# LOW COST 27 MHZ 3.3 VOLT VCXO

# ICS728

## Description

The ICS728 combines the functions of a VCXO (Voltage Controlled Crystal Oscillator) and PLL (Phase Locked Loop) frequency doubler onto a single chip. Used in conjunction with an external pullable quartz crystal, this monolithic integrated circuit replaces more costly hybrid (canned) VCXO devices. The ICS728 is designed primarily for data and clock recovery applications within end products such as set-top box receivers.

The ICS728 exhibits a moderate VCXO gain of 110 ppm/V typical, when used with a high quality external pullable quartz crystal.

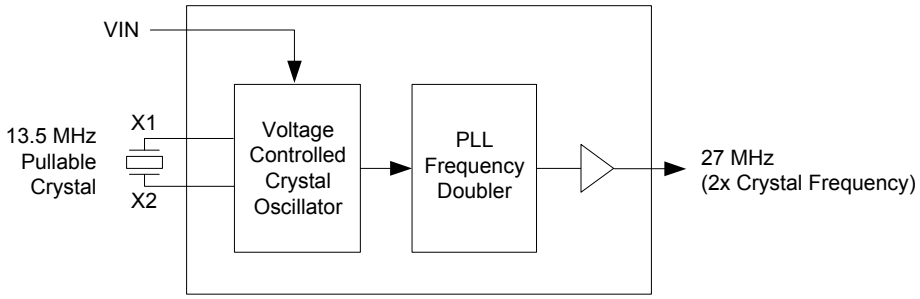
The frequency of the on-chip VCXO is adjusted by an external control voltage input into pin VIN. Because VIN is a high impedance input, it can be driven directly from an PWM RC integrator circuit. Frequency output increases with VIN voltage input. The usable range of VIN is 0 to 3.3 V.

## Features

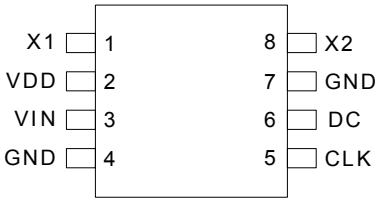
- Ideal for set-top box applications using 13.5 MHz external pullable crystal to generate lock 27 MHz clock transport video clock
- On-chip VCXO with guaranteed pull range of ±110 ppm minimum
- VCXO input tuning voltage 0 to 3.3 V
- Packaged in 8-pin SOIC (150 mil wide)
- Available in Pb (lead) free package

***NOTE: EOL for non-green parts to occur on 5/13/10 per PDN U-09-01***

## Block Diagram



## Pin Assignment




**8-pin (150 mil) SOIC**

## Pin Descriptions

| Pin Number | Pin Name | Pin Type | Pin Description |
|---|---|---|---|
| 1 | XI | Input | Crystal connection. Connect to the external pullable crystal. |
| 2 | VDD | Power | Connect to +3.3 V (0.01uf decoupling capacitor recommended). |
| 3 | VIN | Input | Voltage input to VCXO. Zero to 3.3 V analog input which controls the oscillation frequency of the VCXO. |
| 4 | GND | Power | Connect to ground. |
| 5 | CLK | Output | Clock output. |
| 6 | DC | __ | Do not connect to this pin |
| 7 | GND | Power | Connect to ground. |
| 8 | X2 | Input | Crystal connection. Connect to the external pullable crystal. |

# External Component Selection

The ICS728 requires a minimum number of external components for proper operation.

### Decoupling Capacitor

A decoupling capacitor of 0.01µF must be connected between VDD (pin 2) and GND (pin 4), as close to these pins as possible. For optimum device performance, the decoupling capacitor should be mounted on the component side of the PCB. Avoid the use of vias in the decoupling circuit.

### Series Termination Resistor

When the PCB trace between the clock output (CLK, pin 5) and the load is over 1 inch, series termination should be used. 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

## Quartz Crystal

The ICS728 VCXO function consists of the external crystal and the integrated VCXO oscillator circuit. To assure the best system performance (frequency pull range) and reliability, a crystal device with the recommended parameters (shown below) must be used, and the layout guidelines discussed in the following section shown must be followed.

The frequency of oscillation of a quartz crystal is determined by its “cut” and by the load capacitors connected to it. The ICS728 incorporates on-chip variable load capacitors that “pull” (change) the frequency of the crystal. The crystal specified for use with the ICS728 is designed to have zero frequency error when the total of on-chip + stray capacitance is 14 pF.

**Recommended Crystal Parameters:**

| | |
|---|---|
| Initial Accuracy at 25° C | ±20 ppm |
| Temperature Stability | ±30 ppm |
| Aging | ±20 ppm |
| Load Capacitance | 14 pf |
| Shunt Capacitance, C0 | 7 pF Max |
| C0/C1 Ratio | 250 Max |
| Equivalent Series Resistance | 35 Ω Max |

The third overtone mode of the crystal and all spurs must be >100 ppm distant from 3x the fundamental resonance measured with a physical load of 14 pF.

The external crystal must be connected as close to the chip as possible and should be on the same side of the PCB as the ICS728. There should be no vias between the crystal pins and the X1 and X2 device pins. There should be no signal traces underneath or close to the crystal.

## Crystal Tuning Load Capacitors

The crystal traces should include pads for small fixed capacitors, one between X1 and ground, and another between X2 and ground. Stuffing of these capacitors on the PCB is optional. The need for these capacitors is determined at system prototype evaluation, and is influenced by the particular crystal used and by PCB layout. The typical required capacitor value is 1 to 4 pF.

To determine the need for and value of the crystal adjustment capacitors, you will need a PC board of your final layout, a frequency counter capable of 1 ppm resolution and accuracy, two power supplies, and some samples of the crystals which you plan to use in production, along with measured initial accuracy for each crystal at the specified crystal load capacitance, CL.

To determine the value of the crystal capacitors:

1. Connect VDD of the ICS728 to 3.3 V. Connect pin 3 of the ICS728 to the second power supply. Adjust the voltage on pin 3 to 0V. Measure and record the frequency of the CLK output.

2. Adjust the voltage on pin 3 to 3.3 V. Measure and record the frequency of the same output.

To calculate the centering error:

$$Error = 10^6 x\left[\frac{(f_{3.0V} - f_{target}) + (f_{0V} - f_{target})}{f_{target}}\right] - error_{xtal}$$

Where:

$f_{target}$ = nominal crystal frequency

$error_{xtal}$ =actual initial accuracy (in ppm) of the crystal being measured

If the centering error is less than ±25 ppm, no adjustment is needed. If the centering error is more than 25 ppm negative, the PC board has excessive stray capacitance and a new PCB layout should be considered to reduce stray

capacitance. (Alternately, the crystal may be re-specified to a higher load capacitance. Contact IDT for details.) If the centering error is more than 25 ppm positive, add identical fixed centering capacitors from each crystal pin to ground. The value for each of these caps (in pF) is given by:

External Capacitor = 2 x (centering error)/(trim sensitivity)

Trim sensitivity is a parameter which can be supplied by your crystal vendor. If you do not know the value, assume it is 30 ppm/pF. After any changes, repeat the measurement to verify that the remaining error is acceptably low (typically less than ±25 ppm).

## Absolute Maximum Ratings

Stresses above the ratings listed below can cause permanent damage to the ICS728. 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 |
| Storage Temperature | -65 to +150° C |
| Soldering Temperature | 260° C |

## Recommended Operation Conditions

| Parameter | Min. | Typ. | Max. | Units |
|---|---|---|---|---|
| Ambient Operating Temperature | 0 | | +70 | ° C |
| Power Supply Voltage (measured in respect to GND) | +3.15 | | +3.45 | V |
| Reference crystal parameters | Refer to page 3 | | | |

## DC Electrical Characteristics

**VDD=3.3 V ±5%** , Ambient temperature 0 to +70° C, unless stated otherwise

| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Operating Voltage | VDD | | 3.15 | | 3.45 | V |
| Output High Voltage | $V_{OH}$ | $I_{OH}$ = -12 mA | 2.4 | | | V |
| Output Low Voltage | $V_{OL}$ | $I_{OL}$ = 12 mA | | | 0.4 | V |
| Output High Voltage (CMOS Level) | $V_{OH}$ | $I_{OH}$ = -4 mA | VDD-0.4 | | | V |
| Operating Supply Current | IDD | Output = 27 MHz, no load | | 12 | | mA |
| Short Circuit Current | $I_{OS}$ | | | ±50 | | mA |
| VIN, VCXO Control Voltage | $V_{IA}$ | | 0 | | 3.3 | V |

## AC Electrical Characteristics

**VDD = 3.3 V ±5%**, Ambient Temperature 0 to +70° C, unless stated otherwise

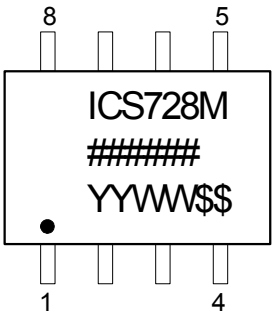
| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Output Frequency | $F_O$ | | | 27 | | MHz |
| Crystal Pullability | $F_P$ | 0V≤ VIN ≤ 3.3 V, Note 1 | ± 110 | | | ppm |
| VCXO Gain | | VIN = VDD/2 ±1 V, Note 1 | | 120 | | ppm/V |
| Output Rise Time | $t_{OR}$ | 0.8 to 2.0 V, $C_L$=15 pF | | | 1.5 | ns |
| Output Fall Time | $t_{OF}$ | 2.0 to 0.8 V, $C_L$=15 pF | | | 1.5 | ns |
| Output Clock Duty Cycle | $t_D$ | Measured at 1.4 V, $C_L$=15 pF | 40 | 50 | 60 | % |
| Maximum Output Jitter, short term | $t_J$ | $C_L$=15 pF | | 100 | | ps |

Note 1: External crystal device must conform with Pullable Crystal Specifications listed on page 3.

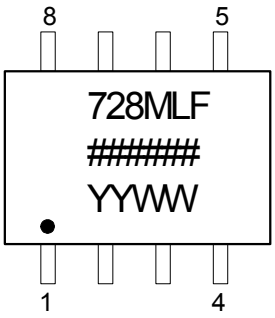
## Thermal Characteristics

| 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 |

## Marking Diagram




## Marking Diagram (Pb free)

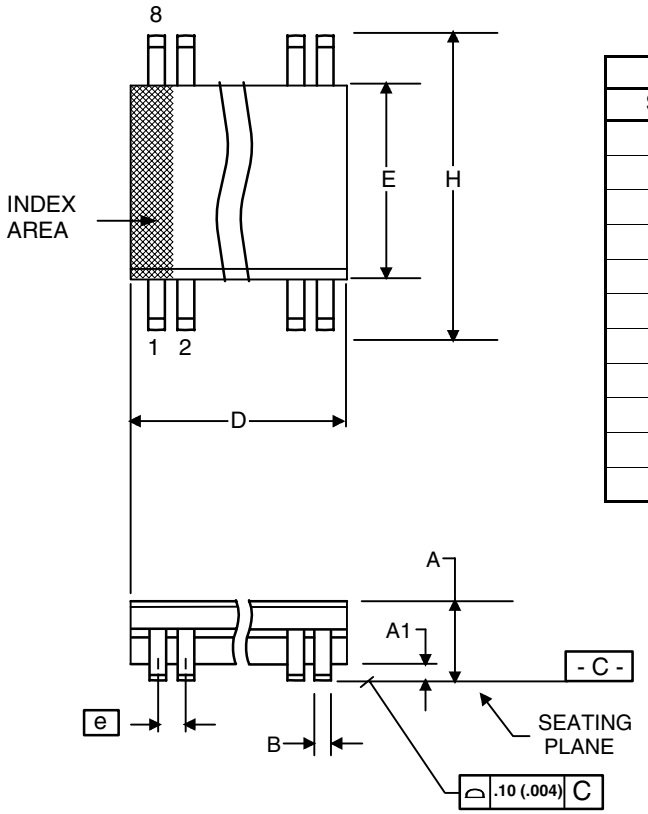



Notes:

1. ###### is the lot number.
2. YYWW is the last two digits of the year and week that the part was assembled.
3. “LF” denotes Pb (lead) free package.
4. Bottom marking: (origin)
   Origin = country of origin of not USA.

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

Package dimensions are kept current with JEDEC Publication No. 95




| | Millimeters | | Inches | |
|---|---|---|---|---|
| Symbol | Min | Max | Min | Max |
| A | 1.35 | 1.75 | 0.0532 | 0.0688 |
| A1 | 1.10 | 0.25 | 0.0040 | 0.0098 |
| B | 0.33 | 0.51 | 0.013 | 0.020 |
| C | 0.19 | 0.25 | 0.0075 | 0.0098 |
| D | 4.80 | 5.00 | .1890 | .1968 |
| E | 3.80 | 4.00 | 0.1497 | 0.1574 |
| e | 1.27 Basic | | 0.050 Basic | |
| H | 5.80 | 6.20 | 0.2284 | 0.2440 |
| h | 0.25 | 0.50 | 0.010 | 0.020 |
| L | 0.40 | 1.27 | 0.016 | 0.050 |
| a | 0° | 8° | 0° | 8° |

## Ordering Information

| Part / Order Number | Marking | Shipping Packaging | Package | Temperature |
|---|---|---|---|---|
| 728M* | see page 6 | Tubes | 8-pin SOIC | 0 to +70° C |
| 728MT* | | Tape and Reel | 8-pin SOIC | 0 to +70° C |
| 728MLF | | Tubes | 8-pin SOIC | 0 to +70° C |
| 728MLFT | | Tape and Reel | 8-pin SOIC | 0 to +70° C |

***NOTE: EOL for non-green parts to occur on 5/13/10 per PDN U-09-01**

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

## Revision History

| Rev. | Originator | Date | Description of Change |
|---|---|---|---|
| A | J. Sarma | 12/14/04 | Release from Prelim to Final; release as General purpose device. |
| B | J. Sarma | 01/25/05 | Add marking diagrams; add LF. |
| C | | 11/04/09 | Added EOL note for non-green parts. |

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