Many-valued Logic-memory Elements Based on Nano-scale Electromechanical Oscillators

Yingming Yan$^1$, B. Zhang$^2$, and Shigu Cao$^3$,*

$^1$Exponent, Hong Kong SAR, China
$^2$Physics Department of Hong Kong University of Science and Technology, Hong Kong SAR, China
$^3$HKUST Shenzhen-Hong Kong Collaborative Innovation Research Institute, Futai, Shenzhen, China

Abstract—With nonlinear effects in the electromechanical oscillators, subharmonic oscillations can be generated, whose period is multiple that of the driving signal. Such oscillations possess multiple states with identical amplitude and evenly offset phases. Their phases can be used to encode information which was proposed early to half a century ago with the name “Parametron”. Until recently, the oscillations with a period tripled that of the drive just realized through enhanced energy transfer between the modes with a ratio of eigenfrequencies close to 1:3 in the micro-scale mechanical resonator. In this paper, we demonstrate a well-designed structure of a nano-scale GaAs beam resonator that can generate period-tripled subharmonic oscillations through the mode coupling at 1:3 internal resonances using numerical simulation and theoretical analysis. The generated states can be used to encode and store information on a base-3 basis. Similar to the micro-scale counterpart, for encoding, an extra excitation pulse is required. By changing its phase, the resonator can switch among the stable states. Furthermore, multiple sets of period-tripled states can be generated via different excitation schemes or nonlinear effects. This design has a smaller size, lower energy consumption, and higher operating frequency in comparison with the micro-scale resonators, which favors the practical applications of the mechanical-based many-valued logic elements.

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*Corresponding author: Shi-Gu Cao (sgcao@alumni.ust.hk).