Goldstone Solar System Radar Waveform Generator

Pre-distortion of the transmitted signal to compensate for time-base distortion allows reception of an undistorted signal.

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Due to distances and relative motions among the transmitter, target object, and receiver, the time-base between any transmitted and received signal will undergo distortion. Pre-distortion of the transmitted signal to compensate for this time-base distortion allows reception of an undistorted signal. In most radar applications, an arbitrary waveform generator (AWG) would be used to store the pre-calculated waveform and then play back this waveform during transmission. The Goldstone Solar System Radar (GSSR), however, has transmission durations that exceed the available memory storage of such a device. A waveform generator capable of real-time pre-distortion of a radar waveform to a given time-base distortion function is needed.

To pre-distort the transmitted signal, both the baseband radar waveform and the RF carrier must be modified. In the GSSR, this occurs at the up-conversion mixing stage to an intermediate frequency (IF). A programmable oscillator (PO) is used to generate the IF along with a time-varying phase component that matches the time-base distortion of the RF carrier. This serves as the IF input to the waveform generator where it is mixed with a baseband radar waveform whose time-base has been distorted to match the given time-base distortion function producing the modulated IF output. An error control feedback loop is used to precisely control the time-base distortion of the baseband waveform, allowing its real-time generation.

The waveform generator produces IF modulated radar waveforms whose time-base has been pre-distorted to match a given arbitrary function. The following waveforms are supported: continuous wave (CW), frequency hopped (FH), binary phase code (BPC), and linear frequency modulation (LFM). The waveform generator takes as input an IF with a time varying phase component that matches the time-base distortion of the carrier. The waveform generator supports interconnection with deep-space network (DSN) timing and frequency standards, and is controlled through a 1 Gb/s Ethernet UDP/IP interface.

This real-time generation of a time-base distorted radar waveform for continuous transmission in a planetary radar is a unique capability.

This work was done by Kevin J. Quirk, Ferze D. Patawaran, Danh H. Nguyen, and Huy Nguyen of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-47730

Fast and Adaptive Lossless Onboard Hyperspectral Data Compression System

Implementation in a field-programmable gate array provides a practical, real-time system.

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Modern hyperspectral imaging systems are able to acquire far more data than can be downlinked from a spacecraft. Onboard data compression helps to alleviate this problem, but requires a system capable of power efficiency and high throughput. Software solutions have limited throughput performance and are power-hungry. Dedicated hardware solutions can provide both high throughput and power efficiency, while taking the load off of the main processor. Thus a hardware compression system was developed. The implementation uses a field-programmable gate array (FPGA).

The implementation is based on the fast lossless (FL) compression algorithm reported in "Fast Lossless Compression of Multispectral-Image Data" (NPO-42517), *NASA Tech Briefs*, Vol. 30, No. 8 (August 2006), page 26, which achieves excellent compression performance and has low complexity. This algorithm performs predictive compression using an adaptive filtering method, and uses adaptive Golomb coding. The implementation also packetizes the coded data. The FL algorithm is well suited for implementation in hardware. In the FPGA implementation, one sample is compressed every clock cycle, which makes for a fast and practical real-time solution for space applications.

Benefits of this implementation are:
- The underlying algorithm achieves a combination of low complexity and compression effectiveness that exceeds that of techniques currently in use.
- The algorithm requires no training data or other specific information about the nature of the spectral bands for a fixed instrument dynamic range.
- Hardware acceleration provides a throughput improvement of 10 to 100 times vs. the software implementation.

A prototype of the compressor is available in software, but it runs at a speed that does not meet spacecraft requirements. The hardware implementation targets the Xilinx Virtex IV FPGAs, and makes the use of this compressor practical for Earth satellites as well as beyond-Earth missions with hyperspectral instruments.

This work was done by Nazeeh I. Aranki, Didier Keymeulen, and Matthew A. Klimesh of Caltech, and Alireza Bakhshi of B&A Engineering for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-46867