TB097

Interfacing a Micro Crystal MS1V-T1K 32.768 kHz Tuning Fork Crystal to a PIC16F690/SS

Author: *Steven Bible*
Microchip Technology Inc.

Stéphane De Boni
Micro Crystal

INTRODUCTION

This technical brief discusses the interfacing and characterization of the Micro Crystal MS1V-T1K 32.768 kHz tuning fork (watch) crystal with the PIC16F690 PIC® microcontroller Timer1 low-power oscillator. This information can be used to assist the designer in interfacing 32.768 kHz tuning fork crystal to the PIC16F690 MCU.

The information in this technical brief is intended as a design suggestion. The designer should verify proper operation for their particular application.

MICRO CRYSTAL MS1V-T1K

The Micro Crystal MS1V-T1K is a high-quality tuning fork quartz crystal resonator. It is packaged in a square-bodied 2x2x6 mm metal-can package with formed leads intended for surface mounting and reflow soldering.

More information about the MS1V-T1K can be found in the data sheet available on the Micro Crystal web site www.microcrystal.com.

PIC16F690

The PIC16F690 clock oscillator can be configured as a Timer1 oscillator by setting control bit T1OSCEN (T1CON<3>). The oscillator is a low-power oscillator and will continue to run during Sleep. This mode of operation is only allowed if the primary system clock is configured for the internal oscillator.

More information can be found in the PIC16F631/677/685/687/689/690 Data Sheet (DS41262) available from the Microchip web site www.microchip.com.

SCHEMATIC DIAGRAM

The schematic for the circuit is shown in Figure 1. The tuning fork crystal resonator is connected to the PIC16F690 OSC1 and OSC2 pins. Capacitors C_D and C_G are the load capacitors and resistor R_D is the dumping resistor.

Load Capacitors

The load capacitors C_D and C_G are regarded in series. To determine the total effective load capacitance, the board layout stray (parasitic) capacitance has to be taken into account. For best frequency accuracy, the total effective load capacitance should match the crystal's C_L specification.

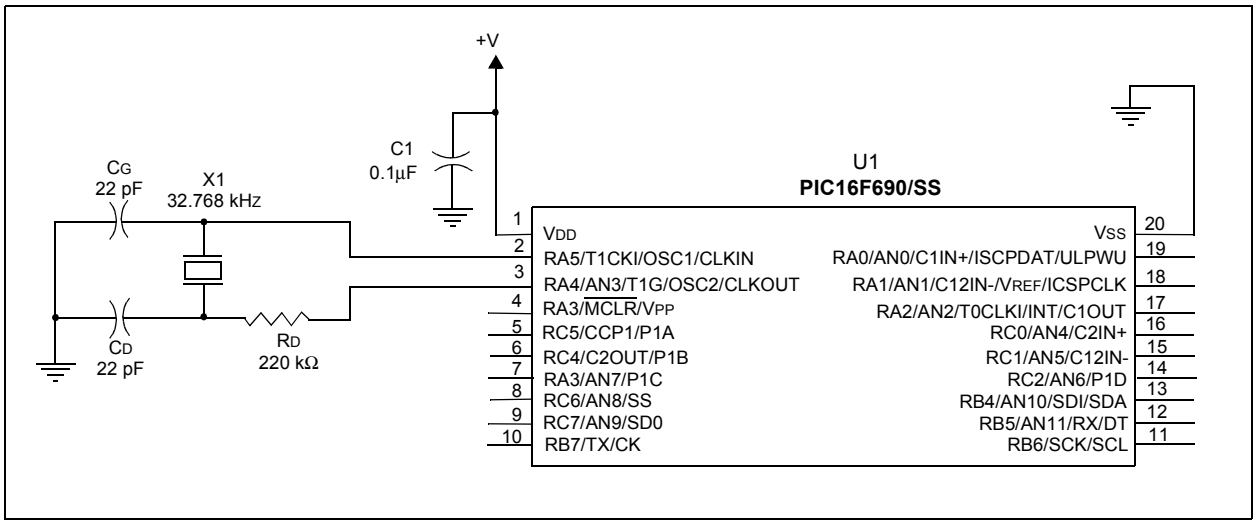
EQUATION 1: LOAD CAPACITORS

$$C_{EffectiveLoad} = \frac{C_D \bullet C_G}{C_D + C_G} + C_{Stray}$$

Overtone Mode Suppression

Resistor R_D together with load capacitor C_D form a low-pass filter that will suppress the crystal resonator's overtone mode of operation. Resistor R_D also limits the amount of drive to the crystal resonator. The maximum drive current of tuning fork crystals is 1 µW.

FIGURE 1: SCHEMATIC DIAGRAM

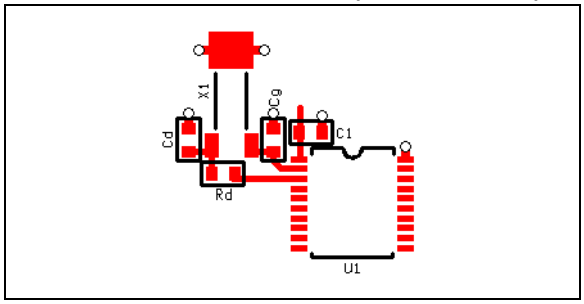


PCB LAYOUT

The PCB layout is shown in Figure 2. The PIC16F690 package is a 20-lead plastic shrink small outline (SSOP). The load capacitors and dumping resistors are 0603 size surface mount packages.

The PCB is 0.062" double sided FR4 material. Not shown in the diagram is a solid ground plane on the bottom side.

FIGURE 2: PCB LAYOUT (TOP COPPER)



CHARACTERIZATION REPORT

A PCB was constructed and submitted to Micro Crystal for characterization. The three page report is shown below.

FIGURE 3: CHARACTERIZATION REPORT (PAGE 1)

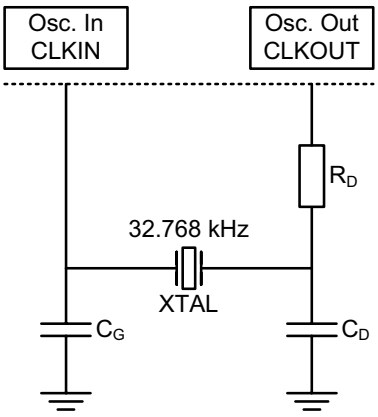
MICRO CRYSTAL SWITZERLAND

Pierce Oscillator

Design and Crystal Recommendations

Microchip PIC16F690

PIC16F690



Oscillator Design Check		
Test Conditions		
Power Supply Voltage V_{DD}	2.0 – 5.0	V
Load Capacitors C_D / C_G	22 / 22	pF
Serial Resistor R_D	220	kΩ
Results		
Effective Load Capacitance	12.33	pF
Oscillation Allowance[1)]	417	kΩ
Oscillator Output Voltage AC[2)]	690	mV_{RMS}
Drive Level[2)]	0.300	µW
Startup Time[1)]	600	ms
R_D min. for Safe Overtone Mode Suppression	110	kΩ

1) Measured at V_{DD} = 2.0 V.
2) Measured at V_{DD} = 5.0 V.

Recommendation		
Crystal		
Crystal Type	MS1V-T1K	
Frequency	32.768	kHz
Load Capacitance C_L	12.5	pF
Tolerance	+/-20	ppm
Oscillator Design		
R_D	220	kΩ
C_D	22	pF
C_G	22	pF

Remarks

The PIC16F690 consists of a self limiting Pierce Oscillator. Due to internal voltage regulator, the oscillator characteristics and performances remain stable down to V_{DD} = 2.4 V. Below this level, the waveforms change; however the oscillator works safely down to V_{DD} = 2.0 V.

The serial resistor R_D is needed for safe overtone mode suppression. Despite a 110 kΩ resistor would be sufficient, a resistor value of 220 kΩ is recommended in order to reduce the crystal's drive level.

Placing C_D = 22 pF and C_G = 22 pF load capacitors on each side of the crystal results in an effective load capacitance of 12.33 pF (including board stray capacitances) which is a perfect match for a crystal specified for C_L = 12.5 pF.

The oscillator circuit provides an oscillation allowance of 417 kΩ; this allows the safe use of smallest SMD quartz crystals (ESR ≤ 80 kΩ).

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Page 1/3

Headquarters: Micro Crystal
Div. of ETA SA
Mühlestrasse 14
CH-2540 Grenchen
Switzerland

Tel. +41 32 655 82 82
Fax +41 32 655 82 83
Internet www.microcrystal.ch
Email sales@microcrystal.ch

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FIGURE 4: CHARACTERIZATION REPORT (PAGE 2)

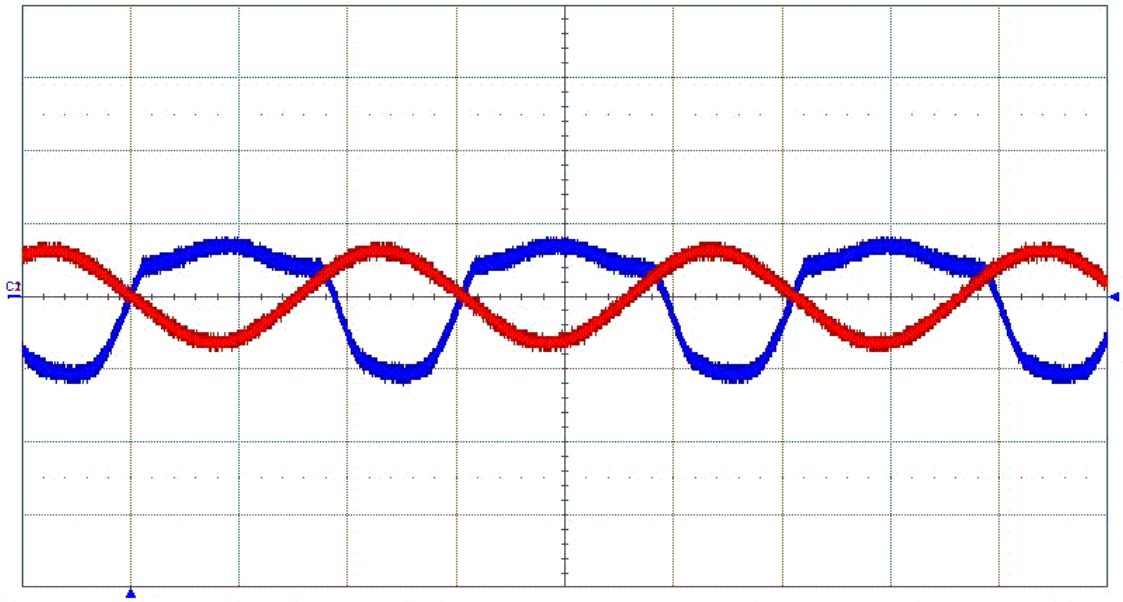
MICRO CRYSTAL SWITZERLAND

Pierce Oscillator

Design and Crystal Recommendations

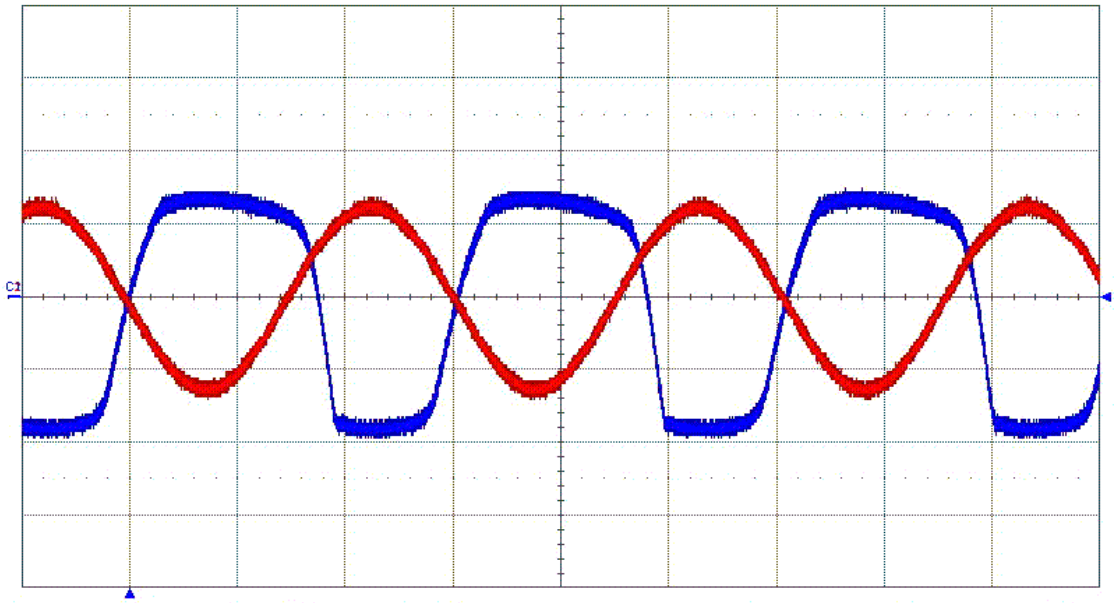
Microchip PIC16F690

Oscillator Input and Output waveforms (V_{DD} = 2.0V):



C1: CLKOUT (500 mV/div - AC) C2: CLKIN (500 mV/div - AC) Time base: 10 µs/div

Oscillator Input and Output waveforms (V_{DD} = 5.0V):



C1: CLKOUT (500 mV/div - AC) C2: CLKIN (500 mV/div - AC) Time base: 10 µs/div

FIGURE 5: CHARACTERIZATION REPORT (PAGE 3)

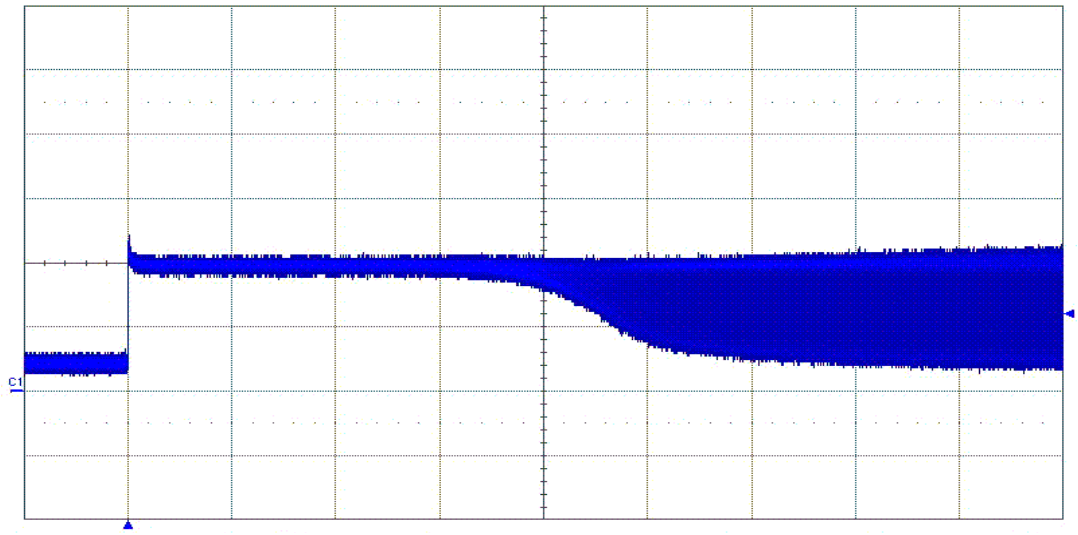
MICRO CRYSTAL SWITZERLAND

Pierce Oscillator

Design and Crystal Recommendations

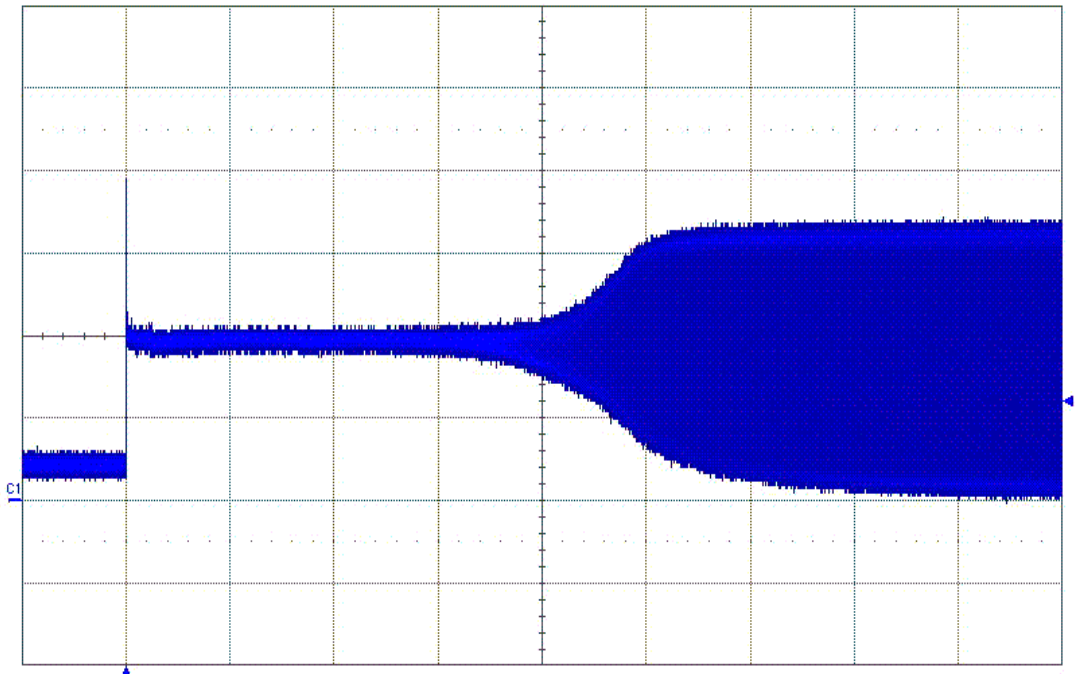
Microchip PIC16F690

Oscillator Output start-up waveform (V_{DD} = 2.0V):



- C1: CLKOUT (500 mV/div - DC) Time base: 100 ms/div

Oscillator Output start-up waveform (V_{DD} = 5.0V):



- C1: CLKOUT (500 mV/div - DC) Time base: 100 ms/div

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