# FIELD PROGRAMMABLE DUAL OUTPUT SS VERSACLOCK SYNTHESIZER ICS252

## Description

The ICS252 is a low cost, dual-output, field programmable clock synthesizer. The ICS252 can generate two output frequencies from 314 kHz to 200 MHz using up to two independently configurable PLLs. The outputs may employ Spread Spectrum techniques to reduce system electro-magnetic interference (EMI).

Using IDT's VersaClock™ software to configure the PLL and output, the ICS252 contains a One-Time Programmable (OTP) ROM to allow field programmability. Programming features include 2 selectable configuration registers.

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

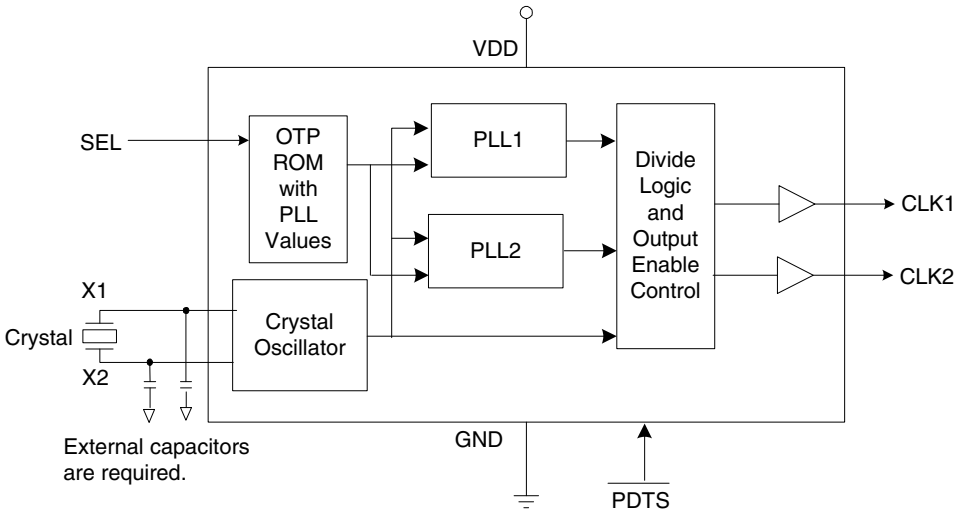
The device also has a power-down feature that tri-states the clock outputs and turns off the PLLs when the $\overline{\text{PDTS}}$ pin is taken low.

The ICS252 is also available in factory programmed custom versions for high-volume applications.

## Features

- 8-pin SOIC package – Pb-free, RoHS compliant
- Two addressable registers
- Input crystal frequency of 5 to 27 MHz
- Clock input frequency of 3 to 150 MHz
- Output clock frequencies up to 200 MHz
- Configurable Spread Spectrum Modulation
- Operating voltage of 3.3 V
- Replaces multiple crystals and oscillators
- Controllable output drive levels
- Advanced, low-power CMOS process

## Block Diagram





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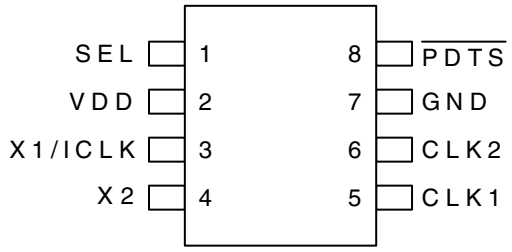
## Pin Assignment




8-pin (150 mil) SOIC

## Output Clock Selection Table

| SEL | CLK1 (MHz) | CLK2 (MHz) | Spread Percentage |
|---|---|---|---|
| 0 | User Configurable | User Configurable | User Configurable |
| 1 | User Configurable | User Configurable | User Configurable |

## Pin Descriptions

| Pin Number | Pin Name | Pin Type | Pin Description |
|---|---|---|---|
| 1 | SEL | Input | Select pin for frequency selection on CLK1 and CLK2. Internal pull-up resistor. |
| 2 | VDD | Power | Connect to +3.3 V. |
| 3 | X1/ICLK | XI | Connect this pin to a crystal or external clock input. |
| 4 | X2 | XO | Connect this pin to a crystal, or float for clock input. |
| 5 | CLK1 | Output | Clock1 output. Weak internal pull-down, low when power down. |
| 6 | CLK2 | Output | Clock2 output. Weak internal pull-down, low when power down. |
| 7 | GND | Power | Connect this to ground. |
| 8 | $\overline{PDTS}$ | Input | Powers down entire chip. Tri-states CLK outputs when low. No internal pull-up resistor. The pin must be tied either directly or through the external resistor to VDD ro GND. External resistor value must be less than 15kOhm. |

## External Components

The ICS252 requires a minimum number of external components for proper operation.

### 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 Capacitor

As with any high-performance mixed-signal IC, the ICS252 must be isolated from system power supply noise to perform optimally.

A decoupling capacitor of 0.01µF must be connected between 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].



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## PCB Layout Recommendations

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

1) The 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 the 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. Distance of the ferrite bead and bulk decoupling from the device is less critical.

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. Other signal traces should be routed away from the ICS252. This includes signal traces just underneath the device, or on layers adjacent to the ground plane layer used by the device.

## ICS252 Configuration Capabilities

The architecture of the ICS252 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 ICS252 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:

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

## Output Drive Control

The ICS252 has two output drive settings. Low drive should be selected when outputs are less than 100 MHz. High drive should be selected when outputs are greater than 100 MHz. (Consult the AC Electrical Characteristics for output rise and fall times for each drive option.)

## 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.

## Spread Spectrum Modulation

The ICS252 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 ICS252 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%.



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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 30-33 kHz. For other applications, a 120 kHz modulation option is available.

## Absolute Maximum Ratings

Stresses above the ratings listed below can cause permanent damage to the ICS252. 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 | -0.5 | | 4.6 | 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 (ICS252M) | 0 | | +70 | °C |
| Ambient Operating Temperature (ICS252MI) | -40 | | +85 | °C |
| Power Supply Voltage (measured in respect to GND) | +3.135 | +3.3 | +3.465 | V |
| Power Supply Ramp Time | | | 4 | ms |



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## 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 | | 3.135 | 3.3 | 3.465 | V |
| Operating Supply Current Input High Voltage | IDD | Configuration Dependent - See VersaClock™ | | | | mA |
| | | Two 33.3333 MHz output, $\overline{PDTS}$ = 1, no load Note 1 | | 16 | | mA |
| | | $\overline{PDTS}$ = 0 | | 500 | | µA |
| Input High Voltage | $V_{IH}$ | SEL | VDD/2+1 | | | V |
| Input Low Voltage | $V_{IL}$ | SEL | | | 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 | $V_{OH}$ | $I_{OH}$ = -8 mA (Low Drive); $I_{OH}$ = -12 mA (High Drive) | 2.4 VDD-0.4 | | | V |
| Output Low Voltage | $V_{OL}$ | $I_{OL}$ = 8 mA (Low Drive); $I_{OL}$ = 12 mA (High Drive) | | | 0.4 | V |
| Short Circuit Current | $I_{OS}$ | | | ±70 | | mA |
| Nominal Output Impedance | $Z_O$ | | | 20 | | Ω |
| Internal Pull-up Resistor | $R_{PUP}$ | SEL | | 120 | | kΩ |
| Internal Pull-down Resistor | $R_{PD}$ | Clock outputs CLK1 and CLK2 | | 120 | | kΩ |
| Input Capacitance | $C_{IN}$ | inputs | | 4 | | pF |

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



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## 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 | | 150 | MHz |
| Output Frequency | | | 0.314 | | 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 | % |
| Power-up Time | | PLL lock time from power-up | | 4 | 10 | ms |
| | | $\overline{PDTS}$ goes high until stable CLK output, Spread Spectrum Off | | .6 | 2 | ms |
| | | $\overline{PDTS}$ goes high until stable CLK output, Spread Spectrum On | | 4 | 7 | ms |
| | | $\overline{PDTS}$ goes high until spread spectrum is stable, Spread Spectrum On | | 10 | 50 | ms |
| One Sigma Clock Period Jitter | | Configuration Dependent | | 50 | | ps |
| Maximum Absolute Jitter | $t_{ja}$ | Deviation from Mean. Configuration Dependent | | ±200 | | ps |

Note 1: Measured with 15 pF load.

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

## Thermal Characteristics

| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Thermal Resistance Junction to Ambient | $\theta_{JA}$ | Still air | | 150 | | °C/W |
| | $\theta_{JA}$ | 1 m/s air flow | | 140 | | °C/W |
| | $\theta_{JA}$ | 3 m/s air flow | | 120 | | °C/W |
| Thermal Resistance Junction to Case | $\theta_{JC}$ | | | 40 | | °C/W |



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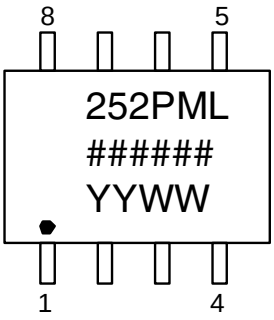
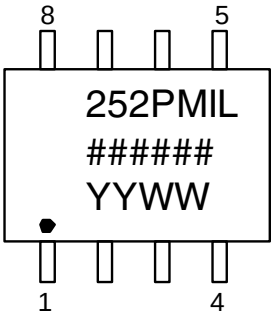
## Marking Diagram




Notes:

1. ###### is the lot number.
2. YYWW is the last two digits of the year and week that the part was assembled.
3. “I” denotes industrial temperature range (if applicable).
4. “L” denotes RoHS compliant package.
5. Bottom marking: country of origin.



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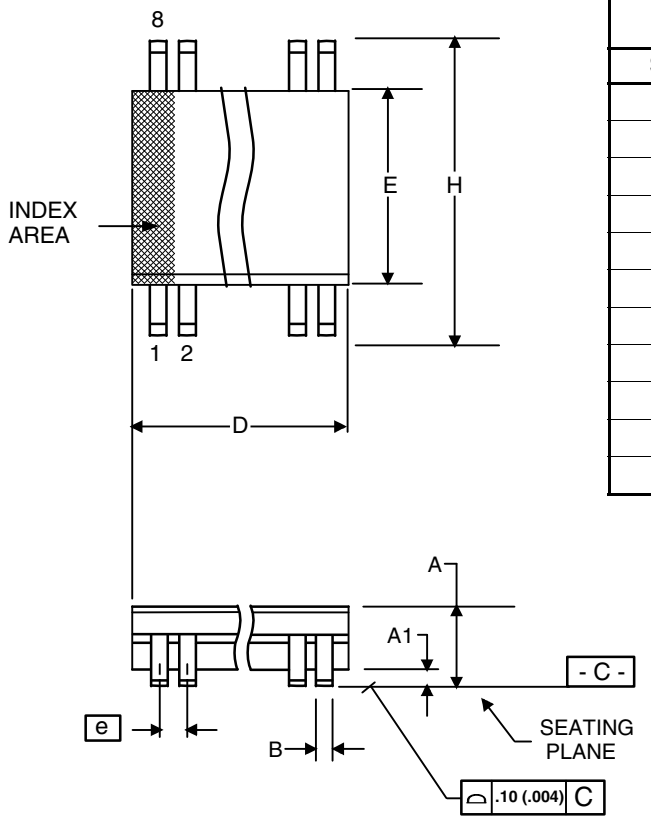
## Package Outline and Package Dimensions (8-pin SOIC, 150 Mil. Body)

Package dimensions are kept current with JEDEC Publication No. 95




| | Millimeters | | Inches | |
|---|---|---|---|---|
| **Symbol** | **Min** | **Max** | **Min** | **Max** |
| A | 1.35 | 1.75 | .0532 | .0688 |
| A1 | 0.10 | 0.25 | .0040 | .0098 |
| B | 0.33 | 0.51 | .013 | .020 |
| C | 0.19 | 0.25 | .0075 | .0098 |
| D | 4.80 | 5.00 | .1890 | .1968 |
| E | 3.80 | 4.00 | .1497 | .1574 |
| e | 1.27 BASIC | | 0.050 BASIC | |
| H | 5.80 | 6.20 | .2284 | .2440 |
| h | 0.25 | 0.50 | .010 | .020 |
| L | 0.40 | 1.27 | .016 | .050 |
| α | 0° | 8° | 0° | 8° |

## Ordering Information

| Part / Order Number | Marking | Shipping Packaging | Package | Temperature |
|---|---|---|---|---|
| 252PMLF | | Tubes | 8-pin SOIC | 0 to +70° C |
| 252PMILF | | Tubes | 8-pin SOIC | -40 to +85° C |
| 252M-XXLF | 252MXXL | Tubes | 8-pin SOIC | 0 to +70° C |
| 252MI-XXLF | 252MIXXL | Tubes | 8-pin SOIC | -40 to +85° C |
| 252M-XXLFT | 252MXXL | Tape and Reel | 8-pin SOIC | 0 to +70° C |
| 252MI-XXLFT | 252MIXXL | Tape and Reel | 8-pin SOIC | -40 to +85° C |

**"LF" suffix to the part number are the Pb-Free configuration and are RoHS compliant.**

**The 252M-XXLF and 252MI-XXLF are factory programmed versions of the 252PMLF and 252PMILF. 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.**

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## Revision History

| Rev. | Originator | Date | Description of Change |
|---|---|---|---|
| A | R.Willner | 04/08/05 | Preliminary release. |
| B | R.Willner | 01/16/06 | Corrected Block Diagram. Released from Prelim to Final. |
| C | R.Willner | 06/13/06 | Added "-XX" part ordering information and specific note pertaining to custom configurations of device. |
| D | R.Willner | 08/10/07 | Removed “Inernal pull-up resistor” info from PDTS pin description and added extrenal pull-up resistor statement/information. |
| E | R.Willner | 08/20/07 | Changed S1 pin name to “SEL”; removed references to PDTS pin; changed pull-up resistor value from 190 to 120 kOhms. |
| F | R.Willner | 03/16/09 | Correct page 1 text to have 2 selectable configuration registers. |
| G | — | 08/18/09 | Added EOL note per PDN U-09-01. |
| H | — | 05/13/10 | Removed EOL note and non-green orderables. |
| J | RDW | 05/20/10 | Changed max VDD Supply Voltage from 7V to 4.6V. |
| K | A.T. | 03/02/12 | Added PDTS#/spread spectrum condition and values to "Power-up Time" parameter |



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