Title: Fast Startup and Fully Differential Crystal Oscillator

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Abstract: Crystal oscillators are essential circuits in low-power wireless systems. The de-facto standard circuit for a crystal oscillator is the 3-points Pierce oscillator. Despite the simplicity and good performance of this circuit, when designed properly, it has some important drawbacks: Large required capacitance, slow and very inefficient startup and single-ended operation, hence poor common-mode rejection. This paper discusses these drawbacks and presents an alternative circuit to overcome these drawbacks. The proposed crystal oscillator is a switched capacitor circuit, depicted in Figure 1. The load capacitor is connected directly in parallel to the crystal, in contrast to a series connection of two capacitors to ground as in the Pierce oscillator. This reduces the required capacitance with almost a factor four. The proposed oscillator is also fully symmetrical and fully differential, unlike the 3-points Pierce oscillator which is a single-ended circuit. This results in an orders of magnitude better common-mode rejection ratio which is very important when used in a noisy environment.

Energy efficient and fast startup of the crystal oscillator is essential in low-power wireless systems with short receive and transmit periods. This is achieved by the proposed self-timed energy injection, depicted in Figure 2. Unlike several other fast-startup crystal oscillators, it doesn't require an accurate additional oscillator, nor does it require calibration. A block-wave is applied to the crystal via short drive pulses. The switching moment of the block-wave is aligned to the zero-crossing of the harmonic current by differentiating and comparing the open-loop voltage across the crystal, which is exactly 90 degrees out of phase with the harmonic current.

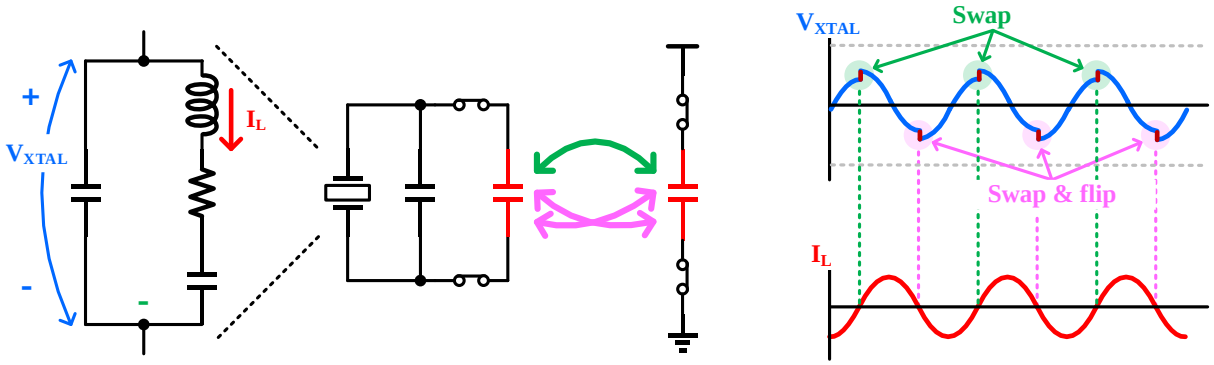

Fig.1. Proposed Switched Capacitor Crystal Oscillator during steady-state operation.

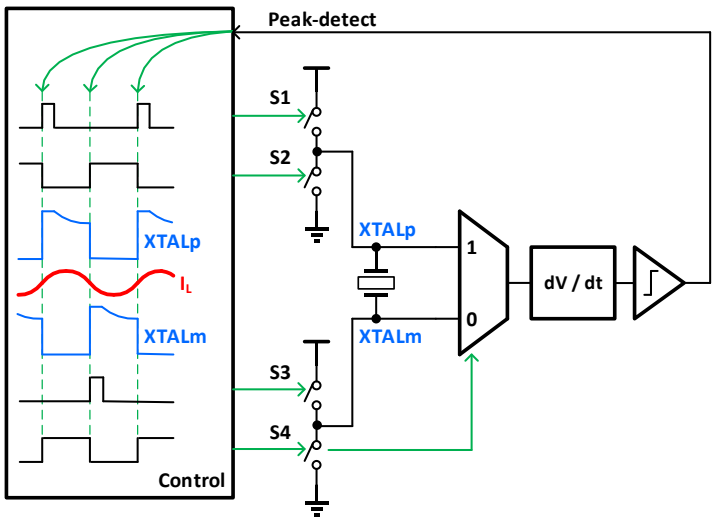

Fig.2. Proposed Fast-startup by self-timed energy injection.

Author / Presenter BIO:

- Master in 1990 (Twente University, NL), PhD in 1996 (TU Eindhoven, NL).
- Working as a designer/inventor of analog circuits ever since.
- Currently Senior Member of Technical Staff at Renesas.
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