Datasheet

Power LSI series for Digital Camera and Digital Video Camera

6ch Internal Power MOSFET System Switching Regulator + 1ch LDO

BD9361GUL

●Outline

6-Channel Switching Regulator Controller for Digital Camera that contains an internal FET, and 1-Channel LDO.
It is optimal power supply composition for Digital Camera or Digital Video Camera which carries CMOS sensor.
It contributes to mounting area reduction, because CH1～CH4 have built-in feedback resister and WL-CSP of compact package is adopted.

●Features

1) 2.5V minimum input operating, and Supplies power for the internal circuit by step-up converter(CH1).
2) CH1 step-up converter, CH2 cross converter, CH3,4 step-down converter CH5 step-down converter controllable output voltage by external resister.CH6 boost converter for LED,
3) All channels contain internal Power MOSFET and compensation.
4) Operating frequency of 2.0 MHz (CH3,4,5) and 1.0MHz (CH1,2,6).
5) Includes Over Voltage Protection (OVP) for CH1, 2, 6.
6) Includes LDO controllable output voltage by serial communication.
7) Contains sequence control circuit for CH1～3. It is possible to select sequence CH1⇒CH3⇒CH4⇒CH2 and CH1⇒CH4⇒CH3⇒CH2 by SEQ_CTL pin CH1, 2, 3, 4. CH5, 6, and LDO are possible to turn ON/OFF by serial communication.
8) Built-In discharge switch (CH2,3,4) and contains off sequence control circuit for CH1～4 with inverted start-up sequence.
9) Included cut off output voltage circuit during over current (timer latch type).
10) Include back-gate control for CH1 with soft start function

●Use

For Digital Camera, Digital Video Camera

●Key Specifications

・Input voltage accuracy :	2.5V～5.5V
・Output voltage	
CH1 output voltage:	5.0V±1.5%(typ.)
CH2 output voltage:	3.3V±1.5% (typ.)
CH3 output voltage:	1.1V±1.5% (typ.)
CH4 output voltage (VOSEL4=H):	1.8V±1.5% (typ.)
CH4 output voltage (VOSEL4=L):	1.5V±1.5% (typ.)
CH5 reference voltage:	0.8V±1.25% (typ.)
CH6 reference voltage:	0.4V±5.0% (typ.)
LDO output voltage:	2.8V±1.5% (typ.)
・Load current	
CH1 load current:	1.0A (max)
CH2 load current:	800mA (max)
CH3 load current:	1.5A (max)
CH4 load current:	800mA (max)
CH5 load current:	500mA (max)
CH6 load current:	50mA (max)
LDO load current:	200mA (max)
・Frequency(CH3,4,5):	2.0MHz(typ.)
・Frequency (CH1,2,6):	1.0MHz(typ.)

●Function block diagram

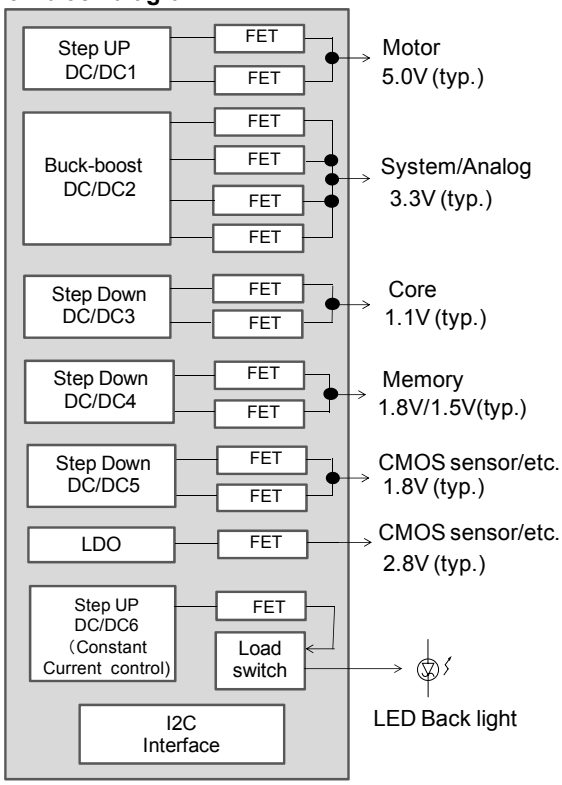

Fig1. Function block diagram

●package

WLCSP package（3.14mm×3.14mm 0.5mm pitch）

●PIN Assignments (TOP VIEW)

	1	2	3	4	5	6
A	PGND3	LX3	HX3	VOUT2	LX22	PGND2
B	LX6	SEQ_CTL	SDA	SCL	VOSEL4	LX21
C	PGND6	LED	VOUT6	STB1234	VDD	HX2BAT
D	HX4	INV6	VO3	VO2	VO1	HX1
E	LX4	VO4	INV5	GND	VCCOUT	LX1
F	PGND45	LX5	HX5	VINREG	REGOUT	PGND1

Fig2. PIN Assignments

○Products：Silicon monolithic IC ○This product is not designed for normal operation with in a radioactive

Status of this document
The Japanese version of this document is the official specification. Please use the translation version of this document as a reference to expedite understanding of the official version.
If these are any uncertainty in translation version of this document, official version takes priority.

●Block Diagram

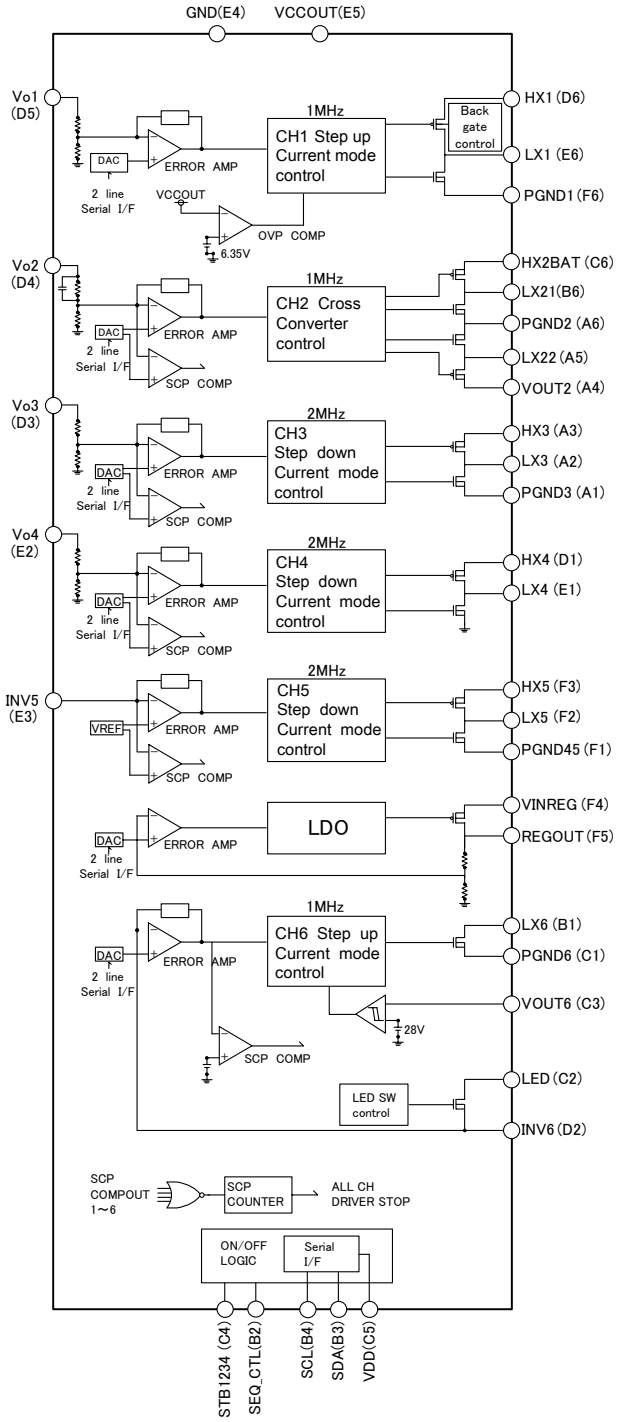

Fig3. Block diagram

●Pin description

No.	Symbol	Description
E5	VCCOUT	IC Power Supply Input in part of controller Please connect to HX1 terminal. Please connect 10uF ceramic capacitor to this terminal.
C5	VDD	Power Supply Input for serial signal. Please connect 1uF ceramic capacitor to this terminal.
E4	GND	Ground terminal
F6,A6,A1,F1,C1	PGND1,2,3,45,6	Ground for Internal FET
D6	HX1	Terminal for output voltage of CH1 (step-up). Please connect to VCCOUT terminal.
A3,D1,F3	Hx2BAT,HX3,4,5	The power supply to switching regulator is inputted into this terminal. This terminal supplies power to output stage of switching regulator and control circuit.
E6,A2,E1,F2,B1	Lx1,3,4,5,6	Terminal for Connecting Inductor. Please refer to the 13 page for recommended value.
A4	VOUT2	CH2 DC/DC Output
B6	Lx21	Terminal for Connecting Inductor For CH2 Input
A5	Lx22	Terminal for Connecting Inductor For CH2 Output
D5,D4,D3,E2	Vo1,2,3,4	Output voltage Feed-back pin Please connect each channel's output to Vo1～Vo4 terminals, because CH1～CH4 have built-in feedback resister.
E3,D2	INV5,6	Error Amp Inverted Input Please refer to the 21 page for the calculation method of feedback resister.
F4	VINREG	LDO Input terminal
F5	REGOUT	LDO Output terminal
C3	VOUT6	CH6 DC/DC OVP monitor terminal
C2	LED	Terminal for connecting LED Cathode
C4	STB1234	ON/OFF switch H: operating over 1.5V
B4	SCL	2 Line serial clock Input Pin
B3	SDA	2 Line serial data Input Pin
B5	VOSEL4	CH4 initial Output voltage control pin (HX2BAT:1.8V,GND:1.5V) Please regularly connect this terminal to HX2BAT or GND.
B2	SEQ_CTL	Sequence control terminal HX2BAT:CH1→CH3→CH4→CH2 GND: CH1→CH4→CH3→CH2 Please regularly connect this terminal to HX2BAT or GND.

●**Absolute maximum ratings（Ta＝25℃）**

Item	Symbol	Limit	Unit
Maximum applied power Supply voltage	HX2BAT, VCCOUT	−0.3～7	V
Maximum applied input voltage	VHx1～5,	−0.3～7	V
	VINREG	−0.3～7	V
	VLx6	−0.3～30	V
Maximum Output current	IomaxHx1, Lx1	±2.8	A
	IomaxHx2BAT	±2.5	A
	IomaxHx3	±2.0	A
	IomaxHx4,5	±1.0	A
	IomaxLx6	±1.0	A
	REGOUT	300	mA
Power Dissipation	Pd	1.25 (*1)	W
Operating Temperature	Topr	−25～+85	℃
Storage Temperature	Tstg	−55～+150	℃
Junction Temperature	Tjmax	+150	℃

*1 Should be derated by 10.0mW/℃ at Ta=25℃ or more. When mounted on a glass epoxy PCB of 50mm×50 mm×1.74 mm

●**Operating condition**

Item	Symbol	Limit			Unit
		MIN	TYP	MAX	
HX2BAT voltage (Power supply voltage)	HX2BAT	2.5	-	5.5	V
VDD voltage (serial traffic power supply voltage)	VDD	1.5	-	3.6	V
Control input voltage	Vin	0	-	VDD	V
SCL input frequency range	Fscl	-	-	400	KHz
LDO terminal connection capacity	CoLDO	1.0	2.2	-	uF

●**Protective functions**

Item	SCP	OCP	OVP	condition
CH1 Boost synchronous rectification	○	○	○	Stop when shorted output OVP: HX1 monitor
CH2 Cross synchronous rectification	○	○	○	SCP: Vo monitor OVP:VOUT2 monitor
CH3 Buck synchronous rectification	○	○	×	SCP: Vo monitor
CH4 Buck synchronous rectification	○	○	×	SCP: Vo monitor
CH5 Buck synchronous rectification	○	○	×	SCP: Error amp output (internal node) monitor
CH6 Boost back light	×	○	○	OVP: VOUT6 monitor

●**Over current protective part**

Item	Symbol	Limit			Unit	condition
		MIN	TYP	MAX		
CH1 LX1 OCP detecting current	IOCP1	2.8	−	−	A	
CH2 HX2BAT OCP detecting current	IOCP2	2.5	−	−	A	
CH3 HX3 OCP detecting current	IOCP3	2.0	−	−	A	
CH4 HX4 OCP detecting current	IOCP4	1.2	−	−	A	
CH5 LX5 OCP detecting current	IOCP5	1.2	−	−	A	
CH6 Lx6 OCP detecting current	IOCP7	1.2	−	−	A	

●**Electrical characteristics**

（Unless specified, Ta=25℃, VCCOUT=5.0V, HX, HX2BAT,REGIN=3.6V, STB1234=3.0V, ALL DCDC, LOD ON）

Item	Symbol	Limit			Unit	condition
		MIN	TYP	MAX		
【 Low-voltage input malfunction prevention circuit 】						
Detecting voltage (HX2BAT)	Vstd1B	-	2.1	2.2	V	HX2BAT monitor
Release voltage (HX2BAT)	Vstd2B	2.0	2.2	2.4	V	HX2BAT monitor
Hysteresis width	⊿VstdB	50	100	200	mV	
Detecting voltage (VCCOUT)	Vstd1V	-	2.3	2.4	V	VCCOUT monitor
Release voltage (VCCOUT)	Vstd2V	2.3	2.5	2.7	V	VCCOUT monitor
Hysteresis width	⊿VstdV	100	200	300	mV	
【Short Circuit Protection】						
SCP detect time	Tscp	16	21	26	ms	
Timer start threshold voltage	Vscp2	1.31	1.68	2.04	%	Vo2 monitor
Timer start threshold voltage	Vscp3	0.42	0.54	0.66	%	Vo3 monitor
Timer start threshold voltage	Vscp4	0.69	0.89	1.08	%	Vo4 monitor
Timer start threshold voltage	Vscp5	0.28	0.36	0.44	V	INV5 monitor
【OVP】						
CH1 OVP Threshold	VOVP1	5.75	6.35	6.95	V	HX1 monitor
CH2 OVP Threshold	VOVP2	5.75	6.35	6.95	V	VOUT2 monitor
CH6 OVP Threshold	VOVP6	26.5	28	29.5	V	VOUT6 monitor
【Output Voltage】						
CH1 Output voltage range	RVO1	4.80	-	5.30	V	100mV step
CH1 Output voltage(default)	VO1d	4.925	5.000	5.075	V	
CH1 Output Voltage accuracy	VO1o	-2.0	-	2.0	%	
CH2 Output voltage range	RVO2	2.80	-	3.35	V	50mV step
CH2 Output voltage(default)	VO2dL	3.250	3.300	3.350	V	
CH2 Output voltage(default)	VO2o	-2.0	-	2.0	%	
CH2 Output Voltage accuracy	RVO3	0.900	-	1.250	V	25mV step
CH3 Output voltage range	VO3d	1.083	1.100	1.117	V	
CH3 Output voltage(default)	VO3o	-2.0	-	2.0	%	
CH3 Output Voltage accuracy	RVO4	1.775	-	1.850	V	25mV step
CH4 Output voltage range	VO4dH	1.773	1.800	1.827	V	VOSEL4=H
CH4 Output voltage(default)	VO4AdL	1.477	1.500	1.523	V	VOSEL4=L
CH4 Output voltage(default)	VO4o	-2.0	-	2.0	%	
CH4 Output Voltage accuracy	RVo6	12.5	-	400	mV	12.5mV step
CH6 Output voltage range	Vo6	380	400	420	mV	
【 Error Amp 】						
Input Bias current	IINV5,6	-	0	50	nA	INV5,6
INV5 Threshold	VINV5	0.790	0.800	0.810	V	

○This product is not designed for normal operation within a radioactive environment.

●**Electrical characteristics**

（Unless specified, Ta=25℃, VCCOUT=5.0V, HX, HX2BAT,REGIN=3.6V, STB1234=3.0V, ALL DCDC, LOD ON）

Item	Symbol	Limit			Unit	condition
		MIN	TYP	MAX		
【Oscillating circuit】						
Frequency CH3,4	fosc1	1.6	2.0	2.4	MHz	
Frequency CH1,2,5-7	fosc2	0.8	1.0	1.2	MHz	
Max duty 1（step-up）	Dmax1	86	92	96	%	
Max duty CH2 Lx21	Dmax21	-	-	100	%	
Max dutyCH2 Lx22	Dmax22	86	92	96	%	
Max duty 3, 4,5（step-down）	Dmax34	-	-	100	%	
【Soft Start】						
CH1 Soft Start Time	Tss1	1.8	3.0	5.4	msec	
CH2,5 Soft Start Time	Tss2,5	2.4	4.2	6.0	msec	
CH3,4 Soft Start Time	Tss3,4	1.2	2.1	3.0	msec	
CH6 Duty　Restriction time	TDTC	5.0	8.2	11.8	msec	
【OFF detect comparator】						
CH2 OFF Threshold	VOFF2	-	0.420	0.560	V	Vo2 monitor
CH3 OFF Threshold	VOFF3	-	0.135	0.180	V	Vo3 monitor
CH4 OFF Threshold	VOFF4	-	0.220	0.295	V	Vo4 monitor

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●**Electrical characteristics**

（Unless specified, Ta=25℃, VCCOUT=5.0V, HX, HX2BAT,REGIN=3.6V, STB1234=3.0V, ALL DCDC, LOD ON）

Item		Symbol	Limit			Unit	condition
			MIN	TYP	MAX		
【Output Driver】							
CH1 Highside SW ON Resistance		RON1P	-	80	150	mΩ	Hx1=5V
CH1 Lowside SW ON Resistance		RON1N	-	60	120	mΩ	VCCOUT=5.0V
CH2 Lx21 Highside SW ON resistance		RON21P	-	120	180	mΩ	Hx2BAT=3.6V
CH2 Lx21 Lowside SWON resistance		RON21N	-	120	180	mΩ	VCCOUT=5.0V
CH2 Lx22 High side SW ON resistance		RON22P	-	150	230	mΩ	VOUT2=3.3V
CH2 Lx22 Low side SW ON resistance		RON22N	-	120	180	mΩ	VCCOUT=5.0V
CH3 High side SW ON Resistance		RON3P	-	150	230	mΩ	Hx3=3.6V , VCCOUT=5V
CH3 Low side SW ON Resistance		RON3N	-	110	170	mΩ	VCCOUT=5.0V
CH4 High side SW ON Resistance		RON45P	-	150	230	mΩ	Hx4=3.6V, VCCOUT=5V
CH4 Low side SW ON Resistance		RON45N	-	120	180	mΩ	VCCOUT=5.0V
CH5 High side SW ON Resistance		RON45P	-	200	300	mΩ	Hx4=3.6V, VCCOUT=5V
CH5 Low side SW ON Resistance		RON45N	-	150	230	mΩ	VCCOUT=5.0V
CH6 NMOS SW ON resistance		RON6N	-	500	750	mΩ	VCCOUT=5.0V
LED PIN SW ON resistance		RLED	-	2.0	3.0	Ω	VCCOUT=5.0V
【Discharge switch】							
CH2 discharge SW ON resistance		RDSW2	-	100	200	Ω	VCCOUT=5.0V
CH3 discharge SW ON resistance		RDSW3	-	100	200	Ω	VCCOUT=5.0V
CH4 discharge SW ON resistance		RDSW4	-	100	200	Ω	VCCOUT=5.0V
CH5 discharge SW ON resistance		RDSW5	-	100	200	Ω	VCCOUT=5.0V
【STB1234】							
STB Control Voltage	Active	VSTBH1	1.5	-	5.5	V	
	Non Active	VSTBL1	-0.3	-	0.3	V	
Pull Down Resistance		RSTB1	250	400	700	kΩ	
【SEQ_CTL, VOSEL4】							
SEQ_CTL VOSEL4 Control Voltage	H level	VCTLH	HX2B AT-0.3	-	HX2B AT+0.3	V	
	L level	VCTLL	0	-	0.3	V	
【LDO】							
Output voltage		VLDO1	1.5	-	3.3	V	Vo=1.5V,1.8V,2.7V ,2.8V , 2.9V 3.0V,3.1V,3.3V
Output voltage accuracy		LDOACC	2.758	2.800	2.842	V	
Line regulation		VDL	-	2	20	mV	VINREG=REGOUT+1.0V to 5.5V Iout=10uA
Load regulation		VDLo	-	10	80	mV	Io=0.01mA to 100mA
PSRR		RR	40	50	-	dB	VR=-20dBv f=1KHz Io=10mA
Over current protect		ILMAX	220	350	700	mA	Vo=REGOUT*0.8
Output short current		ISHORT	20	70	150	mA	Vo=0V
Discharge resister		LDODCR	0.5	1	1.5	kΩ	
【Circuit Current】							
Stand-by Current	VCCOUT terminal	ISTB1	-	0	5	μA	
	Hx terminal	ISTB2	-	0	5	μA	Step-down Cross- converter
	Lx terminal	ISTB3	-	0	5	μA	Step-up
	VINREG	ISTB4	-	0	5	μA	
Circuit Current when start-up （HX2BAT current when voltage supplied for the terminal）		IST	-	300	600	μA	HX2VAT=3.6V
Circuit Current （VCCOUT current when voltage supplied for the terminal）		Icc2	-	5.0	9.7	mA	CH1～6 Switching OFF LDO ON

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●**Specification for serial control**

Electrical characteristics（Unless specified, Ta=25℃, VDD=3.3V）

Item	Symbol	Limit			Unit	condition
		MIN	TYP	MAX		
SCL、SDA						
H level input voltage	V_{INH}	VDD*0.7	-	VDD+0.3	V	
L level input voltage	V_{INL}	-0.3	-	VDD*0.3	V	
H level input current	I_{INH}	-10	-	10	μA	Input voltage＝0.9×VDD
L level input current	I_{INL}	-10	-	10	μA	Input voltage＝0.1×VDD
L level output voltage (SDA)	V_{OL}	-	-	0.4	V	I_{IN}=3.0mA
Bus capacitance	Cb	-	-	400	pF	

AC timing characteristics（Unless specified, Ta=25℃, VDD=3.3V）

Item	Symbol	FAST-MODE*			STANDARD-MODE*			Unit
		MIN	TYP	MAX	MIN	TYP	MAX	
SCL frequency	fSCL	-	-	400	-	-	100	kHz
HIGH period of the SCL clock	fHIGH	0.6	-	-	4	-	-	uS
LOW period of the SCL clock	fLOW	1.3	-	-	4.7	-	-	uS
SDA/SCL rise time	tR	-	-	0.3	-	-	1	uS
SDA/SCL fall rime	tF	-	-	0.3	-	-	1	uS
Start condition hold time	tHD：STA	0.6	-	-	4	-	-	uS
Start condition set-up time	tSU：STA	0.6	-	-	4.7	-	-	uS
Data hold time	tHD：DAT	0	-	0.9	0	-	3.45	uS
Data set-up time	tSU：DAT	100	-	-	250	-	-	nS
Set-up time for stop condition	tSU：STO	0.6	-	-	4	-	-	uS
Bus free time between a STOP and START condition	tBUF	1.3	-	-	4.7	-	-	uS
Noise cancel time	t1	0	-	50	0	-	50	nS

FAST-MODE and STANDARD-MODE are sectioned by clock speed.
STANDARD-MODE clock speed is 100lHz, and FAST-MODE clock speed is 400 kHz.
These clock speed are assumed maximum frequency, it is possible to use clock speed 100 kHz on FAST-MODE.

●**Serial data timing**

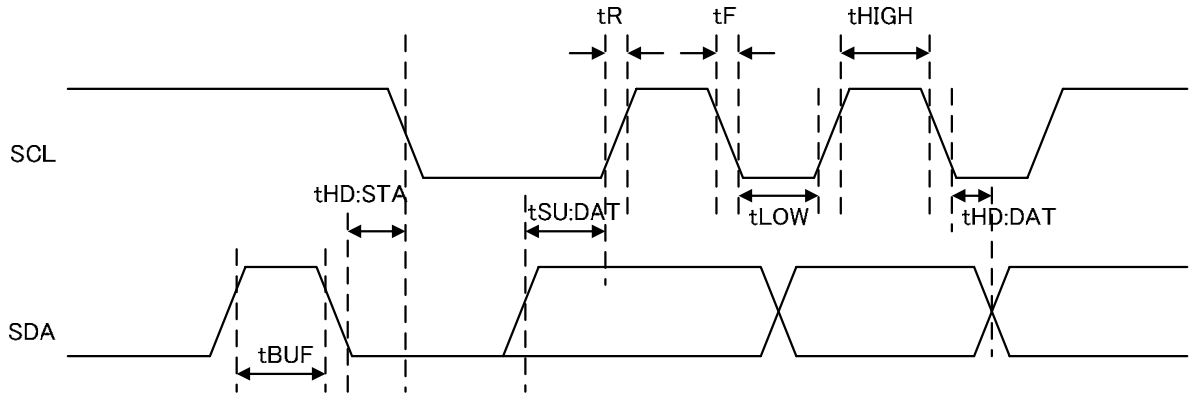


Fig4. Serial data timing

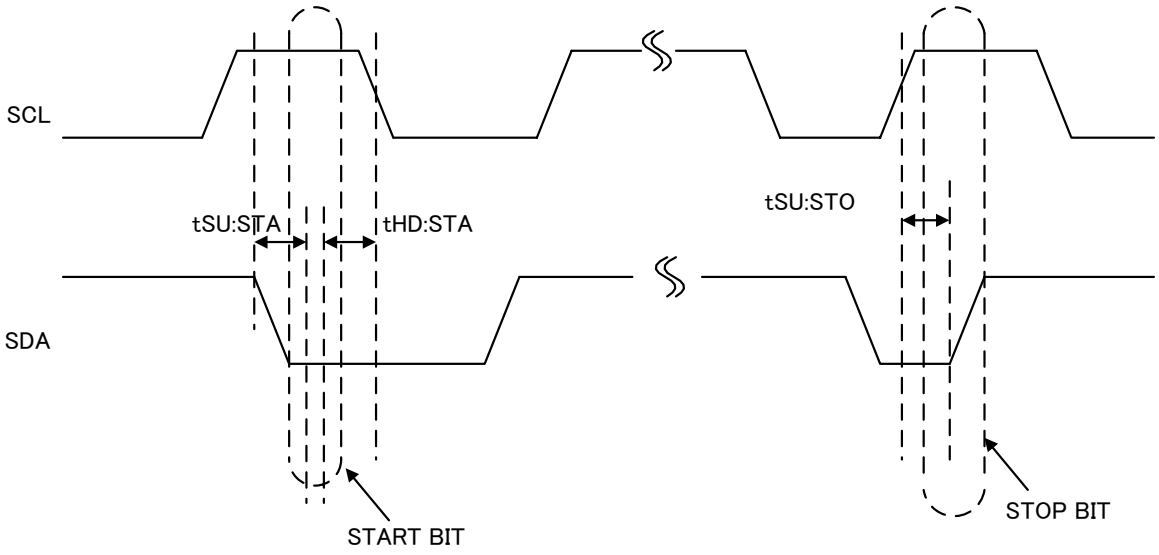
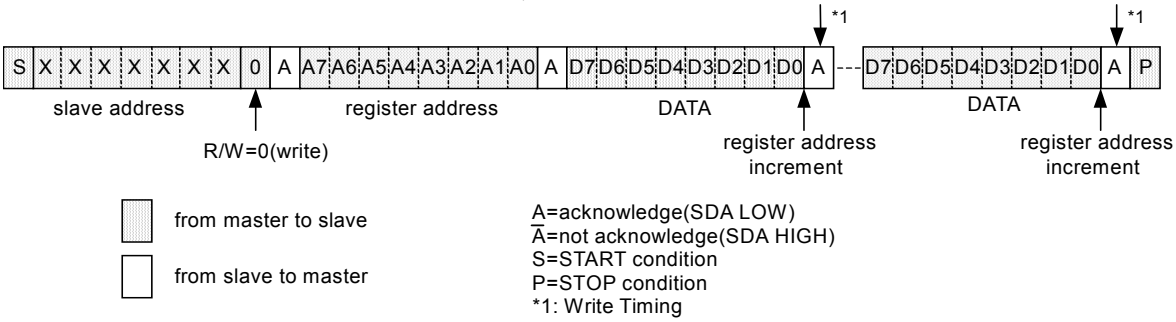


Fig5. Start bit, stop bit timing diagram

●Serial I/F, Read/Write function

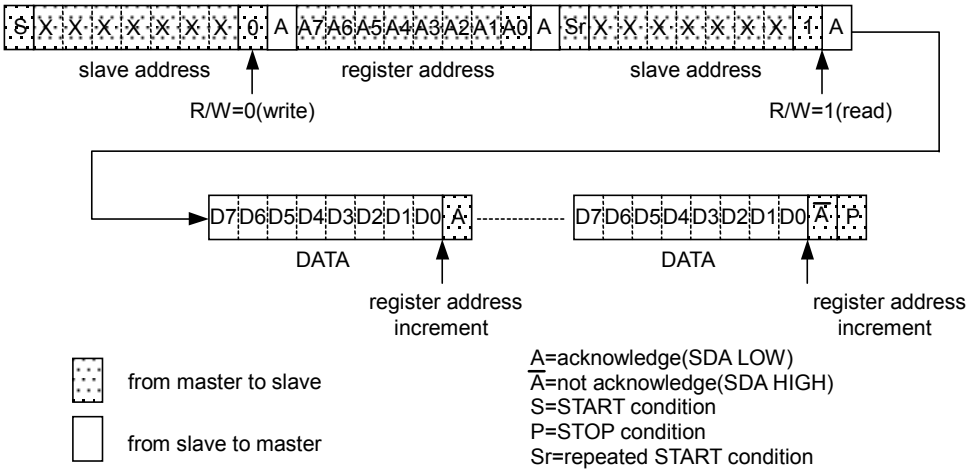
1. Writing protocol

A register address is transferred by the next 1 byte that transferred the slave address and the write-in command. The 3rd byte writes data in the internal register written in by the 2nd byte, and after 4th byte or, the increment of register address is carried out automatically. However, when a register address turns into the last address, it is set to 00h by the next transmission. After the transmission end, the increment of the address is carried out.



2. Multiple reading protocols

After specifying an internal address, it reads by repeated START condition and changing the data transfer direction. The data of the address that carried out the increment is read after it. If an address turns into the last address, the next byte will read out 00h. After the transmission end, the increment of the address is carried out.



※As for reading protocol and multiple reading protocols, please do A($\overline{\text{not}}$ acknowledge) after doing the final reading operation. It stops with read when ending by A (acknowledge), and SDA stops in the state of Low when the reading data of that time is 0. However, this state returns usually when SCL is moved, data is read, and A (not acknowledge) is done.

●Application circuit

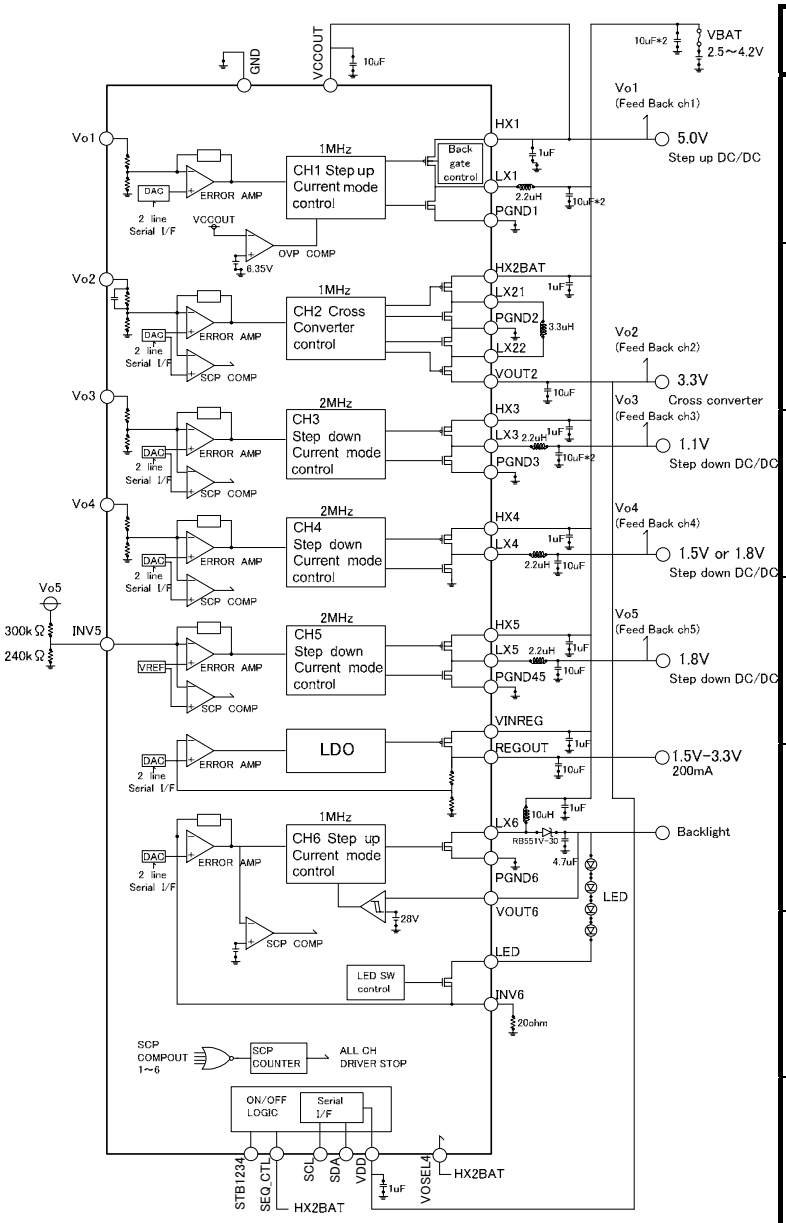


Fig6. Applied circuit diagram

●Recommended maximum load

	Vo (V)	Vin (V)	Io_max (mA)	condition (Recommended parts)
CH1	Boost 5.0	2.5	1000	L=2.2uH (TOKO:DE4518C) (YUDEN:NR4018T) C=20uF (MURATA: GRM31CB31E106KA75L)
		3.0	1000	
		3.6	1000	
		4.2	1000	
CH2	Cross 3.3	2.5	800	L=3.3uH (TOKO:DE3518) (YUDEN:NR3015T) C=10uF (MURATA: GRM31CB31E106KA75L)
		3.0	800	
		3.6	800	
		4.2	800	
CH3	Buck 1.1	1.8	1500	L=2.2uH (TOKO:DE2815) (YUDEN:NR3015T) C=10uF (MURATA: GRM31CB31E106KA75L)
		2.5	1500	
		3.6	1500	
		4.2	1500	
CH4	Buck 1.8	1.8	800	L=2.2uH (TOKO:DE2815) (YUDEN:NR3015T) C=10uF (MURATA: GRM31CB31E106KA75L)
		2.5	800	
		3.6	800	
		4.2	800	
CH5	Buck 1.8	2.5	500	L=2.2uH (TOKO:DE2815) (YUDEN:NR3015T) C=10uF (MURATA: GRM31CB31E106KA75L) R1=300kΩ,R2=240kΩ
		3.6	500	
		4.2	500	
		5.0	500	
CH6	Boost (worth 3 light LED)	2.5	50	L=10uH (TOKO:DE2815) (YUDEN:NR3015T) C=4.7uF (MURATA: GRM21BB31E475KA75L) Diode (RB551V-30)
		3.0	50	
		4.2	50	
		5.0	50	
CH6	Boost (worth 6 light LED)	1.8	30	L=10uH (TOKO:DE2815) (YUDEN:NR3015T) C=4.7uF (MURATA: GRM21BB31E475KA75L) Diode (RB551V-30)
		2.5	30	
		3.6	30	
		4.2	30	
LDO	2.8	3.3	200	C=2.2uF (MURATA: GRM21BB31E225KA75L)
		3.6	200	
		4.2	200	
		5.5	200	

○ Operation notes

・we are confident that the above applied circuit diagram should be recommended, but please thoroughly confirm its characteristics when using it. In addition, when using it with the external circuit's constant changed, please make a decision that allows a sufficient margin in light of the fluctuations of external components and ROHM's IC in terms of not only static characteristic but also transient characteristic.

●**Efficiency data (1)**

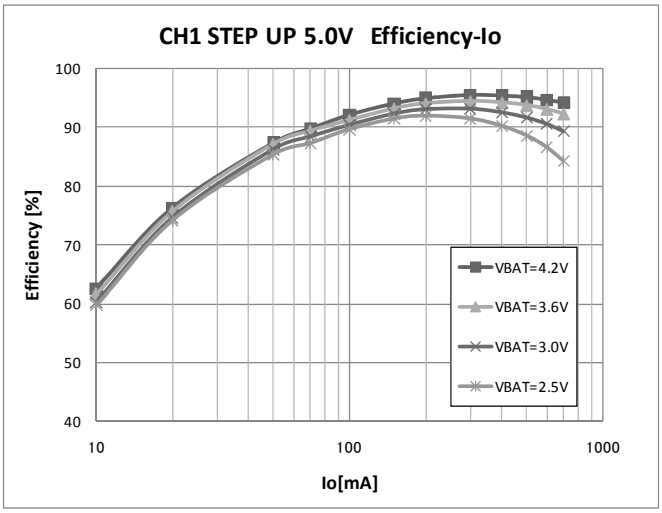


Fig7. CH1 5.0V voltage boost efficiency－Io
Inductor : 2.2uH (YUDEN: NR4018T)

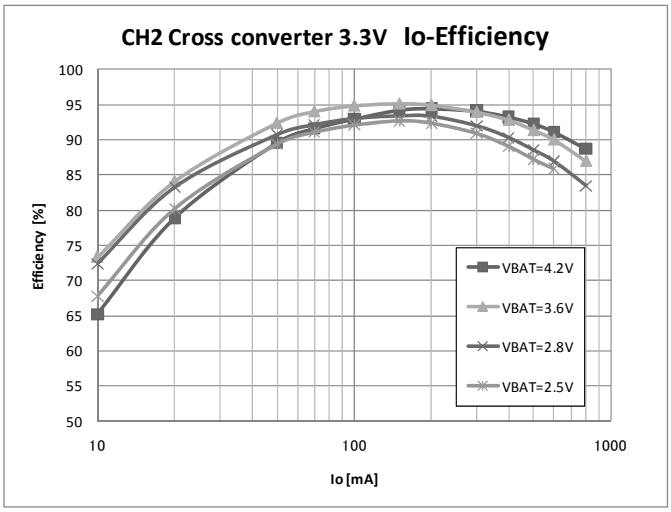


Fig8. CH2 3.3V Cross converter efficiency－Io
Inductor : 3.3uH (YUDEN: NR3015T)

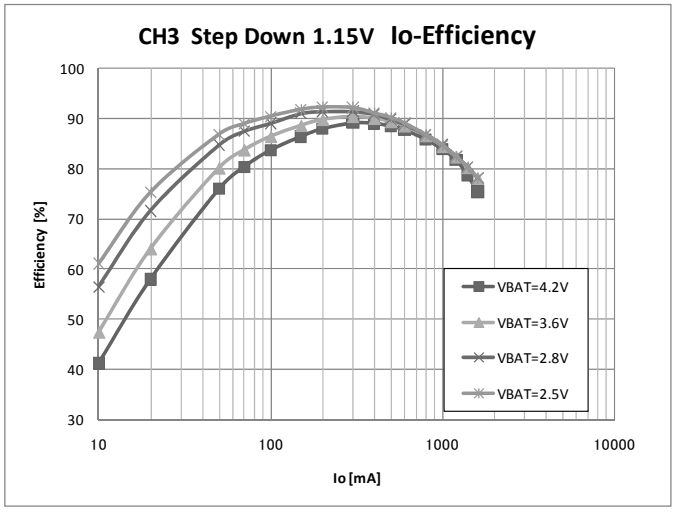


Fig9. CH3 1.15V Step-down efficiency－Io
Inductor : 2.2uH (YUDEN: NR3015T)

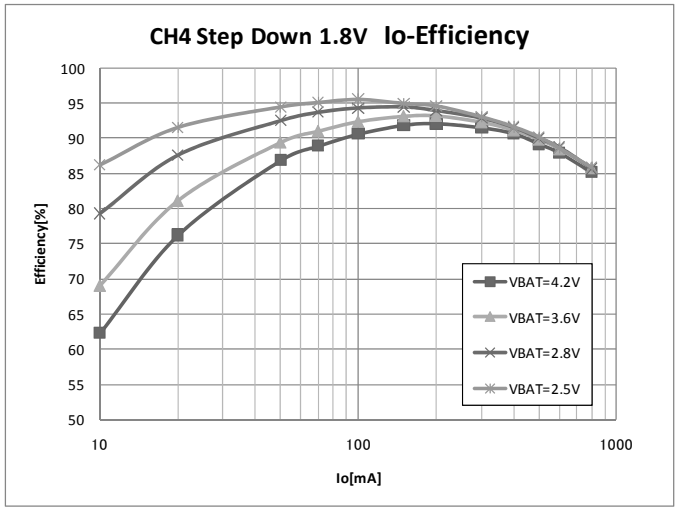


Fig10. CH4 1.8V Step-down efficiency－Io
Inductor : 2.2uH (YUDEN: NR3015T)

●**Efficiency data (2)**

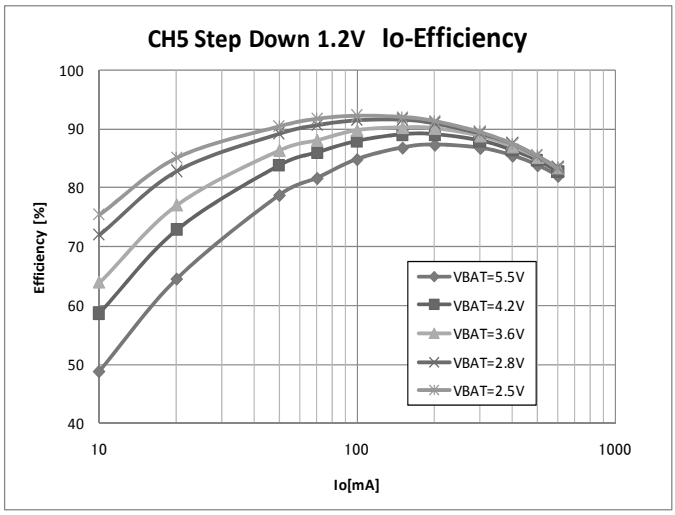


Fig11. CH5 1.2V Step-down efficiency－Io
Inductor : 2.2uH (YUDEN: NR3015T)

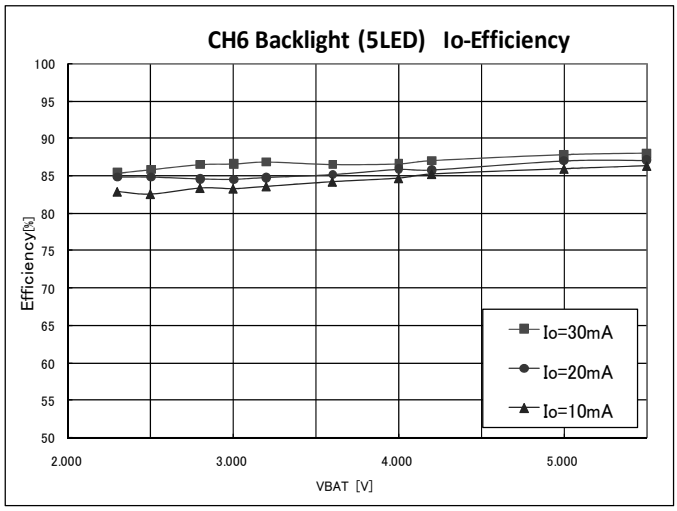


Fig12. CH6 5 LED efficiency－Input voltage
Inductor : 10uH (YUDEN: NR3015T)

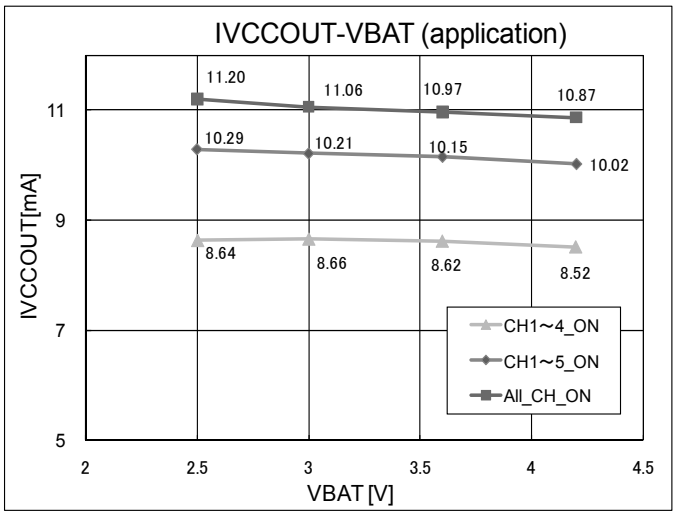


Fig13. VCCOUT Input current － Input voltage
(Recommended application)

●**Start up and OFF sequence wave form(1)**

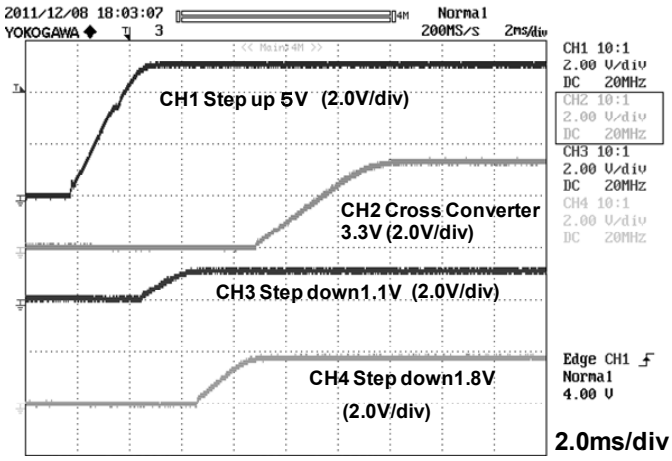


Fig14. CH1～4 Start up wave form
（SEQ_ CTL=H）

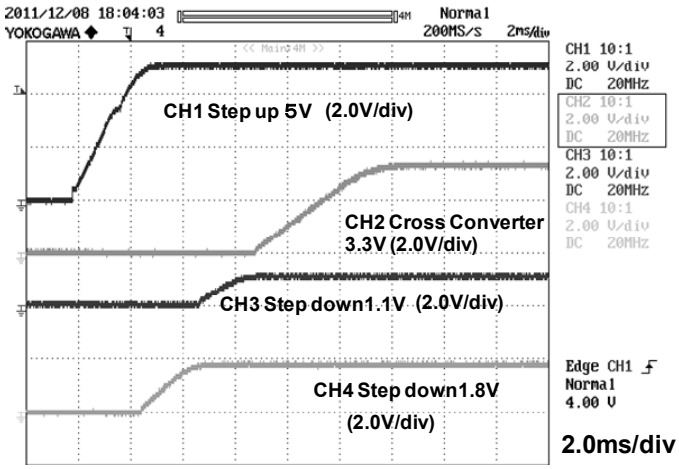


Fig15. CH1～4 wave form of OFF sequence
（SEQ_ CTL=H）

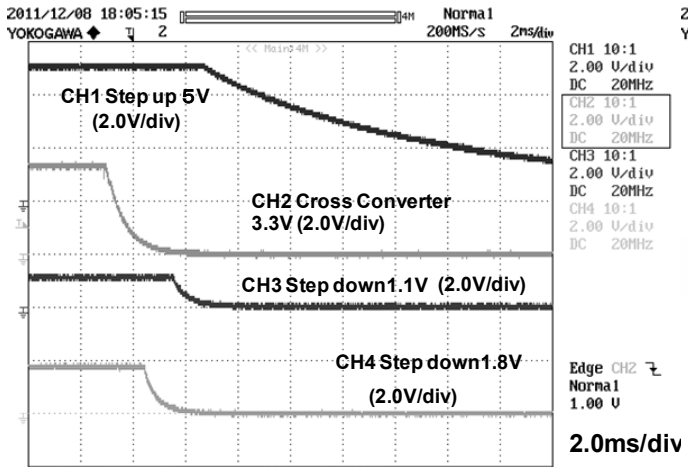


Fig16. CH1～4 Start up wave form
（SEQ_ CTL=L）

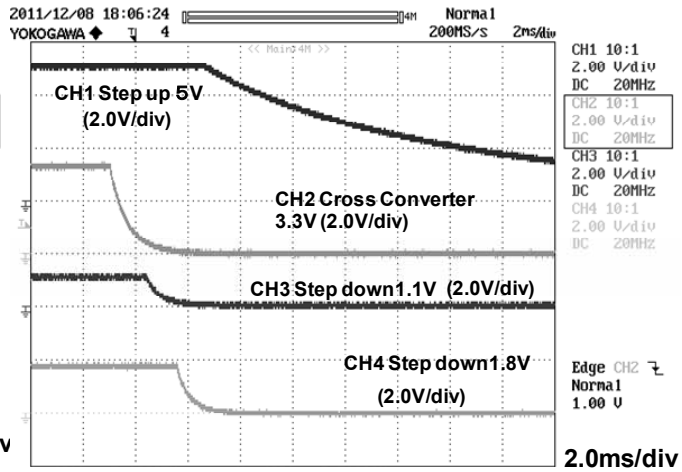


Fig17. CH1～4 wave form of OFF sequence
（SEQ_ CTL=L）

●**Start up and OFF sequence wave form(2)**

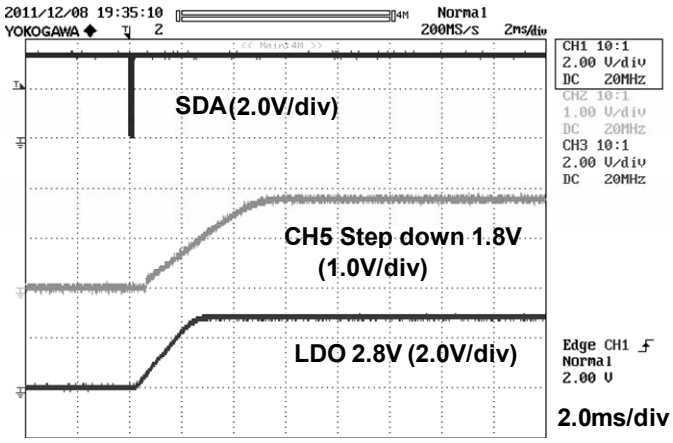


Fig18. CH5, LDO Start up wave form

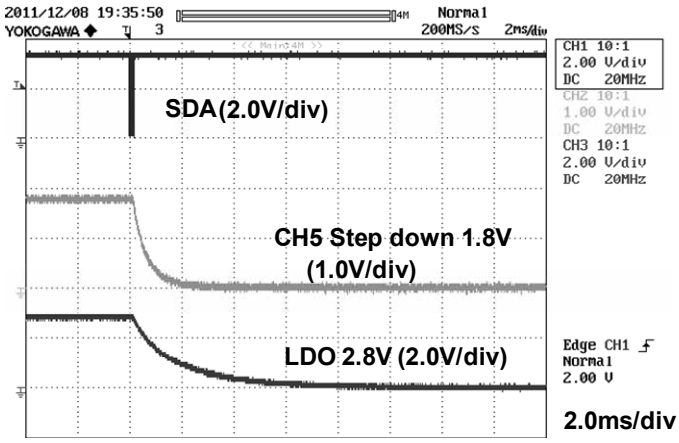


Fig19. CH5, LDO wave form of OFF sequence

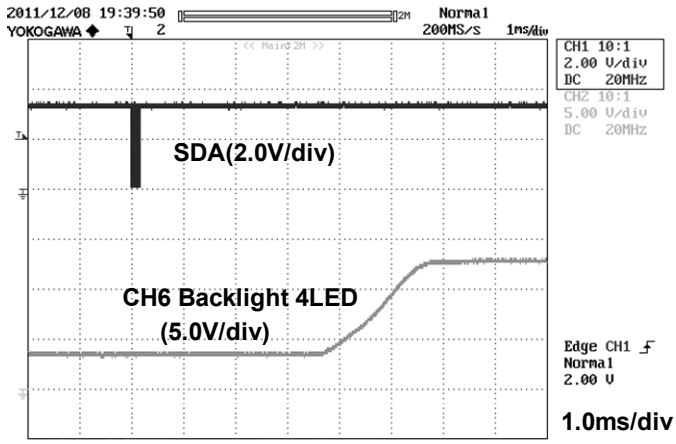


Fig20. CH6 Start up wave form

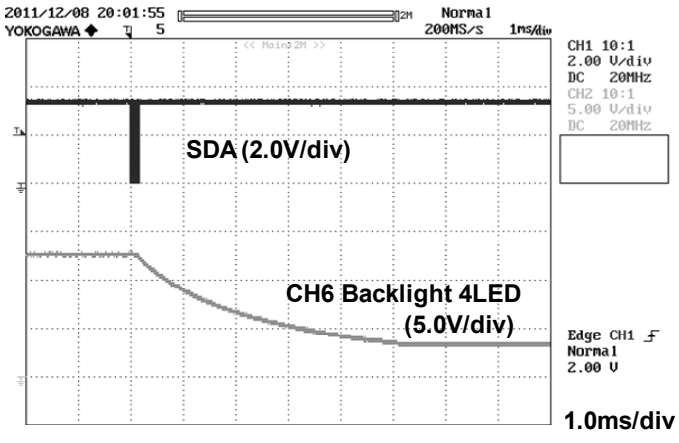


Fig21. CH6 wave form of OFF sequence

●**Temperature characteristic**

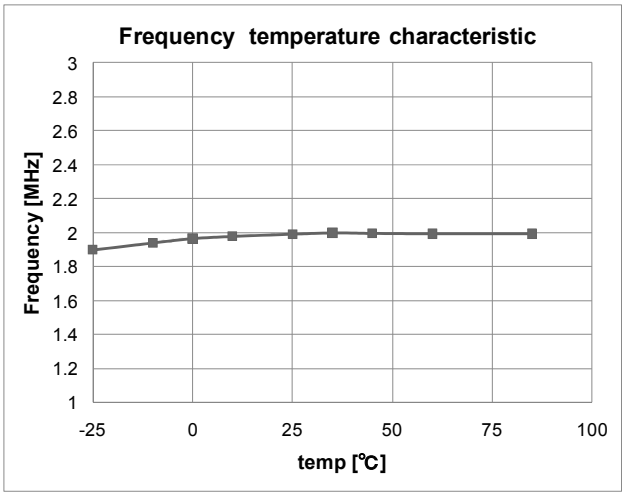


Fig22. Frequency－Temp（2MHz）

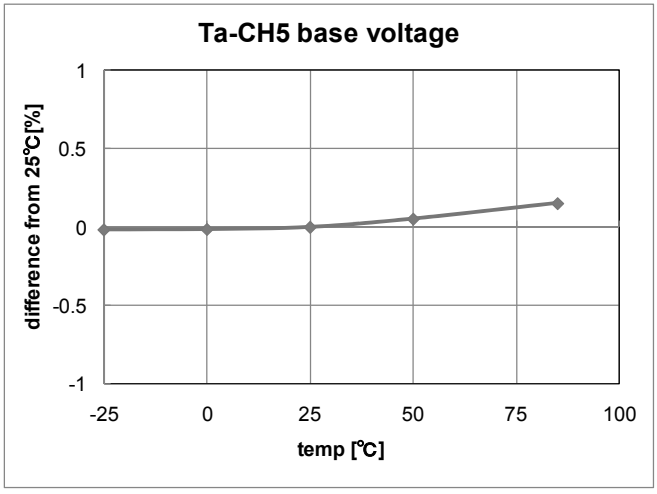
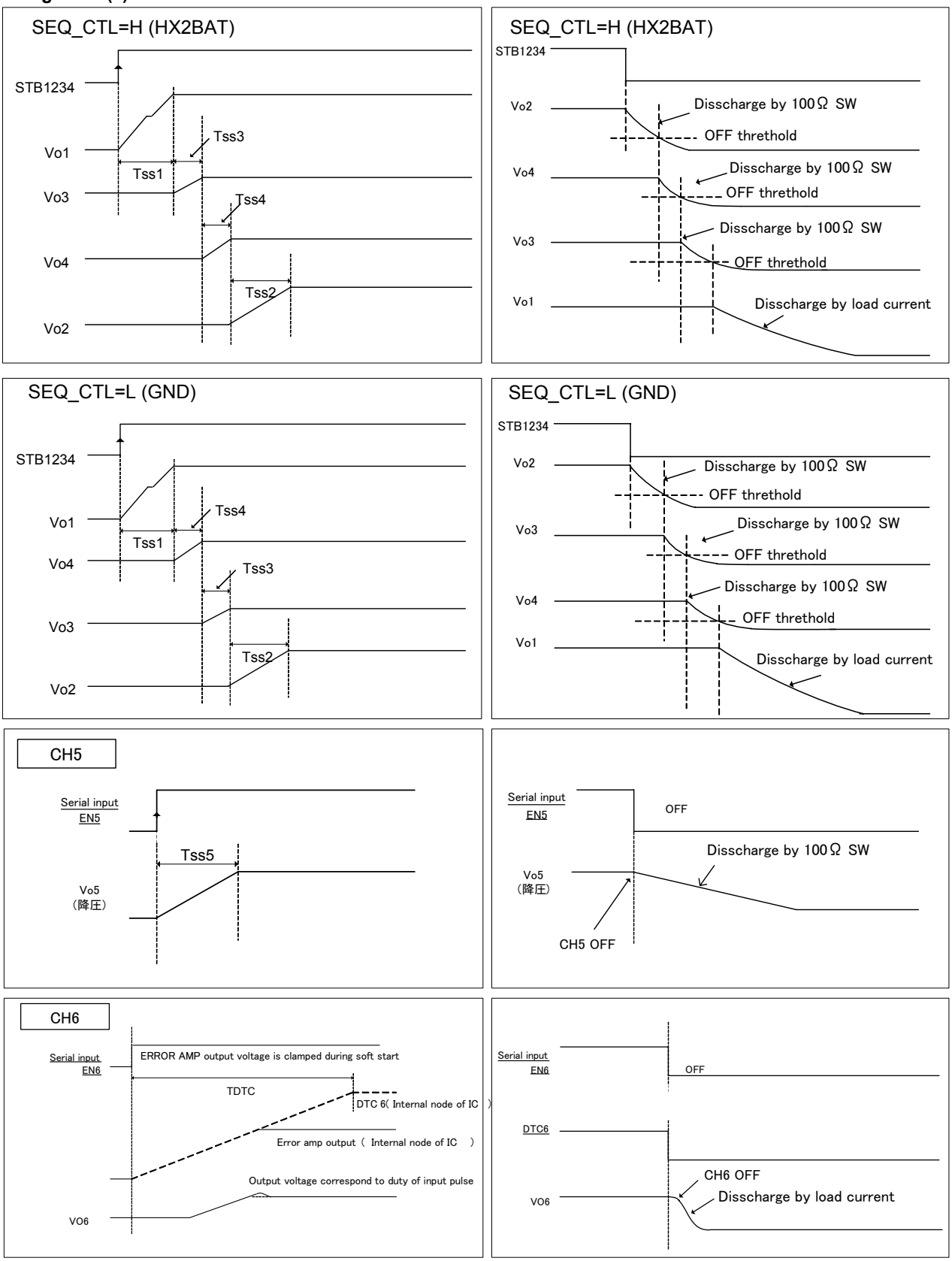


Fig23. CH5 Base voltage－Temp

●**Timing chart (1)**



Tss1 : typ 3.0msec Tss2 : typ 4.2msec
Tss3 : typ 2.1msec Tss4 : typ 2.1msec
Tss5 : typ 4.2msec TDTC: typ 8.2msec

Fig24.CH1～CH6 Start up and OFF Sequence

●**SLAVE address**

SLAVE address
29h (010 1001)

●**Resister map**

Attention

- "W" is resister bit to write.
- "R" is resister bit to read.
- "R/W" is resister bit to read or write.
- "－" is resister bit not to use.

Address	Address name	R/W	D7	D6	D5	D4	D3	D2	D1	D0	Initial value	Function
00h	SFTRST	W	-	-	-	-	-	-	-	SFT RST	00h	Input to reset software
01h	ENCNT	R/W	-	-	-	-	CH1 PFM	EN LDO	EN6	EN5	08h	ON/OFF for each CH
02h	VCNT12	R/W	VCNT2[3:0]				VCNT1[3:0]				64h	Adjustment to CH1, CH2 output voltage
03h	VCNT34	R/W	-	VCNT4[2:0]			VCNT3[3:0]				※8h	Adjustment to CH3, CH4 output voltage
04h	VCNT6LDO	R/W	LDOCNT[2:0]			VCNT6[4:0]					60h	Adjustment to INV6, LDO output voltage

※※h → See resister map

Resister reset condition ： (Resister reset mean all resister turn into initial value)

① **In the operation of HX2BAT UVLO or VCCOUT UVLO.**
② **Initialized after OFF sequence of CH1～4.**

Logic reset condition ： Logic reset mean all resister and internal logic circuit (soft start circuit etc.) are initialized in disregard of sequence with the following condition directly.

① **In the operation of HX2BAT UVLO or VCCOUT UVLO.**
② **Initialized CH1～4 output voltage are OFF with OFF sequence.**

Please input "0" to "-" resister. Empty resisters are used to test mode resister.
Please transmit "0" to "-" resister to avoid test mode while data is transmitted.
If address "00h" get "01" data, it occur logic reset directly, address "00h" is initialized, and start-up sequence is beginning.
Don't use this mode, if you don't need.

●**Resister Map 1**

Address	Address name	R/W	D7	D6	D5	D4	D3	D2	D1	D0	Initial value	Data content
00h	SFT RST	W	-	-	-	-	-	-	-	SFT RST	00h	Input to reset software

D0: SFTRST software reset
'0': Reset cancel (Initial)
'1': reset → Reset automatically by 1 shot pulse.

Address	Address name	R/W	D7	D6	D5	D4	D3	D2	D1	D0	Initial value	Data content
01h	ENCNT	R/W	-	-	-	-	CH1PFM	ENLDO	EN6	EN5	08h	ON/OFF for each CH

D0: EN5 CH5 ON/OFF signal
'0': CH5 OFF (initial value)
'1': CH5 ON

D1: EN6 CH6 ON/OFF signal
'0': CH6 OFF (initial value)
'1': CH6 ON

D2: ENLDO LDO ON/OFF signal
'0': LDO OFF (initial value)
'1': LDO ON

D3: CH1PFM CH1 PFM mode switch signal
'0': CH1 synchronous mode
'1': CH1 reverse current detect mode (initial value)

●**Resister Map 2**

Address	Address name	R/W	D7	D6	D5	D4	D3	D2	D1	D0	Initial Value	Function
02h	VCNT12	R/W	VCNT2[3:0]				VCNT1[3:0]				64h	Adjustment to CH1,CH2 output voltage
03h	VCNT34	R/W	-	VCNT4[2:0]			VCNT3[3:0]				※8h	Adjustment to CH3, CH4 output voltage
04h	VCNT6 LDO	R/W	LDOCNT[2:0]			VCNT6[4:0]					60h	Adjustment to INV6,LDO output voltage

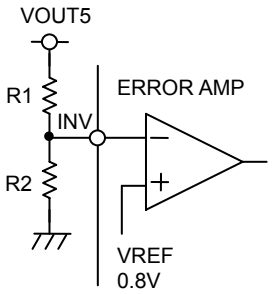
Data					Output voltage [V]					
D4	D3	D2	D1	D0	VCNT1 [D3～D0]	VCNT2 [D3～D0]	VCNT3 [D3～D0]	VCNT4 [D2～D0]	VCNT6 [D4～D0]	LDOCNT [D2～D0]
0	0	0	0	0	4.800	2.800	0.900	1.475	0.4000	1.500
0	0	0	0	1	4.800	2.800	0.925	1.500(*1)	0.3875	1.800
0	0	0	1	0	4.800	2.850	0.950	1.525	0.3750	2.700
0	0	0	1	1	4.900	2.900	0.975	1.550	0.3625	2.800
0	0	1	0	0	5.000	3.200	1.000	1.775	0.3500	2.900
0	0	1	0	1	5.100	3.250	1.025	1.800(*2)	0.3375	3.000
0	0	1	1	0	5.200	3.300	1.050	1.825	0.3250	3.100
0	0	1	1	1	5.300	3.350	1.075	1.850	0.3125	3.300
0	1	0	0	0	5.300	3.350	1.100	-	0.3000	-
0	1	0	0	1	5.300	3.350	1.125	-	0.2875	-
0	1	0	1	0	5.300	3.350	1.150	-	0.2750	-
0	1	0	1	1	5.300	3.350	1.175	-	0.2625	-
0	1	1	0	0	5.300	3.350	1.200	-	0.2500	-
0	1	1	0	1	5.300	3.350	1.225	-	0.2375	-
0	1	1	1	0	5.300	3.350	1.250	-	0.2250	-
0	1	1	1	1	5.300	3.350	1.250	-	0.2125	-
1	0	0	0	0	-	-	-	-	0.2000	-
1	0	0	0	1	-	-	-	-	0.1875	-
1	0	0	1	0	-	-	-	-	0.1750	-
1	0	0	1	1	-	-	-	-	0.1625	-
1	0	1	0	0	-	-	-	-	0.1500	-
1	0	1	0	1	-	-	-	-	0.1375	-
1	0	1	1	0	-	-	-	-	0.1250	-
1	0	1	1	1	-	-	-	-	0.1125	-
1	1	0	0	0	-	-	-	-	0.1000	-
1	1	0	0	1	-	-	-	-	0.0875	-
1	1	0	1	0	-	-	-	-	0.0750	-
1	1	0	1	1	-	-	-	-	0.0625	-
1	1	1	0	0	-	-	-	-	0.0500	-
1	1	1	0	1	-	-	-	-	0.0375	-
1	1	1	1	0	-	-	-	-	0.0250	-
1	1	1	1	1	-	-	-	-	0.0125	-

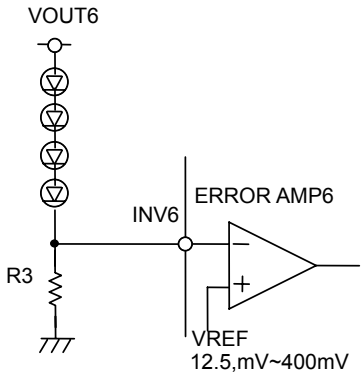
(*1) VOSEL4 = L (*2) VOSEL4 = H

→ Initial value.

●**Setting method of IC peripheral components**

(1) Design of feedback resistor constant





CH5 output voltage

$$Vo = \frac{(R1+R2)}{R2} \times 0.8\ [V] \quad \cdots \quad (1)$$

CH6 output current

$$Io = \frac{INV6}{R3}\ [A] \quad \cdots \quad (2)$$

Fig25. Feedback resistor setting method

(a)CH5 setting

The reference voltage of CH5's ERROR AMP is 0.8V inside IC. Please refer to Formula (1) for determining the output voltage. This IC has phase compensation. R1 and R2 are recommended as more than 100kΩ.

(b)CH6 setting

LED current is decided (2) formula. Please decide R3 value for LED current range. It is possible to control Dimming by only serial I/F.

(2) Points for attention in terms of PCB layout of base-plate

○For a switching regulator, in principle a large current transiently flows through the route of power supply – coil – output capacitor. Ensure that the wiring impedance is lowered as much as possible by making the pattern as wide as possible and the layout as short as possible.

○Interference of power supply noise with feedback terminals (Vo, INV) may cause the output voltage to oscillate.
Ensure that the power supply noise's interference is avoided by making the wiring between feedback resistor and feedback terminal as short as possible.

●Block explanation

1. SCP, Timer Latch

It is a timer latch type of short-circuit protection circuit.
For CH6, the error AMP output voltage is monitored, and detected when the feedback voltage deviates from control, for CH1～5, it is detected when the voltage of INV terminal becomes lower than 60%, and in 21ms the latch circuit operates and the outputs of all the channels are fixed at OFF.
In order to reset the latch circuit, please turn off all the STB terminals before turning them on once again or turning power supply on once again.

2. U.V.L.O

It is a circuit to prevent malfunction at low voltage.
It is to prevent malfunction of internal circuit at the time of rising or dropping to a lower value of power supply voltage.
If the voltage of VCCOUT terminal becomes lower than 2.3V, or the voltage of HX2BAT terminal becomes lower than 2.1V, then the output of each DC/DC converter is reset to OFF, and SCP's timer latch & soft start circuit are reset. In order to cancel UVLO of VCCOUT, it is necessary to set VCCOUT more than 2.5V. And in order to cancel UVLO of HX2BAT, it is necessary to set HX2BAT more than 2.2V.

3. OSC

It is an oscillation circuit the frequency of which is fixed by a built-in CR.
The operating frequencies of CH3, 4, 5 are set at 2MHz, and the operating frequencies of CH1, 2, 6 are set at 1MHz.

4. ERRAMP 1～6

It is an error amplifier to detect output signal and output PWM control signal.
The reference voltages of ERRAMP (Error Amplifier) of CH1～4 are internally set at 0.6V, and the reference Voltages of ERRAMP (Error Amplifier) of CH5 are set at 0.8V and the reference voltages of ERRAMP (Error Amplifier) of CH6 are set at 0.4V.
In addition, each CH incorporates a built-in element for phase compensation.

5. Current mode control block

CH1, 3～6 adopt the PWM method based on current mode.
For a current- mode DC/DC converter, FET at the main side of synchronous rectification is turned on when detecting the clock edge, and turned off by detecting the peak current by means of the current comparator.

6. Cross Control

DUTY controller for CH2 cross converter. It have PWM comparator that compare 1MHz SLOPE and ERROR AMP output and logic circuit for control 4 FET ON/OFF switching.. LX21 MAX ON DUTY is 100%, LX21 MAX ON DUTY is 92%.

7. Back gate Control

PchFET backgate selector controller in CH1.
PchFET have body Di between backgate and source,drain ordinary. This circuit intercept CH1 step up output voltage by cutting body Di line at STB OFF and control soft start .CH1 softstart output voltage from 0V like a slope.

8. Nch DRIVER , Pch DRIVER

Internal Nch, Pch FET driver CMOS inverter type output circuit.

9. ON/OFF LOGIC

It is the voltage applied to STB terminal and can control the ON/OFF of CH1～CH4.
If the voltage more than 1.5V is applied, then it becomes ON, but if open or 0V is applied, then it becomes off, furthermore, it all the channels are turned off, then the whole IC will be in standby state. In addition, STB1234 terminals contain respectively a built-in pull-down resistor of about 400kΩ.

10. SOFT START

It is a circuit to apply the soft start to the output voltage of DC/DC converter and prevent the rush current at the start-up. Soft start time varies with the channels.

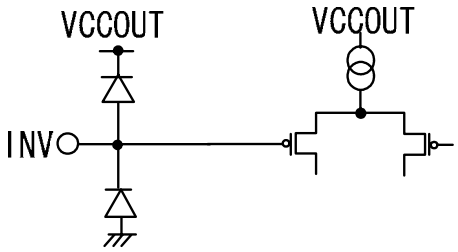
a. CH1 ・・・ reach the target voltage in 3.0ms.
b. CH3,4 ・・・ reach the target voltage in 2.1ms.
c. CH2,5 ・・・ reach the target voltage in 4.2ms.
d. CH6 ・・・ reach the target voltage in 8.2ms.

11. OVP COMP6

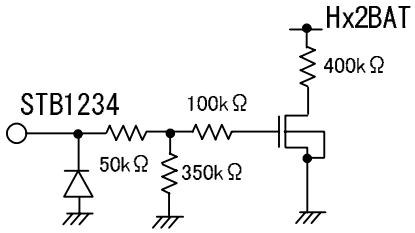
In CH6, When LED is OPEN, INV6 become L and output voltage increase suddenly. If this condition continue,Lx6 voltage increase and exceed break down voltage. CH6 have Over voltage protection (OVP).When VOUT6 pin is inputted over 28Vtyp,OVP stop CH6 function..OVP latch CH6 function and reset by All STB=L

●**PIN equivalent circuit**

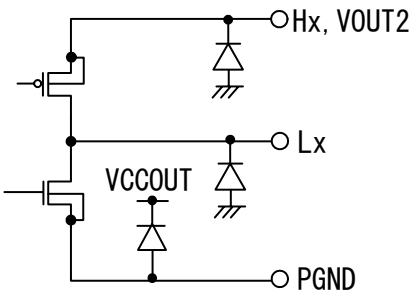
INV5,INV6
(Error amplifier's inversion input)



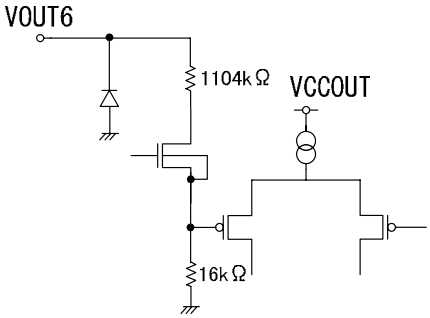
STB1234
(operating when CH1～4 ON/OFF switch is High)



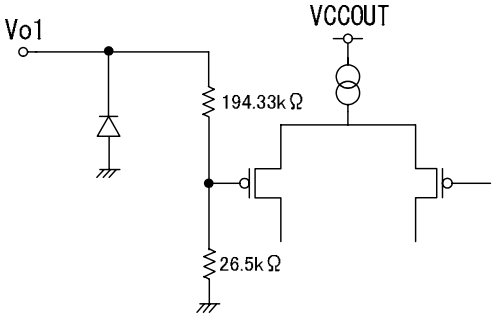
Hx1,2BAT,3,45,VOUT2 (Pch FET source terminal)
Lx1,21,22,3,4,5(Nch,Pch FET drain terminal)
PGND1,2,345 (output stage earthing terminal)



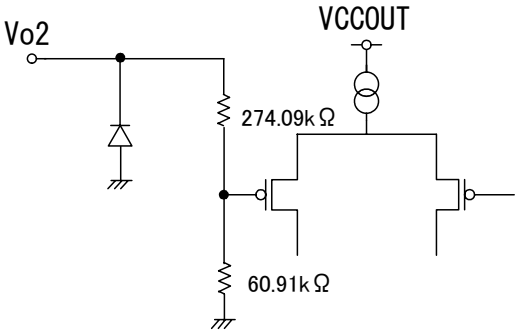
VOUT6
（CH6 OVP monitor terminal）



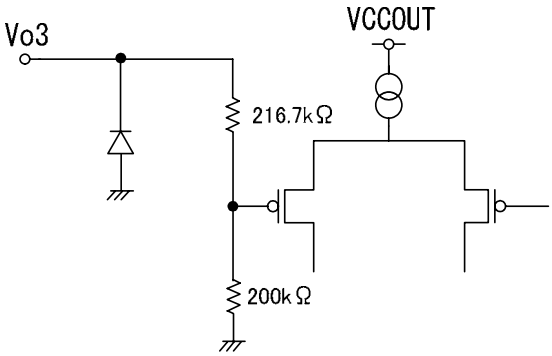
Vo1
（CH1 Output voltage Feed-back pin）



Vo2
（CH2 Output voltage Feed-back pin）



Vo3
（CH3 Output voltage Feed-back pin）



Vo4
（CH4 Output voltage Feed-back pin）

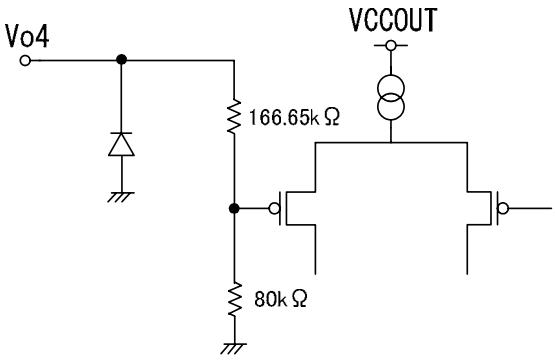
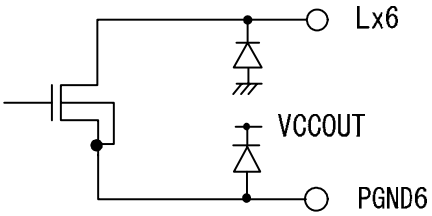
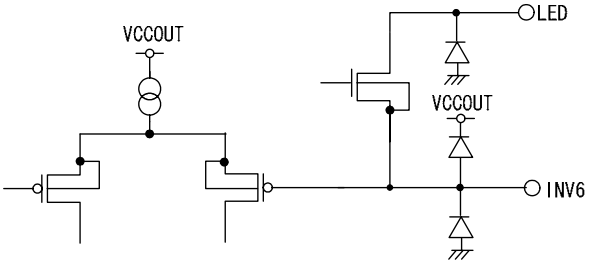


Fig26. PIN equivalent circuit (1)

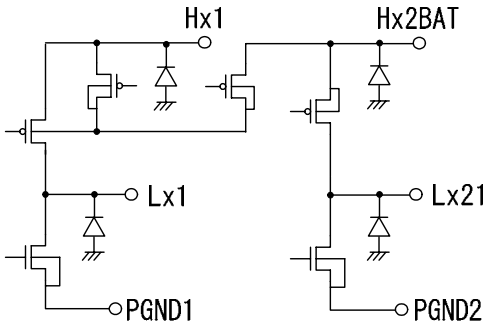
Lx6 (Nch FET drain terminal)
PGND6 (output stage earthing terminal)



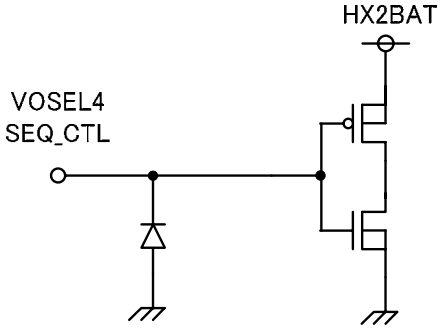
INV7（CH7 Error amplifier's inversion input）
LED（LED cathode connection terminal）



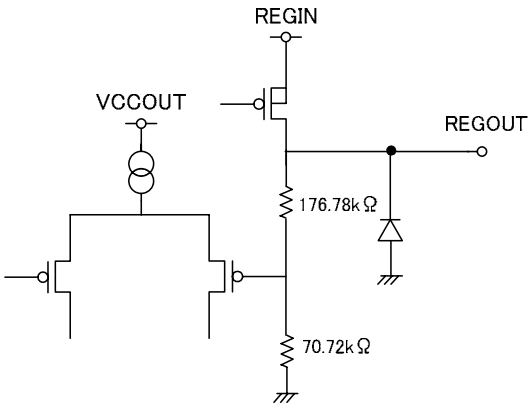
Hx1,2BAT(Pch FET source terminal)
Lx1,21(Nch,Pch FET drain terminal)
PGND1,2 (output stage earthing terminal)



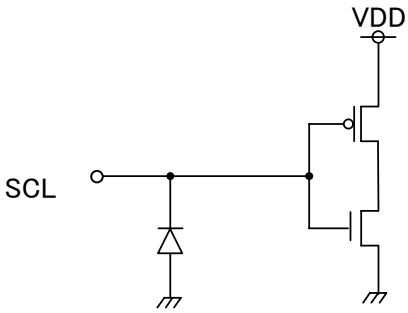
VOSEL4（CH4 initial Output voltage control pin）
SEQ_CTL（Sequence control terminal）



REGOUT
（LDO output terminal）



SCL
（2 Line serial clock Input Pin）



SDA
（2 Line serial data Input Pin）

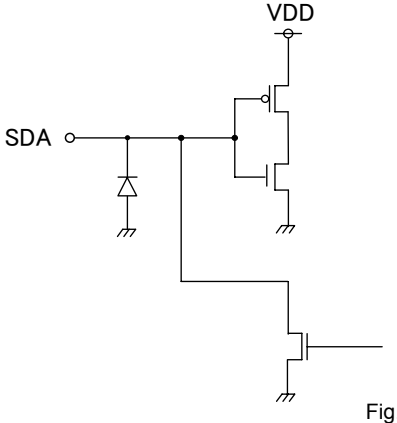


Fig.27 PIN equivalent circuit (2)

●Usage Notes

1.） Absolute Maximum Ratings

Although the quality of this product has been tightly controlled, deterioration or even destruction may occur if the absolute maximum ratings, such as for applied pressure and operational temperature range, are exceeded. Furthermore, we are unable to assume short or open mode destruction conditions. If special modes which exceed the absolute maximum ratings are expected, physical safely precautions such as fuses should be considered.

2.） GND Potential

The potential of the GND pin should be at the minimum potential during all operation status
In addition, please try to do not become electric potential below GND for the terminal other than NON5 including the transient phenomenon in practice.
Please do not go down below 0.3V for the NON5 terminal with transient phenomenon and the like when you use.

3.） Heat Design

Heat design should consider tolerance dissipation (Pd) during actual use and margins which should be set with plenty of room.

4.） Short-circuiting Between Terminals and Incorrect Mounting

When attaching to the printed substrate, pay special attention to the direction and proper placement of the IC. If the IC is attached incorrectly, it may be destroyed. Destruction can also occur when there is a short, which can be caused by foreign objects entering between outputs or an output and the power GND.

5.） Operation in Strong Magnetic Fields

Exercise caution when operating in strong magnet fields, as errors can occur.

6.） About common impedance

Please do sufficient consideration for the wiring of power source and GND with the measures such as lowering common impedance, making ripple as small as possible (making the wiring as thick and short as possible, dropping ripple from L.C) and the like.

7.） STB terminal voltage

When you set each channel to standby, set STB terminal voltage as less than 0.3V, and when you set each channel to active, set STB terminal voltage as more than 1.5V. Use capacitor less than 0.01uF, when you connect STB terminal to capacitor. It becomes a cause of malfunction.

8.) Heat Protection Circuit (TSD circuit)

This IC has a built-in Temperature Protection Circuit (TSD circuit). The temperature protection circuit (TSD circuit) is only to cut off the IC from thermal runaway, and has not been designed to protect or guarantee the IC. Therefore, the user should not plan to activate this circuit with continued operation in mind.

9.) Rush current at the time of power supply injection.

An IC which has plural power supplies, or CMOS IC could have momentary rush current at the time of power supply injection.
Please take care about power supply coupling capacity and width of power Supply and GND pattern wiring.

10.) Influence by strong light

When large amount of light like strobe is come in, IC can act under wrong operation. Please make light removal system and check operations adequately.

11.) IC Terminal Input

This IC is a monolithic IC, and between each element there is a P+ isolation and P substrate for element separation. There is a P-N junction formed between this P-layer and each element's N-layer, which makes up various parasitic elements.
For example, when resistance and transistor are connected with a terminal as in figure 36:

- ○ When GND>(terminal A) at the resistance, or GND>(terminal B) at the transistor (NPN), the P-N junction operates as a parasitic diode.
- ○ Also, when GND>(terminal B) at the transistor, a parasitic NPN transistor operates by the N-layer of other elements close to the aforementioned parasitic diode.

With the IC's configuration, the production of parasitic elements by the relationships of the electrical potentials is inevitable.
The operation of the parasitic elements can also interfere with the circuit operation, leading to malfunction and even destruction.
Therefore, uses which cause the parasitic elements to operate, such as applying voltage to the input terminal which is lower than the GND(P-substrate), should be avoided.

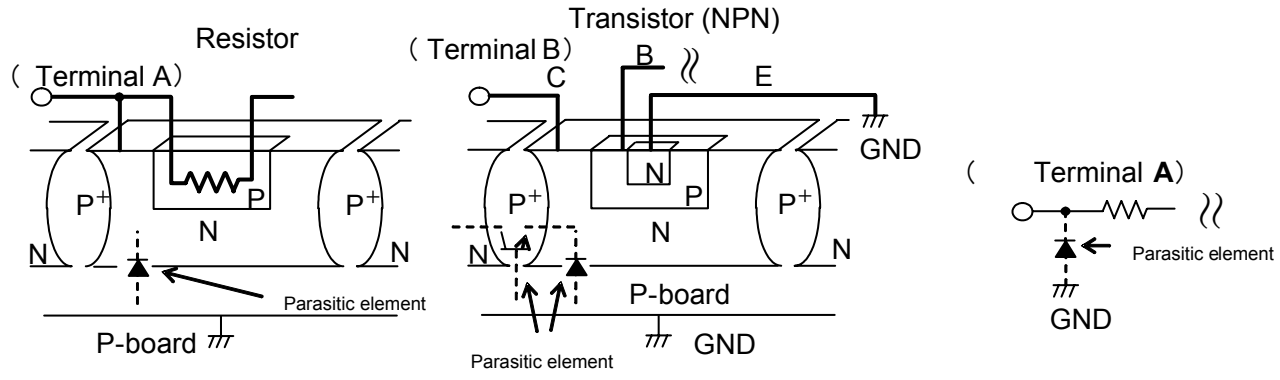
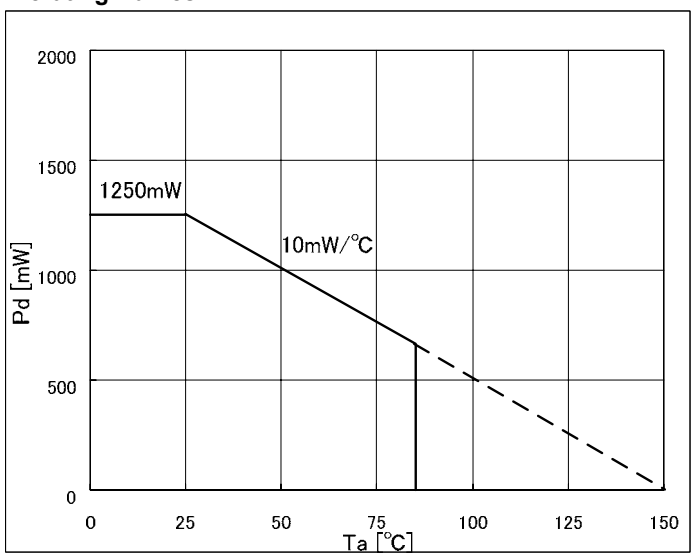


Fig. 28 Simplified structure of a Bipolar IC

●**Thermal Derating Curves**



When mounted on a glass epoxy PCB of 50mm×50 mm×1.74 mm
Should be derated by 10.0mW/℃ at Ta=25℃ or more.
Heat design should consider tolerance dissipation (Pd) during actual use and margins which should be set with plenty of room.

Fig.29 Power dissipation

●**Ordering Information**

B D 9 3 6 1 G U L - E2

Package
GUL: VCSP50L3

Packaging and forming specification
E2: Embossed tape and reel

●**Package and Marking Diagram**

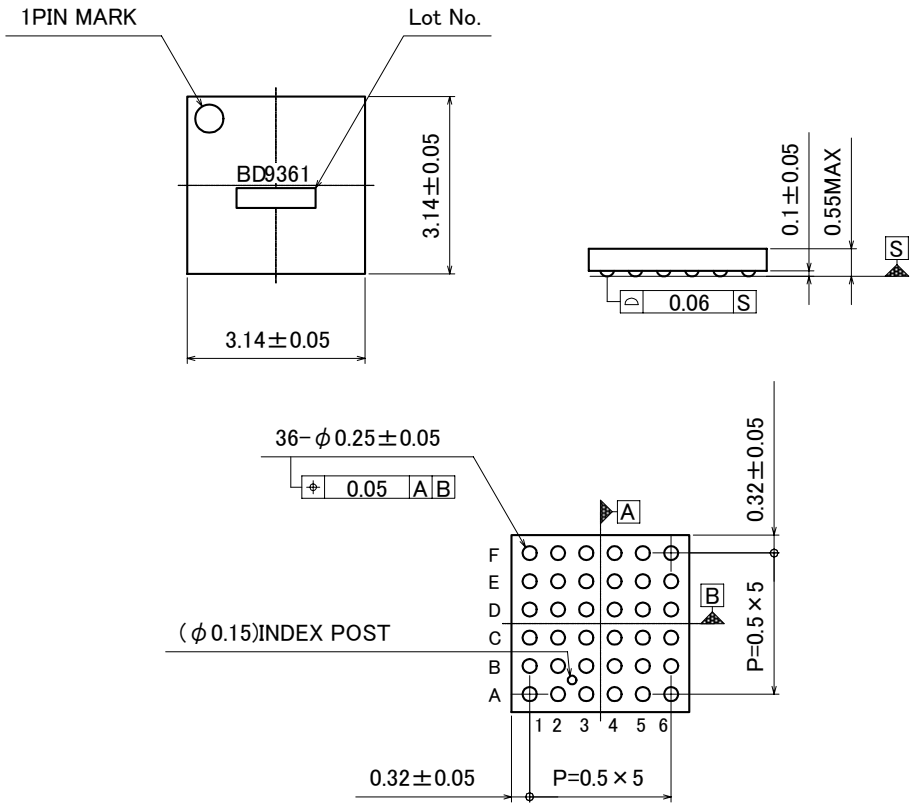


Fig.30 Package and Marking Diagram

Notice

●General Precaution

1) Before you use our Products, you are requested to carefully read this document and fully understand its contents. ROHM shall not be in any way responsible or liable for failure, malfunction or accident arising from the use of any ROHM's Products against warning, caution or note contained in this document.

2) All information contained in this document is current as of the issuing date and subject to change without any prior notice. Before purchasing or using ROHM's Products, please confirm the latest information with a ROHM sales representative.

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1) Our Products are designed and manufactured for application in ordinary electronic equipments (such as AV equipment, OA equipment, telecommunication equipment, home electronic appliances, amusement equipment, etc.). If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment, transport equipment, traffic equipment, aircraft/spacecraft, nuclear power controllers, fuel controllers, car equipment including car accessories, safety devices, etc.) and whose malfunction or failure may cause loss of human life, bodily injury or serious damage to property ("Specific Applications"), please consult with the ROHM sales representative in advance. Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of any ROHM's Products for Specific Applications.

2) ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
   [a] Installation of protection circuits or other protective devices to improve system safety
   [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

3) Our Products are designed and manufactured for use under standard conditions and not under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc, prior to use, must be necessary:
   [a] Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
   [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
   [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2
   [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
   [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
   [f] Sealing or coating our Products with resin or other coating materials
   [g] Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
   [h] Use of the Products in places subject to dew condensation

4) The Products are not subject to radiation-proof design.

5) Please verify and confirm characteristics of the final or mounted products in using the Products.

6) In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse) is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.

7) De-rate Power Dissipation (Pd) depending on Ambient temperature (Ta). When used in sealed area, confirm the actual ambient temperature.

8) Confirm that operation temperature is within the specified range described in the product specification.

9) ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

●Precaution for Mounting / Circuit board design

1) When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.

2) In principle, the reflow soldering method must be used; if flow soldering method is preferred, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

●Precautions Regarding Application Examples and External Circuits

1) If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.

2) You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

●Precaution for Electrostatic

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of Ionizer, friction prevention and temperature / humidity control).

●Precaution for Storage / Transportation

1) Product performance and soldered connections may deteriorate if the Products are stored in the places where:
   [a] the Products are exposed to sea winds or corrosive gases, including Cl2, H2S, NH3, SO2, and NO2
   [b] the temperature or humidity exceeds those recommended by ROHM
   [c] the Products are exposed to direct sunshine or condensation
   [d] the Products are exposed to high Electrostatic

2) Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.

3) Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.

4) Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

●Precaution for Product Label

QR code printed on ROHM Products label is for ROHM's internal use only.

●Precaution for Disposition

When disposing Products please dispose them properly using an authorized industry waste company.

●Precaution for Foreign Exchange and Foreign Trade act

Since our Products might fall under controlled goods prescribed by the applicable foreign exchange and foreign trade act, please consult with ROHM representative in case of export.

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