DESIGN OF RECONFIGURABLE FREQUENCY MEASUREMENT SYSTEMS FOR HIGH-ACCURACY QCM SENSORS

Elena Lago Pousa, Mª José González Braña, Mª José Moure, Mª Dolores Valdés and Juan J. Rodríguez-Andina

Abstract

Quartz Crystal Microbalance (QCM) sensors are widely used as high-accuracy mass sensors in several application domains. Their sensing principle is the variation of frequency of a crystal-based oscillator circuit with the mass deposited on the plates of the crystal. Therefore, the main parameter to be measured in QCM applications is the oscillation frequency, which in practice ranges from 5 to 27 MHz. The topology of the QCM determines some of its characteristics, as the noise immunity or the maximum achievable accuracy, which in a practical application must allow the minimum significant change on the mass to be measured. As environmental conditions (e.g., temperature) influence both the behaviour of the oscillator and the measurement instrumentation, it is desirable to design QCM sensors with an integrated measurement system including compensation of these effects. In addition, this would allow autonomous measurement systems to be developed.

This paper presents the design of a FPGA-based reconfigurable system for frequency measurement in QCM sensors for mass measurement in damping media. The two main frequency measurement methods are considered: counting clock pulses during a predefined time interval or measuring the clock period and computing the inverse value. The advantages and disadvantages of both methods for the intended application are discussed. It can be concluded that, according to the frequency range and the reference clock used, the first method is preferred in this case.

The use of FPGAs has many advantages with respect to the traditional ASIC solution, the most important being the possibility of adapting the system to different crystal/oscillator topologies, the use of configurable timing references and the availability of reconfigurable arithmetic resources that ease the implementation of the circuitry to compensate the effect of the environmental conditions. Using a 9MHz QCM, different implementations of the frequency meter are tested in both Spartan-3 and Virtex-II FPGAs from Xilinx. From the experimental results obtained, the advantages and disadvantages of using different logic resources available on those devices (as, for instance, distributed vs. embedded RAM or taking advantage of integrated DLLs for synchronization and frequency division) are discussed.