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Using Resonators with the MC(9)S08Rx Family

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Introduction

This engineering bulletin discusses special considerations for using ceramic resonators with the MC(9)S08Rx Family of microcontrollers in environments where the resonator element may be subject to mechanical stress such as the impact due to the system being dropped and the MCU is in run mode.

Background Information

A key feature of the MC(9)S08Rx microcontrollers is low-power operation. Many elements of the design of these microcontrollers contribute to the ability to operate at low voltages with low current consumption. One of these elements is the innovative low-power oscillator incorporated in the MC(9)S08Rx microcontrollers.

A ceramic resonator is a piezoelectric transducer. It converts electrical energy to force and force to energy. In normal operation, the resonator mechanically vibrates at a resonant frequency in response to the electric potential applied to it by the microcontroller's oscillator circuitry. But if the piezoelectric element is subject to an external stress such as an impact to the resonator, then an electric current is generated. This current charges the load capacitors creating a differential voltage from EXTAL to XTAL (see Figure 1). The differential voltage is proportional to the transient force that was applied to the resonator. This voltage is partially dissipated by the feedback resistor.

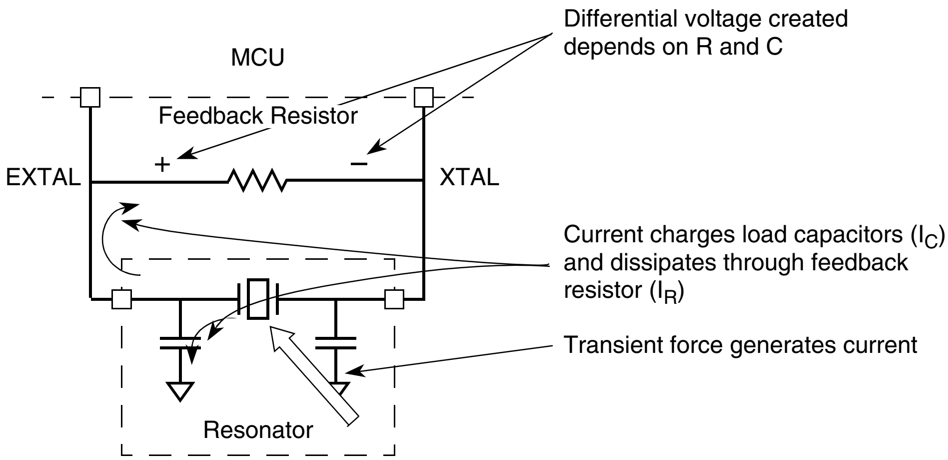

Figure 1. Effects of Transient Force on Resonator Circuit

As the differential voltage between EXTAL and XTAL increases through the point where their overlap is just larger than the hysteresis of the input buffer, narrow clock pulses can be generated by the buffer (see Figure 2).

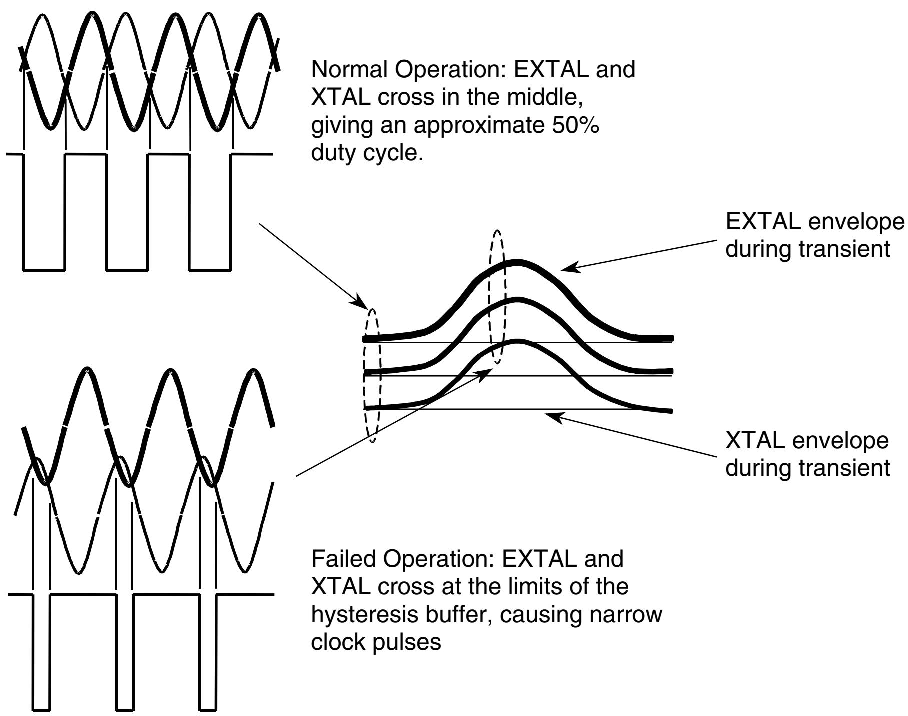

Figure 2. Normal and Transient Resonator Waveforms

These narrow pulses effectively are a high frequency input to the clock input of the microcontroller. This causes an attempt to run the microcontroller at frequencies out of the specified range of operation. The internal logic of the microcontroller was not designed to handle frequencies beyond the specification and therefore the operation of the microcontroller may become unpredictable. Experiments have shown that many of these events cause operation typical of code runaway where the MCU is operating out of the normal software flow. The highest force events may cause the MCU to simply quit operating.

Recommendations

There are several ways to deal with this issue. Not all the following recommendations may apply to a given application. The designer must examine these and verify which ones are effective in eliminating the effects of mechanical stresses on the resonator.

- **Mechanical Protection:** Protecting the resonator from the sources of mechanical stress may resolve the issue at the source. The possible solutions include using resonators with longer, more flexible leads that keep mechanical shocks from being transmitted from the pc board to the resonator. Another mechanical solution is to protect the resonator from shock with additional padding.
- **Stop Mode:** If the application can sense when it is in an environment subject to shock then place the MCU in Stop Mode. In Stop, the MCU is not being clocked by the external resonator and therefore would not be subject to the high frequency events brought on by mechanical stress to the resonator.
- **Code Runaway Protection:** The MC(9)S08Rx MCU's offer several ways to detect and deal with code runaway conditions. These methods need to be analyzed for the particular application and implemented in ways that are appropriate for that application. These methods will be discussed briefly here. Additional documentation on how to implement them may be found in the data sheet and application notes.
  - The Computer Operating Properly or COP watchdog allows for detection of software execution outside of the expected flow. If the COP is not serviced as expected, then a reset occurs. After reset, the System Reset Status (SRS) register may be interrogated to determine if a COP reset has occurred and then take appropriate action to recover.
  - The illegal address reset is triggered by attempts to access addresses that are outside the valid range for ROM/Flash, RAM, or registers as might happen if the CPU has runaway. After reset, the System Reset Status (SRS) register may be interrogated to determine if an illegal address reset has occurred and then take appropriate action to recover. (Note that the illegal address reset is not available in the 60K versions.)
  - If the CPU attempts to execute an opcode that is not valid, then an illegal opcode reset occurs. This might happen if the CPU attempts to execute in the valid program code range, but, because it is not operating correctly, it tries to execute data as an opcode. A way to make use of this fact is to fill any unused ROM/Flash and RAM locations with an illegal opcode (e.g., $8D). Then if the CPU starts executing in these areas, it will cause a reset. After reset, the System Reset Status (SRS) register may be interrogated to determine if an illegal opcode reset has occurred and then take appropriate action to recover.
- **Circuit Modifications:** A final option involves modifying the oscillator circuit components. Because this modification involves an extreme change to the component values, care must be taken in implementing this option. Board layout becomes more critical. Careful evaluation and characterization of the final product should be performed to verify correct operation under all voltage and environmental conditions.

  Looking back at the root cause discussion, it was noted that the voltage differential between EXTAL and XTAL is dissipated by the feedback resistor. If the value of the feedback resistor is decreased, then that charge will be dissipated faster through the resistor. It also has the effect of re-biasing the amplifier quicker allowing it to adjust to the changing current demand. For the MC(9)S08Rx MCU's only, the feedback resistor may be reduced to 22 kohm.

The consequence of this change to the feedback resistor is that this raises the minimum gain (gm_min) that the amplifier must provide to start and sustain acceptable amplitude. The gain of the amplifier can't be increased, so other components must be changed to compensate.

The typical value for the internal load capacitors in ceramic resonators in the 8/16 MHz range is 30 pF. This must be reduced to 15 pF in order to use the 22 Kohm feedback resistor. Additionally, the resonator must also have an ESR of less than 50 ohm and case capacitance of 5 pF or lower. The resonator should be physically close to the OSC1 and OSC2 pins with short pc board traces to reduce parasitic capacitances.