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Limitations of 16 MHz Crystal Oscillators

Covers MC68HC08AZ60A, MC68HC908AZ32A, and MC68HC908AS32A Microcontrollers

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1 Introduction

This bulletin discusses the limitations of using 16 MHz crystal oscillators with the MC68HC08AZ60A, MC68HC908AZ32A, and MC68HC908AS32A microcontrollers and describes how to implement a stable oscillator circuit.

Typically a 4.9152 MHz crystal oscillator is used with a MC68HC08AZ60A. Applications running 16 MHz crystals require greater consideration and attention towards the oscillator layout, component choices, and operating conditions than a 4.9152 MHz crystal requires. As a result, you may experience difficulties running a 16 MHz crystal in your application.

2 Using 16 MHz Crystal Oscillators with the MC68HC08AZ60A, MC68HC908AZ32A, or MC68HC808AS32A

Oscillator circuits can be viewed as a loop: an amplifier drives the circuit components and a crystal provides feedback to the amplifier. The fundamental criteria for oscillation, as postulated by Barkhausen, is that the initial gain in the oscillator circuit is at least unity and that the phase shift is zero at the resonant frequency.

If the initial gain is greater than unity, noise within the circuit is amplified and fed back in phase at the desired frequency to the input. If the gain is at least unity, oscillation will be maintained.

The gain margin of an oscillator circuit indicates the amount the gain can vary while maintaining oscillation. For stable and reliable oscillator operation, gain margin must be maximized where possible. This is especially important where higher frequency crystals are used because gain margin is inversely proportional to frequency.

Undesired parasitic loads in the oscillator circuit will cause losses that reduce the gain and, consequently, the gain margin. To maximize the gain margin for higher frequency crystal oscillators, carefully select a crystal and component for the oscillator circuit. Good layout practices minimize undesired parasitic loads in the circuit.

3 16 MHz Crystal Oscillator Best Practices

Reliable and stable operation of a 16 MHz crystal oscillator with an MC68HC08AZ60A, MC68HC908AZ32A, or MC68HC808AS32A MCU necessitates circuit layout and routing which are 100% optimized for the crystal and its components. Therefore, you must ensure that your board is designed for optimum oscillator performance.

When designing PCBs for 16 MHz crystal oscillators, the following precautions must be taken for oscillator circuitry:

- When using PCB layout software, first impose the routing of the oscillator and its associated components. Layout constraints must be reported on the other signals, not on the oscillator circuit.
- Mount the oscillator components as close to the MCU as possible.
- Parasitic capacitance will reduce gain margin. Keep this to an absolute minimum.
  - OSC1 to V_{SS} × 1 pF
  - OSC2 to V_{SS} × 1 pF
  - OSC1 to OSC2 × 0.6 pF
- The effective series resistance of the crystal oscillator must not exceed 40 Ω. Lower is better.
- Keep OSC1 and OSC2 tracks as short as possible: 7.0 mm or less.
- Keep high-frequency clock trace lengths to a minimum.
- All routing from OSC1 and OSC2 through the external oscillator circuit components to the actual connection to V_{SS} must be considered.

- Because V_{SSA} is the ground connection for the analog portion of the clock generation module, it is important to connect V_{SSA} to V_{SS}.
- For minimum capacitance there must be no ground or power plane underneath the oscillator pins, the components that make up the oscillator circuit, and the oscillator circuit routing. Equally avoid the use of multi-layer PCBs.
- Isolate OSC1 from OSC 2 with a V_{SS} shield where possible. The shield is required for noise isolation, but must be spaced 1 mm from the OSC1 and OSC2 traces to reduce capacitance.
- Do not cross the oscillator component tracks with any other track on any level.
- Surface mount components reduce the susceptibility of signal contamination.
- Load capacitors must be low leakage and stable across temperature—NPO or C0G type.

These precautions require careful crystal selection and good oscillator circuit design, which may not match the cost or physical space limitations of the application.

4 16 MHz Crystal Oscillator Alternative Strategies

Achieving optimum oscillator performance will not always be possible. Applications are obliged to satisfy other requirements over and above the layout and routing of the oscillator circuit, and therefore, some compromise is required.

If you are unable to fulfil all the requirements for optimum oscillator performance, use a lower frequency crystal with the PLL module to generate the desired customer bus frequency or change the clock source from a crystal to a resonator.

5 Disclaimer

As with any application assistance Freescale provides, this is our best-recommended solution. You retain the final decision relative to the total design and functionality of the end product. Freescale neither guarantees nor will be held liable for the success of its end-customer designs or projects.

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