LED Control IC
W2RF002RF

Most Suitable IC for Controlling LED Effects within Applications

- Free-running PWM gradation control, with up to 1,024 levels, enables the representation of beautiful fade-in and fade-out effects.
- CPU load can be reduced by controlling lighting gradation and speed.
- Up to 49 pieces of this IC can be connected on the same serial bus communication line. Device group setting is also possible.
- 24 Line Outputs are contained in the 7 x 7 mm package.
- Use with Omron's W2RV005RM Constant Current IC to directly drive multiple LED's in series.
- RoHS Compliant

Ordering Information

Description	Model
LED Control IC	**W2RF002RF**

Specifications

Absolute Maximum Ratings (Ta = 25°C)

Item	Symbol	Rating
Supply Voltage	V_{DD}	-0.3 to 7.0 V
Input Voltage	V_{IN}	-0.3 to V_{DD} + 0.3 ≤ 7.0 V
Communication Output Voltage (SCL-O, SDA-O)	V_{SOUT}	-0.3 to V_{DD} + 0.3 ≤ 7.0 V
Driving Output Voltage	V_{DOUT}	-0.3 to 20 V
Driving Output Current/pin (See note 1)	I_{DOUT}	50 mA (when V_{DD} = 5.0 V)
		30 mA (when V_{DD} = 3.3 V)
Power Dissipation	Pd	1.19 W (See note 2)
Operating Temperature	T_{OPR}	-20 to 85 °C
Storage Temperature	T_{STG}	-40 to 150 °C

Note: 1. Take the power consumption and power dissipation rating into consideration.

2. When implemented on a standard board (70 x 70 x 1.6 mm, Cu 3%, Single-sided glass epoxy board). The value reduces at a rate of about 9.52 mW/°C when the IC is used at Ta = 25°C or higher.

Recommended Operating Conditions

Item	Symbol	Rating
Supply Voltage	V_{DD}	3.0 to 5.5 V
Input Voltage	V_{IN}	0 to V_{DD} V
Communication Output Current (SCL-O, SDA-O)	I_{SOUT}	-10 to 10 mA
Communication Clock Frequency (SCL-I)	f_{SCL}	Max. 5 MHz (See note 1)

Note: 1. Take the timing characteristics into consideration.

DC Electrical Characteristics (Ta = 25°C, V_{DD} = 5V)

Item	Symbol	Condition	Spec.			Unit	Applicable terminal
			Min.	Typ.	Max.		
High-level Input Voltage	V_{IH}	- - -	V_{DD} x 0.7	- - -	- - -	V	SDA-I, SCL-I, $\overline{RST}$, INV, ADRA0 to 2, ADRB0 to 2
Low-level Input Voltage	V_{IL}	- - -	- - -	- - -	V_{DD} x 0.3	V	
High-level Communication Output Voltage	V_{SOH}	I_{OUT} = -10 mA	V_{DD} - 0.5	- - -	- - -	V	SDA-O, SCL-O
Low-level Communication Output Voltage	V_{SOL}	I_{OUT} = 10 mA	- - -	- - -	0.5	V	
Driving Output Voltage 1	V_{DO1}	I_{OUT} = 50 mA	- - -	0.27	0.60	V	OUTA0 to 7 OUTB0 to 7 OUTC0 to 7
Driving Output Voltage 2	V_{DO2}	I_{OUT} = 20 mA	- - -	0.10	0.22	V	
Driving Output Leakage Current	I_{DOZ}	V_{OUT} = 5 V	- - -	- - -	1.0	µA	
Operating Current Consumption	I_{DD}	Total Output: I_{OUT} = 50 mA	- - -	3.2	5.3	mA	V_{DD}

Timing Characteristics (Ta = 25°C, V_{DD} = 5V)

Item	Symbol	Condition	Spec.			Unit	Applicable terminal
			Min.	Typ.	Max.		
Driving Output PWM Cycle	T_{PWM}	- - -	3.88	4.00	4.12	ms	OUTA0 to 7 OUTB0 to 7 OUTC0 to 7
Communication Clock Pulse Width	t_{SCL}	- - -	100	- - -	- - -	ns	SCL-I
Setup Time	t_{SET}	- - -	50	- - -	- - -	ns	SDA-I, SCL-I
Hold Time	t_{HLD}	- - -	50	- - -	- - -	ns	

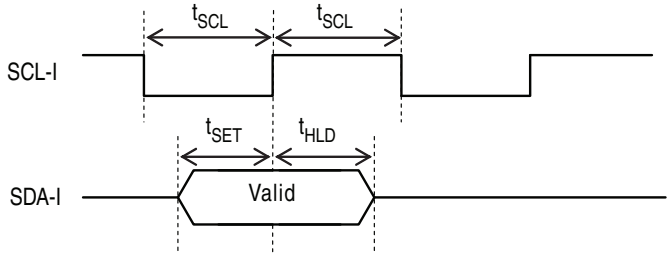
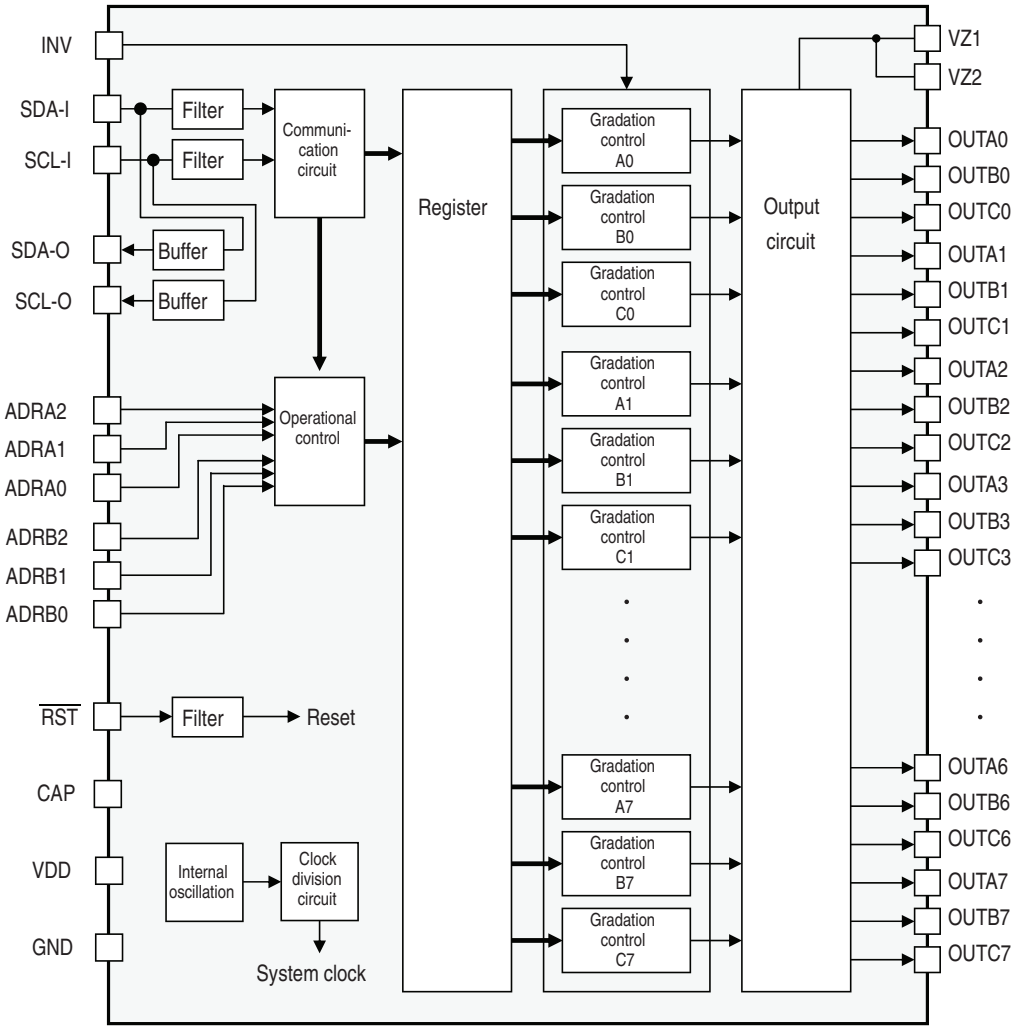


Fig. 1 Input timing waveforms

Engineering Data

Block Diagram



Terminal Designation

Terminal Number	Terminal Name	Description	I/O	Logic	Function
1	SDA-I	Serial data input	I		CMOS, filter
2	SCL-I	Serial clock input	I		
3	$\overline{RST}$	Reset (See note 1)	I	L: Reset	CMOS, filter, pull-up
4	V_{DD}	Power source	P		
5	CAP	Capacitor (See note 2)	- - -		
6	GND	Ground	P		
7	ADRA2	Device address A2	I	Refer to Operaton section (See note 4)	CMOS
8	ADRA1	Device address A1	I		
9	ADRA0	Device address A0	I		
10	ADRB2	Device address B2	I		
11	ADRB1	Device address B1	I		
12	ADRB0	Device address B0	I		
13	INV	Output inversion	I		
14	GND	Ground	P		
15	OUTA0	Output A0	O		N-ch open drain
16	OUTB0	Output B0	O		
17	OUTC0	Output C0	O		
18	OUTA1	Output A1	O		
19	OUTB1	Output B1	O		
20	OUTC1	Output C1	O		
21	VZ1	Output protection 1(See note 3)	- - -		
22	GND	Ground	P		
23	OUTA2	Output A2	O		N-ch open drain
24	OUTB2	Output B2	O		
25	OUTC2	Output C2	O		
26	OUTA3	Output A3	O		
27	OUTB3	Output B3	O		
28	OUTC3	Output C3	O		
29	GND	Ground	P		
30	OUTA4	Output A4	O		N-ch open drain
31	OUTB4	Output B4	O		
32	OUTC4	Output C4	O		
33	OUTA5	Output A5	O		
34	OUTB5	Output B5	O		
35	OUTC5	Output C5	O		
36	GND	Ground	P		
37	VZ2	Output protection 2(See note 3)	- - -		
38	OUTA6	Output A6	O		N-ch open drain
39	OUTB6	Output B6	O		
40	OUTC6	Output C6	O		
41	OUTA7	Output A7	O		
42	OUTB7	Output B7	O		
43	OUTC7	Output C7	O		
44	GND	Ground	P		
45	TST1	Not used (See note 4)	- - -		
46	TST2	Not used (See note 4)	- - -		
47	SDA-O	Serial data buffer output	O		CMOS
48	SCL-O	Serial clock buffer output	O		

Note: 1. The $\overline{RST}$ terminal is connected to an internal 100 kΩ pull-up resistor. When this terminal is not used, connect a 0.1 μF capacitor between the terminal and ground to prevent misoperation at power-on.

2. Connect the CAP terminal to a capacitor for smoothing power supply. Connect a 0.1 μF capacitor between the terminal and GND.

3. The VZ1 and VZ2 terminals are for driving output protection. Connect them to the power source of a driving system. When several driving system power supplies are used, connect the terminals to the highest potential among them. When these terminals are not used, leave them open.

4. Always leave the TST1 and TST2 terminals open.

5. Leave unused output terminals open.

Operation

■ Functional Overview

Receiving Commands

The IC recieves commands with two-wire serial communication to control 24 LED lines. Commands are received in a 40-bits-per-command communication format.

Gradation Control

The lighting of the 24 LED lines is controlled individually or by group with 16-level lighting gradation and 32-level lighting speed. The exponential control of output duty cycle allows lighting gradation that matches the human visual characteristics. In addition, the specification of lighting speed allows fade-in and fade-out with up to 1,024 levels.

Number of Control Lines

The IC has two device address lines, each of which can be configured in seven ways by terminal configuration. This provides up to 49 patterns of device address configuration, allowing up to 1,176 lines to be controlled on the same communication line. Two device address lines can be combined to configure a device group.

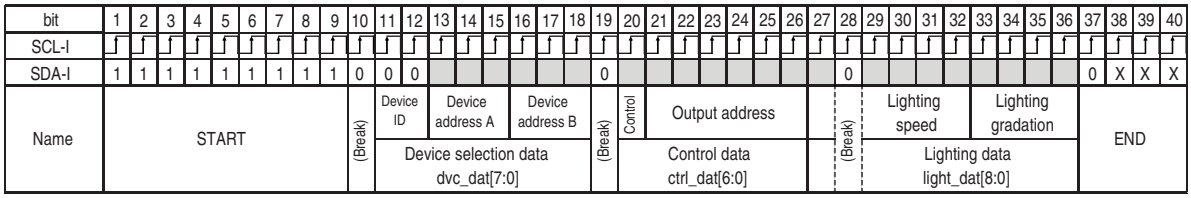
■ Communication Specifications

Input signals to SDA-I and SCL-I are input via the filter circuit (0.1μs delay) to the communication circuit. An SDA-I signal that is input to the communication circuit is taken in as serial data at the rising edge of an SCL-I signal. When serial data is received in a different format from the communication format, the data will be invalid.

When the START signal, “111111111” is detected, the communication circuit takes in data as new serial data, whether it is on stand-by or in the middle of intake of serial data.

Input signals to SDA-I and SCL-I will be output via the asynchronous buffer to SDA-O and SCL-O without going through the filter circuit.

Communication Format



Description of Communication Format

Device Selection Data	**Device ID**	Device-specific ID (Fixed to “00” for this IC)
	Device Address A	Specified with the ADRA0 to 2 terminals
	Device Address B	Specified with the ADRB0 to 2 terminals
Control Data	**Control**	Specifies control (data saving / immediate reflection)
	Output Address	Specifies the terminal to output (Individual specification and collective specification are possible)
Lighting Data	**Lighting Speed**	Specifies changing speed of free-running gradation control (32 levels)
	Lighting Gradation	Specifies the brightness of lighting (16 levels)

■ Control Command

Device Selection Data (8 bits)

Device selection data dvc_dat (7:0)							
Device ID		**Device Address A**			**Device Address B**		
0	0	ADRA2	ADRA1	ADRA0	ADRB2	ADRB1	ADRB0

The device ID is fixed. The correspondence between the device addresses A and B and the setting terminals ADRA0 to 2 and ADRB0 to 2 is shown in the table. (Setting “L”...Data “0”. Setting “H”...Data “1”).

When ADRA0 to 2 = “111”, the device address A line is specified collectively, and when ADRB0 to 2 = “111”, the device address B line is specified collectively.

Because up to 7 addresses can be specified for each of device address A and device address B, their combination allows the specification of up to 49 addresses.

Control Data (7 bits)

Control data ctrl_dat (6:0)						
Control	**Output Address**					
ctrl	o_adr(5)	o_adr(4)	o_adr(3)	o_adr(2)	o_adr(1)	o_adr(0)

The control signal, 'ctrl', activates the operational control shown in the following table.

- When ctrl = "0", latch operation is activated, in which data is only stored in latch registers and will not be reflected in the output.
- When ctrl = "1", load operation is activated, in which data is stored in the specified latch registers and the data of the latch registers in all addresses will be stored in the load registers.

Control (ctrl)	Operational Control
0	Latch
1	Load

The output terminals in the following table are specified with the output address o_adr(5:0)

Output Address o_adr (5:0)						Output Terminal
(5)	(4)	(3)	(2)	(1)	(0)	
0	0	0	0	0	0	OUTA0
0	0	0	0	0	1	OUTA1
0	0	0	0	1	0	OUTA2
0	0	0	0	1	1	OUTA3
0	0	0	1	0	0	OUTA4
0	0	0	1	0	1	OUTA5
0	0	0	1	1	0	OUTA6
0	0	0	1	1	1	OUTA7
0	0	1	0	0	0	OUTB0
0	0	1	0	0	1	OUTB1
0	0	1	0	1	0	OUTB2
0	0	1	0	1	1	OUTB3
0	0	1	1	0	0	OUTB4
0	0	1	1	0	1	OUTB5
0	0	1	1	1	0	OUTB6
0	0	1	1	1	1	OUTB7
0	1	0	0	0	0	OUTC0
0	1	0	0	0	1	OUTC1
0	1	0	0	1	0	OUTC2
0	1	0	0	1	1	OUTC3
0	1	0	1	0	0	OUTC4
0	1	0	1	0	1	OUTC5
0	1	0	1	1	0	OUTC6
0	1	0	1	1	1	OUTC7
0	1	1	0	0	0	OUTA0, OUTA2, OUTA4, OUTA6
0	1	1	0	0	1	OUTA1, OUTA3, OUTA5, OUTA7
0	1	1	0	1	0	OUTB0, OUTB2, OUTB4, OUTB6
0	1	1	0	1	1	OUTB1, OUTB3, OUTB5, OUTB7
0	1	1	1	0	0	OUTC0, OUTC2, OUTC4, OUTC6
0	1	1	1	0	1	OUTC1, OUTC3, OUTC5, OUTC7
0	1	1	1	1	0	OUTA0, OUTA2, OUTA4, OUTA6 OUTB0, OUTB2, OUTB4, OUTB6 OUTC0, OUTC2, OUTC4, OUTC6
0	1	1	1	1	1	OUTA1, OUTA3, OUTA5, OUTA7 OUTB1, OUTB3, OUTB5, OUTB7 OUTC1, OUTC3, OUTC5, OUTC7

Output Address o_adr (5:0)						Output Terminal
(5)	(4)	(3)	(2)	(1)	(0)	
1	0	0	0	0	0	OUTA0, OUTA1, OUTA4, OUTA5
1	0	0	0	0	1	OUTA2, OUTA3, OUTA6, OUTA7
1	0	0	0	1	0	OUTB0, OUTB1, OUTB4, OUTB5
1	0	0	0	1	1	OUTB2, OUTB3, OUTB6, OUTB7
1	0	0	1	0	0	OUTC0, OUTC1, OUTC4, OUTC5
1	0	0	1	0	1	OUTC2, OUTC3, OUTC6, OUTC7
1	0	0	1	1	0	OUTA0, OUTA1, OUTA4, OUTA5 OUTB0, OUTB1, OUTB4, OUTB5 OUTC0, OUTC1, OUTC4, OUTC5
1	0	0	1	1	1	OUTA2, OUTA3, OUTA6, OUTA7 OUTB2, OUTB3, OUTB6, OUTB7 OUTC2, OUTC3, OUTC6, OUTC7
1	0	1	0	0	0	OUTA0, OUTA1, OUTA2, OUTA3
1	0	1	0	0	1	OUTA4, OUTA5, OUTA6, OUTA7
1	0	1	0	1	0	OUTB0, OUTB1, OUTB2, OUTB3
1	0	1	0	1	1	OUTB4, OUTB5, OUTB6, OUTB7
1	0	1	1	0	0	OUTC0, OUTC1, OUTC2, OUTC3
1	0	1	1	0	1	OUTC4, OUTC5, OUTC6, OUTC7
1	0	1	1	1	0	OUTA0, OUTA1, OUTA2, OUTA3 OUTB0, OUTB1, OUTB2, OUTB3 OUTC0, OUTC1, OUTC2, OUTC3
1	0	1	1	1	1	OUTA4, OUTA5, OUTA6, OUTA7 OUTB4, OUTB5, OUTB6, OUTB7 OUTC4, OUTC5, OUTC6, OUTC7
1	1	0	0	0	0	OUTA0, OUTB0, OUTC0
1	1	0	0	0	1	OUTA1, OUTB1, OUTC1
1	1	0	0	1	0	OUTA2, OUTB2, OUTC2
1	1	0	0	1	1	OUTA3, OUTB3, OUTC3
1	1	0	1	0	0	OUTA4, OUTB4, OUTC4
1	1	0	1	0	1	OUTA5, OUTB5, OUTC5
1	1	0	1	1	0	OUTA6, OUTB6, OUTC6
1	1	0	1	1	1	OUTA7, OUTB7, OUTC7
1	1	1	0	0	0	(No terminal)
1	1	1	0	0	1	All OUTA
1	1	1	0	1	0	All OUTB
1	1	1	0	1	1	All OUTA, All OUTB
1	1	1	1	0	0	All OUTC
1	1	1	1	0	1	All OUTA, All OUTC
1	1	1	1	1	0	All OUTB, All OUTC
1	1	1	1	1	1	All OUTA, All OUTB, All OUTC

Lighting Data (9 bits)

Lighting data light_dat (8:0)								
Lighting speed					Lighting gradation			
spd(4)	spd(3)	spd(2)	spd(1)	spd(0)	brt(3)	brt(2)	brt(1)	brt(0)

Lighting is controlled in each line with the values of the load registers. In lighting control, the gradation changes to the specified one at the specified lighting speed

The Lighting speed follows the table below.
The change time is specified with 5 bits;

Lighting Speed spd(4:0)					Change time per 1/15 of brightness	Change time from 0/15 to 15/15 of brightness (and vice versa)
(4)	(3)	(2)	(1)	(0)		
0	0	0	0	0	Less than 60 μs	Less than 1 ms
0	0	0	0	1	8.5 ms	0.128 s
0	0	0	1	0	10.7 ms	0.160 s
0	0	0	1	1	12.8 ms	0.192 s
0	0	1	0	0	14.9 ms	0.224 s
0	0	1	0	1	17.1 ms	0.256 s
0	0	1	1	0	21.3 ms	0.320 s
0	0	1	1	1	25.6 ms	0.384 s
0	1	0	0	0	29.9 ms	0.448 s
0	1	0	0	1	34.1 ms	0.512 s
0	1	0	1	0	42.7 ms	0.640 s
0	1	0	1	1	51.2 ms	0.768 s
0	1	1	0	0	59.7 ms	0.896 s
0	1	1	0	1	68.3 ms	1.024 s
0	1	1	1	0	85.3 ms	1.280 s
0	1	1	1	1	102 ms	1.536 s
1	0	0	0	0	119 ms	1.792 s
1	0	0	0	1	137 ms	2.048 s
1	0	0	1	0	171 ms	2.560 s
1	0	0	1	1	205 ms	3.072 s
1	0	1	0	0	239 ms	3.584 s
1	0	1	0	1	273 ms	4.096 s
1	0	1	1	0	341 ms	5.120 s
1	0	1	1	1	410 ms	6.144 s
1	1	0	0	0	478 ms	7.168 s
1	1	0	0	1	546 ms	8.192 s
1	1	0	1	0	683 ms	10.24 s
1	1	0	1	1	819 ms	12.29 s
1	1	1	0	0	956 ms	14.34 s
1	1	1	0	1	1,092 ms	16.38 s
1	1	1	1	0	1,365 ms	20.48 s
1	1	1	1	1	1,638 ms	24.58 s

Note: The change time per 1/15 of brightness represents the time required for a change from, for example, 10/15 to 11/15 of brightness.

The change time from 0/15 to 15/15 of brightness and vice versa represents the time required for a change from 0/15 of brightness (light OFF) to 15/15 of brightness (light completely ON). However, these times are median values and depend on the driving output PWM cycle.

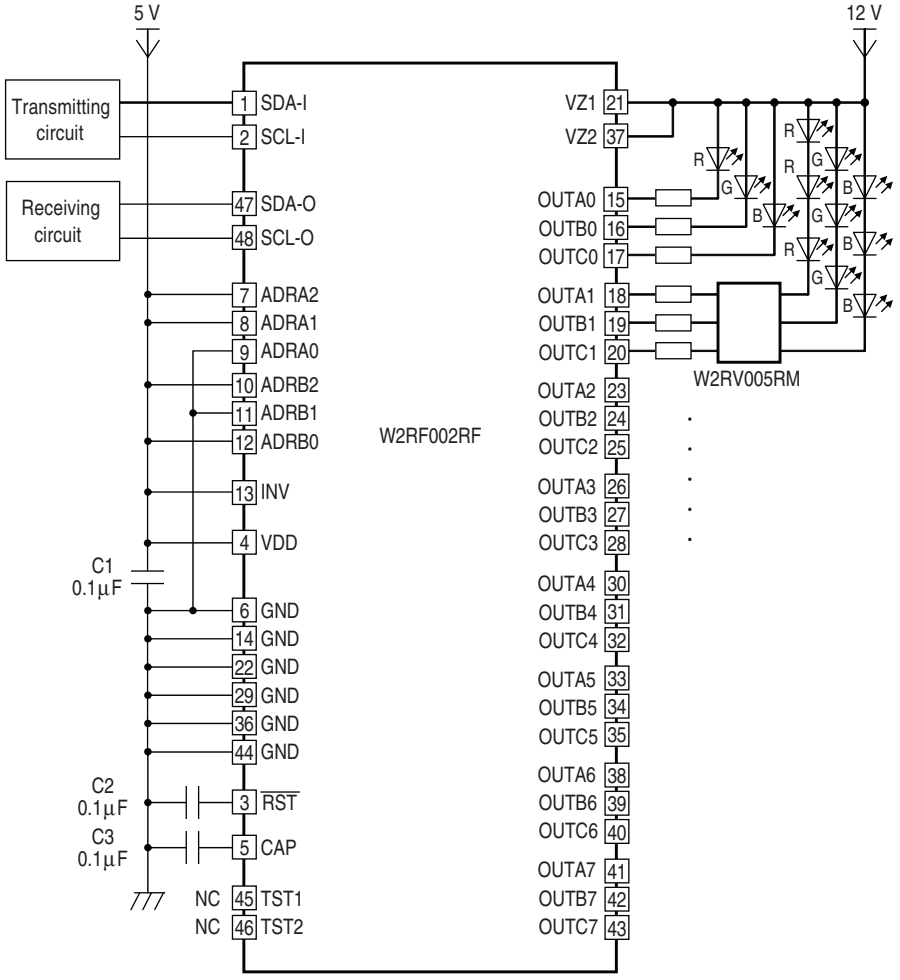
The Lighting gradation follows the table below.
The brightness is specified with 4 bits;

Lighting Gradation brt(3:0)				Brightness	PWM duty ratio (reference)
(3)	(2)	(1)	(0)		
0	0	0	0	0/15 (light OFF)	0 %
0	0	0	1	1/15	0.42 %
0	0	1	0	2/15	0.84 %
0	0	1	1	3/15	1.25 %
0	1	0	0	4/15	1.78 %
0	1	0	1	5/15	2.61 %
0	1	1	0	6/15	3.76 %
0	1	1	1	7/15	5.42 %
1	0	0	0	8/15	7.96 %
1	0	0	1	9/15	11.3 %
1	0	1	0	10/15	16.7 %
1	0	1	1	11/15	23.3 %
1	1	0	0	12/15	35.2 %
1	1	0	1	13/15	48.4 %
1	1	1	0	14/15	73.4 %
1	1	1	1	15/15 (Light completely ON)	100 %

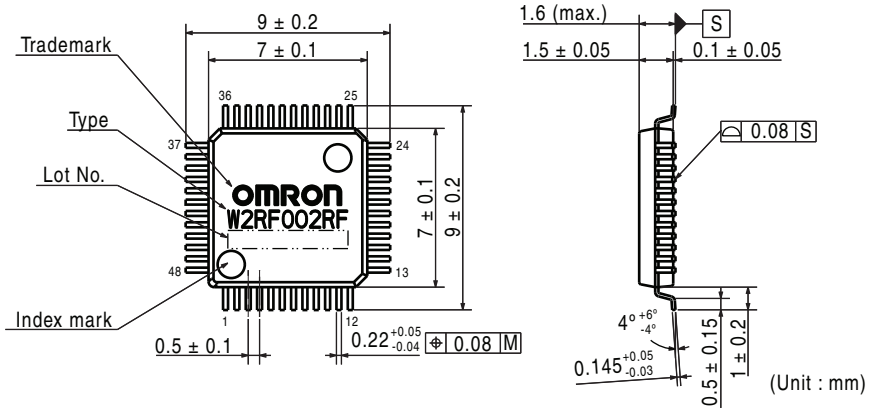
■ Functional Terminals/Setting Terminals

ADR terminals	The ADRA terminal and ADRB terminal set device address A and device address B, respectively. For "H" setting, connect the terminal to V_{DD} and for "L" setting, connect the terminal to GND
INV terminal	This terminal sets the polarity of OUT terminal. • When the terminal is used with "L" as active (e.g., for directly driving an LED), connect the terminal to V_{DD} • When the terminal is used with the "H" as active (e.g., for driving an LED with a driving transistor), connect the terminal to GND.
$\overline{\text{RST}}$ terminal	When the voltage of the $\overline{\text{RST}}$ terminal becomes "L", the internal circuit will be reset and the output will be open.

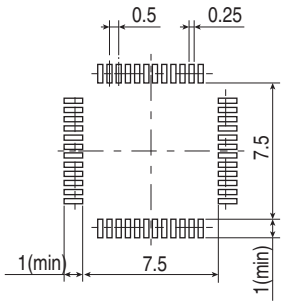
■ Application Example



Dimensions



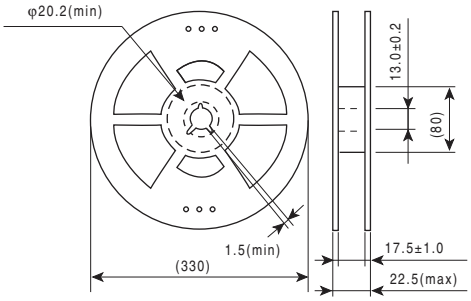
Recommended PCB Layout



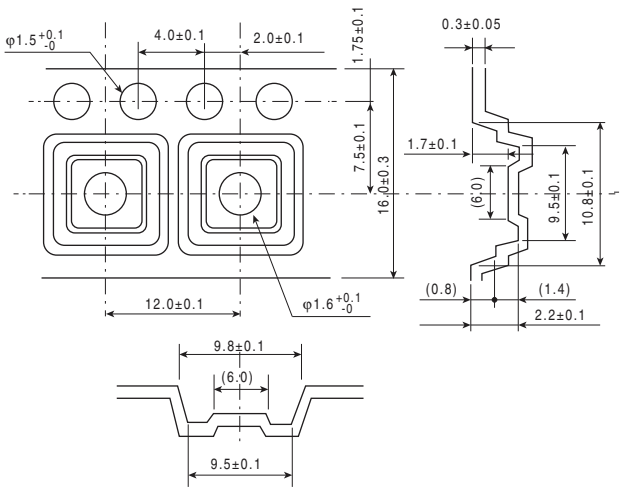
Tape Packaging

Packaging style: Embossed taping
Packaging quantity: 1,500 pcs/reel

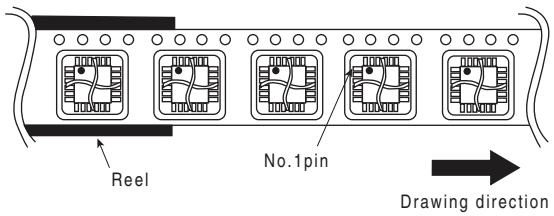
Reel Dimensions



Embossed Tape Dimensions



Direction of Insertion



Precautions for Use

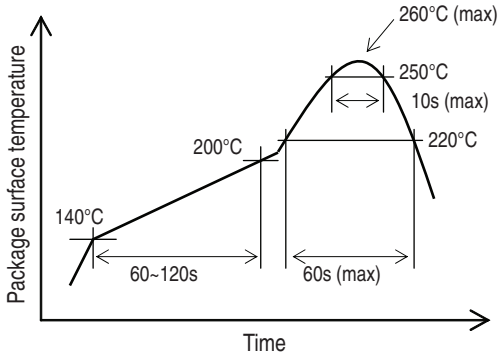
■ Correct Use

- The absolute maximum rating is the limit value which should not be exceeded even in a flash. Exceeding this value can cause deterioration of the characteristics or complete failure of the IC.
- Check the operation at the communication frequency to be used before using the device.
- Sufficiently take into consideration the static electricity, chattering and voltage of the input to be connected when determining each input circuit.
- Although the device contains an ESD protection circuit, static electricity that exceeds the function may damage the device. When handling the device, exercise due caution by, for example, grounding the human body.
- Due to potential damage, do not use product that has been dropped or that has come into contact with water.

■ Recommended Reflow Conditions

Allowable Temperature Profile Conditions

Product mounting method should be by Reflow and we recommend the following temperature profile. Reflow no more than two times, maximum.



Storage Conditions before Mounting

Moisture absorption by the plastic package will increase the possibility of faults, such as cracks; therefore, take enough care for storage.

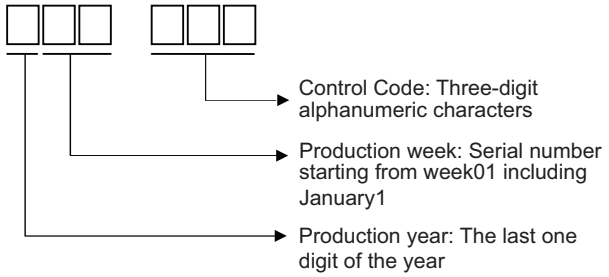
Storage Conditions	Period
5 to 30°C, 40 to 70%RH	One Year

■ RoHS Directive Compliance

Models that are indicated as being RoHS compliant are free of the following six substances.

Lead:	1,000 ppm max.
Mercury:	1,000 ppm max.
Cadmium:	100 ppm max.
Hexavalent chromium:	1,000 ppm max.
PBB:	1,000 ppm max.
PBDE:	1,000 ppm max.

■ Lot Code Indication



All sales are subject to Omron Electronic Components LLC standard terms and conditions of sale, which can be found at http://www.components.omron.com/components/web/webfiles.nsf/sales_terms.html

ALL DIMENSIONS SHOWN ARE IN MILLIMETERS.
To convert millimeters into inches, multiply by 0.03937. To convert grams into ounces, multiply by 0.03527.

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OMRON ELECTRONIC COMPONENTS LLC
55 E. Commerce Drive, Suite B
Schaumburg, IL 60173
847-882-2288

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