Digital IF and IP Modems

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Overview

RT Logic is leading the way in the emerging field of satellite ground network architectures employing Digital IF front-ends and IP-Modems. In typical modems or radios, the Analog-to-Digital conversion is collocated with the DSP functions of the receiver. However, RT Logic's Digital IF technology allows a customer to conduct the analog-to-digital converter (ADC) very close to the antenna and then package the ADC samples into Digital IF packets. Using COTS network devices and standard IP packets, the ADC samples can be transferred to modems across the building or around the world without the negative effects of cable loss or distortions.

RT Logic has implemented systems for NASA programs using both of the leading standard formats for digitized IF data over IP networks: VITA-49 and Signal Data Distribution Standard (SDDS). Algorithms for these efforts support both narrowband and wideband data. We are also active in supporting the United States (US) Army's Open Standards Digital Interface (OSDI) development group for establishment of using VITA-49 in the next generation, all digital ground station architectures.

RT Logic products cover both ends of the architecture – digitization of RF bandwidth into samples contained in industry-standard IP packets, and the demodulation and/or remodulation of those samples in the IPmodem which can be local to the Digital IF front end or remotely located on the other side of the world. The generalized digital based ground station architecture - below - provides the basis for increased ease in scalability, maintenance, operations, standardization, test, and deployment, while preserving tracking performance, dynamic range, and control.

Key Features
- VITA-49 and SDDS standards
- RF to IP Packets and IP Packets to RF
- Software-based demodulation & modulation
- Leverages commodity IP-switching technology

Proven Benefits
- Improved scalability
- Improved control
- Reduced footprint
- Reduced maintenance
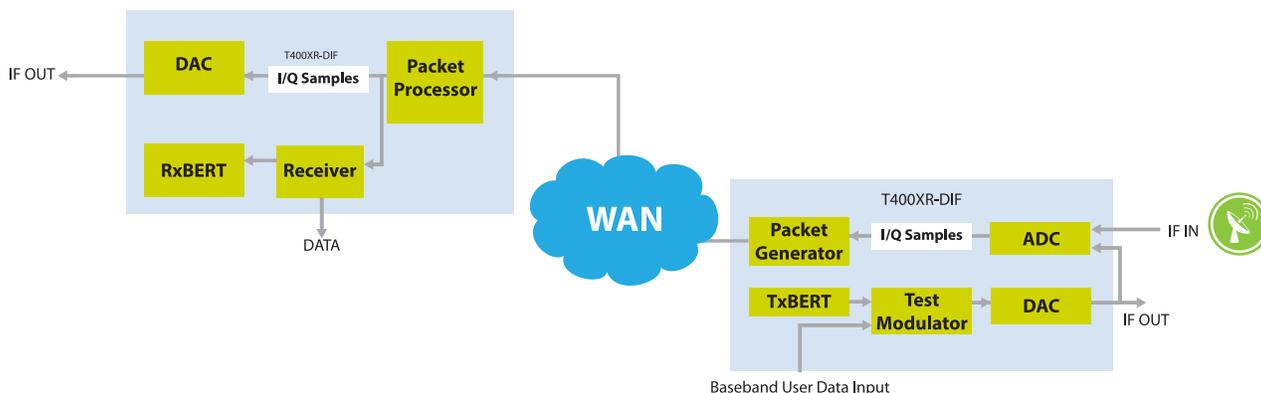
Current Non-Digital IF Architecture - Issues

Many current generation ground station sites use a single carrier conversion architecture illustrated in the diagram at right. A bank of modems operate at a common IF (such as 70 Megahertz (MHz) and racks of RF converters provide an upconverter and a downconverter for each modem. Distribution within the terminal is at RF which may be as simple as RF lines running from the converters to the combiners and dividers. Carriers are combined at RF for the uplink and likewise divided at RF on the downlink. The single carrier conversion architecture is the natural extension of a single carrier data stream where RF combiners and dividers are added to accommodate multiple carriers.

The single carrier conversion terminal architecture has limitations when driven by increased mission capacities for data rate and bandwidth, which in turn drive requirements for higher frequencies where management of the following increases in complexity:

- Acceptable noise levels becomes more difficult along with increased distortion due to linearity of active components, amplitude response flatness, and phase response linearity of all components.
- Monitoring and control functions require a separate network. One modem and two converters must be configured for each link.
- Scalability is real estate limited, as each link requires dedicated up and down converters.
- Extreme care is necessary for deployment of a system implemented primarily at RF.
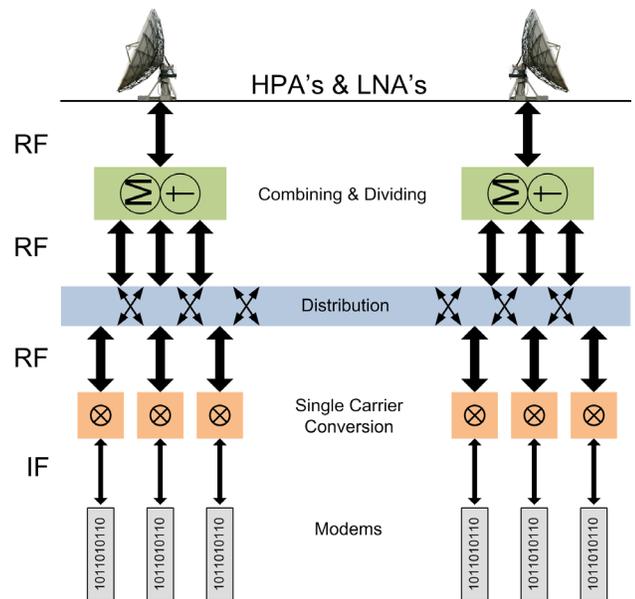
Next Generation Digital IF Architecture - Advantages

In contrast to single carrier conversion, the generalized Digital IF satellite communications Earth terminal architecture is illustrated at right. The following architectural differences apply relative to the single carrier conversion architecture:

- The modems operate directly over a common digital IF using IP format. The common digital IF format is a packet encapsulated overlapping-frame format conveying complex frequency-domain samples.
- Digital IF distribution is handled by either an Ethernet switch or a high speed IP router. Combining and dividing is done digitally, leveraging frequency domain processing. This simplifies switching by requiring minimal digital IF bit rates between modems and combiner-dividers, and minimizes computational loading on the combiner.
- RF deconstruction employs complex sampling and Fast Fourier Transform (FFT) algorithms to reduce RF downlink signals into digital IF. RF reconstruction employs inverse FFT algorithms and In-Phase/ Quadrature(I/Q) signal generation to convert Digital IF signals to RF for the uplink. RF conversion is done as close as possible to respective High Powered Amplifiers (HPA) and Low Noise Amplifiers (LNA). Ideally, conversion would be integrated into HPAs and LNAs, with IF interfaces to each accomplished using Ethernet.

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