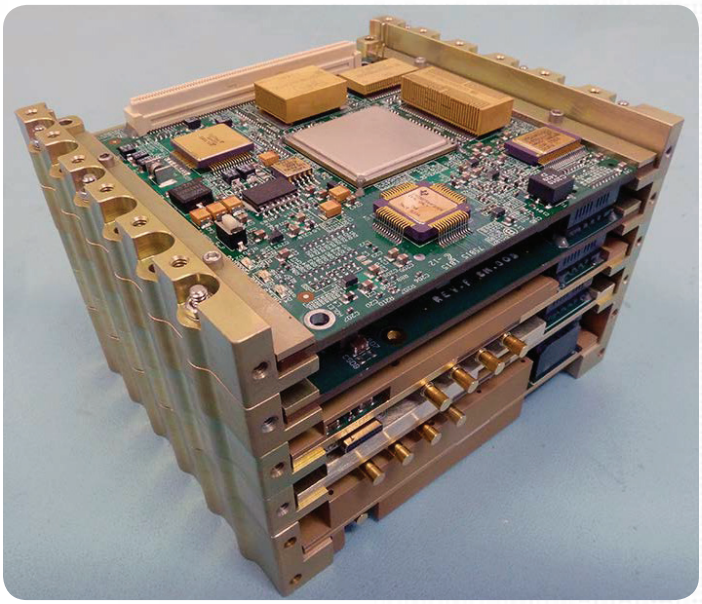
SPACE DYNAMICS LABORATORY

IRIS

DEEP SPACE SMALL SATELLITE RADIO



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

To meet this need, the Jet Propulsion Laboratory designed the Iris deep space small satellite radio. Iris is a software-defined telecommunications subsystem designed specifically for orbits beyond LEO, such as MEO, GEO, Lunar, and interplanetary missions.

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

The Space Dynamics Laboratory is responsible for fabricating and testing the Iris radios in our NASA-certified facilities and providing mission support.

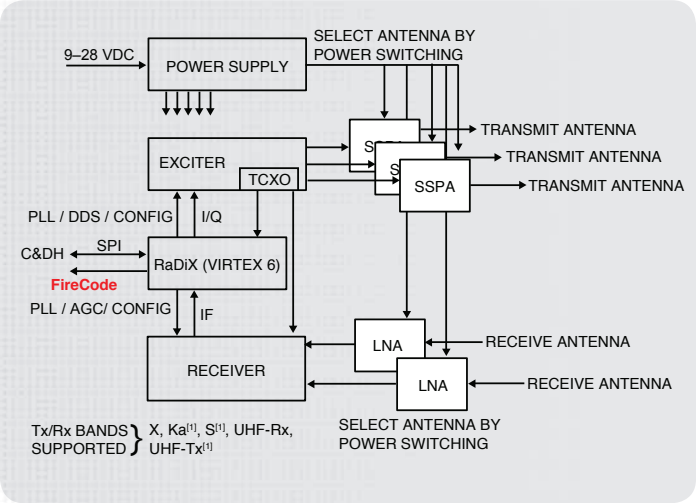
FEATURES

- 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
- CCSDS compatible
- **Transponder Volume:** ~0.5 U
- **Mass:** 1.1 kg
- **Power:** 35 W DC power consumption at 3.8 W RF output power
- **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 & media measurements & occultations, gravity fields, radars & radiometers)
- Ka-band, S-band, UHF options with additional NRE
- Disruption/Delay Tolerant Networking (DTN)
- Proximity operations Near Earth Network (NEN) compatibility
- Space Network (SN) compatibility



Iris V2.1 Block Diagram

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IRIS

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]
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
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
Voltage-Controlled Oscillator (VCO)	Internal Temperature Controlled Crystal Oscillator (TCXO), external 10 MHz[1]
Ranging Delay Variation	< ±30 nsec
Telemetry Symbol Rates (downlink)	• From 62.5 bps to 8.192 M[1] semaphores — (< 62.5 bps)[1] • Other arbitrary rates[2]
Subcarriers (downlink)	• 25 kHz • 281.25 kHz • Arbitrary subcarriers to 10 MHz[2] • 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
Carrier Loop BW	Configurable (100 Hz typical)
Command Uplink Rates (bps)	• From 62.5 PM/PSK/NRZ to 8000 • Other arbitrary rates[2]
Command Uplink Subcarriers	• 16 kHz • Direct carrier modulation • Arbitrary subcarriers[2]
Command/Telemetry Interface	• Command & telemetry dictionary, configurable[2] • **Uplink:** TC Space Data Link Protocol CCSDS 232.0-B-3 • **Downlink:** AOS Space Data Link Protocol CCSDS 732.0-B-3

MASS & POWER

Transponder Stack Mass	875 g
SSPA Mass	125 g
LNA Mass	85 g
Input Supply Voltage	9–28 VDC
Input Supply Power	0.5–35 W (see power states)**

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) • 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:** 32/34 GHz Deep Space[1]; 26 GHz near Earth[1]
Coherent Turnaround Ratio X-band	• 880/749 • Standard S- & Ka-band ratios[1], arbitrary ratios[2]
UHF Frequency Range	390–450 MHz receive, transmit[1]

RECEIVER SPECIFICATIONS

Noise Figure	5 dB X-band & 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 Solid-State Power Amplifyer (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)
TLM Encoding	• Convolutional 7-1/2 • Manchester, bi-phase & bypass (NRZ) • Reed Solomon (255,223) • Turbo 1/2 • Turbo 1/3 • Turbo 1/6, block size 8920 bits
TLM Phase Deviation	0° to 180°
Diff 1-Way Ranging (coherent 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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