National Aeronautics and Space Administration

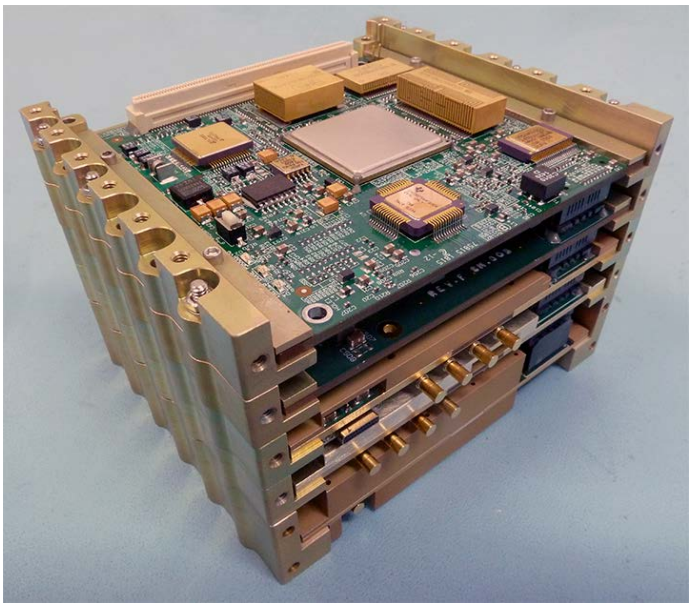
# Iris V2.1 CubeSat Deep Space Transponder

## X-, Ka-, S-Band, and UHF

## Deep Space Telecommunications and Navigation

### Features

- Deep Space Network Compatible
- Low Volume, Mass, and Cost
- Configurable Software Defined Coherent Transponder
- ~0.5 U Volume
- 1.2 kg Mass
- 35 W DC Power Consumption at 3.8 W Radio Frequency Output, Full Transpond
- Deep Space Network Capability at X-Band Frequencies for Command, Telemetry, and Navigation
- Ka-Band, S-Band, UHF Options with additional NRE
- Passive (Conductive) Thermal Dissipation
- Radiation Tolerant Parts for Extended Deep Space Missions
- Configurable for Earth Orbit
- Targeted for NPR 7120.8 technology demonstrations and Class-D space flight projects
- CCSDS Compatible



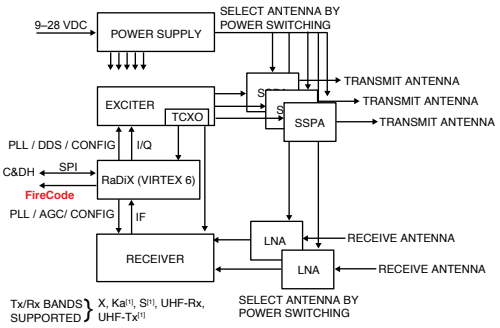
Iris Version 2.1 is a CubeSat/SmallSat compatible transponder developed by the National Aeronautics and Space Administration's (NASA's) Jet Propulsion Laboratory (JPL) as a low volume and mass, lower power and cost, software/firmware defined telecommunications subsystem for deep space. Iris is a deep-space transponder targeted for NPR 7120.8 technology demonstrations and Class-D space flight projects, utilizing COTS-grade components. Iris V2.1's features include ~0.5 U volume, 1.2 kg mass, 35 W DC power consumption when fully transponding at 3.8 W radio frequency output (12.6  W DC input for receive only), and interoperability with NASA's Deep Space Network (DSN) at X-Band frequencies (7.2 GHz uplink, 8.4 GHz downlink) for command, telemetry, and navigation.

Iris V2.1 is designed with an environmentally robust architecture including radiation tolerant parts needed for deep space missions with durations of a few years and thermal management needed for navigation tracking sessions of several hours.

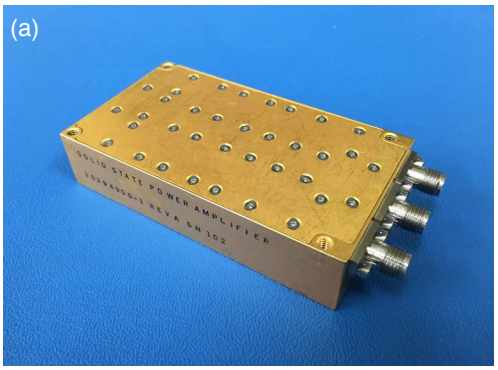
Iris uses a hardware slice architecture and reconfigurable software and firmware enabling extension and adaptation to new capabilities. Among those now planned are: Radio Science support (atmospheric and media measurements and occultations, gravity fields, radars, and radiometers); additional frequency bands (Ka-, S-, UHF); Disruption/Delay Tolerant Networking (DTN); proximity operations (at other planets such as Mars); Near Earth Network (NEN) compatibility; and Space Network (SN) compatibility.

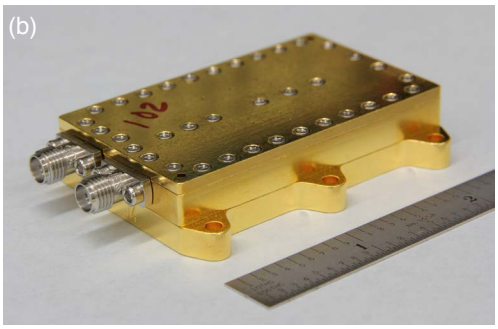
# Iris V2.1

| General Specifications | |
|---|---|
| Network Compatibility | DSN, NEN[1], SN[1] |
| Redundancy | Single string |
| Design Lifetime | 3 years |
| Frequency Bands | X-band, UHF receive, Ka-[1], S-[1], UHF transmit[1] |
| Envelope | 100.5 x 101.0 x 56.0 mm |
| LNA Envelope | 69.4 x 47.5 x 13.0 mm |
| SSPA Envelope | 86.6 x 42.7 x 17.8 mm |
| Flight Operating Temperature | –20°C to +50°C |
| Solid State Power Amplifier | 3 RF paths, dedicated to 3 antennas, path selectable via power switching |
| Low Noise Receive Amplifier | 2 RF paths, dedicated to 2 antennas, path selectable via power switching |
| VCO | Internal TCXO, external 10 MHz[1] |
| TCXO Allan Deviation | $10^{-9}$ at 1 sec (non-coherent operation) |
| Ranging Delay Variation | < ±30 nsec |
| Telemetry Symbol Rates (downlink) | 62.5 bps, 125, 250, 500, 1 k, 2 k, 4 k<br>8 k, 16 k, 32 k, 64 k, 128 k, 256 k, 512 k[1]<br>1.024 M[1], 2.048 M[1], 4.046 M[1], 8.192 M[1], semaphores — (< 62.5 bps)[1], Other arbitrary rates[2] |
| Subcarriers, Downlink | 25 kHz<br>281.25 kHz<br>Arbitrary subcarriers to 10 MHz[2]<br>Direct carrier modulation |
| FPGA | Virtex 6 (LX130T or LX204T*) |
| CPU | Gaisler LEON3-FT softcore (on Virtex 6) |
| Memory | 32 Mbit non-volatile NOR-Flash (radiation tolerant)<br>16 Mbit volatile SRAM (radiation tolerant)<br>4 Mbit volatile EDAC SRAM (radiation tolerant) |
| Interface | Point-to-point SPI |
| Launch Capability | Non-operational at launch |
| Radiation, SEL Levels<br>TID Levels | LET >37 MeV–cm²/mg (Virtex 6)<br>15 krad (ELDRS to 5 krad) |
| Telemetry Encoder | Firmware encoder |
| Command Detector | Firmware decode with FireCode (spacecraft reset direct command) |
| Mounting | CubeSat stack in chassis with separate SSPA and LNA modules |
| Carrier Loop BW | Configurable (100 Hz typical) |
| Command uplink rates (bps) | 62.5 PM/PSK/NRZ, 125, 250, 500, 1000<br>2000, 4000, 8000, Arbitrary rates[2] |
| Command uplink subcarriers | 16 kHz<br>Direct Carrier modulation<br>Arbitrary subcarriers[2] |



Iris V2.1 Block Diagram




Iris V2.1 SSPA (a) and LNA (b) are mounted separately for thermal reasons.

[1]Capability under development or planned.
[2]Capability supportable due to software/firmware reconfigurability with additional NRE.
*Select at build.

# Iris V2.1

| General Specifications (Continued) | |
|---|---|
| Command/Telemetry Interface | Command and Telemetry Dictionary, configurable[2]<br>Uplink: TC Space Data Link Protocol<br>CCSDS 232.0-B-3<br>Downlink: AOS Space Data Link Protocol<br>CCSDS 732.0-B-3 |
| **Mass and Power** | |
| Stack Mass | 1000 g including thermal enclosure (no UHF) not including cables |
| SSPA Mass | 150 g |
| LNA Mass | 80 g |
| Input Supply Voltage | 9–28 VDC |
| Input Supply Power | 0.5–35 W (see power states)** |

| Iris Mode | DC Input (W) |
|---|---|
| Battery Connect | 0.5 |
| X-Receive Only | 12.6 |
| X-Transmit Only | 30.8 |
| X-Transmit/Receive | 35.0 |

| Transponder Specifications | |
|---|---|
| X-Band Uplink Frequency Range | 7.145 – 7.190 GHz (channel assignment programmed in firmware)<br>7.190 – 7.235 (near Earth supported) |
| X-Band Downlink Frequency Range | 8.400 – 8.450 GHz (channel assignment programmed in firmware))<br>8.450 – 8.500 (near Earth supported) |
| Other Bands | S-Band: Deep Space[1]/near Earth[1]<br>Ka-Band: 32/34 GHz Deep Space[1]; 26 GHz near Earth[1] |
| Coherant Turnaround Ratio X-band | 880/749<br>Standard S- and Ka-Band ratios[1], arbitrary ratios[2] |
| UHF Frequency Range | 390–450 MHz receive, transmit[1] |
| **Receiver Specifications** | |
| Noise Figure | 5 dB X-Band and UHF |
| Carrier Tracking Signal Range | –70 to –130 dBm |
| Tracking Range | 100 MHz |
| Ranging Filter Type | Digital |
| Ranging Filter | 1500 kHz |
| **Exciter (X-Band)** | |
| 8.4 GHz Output Power (SSPA) | 3.8 W BOL (–15 dBm drive from exciter) |
| X-Band Phase Noise (1 Hz offset)<br>(100 Hz – 100 kHz offset) | TBM (–20 dBc/Hz)<br>TBM (–60 dBc/Hz) |
| X-Band Spurious & Harmonic Outputs | < –40 dBc (–60 dBc at SSPA) |
| TLM Encoding | Convolutional 7-1/2<br>Manchester, Bi-Phase, and bypass (NRZ)<br>Reed Solomon (255,223)<br>Turbo 1/2<br>Turbo 1/3<br>Turbo 1/6, block size 8920 bits |
| TLM Phase Deviation | 0 to 180 degrees |
| Diff 1-way Ranging (coh w/DL carrier) | X-Band 2F1: 19.2 MHz 17.5° typical |

[1]Capability under development or planned.
[2]Capability supportable due to software/firmware reconfigurability with additional NRE.
**Power numbers with LX130T FPGA.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