QUAD PLL FIELD PROGRAMMABLE VERSACLOCK SYNTHESIZER ICS348

Description

The ICS348 field programmable clock synthesizer generates up to 9 high-quality, high-frequency clock outputs including multiple reference clocks from a low frequency crystal or clock input. The ICS348 has 4 independent on-chip PLLs and is designed to replace crystals and crystal oscillators in most electronic systems.

Using IDT's VersaClock™ software to configure PLLs and outputs, the ICS348 contains a One-Time Programmable (OTP) ROM to allow field programmability. Programming features include eight selectable configuration registers, up to two sets of four low-skew outputs.

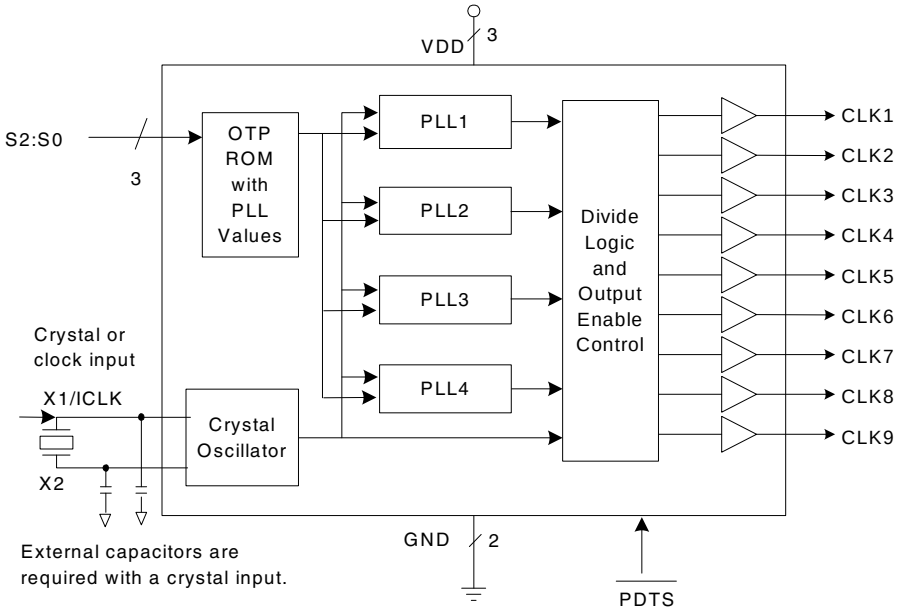
Using Phase-Locked Loop (PLL) techniques, the device runs from a standard fundamental mode, inexpensive crystal, or clock. It can replace multiple crystals and oscillators, saving board space and cost.

The ICS348 is also available in factory programmed custom versions for high-volume applications.

Features

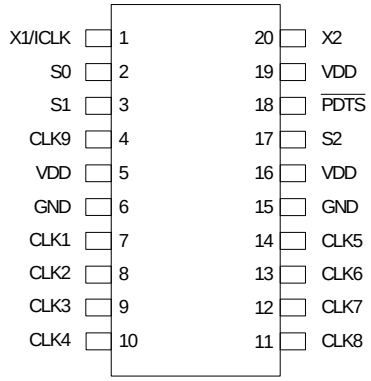
- Packaged as 20-pin SSOP (QSOP) (Pb-free)
- Eight addressable registers
- Replaces multiple crystals and oscillators
- Output frequencies up to 200 MHz at 3.3V
- Input crystal frequency of 5 to 27 MHz
- Input clock frequency of 2 to 50 MHz
- Up to nine reference outputs
- Up to two sets of four low-skew outputs
- Operating voltages of 3.3 V
- Advanced, low power CMOS process
- For one output clock, use the ICS341 (8-pin). For two output clocks, use the ICS342 (8-pin). For three output clocks, use the ICS343 (8-pin). For more than three outputs, use the ICS345 or ICS348.

Block Diagram



© 2019 Renesas Electronics Corporation

Pin Assignment



20-pin (150 mil) SSOP (QSOP)

Pin Descriptions

Pin Number	Pin Name	Pin Type	Pin Description
1	X1	XI	Crystal Input. Connect this pin to a crystal or external input clock.
2	S0	Input	Select pin 0. Internal pull-up resistor.
3	S1	Input	Select pin 1. Internal pull-up resistor.
4	CLK9	Output	Output clock 9. Weak internal pull-down when tri-state.
5	VDD	Power	Connect to +3.3 V.
6	GND	Power	Connect to ground.
7	CLK1	Output	Output clock 1. Weak internal pull-down when tri-state.
8	CLK2	Output	Output clock 2. Weak internal pull-down when tri-state.
9	CLK3	Output	Output clock 3. Weak internal pull-down when tri-state.
10	CLK4	Output	Output clock 4. Weak internal pull-down when tri-state.
11	CLK8	Output	Output clock 8. Weak internal pull-down when tri-state.
12	CLK7	Output	Output clock 7. Weak internal pull-down when tri-state.
13	CLK6	Output	Output clock 6. Weak internal pull-down when tri-state.
14	CLK5	Output	Output clock 5. Weak internal pull-down when tri-state.
15	GND	Power	Connect to ground.
16	VDD	Power	Connect to +3.3 V.
17	S2	Input	Select pin 2. Internal pull-up resistor.
18	$\overline{\text{PDTS}}$	Input	Power down tri-state. Powers down entire chip and tri-states clock outputs when low. Internal pull-up resistor.
19	VDD	Power	Connect to +3.3 V.
20	X2	XO	Crystal Output. Connect this pin to a fundamental crystal. Float for clock input.

© 2019 Renesas Electronics Corporation

External Components

Series Termination Resistor

Clock output traces over one inch should use series termination. To series terminate a 50Ω trace (a commonly used trace impedance), place a 33Ω resistor in series with the clock line, as close to the clock output pin as possible. The nominal impedance of the clock output is 20Ω.

Decoupling Capacitors

As with any high-performance mixed-signal IC, the ICS348 must be isolated from system power supply noise to perform optimally.

Decoupling capacitors of 0.01µF must be connected between each VDD and the PCB ground plane.

Crystal Load Capacitors

The device crystal connections should include pads for small capacitors from X1 to ground and from X2 to ground. These capacitors are used to adjust the stray capacitance of the board to match the nominally required crystal load capacitance. Because load capacitance can only be increased in this trimming process, it is important to keep stray capacitance to a minimum by using very short PCB traces (and no vias) between the crystal and device. Crystal capacitors must be connected from each of the pins X1 and X2 to ground.

The value (in pF) of these crystal caps should equal (C_L -6 pF)*2. In this equation, C_L= crystal load capacitance in pF. Example: For a crystal with a 16 pF load capacitance, each crystal capacitor would be 20 pF [(16-6) x 2] = 20.

PCB Layout Recommendations

For optimum device performance and lowest output phase noise, the following guidelines should be observed.

1) Each 0.01µF decoupling capacitor should be mounted on the component side of the board as close to the VDD pin as possible. No vias should be used between decoupling capacitor and VDD pin. The PCB trace to VDD pin should be kept as short as possible, as should the PCB trace to the ground via.

2) The external crystal should be mounted just next to the device with short traces. The X1 and X2 traces should not be routed next to each other with minimum spaces, instead they should be separated and away from other traces.

3) To minimize EMI, the 33Ω series termination resistor, if needed, should be placed close to the clock output.

4) An optimum layout is one with all components on the same side of the board, minimizing vias through other signal layers.

ICS348 Configuration Capabilities

The architecture of the ICS348 allows the user to easily configure the device to a wide range of output frequencies, for a given input reference frequency.

The frequency multiplier PLL provides a high degree of precision. The M/N values (the multiplier/divide values available to generate the target VCO frequency) can be set within the range of M = 1 to 2048 and N = 1 to 1024.

The ICS348 also provides separate output divide values, from 2 through 20, to allow the two output clock banks to support widely differing frequency values from the same PLL.

Each output frequency can be represented as:

$$OutputFreq = \frac{REFFreq}{OutputDivide} \cdot \frac{M}{N}$$

IDT VersaClock Software

IDT applies years of PLL optimization experience into a user friendly software that accepts the user's target reference clock and output frequencies and generates the lowest jitter, lowest power configuration, with only a press of a button. The user does not need to have prior PLL experience or determine the optimal VCO frequency to support multiple output frequencies.

VersaClock software quickly evaluates accessible VCO frequencies with available output divide values and provides an easy to understand, bar code rating for the target output frequencies. The user may evaluate output accuracy, performance trade-off scenarios in seconds.

Using VersaClock Products with an Input Clock Source

In order to ensure proper startup with an input clock rather than a crystal, the supply voltage must be within the operating range (3.3V ±10%) and the input signal must be stable and free from glitching. The input clock must provide pulses of at least 20ns, and no more than 500ns, for at least 160 clock cycles without any interruptions to the clock or power during this period. It may take up to 4ms for output frequencies to reach their target frequency values.

An alternative method is to have the $\overline{PDTS}$ pin asserted low while power supplies and clock sources stabilize.Once the power supply and input clock source are constant and within the acceptable frequency range, bring $\overline{PDTS}$ high. This approach is preferred if the clock source is derived from another PLL, or the source oscillator produces unpredictable output pulses prior to stabilization. No considerations need to be taken when using a crystal input source with VersaClock products.

© 2019 Renesas Electronics Corporation

Absolute Maximum Ratings

Stresses above the ratings listed below can cause permanent damage to the ICS348. These ratings, which are standard values for IDT commercially rated parts, are stress ratings only. Functional operation of the device at these or any other conditions above those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods can affect product reliability. Electrical parameters are guaranteed only over the recommended operating temperature range.

Parameter	Condition	Min.	Typ.	Max.	Units
Supply Voltage, VDD	Referenced to GND			7	V
Inputs	Referenced to GND	-0.5		VDD+0.5	V
Clock Outputs	Referenced to GND	-0.5		VDD+0.5	V
Storage Temperature		-65		150	°C
Soldering Temperature	Max 10 seconds			260	°C
Junction Temperature				125	°C

Recommended Operation Conditions

Parameter	Min.	Typ.	Max.	Units
Ambient Operating Temperature (ICS348RP)	0		+70	°C
Ambient Operating Temperature (ICS348RIP)	-40		+85	°C
Power Supply Voltage (measured in respect to GND)	+3.15	+3.3	+3.45	V
Power Supply Ramp Time			4	ms

© 2019 Renesas Electronics Corporation

DC Electrical Characteristics

Unless stated otherwise, **VDD = 3.3 V ±5%**, Ambient Temperature -40 to +85°C

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Operating Voltage	VDD		3.15		3.45	V
Operating Supply Current Input High Voltage	IDD	Configuration Dependent - See VersaClock™ Estimates				mA
		Nine 33.3333 MHz outs, $\overline{PDTS}$ = 1, no load, Note 1		23		mA
		$\overline{PDTS}$ = 0, no load		20		µA
Input High Voltage	V_{IH}	S2:S0	2			V
Input Low Voltage	V_{IL}	S2:S0			0.4	V
Input High Voltage, $\overline{PDTS}$	V_{IH}		VDD-0.5			V
Input Low Voltage, $\overline{PDTS}$	V_{IL}				0.4	V
Input High Voltage	V_{IH}	ICLK	VDD/2+1			V
Input Low Voltage	V_{IL}	ICLK			VDD/2-1	V
Output High Voltage (CMOS High)	V_{OH}	I_{OH} = -4 mA	VDD-0.4			V
Output High Voltage	V_{OH}	I_{OH} = -12 mA	2.4			V
Output Low Voltage	V_{OL}	I_{OL} = 12mA			0.4	V
Short Circuit Current	I_{OS}			±70		mA
Nominal Output Impedance	Z_O			20		Ω
Internal pull-up resistor	R_{PUS}	S2:S0, $\overline{PDTS}$		250		kΩ
Internal pull-down resistor	R_{PD}	CLK outputs		525		kΩ
Input Capacitance	C_{IN}	Inputs		4		pF

Note 1: Example with 25 MHz crystal input with nine outputs of 33.$\overline{3}$ MHz, no load, and VDD = 3.3 V.

© 2019 Renesas Electronics Corporation

AC Electrical Characteristics

Unless stated otherwise, **VDD = 3.3 V ±5%**, Ambient Temperature -40 to +85° C

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Input Frequency	F_{IN}	Fundamental Crystal	5		27	MHz
		Input Clock	2		50	MHz
Output Frequency		VDD=3.3 V	0.25		200	MHz
Output Rise Time	t_{OR}	20% to 80%, Note 1		1		ns
Output Fall Time	t_{OF}	80% to 20%, Note 1		1		ns
Duty Cycle		Note 2	40	49-51	60	%
Output Frequency Synthesis Error		Configuration Dependent		TBD		ppm
Power-up time		PLL lock-time from power-up, Note 3		3	10	ms
		$\overline{PDTS}$ goes high until stable CLK output, Note 3		0.2	2	ms
One Sigma Clock Period Jitter		Configuration Dependent		50		ps
Maximum Absolute Jitter	t_{ja}	Deviation from Mean. Configuration Dependent		±200		ps
Pin-to-Pin Skew		Low Skew Outputs	-250		250	ps

Note 1: Measured with 15 pF load.

Note 2: Duty Cycle is configuration dependent. Most configurations are minimum 45% and maximum 55%.

Note 3: IDT test mode output occurs for first 170 clock cycles on CLK7 for each PLL powered up. $\overline{PDTS}$ transition high on select address change.

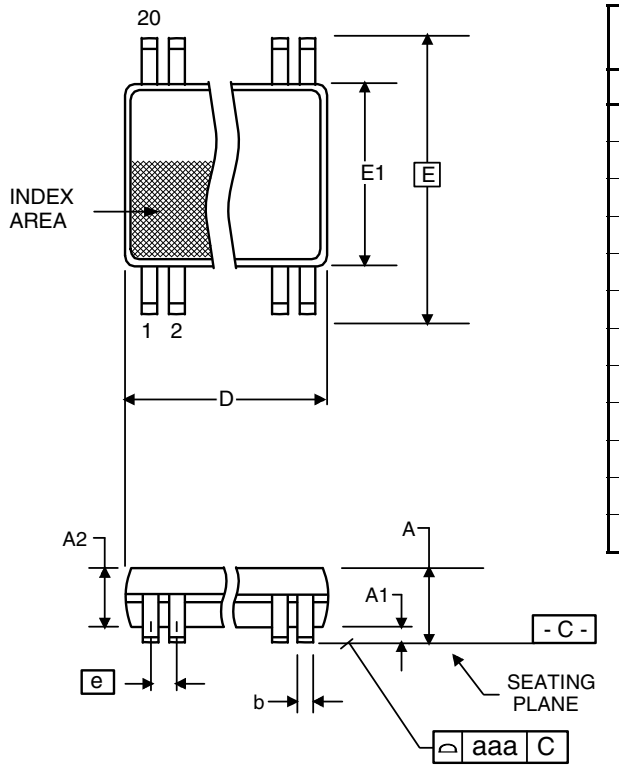
Thermal Characteristics

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Thermal Resistance Junction to Ambient	θ_{JA}	Still air		135		°C/W
	θ_{JA}	1 m/s air flow		93		°C/W
	θ_{JA}	3 m/s air flow		78		°C/W
Thermal Resistance Junction to Case	θ_{JC}			60		°C/W

© 2019 Renesas Electronics Corporation

Package Outline and Package Dimensions (20-pin SSOP, 150 Mil. Wide Body)

Package dimensions are kept current with JEDEC Publication No. 95



	Millimeters		Inches	
Symbol	Min	Max	Min	Max
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
A2	--	1.50	--	0.059
b	0.20	0.30	0.008	0.012
c	0.18	0.25	0.007	0.010
D	8.55	8.75	0.337	0.344
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	.635 Basic		.025 Basic	
L	0.40	1.27	0.016	0.050
α	0°	8°	0°	8°
aaa	--	0.10	--	0.004

Ordering Information

Part / Order Number	Marking	Shipping Packaging	Package	Temperature
348RPLF	ICS348RPLF	Tubes	20-pin SSOP	0 to +70° C
348RPLFT	ICS348RPLF	Tape and Reel	20-pin SSOP	0 to +70° C
348RIPLF	ICS348RIPLF	Tubes	20-pin SSOP	-40 to +85° C
348RIPLFT	ICS348RIPLF	Tape and Reel	20-pin SSOP	-40 to +85° C
348R-XXLF	348R-XXLF	Tubes	20-pin SSOP	0 to +70° C
348R-XXLFT	348R-XXLF	Tape and Reel	20-pin SSOP	0 to +70° C
348RI-XXLF	348RI-XXLF	Tubes	20-pin SSOP	-40 to +85° C
348RI-XXLFT	348RI-XXLF	Tape and Reel	20-pin SSOP	-40 to +85° C

"LF" suffix to the part number denotes Pb-Free configuration, RoHS compliant.

The 348R-XXLF and 348RI-XXLF are factory programmed versions of the 348RPLF and 348RIPLF. A unique "-XX" suffix is assigned by the factory for each custom configuration, and a separate data sheet is kept on file. For more information on custom part numbers programmed at the factory, please contact your local IDT sales and marketing representative.

While the information presented herein has been checked for both accuracy and reliability, IDT assumes no responsibility for either its use or for the infringement of any patents or other rights of third parties, which would result from its use. No other circuits, patents, or licenses are implied. This product is intended for use in normal commercial applications. Any other applications such as those requiring extended temperature range, high reliability, or other extraordinary environmental requirements are not recommended without additional processing by IDT. IDT reserves the right to change any circuitry or specifications without notice. IDT does not authorize or warrant any IDT product for use in life support devices or critical medical instruments.

© 2019 Renesas Electronics Corporation

Revision History

Rev.	Date	Originator	Description of Change
N	09/06/13	S. Zheng	Added brief applications section/verbiage “Using VersaClock Products with an Input Clock Source” on page 3.

© 2019 Renesas Electronics Corporation

IMPORTANT NOTICE AND DISCLAIMER

RENESAS ELECTRONICS CORPORATION AND ITS SUBSIDIARIES (“RENESAS”) PROVIDES TECHNICAL SPECIFICATIONS AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION, ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for developers skilled in the art designing with Renesas products. You are solely responsible for (1) selecting the appropriate products for your application, (2) designing, validating, and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. Renesas grants you permission to use these resources only for development of an application that uses Renesas products. Other reproduction or use of these resources is strictly prohibited. No license is granted to any other Renesas intellectual property or to any third party intellectual property. Renesas disclaims responsibility for, and you will fully indemnify Renesas and its representatives against, any claims, damages, costs, losses, or liabilities arising out of your use of these resources. Renesas' products are provided only subject to Renesas' Terms and Conditions of Sale or other applicable terms agreed to in writing. No use of any Renesas resources expands or otherwise alters any applicable warranties or warranty disclaimers for these products.

(Rev.1.0 Mar 2020)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Contact Information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:
www.renesas.com/contact/

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.

© 2020 Renesas Electronics Corporation. All rights reserved.