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Loading Effects of Grounding the Crystal Lid In a Ceramic SMD Packaged Crystal

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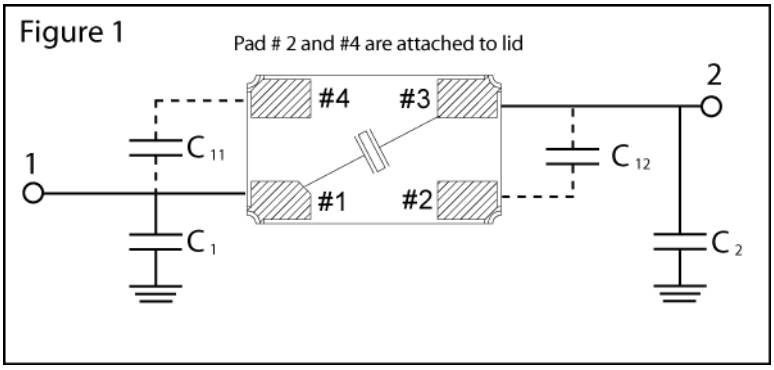
In the typical crystal oscillator application circuit the crystal is connected in a pi circuit as shown in Figure 1. The crystal is in the series arm with loading capacitors C1 and C2 in the shunt arms. Terminals 1 and 2 are connected to the oscillator IC. The typical four lead SMD ceramic crystal, as shown pictorially in Figure 1, has two pads connected to the crystal and two pads, which may be grounded, connected to the metal lid. As illustrated in Figure 1, there are stray capacitances (C11,C12) between the crystal and the metal lid. The two stray capacitances will not be equal in value. The capacitance between the top crystal electrode and the lid will be much larger than the other capacitance which is mostly between the ground pin and the signal pin from the lower electrode.



The frequency of the crystal oscillator may be affected slightly by grounding the crystal lid. The amount of this frequency difference can be predicted by examining the equivalent circuits of the grounded and ungrounded cases. Figure 2 shows the equivalent circuit for the ungrounded case. The stray capacitors appear in series across the crystal and will add directly to the effective load capacitance of the crystal oscillator circuit.

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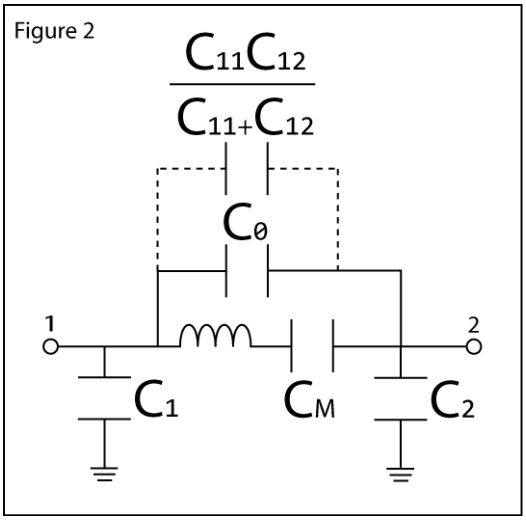
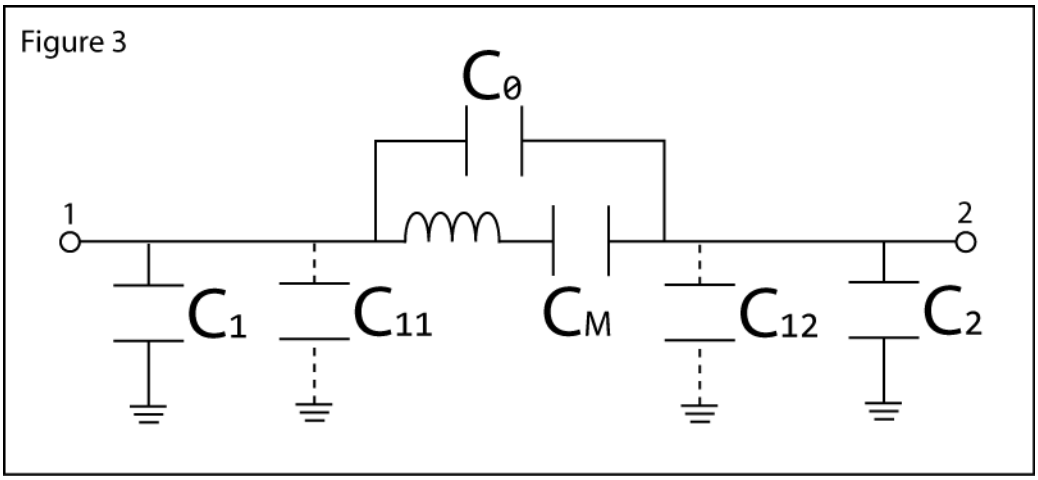


Figure 3 shows the equivalent circuit which results when the crystal lid is grounded. In this case the stray capacitors appear in shunt with the loading capacitors. Evaluation of the effective crystal load capacitance for the two circuit arrangements shows a slight difference between the two cases. For typical values of stray capacitance the difference is a small fraction of a Pico Farad and the affect should be negligible.



In the crystal test station (Saunders 250B) the crystal is measured in a low impedance test circuit and the stray capacitances (C11,C12) are effectively shorted out by the terminations when the lid is grounded thus reducing the effective load capacity. As a result, the frequency for a loaded crystal will be lower for the ungrounded crystal than for the grounded crystal when measured in this circuit.