

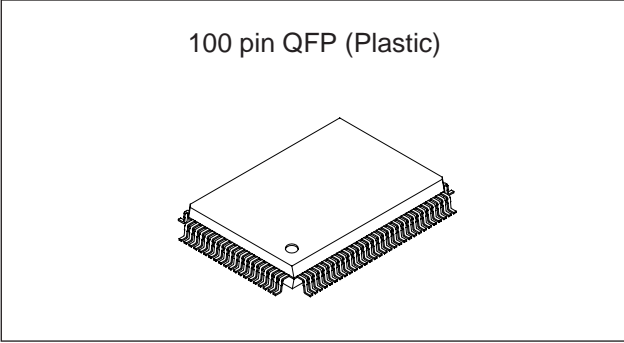
# CXP88616/88624

## CMOS 8-bit Single Chip Microcomputer

### Description

The CXP88616/88624 is a CMOS 8-bit micro-computer which consists of A/D converter, serial interface, timer/counter, time base timer, high precision timing pattern generation circuits, PWM output, VISS/ VASS circuit, remote control receiving circuit, VSYNC separator and the measurement circuit which measure signals of capstan FG amplifier and drum FG/PG amplifier and other servo systems, as well as basic configurations like 8-bit CPU, ROM, RAM and I/O port. They are integrated into a single chip.

Also, CXP88616/88624 provides sleep/stop function which enables to lower power consumption.



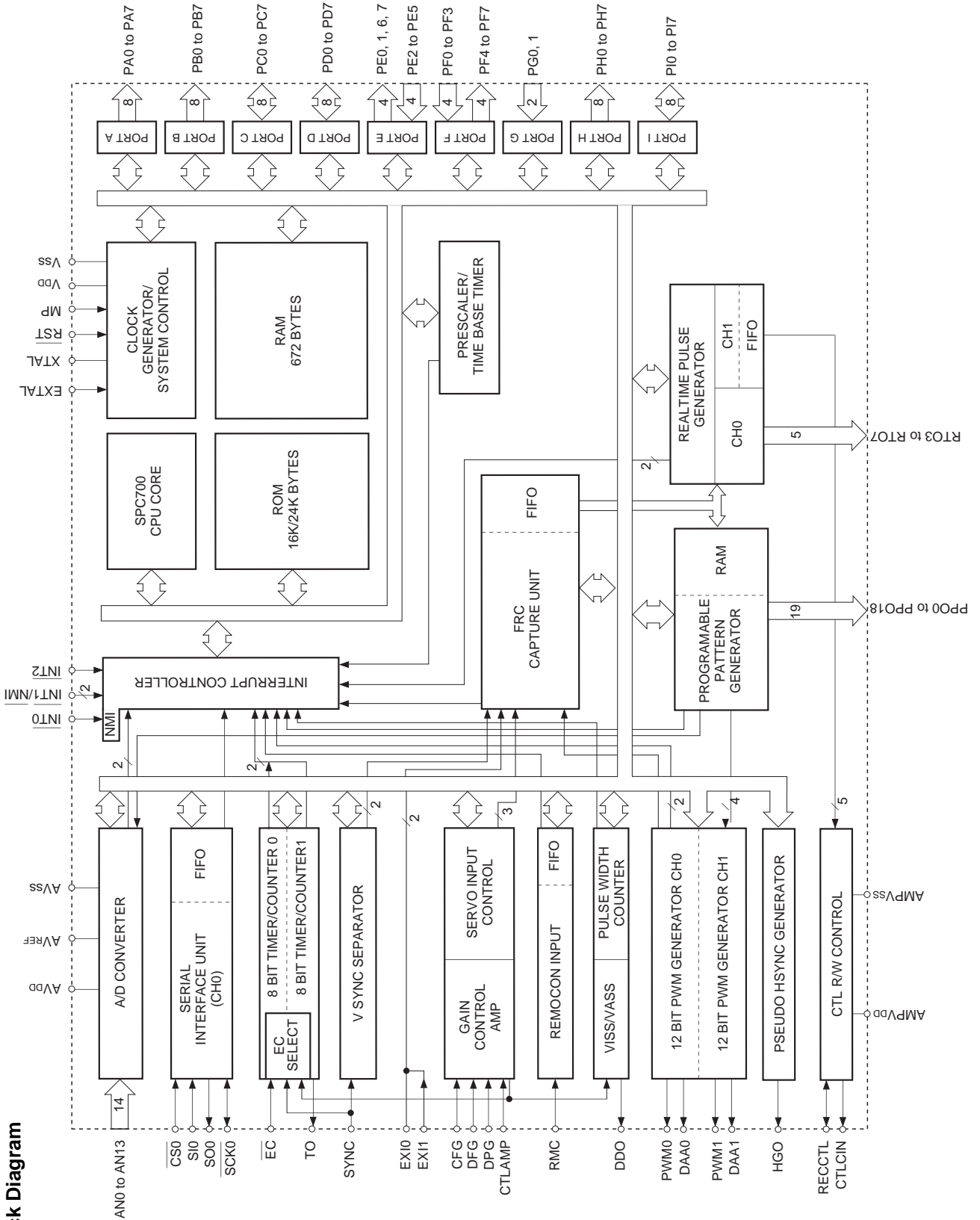
### Structure

Silicon gate CMOS IC

### Features

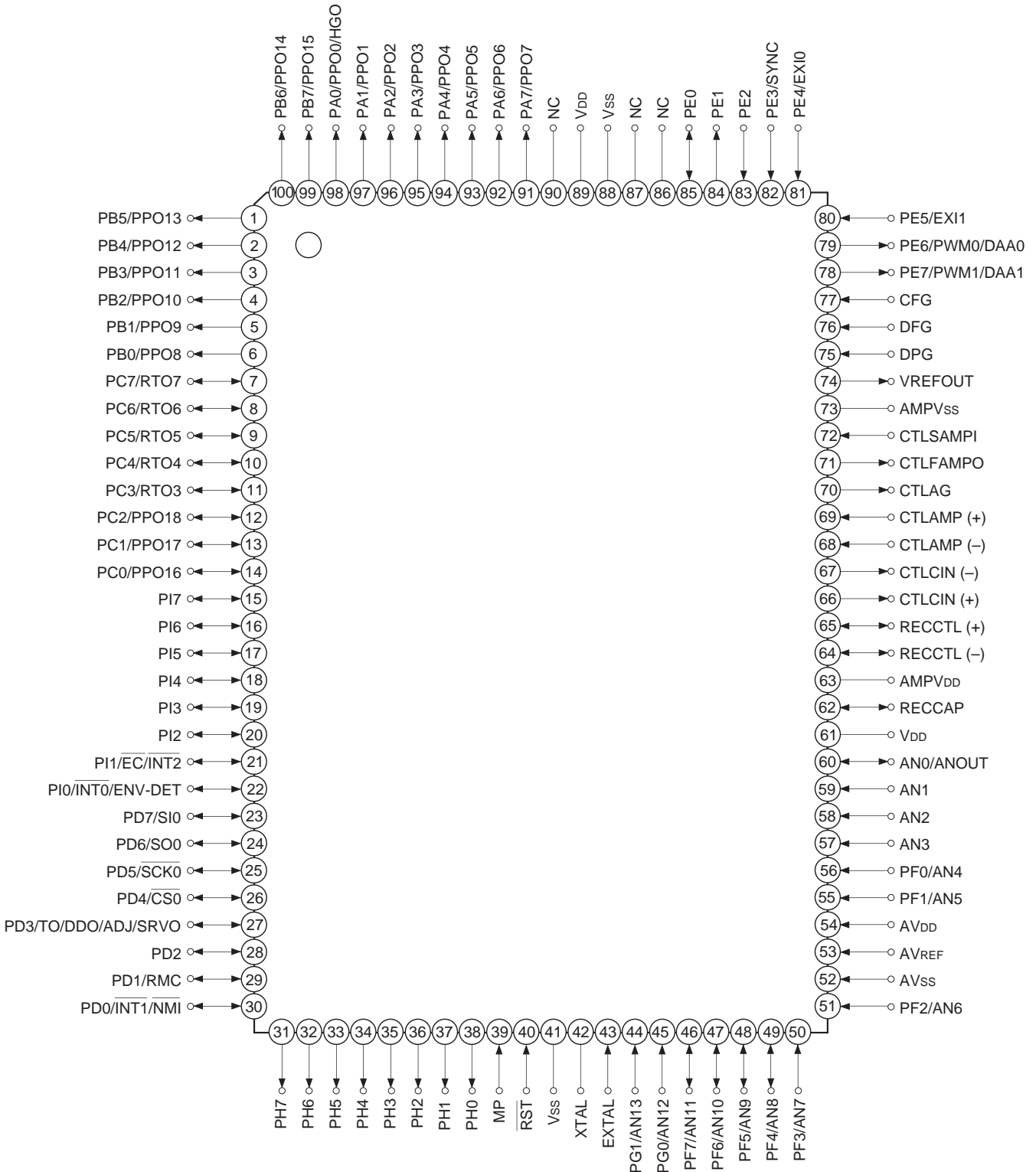
- A wide instruction set (213 instructions) which cover various types of data
  - 16-bit arithmetic/multiplication and division/boolean bit operation instructions
- Minimum instruction cycle      250ns at 16MHz operation
- Incorporated ROM capacity      16K bytes (CXP88616)  
  24K bytes (CXP88624)
- Incorporated RAM capacity      672 bytes (including PPG RAM)
- Peripheral function
  - A/D converter                                 8 bits, 14 channels, successive approximation system (Conversion time of 20 $\mu$ s/16MHz)
  - Serial interface                              Incorporated 8-bit, 8-stage FIFO for data (Auto transfer for 1 to 8 bytes), 1 channel
  - Timer    8-bit timer/counter, 2 channels  
   19-bit time base timer
  - High precision timing pattern generation PPG 19 pins 32-stage programmable circuit  
   RTG 5 pins, 1 channel  
   5-bit, 8-stage FIFO (RECCTL control), 1channel
  - PWM/DA gate output                        12 bits, 2 channels (Repetitive frequency 62.5kHz/16MHz)
  - Analog signal input circuit                DA gate pulse output, 13 bits, 2 channels  
   Capstan FG amplifier circuit  
   Drum FG amplifier circuit  
   Drum PG amplifier circuit  
   PBCTL amplifier circuit  
   Recording current control circuit  
   Capstan FG, Drum FG/PG, CTL input
  - CTL write/rewrite circuit                   Incorporated 26-bit and 8-stage FIFO
  - Servo input control                           Pulse duty auto detection circuit
  - VSYNC separator                             32kHz oscillation circuit, ultra-low speed instruction mode
  - FRC capture unit                             8-bit pulse measurement counter, 6-stage FIFO
  - VISS/VASS circuit                           PPG 1 pin, output 8 pins
  - 32kHz timer/event counter
  - Remote control reception circuit
  - Tri-state output
  - Pseudo HSYNC output function
  - High speed head switching circuit
- Interruption                                    20 factors, 15 vectors, multi-interruption possible
- Standby mode                                   SLEEP/STOP
- Package                                         100-pin plastic QFP
- Piggyback/evaluation chip                 CXP88800 100-pin ceramic QFP

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Block Diagram

Pin Assignment (Top View)



- Note)**
1. NC (Pin 90) is always connected to V<sub>DD</sub>. NC (Pins 86 and 87) are left open.
  2. V<sub>DD</sub> (Pins 61 and 89) are both connected to V<sub>DD</sub>
  3. V<sub>SS</sub> (Pins 41 and 88) are both connected to GND.
  4. MP (Pin 39) must be connected to GND.

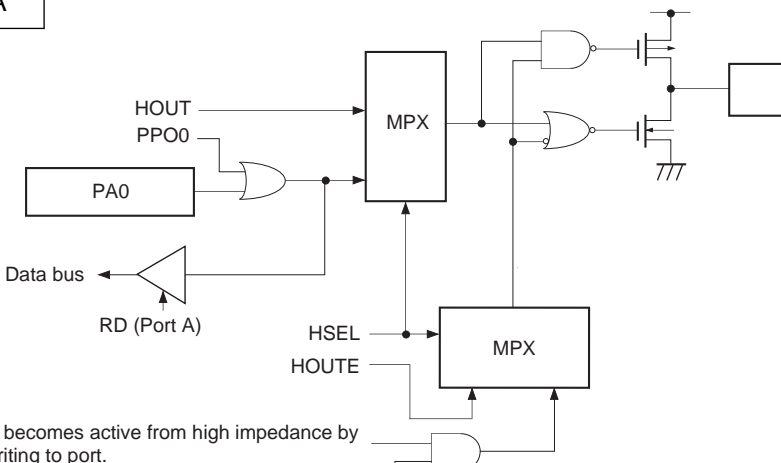
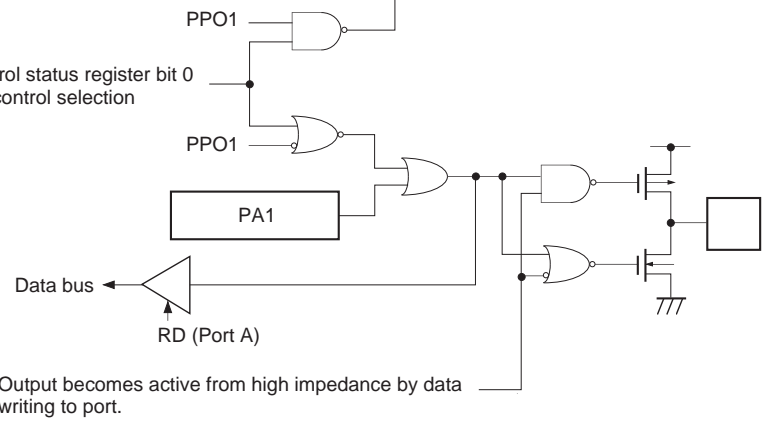
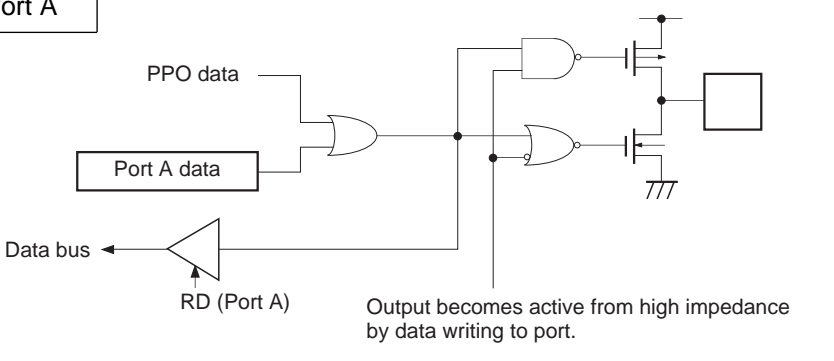
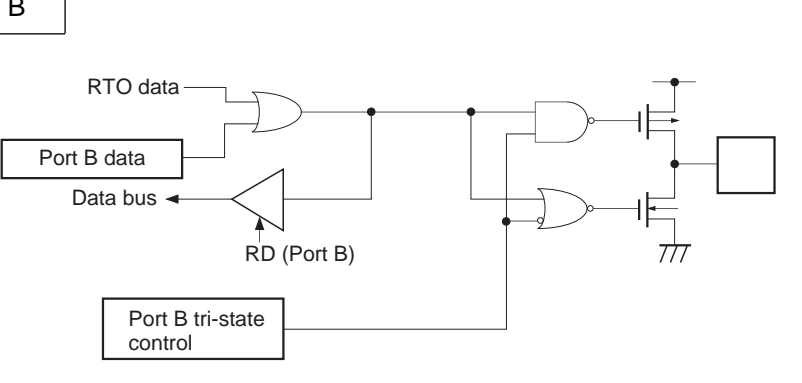
Pin Description

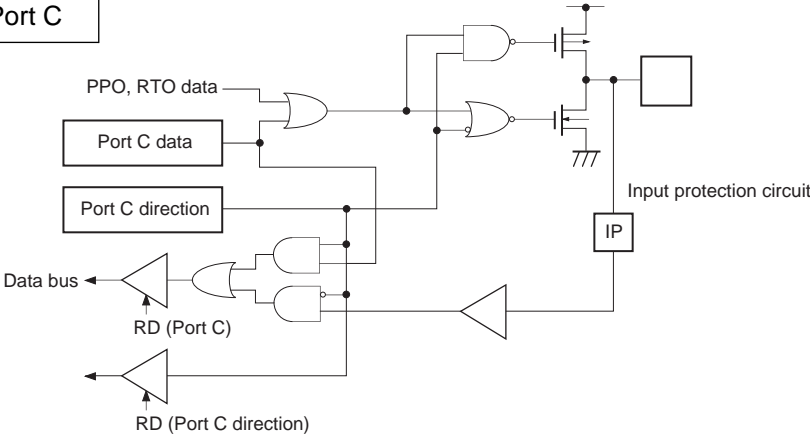
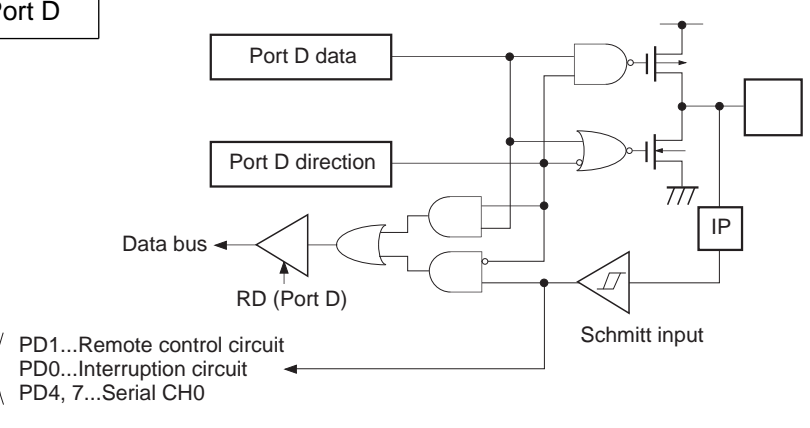
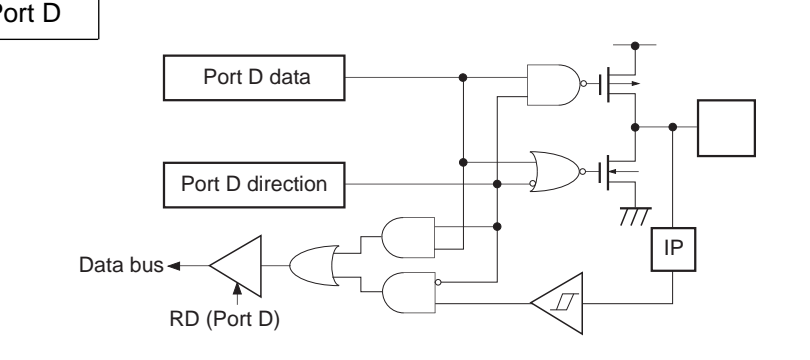
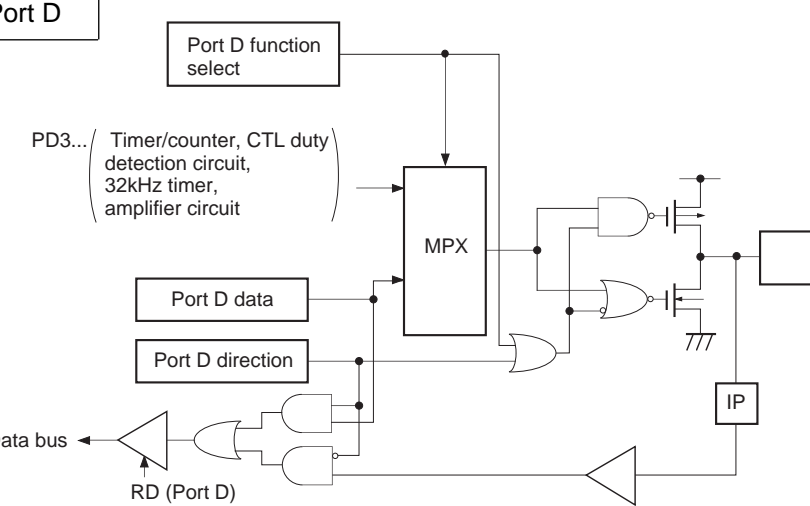
Symbol	I/O	Description		
PA0/PPO0 /HGO	Output/Real-time output/Output	(Port A) 8-bit output port. Data is gated with PPO contents by OR-gate and they are output. (8 pins)	Pseudo HSYNC output pin.	
PA1/PPO1 to PA7/PPO7	Output/Real-time output			
PB0/PPO8 to PB7/PPO15	Output/Real-time output	(Port B) 8-bit output port. Data is gated with PPO contents by OR-gate and they are output. Tri-state control is possible. (8 pins)	Programmable pattern generator (PPG) output. Functions as high precision real-time pulse output port. (19 pins) PA0 can be tri-state controlled with PPG.	
PC0/PPO16 to PC2/PPO18	I/O/Real-time output	(Port C) 8-bit output port. I/O can be set in a unit of single bits. Data is gated with PPO or RT contents by OR-gate and they are output. (8 pins)		
PC3/RTO3 to PC7/RTO7	I/O/Real-time output		Real-time pulse generator (RTG) output. Functions as high precision real-time pulse output port. (5 pins)	
PD0/ $\overline{\text{INT1}}$ /NMI	I/O/Input/Input	(Port D) 8-bit output port. I/O can be set in a unit of single bits. (8 pins)	Input pin to request external interruption and non-maskable interruption.	
PD1/RMC	I/O/Input		Remote control receiving circuit input pin.	
PD2	I/O			
PD3 /TO DDO/SRVO	I/O/Output/Output/Output		Timer/counter, CTL duty detector and servo amplifier output pin.	
PD4/ $\overline{\text{CS0}}$	I/O/Input		Serial chip select (CH0) input pin.	
PD5/ $\overline{\text{SCK0}}$	I/O/I/O		Serial clock (CH0) I/O pin.	
PD6/SO0	I/O/Output		Serial data (CH0) output pin.	
PD7/SI0	I/O/Input		Serial data (CH0) input pin.	
PE0	Output			
PE1	Output			
PE2	Input			
PE3/SYNC	Input/Input	(Port E) 8-bit port. Bits 2, 3, 4 and 5 are for inputs; bits 0, 1, 6 and 7 are for outputs. (8 pins)	Composite sync signal input pin.	
PE4/EXI0	Input/Input		External input pin for FRC capture unit. (2 pins)	
PE5/EXI1	Input/Input			
PE6/PWM0/DAA0	Output/Output		PWM output pin. (2 pins)	DA gate pulse output pin. (2 pins)
PE7/PWM1/DAA1	Output/Output			

Description	I/O	Description		
AN0/ANOUT	Input/Output	Analog circuit internal waveform output pin.		
AN1 to AN3	Input			
PF0/AN4 to PF3/AN7	Input/Input	(Port F) Lower 4 bits are for inputs; upper 4 bits are for outputs. Lower 4 bits are standby release input pins. (8 pins)	Analog input pin for A/D converter. (14 pins)	
PF4/AN8 to PF7/AN11	Output/Input			
PG0/AN12 PG1/AN13	Input/Input			(Port G) 2-bit input port. (2 pins)
PH0 to PH7	Output	(Port H) 8-bit output port; N-ch open drain output of medium drive voltage (12V) and large current (12mA). (8 pins)		
PI0/ $\overline{\text{INT0}}$ / ENV-DET	I/O/Input	(Port I) 8-bit I/O port. I/O can be set in a unit of single bits. Function as standby release input can be set in a unit of single bits. (8 pins)	Input pin to request external interruption. Active when falling edge.	Trigger pulse input pin for head switching.
$\overline{\text{PI1}}/\overline{\text{EC}}/\overline{\text{INT2}}$	I/O/Input/Input		External event input pin for timer/counter.	Input pin to request external interruption. Active when falling edge.
PI2 to PI7	I/O			
CFG	Input	Capstan FG input pin.		
DFG	Input	Drum FG input pin.		
DPG	Input	Drum PG input pin.		
RECCTL (+) RECCTL (-)	I/O	RECCTL signal output pin. (2 pins)	PBCTL signal input pin. (2 pins)	
CTLCIN (+) CTLCIN (-)	Output	Connected to RECCTL (+) and RECCTL (-) with the internal switch for playback. (2 pins)		
CTLAMP (+) CTLAMP (-)	Input	Input PBCTL signal with capacitor coupled. (2 pins)		
CTLFAMPO	Output	PBCTL signal 1st amplifier output.		
CTLSAMPI	Input	PBCTL signal 2nd amplifier input.		
RECCAP	I/O	Capacitor connecting pin for the slope setting of the CTL writing trapezoidal wave.		
VREFOUT	Output	Capacitor connecting pin for the VREF level smoothing of DPG, DFG and CFG.		
CTLAG	Output	Capacitor connecting pin for the CTL and AGND smoothing.		
AMPV <sub>SS</sub>		Analog signal input circuit GND pin.		
AMPV <sub>DD</sub>		Analog signal input circuit power supply pin.		

Symbol	I/O	Description
EXTAL	Input	Connecting pin of crystal oscillator for system clock. When supplying the external clock, input it to EXTAL pin and input the opposite phase clock to XTAL pin.
XTAL	Output	
$\overline{\text{RST}}$	Input	System reset pin; Low level active.
NC		NC pin. Connect Pin 90 to V <sub>DD</sub> and leave Pins 86 and 87 open.
MP	Input	Test mode input pin. Always connect to GND.
AV <sub>DD</sub>		Positive power supply pin for A/D converter.
AV <sub>REF</sub>	Input	Reference voltage input pin for A/D converter.
AV <sub>SS</sub>		GND pin for A/D converter.
V <sub>DD</sub>		Positive power supply pin.
V <sub>SS</sub>		GND pin. Connect both V <sub>SS</sub> pins to GND.

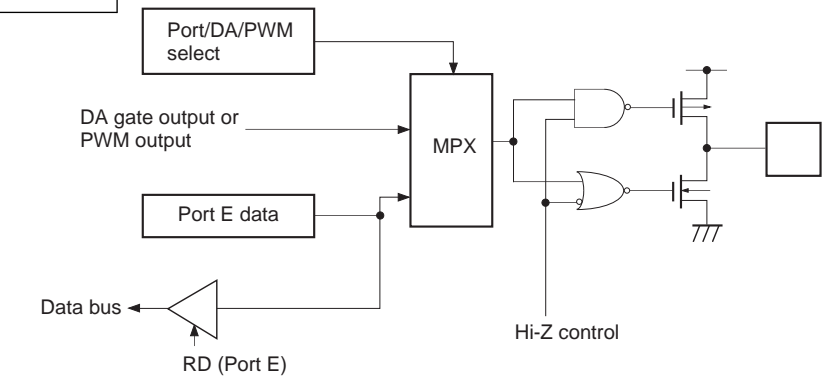
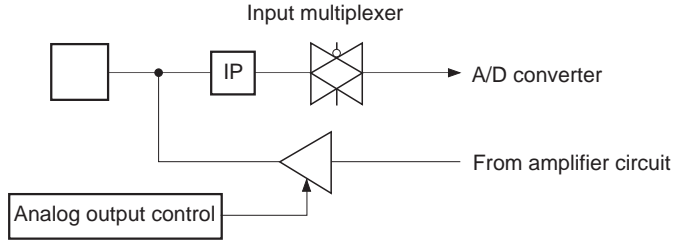
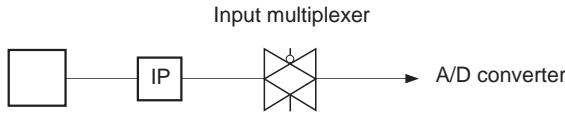
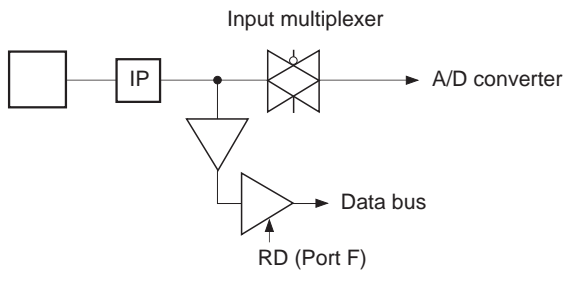
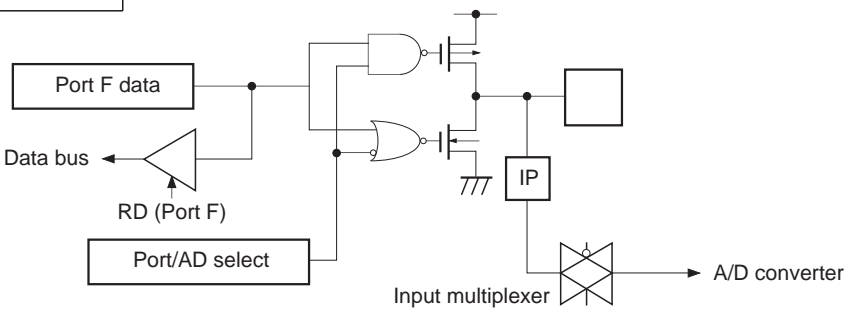
Input/Output Circuit Formats for Pins

Pin	Circuit format	When reset
<p>PA0/PPO0/ HGO</p> <p>1 pin</p>	<p>Port A</p>  <p>Output becomes active from high impedance by data writing to port.</p> <p>PPG control status register bit 0 Tri-state control selection</p> <p>PA1</p>  <p>Output becomes active from high impedance by data writing to port.</p>	<p>Hi-Z</p>
<p>PA2/PPO2 to PA7/PPO7</p> <p>6 pins</p>	<p>Port A</p>  <p>Output becomes active from high impedance by data writing to port.</p>	<p>Hi-Z</p>
<p>PB0/PPO8 to PB7/PPO15</p> <p>8 pins</p>	<p>Port B</p>  <p>Output becomes active from high impedance by data writing to port.</p>	<p>Hi-Z</p>

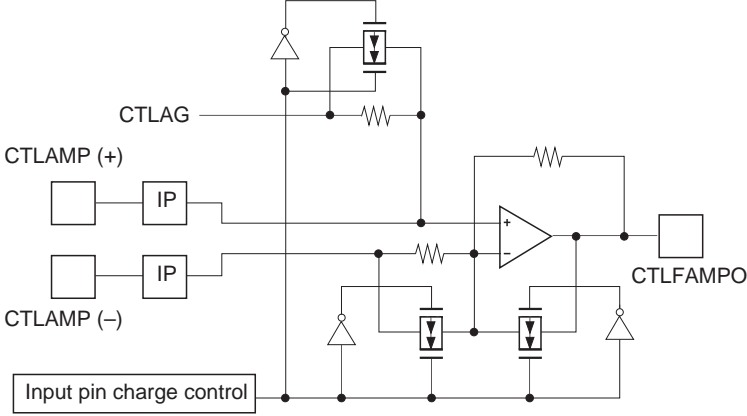
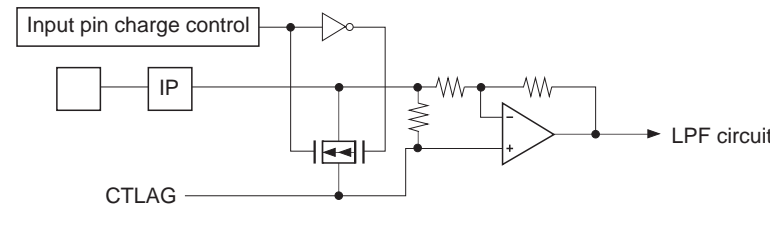
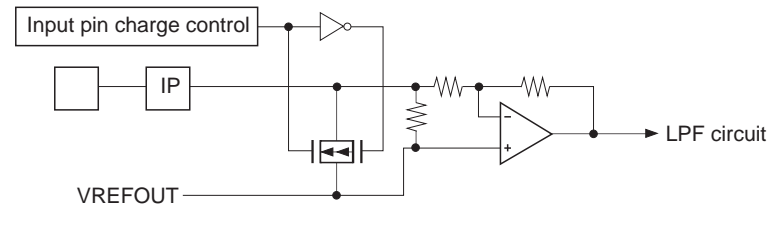
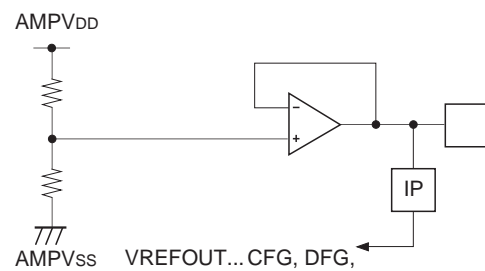
Pin	Circuit format	When reset
<p>PC0/PPO16 to PC2/PPO18</p> <p>PC3/RT03 to PC7/RT07</p> <p>8 pins</p>	<p>Port C</p>  <p>PPO, RTO data</p> <p>Port C data</p> <p>Port C direction</p> <p>Data bus</p> <p>RD (Port C)</p> <p>RD (Port C direction)</p> <p>Input protection circuit</p> <p>IP</p>	<p>Hi-Z</p>
<p>PD0/<math>\overline{\text{INT1}}</math>/<math>\overline{\text{NMI}}</math></p> <p>PD1/RMC</p> <p>PD4/<math>\overline{\text{CS0}}</math></p> <p>PD7/SI0</p> <p>4 pins</p>	<p>Port D</p>  <p>Port D data</p> <p>Port D direction</p> <p>Data bus</p> <p>RD (Port D)</p> <p>Schmitt input</p> <p>IP</p> <p>( PD1...Remote control circuit PD0...Interruption circuit PD4, 7...Serial CH0</p>	<p>Hi-Z</p>
<p>PD2</p> <p>1 pin</p>	<p>Port D</p>  <p>Port D data</p> <p>Port D direction</p> <p>Data bus</p> <p>RD (Port D)</p> <p>IP</p>	<p>Hi-Z</p>
<p>PD3/TO/ DDO/SRVO</p> <p>4 pins</p>	<p>Port D</p>  <p>Port D function select</p> <p>PD3... ( Timer/counter, CTL duty detection circuit, 32kHz timer, amplifier circuit</p> <p>MPX</p> <p>Port D data</p> <p>Port D direction</p> <p>Data bus</p> <p>RD (Port D)</p> <p>IP</p>	<p>Hi-Z</p>



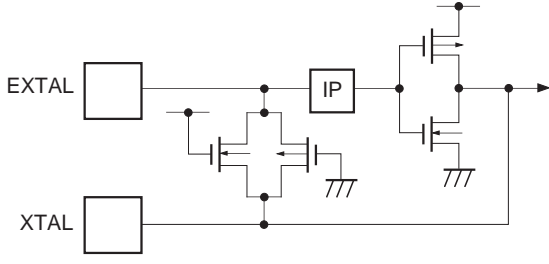
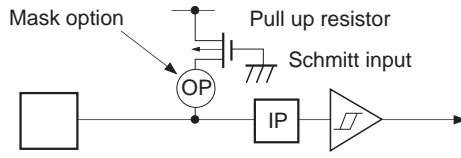
Pin	Circuit format	When reset
<p>PD5/<math>\overline{\text{SCK0}}</math> PD6/<math>\overline{\text{SO0}}</math></p> <p>2 pins</p>	<p>Port D</p> <p>Note) ( PD5 is schmitt input PD6 is inverter input )</p>	<p>Hi-Z</p>
<p>PE0 PE1</p> <p>2 pins</p>	<p>Port E</p>	<p>Hi-Z</p>
<p>PE2</p> <p>1 pin</p>	<p>Port E</p>	<p>Hi-Z</p>
<p>PE3/<math>\overline{\text{SYNC}}</math> PE4/<math>\overline{\text{EXI0}}</math> PE5/<math>\overline{\text{EXI1}}</math></p> <p>3 pins</p>	<p>Port E</p> <p>Note) For PE3/<math>\overline{\text{SYNC}}</math>, CMOS schmitt input or TTL schmitt input can be selected with the mask option.</p>	<p>Hi-Z</p>

Pin	Circuit format	When reset
<p>PE6/PWM0/ DAA0 PE7/PWM1/ DAA1</p> <p>2 pins</p>	<p>Port E</p> 	<p>High level</p>
<p>AN0/ANOUT</p> <p>1 pin</p>		<p>Hi-Z</p>
<p>AN1 to AN3</p> <p>3 pins</p>		<p>Hi-Z</p>
<p>PF0/AN4 to PF3/AN7</p> <p>4 pins</p>	<p>Port F</p> 	<p>Hi-Z</p>
<p>PF4/AN8 to PF7/AN11</p> <p>4 pins</p>	<p>Port F</p> 	<p>Hi-Z</p>

Pin	Circuit format	When reset
<p>PG0/AN12 to PG1/AN13</p> <p>2 pins</p>	<p>Port G</p> <p>Input multiplexer</p> <p>A/D converter</p> <p>Data bus</p> <p>RD (Port G)</p>	<p>Hi-Z</p>
<p>PH0 to PH7</p> <p>8 pins</p>	<p>Port H</p> <p>Port H data</p> <p>Data bus</p> <p>RD (Port H)</p> <p>Medium drive voltage 12 V</p> <p>Large current 12mA</p>	<p>Hi-Z</p>
<p>PI0/<math>\overline{\text{INT0}}</math>/ EVN-DET</p> <p>PI1/<math>\overline{\text{EC}}</math>/<math>\overline{\text{INT2}}</math></p> <p>2 pins</p>	<p>Port I</p> <p>Port I data</p> <p>Port I direction</p> <p>Data bus</p> <p>RD (Port I)</p> <p>Edge detection</p> <p>Standby release</p> <p>IP</p> <p>Interruption circuit</p> <p>Data bus</p> <p>RD (Port I direction)</p>	<p>Hi-Z</p>
<p>PI2 to PI7</p> <p>6 pins</p>	<p>Port I</p> <p>Port I data</p> <p>Port I direction</p> <p>Data bus</p> <p>RD (Port I)</p> <p>Edge detection</p> <p>Standby release</p> <p>IP</p> <p>Data bus</p> <p>RD (Port I direction)</p>	<p>Hi-Z</p>

Pin	Circuit format	When reset
<p>CTLAMP (+) CTLAMP (-) CTLFAMPO</p> <p>3 pins</p>		<p>1/2AMPV<sub>DD</sub></p>
<p>CTLSAMPI</p> <p>1 pin</p>		<p>1/2AMPV<sub>DD</sub></p>
<p>CFG DFG DPG</p> <p>3 pins</p>		<p>1/2AMPV<sub>DD</sub></p>
<p>CTLAG VREFOUT</p> <p>2 pins</p>	 <p>VREFOUT... CFG, DFG, DPG amplifiers CTLAG..... CTL amplifier</p>	<p>1/2AMPV<sub>DD</sub></p>

Pin	Circuit format	When reset
<p>RECCTL (+)</p> <p>1 pin</p>		<p>Hi-Z</p>
<p>RECCTL (-)</p> <p>1 pin</p>		<p>Hi-Z</p>
<p>CTLCLIN (+)</p> <p>1 pin</p>		<p>Hi-Z</p>
<p>CTLCLIN (-)</p> <p>1 pin</p>		<p>Hi-Z</p>
<p>RECCAP</p> <p>1 pin</p>		<p>Low level</p>

Pin	Circuit format	When reset
<p>EXTAL XTAL</p> <p>2 pins</p>	 <ul style="list-style-type: none"> <li>• Shows the circuit composition during oscillation.</li> <li>• Feedback resistor is removed and XTAL becomes High level during stop.</li> </ul>	<p>Oscillation</p>
<p><math>\overline{\text{RST}}</math></p> <p>1 pin</p>		<p>Low level</p>

## Absolute Maximum Ratings

(V<sub>SS</sub> = 0V reference)

Item	Symbol	Rating	Unit	Remarks
Supply voltage	V <sub>DD</sub>	-0.3 to +7.0	V	
	AV <sub>DD</sub>	AV <sub>SS</sub> to +7.0 *1	V	
	AV <sub>SS</sub>	-0.3 to +0.3	V	
	AMPV <sub>DD</sub>	AMPV <sub>SS</sub> to +7.0 *2	V	
	AMPV <sub>SS</sub>	-0.3 to +0.3	V	
Input voltage	V <sub>IN</sub>	-0.3 to +7.0 *3	V	
Output voltage	V <sub>OUT</sub>	-0.3 to +7.0 *3	V	
Medium drive output voltage	V <sub>OUTP</sub>	-0.3 to +15.0	V	Port H
High level output current	I <sub>OH</sub>	-5	mA	
High level total output current	∑I <sub>OH</sub>	-50	mA	Total of output pins
Low level output current	I <sub>OL</sub>	15	mA	Other than large current output ports (value per pin)
	I <sub>OLC</sub>	20	mA	Large current output port *4 (value per pin)
Low level total output current	∑I <sub>OL</sub>	130	mA	Total of output pins
Operating temperature	T <sub>opr</sub>	-20 to +75	°C	
Storage temperature	T <sub>stg</sub>	-55 to +150	°C	
Allowable power dissipation	P <sub>D</sub>	600	mW	QFP package type

\*1) AV<sub>DD</sub> and V<sub>DD</sub> must not exceed +0.3V.

\*2) AMPV<sub>DD</sub> and V<sub>DD</sub> must not exceed +0.3V.

\*3) V<sub>IN</sub> and V<sub>OUT</sub> must not exceed V<sub>DD</sub> +0.3V.

\*4) The large current output port is port H (PH).

**Note)** Usage exceeding absolute maximum ratings may permanently impair the LSI. Normal operation should better take place under the recommended operating conditions. Exceeding those conditions may adversely affect the reliability of the LSI.

## Recommended Operating Conditions

(V<sub>SS</sub> = 0V reference)

Item	Symbol	Min.	Max.	Unit	Remarks
Supply voltage	V <sub>DD</sub>	4.5	5.5	V	Guaranteed operation range for 1/2 and 1/4 frequency dividing clock
		3.5	5.5		Guaranteed operation range for 1/16 frequency dividing clock or during SLEEP mode
		2.5	5.5		Guaranteed data hold operation range during STOP
Analog power supply	AV <sub>DD</sub>	4.5	5.5	V	*1
	AMPV <sub>DD</sub>	4.5	5.5	V	*2
High level input voltage	V <sub>IH</sub>	0.7V <sub>DD</sub>	V <sub>DD</sub>	V	*3
	V <sub>IHS</sub>	0.8V <sub>DD</sub>	V <sub>DD</sub>	V	CMOS schmitt input *4
	V <sub>IHTS</sub>	2.2	V <sub>DD</sub>	V	TTL schmitt input *5
	V <sub>IHEX</sub>	V <sub>DD</sub> - 0.4	V <sub>DD</sub> + 0.3	V	EXTAL pin *6
Low level input voltage	V <sub>IL</sub>	0	0.3V <sub>DD</sub>	V	*3
	V <sub>ILS</sub>	0	0.2V <sub>DD</sub>	V	CMOS schmitt input *4
	V <sub>ILTS</sub>	0	0.8	V	TTL schmitt input *5
	V <sub>ILEX</sub>	-0.3	0.4	V	EXTAL pin *6
Operating temperature	Topr	-20	+75	°C	

\*1) AV<sub>DD</sub> and V<sub>DD</sub> should be set to the same voltage.

\*2) AMPV<sub>DD</sub> and V<sub>DD</sub> should be set to the same voltage.

\*3) Normal input port (each pin of PC, PD2, PD3, PD6, PF0 to PF3, PG and PI2 to PI7), MP pin

\*4) Each pin of  $\overline{RST}$ , PD0/ $\overline{INT1}$ / $\overline{NM1}$ , PD1/RMC, PD4/ $\overline{CS0}$ , PD5/ $\overline{SCK0}$ , PD7/SI0, PE2, PE3/SYNC, PE4/EXI0, PE5/EXI1, PI0/ $\overline{INT0}$ , PI1/ $\overline{EC}$ / $\overline{INT2}$  (For PE3/SYNC, when CMOS schmitt input is selected with mask option.)

\*5) PE3/SYNC (when TTL schmitt input is selected with mask option.)

\*6) Specifies only during external clock input.



**Electrical Characteristics**

**DC Characteristics** ( $V_{DD} = 4.5$  to  $5.5V$ )

( $T_a = -20$  to  $+75^\circ C$ ,  $V_{SS} = 0V$  reference)

Item	Symbol	Pins	Conditions	Min.	Typ.	Max.	Unit
High level output voltage	$V_{OH}$	PA to PD, PE0 to PE1, PE6 to PE7, PF4 to PF7, PH ( $V_{OL}$ only)	$V_{DD} = 4.5V, I_{OH} = -0.5mA$	4.0			V
			$V_{DD} = 4.5V, I_{OH} = -1.2mA$	3.5			V
Low level output voltage	$V_{OL}$	PI ( $V_{OL}$ only)	$V_{DD} = 4.5V, I_{OL} = 1.8mA$			0.4	V
			$V_{DD} = 4.5V, I_{OL} = 3.6mA$			0.6	V
			PH	$V_{DD} = 4.5V, I_{OL} = 12.0mA$			1.5
Input current	$I_{IHE}$	EXTAL	$V_{DD} = 5.5V, V_{IH} = 5.5V$	0.5		40	$\mu A$
	$I_{ILE}$		$V_{DD} = 5.5V, V_{IL} = 0.4V$	-0.5		-40	$\mu A$
	$I_{ILR}$		$\overline{RST}^{*1}$	$V_{DD} = 5.5V, V_{IL} = 0.4V$	-1.5		-400
I/O leakage current	$I_{IZ}$	PA to PG, PI, MP, AN0 to AN3, $\overline{RST}^{*1}$	$V_{DD} = 5.5V, V_I = 0, 5.5V$			$\pm 10$	$\mu A$
Open drain output leakage current (N-CH Tr off state)	$I_{LOH}$	PH	$V_{DD} = 5.5V, V_{OH} = 12V$			50	$\mu A$
Supply current <sup>*2</sup>	$I_{DD1}$	$V_{DD}, V_{SS}$	16MHz crystal oscillation ( $C_1 = C_2 = 15pF$ )		27	45	mA
	$I_{DDS1}$			$V_{DD} = 5.5V^{*3}$			
	$I_{DD2}$		SLEEP mode		1.8	8	mA
	$I_{DDS2}$			$V_{DD} = 5.5V$			
	$I_{DDS3}$		STOP mode (EXTAL pin oscillation stop)			10	$\mu A$
	$V_{DD} = 5V \pm 0.5V$						
Input capacity	$C_{IN}$	PC, PD, PE2 to PE5, PF, PG, PI, RECCTL (+), RECCTL (-), CTLAMP (+), CTLAMP (-), CTLSAMPI, CFG, DFG, DPG	Clock 1MHz 0V other than the measured pins		10	20	pF

\*1)  $\overline{RST}$  pin specifies the input current when the pull-up resistor is selected, and specifies leakage current when no resistor is selected.

\*2) When entire output pins are open.

\*3) When setting upper 2 bits (CPU clock selection) of clock control register (CLC: 00FEH) to "00" and operating in high speed mode (1/2 frequency dividing clock).

AC Characteristics

(1) Clock timing

(Ta = -20 to +75°C, VDD = 4.5 to 5.5V, VSS = 0V reference)

Item	Symbol	Pin	Condition	Min.	Typ.	Max.	Unit
System clock frequency	fc	XTAL EXTAL	Fig. 1, Fig. 2	1		16	MHz
System clock input pulse width	tXL, tXH	XTAL EXTAL	Fig. 1, Fig. 2 External clock drive	28			ns
System clock input rise and fall times	tCR, tCF	XTAL EXTAL	Fig. 1, Fig. 2 External clock drive			200	ns
Event count clock input pulse width	tEH, tEL	$\overline{EC}$	Fig. 3	tsys + 200*1			ns
Event count clock input rise and fall times	tER, tEF	$\overline{EC}$	Fig. 3			20	ms

\*1) tsys indicates three values according to the contents of the clock control register (CLC; 00FEH) upper 2 bits (CPU clock selection).

tsys [ns] = 2000/fc (Upper 2 bits = "00"), 4000/fc (Upper 2 bits = "01"), 16000/fc (Upper 2 bits = "11")

Fig. 1. Clock timing

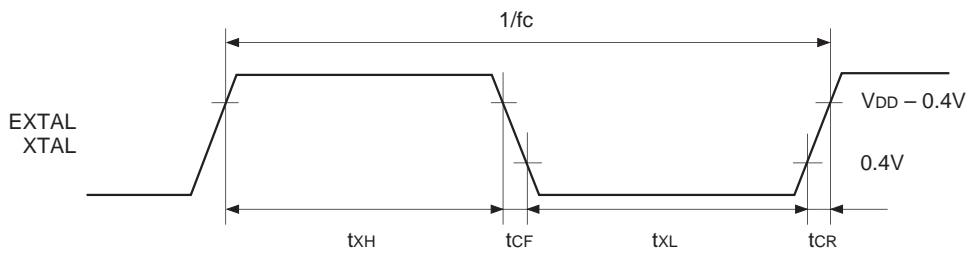


Fig. 2. Clock applied condition

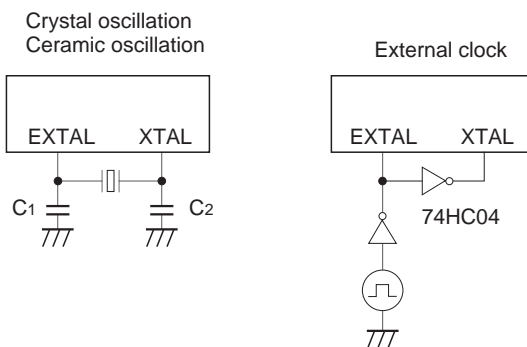
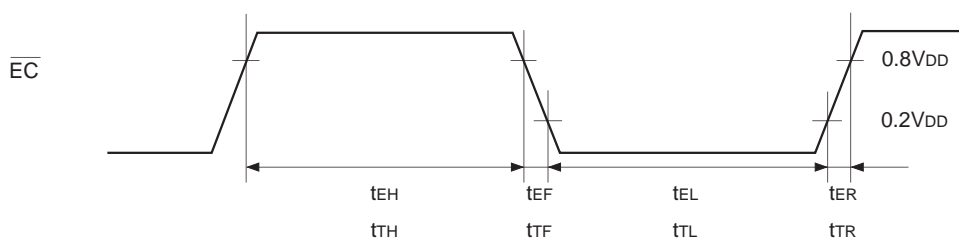


Fig. 3. Event count clock timing



## (2) Serial transfer (CH0)

(Ta = -20 to +75°C, V<sub>DD</sub> = 4.5 to 5.5V, V<sub>SS</sub> = 0V reference)

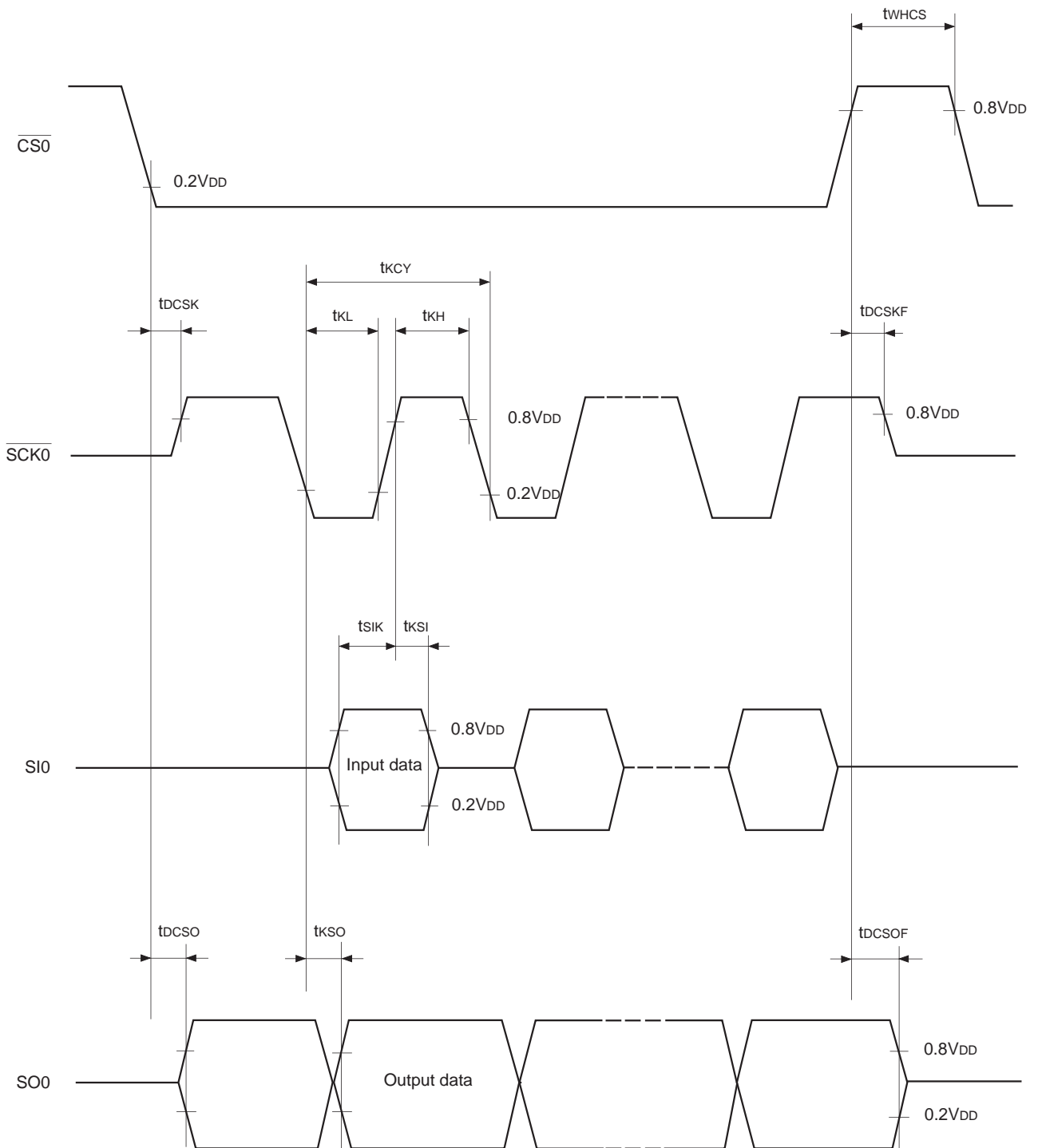
Item	Symbol	Pin	Condition	Min.	Max.	Unit
$\overline{\text{CS0}} \downarrow \rightarrow \overline{\text{SCK0}}$ delay time	t <sub>DCSK</sub>	$\overline{\text{SCK0}}$	Chip select transfer mode ( $\overline{\text{SCK0}}$ = output mode)		t <sub>sys</sub> + 200	ns
$\overline{\text{CS0}} \uparrow \rightarrow \overline{\text{SCK0}}$ floating delay time	t <sub>DCSKF</sub>	$\overline{\text{SCK0}}$	Chip select transfer mode ( $\overline{\text{SCK0}}$ = output mode)		t <sub>sys</sub> + 200	ns
$\overline{\text{CS0}} \downarrow \rightarrow \text{SO0}$ delay time	t <sub>DCSO</sub>	SO0	Chip select transfer mode		t <sub>sys</sub> + 200	ns
$\overline{\text{CS0}} \uparrow \rightarrow \text{SO0}$ floating delay time	t <sub>DCSOF</sub>	SO0	Chip select transfer mode		t <sub>sys</sub> + 200	ns
$\overline{\text{CS0}}$ high level width	t <sub>WHCS</sub>	$\overline{\text{CS0}}$	Chip select transfer mode	t <sub>sys</sub> + 200		ns
$\overline{\text{SCK0}}$ cycle time	t <sub>KCY</sub>	$\overline{\text{SCK0}}$	Input mode	2t <sub>sys</sub> + 200		ns
			Output mode	16000/fc		ns
$\overline{\text{SCK0}}$ high and low level widths	t <sub>KH</sub> t <sub>KL</sub>	$\overline{\text{SCK0}}$	Input mode	t <sub>sys</sub> + 100		ns
			Output mode	8000/fc - 50		ns
SI0 input set-up time (against $\overline{\text{SCK0}} \uparrow$ )	t <sub>SIK</sub>	SI0	$\overline{\text{SCK0}}$ input mode	100		ns
			$\overline{\text{SCK0}}$ output mode	200		ns
SI0 input hold time (against $\overline{\text{SCK0}} \uparrow$ )	t <sub>KSJ</sub>	SI0	$\overline{\text{SCK0}}$ input mode	t <sub>sys</sub> + 200		ns
			$\overline{\text{SCK0}}$ output mode	100		ns
$\overline{\text{SCK0}} \downarrow \rightarrow \text{SO0}$ delay time	t <sub>KSO</sub>	SO0	$\overline{\text{SCK0}}$ input mode		t <sub>sys</sub> + 200	ns
			$\overline{\text{SCK0}}$ output mode		100	ns

**Note 1** t<sub>sys</sub> indicates three values according to the contents of the clock control register (CLC; 00FEH) upper 2 bits (CPU clock selection).

t<sub>sys</sub> [ns] = 2000/fc (Upper 2 bits = "00"), 4000/fc (Upper 2 bits = "01"), 16000/fc (Upper 2 bits = "11")

**Note 2** The load of  $\overline{\text{SCK0}}$  output mode and SO0 output delay time is 50pF + 1TTL.

Fig. 4. Serial transfer timing (CH0)

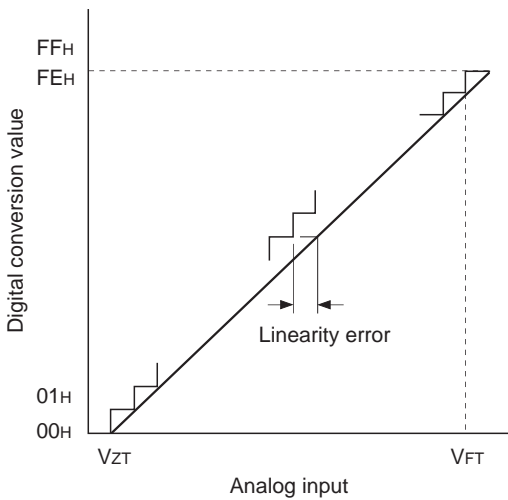


**(3) A/D converter characteristics**

( $T_a = -20$  to  $+75^\circ\text{C}$ ,  $V_{DD} = AV_{DD} = 4.5$  to  $5.5\text{V}$ ,  $AV_{REF} = 4.0$  to  $AV_{DD}$ ,  $V_{SS} = AV_{SS} = 0\text{V}$  reference)

Item	Symbol	Pin	Condition	Min.	Typ.	Max.	Unit
Resolution						8	Bits
Linearity error			Only for A/D converter operation $T_a = 25^\circ\text{C}$ $V_{DD} = AV_{DD} = AV_{REF} = 5.0\text{V}$ $V_{DD} = AV_{SS} = 0\text{V}$			$\pm 1$	LSB
Absolute error						$\pm 2$	LSB
Conversion time	$t_{CONV}$			$160/f_{ADC}^{*1}$			$\mu\text{s}$
Sampling time	$t_{SAMP}$			$12/f_{ADC}^{*1}$			$\mu\text{s}$
Reference input voltage	$V_{REF}$	$AV_{REF}$		$AV_{DD} - 0.5$		$AV_{DD}$	V
Analog input voltage	$V_{IAN}$	AN0 to AN7		0		$AV_{REF}$	V
$AV_{REF}$ current	$I_{REF}$	$AV_{REF}$	Operation mode		0.6	1.0	mA
			SLEEP mode STOP mode 32kHz operation mode			10	$\mu\text{A}$

**Fig. 5. Definitions of A/D converter terms**



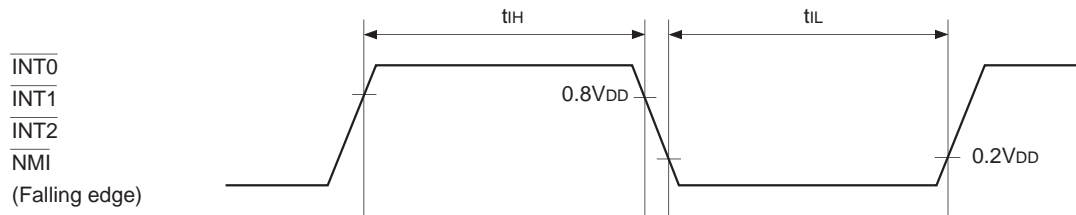
\*1)  $f_{ADC}$  indicates the below values due to the contents of bit 0 (ADCK) of the ADC operation clock selection register (MSC: 01FFH), bits 7 (PCK1) and 6 (PCK0) of the clock control register (address: 00FEH).

PCK1, PCK0 \ ADCK	0 ( $\phi/2$ selection)	1 ( $\phi$ selection)
	00 ( $\phi = f_{EX}/2$ )	$f_{ADC} = f_c/2$
01 ( $\phi = f_{EX}/4$ )	$f_{ADC} = f_c/4$	$f_{ADC} = f_c/2$
11 ( $\phi = f_{EX}/16$ )	$f_{ADC} = f_c/16$	$f_{ADC} = f_c/8$

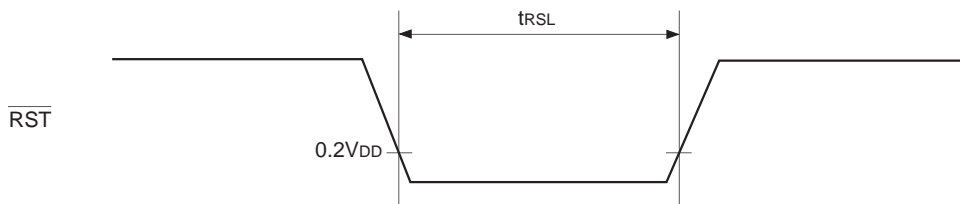
**(4) Interruption, reset input** ( $T_a = -20$  to  $+75^\circ\text{C}$ ,  $V_{DD} = 4.5$  to  $5.5\text{V}$ ,  $V_{SS} = 0\text{V}$  reference)

Item	Symbol	Pin	Condition	Min.	Max.	Unit
External interruption high and low level widths	$t_{IH}$ $t_{IL}$	$\overline{\text{INT0}}$ $\overline{\text{INT1}}$ $\overline{\text{INT2}}$ $\overline{\text{NMI}}$		1		$\mu\text{s}$
Reset input low level width	$t_{RSL}$	$\overline{\text{RST}}$		$32/f_c$		$\mu\text{s}$

**Fig. 6. Interruption input timing**



**Fig. 7. Reset input timing**



## Analog Circuit Characteristics

## (1) Amplifier circuit reference voltage characteristics

(Ta = -20 to +75°C, V<sub>DD</sub> = AMPV<sub>DD</sub> = 5.0V, V<sub>SS</sub> = AMPV<sub>SS</sub> = 0V reference)

Item	Symbol	Pin	Conditions	Min.	Typ.	Max.	Unit
Reference level output voltage	V <sub>OR</sub>	VREFOUT		2.2	2.4	2.6	V
		CTLAG		2.15	2.35	2.55	V
Reference level output current	I <sub>OR</sub>	VREFOUT	VREFOUT = VREFOUT + 0.5V	3.50	6.5		mA
			VREFOUT = VREFOUT - 0.5V	-0.30	-0.85		mA
		CTLAG	CTLAG = CTLAG + 0.5V	2.80	5.5		mA
			CTLAG = CTLAG - 0.5V	-0.30	-0.85		mA

## (2) CTL 1st amplifier characteristics

(Ta = -20 to +75°C, V<sub>DD</sub> = AMPV<sub>DD</sub> = 5.0V, V<sub>SS</sub> = AMPV<sub>SS</sub> = 0V, CTLAG reference)

Item	Symbol	Pin	Conditions	Min.	Typ.	Max.	Unit
Voltage gain *1	A <sub>VCTL1</sub>	RECCTL (+) CTLFAMPO*2	Gain = 16dB RECCTL (-) = 0V	12.5	14.5	16.5	dB
			Gain = 27dB RECCTL (-) = 0V	23.5	25.5	27.5	dB
			Gain = 42dB RECCTL (-) = 0V	39.0	41.5	44.0	dB
			Gain = 58dB RECCTL (-) = 0V	54.5	57.0	59.5	dB
Offset voltage	V <sub>OSCTL1</sub>		CTLAMP (+) and CTLAMP (-) = open	-40	0	+40	mV
Input resistance	R <sub>INCTL1</sub>	CTLAMP (+)	Charge switch OFF CTLAMP (+) = +0.2V	26.0	44.5		kΩ
		CTLAMP (-)	Charge switch OFF CTLAMP (-) = +0.2V	1.20	2.0		kΩ
Charge switch ON resistance	R <sub>CCCTL1</sub>	CTLAMP (+)	Charge switch ON CTLAMP (+) = +0.5V		560	1010	Ω
		CTLAMP (-)	Charge switch ON CTLAMP (-) = +0.5V		560	1010	Ω
RECCTL and CTLCIN connection switch ON resistance	R <sub>READ</sub>	RECCTL (+) CTLCIN (+)	During CTL read operation, CTLCIN (+) - RECCTL (+) = 0.2V	315	400	770	Ω
		RECCTL (-) CTLCIN (-)	During CTL read operation, CTLCIN (-) - RECCTL (-) = 0.2V	315	400	770	Ω
CTLCIN 0V fix switch ON resistance	R <sub>WRITE</sub>	CTLCIN (+)	During CTL write operation, CTLCIN (+) = AMPV <sub>SS</sub> + 0.2V		250	310	Ω
		CTLCIN (-)	During CTL write operation, CTLCIN (-) = AMPV <sub>SS</sub> + 0.2V		250	310	Ω

\*1) When CTLCIN (+), CTLAMP (+) pins and CTLCIN (-), CTLAMP (-) pins are AC coupled, and then the signal is input from RECCTL (+) pin.

\*2) The result after measuring the CTLFAMPO output waveform or voltage gain.

**Note)** The gain increases by approximately 1.5dB when the AC coupling capacitor (47μF) is connected to CTLAMP (+) and CTLAMP (-) pins, and the signal is input from CTLAMP (+) and CTLAMP (-) pins.

**(3) CTL 2nd amplifier characteristics**

(Ta = -20 to +75°C, VDD = AMPVDD = 5.0V, Vss = AMPVSS = 0V, CTLAG reference)

Item	Symbol	Pin	Conditions	Min.	Typ.	Max.	Unit
Voltage gain*1, *2	AVCTL2	CTLSAMPI	Gain = 5dB	4.8	5.8	6.8	dB
			Gain = 11dB	10.4	11.5	12.6	dB
			Gain = 16dB	15.3	16.5	17.7	dB
			Gain = 20dB	19.3	20.5	21.7	dB
LPF cut-off frequency *1, *2	fcCTL		fdc - 3dB	15.0	25.0	40.0	kHz
Offset voltage *2	VOCTL2		CTLSAMPI = open	-50	0	+50	mV
Comparator level *2	VCCTL		Comparator level = +100mV0-p	70.0	100	130	mV0-p
			Comparator level = +250mV0-p	215	245	275	mV0-p
			Comparator level = +400mV0-p	370	400	430	mV0-p
			Comparator level = -100mV0-p	-70.0	-100	-130	mV0-p
		Comparator level = -250mV0-p	-220	-250	-280	mV0-p	
		Comparator level = -400mV0-p	-370	-400	-430	mV0-p	
		Input resistance	RINCTL2	Charge switch OFF CTLSAMPI = +0.2V	10.0	18.0	
Charge switch ON resistance	RCCTL2	Charge switch ON CTLSAMPI = +0.5V		770	1140	Ω	

\*1) When the signal is input with the AC coupling capacitor (47μF) connected to CTLSAMPI pin.

\*2) The result after measuring the output waveform of amplifier internal low-pass filter or voltage value.

**(4) CTLAMP characteristics (1st amplifier + 2nd amplifier)**

(Ta = -20 to +75°C, VDD = AMPVDD = 5.0V, Vss = AMPVSS = 0V reference)

Item	Symbol	Pin	Conditions	Min.	Typ.	Max.	Unit
Voltage gain *1	AVCTL	RECCTL (+)	CTL 1st amplifier gain = 16dB CTL 2nd amplifier gain = 20dB RECCTL (-) = 0V	31.8	35.0	38.2	dB
Input amplitude (peak value)	VPKCTL		RECCTL (-) = 0V			±300	mV0-p
Input sensitivity	VSCTL		CTL 1st amplifier gain = 58dB CTL 2nd amplifier gain = 20dB Comparator level = +400mV0-p -400mV0-p		0.08	0.10	mV0-p
Input dead band	VNSCTL		RECCTL (-) = 0V	0.015	0.04		mV0-p

\*1) As for other combinations of the amplifier gains, CTL 1st amplifier and CTL 2nd amplifier are added respectively.

**Note)** The result when the signal is input from RECCTL (+) pin with CTL 1st amplifier + CTL 2nd amplifier after performing AC coupling of CTL CIN (+), CTLAMP (+) pins and CTL CIN (-), CTLAMP (-) pins, and CTLFAMPO, CTLSAMPI pins.



## (5) CFGAMP characteristics

(Ta = -20 to +75°C, V<sub>DD</sub> = AMPV<sub>DD</sub> = 5.0V, V<sub>SS</sub> = AMPV<sub>DD</sub> = 0V, VREFOUT reference)

Item	Symbol	Pins	Conditions	Min.	Typ.	Max.	Unit
Voltage gain *1, *2	AVCFG	CFG	Gain = 0dB	-0.3	0.6	2.2	dB
			Gain = 20dB	19.2	20.8	22.4	dB
			Gain = 34dB	33.2	34.8	36.4	dB
			Gain = 38dB	37.0	38.7	40.4	dB
LPF cut-off frequency *1, *2	fCCFG		f <sub>DC</sub> - 3dB	30.0	55.0	80.0	kHz
Offset voltage *2	VOSCFG		CFG = open	-50	0	+50	mV
Comparator judgment level width *2	VCCFG		Comparator schmitt width = 320mVp-p	260	320	360	mVp-p
			Comparator schmitt width = 160mVp-p	110	155	200	mVp-p
Input sensitivity *1	VSCFG		Gain = 38dB Comparator level = 320mVp-p		4.20	5.00	mVp-p
			Gain = 38dB Comparator level = 160mVp-p		2.10	2.40	mVp-p
Input dead band *1	VNSCFG		Gain = 38dB Comparator level = 320mVp-p	3.40	4.10		mVp-p
			Gain = 38dB Comparator level = 160mVp-p	1.50	2.00		mVp-p
Input resistance	RINCFG	Charge switch OFF CFG = +0.2V	5.5	8.3		kΩ	
Charge switch ON resistance	RCCFG	Charge switch ON CFG = +0.5V		455	710	Ω	
Digital output waveform duty *1, *3	DTYCFG	CFG = sine wave with 50% duty	48.0	50.0	52.0	%	
Input amplitude (peak value) *1	VPKCFG				±2.4	V <sub>0-p</sub>	

\*1) When the signal is input with the AC coupling capacitor (47μF) connected to CFG pin.

\*2) The result after measuring the output waveform of amplifier internal low-pass filter or voltage value.

\*3) The result after measuring the digital signal waveform output from the amplifier circuit.

**(6) DFGAMP characteristics**

(Ta = -20 to +75°C, VDD = AMPVDD = 5.0V, VSS = AMPVSS = 0V, VREFOUT reference)

Item	Symbol	Pins	Conditions	Min.	Typ.	Max.	Unit
Voltage gain *1, *2	AVDFG	DFG	Gain = 0dB	-0.3	0.6	2.2	dB
			Gain = 20dB	19.2	20.8	22.4	dB
			Gain = 34dB	33.2	34.8	36.4	dB
			Gain = 38dB	37.0	38.7	40.4	dB
LPF cut-off frequency *1, *2	fCDFG		fDC - 3dB	30.0	55.0	80.0	kHz
Offset voltage *2	VOSDFG		DFG = open	-50	0	+50	mV
Comparator judgment level width *2	VCDFG		Comparator schmitt width = 320mVp-p	260	320	360	mVp-p
			Comparator schmitt width = 160mVp-p	110	155	200	mVp-p
Input sensitivity *1	VSDFG		Gain = 38dB Comparator level = 320mVp-p		4.20	5.00	mVp-p
			Gain = 38dB Comparator level = 160mVp-p		2.10	2.40	mVp-p
Input dead band *1	VNSDFG		Gain = 38dB Comparator level = 320mVp-p	3.40	4.10		mVp-p
			Gain = 38dB Comparator level = 160mVp-p	1.50	2.00		mVp-p
Input resistance	RINDFG		Charge switch OFF DFG = +0.2V	5.5	8.3		kΩ
Charge switch ON resistance	RCDFG		Charge switch ON DFG = +0.5V		455	710	Ω
Digital output waveform duty *1, *3	DTYDFG	DFG = sine wave of 50% duty	48.0	50.0	52.0	%	
Input amplitude (peak value) *1	VPKDFG				±2.4	V <sub>0-p</sub>	

\*1) When the signal is input with the AC coupling capacitor (47μF) connected to DFG pin.

\*2) The result after measuring the output waveform of amplifier internal low-pass filter or voltage value.

\*3) The result after measuring the digital signal waveform output from the amplifier circuit.

## (7) DPGAMP characteristics

(Ta = -20 to +75°C, V<sub>DD</sub> = AMPV<sub>DD</sub> = 5.0V, V<sub>SS</sub> = AMPV<sub>SS</sub> = 0V, VREFOUT reference)

Item	Symbol	Pins	Conditions	Min.	Typ.	Max.	Unit
Voltage gain *1, *2	A <sub>VDPG</sub>	DPG		11.1	12.0	13.2	dB
LPF cut-off frequency *1, *2	f <sub>CDPG</sub>		f <sub>DC</sub> - 3dB	30.0	55.0	85.0	kHz
Offset voltage *2	V <sub>OSDPG</sub>		DFG = open	-35	0	+35	mV
Comparator level *2	V <sub>CDPG</sub>		Comparator level = 600mV <sub>0-p</sub>	570	605	640	mV <sub>0-p</sub>
			Comparator level = 400mV <sub>0-p</sub>	370	400	432	mV <sub>0-p</sub>
			Comparator level = 200mV <sub>0-p</sub>	175	200	220	mV <sub>0-p</sub>
			Comparator level = 100mV <sub>0-p</sub>	72	100	125	mV <sub>0-p</sub>
			Comparator level = -600mV <sub>0-p</sub>	-572	-605	-643	mV <sub>0-p</sub>
			Comparator level = -400mV <sub>0-p</sub>	-368	-400	-438	mV <sub>0-p</sub>
			Comparator level = -200mV <sub>0-p</sub>	-174	-200	-223	mV <sub>0-p</sub>
			Comparator level = -100mV <sub>0-p</sub>	-71	-100	-124	mV <sub>0-p</sub>
Input sensitivity *1	V <sub>SDPG</sub>		Comparator level = 600mV <sub>0-p</sub> , 200mV <sub>0-p</sub>		150	180	mV <sub>0-p</sub>
			Comparator level = 400mV <sub>0-p</sub> , 100mV <sub>0-p</sub>		100	120	mV <sub>0-p</sub>
			Comparator level = -600mV <sub>0-p</sub> , -200mV <sub>0-p</sub>		-155	-185	mV <sub>0-p</sub>
			Comparator level = -400mV <sub>0-p</sub> , -100mV <sub>0-p</sub>		-109	-130	mV <sub>0-p</sub>
Input dead band *1	V <sub>NSDPG</sub>		Comparator level = 600mV <sub>0-p</sub> , 200mV <sub>0-p</sub>	113	142		mV <sub>0-p</sub>
			Comparator level = 400mV <sub>0-p</sub> , 100mV <sub>0-p</sub>	70	90		mV <sub>0-p</sub>
			Comparator level = -600mV <sub>0-p</sub> , -200mV <sub>0-p</sub>	-120	-150		mV <sub>0-p</sub>
			Comparator level = -400mV <sub>0-p</sub> , -100mV <sub>0-p</sub>	-80	-103		mV <sub>0-p</sub>
Input resistance	R <sub>INDPG</sub>		Charge switch OFF DPG = +0.2V	24.0	44.5		kΩ
Charge switch ON resistance	R <sub>CDPG</sub>	Charge switch ON DPG = +0.5V		450	860	Ω	
Input amplitude (peak value) *1	V <sub>PKDPG</sub>				±2.4	V	

\*1) When the signal is input with the AC coupling capacitor (47μF) connected to DPG pin.

\*2) The result after measuring the output waveform of amplifier internal low-pass filter or voltage value.

**(8) CTL write circuit characteristics**

(Ta = -20 to +75°C, VDD = AMPVDD = 5.0V, Vss = AMPVss = 0V reference)

Item	Symbol	Pins	Conditions	Min.	Typ.	Max.	Unit
Output resistance	ROH	RECCAP	RECCAP = AMPVDD - 0.5V	450	625	1005	Ω
	ROL		RECCAP = AMPVDD + 0.5V	410	555	840	Ω
Output current *1	IOREC	RECCTL (+) RECCTL (-)	Write current = 2.0mA	1.3	2.0	2.9	mA
			Write current = 2.5mA	1.7	2.5	3.7	mA
			Write current = 3.0mA	2.1	3.1	4.5	mA
			Write current = 3.5mA	2.6	3.6	5.2	mA
			Write current = 4.0mA	2.9	4.0	5.9	mA
			Write current = 4.5mA	3.3	4.6	6.6	mA
			Write current = 5.0mA	3.7	5.1	7.2	mA
			Write current = 5.5mA	4.0	5.6	8.0	mA
Write current = 6.0mA	4.4	6.1	8.9	mA			

\*1) The current value which flows when RECCTL (+) pin and RECCTL (-) pin are shorted.

**(9) Amplifier operating current characteristics**

(Ta = -20 to +75°C, VDD = AMPVDD = 5.0V, Vss = AMPVss = 0V reference)

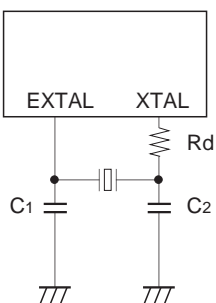
Item	Symbol	Pins	Conditions	Min.	Typ.	Max.	Unit
Amplifier operating current	IAMP	AMPVDD	When the amplifier is operating *1		7.6	12.0	mA
			When the amplifier is not operating			10	μA

\*1) The CTL recording current is added during CTL write.

**Note)** The amplifier operation and NOT-operation is controlled according to the contents of amplifier power supply control register (ASWC: 05E2H) bits 5, 4, 1 and 0.

Supplement

Fig. 8. Recommended oscillation circuit



Manufacturer	Model	fc (MHz)	C1 (pF)	C2 (pF)	Rd ( $\Omega$ )
RIVER ELETEC CO., LTD.	HC-49/U03	8.00	10	10	0
		10.00	5	5	
		12.00			
		16.00			
KINSEKI LTD.	HC-49/U (-S)	8.00	16 (12)	16 (12)	0
		10.00	16 (12)	16 (12)	
		12.00	12	12	
		16.00	12	12	

Mask option table

Item	Content	
	Reset pin pull-up resistor	Non-existent
Input circuit format*1	CMOS schmitt	TTL schmitt

\*1) The input circuit format can be selected for PE3/SYNC pin.

Characteristics Curve

