National Aeronautics and Space Administration

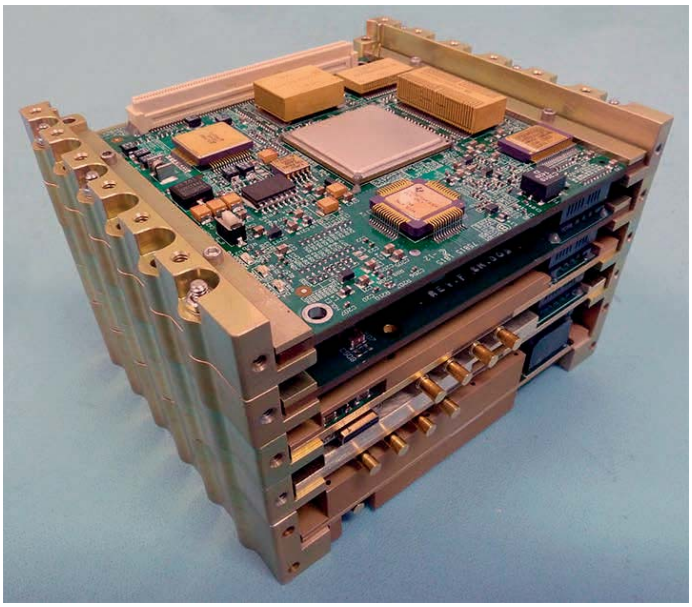
Iris V2 CubeSat Deep Space Transponder

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
- 26 W DC Power Consumption at 5 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
- Passive (Conductive) Thermal Dissipation
- Radiation Tolerant Parts for Extended Deep Space Missions
- Configurable for Earth Orbit



Iris Version 2 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 V2's features include 0.5 U volume, 1.1 kg mass, 26 W DC power consumption when fully transponding at 5 W radio frequency output (8 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.

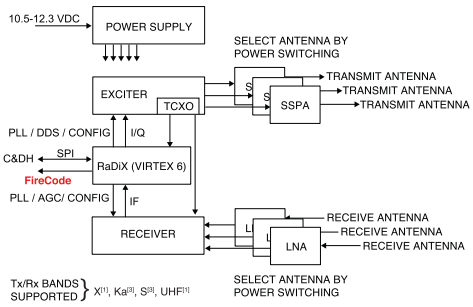
Iris V2 is designed with an environmentally robust architecture including radiation tolerant parts needed for deep space missions with durations of a few years and thermal management needed for navigation tracking sessions of several hours.

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.

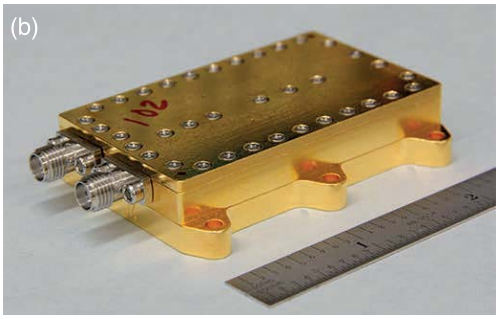
Iris V2

General Specifications	
Network Compatibility	DSN[1], NEN[3], SN[3]
Redundancy	Single string
Design Lifetime	3 years
Frequency Bands	X-band[1], UHF receive[1], Ka-[3], S-[2], UHF transmit[3]
Envelope	104 x 118.5 x 65 mm
LNA Envelope	75.5 x 43 x 13 mm
SSPA Envelope	87.5 x 43 x 23 mm
Flight Operating Temperature	–20 to +50°C
Solid State Power Amplifier	3 RF paths, dedicated to 3 antennas, path selectable via power switching
Low Noise Receive Amplifier	3 RF paths, dedicated to 3 antennas, path selectable via power switching
VCO	Internal TCXO[1], external 10 MHz[3]
TCXO Allan Deviation	10^{-9} at 1 sec (non-coherent operation)
Ranging Delay Variation	< ±30 nsec
Telemetry Symbol Rates (downlink)	62.5 bps[1] 8 k[1] 1.024 M[3] 125[2] 16 k[1] 2.048 M[3] 250[1] 32 k[2] 4.046 M[3] 500[2] 64 k[1] 8.192 M[3] 1 k[1] 128 k[2] semaphores — (< 62.5 bps)[3] 2 k[2] 256 k[1] Other arbitrary rates[4] 4 k[1] 512 k[3]
Subcarriers, Downlink	25 kHz[1] 281.25 kHz[1] Arbitrary subcarriers to 10 MHz[4] Direct carrier modulation[2]
FPGA	Virtex 6 (–130[2], –240[3])
CPU	Gaisler LEON3-FT softcore (on Virtex 6)
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
Launch Capability	Non-operational at launch
Radiation, SEE Levels (100 mil (Al))	LET >37 MeV–cm²/mg (Virtex 6), 20 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 (20 Hz typical)
Command uplink rates (bps)	62.5[1] PM/PSK/NRZ 2000[2] 125[2] 4000[2] 250[2] 8000[1] 500[2] Arbitrary rates[4] 1000[1]
Command uplink subcarriers	16 kHz[1] Arbitrary subcarriers[4] Direct Carrier modulation[2]
Command/Telemetry Interface	Command and Telemetry Dictionary[1], configurable[4]

[1]Compatibility verified in Version 1 and/or Version 2.
[2]Compatibility supported in Version 2 but not yet verified.
[3]Capability under development or planned.
[4]Capability supportable due to software/firmware reconfigurability.



Iris V2 Block Diagram



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

Iris V2

Mass and Power	
Stack Mass	1000 g including thermal enclosure (no UHF) not including cables
SSPA Mass	130 g
LNA Mass	70 g
Input Supply Voltage	10.5–12.3 VDC[1], 9–15 VDC[2]
Input Supply Power	0.5–26 W (see power states)[1] Iris Mode / DC Input (W): Battery Connect: 0.5 FPGA On (Start-up): 5.3 X-Receive Only: 7.9* X-Transmit Only: 23.3 X-Transmit/Receive: 25.9 *5.5 W receive-only mode[3].
Transponder Specifications	
X-Band Uplink Frequency Range	7.145 – 7.190 GHz (channel assignment programmed in firmware)[1] 7.190 – 7.235 (near Earth supported)[2]
X-Band Downlink Frequency Range	8.400 – 8.450 GHz (channel assignment programmed in firmware))[1] 8.450 – 8.500 (near Earth supported)[2]
Other Bands	S-Band: Deep Space[3]/near Earth[3] Ka-Band: 32/34 GHz Deep Space[3]; 26 GHz near Earth[3]
Coherant Turnaround Ratio	880/749[1], standard S- and Ka-Band ratios[3], arbitrary ratios[4]
UHF Frequency Range	390–450 MHz receive[2], transmit[3]
Receiver Specifications	
Noise Figure	5 dB X-Band and UHF[1]
Carrier Tracking Signal Range	–70 to –130 dBm[1]
Tracking Range	100 MHz[1]
Ranging Filter Type	Digital
Ranging Filter	2000 kHz
Exciter (X-Band)	
8.4 GHz Output Power (SSPA)	37 dBm (5 W) (–15 dBm drive from exciter)
X-Band Phase Noise (1 Hz offset) (100 Hz – 100 kHz offset)	TBM (–80 dBc) TBM (–135 dBc)
X-Band Spurious & Harmonic Outputs	< –40 dBc (–60 dBc at SSPA)
TLM Encoding	Convolutional 15-1/2[2] Convolutional 15-1/4[2] Convolutional 7-1/2[1] Manchester, Bi-Phase, and bypass (NRZ)[1] Reed Solomon (255,223)[1] Turbo 1/2[2] Turbo 1/3[2] Turbo 1/6, block size 8920 bits[1]
TLM Phase Deviation	0 to 180 degrees[2]
Diff 1-way Ranging (coh w/DL carrier)	X-Band 2F1: 19.2 MHz[1] programmable modulation index 17.5° typical

[1]Compatibility verified in Version 1 and/or Version 2.
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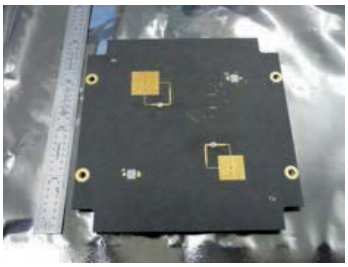
Iris V2

Suggested CubeSat Antennas & Data Rates to DSN 34 m

for 70 m, multiply rates by 4
for 20 m, 100°K, divide rates by 10

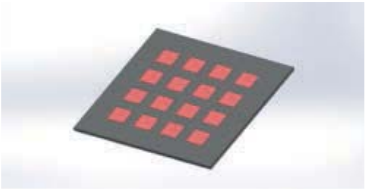
- LGA — Single Tx & Rx patches on 10x10 cm face
- Included with Iris V2
- 5 dBi gain — wide field-of-view
- 1 Mbps at Moon

Mars ~1 AU (bps)		
Opposition	Arrive	Conjunction
31	10	1



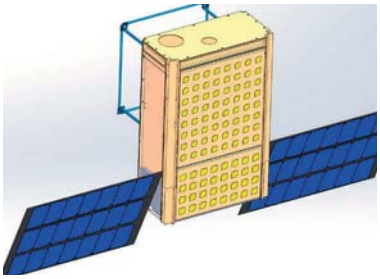
- MGA — 4x4 Tx patch array
- Fits 10x10 cm face
- 16 dBi gain (needs pointing)

Mars ~1 AU (bps)		
Opposition	Arrive	Conjunction
500	125	16



- HGA — 8x8 Tx patch array
- 20x20 cm flat panel (6 U)
- Deployable w/solar panel (NEA Scout)
- 21 dBi gain (needs good pointing)

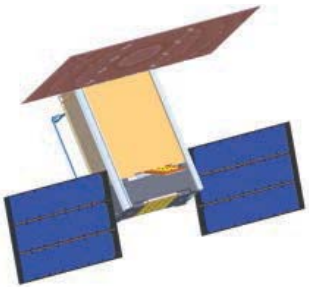
Mars ~1 AU (bps)		
Opposition	Arrive	Conjunction
1000	250	62



- VHGA — Tx reflect array
- Deployed on 6 U (MarCO) 3 panel
- 28 dBi gain (needs good pointing)

Mars ~1 AU (bps)		
Opposition	Arrive	Conjunction
4000	2000	250

- Ka-Band 3 U Turkey Tail version also in development



- KaPDR — Ka Parabolic Reflector (0.5 m) in development
- Deployable from 10x10 cm face (3 U)
- >40 dBi gain (needs very good pointing)
- 32/34 GHz @ 2 W RF

Mars ~1 AU (bps)		
Opposition	Arrive	Conjunction
512k	128k	32k

For More Information Contact:

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