R8A66170DD/SP
4-CH 16-BIT PWM GENERATOR

DESCRIPTION

R8A66170 is a programmable 4-channel PWM generator produced using the silicon gate CMOS process.

R8A66170 can connect directly to the MPU data bus, and consists of a 16-bit prescaler and a PWM counter.

The pulse output includes three kinds of modes, allowing the independent control of each channel.

R8A66170 provides a software servo system in combination with the A-D function and the timer function of a one-chip microcomputer. R8A66170 is a succession product of M66240.

FEATURES

- 4-channel individually controllable
- Built-in three kind of pulse output modes
- PWM repetitive frequency: 50 kHz (max.) (Mode 0, 8-bit resolution, fxin/255 at prescaler setting = 0)
- Output polarity selection possible
- External triggering possible
- The output after reset is in the high impedance state.
- Change of mode setting becomes effective after the current cycle.
- High output current : Io = ±24 mA (VCC = 5.0V)
- Wide operating power voltage range (VCC = 5.0V or 3.3V single power supply)
- Wide operating temperature range (Ta = -40~85 ºC)

APPLICATION

- Control of DC motors and stepping motors
- Control of Heater phase controllers
- Software servos for office automation equipment , and industrial equipment

PIN CONFIGURATION (TOP VIEW)
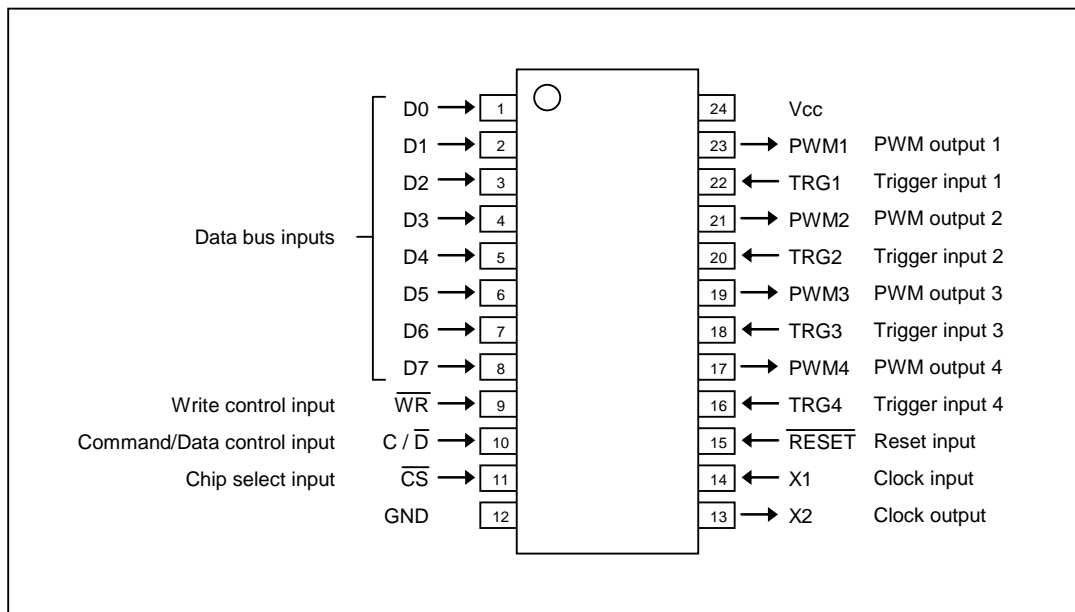
FUNCTION

Four separate 16-bit prescalers and 16-bit PWM counters can be separately programmed by the control instruction from the MPU.
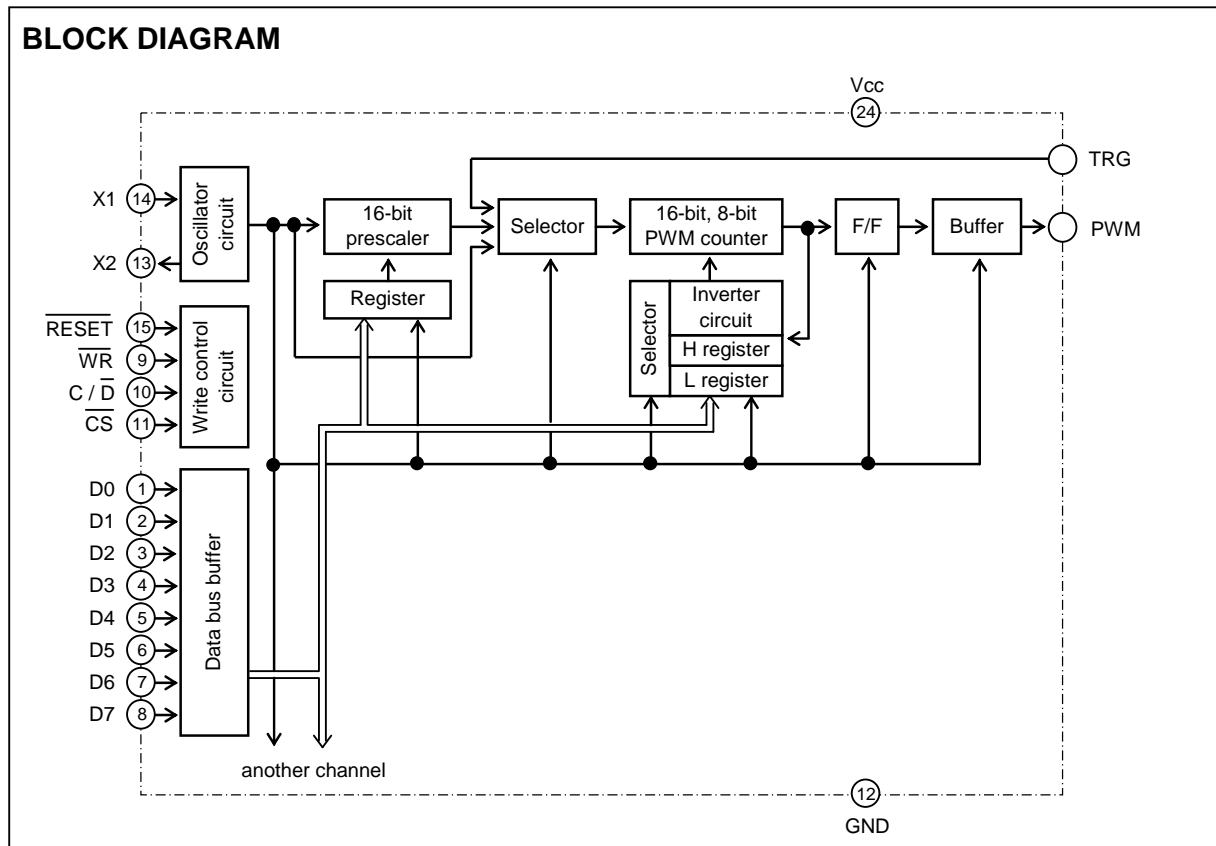
The output is made in one of three modes (Mode 0, Mode 1, and Mode 2).

In Mode0, setting only the value of H width repeatedly outputs the set pulse width.

In Mode1, setting only the value of H width outputs one shot of the pulse width set by trigger input.

In Mode2, setting both H width and L width repeatedly outputs the set pulse width.

BLOCK DIAGRAM

PIN DESCRIPTIONS

Pin name	Description	I/O	Function
$\overline{\text{RESET}}$	Reset input	Input	Clears the command register and the flip-flop at "L".
D0~D7	Data bus input	Input	Inputs the data from MPU over the 8-bit data bus.
$\overline{\text{WR}}$	Write control input	Input	Writes the data on data bus to the control register or data register when its state changes from "L" to "H" of rising edge.
C/$\overline{\text{D}}$	Command/Data control input	Input	The Data on data bus is regarded as a command at "H" level, and as data at "L" level.
$\overline{\text{CS}}$	Chip select input	Input	Communication with MPU is enabled at "L" level. Any control from MPU is ignored at "H" level.
X_1	Clock input	Input	Input and output to the built-in clock generator circuit. By providing a crystal resonator between X_1 and X_2, sets the frequency.
X_2	Clock output	Output	To make external clock input, connect the clock source to X_1 pin and leave X_2 pin open.
TRG1~TRG4	Trigger input	Input	These are used when external trigger is selected in mode setting. These should be set to "L" level when not in use.
PWM1~PWM4	PWM output	Output	PWM output pins. Outputs become the high-impedance state after reset is inputted or after disable is specified by command 3. D0 of command 1 allows the selection of output polarity.

OPERATION

Commands

The information on data bus inputs D0 through D7 is treated as command when command / data control input C/$\overline{\text{D}}$ = 1, and is treated as data when C/$\overline{\text{D}}$ = 0.

There are three kinds of commands. (See Figure 1.)

- Command 1 selects the output mode and external trigger input of each channel and sets the output polarity of H width.
- Command 2 specifies, on a byte basis, to which 16-bit register of the prescaler and PWM counter of each channel data is to be written. The second and subsequent bytes of command 2 write prescaler value and PWM value. Depending on the location specified by command 2, the data of the second and subsequent bytes must be written in the order shown in Figure2.
- Command 3 is used to start or stop the prescalers and PWM counters operation.

Data input

At initialization, all 16-bit of prescaler values must be written.

In mode 0 or 1, the PWM values must be written to all 16-bits of H register (*1), In mode 2, the value must be written to all 16-bits of H and L registers.

   (*1): In mode0, at 8-bit resolution, only the lower byte of the H register is used.

In case of changing the value of prescaler and PWM during for operation, the procedure is as follows.

- To change the values of all 16-bits in the prescaler or the PWM counter during operation, values should be written to the upper byte first and then to the lower byte.
- To change the values of the lower byte only, the values of only the lower byte should be written.
- To change the values of the upper byte only, the values of all 16-bits should be written.
- To change the values of H register in Mode 2, the H register values should be written followed by the L register value.

When values are written to the lower byte (lower byte of L register in Mode 2), the write cycle of data registers is completed.

(Note)

- If the data registers values is changed during a PWM signal is outputted (exactly, finish to write those values), the PWM output is updated at the start of next cycle.
- To change the mode (i.e., to execute command 1), disable the output first (i.e., execute command 3).

Figure 3 shows the flow chart of the basic operation.

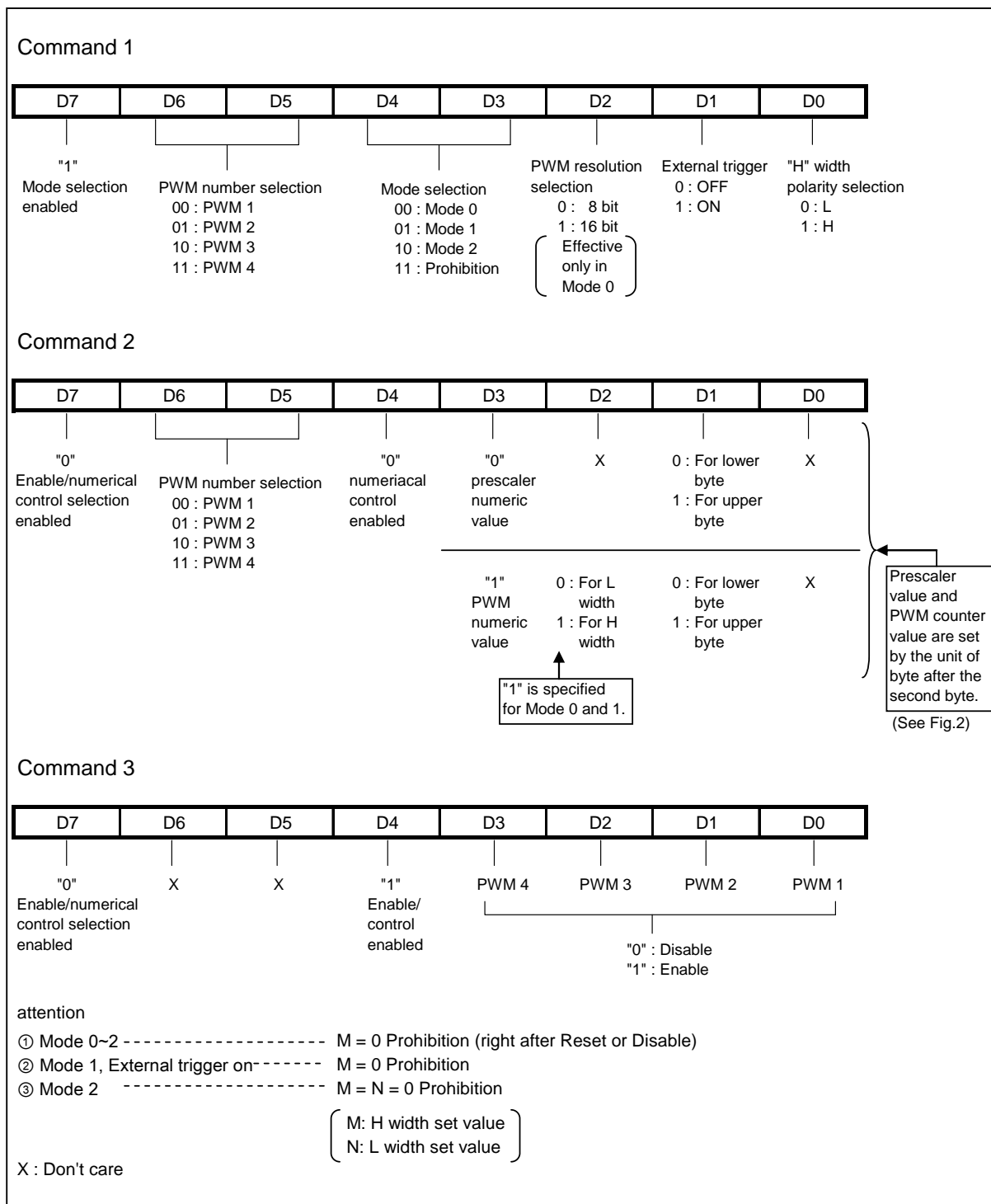The order of the prescaler's and PWM counter's data setting is not fixed.

Command 1

D7	D6	D5	D4	D3	D2	D1	D0

"1"
Mode selection enabled

PWM number selection
00 : PWM 1
01 : PWM 2
10 : PWM 3
11 : PWM 4

Mode selection
00 : Mode 0
01 : Mode 1
10 : Mode 2
11 : Prohibition

PWM resolution selection
0 : 8 bit
1 : 16 bit
(Effective only in Mode 0)

External trigger
0 : OFF
1 : ON

"H" width polarity selection
0 : L
1 : H

Command 2

D7	D6	D5	D4	D3	D2	D1	D0

"0"
Enable/numerical control selection enabled

PWM number selection
00 : PWM 1
01 : PWM 2
10 : PWM 3
11 : PWM 4

"0"
numeriacal control enabled

"0"
prescaler numeric value

X

0 : For lower byte
1 : For upper byte

X

"1"
PWM numeric value

0 : For L width
1 : For H width

0 : For lower byte
1 : For upper byte

X

"1" is specified for Mode 0 and 1.

Prescaler value and PWM counter value are set by the unit of byte after the second byte.
(See Fig.2)

Command 3

D7	D6	D5	D4	D3	D2	D1	D0

"0"
Enable/numerical control selection enabled

X

X

"1"
Enable/ control enabled

PWM 4

PWM 3

PWM 2

PWM 1

"0" : Disable
"1" : Enable

attention

① Mode 0~2 - - - - - - - - - - - - - - - - - - - M = 0 Prohibition (right after Reset or Disable)
② Mode 1, External trigger on - - - - - - M = 0 Prohibition
③ Mode 2 - - - - - - - - - - - - - - - - - - - M = N = 0 Prohibition

(M: H width set value)
(N: L width set value)

X : Don't care

Fig.1 Commands

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First byte (Command 2)			The second byte	The third byte	The fourth byte	The fifth byte	Remark
D3	D2	D1					
1	1	1	Upper byte of PWM H register	Lower byte of PWM H register	-	-	In Mode 0 or 1
1	1	0	Lower byte of PWM H register	-	-	-	
1	1	1	Upper byte of PWM H register	Lower byte of PWM H register	Upper byte of PWM L register	Lower byte of PWM L register	In Mode 2
1	1	0	Lower byte of PWM H register	Upper byte of PWM L register	Lower byte of PWM L register	-	
1	0	1	Upper byte of PWM L register	Lower byte of PWM L register	-	-	
1	0	0	Lower byte of PWM L register	-	-	-	
0	X	1	Upper byte of prescaler register	Lower byte of prescaler register	-	-	
0	X	0	Lower byte of prescaler register	-	-	-	

Fig.2 Data-setting sequence for registers
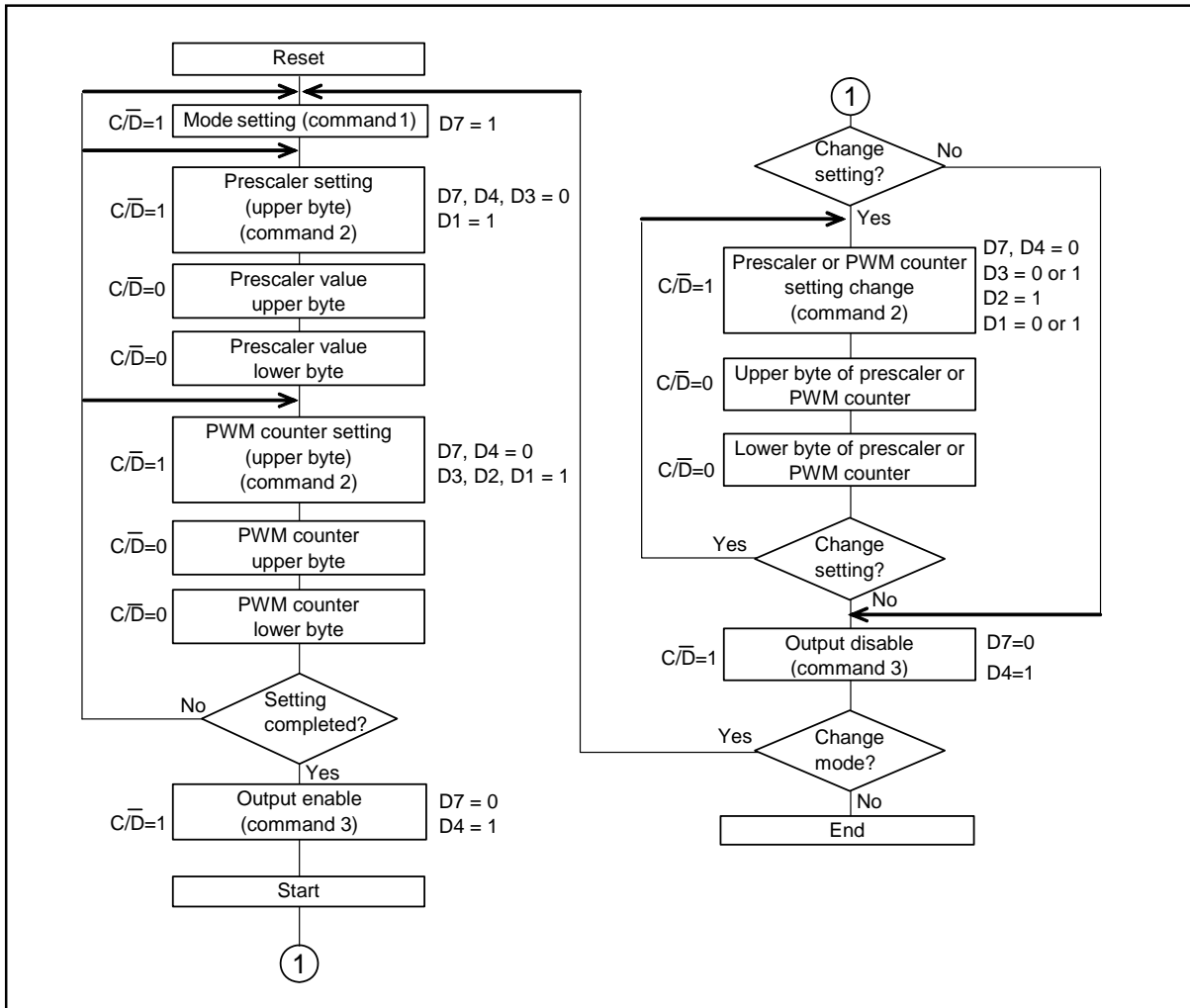
Fig.3 Flow chart in Mode 0 or 1 (for one channel)

PWM WAVEFORM OUTPUT

R8A66170 has a built-in 16-bit prescaler and a PWM counter. The duty cycle of output pulse can be freely specified by changing the values of the prescaler and the PWM counter. The output is made in one of three modes (Mode 0, Mode 1, and Mode 2). The description of these modes is given below.

(1) Mode 0

This mode is selected by writing "0" to D4 and D3 in command 1. Figure 9 shows the block diagram in this mode (for one channel). The 16-bit PWM counter can be used as an 8-bit PWM counter only in this mode (command 1: D2 = 0). The setting with PWM resolution = 8-bits must be written to the lower 8 bytes of H register.

In this mode, the H output pulse width is determined by the prescaler register value L and PWM register value M.
The PWM output cycle time is determined by the prescaler register value L, irrespective of the PWM register value M. (See Fig.4)
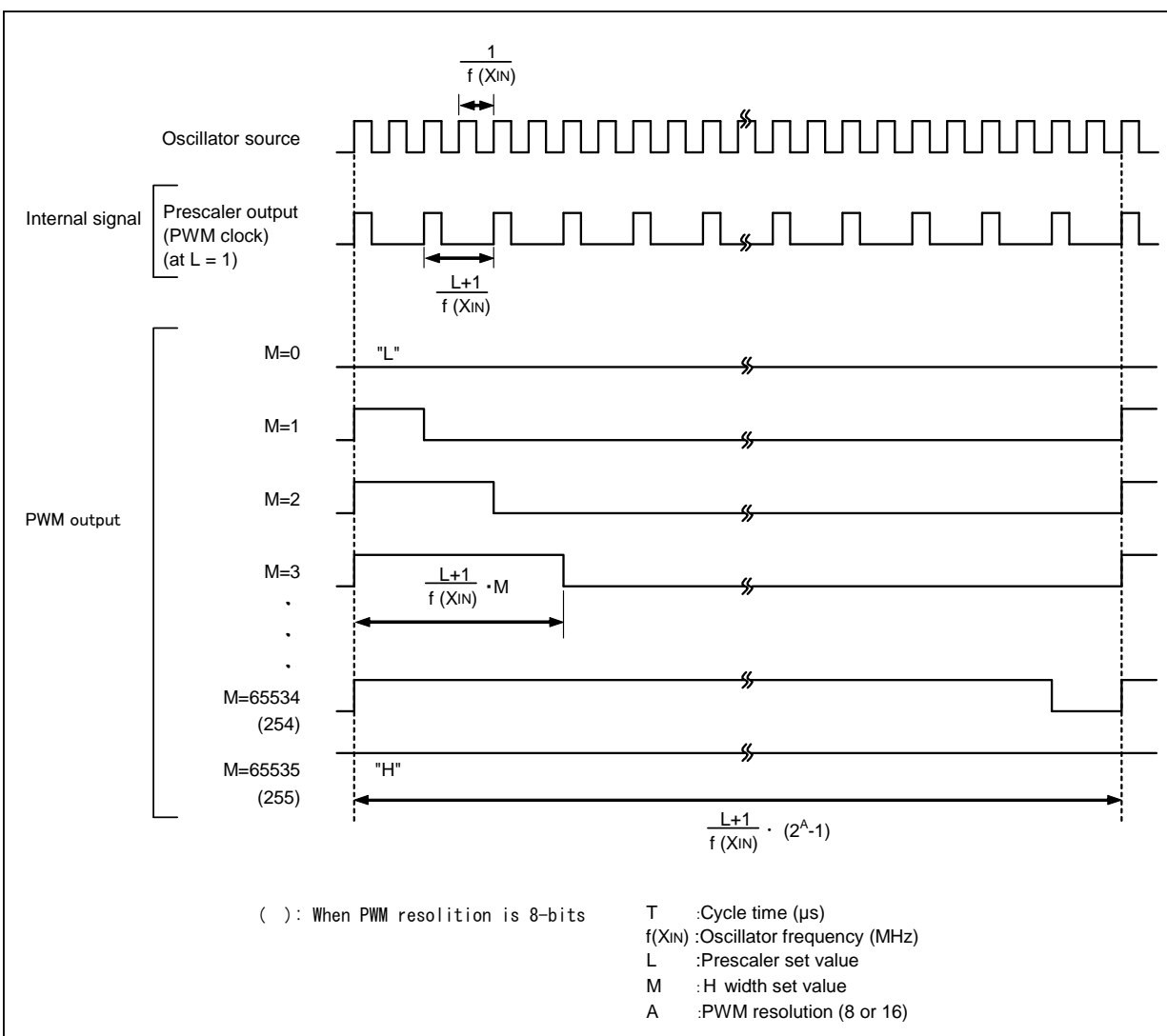
Fig.4 (When H width polarity is "H")

(2) Mode1

This mode is selected by setting D4 = 0 and D3 = 1 in command 1. Figure 10 shows the block diagram in this mode (for one channel).

This mode outputs the pulse which is determined by value M of PWM register as one shot by trigger signal.

The type of this output operation is determined by whether the external trigger signal or the internal trigger signal is used. Operation varies according to the choice of external and internal trigger signals.

(a) External trigger selected (D1 = 1 in command 1)

This mode outputs, when a trigger pulse is applied to trigger input TRG, one shot of output pulse. Therefore, cycle time T becomes cycle time f_{IN} of the trigger pulse to be applied to trigger input TRG.

The output pulse width is determined by the prescaler register value L and PWM register value M. (See Fig.5)
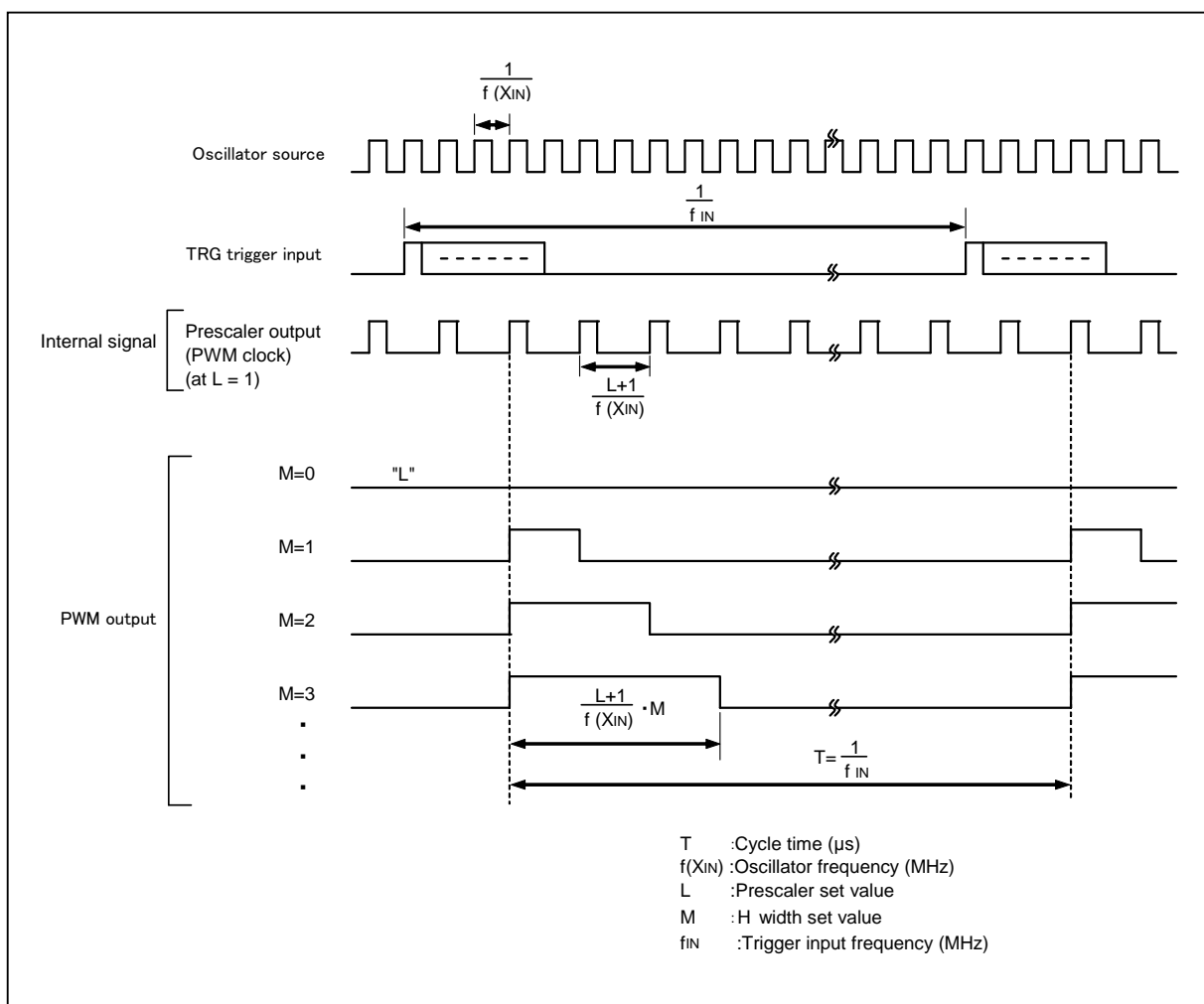
Fig.5 (When H width polarity is "H")

(b) Internal trigger selected (D1 = 0 in command 1)

In this mode, the trigger signal is generated by the prescaler. Therefore, the cycle time T of output pulse is determined by the prescaler register value L.

In this case, the oscillator source becomes the PWM counter clock and the output pulse width is determined by the PWM register value M. (See Fig.6)
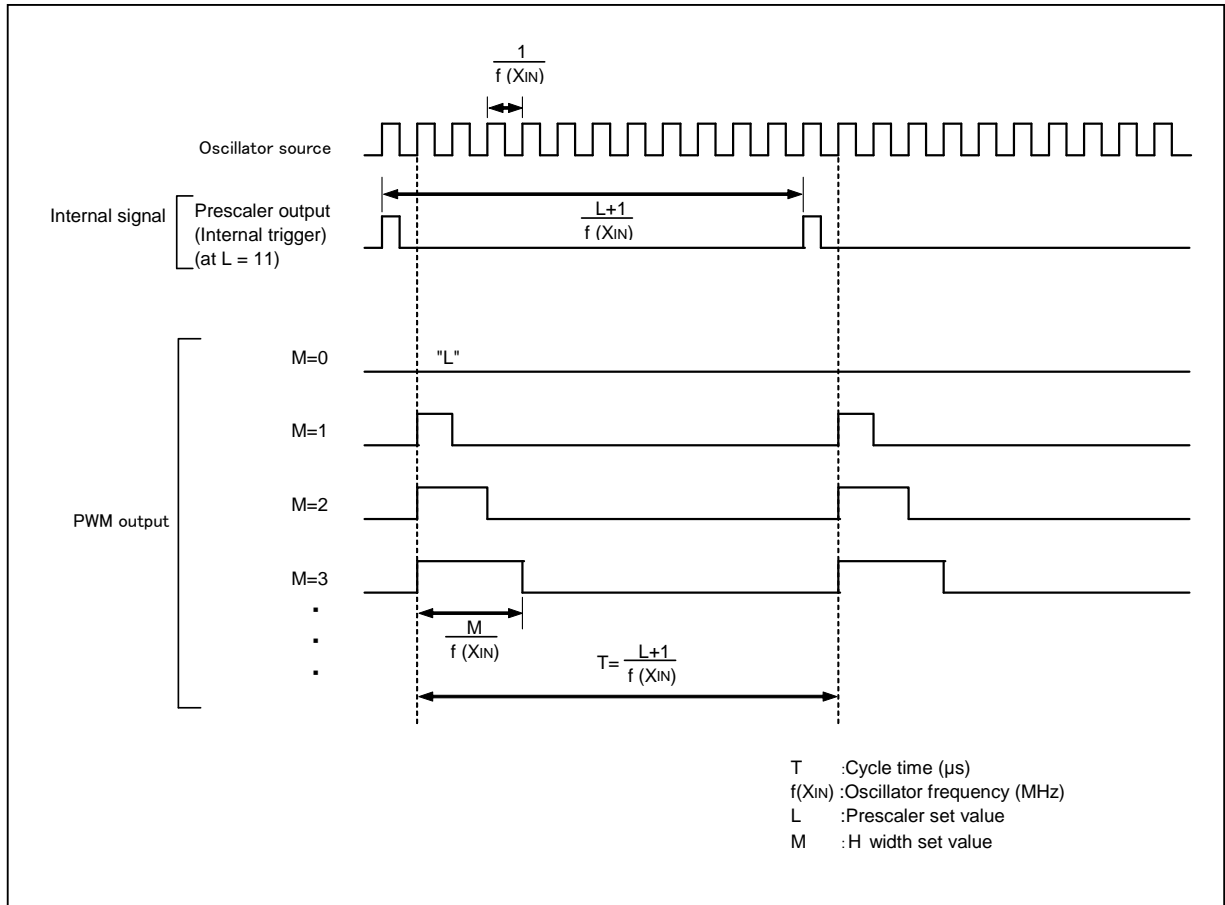
Fig.6 (When H width polarity is "H")

In Mode 1, the retrigger state is caused when the cycle time of trigger pulse gets smaller than the value M of PWM register.

(3) Mode 2

This mode is selected by writing D4 = 1 and D3 = 0 in command 1. Fig.11 shows the block diagram of this mode (for one channel).

The high-level pulse value M is set to the H register of PWM in Mode 0 and 1, but in this mode, the high-level pulse value M is set to the H register of PWM and the low-level pulse value N is set to the L register of PWM. Therefore, the pulse width and cycle time T of PWM output are determined by value L of the prescaler register and values M and N of H and L registers of PWM. (See Fig.7)
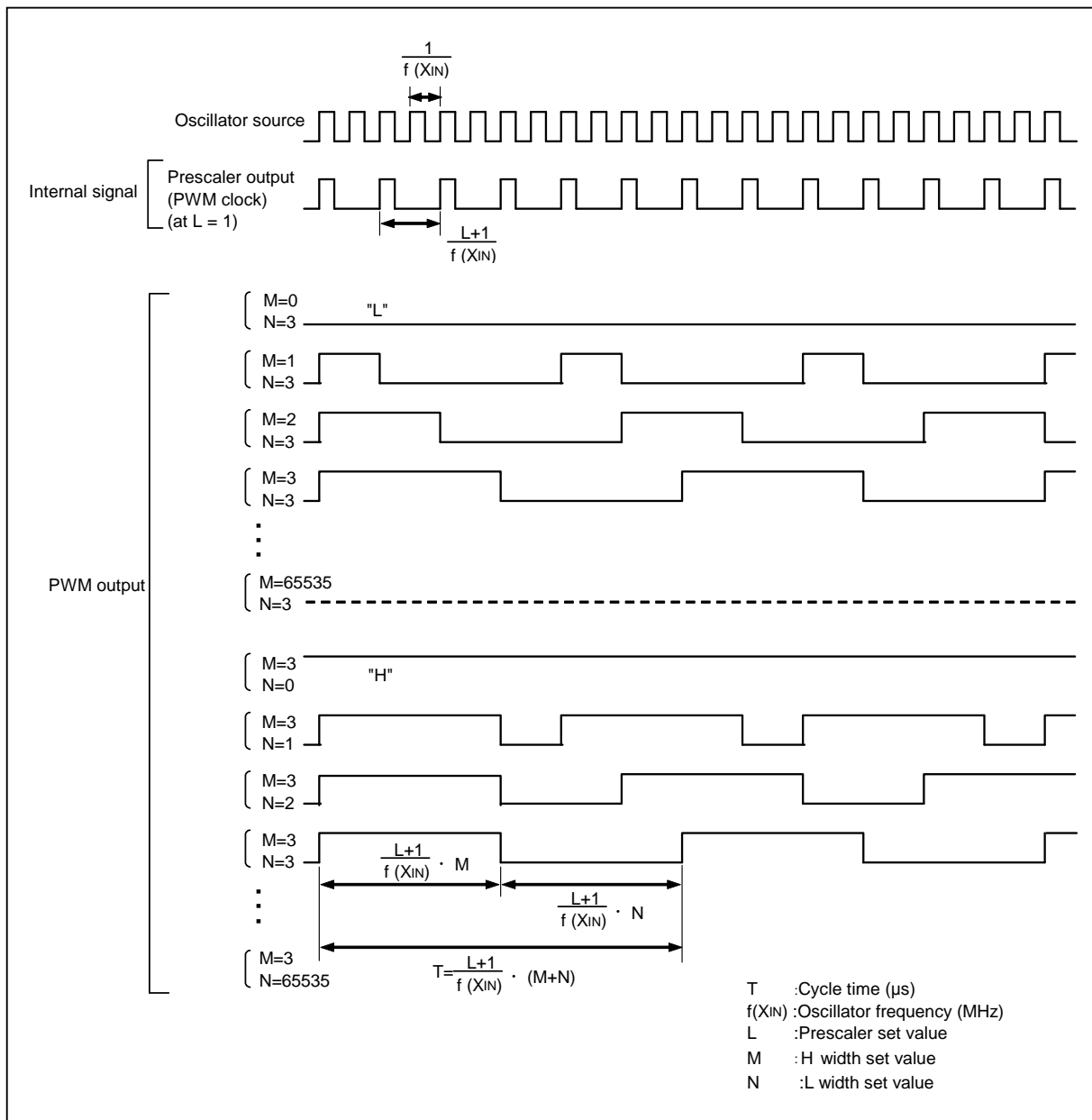
Fig.7 (When H width polarity is "H")

Initial state

In the case of command 1, if the D1 is set as "external trigger ON" it does not output a pulse to PWM output and its status is held in the high impedance even if the operation of internal circuit is started by specifying enable condition with command 3.

In this case the pulse can be output to PWM output by entering H level into TRG input in Mode 0,Mode 2 or entering H pulse into TRG input in Mode1. (See Fig.8)

In Mode 0 or Mode 2, putting TRG input to L level during PWM is outputting pulse makes PWM output keeps its state. When TRG input is put back to H level, the operation are resumed from that point.
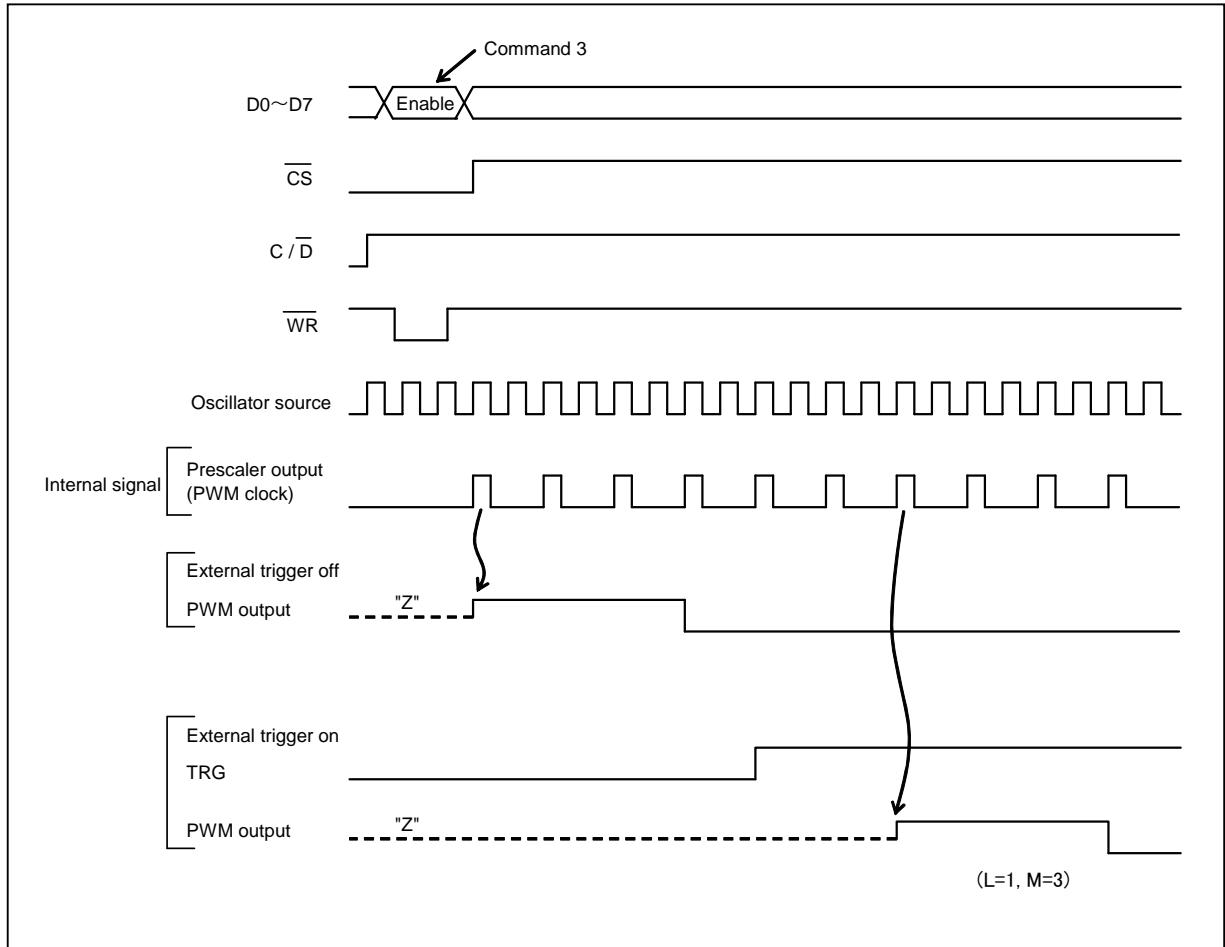
Fig.8 (When H width polarity is "H")
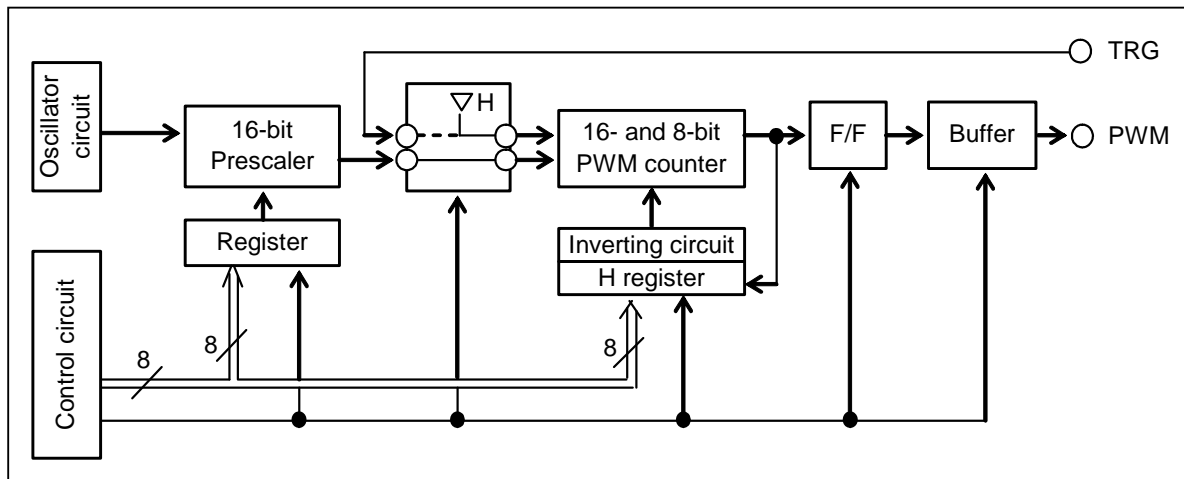
Fig.9 Block diagram in Mode 0 (for one channel)
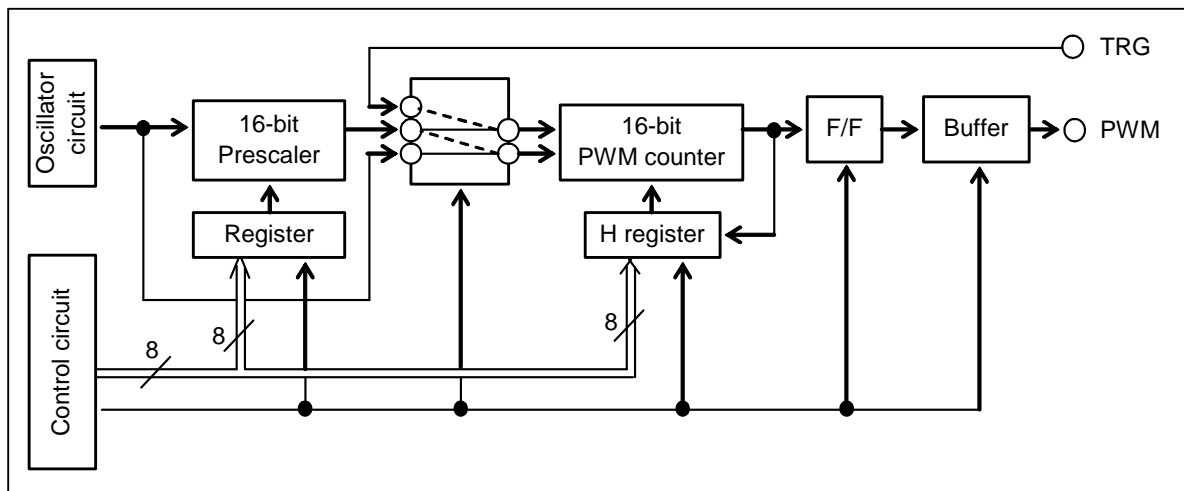
Fig.10 Block diagram in Mode 1 (for one channel)
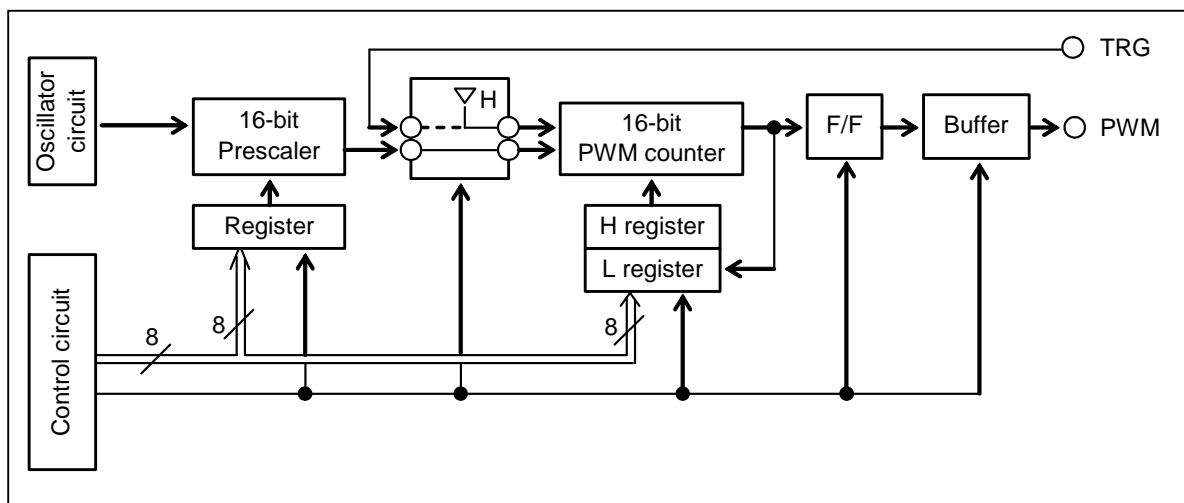
Fig.11 Block diagram in Mode 2 (for one channel)

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ABSOLUTE MAXIMUM RATINGS (Ta=-40~85°C, unless otherwise noted)

Symbol	Parameter	Conditions	Ratings	Unit
Vcc	Power voltage		-0.5~+7.0	V
VI	Input voltage		-0.5~Vcc+0.5	V
VO	Output voltage		-0.5~Vcc+0.5	V
Pd	Power dissipation		500	mW
Tstg	Storage temperature		-65~150	°C

RECOMMENDED OPERATING CONDITIONS (Ta=-40~85°C, unless otherwise noted)

Symbol	Parameter		Limits			Unit
			Min.	Typ.	Max.	
Vcc	Power voltage	5.0V support	4.5	5.0	5.5	V
		3.3V support	3.0	3.3	3.6	V
GND	Power voltage			0		V
VI	Input voltage		0		Vcc	V
VO	Output voltage		0		Vcc	V
Topr	Ambient operating temperature		-40		85	°C

ELECTRICAL CHARACTERISTICS
5.0V version support specifications (Ta=-40~85°C, Vcc=4.5~5.5V, unless otherwise noted)

Symbol	Parameter	Test conditions		Limits			Unit
				Min.	Typ.	Max.	
VT+	Positive going threshold voltage	$\overline{\text{RESET}}$, TRG1~4	IO=20uA	0.35×Vcc		0.8×Vcc	V
VT-	Negative going threshold voltage			0.2×Vcc		0.65×Vcc	V
VH	Hysteresis width			0.4			V
VIH	"H" input voltage	D0~D7, $\overline{\text{CS}},\overline{\text{WR}},$C/$\overline{\text{D}}$	IO=20uA	0.75×Vcc			V
VIL	"L" input voltage					0.25×Vcc	V
VIH	"H" input voltage	X1	IO=20uA	0.8×Vcc			V
VIL	"L" input voltage					0.2×Vcc	V
VOH	"H" output voltage	PWM1~ PWM4	IOH=-24mA	Vcc - 0.8			V
VOL	"L" output voltage		IOL=24mA			0.55	V
IIH	"H" input current	VI=Vcc				1.0	uA
IIL	"L" input current	VI=GND				-1.0	uA
IOZH	Off-state "H" output current	VO=Vcc				5.0	uA
IOZL	Off-state "L" output current	VO=GND				-5.0	uA
Icc	Quiescent current consumption	VI=Vcc, GND, Outputs are open.				100	uA

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ELECTRICAL CHARACTERISTICS

3.3V version support specifications (Ta=-40~85°C, Vcc=3.0~3.6V, unless otherwise noted)

Symbol	Parameter		Test conditions	Limits			Unit
				Min.	Typ.	Max.	
V_{T+}	Positive going threshold voltage	$\overline{RESET}$, TRG1~4	I_O=20uA	0.35×Vcc		0.8×Vcc	V
V_{T-}	Negative going threshold voltage			0.2×Vcc		0.65×Vcc	V
V_H	Hysteresis width			0.4			V
V_{IH}	"H" input voltage	D0~D7, $\overline{CS}$,$\overline{WR}$,$\overline{C/D}$	I_O=20uA	0.75×Vcc			V
V_{IL}	"L" input voltage					0.25×Vcc	V
V_{IH}	"H" input voltage	X1	I_O=20uA	0.8×Vcc			V
V_{IL}	"L" input voltage					0.2×Vcc	V
V_{OH}	"H" output voltage	PWM1~ PWM4	I_{OH}=-12mA	Vcc - 0.6			V
V_{OL}	"L" output voltage		I_{OL}=12mA			0.4	V
I_{IH}	"H" input current		V_I=Vcc			1.0	uA
I_{IL}	"L" input current		V_I=GND			-1.0	uA
I_{OZH}	Off-state "H" output current		V_O=Vcc			5.0	uA
I_{OZL}	Off-state "L" output current		V_O=GND			-5.0	uA
I_{CC}	Quiescent current consumption		V_I=Vcc, GND, Outputs are open.			100	uA

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SWITCHING CHARACTERISTICS (Ta=-40~85°C, Vcc=4.5~5.5V or Vcc=3.0~3.6V, unless otherwise noted)

Symbol	Parameter	Test conditions	5.0V specification			3.3V specification			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	
tpZL($\overline{\text{W}}$-PWM)	Output enable time after write (Mode0, 2, external trigger OFF)	CL=50pF			$\frac{2}{f}$ +110			$\frac{2}{f}$ +130	ns
tpZH($\overline{\text{W}}$-PWM)					$\frac{2}{f}$ +110			$\frac{2}{f}$ +130	ns
tpZL($\overline{\text{W}}$-PWM)	Output enable time after write (Mode1, external trigger OFF)				$\frac{3}{f}$ +110			$\frac{3}{f}$ +130	ns
tpZH($\overline{\text{W}}$-PWM)					$\frac{3}{f}$ +110			$\frac{3}{f}$ +130	ns
tpZL(T-PWM)	Output enable time after trigger (Mode0, 2, external trigger ON)				$\frac{2}{f}$ +110			$\frac{2}{f}$ +130	ns
tpZH(T-PWM)					$\frac{2}{f}$ +110			$\frac{2}{f}$ +130	ns
tpZL(T-PWM)	Output enable time after trigger (Mode1, external trigger ON)				$\frac{L+2}{f}$ +110			$\frac{L+2}{f}$ +130	ns
tpZH(T-PWM)					$\frac{L+2}{f}$ +110			$\frac{L+2}{f}$ +130	ns
tpLH(X1-PWM)	Output propagation time after clock (all modes)				110			130	ns
tpHL(X1-PWM)					110			130	ns
tpLH(T-PWM)	Output propagation time after trigger (Mode1, external trigger ON)				$\frac{L+2}{f}$ +110			$\frac{L+2}{f}$ +130	ns
tpHL(T-PWM)					$\frac{L+2}{f}$ +110			$\frac{L+2}{f}$ +130	ns
tpLZ($\overline{\text{R}}$-PWM)	Output disable time after reset				150			160	ns
tpHZ($\overline{\text{R}}$-PWM)					150			160	ns
tpLZ($\overline{\text{W}}$-PWM)	Output disable time after write				150			160	ns
tpHZ($\overline{\text{W}}$-PWM)					150			160	ns

f : Clock input frequency (MHz)
L: Prescaler set value

TIMING REQUIREMENTS (Ta=-40~85°C, Vcc=4.5~5.5V or Vcc=3.0~3.6V, unless otherwise noted)

Symbol	Parameter	Test conditions	5.0V specification			3.3V specification			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	
tc(X1)	Clock cycle		78.5			78.5			ns
tWH(X1)	Clock "H" pulse width		35			35			ns
tWL(X1)	Clock "L" pulse width		35			35			ns
tr(X1)	Clock rise time				20			20	ns
tf(X1)	Clock fall time				20			20	ns
tsu(A-$\overline{W}$)	Address setup time before write ($\overline{CS}$, C/$\overline{D}$)		0			0			ns
th($\overline{W}$-A)	Address hold time after write ($\overline{CS}$, C/$\overline{D}$)		0			0			ns
tsu(D-$\overline{W}$)	Data setup time before write		100			100			ns
th($\overline{W}$-D)	Data hold time after write		0			0			ns
tw($\overline{W}$)	Write pulse width		100			100			ns
trec($\overline{W}$)	Write recovery time		100			100			ns
tw(T)	Trigger pulse width		100			100			ns
tw($\overline{R}$)	Reset pulse width		100			100			ns
trec($\overline{R}$-$\overline{W}$)	Recovery time before write		100			100			ns

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TIMING DIAGRAM
(1) MCU interface
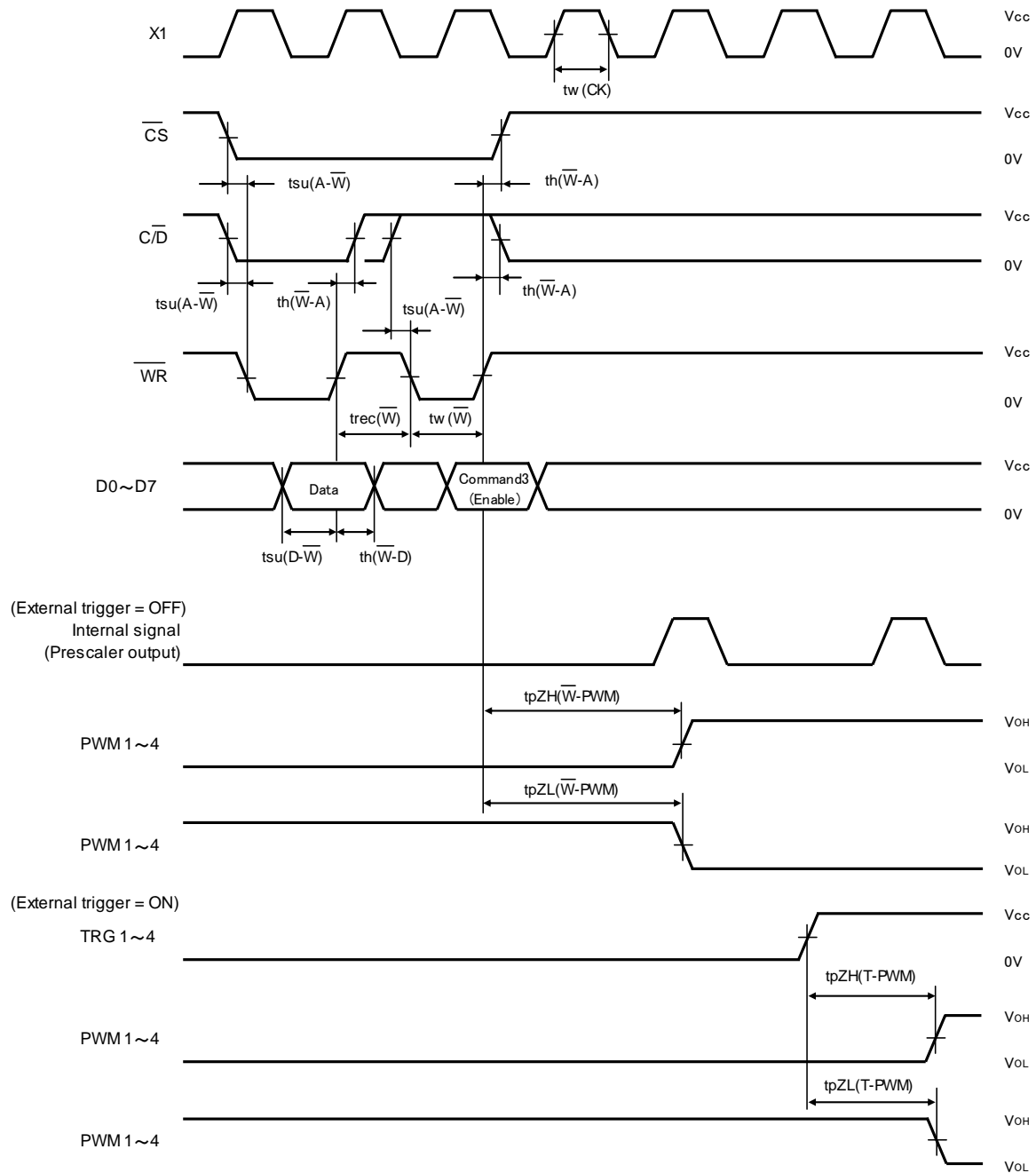
(2) In operation

Mode 0,2 (external trigger ON, OFF)

X1   50%   50%   Vcc   0V

Internal signal (Prescaler output)

tpLH(X1-PWM)   tpHL(X1-PWM)

PWM 1∼4   50%   50%   VOH   VOL

tpHL(X1-PWM)   tpLH(X1-PWM)

PWM 1∼4   50%   50%   VOH   VOL

Mode 1 (external trigger ON)

X1   50%   Vcc   0V

Internal signal (Prescaler output)

tw (T)

TRG 1∼4   50%   50%   Vcc   0V

tpLH(T-PWM)   tpHL(X1-PWM)

PWM 1∼4   50%   50%   VOH   VOL

tpHL(T-PWM)

tpLH(X1-PWM)

PWM 1∼4   50%   50%   VOH   VOL

Mode 1 (external trigger OFF)

X1   50%   50%   Vcc   0V

Internal signal (Prescaler output)

tpLH(X1-PWM)   tpHL(X1-PWM)

PWM 1∼4   50%   50%   VOH   VOL

tpHL(X1-PWM)   tpLH(X1-PWM)

PWM 1∼4   50%   50%   VOH   VOL
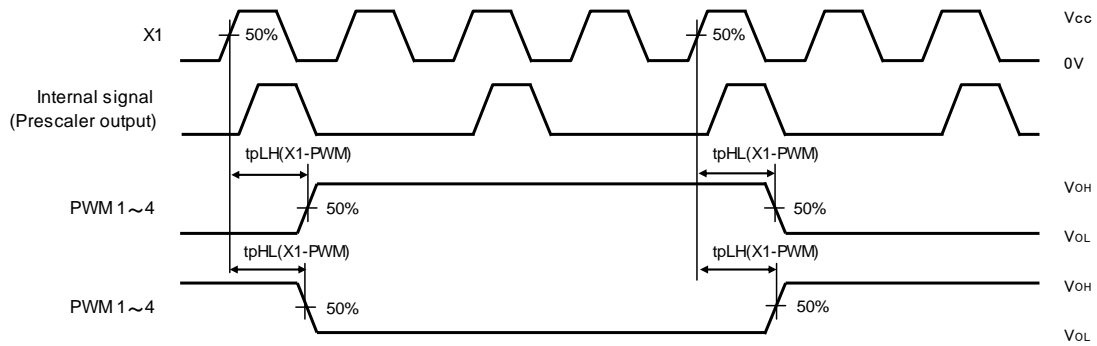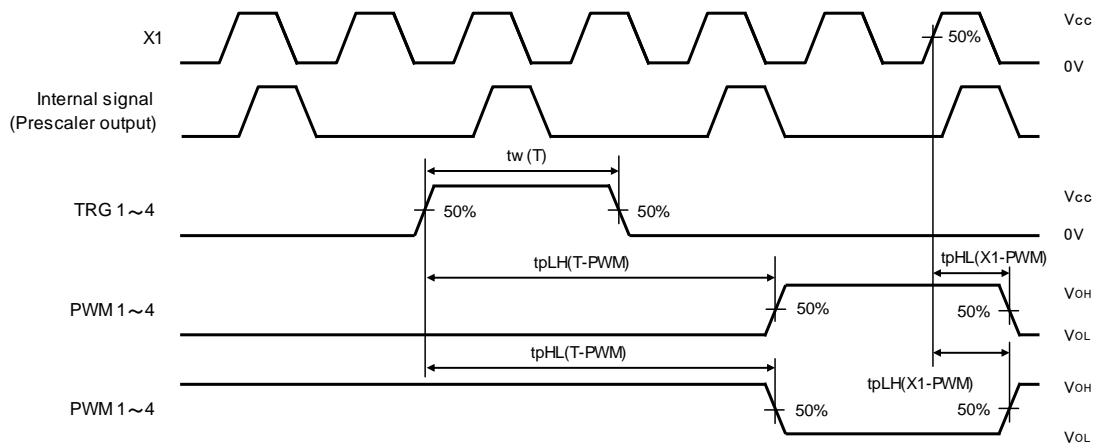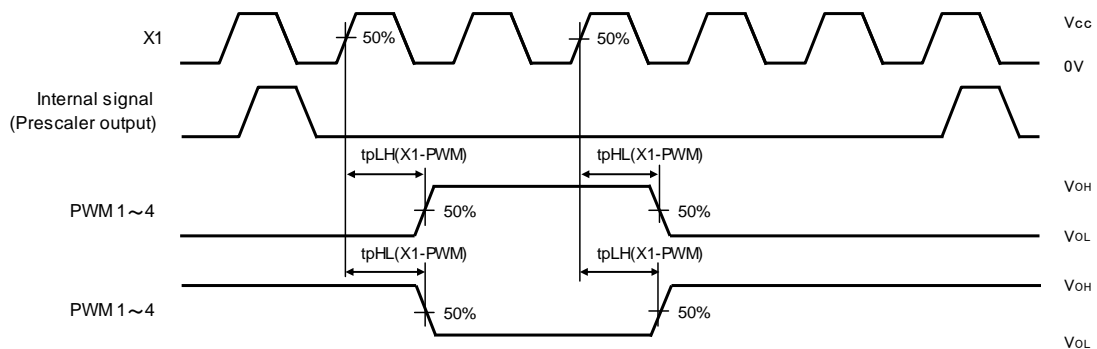
(3) At reset
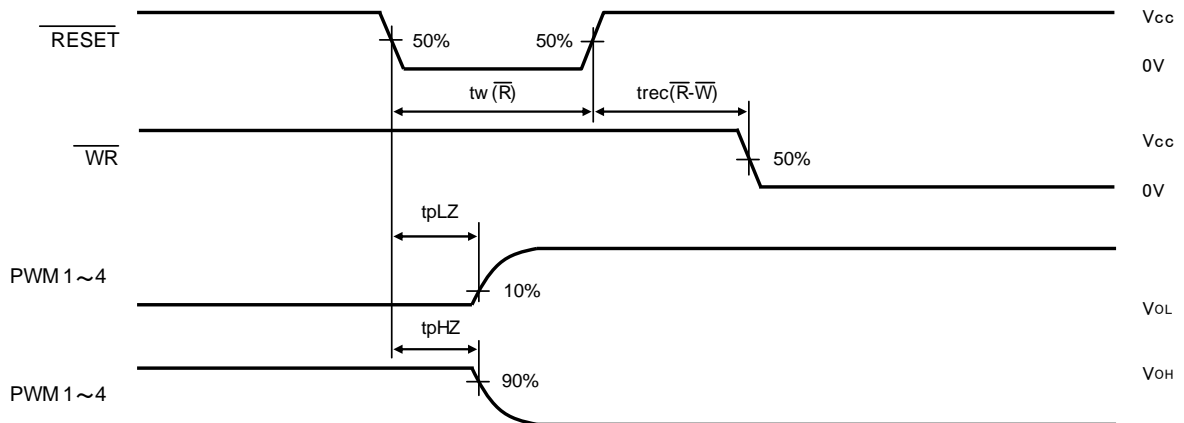
(4) At disable
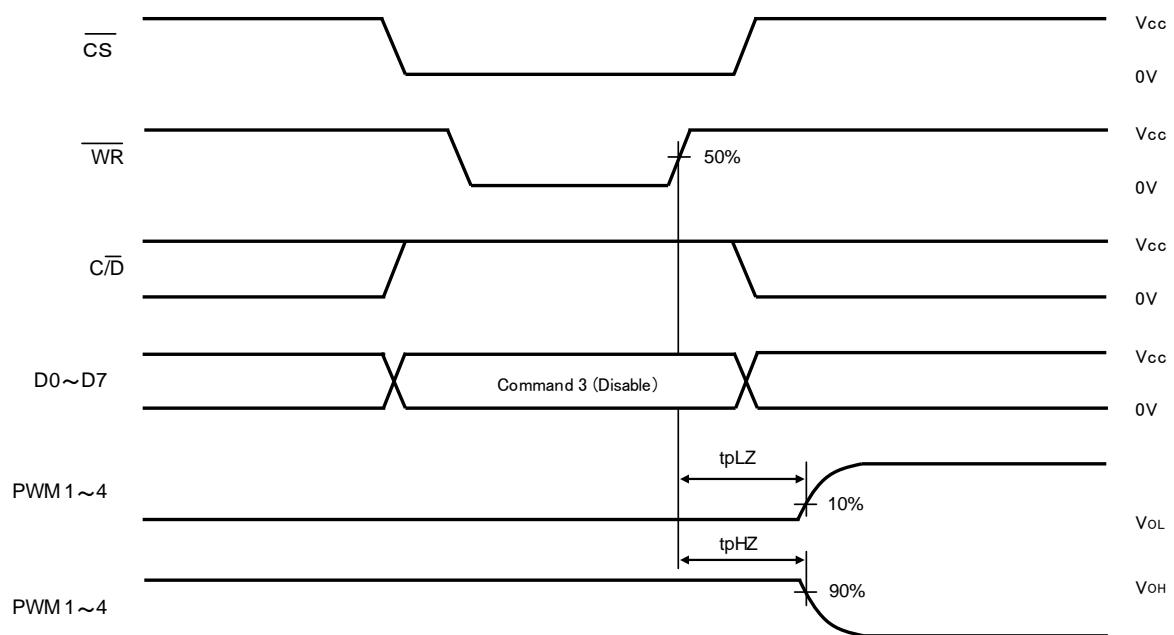
TEST CIRCUIT
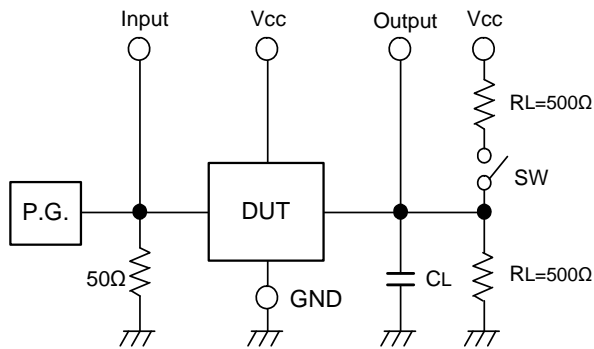
Parameter	SW
tTLH, tTHL	Open
tpLH, tpHL	
tpLZ	Close
tpHZ	Open
tpZL	Close
tpZH	Open

Input　　Vcc　　Output　Vcc

RL=500Ω

P.G.　　DUT　　　　SW

50Ω　　　GND　　CL　RL=500Ω

(1) Characteristics of pulse generater(P.G.) (10%～90%)
　　tr=3ns, tf=3ns
(2) C$_L$ includes stray probe and wiring capacitance.

APPLICATION EXAMPLE

MCU

Pulse cycle measuring

Analog input

Run-system motor

FG pulse

ROM

R8A66170　Driver

RAM

Peripheral

Eraser　Voltage

Lamp　Light volume

Fixing heater　Temperatrure
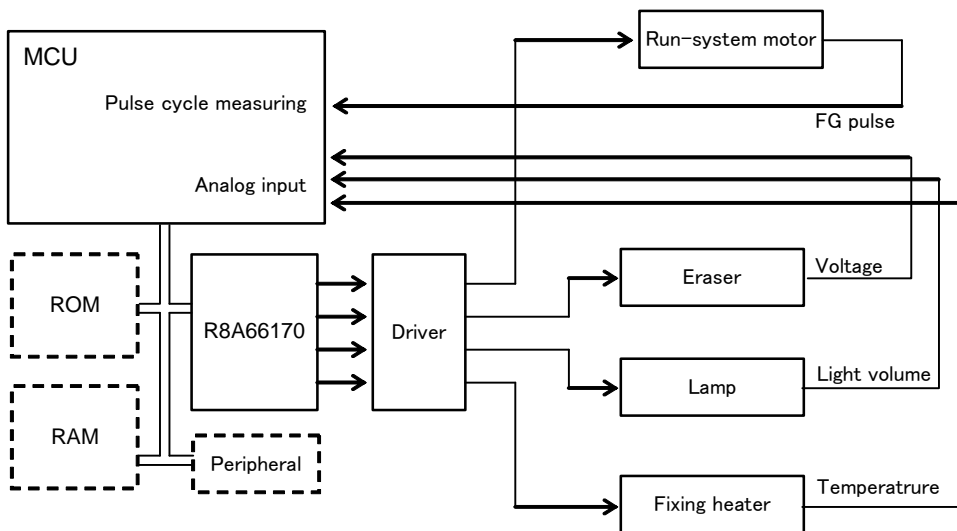
RENESAS

PACKAGE OUTLINE

Product Name	Package	RENESAS Code	Previous Code
R8A66170DD	24pin DIP	PRDP0024AF-A	24P4X-A
R8A66170SP	24pin SOP	PRSP0024DF-A	24P2X-B

NOTE!
1. DIMENSIONS "*1" AND "*2" DO NOT INCLUDE MOLD FLASH.
2. DIMENSION "*3" DOES NOT INCLUDE TRIM OFFSET.

Reference Symbol	Dimension in Millimeters		
	Min	Nom	Max
e1	——	7.62	——
D	31.24	31.75	32.51
E	6.42	6.55	6.68
A	——	——	5.33
A1	0.36	——	——
A2	3.16	3.30	3.43
bp	——	0.46	——
b3	——	1.52	——
c	0.25	0.27	0.30
θ	0°	——	15°
e	——	2.54	——
L	2.92	3.30	3.81

NOTE!
1. DIMENSIONS "*1" AND "*2" DO NOT INCLUDE MOLD FLASH.
2. DIMENSION "*3" DOES NOT INCLUDE TRIM OFFSET.

Reference Symbol	Dimension in Millimeters		
	Min	Nom	Max
D	15.19	15.39	15.49
E	7.39	7.49	7.59
A2	——	2.34	——
A1	0.10	0.20	0.30
A	——	——	2.65
bp	0.31	0.41	0.51
c	0.20	0.25	0.33
θ	0°	——	8°
HE	10.01	10.31	10.64
e	——	1.27	——
x	——	——	0.25
y	——	——	0.10
ZD	——	0.71	——
Lp	0.36	——	——
L1	——	1.41	——

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