Description

The ICS309 is a versatile serially programmable, triple PLL with spread spectrum clock source. The ICS309 can generate any frequency from 250kHz to 200 MHz, and up to 6 different output frequencies simultaneously. The outputs can be reprogrammed on the fly, and will lock to a new frequency in 10 ms or less.

To reduce system EMI emissions, spread spectrum is available that supports modulation frequencies of 31 kHz and 120 kHz, as well as modulation amplitudes of +/-0.25% to +/-2.0%. Both center- and down-spread options are available.

The device includes a $\overline{\text{PDTS}}$ pin which tri-states the output clocks and powers down the entire chip.

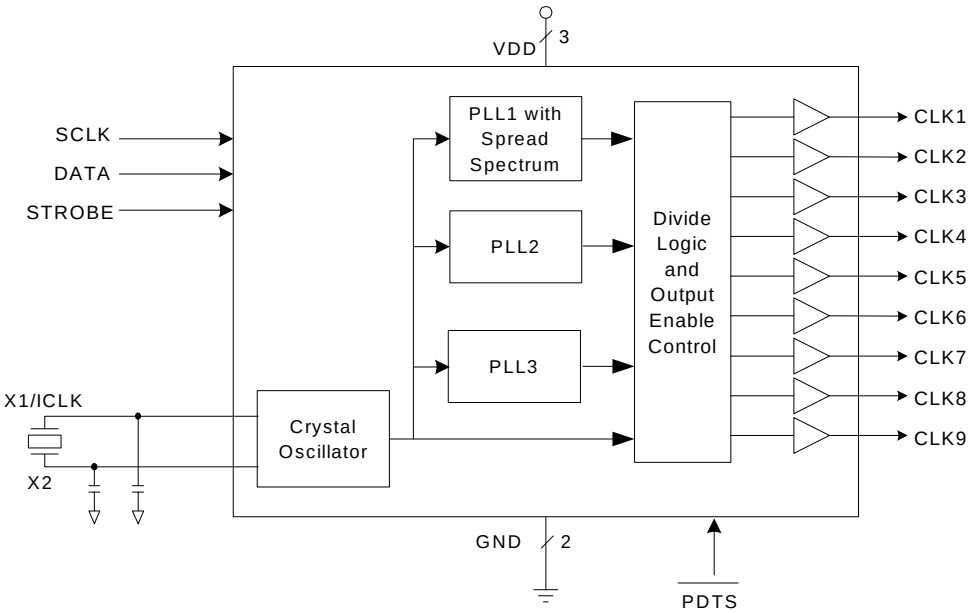
The ICS309 default for non-programmed start-up are buffered reference clock outputs on all clock output pins.

ICS' VersaClock™ programming software allows the user to configure up to 9 outputs with target frequencies, spread spectrum capabilities or buffered reference clock outputs. The VersaClock™ software automatically configures the PLLs for optimal overall performance.

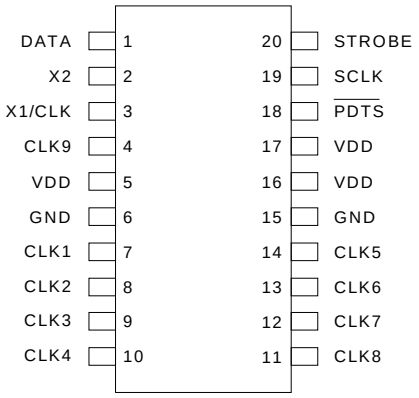
Features

- Packaged in 20 pin SSOP (QSOP)
- Highly accurate frequency generation
  - M/N Multiplier PLL: M = 1..2048, N = 1..1024
- Serially programmable: user determines the output frequency via a 3 wire interface
- Spread Spectrum frequency modulation for reduced system EMI
  - Center or Down Spread up to 4% total
  - Selectable 32kHz and 120kHz modulation
- Eliminates need for custom quartz oscillators
- Input crystal frequency of 5 - 27 MHz
  - Optional programmable on-chip crystal capacitors
- Output clock frequencies up to 200 MHz
- Operating voltage of 3.3 V
- Up to 9 reference clock outputs

Block Diagram



Pin Assignment



20 pin (150 mil) SSOP (QSOP)

Pin Descriptions

Pin Number	Pin Name	Pin Type	Pin Description
1	DATA	Input	Serial data input.
2	X2	XO	Input crystal connection. Leave unconnected for clock input.
3	X1/CLK	XI	Crystal connection (REF frequency). Connect to a parallel resonant crystal or an input clock.
4	CLK9	Output	Output clock 9. Default of Reference frequency output when unprogrammed.
5	VDD	Power	Connect to +3.3V.
6	GND	Power	Connect to Ground.
7	CLK1	Output	Output clock 1. Default of Reference frequency output when unprogrammed.
8	CLK2	Output	Output clock 2. Default of Reference frequency output when unprogrammed.
9	CLK3	Output	Output clock 3. Default of Reference frequency output when unprogrammed.
10	CLK4	Output	Output clock 4. Default of Reference frequency output when unprogrammed.
11	CLK8	Output	Output clock 8. Default of Reference frequency output when unprogrammed.
12	CLK7	Output	Output clock 7. Default of Reference frequency output when unprogrammed.
13	CLK6	Output	Output clock 6. Default of Reference frequency output when unprogrammed.
14	CLK5	Output	Output clock 5. Default of Reference frequency output when unprogrammed.
15	GND	Power	Connect to Ground.
16	VDD	Power	Connect to +3.3V.
17	VDD	Power	Connect to +3.3V.
18	$\overline{\text{PDTS}}$	Input	Powers down entire chip, tri-states all outputs when low. Internal pull-up.
19	SCLK	Input	Serial Shift register clock. See timing diagram.
20	STROBE	Input	Strobe to load data. See timing diagram.

Configuring the ICS309

Initial State: The ICS309 may be configured to have up to 9 frequency outputs, utilizing the 4 on-board PLLs and spread spectrum circuitry. Unprogrammed, the part has the following outputs, related to the reference input clock:

Default Outputs	
Output	**Frequency**
Clock 1 (Pin 7)	Reference Output
Clock 2 (Pin 8)	Reference Output
Clock 3 (Pin 9)	Reference Output
Clock 4 (Pin 10)	Reference Output
Clock 5 (Pin 14)	Reference Output
Clock 6 (Pin 13)	Reference Output
Clock 7 (Pin 12)	Reference Output
Clock 8 (Pin 11)	Reference Output
Clock 9 (Pin 4)	Reference Output

The input crystal range for the ICS309 is 5MHz to 27MHz.

The ICS309 can be programmed to set the output functions and frequencies. 160 data bits generated by the VersaClock^{TM} software are written in DATA pin in this order: MSB (left most bit) first.

As show in Figure 2, after these 160 bits are clocked into the ICS309, taking STROBE high will send this data to the internal hatch and the CLK output will lock within 10 ms.

Note: If STROBE is in the high state and SCLK is pulsed, DATA is clocked directly to the internal latch and the output conditions will change accordingly. Although this will not damage the ICS309, it is recommended that STROBE be kept low while DATA is being clocked into the ICS309 in order to avoid unintended changes on the output clocks.

All outputs may be turned off during initialization by bringing the $\overline{\text{PDTS}}$ pin to Ground. When $\overline{\text{PDTS}}$ is brought high, after the Strobe pin in brought high, the programmed output frequencies will be available.

AC Parameters for Writing to the ICS309

Parameter	Condition	Min.	Max.	Units
t_{SETUP}	Setup time	10		ns
t_{HOLD}	Hold time after SCLK	10		ns
t_W	Data wait time	10		ns
t_S	Strobe pulse width	40		ns
	SCLK Frequency		30	MHz

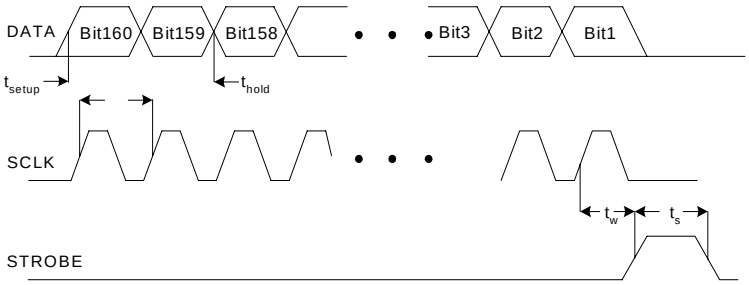


Figure 2. Timing Diagram for Programming the ICS309

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 ICS309 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) been 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 -6pF)*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.

Optional on-chip capacitors may be programmed for crystals with 18 pF load capacitance.

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 each clock output.

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

ICS309 Configuration Capabilities

The architecture of the ICS309 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 ICS309 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:

Output Freq. = (Ref. Freq)*(M/N)/Output Divide

ICS VersaClock Software

ICS 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.

Spread Spectrum Modulation

The ICS309 utilizes frequency modulation (FM) to distribute energy over a range of frequencies. By modulating the output clock frequencies, the device effectively lowers energy across a broader range of frequencies; thus, lowering a system's electro-magnetic interference (EMI). The modulation rate is the time from transitioning from a minimum frequency to a maximum frequency and then back to the minimum.

Spread Spectrum Modulation can be applied as either "center spread" or "down spread". During center spread modulation, the deviation from the target frequency is equal in the positive and negative directions. The effective average frequency is equal to the target frequency. In applications where the clock is driving a component with a maximum frequency rating, down spread should be applied. In this case, the maximum frequency, including modulation, is the target frequency. The effective average frequency is less than the target frequency.

The ICS309 operates in both center spread and down spread modes. For center spread, the frequency can be modulated between +/- 0.125% to +/-2.0%. For down spread, the frequency can be modulated between -0.25% to -4.0%.

Both output frequency banks will utilize identical spread spectrum percentage deviations and modulation rates, if a common VCO frequency can be identified.

Spread Spectrum Modulation Rate

The spread spectrum modulation frequency applied to the output clock frequency may occur at a variety of rates. For applications requiring the driving of "down-circuit" PLLs, Zero Delay Buffers, or those adhering to PCI standards, the spread spectrum modulation rate should be set to 30-33kHz. For other applications, a 120kHz modulation option is available.

Absolute Maximum Ratings

Stresses above the ratings listed below can cause permanent damage to the ICS309. These ratings, which are standard values for ICS 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

Recommended Operation Conditions

Parameter	Min.	Typ.	Max.	Units
Ambient Operating Temperature	0		+70	°C
Power Supply Voltage (measured in respect to GND)	+3.00		+3.60	V

DC Electrical Characteristics

VDD=3.3V +/-10%, Ambient temperature 0 to +70°C, unless stated otherwise

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Operating Voltage	VDD		3.00		3.60	V
Operating Supply Current Input High Voltage	IDD	Configuration Dependent - See VersaClock™ Estimates				mA
		Ex. 25 MHz crystal, VDD=3.3V, No load, 9 reference clocks out, $\overline{PDTS}$ = 1		6		mA
		Ex. 25 MHz crystal, VDD=3.3V, No load, 9 - 33.3333 MHz outs, $\overline{PDTS}$ = 1		25		mA
		$\overline{PDTS}$ = 0		20		µA
Input High Voltage	V_{IH}	X1/ICLK only	(VDD/2)+1			V
Input Low Voltage	V_{IL}	X1/ICLK only			(VDD/2)-1	V
Input High Voltage	V_{IH}		VDD-0.5			V
Input Low Voltage	V_{IL}	$\overline{PDTS}$, SCLK, DATA, STROBE			0.8	V

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Output High Voltage	V_{OH}	I_{OH} = -8 mA	2.4			V
Output Low Voltage	V_{OL}	I_{OL} = 8 mA			0.4	V
Output High Voltage, CMOS level	V_{OH}	I_{OH} = -4 mA	VDD-0.4			V
Short Circuit Current		CLK outputs		±70		mA
Input Capacitance	C_{IN}	$\overline{PDTS}$ pin		4		pF
Internal pull-down resistor	R_{PD}	CLK outputs		525		kΩ
Internal Pull-up Resistor	R_{PU}	$\overline{PDTS}$ pin		250		kΩ

AC Electrical Characteristics

VDD = 3.3V +/-10%, Ambient Temperature 0 to +70° C, unless stated otherwise

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Input Frequency	F_{IN}	Fundamental crystal	5		27	MHz
		Input Clock	2		50	MHz
Output Frequency		VDD=3.3V	0.25		200	MHz
Output Clock Rise Time	t_{OR}	0.8 to 2.0 V, Note 1		0.8		ns
Output Clock Fall Time	t_{OF}	2.0 to 8.0 V, Note 1		0.8		ns
Output Clock Duty Cycle			45	49-51	55	%
Power-up time		STROBE goes high until stable CLK out		3	10	ms
		$\overline{PDTS}$ goes high until stable CLK out		8	20	ms
Maximum Output Jitter, short term	t_j	Reference Clock		±300		ps
Maximum Output Jitter, short term	t_j	All other clocks, C_L=15pF Configuration dependent		±200		ps

Note 1: Measured with 15 pF load.

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

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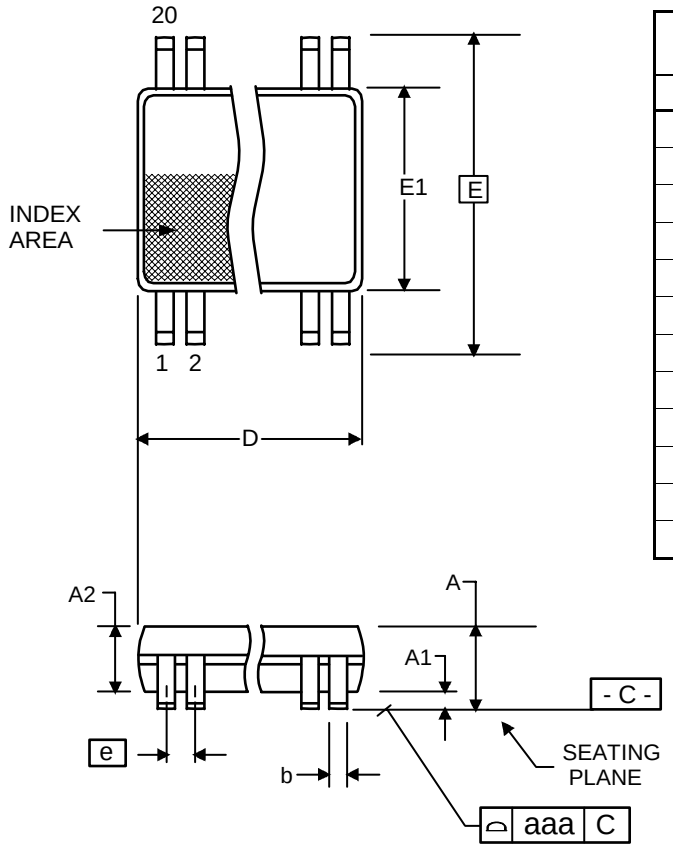
Package Outline and Package Dimensions (20 pin SSOP, 150 Mil. Wide Body)

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
ICS309R	ICS308R (top line) YYWW (2nd line)	Tubes	20 pin SSOP	0 to +70° C
ICS309R-T		Tape and Reel	20 pin SSOP	0 to +70° C