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RADIO SCIENCE SYSTEM DESIGN AND MEASUREMENT RESULTS FOR THE NASA DEEP SPACE NETWORK (DSN)

Abstract

Radio science measurements have been performed using the NASA Deep Space Network (DSN) with many different spacecraft over several decades. Radio science has been used for the study of planetary atmospheres, the solar corona and the search for gravity waves, among other things. The majority of these measurements are made using the X and Ka-band deep space bands. Although the primary mission for the DSN is tracking, telemetry and command (TTC) for NASA's many deep-space spacecraft, radio science measurements continue to be an important secondary mission. The science requirements for these measurements have resulted in stringent performance requirements for both the spacecraft and ground system equipment. In particular, the requirements for amplitude stability, phase stability (Allen deviation) and phase noise are very demanding. The system Allen deviation requirement at Ka-band is ¡ 2.4 E-15 over 1000 seconds, while the phase noise requirement is ¡ -50 dBc/Hz for a 1 Hz offset. Various design techniques have been used for the DSN radio frequency (RF) electronics, high power transmitters and antenna structures to meet the stringent requirements for all 3 of these parameters. Some details for the design techniques will be described in the paper. Another important consideration for a radio science system is the verification approach for components, as well as for individual subsystems and then the overall system. Phase-locked oscillators (PLOs) are one of the key component types that determine overall phase noise and Allen deviation system performance. Measurement techniques used for PLOs, as well as for the overall ground system, will be discussed. Measurement results for the 2 new DSN antennas, recently built under the DSN Aperture Enhancement Project (DAEP) will also be shown. In addition, some recent radio science measurements from the Cassini and JUNO missions, using the new antennas, will be presented.