



Coherent Frequency Reference System for the NASA Deep Space Network

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The NASA Deep Space Network (DSN) requires state-of-the-art frequency references that are derived and distributed from very stable atomic frequency standards. A new Frequency Reference System (FRS) and Frequency Reference Distribution System (FRD) have been developed, which together replace the previous Coherent Reference Generator System (CRG). The FRS and FRD each provide new capabilities that significantly improve operability and reliability.

The FRS allows for selection and switching between frequency standards, a flywheel capability (to avoid interruptions when switching frequency stan-

dards), and a frequency synthesis system (to generate standardized 5-, 10-, and 100-MHz reference signals). The FRS is powered by redundant, specially filtered, and sustainable power systems and includes a monitor and control capability for station operations to interact and control the frequency-standard selection process. The FRD receives the standardized 5-, 10-, and 100-MHz reference signals and distributes signals to distribution amplifiers in a fan out fashion to dozens of DSN users that require the highly stable reference signals. The FRD is also powered by redundant, specially filtered, and sustainable power systems.

The new DSN Frequency Distribution System, which consists of the FRS and FRD systems described here, is central to all operational activities of the NASA DSN. The frequency generation and distribution system provides ultra-stable, coherent, and very low phase-noise references at 5, 10, and 100 MHz to between 60 and 100 separate users at each Deep Space Communications Complex.

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Diamond Heat-Spreader for Submillimeter-Wave Frequency Multipliers

Superior thermal management provides a 100-percent increase in power-handling capability.

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The planar GaAs Shottky diode frequency multiplier is a critical technology for the local oscillator (LO) for submillimeter-wave heterodyne receivers due to low mass, tenability, long lifetime, and room-temperature operation. The use of a W-band (75–100 GHz) power amplifier followed by a frequency multiplier is the most common for submillimeter-wave sources. Its greatest challenge is to provide enough input power to the LO for instruments onboard future planetary missions.

Recently, JPL produced 800 mW at 92.5 GHz by combining four MMICs in parallel in a balanced configuration. As more power at W-band is available to the multipliers, their power-handling capability becomes more important. High operating temperatures can lead to degradation of conversion efficiency or catastrophic failure.

The goal of this innovation is to reduce the thermal resistance by attaching diamond film as a heat-spreader on the backside of multipliers to improve their

power-handling capability. Polycrystalline diamond is deposited by hot-filament chemical vapor deposition (CVD). This diamond film acts as a heat-spreader to both the existing 250- and 300-GHz triplers, and has a high thermal conductivity (1,000–1,200 W/mK). It is approximately 2.5 times greater than copper (401 W/mK) and 20 times greater than GaAs (46 W/mK). It is an electrical insulator (resistivity $\approx 10^{15}$ Ω -cm), and has a low relative dielectric constant of 5.7.

Diamond heat-spreaders reduce by at least 200 °C at 250 mW of input power, compared to the tripler without diamond, according to thermal simulation. This superior thermal management provides a 100-percent increase in power-handling capability. For example, with this innovation, 40-mW output power has been achieved from a 250-GHz tripler at 350-mW input power, while the previous triplers, without diamond, suffered catastrophic failures. This breakthrough provides a stepping-stone for

frequency multipliers-based LO up to 3 THz. The future work for this design is to apply the high output power from both the 250 and 300 GHz to multiple chains in order to generate milliwatts at 2–3 THz.

Using the first generation of results for this innovation, 40 mW of output power were produced from a 240-GHz tripler at 350-mW input power, and 27-mW output power was produced from a 300-GHz tripler at 408-mW input power. This is two times higher than the current state-of-the-art output power capability. A finite-element thermal simulation also shows that 30- μ m thick diamond dropped the temperature of the anodes by at least 200 °C.

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