = “L” Stop Switching (All channels)	H	Internal Temperature ≥ 150°C	Internal Temperature < 100°C	Lights out Protection-3

Function	Detect Pin	DRV_1 to 4 SH_1 to 4 (*1)	PCNT (*7)	Protection Conditions	Protection release Condition	State
VO Under Voltage Protection	VO (by TEMPx) (*8)	Switching (All channels) − Output current -10% − Disable output current increase	L	TEMPx ≤ 1.5V	TEMPx > 1.5V − Enable output current increase	Dimming Protection

*1: External FETs: DRV_1 to 4 drive Pch. FETs for constant current control, SH_1 to 4 drive Nch. FETs for PWM control.
*2: Protection condition is detected by each channel. Protect operation is performed to all the channels. (Avoid to change in color toning)
*3: Setting value is changed for each LED current and dimming type. Refer to 9.6 Current Detection.
*4: Setting value is changed for each VIN voltage. Refer to 9.3 Power Supply Protection.
*5: Configures of the external circuit of TEMPx input voltage to lower than 1.5V in temperature as external over temperature protection.
*6: It becomes “X” because IC internal power supply circuit for IO stops.
*7: In case of DALI interface products, please refer the hardware manual of S6AL211A21, S6AL211A31 for relation of PCNT output and Query response
*8: Supply the power from VO to external temperature sensors for detects the VO Under Voltage protection by TEMPx terminals.

Note:

- *Value of current and voltage and temperature, which are described in <Protect Function> represents the TYP value of the electrical characteristics. Protection conditions of the actual variation in the range of electrical characteristics.*

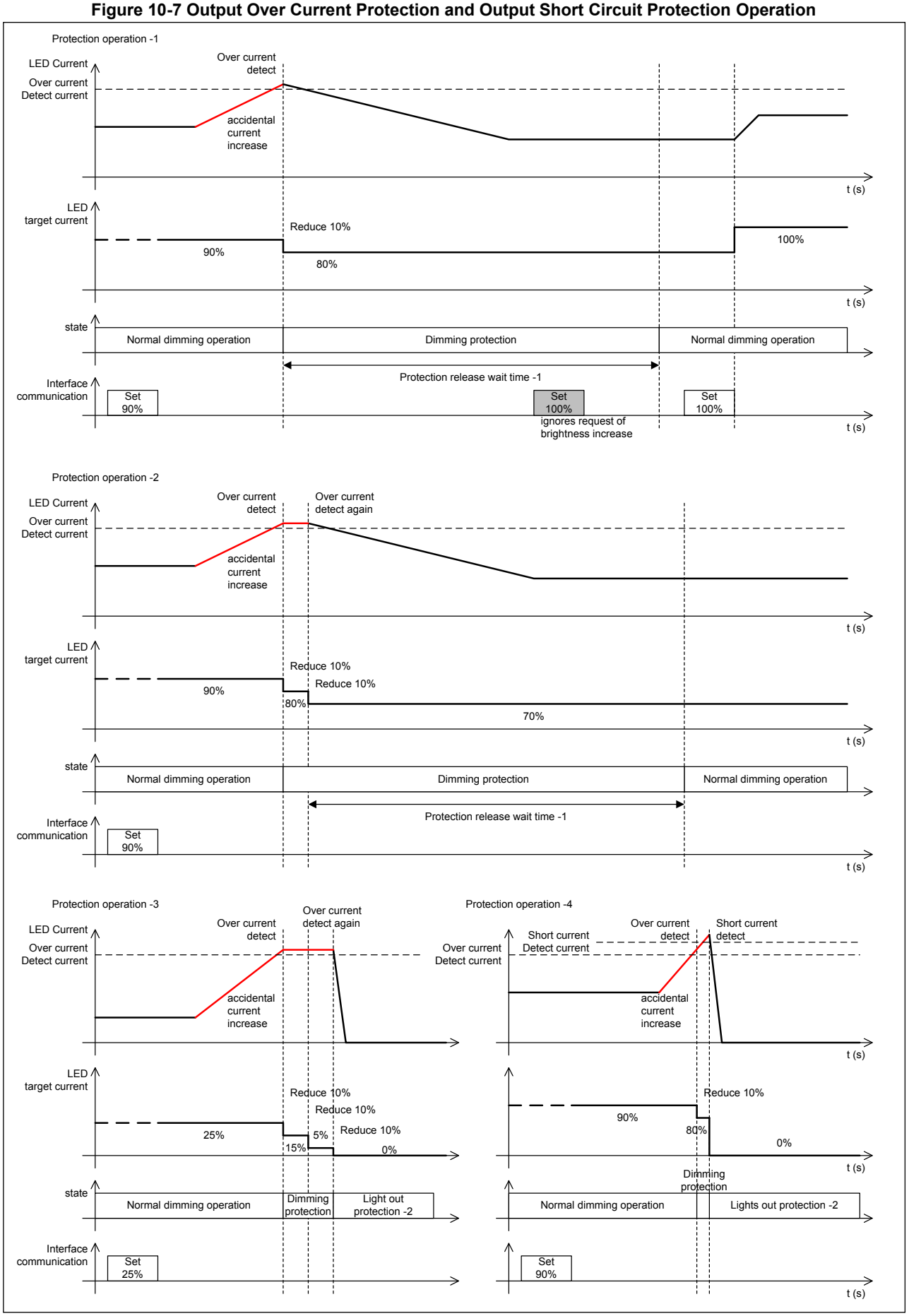
Table 10-2 Protection Release Time

Parameter	Conditions	Value			Unit	Remarks
		Min	Typ	Max		
Protection release wait time -1	Output Over Current Protection, Max Duty Protection, Input Low Voltage Protection	-	10	-	s	Design Standard Value
Protection release wait time -2	External Over Temperature Protection, Internal Over Temperature Protection VO Under Voltage Protection	-	30	-	s	
Restart wait time	Input Over Voltage Protection,	-	4	-	s	

Output Over Current Protection and Output Short Circuit Protection

- This function protects the LEDs from over current.
- Protective factor is the LED current value which measured difference voltage between CS_xP and CS_xN.
- If peak measurement value of the LED output current (I_LED_max) exceeds the “Output Over Current detection Voltage”, “Dimming Protection” is performed as the “Output Over Current Protection”.
- If average measurement value of the LED output current (I_LED_ave) exceeds the “Output Short Circuit detection Voltage”, “Lights out Protection-2” is performed as the “Output Short Circuit Protection”.

Figure 10-7 Output Over Current Protection and Output Short Circuit Protection Operation



Max Duty Protection

- This function protects the output side circuit from over voltage. If not be measured correctly the LED current such as open lighting LEDs, open sense resister, open sense signal line and so on.
- Protective factor is PWM duty (ON time) value which used in DCDC constant current control.
- If duty value exceeds the “Max Duty Protection detection value”, “Lights out Protection-2” is performed as the “Max Duty Protection”.

Input Over Voltage Protection

- This function protects the output side circuit from over voltage.
- Protective factor is VIN voltage value.
- If VIN pin voltage becomes greater than the “Recommended Operating Conditions” (exceeds the “Input Over Voltage Protection Detection Voltage”), “Lights out Protection-1” is performed as the “Input Over Voltage Protection”.

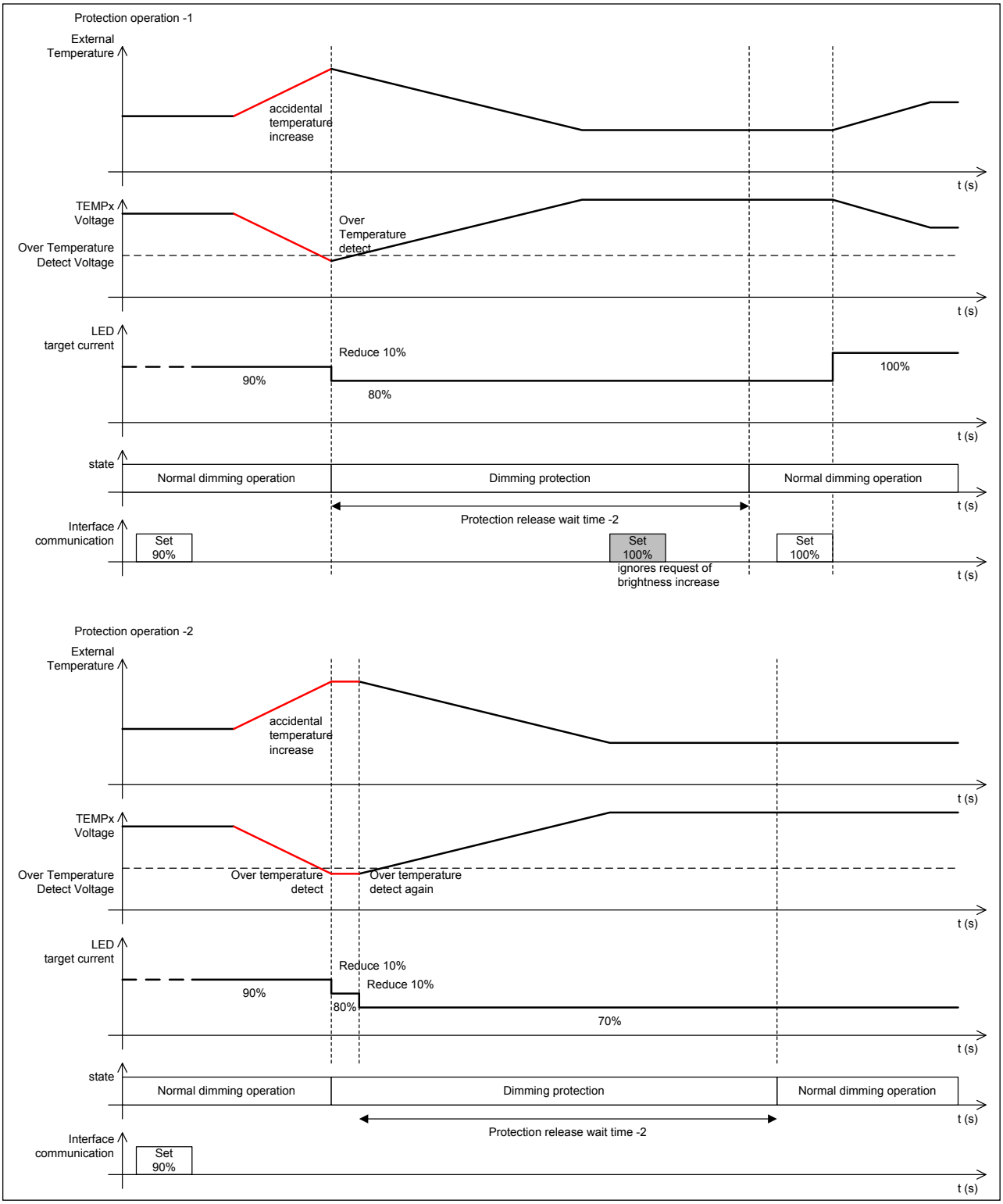
Input Low Voltage Protection and Input Under Voltage Shutdown

- This function protects the failure operation by low power supply voltage to the IC or the power supply circuit from overload.
- Protective factor is VIN voltage value.
- If VIN pin voltage becomes less than the “Recommended Operating Conditions” (exceeds the “Input Low Voltage Protection Detection Voltage”), “Dimming Protection” is performed as the “Input Low Voltage Protection”.
- If VIN pin voltage is under the “Input Under Voltage Shutdown Threshold Voltage”, “Lights out Protection-3” is performed as the “Input Under Voltage Shutdown”.
- When during the shutdown, to avoid the failure operation, IC stops functions other than protection. (3V LDO output also stops)

External Over Temperature Protection

- This function protects the LEDs from breakdown or decrease the life time by cause of the high temperature.
- Protective factor is the temperature value which measured TEMPx pin voltage. It is connecting the external temperature sensor which placed near the LEDs.
- If temperature value is under the “External Over Temperature Protection Detection Voltage”, “Dimming Protection” is performed as the “External Over Temperature Protection”.

Figure 10-8 External Over Temperature Protection Operation



Internal Over Temperature Protection and Internal Over Temperature Shutdown

- This function protects the failure operation or IC breakdown by cause of the IC high temperature.
- Protective factor is the temperature value which measured IC Internal Temperature.
- If temperature value exceeds the “Internal Over Temperature Protection Detection Temperature”, “Dimming Protection” is performed as the “Internal Over Temperature Protection”.
- If temperature value exceeds the “Internal Over Temperature Shutdown Detection Temperature”, “Lights out Protection-3” is performed as the “Internal Over Temperature Shutdown”.

VO Under Voltage Protection

- This function protects the failure operation which connected circuit to VO pin such as temperature sensor, communication circuit by cause of the LDO under voltage.
- Supply the power from VO to external temperature sensors for detects the VO Under Voltage protection by TEMPx terminals.
- Protective factor is the TEMPx input voltage value that relates the VO output voltage value.
- If VO output current value exceeds the “Maximum Output Current”, the LDO Over Current Limit function performed reduce the VO output voltage and current by the conventional fold-back current limiting characteristic, it detected by TEMPx terminals.
- If TEMPx value is under the ‘VO under voltage Protection Detection Voltage’, ‘Dimming Protection’ is performed as the ‘VO Under Voltage Protection’. It shares the operation with ‘External Over Temperature Protection’.

10.5.3 Function of Protection Status Output

S6AL211 series has a feedback output pin (PCNT) for outputting to an external IC. It informs moved to the protection states (Lights out Protection-1, -2 and -3) which has safety problem.

It can be used as a signal which informs the failure lighting to the MCU in the lighting system.

10.6 Standby Function

S6AL211 series are integrated with the standby function.

It reduces the power consumption of the IC by stops the functions other than minimum necessary functions.

Move to the Standby State

When the all channels brightness is set to the Lights out (0% brightness), the LED current flow turns to 0A. Then IC moves to the Standby state after the “Standby transition wait time”.
When IC receives communication from communication interface or input from sensors during the “Standby transition wait time”, IC returns to the Normal Dimming Operation.
And, IC does not move to the Standby state from Lights out by protection function.

Standby State

It is a state of low power consumption. IC stops functions other than the communication interface and sensor inputs for acceptance of return to the Normal Dimming Operation.
3V LDO continues an output.

Return to the Normal State from Standby State

When IC receives communication from communication interface or sensor inputs, IC returns to the Normal Dimming Operation.

Table 10-3 Standby Transition Wait Time

Parameter	Conditions	Value			Unit	Remarks
		Min	Typ	Max		
Standby transition wait time	-	-	4	-	s	Design Standard Value

10.7 Power-on and Power-off

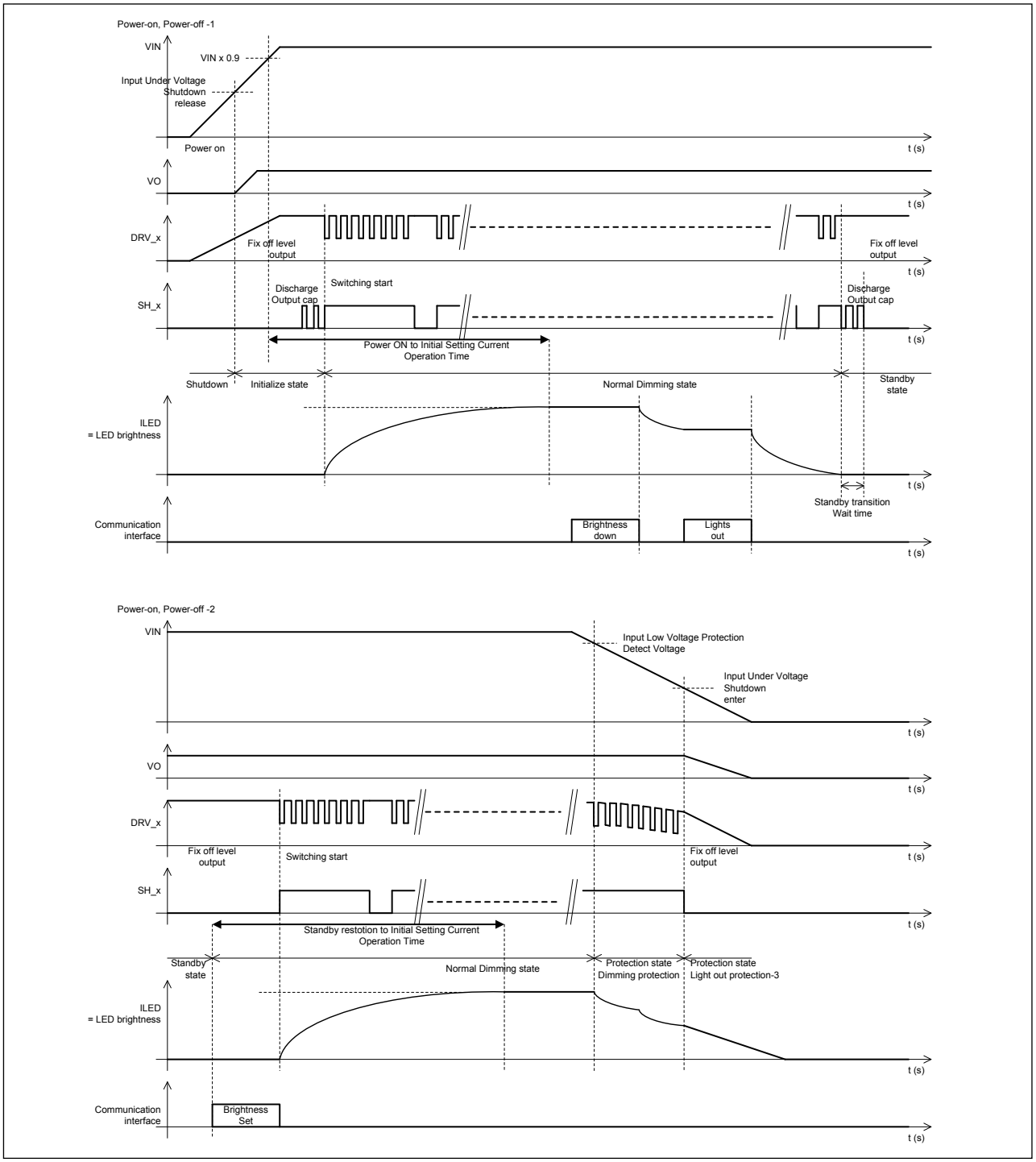
When power is supplied to the S6AL211 series, the constant current control circuit outputs a stable output current to within 0.3s after reaching the recommended operating voltage.

(When don't use the Fade function and DALI, Not include 0.6s of waiting time for the Power Level command.)

After the Power-on, the brightness becomes to the set value "POWER ON LEVEL". (Please refer to the hardware manual of each IC: S6AL211A21, S6AL211A31 and S6AL211A94 for "POWER ON LEVEL".)

If the power supply is stopped without Lights out setting, IC stops switching operation of the constant current control circuit safely by functions of the Input Low Voltage Protection and the Input Under Voltage shutdown.

Figure 10-9 Power-on and Power-off Timing Chart



10.8 LDO

S6AL211 series are integrated a 3V LDO regulator for supplying the power to the peripheral circuits. It can be used, for example, the power supply of the sensors (temperature sensor, ambient light sensor, human motion detect sensor), PullUp power of I^2C Bus and the power supply of the communication module. Therefore it reduces the BOM cost, reduces board mounting area and realizes the other power ICs unnecessary.

LDO continues an output in standby state.

VO pin must be connected to a bypass capacitor.

If the output current of the LDO becomes over current, reduce the output voltage and current by the conventional fold-back current limiting characteristic.

10.9 External Inputs for Dimming

S6AL211A94 corresponds to external input for dimming function of the following.

- Ambient light sensor Input: SENSE3 (ADD3) Pin
- Trigger Input (Human Motion detect sensor): SENSE4 (ADD4) Pin

10.9.1 Ambient Light Sensor Input Dimming (SENSE3/ADD3 Pin)

It operates the dimming control by the ambient light sensor input.

Please refer to the S6AL211A94 hardware manual for details.

10.9.2 Trigger Input Dimming (SENSE4/ADD4 Pin)

It operates the dimming control by trigger signal from the motion (human detect) sensor.

Please refer to the S6AL211A94 hardware manual for details.

10.10 Communication Interfaces

S6AL211 series corresponds to some communication interfaces for dimming and color control function.

Therefore, it can be controlled from the external master devices or the external MCUs.

DALI (S6AL211A21, S6AL211A31)

- Standard : IEC 62386-101 Edition 1.0, -102 Edition 1.0 (Device type 0), -207 Edition 1.0 (Device type 6)
- Master / Slave mode
- Two-wire half-duplex communication
- Transmission rate : 1200bps ±10%

It is necessary of the external IC, the isolation and level conversion circuits.

UART (S6AL211A94)

- Transmission rate : 115.2 kbps(typ)

It can be controlled from the external module which has the UART interface. For example Bluetooth module

It easily makes the remote control system.

I^2C (S6AL211A21, S6AL211A31)

- SCL clock frequency : 75 kHz (max)

10.10.1 DALI

Supported Commands

Supported to the following standards:

- IEC 62386-101 Edition 1.0
- IEC 62386-102 Edition 1.0 (Device type 0)
- IEC 62386-207 Edition 1.0 (Device type 6)

Non-volatile Memory Data Storage

- DALI variable definition data : 38Byte (13+8kinds)
- Memory bank: 48Byte (3banks)

Address Setting Function

After receiving the “INITIAL” command, can be specified short address in one of the following ways:

- Addressing by a physical selection (ADD6 Pin = “H”)
- Random address setting
- Single direct address setting

Fade Control

- Normal rate fade (IEC 62386-102)
- High rate fade (IEC 62386-207)

Configurable Dimming Steps

256 steps (set value 0 : Lights out, set value 254 : 100% brightness, set value 255 : Stop Fading)

Dimmable Channels

Single color (same control to all channels)

Communication Failure Detection

When ADD5 Pin continued to detect a fault level (“L”) of between 500 ms, fault condition is satisfied.
IC performs the specified operation.
Please connect output signal from the diagnosis circuit which is external for DALI communication / Isolation.
When simple failure detection is needed, output signal of external DALI communication / Isolation circuit (connected signal to IF1 pin) connects to ADD5 pin. IC detects DALI signal disconnection which does not need additional external parts.

Data Format

IEC 62386-102

10.10.2 UART

Dimmable Channels
4 channels (such as Red, Green, Blue, White or White×4 etc.)

Assign Channel of 4color Application
ch.1: Red, ch.2: Green, ch.3: Blue, ch.4: White

Dimming Control Curve
Linear and Logarithmic curve

Fade Control
- Fade function : Fade in / Fade out
- Fade time : 0.5s, 1.0s, 2.0s and no fade

Configurable Dimming Steps
256 steps (set value 0 : Lights out, set value 255 : 100% brightness)

Data Format
Please refer to the hardware manual of S6AL211A94.

10.10.3 I^2C

Slave Address
55h

Data Format
Please refer to the hardware manual of S6AL211A21, S6AL211A31 for details.

11. Application Circuit Example

11.1 Application Circuit Example 1

Figure 11-1 Office Base Lighting System : DALI, Dimming Type C, VIN = 24V

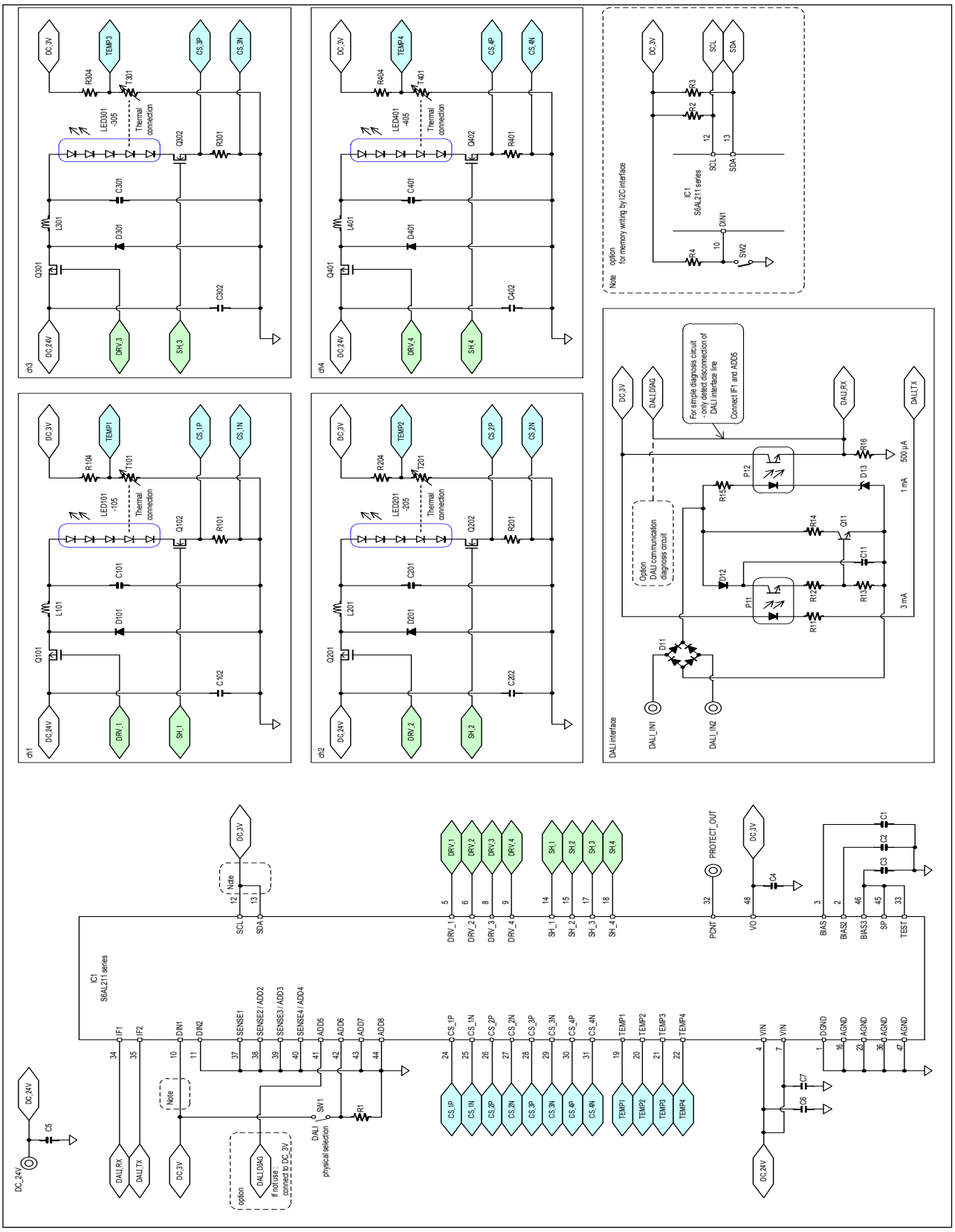


Table 11-1 Recommended Parts List: DALI, Dimming Type C, VIN = 24V

Block	Ref Designator	Value	Unit	Part Number	Vendor (Maker name)	Note
IC	IC1	-	-	S6AL211 series	Cypress	
	C1	0.1	µF	-	-	
	C2	4.7	µF	-	-	
	C3	4.7	µF	-	-	
	C4	4.7	µF	-	-	
	C5	10	µF	-	-	50V or 35V
	C6	100	pF	-	-	50V or 35V
	C7	100	pF	-	-	50V or 35V
	R1	100	kΩ	-	-	
	R2	10	kΩ	-	-	
	R3	10	kΩ	-	-	
	R4	100	kΩ	-	-	
	SW1	-	-	-	-	
	SW2	-	-	-	-	
LED ch.1	Q101	-	-	FDC658AP	FAIRCHILD	30V, Pch. FET
	Q102	-	-	FDC8886	FAIRCHILD	30V, Nch. FET
	D101	-	-	SS23	FAIRCHILD	Vf 0.5V at 2A
	L101	220	µH	SLF12575	TDK	Imax 1.3A
	C101	10	µF	C3216X5R1H106K	TDK	50V
	C102	4.7	µF	-	-	50V or 35V
	R101	0.2	Ω	RL1632R-R200-F	SSM	1/2W
	R102	7.5	kΩ	-	-	
	LED_101-105	-	-	LUW W5AM-KZ-7E-Z	OSRAM	Golden DRAGON Plus white 6500K IF max 1000 mA Vf 3.2V at 350 mA
	T101	-	-	NTCG104EF104FT1	TDK	Thermistor 100 kΩ B25/85 4308K
LED ch.2, 3, 4	same parts as LED ch.1					
DALI interface	D11	-	-	MB2S	FAIRCHILD	bridge diode 200V, 0.5A
	D12	-	-	MBR140SFT1	ON semiconductor	Schottky Barrier diode
	D13	-	-	MMSZ5229B	FAIRCHILD	Zener Diode, 4.3V, 0.5W
	P11	-	-	PS2561L-1-A	CEL	Photo coupler
	P12	-	-	PS2561L-1-A	CEL	Photo coupler
	Q11	-	-	FMMT491A	Diodes	NPN Tr, 40V
	C11	22	µF	-	-	50V or 35V
	R11	680	Ω	-	-	
	R12	330	Ω	-	-	
	R13	3.3	kΩ	-	-	
	R14	4.7	Ω	-	-	
	R15	10	kΩ	-	-	
	R16	5.6	kΩ	-	-	

Cypress	:	Cypress Semiconductor Corp.
FAIRCHILD	:	Fairchild Semiconductor International, Inc.
TDK	:	TDK Corporation
SSM	:	Susumu Co., Ltd
OSRAM	:	OSRAM Opto Semiconductors Inc.
ON semiconductor	:	ON Semiconductor
CEL	:	California Eastern Laboratories, Inc.
Diodes	:	Diodes Incorporated

11.2 Application Circuit Example 2

Figure 11-2 Consumer Down Lighting System: UART, Dimming Type C, VIN = 24V

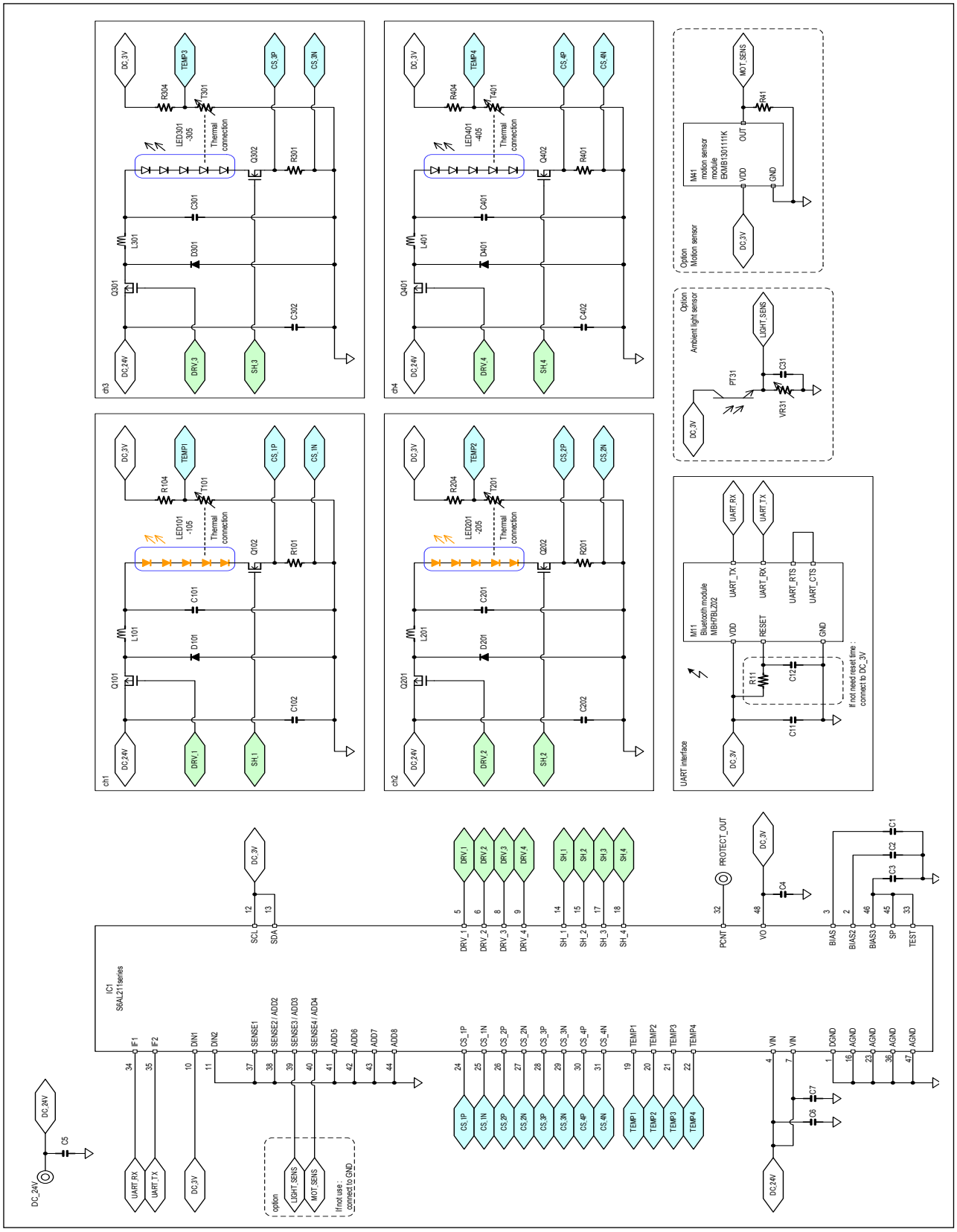


Table 11-2 Recommended Parts List: UART, Dimming Type C, VIN = 24V

Block	Ref Designator	Value	Unit	Part Number	Vendor (Maker name)	Note
IC	IC1	-	-	S6AL211 series	Cypress	
	C1	0.1	µF	-	-	
	C2	4.7	µF	-	-	
	C3	4.7	µF	-	-	
	C4	4.7	µF	-	-	
	C5	10	µF	-	-	50V or 35V
	C6	100	pF	-	-	50V or 35V
	C7	100	pF	-	-	50V or 35V
LED ch.1	Q101	-	-	FDC658AP	FAIRCHILD	30V, Pch. FET
	Q102	-	-	FDC8886	FAIRCHILD	30V, Nch. FET
	D101	-	-	SS23	FAIRCHILD	Vf 0.5V at 2A
	L101	220	µH	SLF12575	TDK	Imax 1.3A
	C101	10	µF	C3216X5R1H106K	TDK	50V
	C102	4.7	µF	-	-	50V or 35V
	R101	0.2	Ω	RL1632R-R200-F	SSM	1/2W
	R102	7.5	kΩ	-	-	
	LED_101-105	-	-	LCW W5AM-KX-7U-Z	OSRAM	Golden DRAGON Plus warm white 2700K IF max 1000 mA, Vf 3.2V at 350 mA
	T101	-	-	NTCG104EF104FT1	TDK	Thermistor B25/85 4308K 100 kΩ
LED ch.2	same parts as LED ch.1					
LED ch.3	LED_301-305	-	-	LUW W5AM-KZ-7E-Z	OSRAM	Golden DRAGON Plus white 6500K IF max 1000 mA, Vf 3.2V at 350 mA
	Other parts are same as LED ch.1.					
LED ch.4	same parts as LED ch.3					
UART interface	M11	-	-	MBH7BLZ02	Fujitsu component	Bluetooth model Ver 4.0 Low energy
	C11	1	µF	-	-	
	C12	-	µF	-	-	if need reset time
	R11	-	kΩ	-	-	if need reset time
Ambient light sensor	C31	0.1	µF	-	-	
	VR31	27	kΩ	-	-	target 13.3 kΩ at 2V/150 µA
	PT31	-	-	NJL7502L	JRC	photo Tr target 300lx at 150 µA
Motion sensor	M41	-	-	EKMB1301111K	Panasonic	Passive Infrared Ray motion sensor module PaPIRs 6 µA
	R41	270	kΩ	-	-	11 µA

Cypress	:	Cypress Semiconductor Corp.
FAIRCHILD	:	Fairchild Semiconductor International, Inc.
TDK	:	TDK Corporation
SSM	:	Susumu Co., Ltd
OSRAM	:	OSRAM Opto Semiconductors Inc.
Fujitsu component	:	FUJITSU COMPONENT LIMITED
JRC	:	Japan Radio Co., Ltd.
Panasonic	:	Panasonic Corporation

11.3 Number of Series LEDs

The number of series LEDs by the Dimming type is in the following table.

Table 11-3 Number of Series LEDs

Typical Power Supply Voltage	Dimming Type	LED		Number of Series LEDs
		LED Current at 100% Brightness	Maximum LED Vf Voltage	
24V	B	1A	4.1V at 1A	5
24V	C	1A	4.1V at 1A	5

Note :

- *LED should be selected of exceeding the following maximum rating current value.*

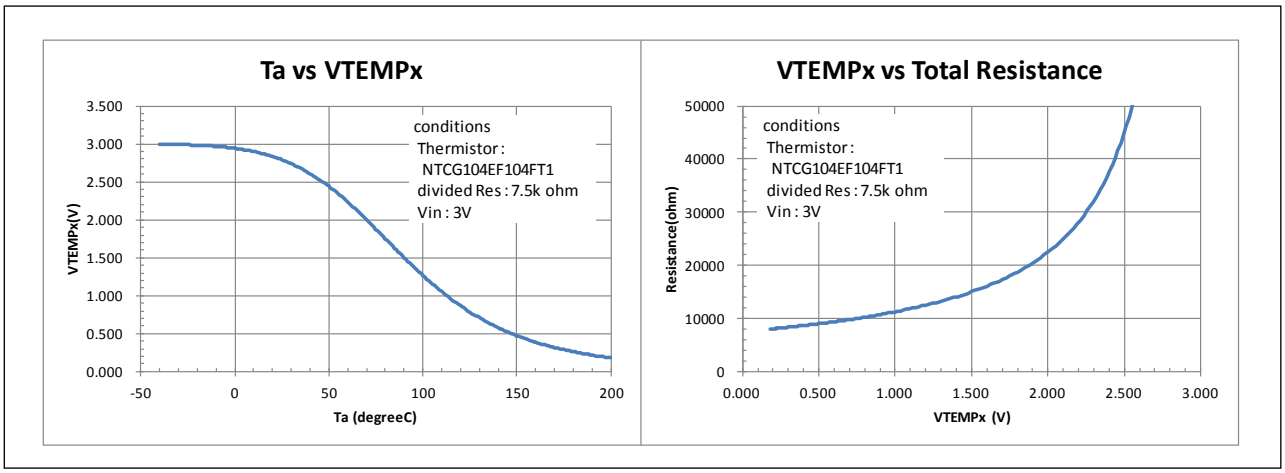
  Common of the Dimming Type B and C

  1.0A at Duty 100%

  2.2A at under 1 ms

11.4 Temperature Sensor Characteristics of Circuit Example

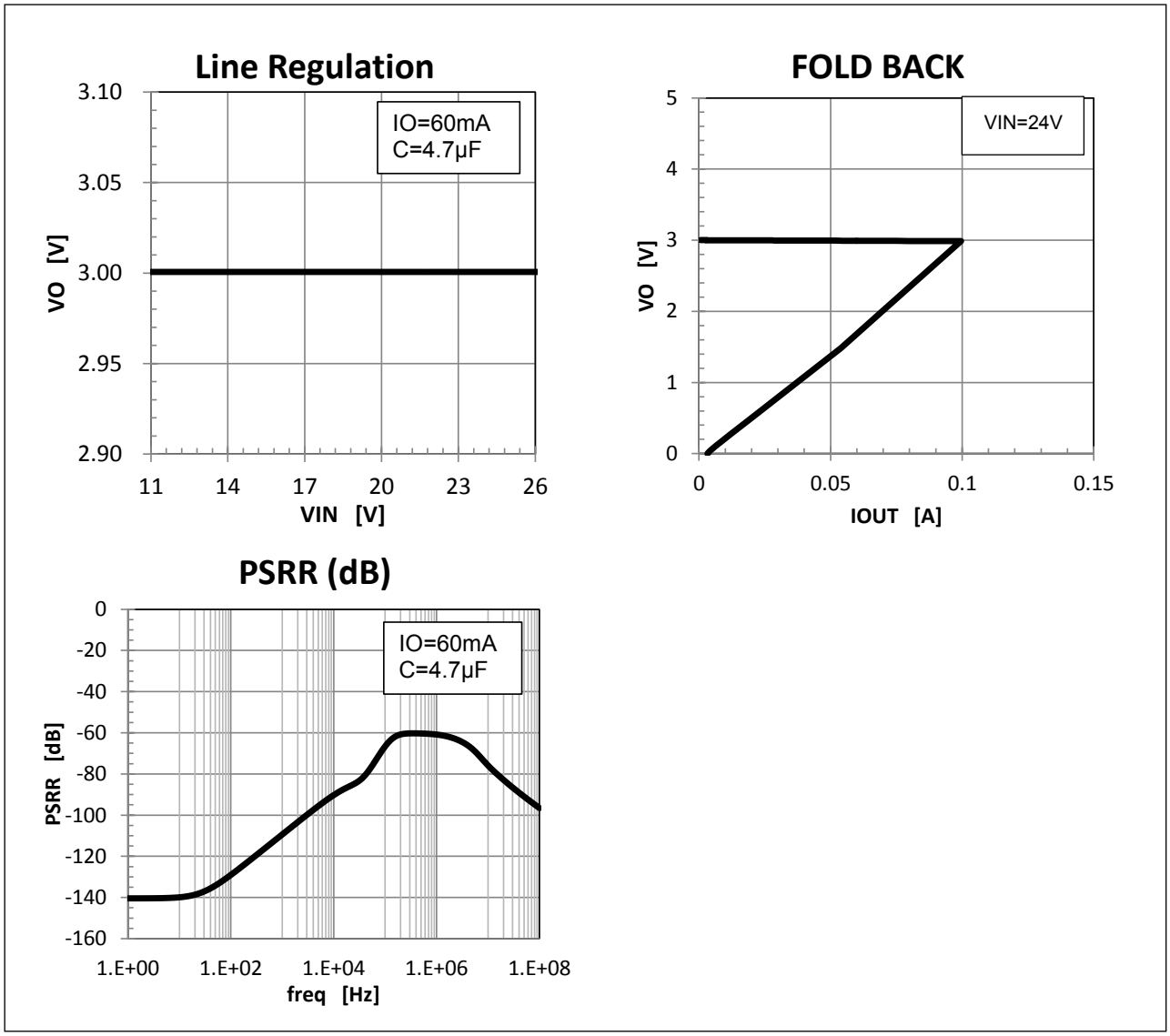
Figure 11-3 Temperature Sensor Characteristics of Circuit Example



12. Typical Characteristics

12.1 LDO

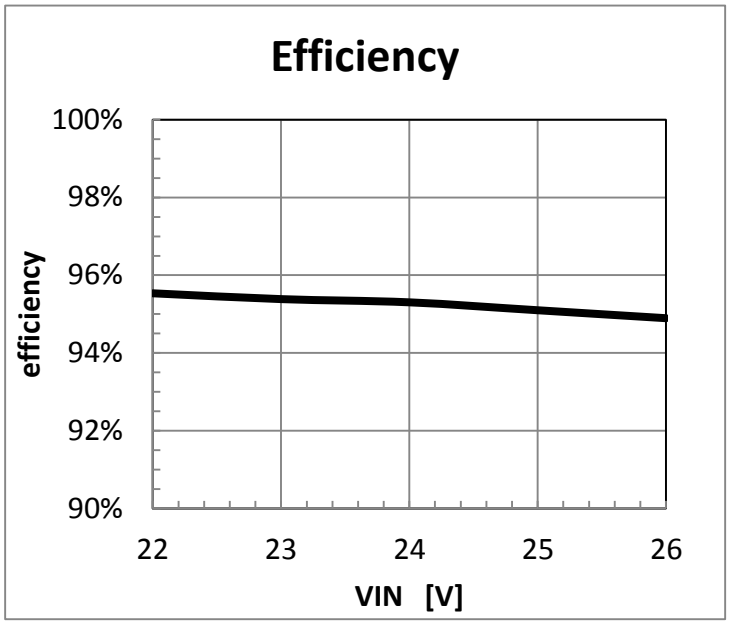
Figure 12-1 LDO Typical Characteristics



12.2 Efficiency

Efficiency : LED Output Power (=LED Current×LED Vf) / Input Power

Figure 12-2 Efficiency Typical Characteristics



13. Usage Precautions

Do not configure the IC over the maximum ratings.

If the IC is used over the maximum ratings, the LSI may be permanently damaged.

It is preferable for the device to normally operate within the recommended usage conditions. Usage outside of these conditions can have an adverse effect on the reliability of the LSI.

Use the device within the recommended operating conditions.

The recommended values guarantee the normal LSI operation under the recommended operating conditions.

The electrical ratings are guaranteed when the device is used within the recommended operating conditions and under the conditions stated for each item.

Printed circuit board ground lines should be set up with consideration for common impedance.

Take appropriate measures against static electricity.

- Containers for semiconductor materials should have anti-static protection or be made of conductive material.
- After mounting, printed circuit boards should be stored and shipped in conductive bags or containers.
- Work platforms, tools, and instruments should be properly grounded.
- Working personnel should be grounded with resistance of 250 kΩ to 1 MΩ in serial between body and ground.

Do not apply negative voltages.

The use of negative voltages below - 0.3V may make the parasitic transistor activated to the LSI, and can cause malfunctions.

14. Ordering Information

Table 14-1 Ordering Information

Part Number	Package	Interface	Dimming Type	Remarks
S6AL211A21	Plastic, LQFP48	DALI	B	-
S6AL211A31			C	-
S6AL211A94		UART(Bluetooth)	C	-

15. Recommended Mounting Conditions [JEDEC Level3] Lead Free

15.1 Recommended Reflow Condition

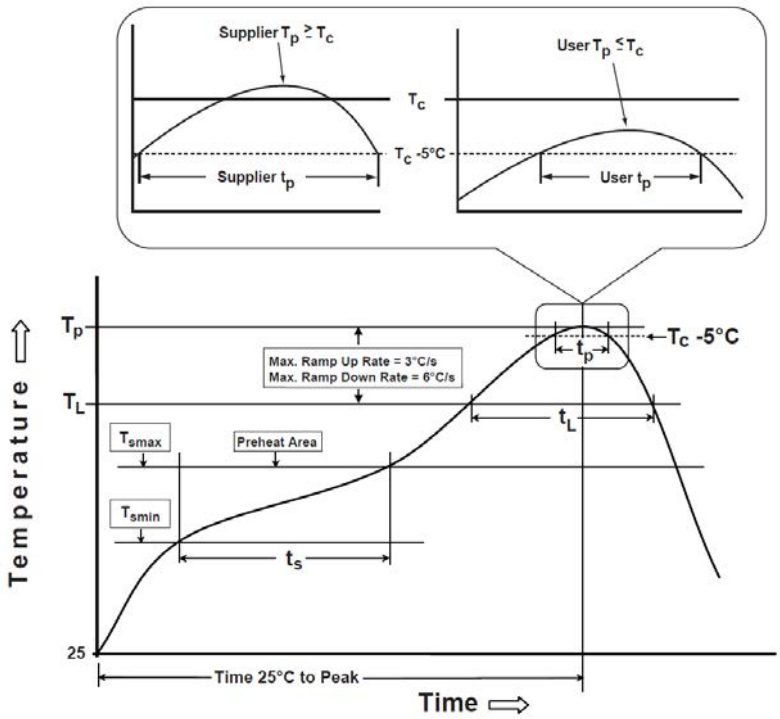
Table 15-1 Recommended Reflow Condition

Items	Contents	
Method	IR(Infrared Reflow) / Convection	
Times	3 times in succession	
Floor life	Before unpacking	Please use within 2 years after production.
	From unpacking to reflow	Within 7 days
	In case over period of floor life(*1)	Baking with 125°C+/-3°C for 24hrs+2hrs/-0hrs is required. Then please use within 7 days. (Please remember baking is up to 2 times)
Floor life condition	Between 5°C and 30°C and also below 60%RH required. (It is preferred lower humidity in the required temp range.)	

*1: Concerning the Tape & Reel product, please transfer product to heatproof tray and so on when you perform baking.
Also please prevent lead deforming and ESD damage during baking process.

15.2 Reflow Profile

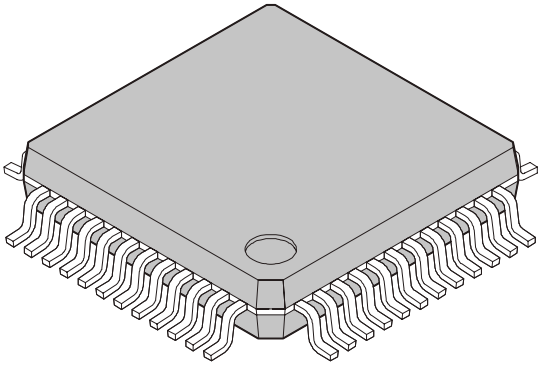
Figure 15-1 Reflow Profile



260°C Max. (J-STD-020D)	
T_L to T_P : Ramp Up Rate	3°C/s Max.
T_S : Preheat & Soak	150 to 200°C, 60 to 120s
T_P - t_P : Peak Temperature	260°C Down, within 30s
T_L - t_L : Liquidous Temperature	217°C, 60 to 150s
T_P to T_L : Ramp Down Rate	6°C/s Max.
Time 25°C to Peak	8min Max.

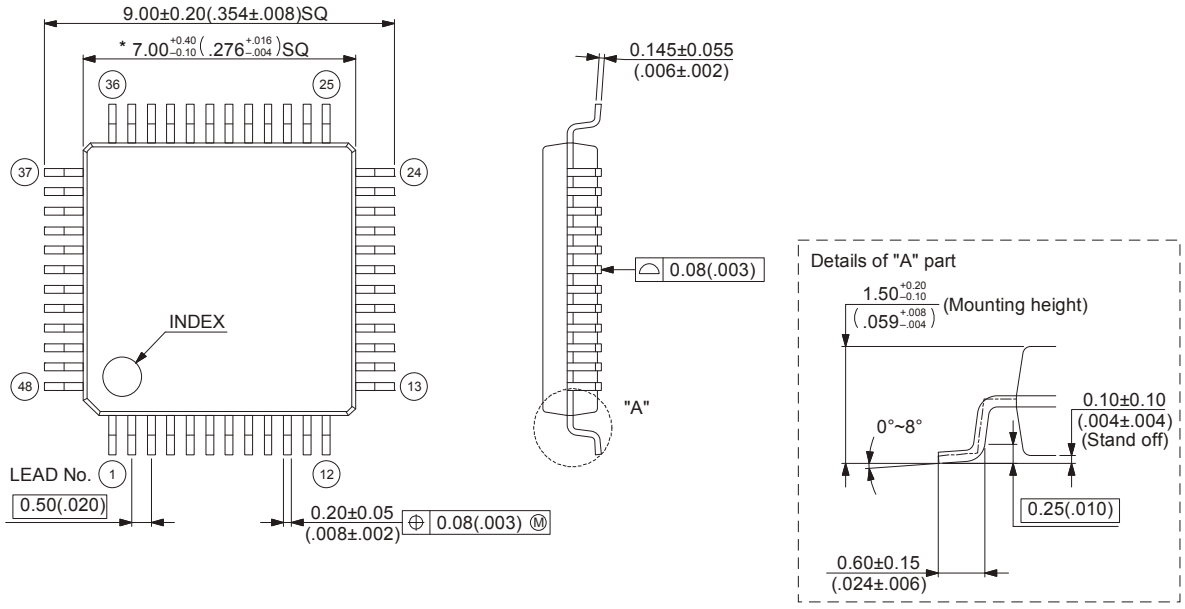
Temperature on the top of the package body is measured.

16. Package Dimensions

48-pin plastic LQFP		
 (FPT-48P-M26)	Lead pitch	0.50 mm
	Package width × package length	7 mm × 7 mm
	Lead shape	Gullwing
	Sealing method	Plastic mold
	Mounting height	1.70 mm MAX
	Weight	0.17 g
	Code (Reference)	P-LFQFP48-7×7-0.50

48-pin plastic LQFP
(FPT-48P-M26)

Note 1) * : These dimensions include resin protrusion.
Note 2) Pins width and pins thickness include plating thickness.
Note 3) Pins width do not include tie bar cutting remainder.



Dimensions in mm (inches).
Note: The values in parentheses are reference values.

17. Major Changes

Page	Section	Change Results
Revision 0.1		
-	-	Initial release
Revision 1.0		
-	-	Preliminary → Full Production
Revision 2.0		
44, 45	11.2 Application Circuit Example 2	Change a recommended part of motion sensor. Change the note of R41.
51	15. Recommended mounting conditions [JEDEC Level3] Lead Free	Section " Recommended mounting conditions [JEDEC Level3] Lead Free" added
Revision 3.0		
18	9.7 Gate Driver for Switching FET	Removed description of Diming type A.
19	9.8 Constant Current Control	
22	10.1 Dimming Function	
46	11.3 Number of Series LEDs	

Colophon

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