RICOH RN5C750

4ch RGB Laser Diode Driver for Display System, for Automotive Applications

NO.EC-544-191115

OVERVIEW

The RN5C750 is a laser-diode driver designed to support four-channel RGB/RGGB displays for driving laser scanning systems. By connecting photo diodes (PD), this device is capable of automatically detecting a threshold current and a light emitting current of each channel of the laser-diode drivers (LD).

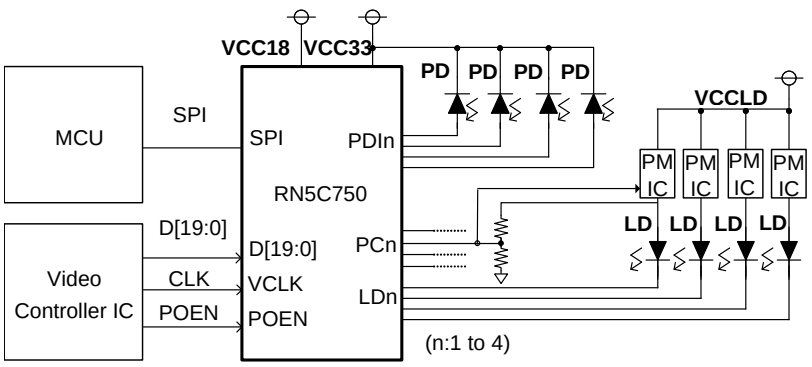
KEY BENEFITS

- 200Mdot/sec High Speed Sink Type 10-Bit Current DAC RGGB 4-Channel Configuration.
- Equipped with TIA/PGA for PD Light Receiving System and Automatic Setting Functions of Increase/ /Decrease Rate for LD Light Emitting Current and LD Threshold Current.
- QFN 56-Pins Wettable Frank Compatible.
- Provided Safe Pin Arrangement with Consideration for Shorting between Adjacent Pins.

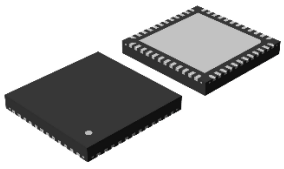
KEY SPECIFICATIONS

- RGGB 4 Channel Current Output (Sink)
- LD1 (R) Maximum Operating Current ····· I_{OP} = 800 mA (I_{COLOR} = up to 500 mA, I_{TH} = up to 300 mA)
- LD2 to 4 (GGB) Maximum Operating Current ····· I_{OP} = 400 mA (I_{COLOR} = up to 250 mA, I_{TH} = up to 150 mA)
- Maximum Output Rate Per 1 Channel ····· 200Mdot/sec
- High Gradation Output by Using 10-Bit Color DAC
- High Speed Output of Typically 1.0-ns Rising/Falling
- 20-bit Parallel Input Video I/F, Maximum Clock Frequency: 200 MHz, LVCMOS I/F
- 10-bit Parallel Input Video I/F, Maximum Clock Frequency: 225 MHz, LVCMOS I/F
- 10-V LD Pin Corresponding to High Forward Voltage (V_F) LD
- Power Saving and Heat Generation Suppression of Package by Using LD Power Source Control
- Protections: LD Overcurrent, LD Pin Short Circuit, PDI Input, Thermal Shutdown
- Pulse-Off Function, Dimming Function
- 12-bit SAR-ADC
- Serial Port Control by Using SPI Communication, SPI Maximum: 25 MHz
- Operating Temperature Range: −40°C to 105°C

TYPICAL APPLICATIONS



PACKAGES

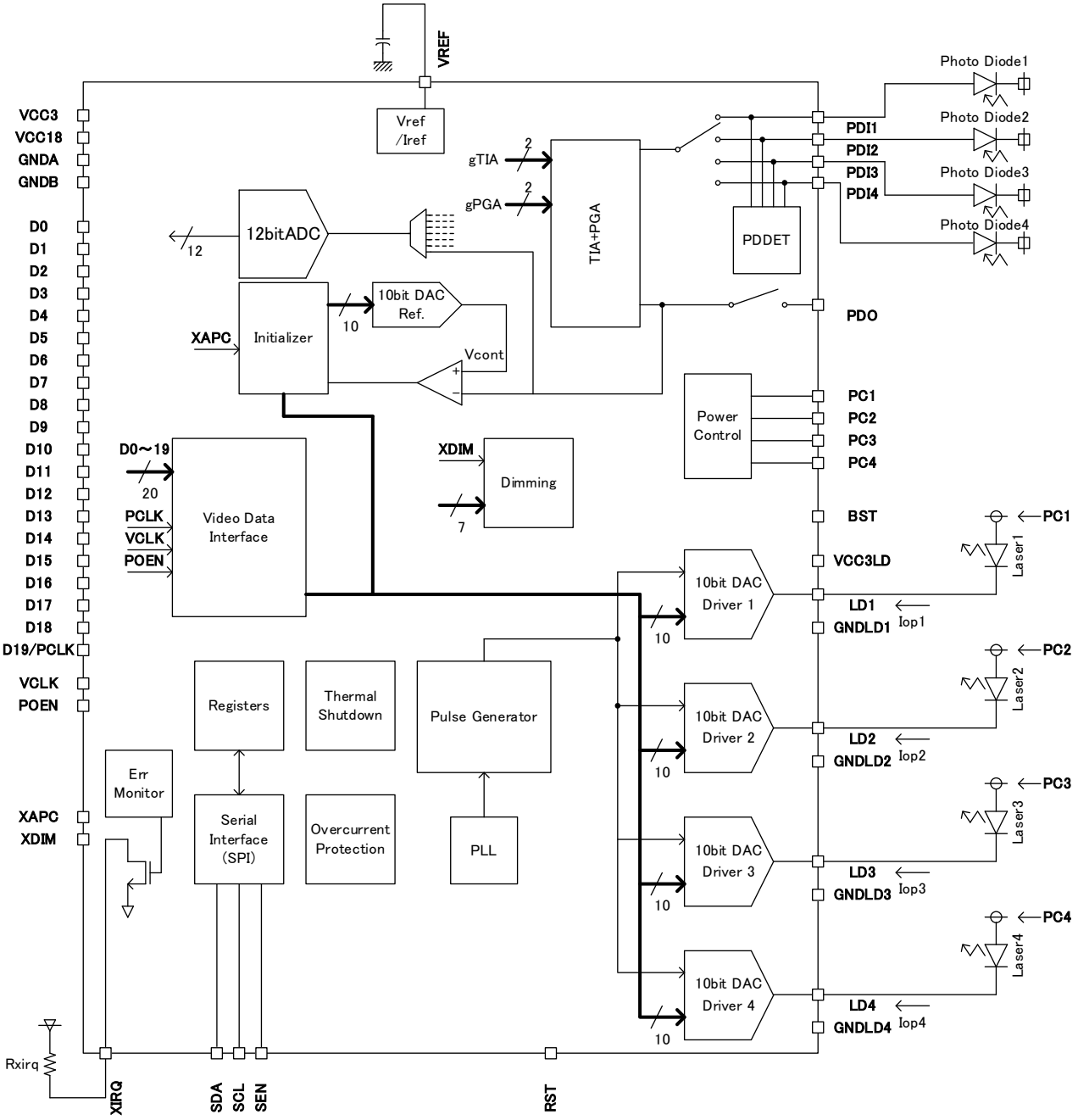


QFN0808-56
8.0mm X 8.0mm, t = 0.8mm (Max.)

APPLICATIONS

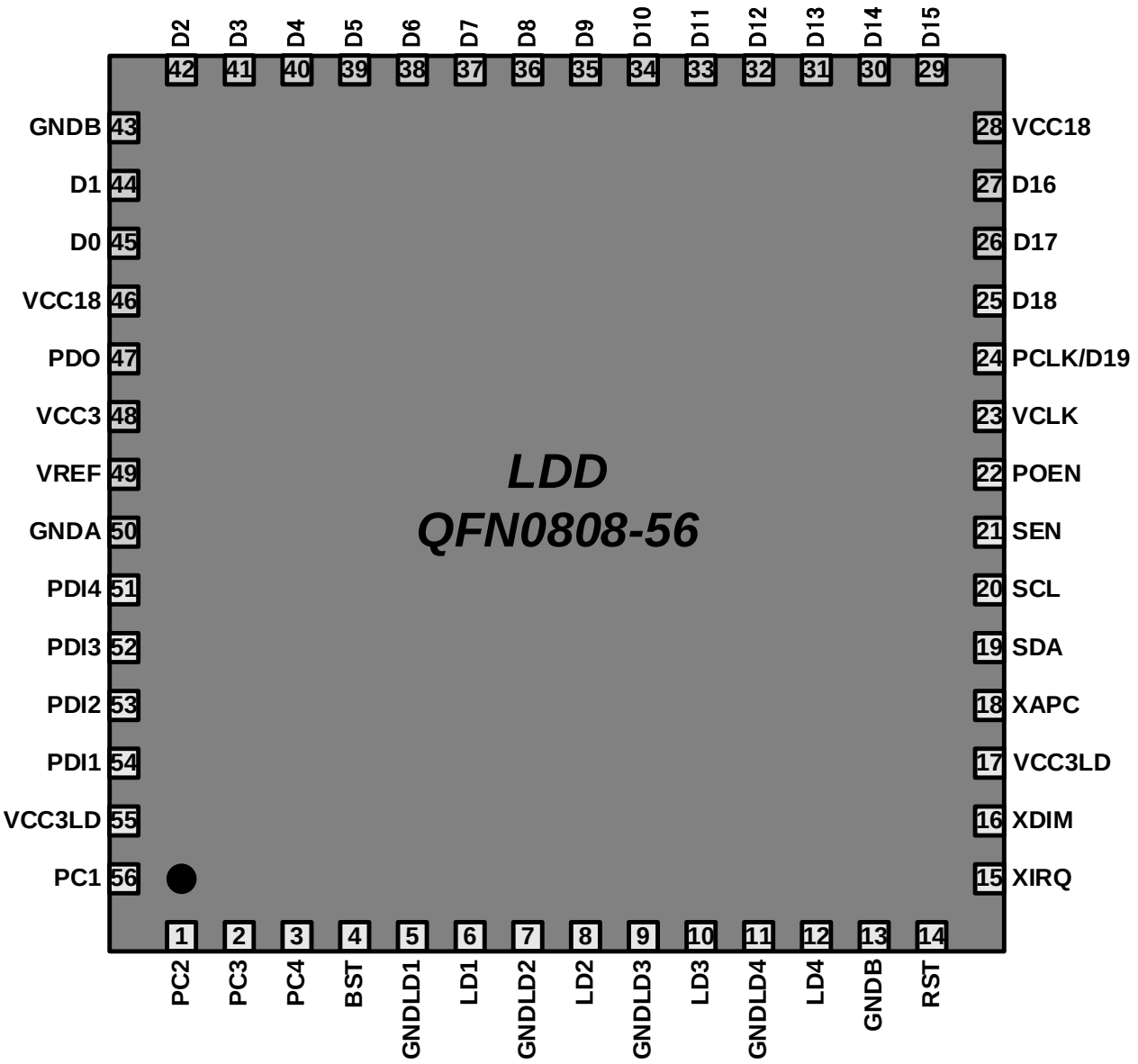
- Head Up Display (HUD)
- Pico-Projector

BLOCK DIAGRAM



RN5C750 Block Diagram

PIN DESCRIPTIONS



RN5C750 (QFN0808-56) Pin Configuration

RN5C750 Pin Description

Pin No.	Pin Name	I/O[1]	Pin Type[2]	Description
1	PC2	O	A	**Laser 2 Driving Power Source Control Signal**
2	PC3	O	A	**Laser 3 Driving Power Source Control Signal**
3	PC4	O	A	**Laser 4 Driving Power Source Control Signal**
4	BST	O	A	**BST Signal for a boosting capacitor**
5	GNDLD1	I	G	**LD1 Driving Block GND Signal**
6	LD1	O	A	**Laser1 Driving Current Signal** This pin connects to the cathode of Laser 1.
7	GNDLD2	I	G	**LD2 Driving Block GND Signal**
8	LD2	O	A	**Laser2 Driving Current Signal** This pin connects to the cathode of Laser 2.
9	GNDLD3	I	G	**LD3 Driving Block GND Signal**
10	LD3	O	A	**Laser3 Driving Current Signal** This pin connects to the cathode of Laser 3.
11	GNDLD4	I	G	**LD4 Driving Block GND Signal**
12	LD4	O	A	**Laser4 Driving Current Signal** This pin connects to the cathode of Laser 4.
13	GNDB	I	G	**Digital Block GND Signal**
14	RST	I	D	**Reset Signal** This pin is active at “High”. This has a 3.3V tolerant I/O buffer with a pull-up resistor.
15	XIRQ	O	D	**Interruption Signal** This pin becomes “Low” when detected interruption and “Hiz” when not detected it or when reset. This has a 3.3 V tolerant I/O buffer.
16	XDIM	I	D	**Power Dimming Valid Range Signal** This pin indicates a valid range for power dimming. This has a 3.3V tolerant I/O buffer with a pull-up resistor.
17	VCC3LD	I	P	**LDn Driving Block 3.3 V Power Source Signal (n: 1 to4)**
18	XAPC	I	D	**Initialization Enabled Signal** The initialization starts at the falling edge of XAPC (“High” to “Low”). From that time forward, the initialization runs during the XAPC of “Low”. This pin has a 3.3 V tolerant I/O buffer with a pull-up resistor.
19	SDA	I/O	D	**SPI Serial Data Line Signal** This has a 3.3 V tolerant I/O buffer and outputs a 1.8 V signal. This pin is an input signal at reset.
20	SCL	I	D	**SPI Serial Clock Line Signal** This has a 3.3 V tolerant I/O buffer.
21	SEN	I	D	**SPI Enabled Signal** This has a 3.3 V tolerant I/O buffer.
22	POEN	I	D	**PO Enabled Signal** To reduce a speckle noise, a light-off pulse set in the register occurs to a video data during the POEN of “High”.
23	VCLK	I	D	**Video Clock Signal** Maximum frequency: 225MHz

[1] I: Input Pin, O: Output Pin, I/O: Input/Output Pin
[2] A: Analog Signal, D: Digital Signal, P: Power, G: Ground

QFN0808-56 Pin Description (Continued)

Pin No.	Pin Name	I/O[1]	Pin Type[2]	Description
24	D19/PCLK	I	D	**VCLK Synchronized Video Data Signal** Dx is enabled at “High”. **Pixel Clock Signal** PCLK is valid when selected the mode 2/3 in the video data input mode. The pixel clock is the same frequency as a dot rate (dot/sec) for output current LDn (n:1 to 4). Maximum frequency: 150MHz
25	D18	I	D	**VCLK Synchronized Video Data Signal** Dx is enabled at “High”.
26	D17	I	D	
27	D16	I	D	
28	VCC18	I	P	**Digital Block 1.8 V Power Source Signal**
29	D15	I	D	**VCLK Synchronized Video Data Signal** Dx is enabled at “High”.
30	D14	I	D	
31	D13	I	D	
32	D12	I	D	
33	D11	I	D	
34	D10	I	D	
35	D9	I	D	
36	D8	I	D	
37	D7	I	D	
38	D6	I	D	
39	D5	I	D	
40	D4	I	D	
41	D3	I	D	
42	D2	I	D	
43	GNDB	I	G	**Digital Block GND Signal**
44	D1	I	D	**VCLK Synchronized Video Data Signal** Dx is enabled at “High”.
45	D0	I	D	
46	VCC18	I	P	**Digital Block 1.8 V Power Source Signal**
47	PDO	IO	A	**TIA-PGA Output Monitoring and ADC Input**
48	VCC3	I	P	**Analog Block 3.3 V Power Source Signal**
49	VREF	O	A	**Internal Reference Voltage Capacitance Signal**
50	GNDA	I	G	**Analog Block GND Signal**
51	PDI4	I	A	**Photo Diode (PD) 4 Monitor Current Signal (Im4)** This pin connects to the anode of PD4.
52	PDI3	I	A	**Photo Diode (PD) 3 Monitor Current Signal (Im3)** This pin connects to the anode of PD3.
53	PDI2	I	A	**Photo Diode (PD) 2 Monitor Current Signal (Im2)** This pin connects to the anode of PD2.
54	PDI1	I	A	**Photo Diode (PD) 1 Monitor Current Signal (Im1)** This pin connects to the anode of PD1.
55	VCC3LD	I	P	**LDn Driving Block 3.3 V Power Source Signal (n: 1 to4)**
56	PC1	O	A	**Laser 1 Driving Power Source Control Signal**
	TAB			Recommended to connect TAB to ground.

[1] I: Input Pin, O: Output Pin, I/O: Input/Output Pin
[2] A: Analog Signal, D: Digital Signal, P: Power, G: Ground

Recommended Processing for Unused Pins

It is recommended that unused pins apply the following processing.

Pin Name	Unused Pin Processing
LD**n**	Shorted to GND
PDI**n**	Open
PDO	Open
PC**n**	Pulled up to VCC3
D[19:0]	Pulled down to GND

(n: 1 to 4)

ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings

Symbol	Parameter	Conditions	Rating	Unit
V_{CC3}	3.3 V Power Source Voltage (1)	Voltage on VCC3 and VCC3LD Pins	−0.3 to +5	V
V_{CC18}	1.8 V Power Source Voltage (1)	VCC18 Pin Voltage	−0.3 to +2.5	V
V_{D18}	1.8 V Digital Pin Voltage (1)	Voltage on D[19:0], PCLK(D19), VCLK, and POEN Pins	−0.3 to V_{CC18} +0.3 Max: +2.5	V
V_{D18TL}	1.8 V Digital 3.3 V Tolerant Pin Voltage (1)	Voltage on XAPC, XDIM, SDA, SCL, SEN, RST, and XIRQ Pins	−0.3 to +5	V
V_{A3}	3.3 V Analog Pin Voltage (1)	Voltage on PCn, PDIn, PDO, VREF, and BST Pins	−0.3 to V_{CC3} +0.3 Max: +5	V
V_{LD}	LD Pin Voltage (1)	Voltage on LDn Pins	−0.3 to +11	V
P_D	Power Dissipation	Refer to Appendix “Power Dissipation”.		
Tj	Junction Temperature Range	−	-40 ~ 150	°C
Tstg	Storage Temperature Range	−	-55 ~ 150	°C

(n: 1 to 4)

ABSOLUTE MAXIMUM RATINGS

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause permanent damage and may degrade the life time and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings is not assured.

RECOMMENDED OPERATING CONDITIONS

Recommended Operating Conditions

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{CC3}	3.3 V Power Source Voltage	3.135	3.3	3.465	V
V_{CC18}	1.8 V Power Source Voltage	1.7	1.8	1.9	V
V_{LD}	LD Pin Voltage			10	V
Ta	Operating Temperature Range	−40	25	105	°C

RECOMMENDED OPERATING CONDITONS

All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

(1) With reference to the GND pin voltage

ELECTRICAL CHARACTERISTICS

All parameters are tested under the recommended operating conditions, unless otherwise noted.

RN5C750 Electrical Characteristics

Symbol	Parameter	Pin	Conditions	Min.	Typ.	Max.	Unit
I_{DD3LD}	3.3 V Power Source Current at Operation	VCC3LD	SLP = L		15		mA
I_{DD3}	3.3 V Power Source Current at Operation	VCC3	SLP = L		0.5		mA
I_{DD18}	1.8 V Power Source Current at Operation	VCC18	SLP = L		75		mA
I_{SS3LD}	3.3 V Power Source Current at Sleep	VCC3LD	SLP = H, D[19:0] = 0		0		mA
I_{SS3}	3.3 V Power Source Current at Sleep	VCC3	SLP = H, D[19:0] = 0		0.5		mA
I_{SS18}	1.8 V Power Source Current at Sleep	VCC18	SLP = H, D[19:0] = 0		60		mA

Operating Conditions: VCLK = 200MHz, Initialization's off, Each DAC code [(1)] = "001h"

RN5C750 Electrical Characteristics: Input / Output Pin

Symbol	Parameter	Pin	Conditions	Min.	Typ.	Max.	Unit
V_{IH}	Input Voltage, High	XAPC, XDIM, RST		V_{CC18} ×0.8			V
		D[19:0], PCLK(D19), VCLK, POEN		V_{CC18}/2 +0.25			V
		SCL, SEN, SDA		V_{CC18} ×0.7			V
V_{IL}	Input Voltage, Low	XAPC, XDIM, RST				V_{CC18} ×0.2	V
		D[19:0], PCLK(D19), VCLK, POEN				V_{CC18}/2 −0.25	V
		SCL, SEN, SDA				V_{CC18} ×0.3	V
V_{OH}	Output Voltage, High	SDA	I_{LOAD} = 4 mA	V_{CC18} −0.4			V
V_{OL}	Output Voltage, Low	XIRQ, SDA	I_{LOAD} = 4 mA			0.4	V
I_{OZ}	Output Off Leakage Current	SDA, XIRQ		−3		3	µA
I_{IZ}	Input Off Leakage Current	XAPC, XDIM, RST, D[19:0], PCLK(D19),, VCLK, POEN, SCL SEN,				0.1	µA

[(1)] Thresh_MIN_DAC, Thresh_Scale_DAC, Thresh_DAC, and Color_Scale_DAC

RN5C750 Electrical Characteristics: LD Output DC

Symbol	Parameter	Pin	Conditions	Min.	Typ.	Max.	Unit
V_{IDON}	Output Voltage at Light-on	LDn	I_{OP_MAX}	1.5			V
I_{TH}	Maximum Threshold Current	LD1		240	300		mA
		LD2/3/4		120	150		
I_{COLOR}	Maximum Light Emitting Current	LD1		400	500		mA
		LD2/3/4		200	250		
I_{OP}	Maximum Operating Current	LD1	$I_{COLOR} + I_{TH}$		800		mA
		LD2/3/4	$I_{COLOR} + I_{TH}$		400		
C_{LDNL}	Color DAC DNL	LDn	V_{LD} = 1.5 V	−5		5	LSB
C_{LINL}	Color DAC INL	LDn	V_{LD} = 1.5 V	−10		30	LSB
C_{SDNL}	Color Scale DAC DNL	LDn	V_{LD} = 1.5 V	−5		5	LSB
C_{SINL}	Color Scale DAC INL	LDn	V_{LD} = 1.5 V	−10		35	LSB
T_{HDNL}	Threshold DAC DNL	LDn	V_{LD} = 1.5 V	−2		2	LSB
T_{HINL}	Threshold DAC INL	LDn	V_{LD} = 1.5 V	−5		25	LSB
T_{HSDNL}	Threshold Scale DAC DNL	LDn	V_{LD} = 1.5 V	−1		2	LSB
T_{HSINL}	Threshold Scale DAC INL	LDn	V_{LD} = 1.5 V	−1		2	LSB
T_{HMDNL}	Thresh MIN DAC DNL	LDn	V_{LD} = 1.5 V	−1		1	LSB
T_{HMINL}	Thresh MIN DAC INL	LDn	V_{LD} = 1.5 V	−5		5	LSB
I_{LDOFF}	Output Current at Reset	LD1	RST = high, V_{LD} = 7 V			6	µA
		LD2/3/4				3	
I_{LDOVC}	LD Pin Overcurrent Detection	LD1				880	mA
		LD2/3/4				440	
V_{LDUVD}	LD Pin short-circuit Detection	LD2/3/4			0.5	0.6	V
V_{BST}	Pin Output	BST			5		V
A_{OCDET}	LD Pin Overcurrent Detection	LDn	LD1: up to 880mA LD2/3/4: up to 440mA	-20		35	%

(n: 1 to 4)

RN5C750 Electrical Characteristics: LD Output AC

Symbol	Parameter	Pin	Conditions	Min.	Typ.	Max.	Unit
t_{RLD}	I_{COLOR} Rising Time	LDn			1		ns
t_{FLD}	I_{COLOR} Falling Time	LDn			1		ns

(n: 1 to 4)

RN5C750 Electrical Characteristics: Initialization Operation

Symbol	Parameter	Pin	Conditions	Min.	Typ.	Max.	Unit
V_{REF}	Reference Voltage	VREF	at start up		2.5		V
V_C	Vcont Reference Voltage		at initialization	0.05		2.45	V
V_{PC}	LD Voltage after PC Processing	LDn	PCREF = 4h (1.5 V), LD Power Source: 5 V or more	1.4	1.5	1.6	V
I_{PDI}	Monitor Input Current	PDIn	GAIN = Fh	2.5			uA
			GAIN = 0h			6	mA
V_{PDO}	Monitor Output Voltage	PDO		0.05		2.45	V
G_{MAX}	Maximum IV Amplification Factor		GAIN = Fh		20250		V/A
G_{MIN}	Minimum IV Amplification Factor		GAIN = 0h		300		V/A
V_{APCA}	Input conversion APC accuracy		GAIN = 0h			33	uA
V_{ADIN}	ADC Input Voltage	PDO		0.05		2.45	V
V_{ADA}	ADC accuracy		TIA-PGA GAIN = 0h to Fh APCCLK = 2MHz	-25		25	mV
I_{NITH}	Threshold Detection Error	LDn	LD-PD Liner Model			5	%
I_{NICS}	Color Scale Detection Error	LDn	LD-PD Liner Model			5	%
I_{PDOVC}	PDI Input Fault Detection (Maximum setting)	PDIn	GAD = 3h		0.33		mA
			GAD = 2h		1		mA
			GAD = 1h		3		mA
			GAD = 0h		9		mA
t_{APC}	Initialization Processing Time		APCCLK = 2MHz, 1ch, Standard Flow			128	µs
t_{PC1}	PC Processing Time1		PCCLK = 0.5 MHz, 1ch, Standard Flow, At startup			130	µs
t_{PC2}	PC Processing Time 2		PCCLK = 0.5MHz, 1ch, Standard Flow, For the 2nd and subsequent times			6	µs

(n: 1 to 4)

RN5C750 Electrical Characteristics: PLL, Reference Clock

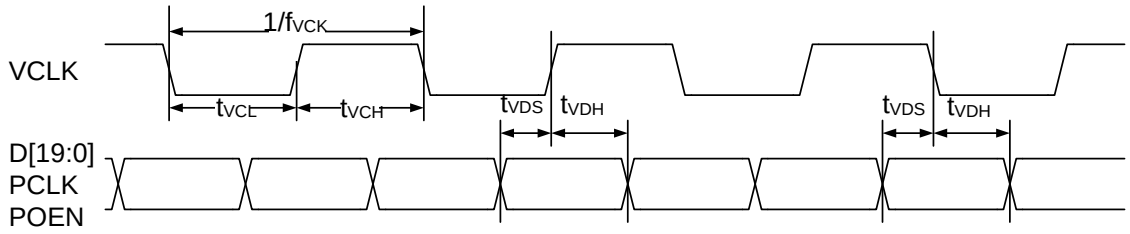
Symbol	Parameter	Pin	Conditions	Min.	Typ.	Max.	Unit
f_{CLKQ}	PLL Frequency (CLKQ)			100		200	MHz
f_R	Comparison Frequency			10		20	MHz

RN5C750 Electrical Characteristics: Overtemperature Protection

Symbol	Parameter	Pin	Conditions	Min.	Typ.	Max.	Unit
T_{DET}	Detection Temperature		TSHUT_DET = 0h		150		°C
			TSHUT_DET = 1h		155		°C
			TSHUT_DET = 2h		160		°C
			TSHUT_DET = 3h		165		°C
T_{REL}	Release Temperature		TSHUT_REL = 0h		135		°C
			TSHUT_REL = 1h		140		°C
			TSHUT_REL = 2h		145		°C
			TSHUT_REL = 3h		150		°C

RN5C750 Electrical Characteristics: Input Video I/F AC

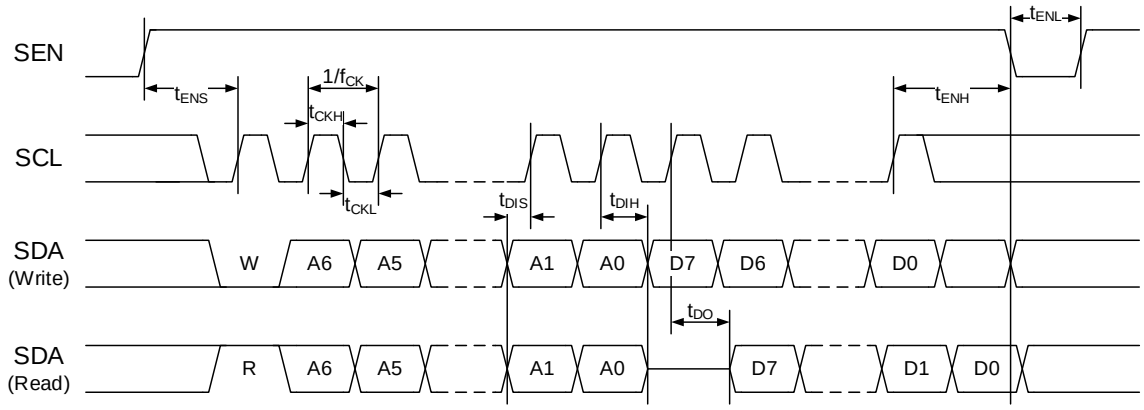
Symbol	Parameter	Pin	Conditions	Min.	Typ.	Max.	Unit
f_{VCK}	VCLK Frequency	VCLK		10		225	MHz
t_{VCL}	VCLK Low Period	VCLK		2			ns
t_{VCH}	VCLK High Period	VCLK		2			ns
t_{VDS}	Data Setup Time	D[19:0], PCLK(D19), POEN	V_{CC18} x 0.5, ±0.25V	0			ns
t_{VDH}	Data Hold Time	D[19:0], PCLK(D19), POEN	V_{CC18} x 0.5, ±0.25V	1.5			ns
t_{DRR}	Data Input Slew Rate	D[19:0], PCLK(D19), POEN	V_{CC18} x 0.5, ±0.25V	1			V/ns



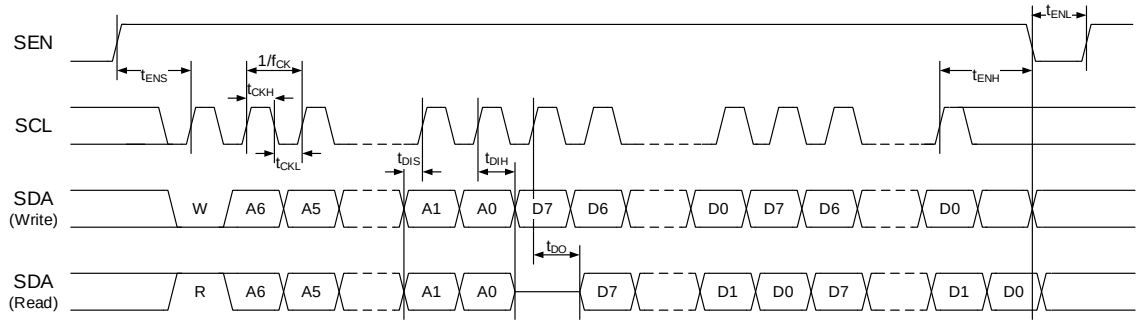
Video Data I/F Timing Chart

RN5C750 Electrical Characteristics: SPI I/F AC

Symbol	Parameter	Pin	Test Conditions/Comments	Min.	Typ.	Max.	Unit
f_{CK}	SCLK Frequency	SCL				25	MHz
t_{CKH}	SCLK High Period	SCL		10			ns
t_{CKL}	SCLK Low Period	SCL		10			ns
t_{ENL}	SEN Low Period	SEN		20			ns
t_{ENS}	Enable Setup Time	SEN		10			ns
t_{ENH}	Enable Hold Time	SEN		10			ns
t_{DIS}	Data Setup Time	SDA		5			ns
t_{DIH}	Data Hold Time	SDA		5			ns
t_{DO}	Data Output Delay Time	SDA				25	ns



Normal Access



Continuous Access (1)

SPI I/F Timing Chart

(1) Address is automatically incremented when during continuous access, without upper limit.

PD-QFN0808-56(105150)-JE-A

The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following measurement conditions are based on JEDEC STD. 51.

Measurement Conditions

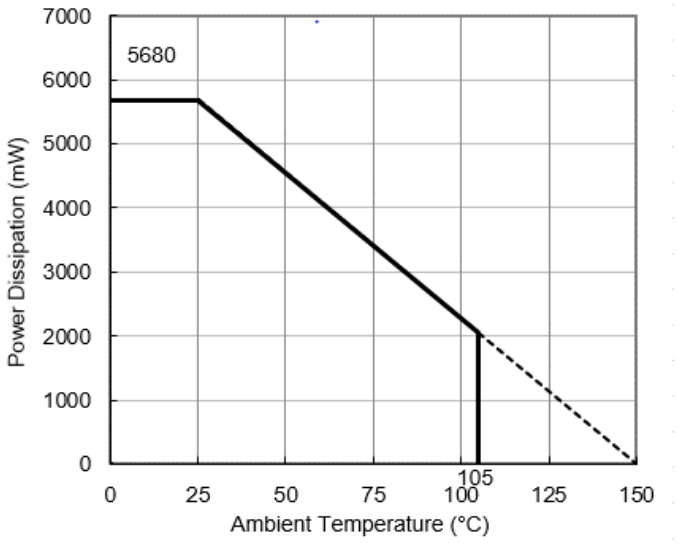
Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 1.6 mm
Copper Ratio	Outer Layer (First Layer): Less than 10% Inner Layers (Second and Third Layers): Approx. 100% of 74.2 mm Square Outer Layer (Fourth Layer): Less than 10%
Through-holes	ϕ 0.3 mm × 25 pcs

Measurement Result (Ta = 25°C, Tjmax = 150°C)

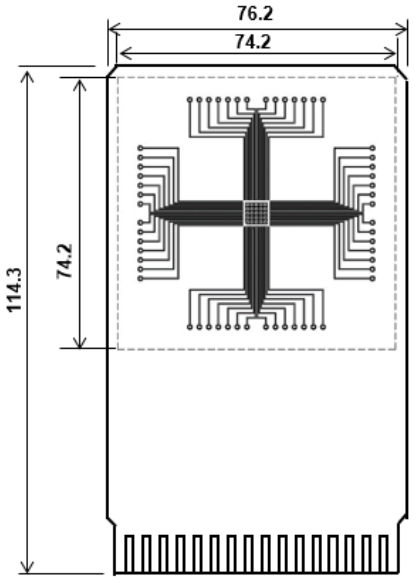
Item	Measurement Result
Power Dissipation	5680 mW
Thermal Resistance (θja)	θja = 22°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 4°C/W

θja: Junction-to-Ambient Thermal Resistance

ψjt: Junction-to-Top Thermal Characterization Parameter

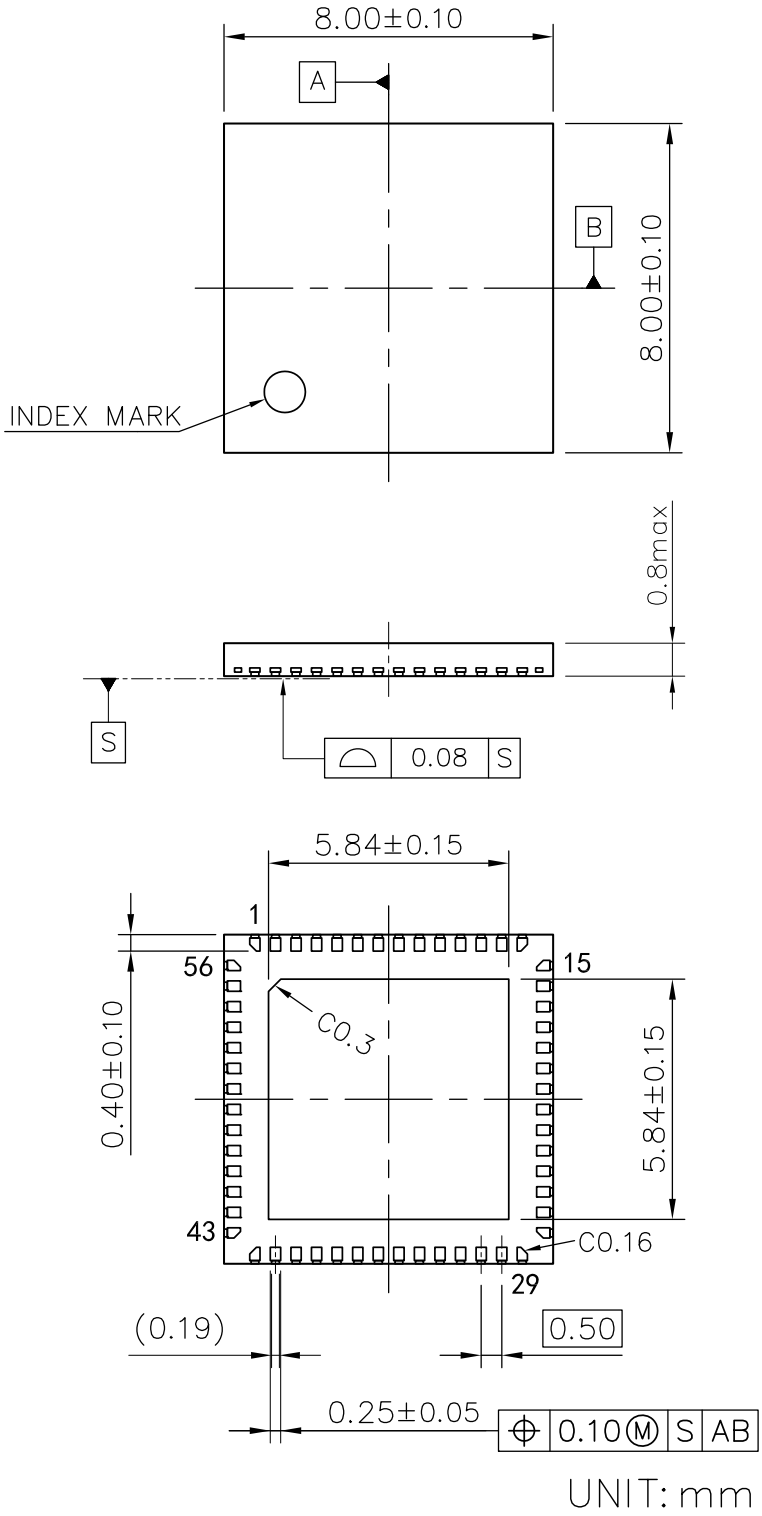


Power Dissipation vs. Ambient Temperature



Measurement Board Pattern

RICOH



QFN0808-56 Package Dimensions

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7. Anti-radiation design is not implemented in the products described in this document.
8. The X-ray exposure can influence functions and characteristics of the products. Confirm the product functions and characteristics in the evaluation stage.
9. WLCSP products should be used in light shielded environments. The light exposure can influence functions and characteristics of the products under operation or storage.
10. There can be variation in the marking when different AOI (Automated Optical Inspection) equipment is used.
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11. Please contact Ricoh sales representatives should you have any questions or comments concerning the products or the technical information.

RoHS Compliant
Halogen Free

Ricoh is committed to reducing the environmental loading materials in electrical devices with a view to contributing to the protection of human health and the environment.
Ricoh has been providing RoHS compliant products since April 1, 2006 and Halogen-free products since April 1, 2012.

RICOH ELECTRONIC DEVICES CO., LTD.

Official website
https://www.e-devices.ricoh.co.jp/en/
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