

# LOW PHASE NOISE CLOCK MULTIPLIER

**ICS601-01**

## Description

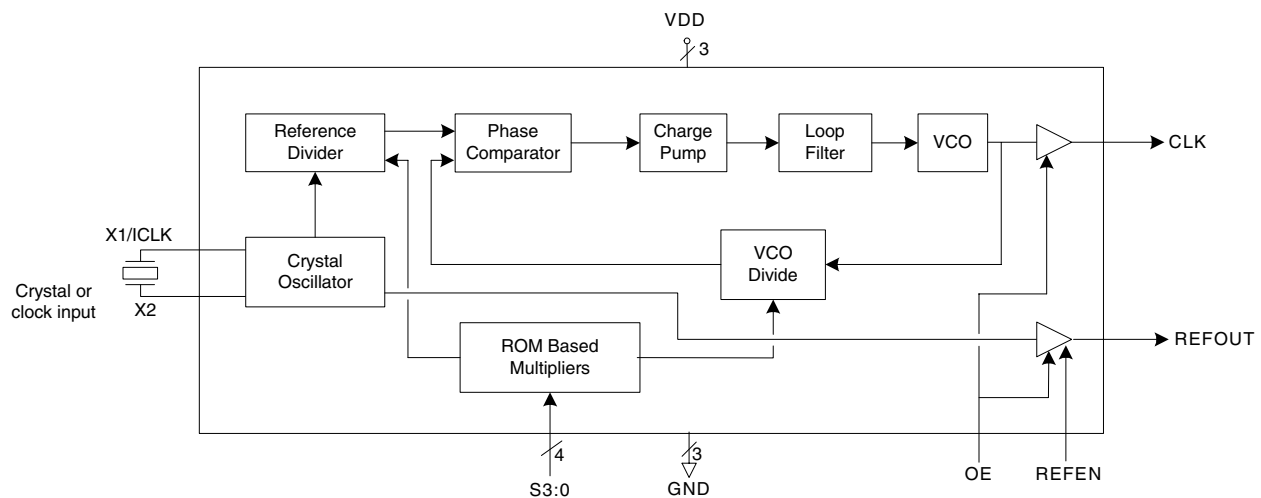
The ICS601-01 is a low-cost, low phase noise, high-performance clock synthesizer for applications which require low phase noise and low jitter. It is IDT's lowest phase noise multiplier, and also the lowest CMOS part in the industry. Using IDT's patented analog and digital Phase-Locked Loop (PLL) techniques, the chip accepts a 10 - 27 MHz crystal or clock input, and produces output clocks up to 156 MHz at 3.3 V.

This product is intended for clock generation. It has low output jitter (variation in the output period), but input to output skew and jitter are not defined nor guaranteed. For applications which require defined input to output timing, use the ICS670-01.

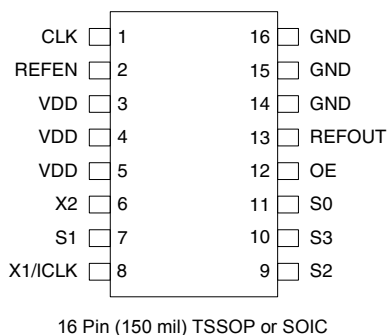
## Features

- Packaged in 16-pin SOIC or TSSOP
- Pb (lead) free package
- Uses fundamental 10 - 27 MHz crystal or clock
- Patented PLL with the lowest phase noise
- Output clocks up to 156 MHz at 3.3 V
- Low phase noise: -132 dBc/Hz at 10 kHz
- Low jitter - 18 ps one sigma typ.
- Full swing CMOS outputs with 25 mA drive capability at TTL levels
- Advanced, low power, sub-micron CMOS process
- Industrial temperature range available
- Operating voltage of 3.3V or 5V

## Block Diagram



## Pin Assignment



## Multiplier Select Table

| S3 | S2 | S1 | S0 | CLK (see note 2 on following page) |
|----|----|----|----|------------------------------------|
| 0  | 0  | 0  | 0  | TEST                               |
| 0  | 0  | 0  | 1  | TEST                               |
| 0  | 0  | 1  | 0  | Input x1                           |
| 0  | 0  | 1  | 1  | Input x3                           |
| 0  | 1  | 0  | 0  | Input x4                           |
| 0  | 1  | 0  | 1  | Input x5                           |
| 0  | 1  | 1  | 0  | Input x6                           |
| 0  | 1  | 1  | 1  | Input x8                           |
| 1  | 0  | 0  | 0  | TEST                               |
| 1  | 0  | 0  | 1  | Crystal osc. pass through (no PLL) |
| 1  | 0  | 1  | 0  | Input x2                           |
| 1  | 0  | 1  | 1  | TEST                               |
| 1  | 1  | 0  | 0  | Input x8                           |
| 1  | 1  | 0  | 1  | Input x10                          |
| 1  | 1  | 1  | 0  | Input x12                          |
| 1  | 1  | 1  | 1  | Input x16                          |

0 = connect directly to ground

1 = connect directly to VDD

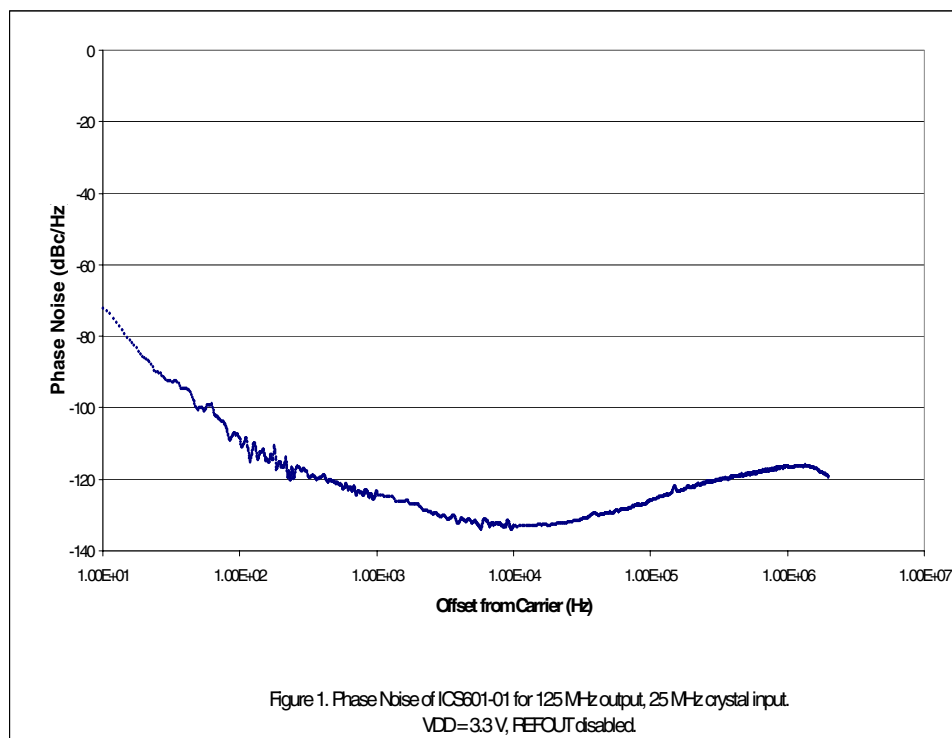
## Pin Descriptions

| Pin Number | Pin Name | Pin Type | Pin Description                                                                                                                 |
|------------|----------|----------|---------------------------------------------------------------------------------------------------------------------------------|
| 1          | CLK      | Output   | Clock output from VCO. Output frequency equals the input frequency times multiplier.                                            |
| 2          | REFEN    | Input    | Reference clock enable. Turns off the buffered crystal oscillator clock (stops low) when low.                                   |
| 3          | VDD      | Power    | Connect to +3.3V or +5V. Must match other VDDs.                                                                                 |
| 4          | VDD      | Power    | Connect to +3.3V or +5V. Must match other VDDs.                                                                                 |
| 5          | VDD      | Power    | Connect to +3.3V or +5V. Must match other VDDs.                                                                                 |
| 6          | X2       | XO       | Crystal connection. Connect to a 10 - 27 MHz fundamental parallel mode crystal. Leave disconnected for an external clock input. |
| 7          | S1       | Input    | Multiplier select pin 1. Determines CLK output per table above. Internal pull-up.                                               |
| 8          | X1/ICLK  | XI       | Crystal connection. Connect to a 10 - 27 MHz fundamental parallel mode crystal or clock.                                        |
| 9          | S2       | Input    | Multiplier select pin 2. Determines CLK output per table above. Internal pull-up.                                               |
| 10         | S3       | Input    | Multiplier select pin 3. Determines CLK output per table above. Internal pull-up.                                               |
| 11         | S0       | Input    | Multiplier select pin 0. Determines CLK output per table above. Internal pull-up.                                               |
| 12         | OE       | Input    | Output Enable. Tri-states both output clocks when low. Internal pull-up.                                                        |
| 13         | REFOUT   | Output   | Buffered crystal oscillator clock output. Controlled by REFIN.                                                                  |
| 14 - 16    | GND      | Power    | Connect to ground.                                                                                                              |

## Achieving Low Phase Noise

Figure 1 shows a typical phase noise measurement in a 125 MHz system. There are a few simple steps that can be taken to achieve these levels of phase noise from the ICS601-01. Variations in VDD will increase the phase noise, so it is important to have a stable, low noise supply voltage at the device. Use decoupling capacitors of 0.1  $\mu$ F in parallel with 0.01  $\mu$ F. It is important to have these capacitors as close as possible to the ICS601-01 supply pins.

Disabling the REFOUT clock is also important for achieving low phase noise; lab tests have shown that this can reduce the phase noise by as much as 10 dBc/Hz.



## External Component/Crystal Selection

The ICS601-01 requires a minimum number of external components for proper operation. Decoupling capacitors of 0.01  $\mu$ F and 0.1  $\mu$ F should be connected between VDD and GND, as close to the part as possible. A series termination resistor of 33  $\Omega$  may be used for each clock output. The crystal must be connected as close to the chip as possible. The crystal should be fundamental mode, parallel resonant. Do not use third overtone. For exact tuning when using a crystal, capacitors should be connected from pins X1 to ground and X2 to ground. In general, the value of these capacitors is given by the following equation, where CL is the crystal load capacitance: Crystal caps (pF) = (CL - 5) x 2. So for a crystal with 16 pF load capacitance, two 22 pF caps can be used. For any given board layout, ICS can measure the board capacitance and recommend the exact capacitance value to use.

## Absolute Maximum Ratings

Stresses above the ratings listed below can cause permanent damage to the ICS601-01. 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.

| Item                                              | Rating              |
|---------------------------------------------------|---------------------|
| Supply Voltage, VDD                               | 7 V                 |
| All Inputs and Outputs                            | -0.5 V to VDD+0.5 V |
| Ambient Operating Temperature, Commercial version | 0 to +70 °C         |
| Ambient Operating Temperature, Industrial version | -40 to +85 °C       |
| Storage Temperature                               | -65 to +150 °C      |
| Junction Temperature                              | 125 °C              |
| Soldering Temperature                             | 260 °C              |

## Recommended Operation Conditions

| Parameter                                         | Min. | Typ. | Max. | Units |
|---------------------------------------------------|------|------|------|-------|
| Ambient Operating Temperature                     | -40  |      | +85  | °C    |
| Power Supply Voltage (measured in respect to GND) | +3.0 |      | +5.5 | V     |

## DC Electrical Characteristics

VDD=3.3 V  $\pm$ 10%, Ambient temperature -40 to +85°C

| Parameter                | Symbol          | Conditions                           | Min.     | Typ.     | Max.    | Units |
|--------------------------|-----------------|--------------------------------------|----------|----------|---------|-------|
| Operating Voltage        | VDD             |                                      | 3.0      |          | 5.5     | V     |
| Input High Voltage       | V <sub>IH</sub> | X1/ICLK pin only<br>Note 1           | VDD/2+1  |          |         | V     |
| Input Low Voltage        | V <sub>IL</sub> | X1/ICLK pin only<br>Note 1           |          |          | VDD/2-1 | V     |
| Input High Voltage       | V <sub>IH</sub> |                                      | 2        |          |         | V     |
| Input Low Voltage        | V <sub>IL</sub> |                                      |          |          | 0.8     | V     |
| Output High Voltage      | V <sub>OH</sub> | CMOS level<br>I <sub>OH</sub> = -4mA | VDD-0.4  |          |         | V     |
|                          |                 | I <sub>OH</sub> = -12mA              | 2.4      |          |         |       |
| Output Low Voltage       | V <sub>OL</sub> | I <sub>OL</sub> = 12mA               |          |          | 0.4     | V     |
| Operating Supply Current | IDD             | No load, 125 MHz                     |          | 22       | 30      | mA    |
| Short Circuit Current    |                 | Each output                          | $\pm$ 40 | $\pm$ 60 |         | mA    |
| Input Capacitance        | C <sub>IN</sub> | OE, select pins                      |          | 5        |         | pF    |

Note 1: Switching occurs nominally at VDD/2

## AC Electrical Characteristics

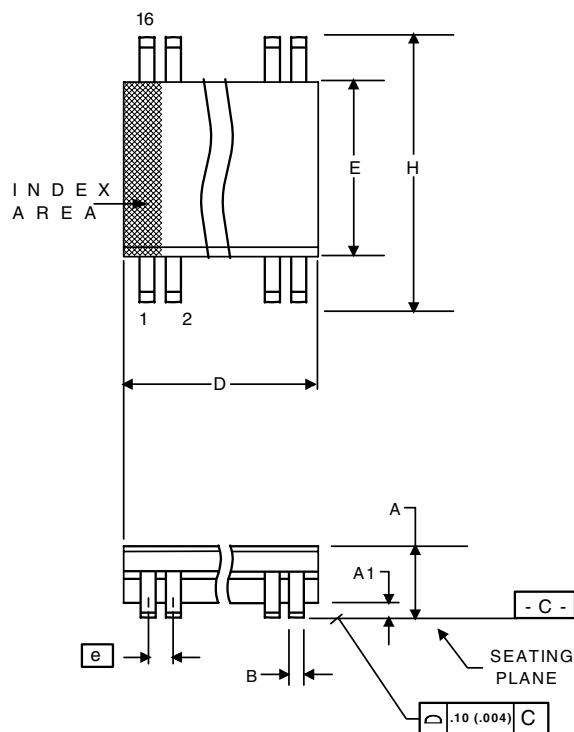
VDD = 3.3V ±10%, Ambient Temperature -40 to +85° C

| Parameter                                      | Symbol          | Conditions           | Min. | Typ. | Max. | Units  |
|------------------------------------------------|-----------------|----------------------|------|------|------|--------|
| Input Frequency                                | Fin             |                      | 10   |      | 27   | MHz    |
| Output Frequency                               |                 | at 3.3V or 5V        |      |      | 156  | MHz    |
| Output Rise Time                               | t <sub>OR</sub> | 0.8 to 2.0V no load  |      |      | 1.5  | ns     |
| Output Fall Time                               | t <sub>OF</sub> | 0.8 to 2.0V, no load |      |      | 1.5  | ns     |
| Output Clock Duty Cycle                        |                 | at VDD/2             | 45   | 50   | 55   | %      |
| Maximum Absolute jitter, short term, 125 MHz   |                 | No load              |      | ±50  | ±75  | ps     |
| Maximum jitter, one sigma, 125 MHz (x5)        |                 | No load              |      | 12   | 20   | ps     |
| Phase Noise, relative to carrier, 125 MHz (x5) |                 | 100 Hz offset        | -90  | -94  |      | dBc/Hz |
| Phase Noise, relative to carrier, 125 MHz (x5) |                 | 1 kHz                | -116 | -120 |      | dBc/Hz |
| Phase Noise, relative to carrier, 125 MHz (x5) |                 | 10 kHz offset        | -118 | -122 |      | dBc/Hz |
| Phase Noise, relative to carrier, 125 MHz (x5) |                 | 100 kHz offset       | -115 | -119 |      | dBc/Hz |

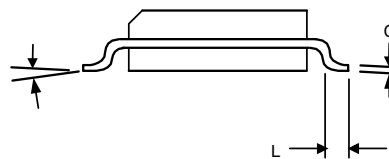
Note 2: Input frequency limited by maximum output frequency and multiplication factor (I.e. For 16x, maximum input frequency is 13.75 MHz).

## Package Outline and Package Dimensions (16 pin SOIC, 150 Mil. Narrow Body)

Package dimensions are kept current with JEDEC Publication No. 95

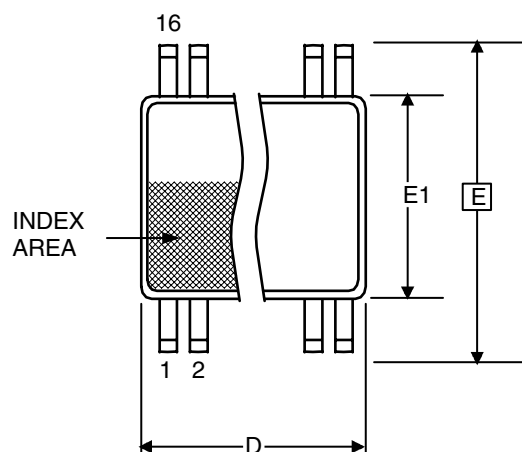


| Symbol   | SOIC       |       |
|----------|------------|-------|
|          | Min        | Max   |
| A        | 1.35       | 1.75  |
| A1       | 0.10       | 0.25  |
| B        | 0.33       | 0.51  |
| C        | 0.19       | 0.25  |
| D        | 9.80       | 10.00 |
| E        | 3.80       | 4.00  |
| e        | 1.27 BASIC |       |
| H        | 5.80       | 6.20  |
| L        | 0.40       | 1.27  |
| $\alpha$ | 0°         | 8°    |

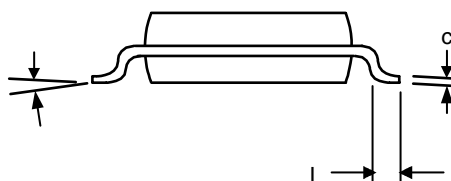
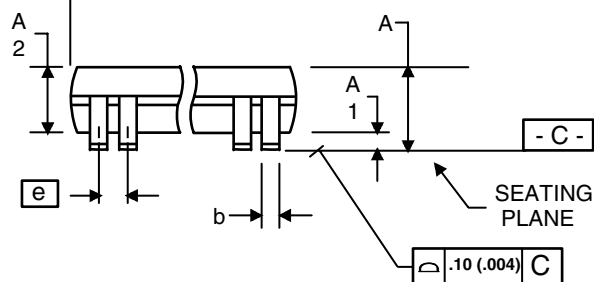


## Package Outline and Package Dimensions (16-pin TSSOP, 4.40 mm Body, 0.65 mm Pitch)

Package dimensions are kept current with JEDEC Publication No. 95



| Symbol   | Millimeters |      | Inches       |       |
|----------|-------------|------|--------------|-------|
|          | Min         | Max  | Min          | Max   |
| A        | --          | 1.20 | --           | 0.047 |
| A1       | 0.05        | 0.15 | 0.002        | 0.006 |
| A2       | 0.80        | 1.05 | 0.032        | 0.041 |
| b        | 0.19        | 0.30 | 0.007        | 0.012 |
| C        | 0.09        | 0.20 | 0.0035       | 0.008 |
| D        | 4.90        | 5.1  | 0.193        | 0.201 |
| E        | 6.40 BASIC  |      | 0.252 BASIC  |       |
| E1       | 4.30        | 4.50 | 0.169        | 0.177 |
| e        | 0.65 Basic  |      | 0.0256 Basic |       |
| L        | 0.45        | 0.75 | 0.018        | 0.030 |
| $\alpha$ | 0°          | 8°   | 0°           | 8°    |



## Ordering Information

| Part / Order Number | Marking      | Shipping Packaging | Package            | Temperature  |
|---------------------|--------------|--------------------|--------------------|--------------|
| 601M-01LF           | ICS601M-01LF | Tubes              | 16-pin narrow SOIC | 0 to 70° C   |
| 601M-01LFT          | ICS601M-01LF | Tape and Reel      | 16-pin narrow SOIC | 0 to 70° C   |
| 601M-01ILF          | ICS601M01ILF | Tubes              | 16-pin narrow SOIC | -40 to 85° C |
| 601M-01ILFT         | ICS601M01ILF | Tape and Reel      | 16-pin narrow SOIC | -40 to 85° C |
| 601G-01LF           | 601G01LF     | Tubes              | 16-pin TSSOP       | 0 to 70° C   |
| 601G-01LFT          | 601G01LF     | Tape and Reel      | 16-pin TSSOP       | 0 to 70° C   |
| 601G-01ILF          | 601G01IL     | Tubes              | 16-pin TSSOP       | -40 to 85° C |
| 601G-01ILFT         | 601G01IL     | Tape and Reel      | 16-pin TSSOP       | -40 to 85° C |

"L" designates Pb (lead) free package; "I" designates industrial grade.

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