9. Telemetry and Command Subsystem

The GOES-NOP telemetry and command (T&C) subsystem provides the functional interface between the spacecraft and ground command and control. It is composed of both radio frequency (RF) and digital (baseband) segments. Telemetry parameters describing the status, configuration, and health of the spacecraft payload and subsystems are downlinked to the Command and Data Acquisition (CDA) station and sent to the Satellite Operations Control Center (SOCC). Commands are received onboard the spacecraft for controlling mission operations and managing expendable resources. To perform these functions, the T&C subsystem's RF segment, configured as shown in Figure 9-1, comprises three antennas, two RF transponder units, and interconnecting microwave devices. The subsystem's digital segment, configured as shown in Figure 9-2, comprises redundant, distributed digital units including an internally redundant pyrotechnic squib driver unit. The T&C subsystem's RF segment configuration allows simultaneous operation of all T&C RF services without interference.

The T&C subsystem primarily interfaces with the NOAA Wallops CDA station during on-orbit operations. The NASA Deep Space Network (DSN) serves as a backup station for on-orbit operations and is the primary ground station for launch and orbit raising activities. The ground interfaces during orbit raising are with the DSN, Air Force Indian Ocean, and NASA Wallops CDA stations. These stations are compatible with the interface to the spacecraft T&C subsystem.

Telemetry

Information from the spacecraft provided via telemetry includes:

- Configuration status and housekeeping data from operational instruments
- Environmental sensing data from space environment monitor (SEM) instruments
- Configuration status and housekeeping data from various spacecraft subsystem units
- Health status for each receiver
- SSPA health status for each transmitter
- Power system parameters and voltages of critical electronic modules

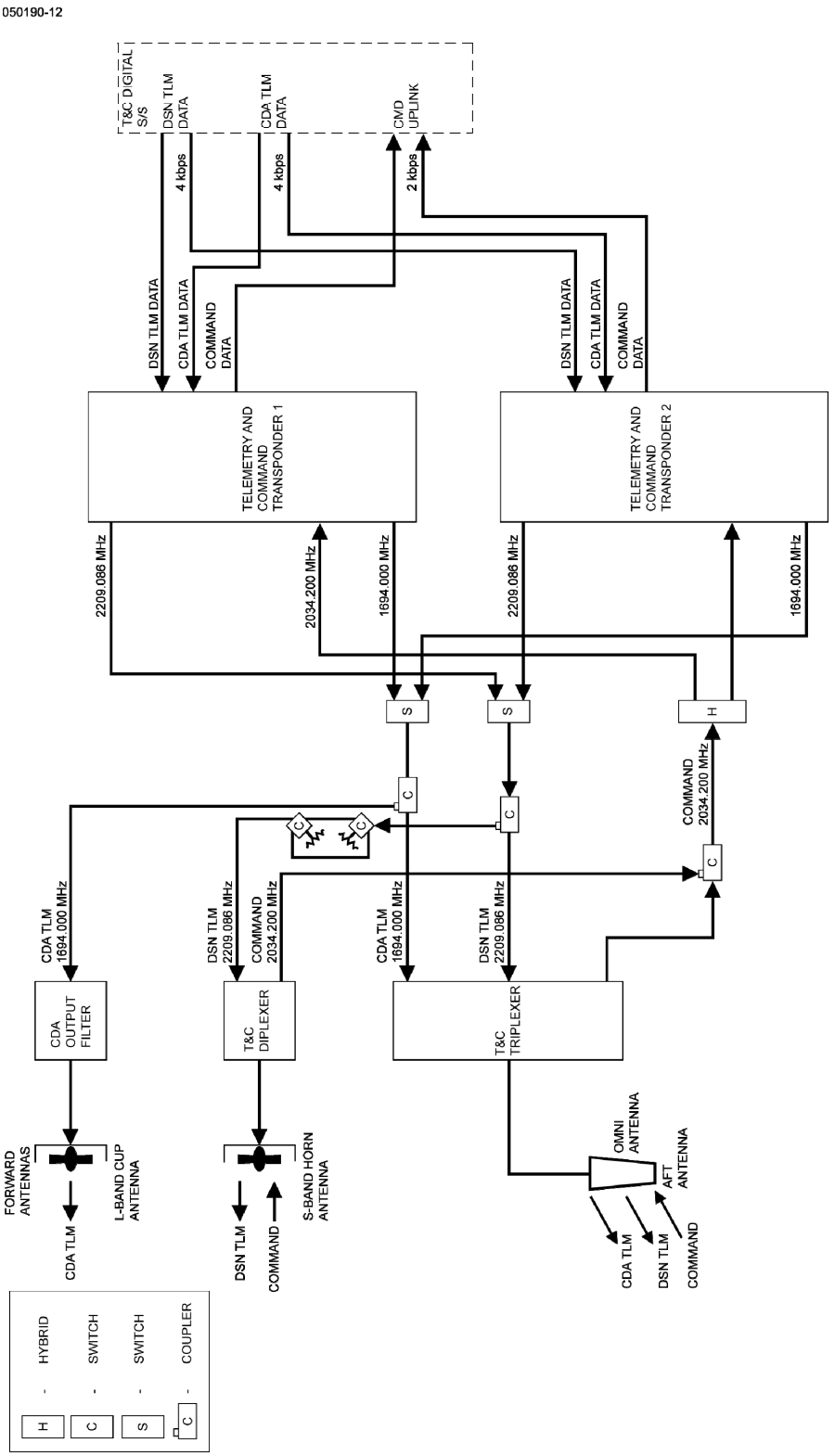

Figure 9-1. Telemetry and Command RF Subsystem Configuration

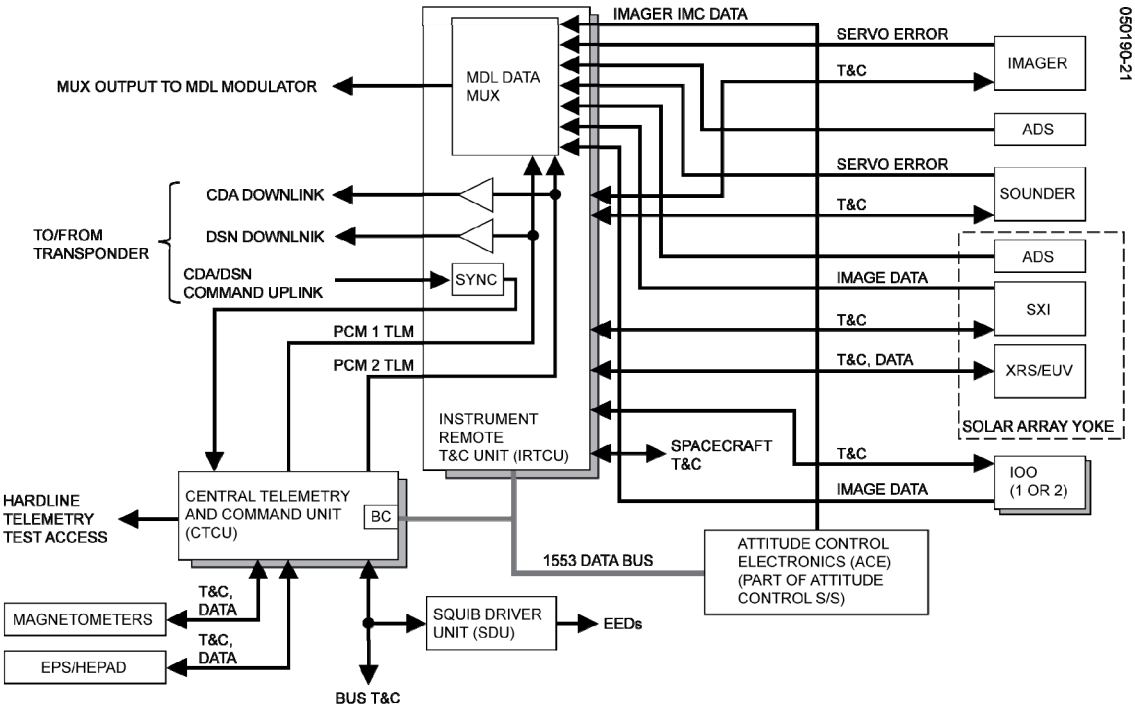

Figure 9-2. Telemetry and Command Digital Subsystem Configuration (Half-diagram)

- On/off status of all commandable equipment and heaters
- Temperatures of all major subassemblies
- Spacecraft attitude determination and control parameters
- Parameters of frame synchronization, spacecraft identification, command counter, secure mode operation, polycode, etc.

The telemetry function is "standby redundant," meaning that only one unit of a given pair is enabled and operational at a time. Most spacecraft housekeeping telemetry, as well as magnetometer and energetic particle sensor (EPS)/high energy proton and alpha detector (HEPAD) telemetry, is gathered by one of two central telemetry and command units (CTCUs) located in the spacecraft bus module. Communications/RF telemetry, some spacecraft housekeeping telemetry, and all remaining instrument telemetry is gathered by one of two instrument remote telemetry and command units (IRTCUs) located in the spacecraft payload module. In turn, the CTCU designated as bus controller (BC) collects the data either from itself or other remote terminal (RT) or attitude control electronics (ACE) units on the MIL-STD-1553 digital data bus (DDB) and then multiplexes, encodes, and formats the data into two (normal/normal or normal/dwell) serial pulse code modulated (PCM) bit streams. Both normal and dwell PCM data are generated simultaneously by the selected BC CTCU; either normal or dwell PCM data are provided to the four telemetry transmitters. Only one of the two CDA transmitters can be on at a time, and only one of the two DSN transmitters can be

on at a time. Each operating transmitter processes either a normal or a dwell PCM stream, depending on the configuration of the BC CTCU. The PCM streams generated by the BC CTCU can be either 1000 bps or 4000 bps. The telemetry data processed are either conditioned or unconditioned analog or bilevel, or serial digital (internal, external, or ACE). Most telemetry inputs are single-ended. For the Imager and Sounder, select analog data are received differentially to minimize susceptibility to noise. Each analog signal is converted into a digital signal at 12 bit resolution, but with few exceptions is downlinked in normal telemetry with a lower resolution of 8 bits. The telemetry segment of the T&C subsystem can dwell upon any channel, except for a few channels such as the serial digital data sources greater than 8 bits long. During each word period, a PCM word and a dwell word are generated, making both normal and dwell PCM available for simultaneous transmission over two RF links.

Command

The command capability provides the spacecraft with:

- Receipt, decoding, processing, and distribution of uplink commands with
  - 2000 bps data rate
  - Uniquely defined spacecraft and CTCU addresses
  - Error detection polycode
- Pulse, SWSI, or serial (proportional, internal, or ACE) command types
- Switchable COMSEC command decryption and authentication
- Simultaneous DSN ranging and commanding
- Command uplink override of every automatic function

The uplink signal, which can contain command and ranging data simultaneously on the same carrier, is routed to both onboard command receivers. The receivers cannot be commanded off (that is, they are "active redundant"), and once they have acquired the carrier, they provide command data to each digital command unit/decoder, each of which is also active redundant. Following detection, locking and demodulation by the command receivers, and bit synchronization by the IRTCU, each command is decoded, processed, and distributed (either internally or over the MIL-STD-1553 DDB to the intended recipient) by the selected CTCU. Commands sent by the bus controller CTCU over the digital data bus are received by remote terminal or onboard processor units such as the CTCU, IRTCU, or ACE. Each CTCU can be operated in either a Bypass (clear text) or Secure (encrypted) mode, the latter of which precludes unauthorized commanding of the spacecraft. Every uplinked command is subjected to a validation process and, if found acceptable, is loaded and/or executed by the CTCU that was selected in the uplinked command. There are two modes of command execution: real-time via the CTCU and delayed buffering (verified, stored, or scheduled) via the ACE. In the real-time mode, validation of the uplinked command is performed within the issuing

CTCU; verification is typically provided by the end-user of the command. If no errors are detected, the command is executed. If an error is detected, processing of the command is halted and an error bit is telemetered to the ground station indicating that the command must be retransmitted. In the delayed buffering mode, the bits of the decoded command are telemetered back to the ground station for verification, and a subsequent execution message must be uplinked. The command unit outputs are completely redundant.

The squib driver unit (SDU) fires electrical pulses needed for space vehicle and instrument pyrotechnic devices. The SDU is suitable for igniting NASA standard initiators (NSI-1) tied to electro-explosive devices (EEDs) used to deploy mechanisms, release structural members, or pressurize the propulsion system. The unit is internally redundant and can drive up to 60 redundant bridgewires (up to one redundant pair simultaneously).

Data

The multi-use data link (MDL) provides a medium-rate (400 kbps) downlink of Imager and Sounder servo error and Imager IMC data. The MDL also provides yoke and Imager/Sounder mounting surface angular displacement sensor data (all differential analog data digitized to 12 bits resolution). Also included are serially digitized SXI data, both spacecraft PCM telemetry streams, plus two analog spares for future use. The MDL processing and multiplexing function resides within the IRTCU.

Ranging

Ranging is performed to determine the spacecraft orbital elements during transfer and geosynchronous orbits. Channelized to the DSN transmitter only for downlink, ranging is accomplished by ground-commanding one of the DSN transponder ranging channels on and into the coherent mode. The ground station uplinks ranging tones to the command receivers, where they are routed to the selected DSN transmitter and downlinked to the ground station with the output (downlink) carrier frequency. In the coherent mode, the downlink carrier frequency is maintained at a ratio of 240 to 221 relative to the uplink carrier. With the ranging channel on, ranging and telemetry are provided simultaneously on the same downlink carrier.

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