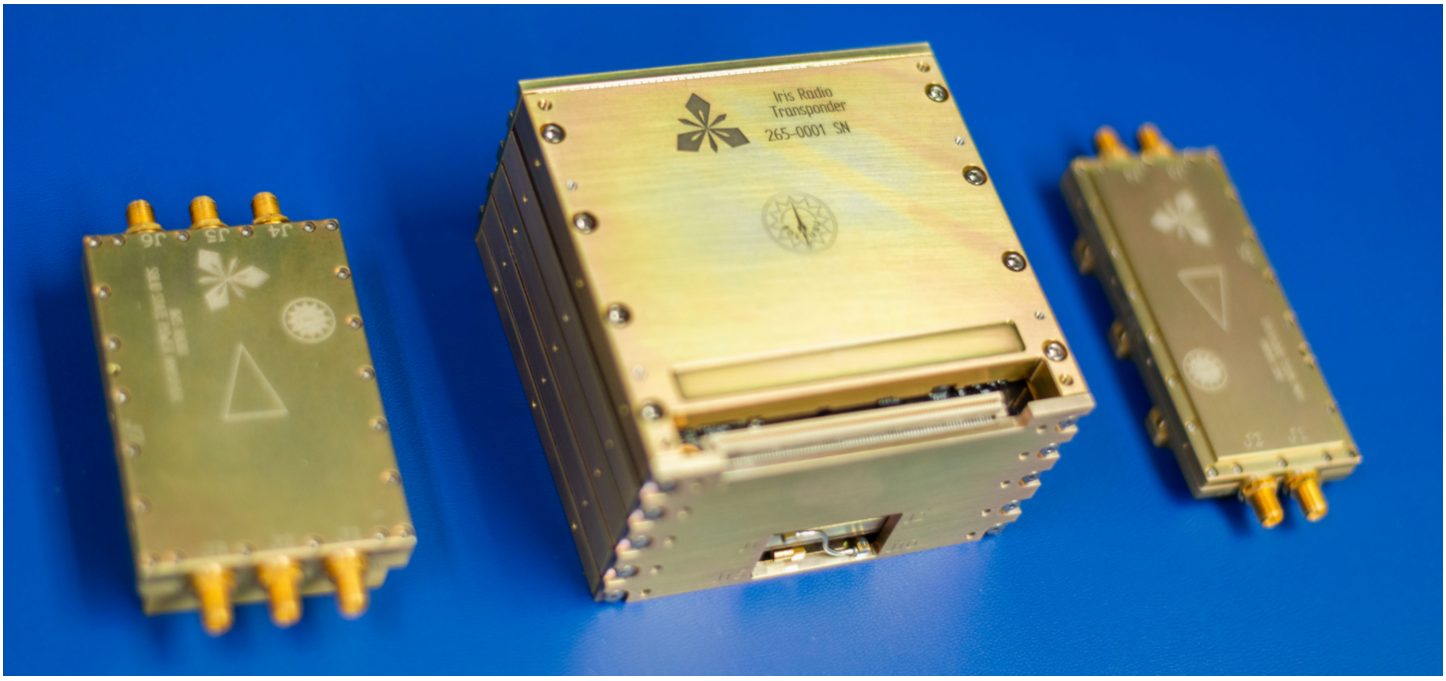
# IRIS RADIO

## For Deep Space Small Satellites




*Iris Radio components, left to right: SSPA, transponder, LNA.*

With more small spacecraft being used for deep space missions, there is a vital need for a unique communications architecture to relay valuable mission data to NASA's Deep Space Network (DSN) and other international ground networks. To meet this need, the Jet Propulsion Laboratory (JPL) created the initial design for the Iris deep space small satellite radio.

The Iris Radio is a software-defined telecommunications subsystem designed specifically for orbits beyond LEO, such as MEO, GEO, Lunar, and interplanetary missions. The Space Dynamics Laboratory is responsible for developing, fabricating, and testing the Iris Radio technology in its NASA-certified facilities and providing mission support.

Iris uses an environmentally robust architecture, including radiation-tolerant parts for deep space, multi-year missions. The design also incorporates the advanced thermal management needed for navigation tracking sessions of several hours.

### FEATURES

- Over-the-air (OTA)-reprogrammable, software-defined coherent transponder
- DSN capability at X-band frequencies for command, telemetry & navigation
- Passive (conductive) thermal dissipation
- Radiation-tolerant parts for extended deep space missions
- Targeted for Class D & commercial space flight projects
- Consultative Committee for Space Data Systems (CCSDS) compatible
- **Transponder volume:** ~0.5 U
- **System mass:** 1.1 kg
- **Power consumption:** 35 W DC power consumption at 3.8 W RF
- **X-band:** 7.2 GHz uplink, 8.4 GHz downlink

### EXTENSION SUPPORT

Iris can easily be extended and adapted to new capabilities due to its hardware slice architecture and OTA-reprogrammable software and firmware.

- Radio science support (atmospheric measurements & occultations, gravity fields, radars, radiometers & others)
- Ka-band, S-band, UHF options available
- Disruption/Delay Tolerant Networking (DTN)
- Proximity operations Near Earth Network (NEN) compatibility
- Space Network (SN) compatibility

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SDL/17-1074 Rev. D

# **IRIS RADIO** For Deep Space Small Satellites

| GENERAL SPECIFICATIONS | |
|---|---|
| Network Compatibility | DSN, NEN[1], SN[1] |
| Design Lifetime | 3 years |
| Frequency Bands | X-band, UHF receive, Ka[1], S[1], UHF transmit[1] |
| Operating Temperature | -20°C to +50°C |
| Solid-State Power Amplifier (SSPA) | 3 RF paths, dedicated to 3 antennas, path selectable via power switching |
| Low Noise Amplifier (LNA) | 2 RF paths, dedicated to 2 antennas, path selectable via power switching |
| Voltage-Controlled Oscillator (VCO) | Internal Temperature Compensated Crystal Oscillator (TCXO) |
| Ranging Modes | • DDOR & PNDDOR<br>• Coherent Sequential<br>• Coherent Regenerative PN |
| Ranging Delay Variation | <±30 nsec |
| Telemetry Symbol Rates (downlink) | • From 62.5 sps to 6.25 Msps<br>• Other arbitrary rates[1] |
| Subcarriers (downlink) | • 25 kHz<br>• Arbitrary subcarriers to 10 MHz[1]<br>• Direct carrier modulation |
| FPGA | Virtex 6 |
| CPU | Gaisler LEON3-FT |
| 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 or SpaceWire |
| Carrier Loop BW | Configurable (100 Hz typical) |
| Command Uplink Rates | • PCM/PSK/PM: 62.5 bps to 8,000 bps<br>• PCM/PM/Bi-Φ: 8,000 bps to 1 Mbps<br>• Other arbitrary rates[1] |
| Command Uplink Subcarriers | • 16 kHz<br>• Direct carrier modulation<br>• Arbitrary subcarriers[1] |
| Command/Telemetry Interface | • Command & telemetry dictionary, configurable[1]<br>• Uplink: TC Space Data Link Protocol CCSDS 232.0-B-3<br>• Downlink: AOS Space Data Link Protocol CCSDS 732.0-B-3 |
| Telemetry Encoding | • Bypass<br>• Convolutional 7-1/2<br>• Reed-Solomon (255,223)<br>• Turbo rates 1/2, 1/3, 1/6<br>• Turbo block sizes 1784 or 8920 bits<br>• LDPC rates 1/2, 2/3, 4/5, 7/8<br>• LDPC block sizes 1024, 4096, or 7136 bits<br>• Additional encoding as required[1] |
| Telemetry Modulation | • NRZ-L, Manchester (Biphase-L)<br>• BPSK, QPSK, OQPSK<br>• Additional schemes[1] |

| 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: Deep space[1]/near Earth[1]<br>• UHF: 390–450 MHz receive, transmit[1] |
| Coherent Turnaround Ratio | • X-band: 880/749<br>• Standard S- & Ka-band ratios[1], arbitrary ratios |

| RECEIVER SPECIFICATIONS | |
|---|---|
| Noise Figure | 2.2 dB X-band |
| Carrier Tracking Signal Range | -70 to -130 dBm |
| Tracking Range | 100 MHz |

| EXCITER (X-BAND) SPECIFICATIONS | |
|---|---|
| 8.4 GHz Output Power SSPA | 3.8 W BOL (-15 dBm drive from Exciter) |
| X-Band Phase Noise (1 Hz offset) (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) |

| MASS & POWER SPECIFICATIONS | |
|---|---|
| Transponder Stack Mass | 875 g |
| LNA Mass | ≤125 g |
| SSPA Mass | ≤230 g |
| Transponder Envelope | 101 x 101 x 56 mm |
| LNA Envelope | 114.3 x 46.0 x 15.5 mm |
| SSPA Envelope | 102.9 x 55.7 x 24.4 mm |
| Input Supply Voltage | 12–28 VDC |
| Input Supply Power | 0.5–35 W |

| Mode | DC Input (W) |
|---|---|
| Battery Connect | <0.04 |
| X-Receive Only | 10.3 |
| X-Transmit Only | 29.6 |
| X-Transmit/Receive | 33.6 |

Iris Radio

[1] Capability supportable with additional non-recurring engineering (NRE).

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