# DIGITAL VIDEO CLOCK SOURCE

ICS664-05

## Description

The ICS664-05 provides clock generation and conversion for clock rates commonly needed in HDTV digital video equipment. The ICS664-05 uses the latest PLL technology to provide excellent phase noise and long term jitter performance for superior synchronization and S/N ratio.

The ICS664-05 is suitable for Digital Video STB and DTV applications. For Transmitter application use ICS664-01 or ICS664-02.

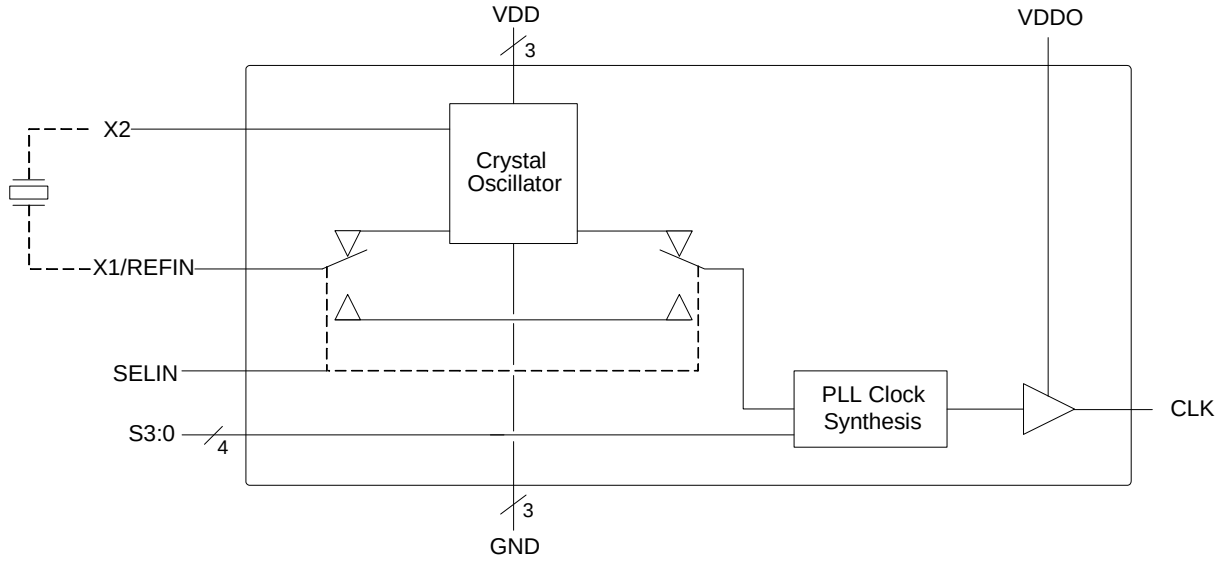
For audio sampling clocks generated from 27 MHz, use the ICS661.

Please contact IDT if you have a requirement for an input and output frequency not included in this document. IDT can rapidly modify this product to meet special requirements.

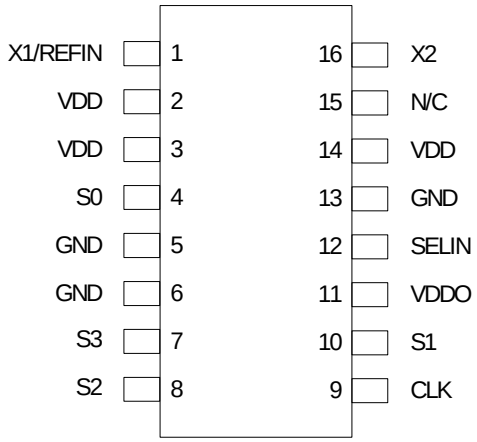
## Features

- Packaged in 16-pin TSSOP
- Available in Pb (lead) free package
- Clock or crystal input provides flexibility
- Low phase noise supports enhanced SNR
- Lowest jitter in class at 100 ps typical
- Exact (0 ppm) multiplication ratios
- Improved phase noise over ICS660
- Provides High definition Video clocks for 720p, 1080i and 1080p YUV standards
- Available in commercial (0 to +70°C) and industrial (-40 to +85°C) temperature ranges

## Block Diagram



## Pin Assignment




16-pin TSSOP

## Output Clock Selection Table

| S3 | S2 | S1 | S0 | Input Frequency (MHz) | Output Frequency (MHz) |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | | Outputs disabled |
| 0 | 0 | 0 | 1 | 27 | 27 |
| 0 | 0 | 1 | 0 | 27 | 74.25 |
| 0 | 0 | 1 | 1 | 27 | 74.$\overline{175824}$ |
| 0 | 1 | 0 | 0 | 27 | 67.5 |
| 0 | 1 | 0 | 1 | 67.5 | 27 |
| 0 | 1 | 1 | 0 | 27 | 148.5000 |
| 0 | 1 | 1 | 1 | 27 | 148.351648 |
| 1 | 0 | 0 | 0 | 74.25 | 54 |
| 1 | 0 | 0 | 1 | 74.$\overline{175824}$ | 54 |
| 1 | 0 | 1 | 0 | 74.25 | 27 |
| 1 | 0 | 1 | 1 | 74.$\overline{175824}$ | 27 |
| 1 | 1 | 0 | 0 | 54 | 74.25 |
| 1 | 1 | 0 | 1 | 54 | 74.$\overline{175824}$ |
| 1 | 1 | 1 | 0 | 54 | 148.5 |
| 1 | 1 | 1 | 1 | 54 | 148.351648 |

## Pin Descriptions

| Pin Number | Pin Name | Pin Type | Pin Description |
|---|---|---|---|
| 1 | X1/REFIN | Input | Connect this pin to a crystal or clock input |
| 2 | VDD | Power | Connect to +3.3 V. |
| 3 | VDD | Power | Connect to +3.3 V. |
| 4 | S0 | Input | Output frequency selection. Determines output frequency per table above. Internal pull-up. |
| 5 | GND | Power | Connect to ground. |
| 6 | GND | Power | Connect to ground. |
| 7 | S3 | Input | Output frequency selection. Determines output frequency per table above. Internal pull-up. |
| 8 | S2 | Input | Output frequency selection. Determines output frequency per table above. Internal pull-up. |
| 9 | CLK | Output | Clock output. |
| 10 | S1 | Input | Output frequency selection. Determines output frequency per table above. Internal pull-up. |
| 11 | VDDO | Power | Connect to +2.5 V to +3.3 V. |
| 12 | SEL | Input | Low for clock input, high for crystal. Internal pull-up. |
| 13 | GND | Power | Connect to ground. |
| 14 | VDD | Power | Connect to +3.3 V. |
| 15 | NC | — | No connect. Do not connect to anything. |
| 16 | X2 | Input | Connect this pin to a crystal. Leave open if using a clock input. |

# Application Information

## Series Termination Resistor

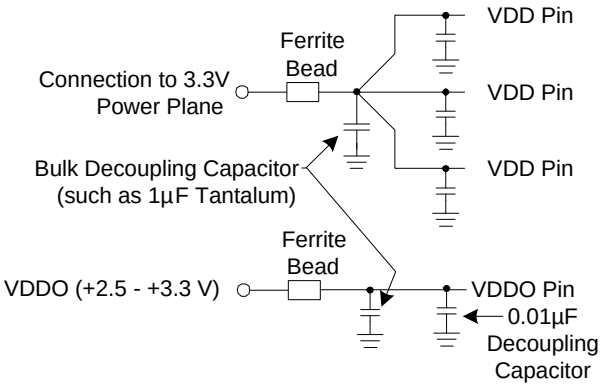
Clock output traces should use series termination. To series terminate a 50Ω trace (a commonly used trace impedance), place a 33Ω resistor in series with the clock line, as close to the clock output pin as possible. The nominal impedance of the clock output is 20Ω

## Decoupling Capacitors

As with any high-performance mixed-signal IC, the ICS664-05 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. To further guard against interfering system supply noise, the ICS664-05 should use one common connection to the PCB power plane as shown in the diagram on the next page. The ferrite bead and bulk capacitor help reduce lower frequency noise in the supply that can lead to output clock phase modulation.

## Recommended Power Supply Connection for Optimal Device Performance




All power supply pins must be connected to the same voltage, except VDDO, which may be connected to a lower voltage in order to change the output level.

To achieve the absolute minimum jitter, power the part with a dedicated LDO regulator, which will provide high isolation from power supply noise. Many companies produce very small, inexpensive regulators; an example is the National Semiconductor LP2985.

## Crystal Load Capacitors

If a crystal is used, the device crystal connections should include pads for 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. To reduce possible noise pickup, use very short PCB traces (and no vias) between the crystal and device.

The value of the load capacitors can be roughly determined by the formula $C = 2(C_L - 6)$ where C is the load capacitor connected to X1 and X2, and $C_L$ is the specified value of the load capacitance for the crystal. A typical crystal $C_L$ is 18 pF, so $C = 2(18 - 6) = 24$ pF. Because these capacitors adjust the stray capacitance of the PCB, check the output frequency using your final layout to see if the value of C should be changed.

## 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. Distance of the ferrite bead and bulk decoupling from the device is less critical.

2) The external crystal should be mounted 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 and obtain the best signal integrity, the 33Ω series termination resistor 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 (the ferrite bead and bulk decoupling capacitor can be mounted on the back). Other signal traces should be routed away from the ICS664-05. This includes signal traces just underneath the device, or on layers adjacent to the ground plane layer used by the device.

## Absolute Maximum Ratings

Stresses above the ratings listed below can cause permanent damage to the ICS664-05. 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 | 5.5 V |
| All Inputs and Outputs | -0.5 V to VDD+0.5 V |
| Ambient Operating Temperature | 0 to +70° 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 (commercial) | 0 | | +70 | °C |
| Ambient Operating Temperature (industrial) | -40 | | +85 | °C |
| Power Supply Voltage (measured in respect to GND) | +2.5 | | +3.6 | V |

## DC Electrical Characteristics

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

| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Operating Voltage | VDD | | 3.0 | | 3.6 | V |
| | VDDO | | 2.5 | | VDD | V |
| Supply Current | IDD | No Load | | 35 | | mA |
| Input High Voltage | $V_{IH}$ | | 2 | | | V |
| Input Low Voltage | $V_{IL}$ | | | | 0.8 | V |
| Output High Voltage | $V_{OH}$ | $I_{OH}$ = -4 mA | VDD-0.4 | | | V |
| Output High Voltage | $V_{OH}$ | $I_{OH}$ = -20 mA | 2.4 | | | V |
| Output Low Voltage | $V_{OL}$ | $I_{OL}$ = 20 mA | | | 0.4 | V |
| Short Circuit Current | $I_{OS}$ | Each output | | ±65 | | mA |
| Nominal Output Impedance | $Z_{OUT}$ | | | 20 | | Ω |
| Input Capacitance | $C_{IN}$ | Input pins | | 7 | | pF |
| Internal Pull-up Resistor | $R_{PU}$ | | | 120 | | kΩ |

## AC Electrical Characteristics

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

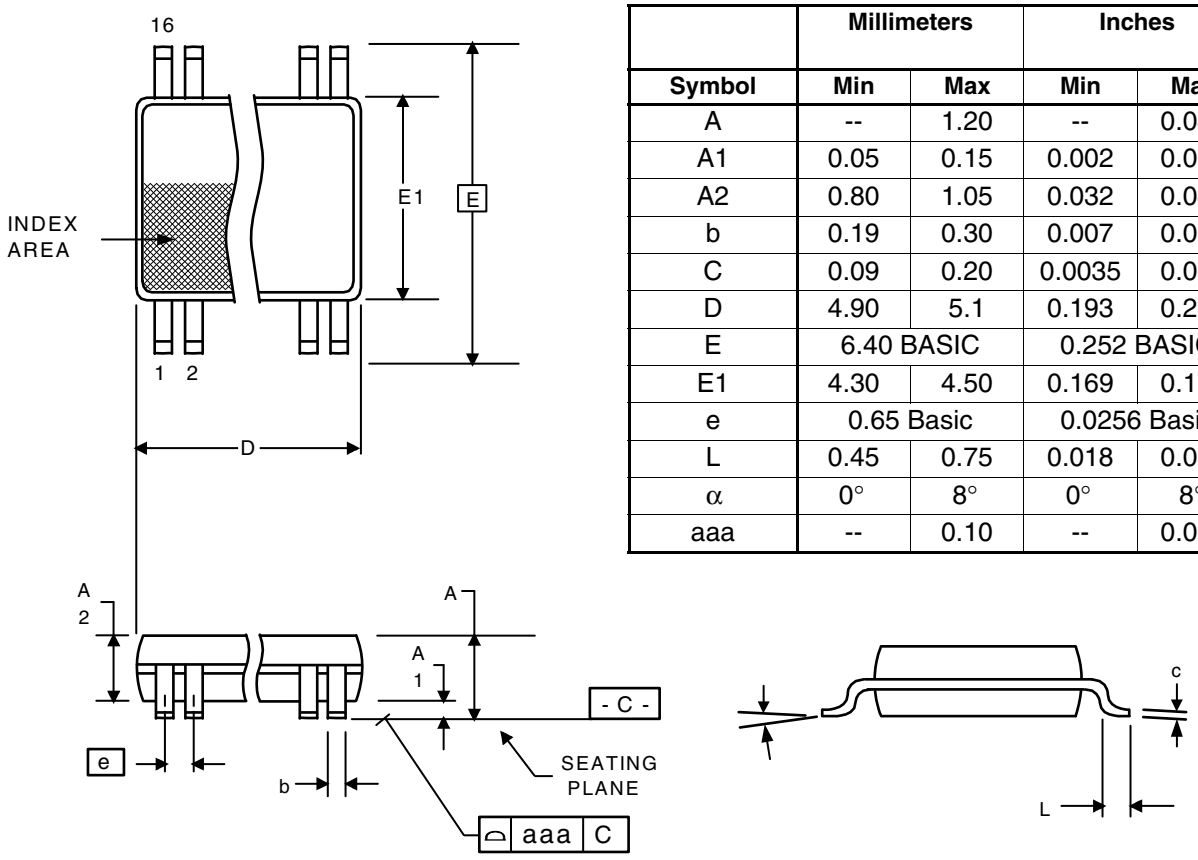
| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Crystal Frequency | | | | | 28 | MHz |
| Output Clock Rise Time | $t_{OR}$ | 20% to 80%, 15 pF load | | 1.5 | | ns |
| Output Clock Fall Time | $t_{OF}$ | 80% to 20%, 15 pF load | | 1.5 | | ns |
| Output Duty Cycle | $t_{OD}$ | at VDD/2, 15 pF load | 40 | 49 to 51 | 60 | % |
| Power-up Time | $t_{PU}$ | Valid power on to valid output | | 1 | | ms |
| Jitter, short term | | | | 100 | | ps p-p |
| Jitter, long term | | 10 µs delay | | 200 | | ps p-p |
| Single Sideband Phase Noise | | 10 kHz offset | | -120 | | dBc |
| Actual Mean Frequency Error versus Target | | | | 0 | | ppm |

## Thermal Characteristics

| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Thermal Resistance Junction to Ambient | $\theta_{JA}$ | Still air | | 78 | | °C/W |
| | $\theta_{JA}$ | 1 m/s air flow | | 70 | | °C/W |
| | $\theta_{JA}$ | 3 m/s air flow | | 68 | | °C/W |
| Thermal Resistance Junction to Case | $\theta_{JC}$ | | | 37 | | °C/W |

## 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, MO-153




| | Millimeters | | Inches | |
|---|---|---|---|---|
| **Symbol** | **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 |
| α | 0° | 8° | 0° | 8° |
| aaa | -- | 0.10 | -- | 0.004 |

## Ordering Information

| Part / Order Number | Marking | Shipping Packaging | Package | Temperature |
|---|---|---|---|---|
| 664G-05 | 664G-05 | Tubes | 16-pin TSSOP | 0 to +70° C |
| 664G-05T | 664G-05 | Tape and Reel | 16-pin TSSOP | 0 to +70° C |
| 664G-05LF | 664G05LF | Tubes | 16-pin TSSOP | 0 to +70° C |
| 664G-05LFT | 664G05LF | Tape and Reel | 16-pin TSSOP | 0 to +70° C |
| 664GI-05LF | 664GI05L | Tubes | 16-pin TSSOP | -40 to +85° C |
| 664GI-05LFT | 664GI05L | Tape and Reel | 16-pin TSSOP | -40 to +85° C |

**Parts that are ordered with a "LF" suffix to the part number are the Pb-Free configuration and are RoHS compliant.**

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