Direct Frequency-to-Digital Gyroscopes with Low Drift and High Accuracy

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MEMS gyroscopes are used in everyday life for a variety of applications such as gaming and image stabilization. However, long-term stability of commercial MEMS gyroscopes is still a big handicap for navigation requirements.

All sensors measure input relative to a reference. Conventional gyroscopes are based on amplitude modulation (AM). They measure rate indirectly and synthesize the reference implicitly from a combination of transducer dynamics and readout circuit gain. By contrast, frequency-modulated (FM) gyroscopes measure rate directly as a frequency and use an external precision reference clock offering several advantages: accurate scale factor, large dynamic range, and robust performance over temperature variation.

Dr. Eminoglu will discuss different techniques to enhance performance with the FM gyroscopes that measure rate signal directly as frequency variations and employs a rate chopping technique to reject drift using a reference clock to set the scale factor. Symmetric and asymmetric readout modes trade-off long- versus short-term errors without changing the transducer or circuits. Chopped at 10Hz, the prototype achieves better than 40ppm scale-factor accuracy, 1.5deg/hr1.5 rate-random walk in symmetric mode and 1mdps/rt-Hz ARW in asymmetric mode.

Dr. Eminoglu joined BSAC as a Ph.D. student in 2012 after receiving his M.S. degree with high honors in Electrical and Electronics Engineering from Middle East Technical University (METU), Ankara, Turkey. His research interests include analog CMOS IC design, interface and control electronics for MEMS inertial sensors. In 2017 he received the Analog Devices Outstanding Student Designer Award and completed his Ph.D. in Electrical Engineering and Computer Sciences at UC Berkeley. He continues his work on high-performance frequency modulated gyroscopes with Prof. Bernhard Boser’s group as a Postdoctoral researcher.