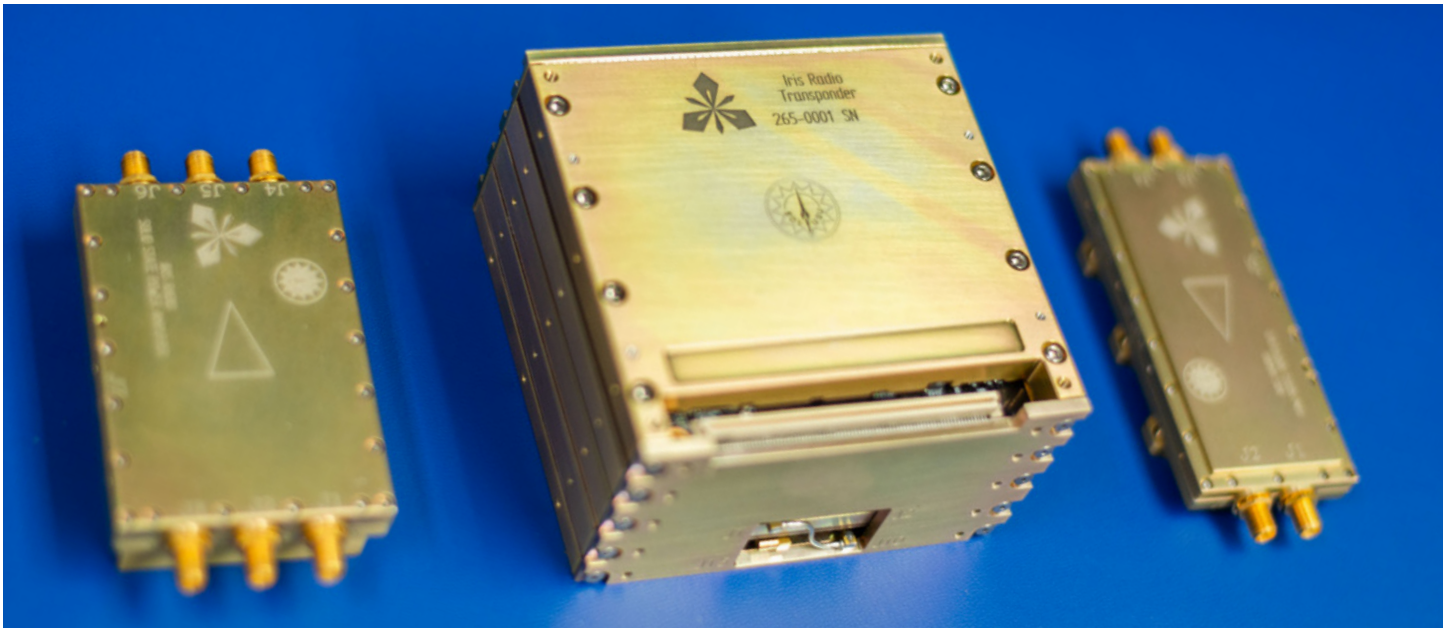
IRIS RADIO

For Deep Space Small Satellites



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

With more nanosatellites being used for deep space missions, the need for a unique communications architecture to relay valuable mission data to NASA's Deep Space Network (DSN) is vital.

To meet this need, the Jet Propulsion Laboratory initially designed 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 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 needed for deep space, multi-year missions. The design also incorporates the advanced thermal management needed for navigation tracking sessions of several hours.

FEATURES

- Configurable, 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 space flight projects
- Consultative Committee for Space Data Systems (CCSDS) compatible
- **Transponder volume:** ~0.5 U
- **System mass:** 1.1 kg
- **Output power:** 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 reconfigurable 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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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 • Coherent Sequential • Coherent Regenerative PN
Ranging Delay Variation	<±30 nsec
Telemetry Symbol Rates (downlink)	• From 62.5 sps to 6.25 Msps • Other arbitrary rates[1]
Subcarriers (downlink)	• 25 kHz • Arbitrary subcarriers to 10 MHz[1] • Direct carrier modulation
FPGA	Virtex 6
CPU	Gaisler LEON3-FT
Memory	• 32-Mbit, non-volatile NOR-Flash (radiation tolerant) • 16-Mbit, volatile SRAM (radiation tolerant) • 4-Mbit, volatile EDAC SRAM (radiation tolerant)
Interface	Point-to-point SPI or SpaceWire[1]
Carrier Loop BW	Configurable (100 Hz typical)
Command Uplink Rates	• From 62.5 to 8,000 bps PM/PSK/NRZ • Other arbitrary rates[1]
Command Uplink Subcarriers	• 16 kHz • Direct carrier modulation • Arbitrary subcarriers[1]
Command/Telemetry Interface	• Command & telemetry dictionary, configurable[1] • Uplink: TC Space Data Link Protocol CCSDS 232.0-B-3 • Downlink: AOS Space Data Link Protocol CCSDS 732.0-B-3
Telemetry Encoding	• Bypass • Convolutional 7-1/2 • Reed-Solomon (255,223) • Turbo rates 1/2, 1/3, 1/6 • Turbo block sizes 1784 or 8920 bits • LDPC rates 1/2, 2/3, 4/5, 7/8 • LDPC block sizes 1024, 4096, or 7136 bits • Additional encoding as required[1]
Telemetry Modulation	• NRZ-L, Manchester (Biphase-L) • BPSK, QPSK, OQPSK • Additional schemes[1]

TRANSPONDER SPECIFICATIONS

X-Band Uplink Frequency Range	• 7.145–7.190 GHz (channel assignment programmed in firmware) • 7.190–7.235 (near Earth supported)
X-Band Downlink Frequency Range	• 8.400–8.450 GHz (channel assignment programmed in firmware) • 8.450–8.500 (near Earth supported)
Other Bands	• S-band: Deep space[1]/near Earth[1] • Ka-band: Deep space[1]/near Earth[1] • UHF: 390–450 MHz receive, transmit[1]
Coherent Turnaround Ratio	• X-band: 880/749 • 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) • 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).