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 7,253 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 analog-to-digital and digital-to-analog converters, the sampling rates of which are chosen to minimize spurious signals and otherwise optimize performance. Several mixers and filters are used to properly route various signals.

This work was done by James Lux, 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 document presents additional information on the means of implementing a capability for wide tuning of microwave receiver and transmitter frequencies in the development reported in the immediately preceding article, “VCO PLL Frequency Synthesizers for Spacecraft Transponders” (NPO-42909). The reference frequency for a PLL-based frequency synthesizer is derived from a numerically controlled oscillator (NCO) implemented in digital logic, such that almost any reference frequency can be derived from a fixed crystal reference oscillator with micro-hertz precision. The frequency of the NCO is adjusted to track the received signal. Then, to create another NCO frequency used to synthesize the transmitted signal coherent with, and at a specified frequency ratio to, the received signal. The frequencies can be changed, even during operation, through suitable digital programming.

The NCOs and the related tracking loops and coherent turnaround logic are implemented in a field-programmable gate array (FPGA). The interface between the analog microwave receiver and transmitter circuits and the FPGA includes analog-to-digital and digital-to-analog converters, the sampling rates of which are chosen to minimize spurious signals and otherwise optimize performance. Several mixers and filters are used to properly route various signals.

This work was done by Daniel Scharf, Fred Hadaegh, 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.

Analysis of Performance of Stereoscopic-Vision Software

A team of JPL researchers has analyzed stereoscopic vision software and produced a document describing its performance. This software is of the type used in maneuvering exploratory robotic vehicles on Martian terrain. The software in question utilizes correlations between portions of the images recorded by two electronic cameras to compute stereoscopic disparities, which, in conjunction with camera models, are used in computing distances to terrain points to be included in constructing a three-dimensional model of the terrain. The analysis included effects of correlation-window size, a pyramidal image down-sampling scheme, vertical misalignment, focus, maximum disparity, stereo baseline, and range ripples. Contributions of sub-pixel interpolation, vertical misalignment, and foreshortening to stereo correlation error were examined theoretically and experimentally. It was found that camera-calibration inaccuracy contributes to both down-range and cross-range error but stereo correlation error affects only the down-range error. Experimental data for quantifying...