# WAN-0154

# Calculating Crystal Oscillator Circuit Values

## INTRODUCTION

Some of Wolfson Microelectronics' ICs feature a crystal oscillator circuit, designed to drive an external crystal. This saves cost over a separate crystal oscillator, but some care is needed in selecting the crystal type and the external load capacitors. This Application Note details how to calculate the required parameters.

## PARAMETERS OF INTEREST

Crystal manufacturers specify the load capacitance their crystal requires. This is because the load capacitors form part of a tuned resonant circuit. They must be of the correct value so that the circuit oscillates at the correct frequency in the best possible manner i.e. with maximum Q.

A common mistake is to assume that this load capacitance figure refers to the value of the load capacitors $C_{L1}$ and $C_{L2}$, as seen in Figure 1. It does not. It refers to the capacitance, $C_L$, which the crystal sees across its terminals, as shown in Figure 2. In a real circuit, it is effectively $C_{L1}$ and $C_{L2}$ in series, in parallel with the chip capacitance, which is $C_{XTI}$ and $C_{XTO}$ in series, as shown in Figure 1. (There is also some PCB track capacitance, but that should be too small to be concerned about.)

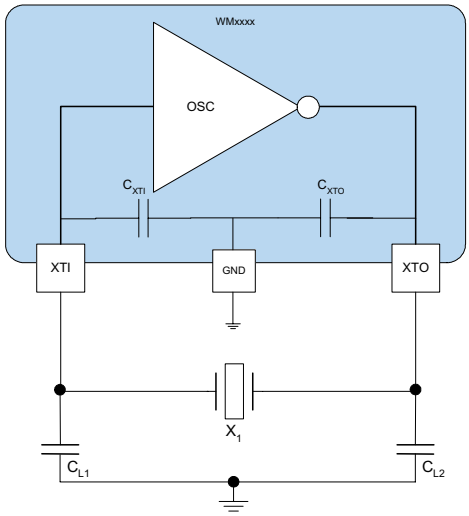


**Figure 1 Oscillator Circuit**

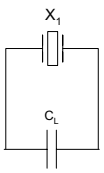


**Figure 2 Crystal Specification**

The oscillator circuit inside Wolfson chips is also designed to work with a range of load capacitances, so the crystal must be chosen to match this. **If the load capacitances are outside the correct range, the oscillator may take a long time to start up or may not oscillate stably.** Furthermore the circuit is designed to work with fundamental oscillation mode crystals, which are the most common type for the frequencies required by Wolfson ICs, rather than harmonic mode ones.

## CALCULATING THE VALUES

The Wolfson oscillator circuit works best with load capacitors in the range 15-22pF. The crystals most readily available favour the higher end of the range, so users should choose 22pF. The capacitors should have NP0 or C0G dielectric.

Please check the datasheet for the XTI and XTO capacitances for your particular chip. For most Wolfson devices, $C_{XTI}$ = 5pF and $C_{XTO}$ = 3pF.

$$C_L = \frac{C_{L1}.C_{L2}}{C_{L1}+C_{L2}} + \frac{C_{XTI}.C_{XTO}}{C_{XTI}+C_{XTO}}$$

Our recommendation is a crystal with load capacitance specification of ideally 15pF. (Somewhere in the range 12-18pF will be okay in practice.) Some manufacturers call this load capacitance “circuit condition”. (This should not be confused with static or shunt capacitance, which is different.) The crystal should be a “fundamental” oscillation type and not a “harmonic” type. The Wolfson oscillator is capable of providing up to 1mW drive, so any crystal requiring 1mW or lower drive level is acceptable. (Typically modern crystals require 100µW, which will work satisfactorily with the Wolfson oscillator circuit.)

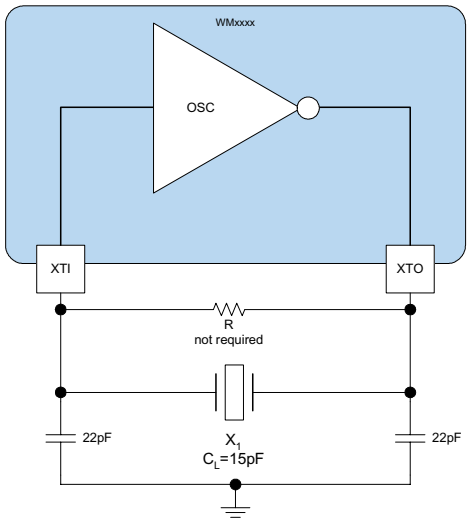


**Figure 3 Recommended Values**

Please also note some manufacturers show a parallel resistor with their oscillator circuit. This is not required for Wolfson chips.

| CRYSTAL PARAMETER | RECOMMENDED VALUE |
|---|---|
| Oscillation mode | Fundamental (AT cut) |
| Load capacitance | 15pF (12-18pF ok) |
| Drive level (max.) | 1mW or lower |

**Table 1 Recommended Crystal Parameters**

## APPLICATION SUPPORT

If you require more information or require technical support, please contact the Wolfson Microelectronics Applications group through the following channels:

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Mail: Applications Engineering at the address on the last page

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