The NASA Spacecraft Transponding Modem

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Abstract:

A new deep space transponder is being developed by the Jet Propulsion Laboratory for NASA. The Spacecraft Transponding Modem (STM) implements the standard transponder functions and the channel service functions that have previously resided in spacecraft Command/Data Subsystems. The STM uses custom ASICs, MMICs, and MCMs to reduce the active device parts count to 70, mass to 1 kg, and volume to 524 cc. The first STMs will be flown on missions launching in the 2003 time frame.

The STM tracks an X-band uplink signal and provides both X-band and Ka-band downlinks, either coherent or non-coherent with the uplink. A NASA standard Command Detector Unit is integrated into the STM, along with a codeblock processor and a hardware command decoder. The decoded command codeblocks are output to the spacecraft command/data subsystem. Virtual Channel 0 (VC-0) (hardware) commands are processed and output as critical controller (CRC) commands.

Downlink telemetry is received from the spacecraft data subsystem as telemetry frames. The STM provides the following downlink coding options: the standard CCSDS (7-1/2) convolutional coding, Reed-Solomon coding with interleave depths one and five, (15-1/6) convolutional coding, and Turbo coding with rates 1/3 and 1/6. The downlink symbol rates can be linearly ramped to match the G/T curve of the receiving station, providing up to a 1 dB increase in data return. Data rates range from 5 bits per second (bps) to 24 Mbps, with three modulation modes provided: modulated subcarrier (3 different frequencies provided), biphase-L modulated direct on carrier, and Offset QPSK. Also, the capability to generate one of four non-harmonically related telemetry beacon tones is provided, to allow for a simple spacecraft status monitoring scheme for cruise phases of missions.

Three ranging modes are provided: standard turn around ranging, regenerative pseudo-noise (PN) ranging, and Differential One-way Ranging (DOR) tones. The regenerative ranging provides the capability of increasing the ground received ranging SNR by up to 30 dB.

Two different avionics interfaces to the command/data subsystem's data bus are provided: a MIL STD 1553B bus or an industry standard PCI interface. Digital interfaces provide the capability to control antenna selection (e.g., switching between high gain and low gain antennas) and antenna pointing (for future steered Ka-band antennas).