VCO PLL Frequency Synthesizers for Spacecraft Transponders

Two documents discuss a breadboard version of advanced transponders that, when fully developed, would be installed on future spacecraft to fly in deep space. These transponders will be required to be capable of operation on any deep-space-communications uplink frequency channel between 7,145 and 7,235 MHz, and any downlink frequency channel between 8,400 and 8,500 MHz. The document focuses on the design and operation of frequency synthesizers for the receiver and transmitter. Heretofore, frequency synthesizers in deep-space transponders have been based on dielectric resonator oscillators (DROs), which do not have the wide tuning bandwidth necessary to tune over all channels in the uplink or downlink frequency bands. To satisfy the requirement for tuning bandwidth, the present frequency synthesizers are based on voltage-controlled-oscillator (VCO) phase-locked loops (PLLs) implemented using monolithic microwave integrated circuits (MMICs) implemented using InGaP heterojunction bipolar transistor (HBT) technology. MMIC VCO PLL frequency synthesizers similar to the present ones have been used in commercial and military applications but, until now, have exhibited too much phase noise for use in deep-space transponders. The present frequency synthesizers contain advanced MMIC VCOs, which use HBT technology and have lower levels of flicker (1/f) phase noise. When these MMIC VCOs are used with high-speed MMIC frequency dividers, it becomes possible to obtain the required combination of frequency agility and low phase noise.

This work was done by Scott Smith, Narayan Mysoor, James Lux, and Brian Cook of Caltech for NASA’s Jet Propulsion Laboratory. For further information, contact iaoffice@jpl.nasa.gov. NPO-42909.

Wide Tuning Capability for Spacecraft Transponders

A paper discusses general problems in estimation and control of the states (positions, attitudes, and velocities) of spacecraft flying in formation, then addresses the particular formation-flying-control problem of synchronization of deadbands. The paper presents a deadband-synchronization algorithm for the case in which the spacecraft are equipped with pulse-width-modulated thrusters for maintaining their required states. The algorithm synchronizes thruster-firing times across all six degrees of freedom of all the spacecraft. The algorithm is scalable, inherently adapts to disturbances, and does not require knowledge of spacecraft masses and disturbance forces. In this algorithm, one degree of freedom of one spacecraft is designated the leader, and all other degrees of freedom of all spacecraft as followers. The Cassini adaptive optimum deadband drift controller is the subalgorithm for control in each degree of freedom, and the adaptation is run until each spacecraft achieves a specified drift period. The adaptation is critical because a different disturbance affects each different degree of freedom. Then the leader communicates its thruster-firing starting times to the followers. Then, for each follower, a deadband-synchronization subalgorithm determines the shift needed to synchronize its drift period with that of the leader.

This work was done by Daniel Scharf, Fred Hadadegh, and Bryan Kang of Caltech for NASA’s Jet Propulsion Laboratory.

The software used in this innovation is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-43258.

Adaptive Deadband Synchronization for a Spacecraft Formation

A paper discusses general problems in estimation and control of the states (positions, attitudes, and velocities) of spacecraft flying in formation, then addresses the particular formation-flying-control problem of synchronization of deadbands. The paper presents a deadband-synchronization algorithm for the case in which the spacecraft are equipped with pulse-width-modulated thrusters for maintaining their required states. The algorithm synchronizes thruster-firing times across all six degrees of freedom of all the spacecraft. The algorithm is scalable, inherently adapts to disturbances, and does not require knowledge of spacecraft masses and disturbance forces. In this algorithm, one degree of freedom of one spacecraft is designated the leader, and all other degrees of freedom of all spacecraft as followers. The Cassini adaptive optimum deadband drift controller is the subalgorithm for control in each degree of freedom, and the adaptation is run until each spacecraft achieves a specified drift period. The adaptation is critical because a different disturbance affects each different degree of freedom. Then the leader communicates its thruster-firing starting times to the followers. Then, for each follower, a deadband-synchronization subalgorithm determines the shift needed to synchronize its drift period with that of the leader.

This work was done by Daniel Scharf, Fred Hadadegh, and Bryan Kang of Caltech for NASA’s Jet Propulsion Laboratory.

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