Dual-Mode Oscillator utilizing Higher Overtones of the SC-cut Resonator Operating over Extended Temperature Range

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A demand for reliable and robust dual-mode oscillators for harsh high-temperature high-pressure environments has been growing recently. For example, robust oscillator circuits are required for driving dual-mode pressure / temperature piezoelectric sensors for down-hole explorations in the oil & gas industry; and they may be essential for future deep geothermal drilling technologies as well[1,2]. This paper presents the dual-mode crystal oscillator (DMXO) that we designed, optimized, and evaluated over an extended temperature range up to 215°C. The designed DMXO comprises two modified Buttler oscillators (i.e., the two gain loops) sharing a common 10-MHz 3rd-overtone stress compensated (SC) quartz resonator. The first loop ensures an excitation of the main 3rd overtone slow thickness-shear mode (i.e., the c mode), while the second loop ensures an excitation of the higher 5th overtone fast thickness-shear mode (i.e., the b mode) in the common volume of the SC resonator. One important advantage of this configuration is that the resonant frequency of the excited b mode is far from (approximately 82% above) the resonant frequency of the main excited c mode; hence the mode separation in the DMXO is simpler. Since the two gain lops share the common SC resonator, the two specific separation filters have been designed to provide sufficient isolation of the two loops each from other. The measured frequency vs. temperature dependencies of the two excited modes are illustrated in Fig. 1. The 3rd overtone c mode is both temperature and stress compensated, while the frequency of 5th overtone b mode decreases almost linearly with temperature with an average negative slope of -30 ppm / °C; hence for the SC resonator's self-thermometry implementation, this higher overtone b mode can be considered as well. We have evaluated the first realized DMXO prototypes over the extended temperature range between 10°C and 215°C, where they operated reliably without any activity dips. Investigations of the DMXO prototype's operation reliability at negative temperatures will follow soon as well.

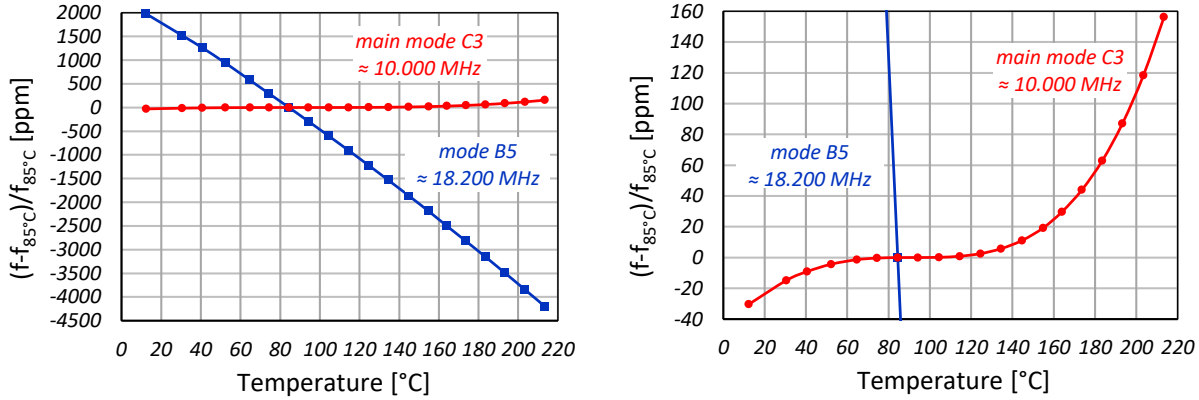

Fig.1 Measured frequency vs. temperature characteristics of the two thickness-shear modes of used SC quartz resonator simultaneously excited with assistance of the developed DMXO.

[1] M. S. Patel, and B. K. Sinha, "A dual-mode thickness-shear quartz pressure sensor for high pressure applications", IEEE Sensors J., vol. 18, no. 12, p. 4893-4901, 2018.

[2] I. Kocis, T. Kristofic, M. Gebura, G. Horvath, M. Gajdos, and V. Stofanik, "Novel deep drilling technology based on electric plasma developed in Slovakia", URSI GASS, Montreal, Canada, August 2017.

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