QubeFlex

CubeSat/SmallSat/LEO Satellite Transceiver/Modem



Compliant with CCSDS & Intelsat Standards

TELEDYNE
PARADISE DATACOM
Everywhereyoulook™

Overview

The **QubeFlex™** software-defined modem is designed for the low-earth orbit CubeSat and smallsat markets. Growing commercial applications demand fast time to market and reliable comms. **QubeFlex**, as part of our end-to-end comms solution, replaces the do-it-yourself approach with a professional off-the-shelf solution suited to your current and future needs.

The **QubeFlex** modem supports CCSDS telemetry, Intelsat and other common space transmission and packet standards. Forward error correction ensures data is protected against transmission loss. High data rates ensure maximum data can be received on each satellite pass.

The **QubeFlex** demodulator will acquire and remain locked to the signal even when faced with the largest Doppler frequency shifts caused by fast-moving low-earth orbit satellites. Demodulator output is formatted for convenient onward computer processing and storage.

In addition to supporting the standard carrier roll-off factors, the **QubeFlex** modem supports larger than normal roll-off factors to allow users to minimise the peak-to-average-power ratio of the generated waveform. This minimises distortion of the transmitted signal and thereby relaxes the design constraints for the smallsat transmission system, which are typically subject to extreme size, weight and power limitations.

The **QubeFlex** modem includes powerful onboard test equipment (spectrum analyzer and a constellation monitor), and is also capable of detecting satellite beacon transmissions, which removes the need for a separate beacon receiver.

Markets and Applications

- CubeSat & smallsats
- Low-earth orbit (LEO) satellites
- Earth & weather observation
- LEO space research projects
- Intelligence gathering
- Space telemetry

Features

- Data rates to 50Mbps (CCSDS maximum is 50Mbps)
- Support for CCSDS telemetry & Intelsat standards including Viterbi/Reed-Solomon error correction & scrambling
- Modem is protocol agnostic but includes explicit support for CCSDS.
- Modulation includes 2.2 to 2.45 GHz S-band
- Supports other bands (including X) when used with external frequency conversion
- Doppler limits: ±700kHz, ±9kHz/s
- Demodulator output options: Ethernet (with optional timestamps & metadata) & EIA-530
- Q-NET™ Navigator network control application included as standard
- Our partners provide fully compatible onboard CubeSat transmission systems - please contact us for details

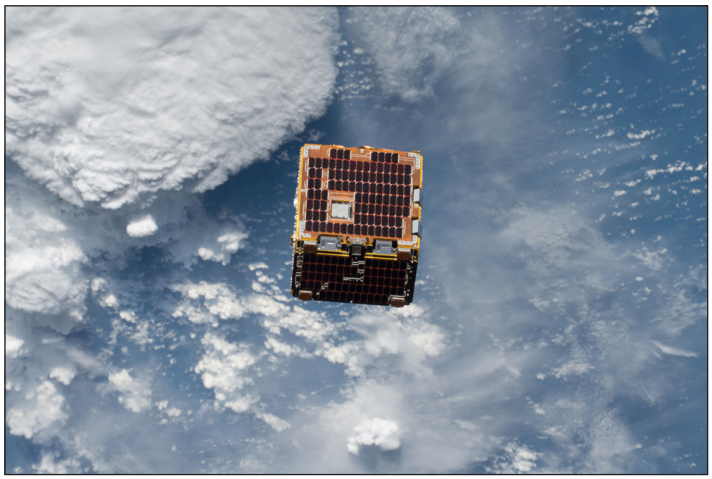


Photo courtesy of NASA

LEO/SmallSat Application: The QubeFlex modem may be used to communicate with LEO satellites such as the one pictured above, which was deployed by the International Space Station.

Why QubeFlex?

Our Flagship Software Defined Modem is Paradise Datacom's most innovative and flexible Satellite Modem to date

STATE OF THE ART

- Extended roll offs, up to 60%
- Modulation includes 2.2 to 2.45 GHz S-Band

SECURE

- SCPC is both secure, and with Paradise Modems, easy to provision

COMPATIBLE

- Supports CCSDS telemetry
- CCSDS compliant Viterbi & Reed-Solomon
- Fully compatible onboard CubeSat transmission systems available
- Supports IF and L-band in one unit.



CONVENIENT

- Optional BUC power Supply reduces need for external equipment
- Built in Beacon Receiver, Spectrum Analyser and Constellation monitor

PRACTICAL

- 1U rack mount chassis
- Simple front panel control with back-lit LCD
- Intuitive web browser and Q-NET compatible
- Built in test tools, no need for expensive test equipment

EFFICIENT

- 5% spectral roll off, saving 15% bandwidth over the standard 20%
- Extended Doppler limits: ±700kHz, ±9kHz/s

WELL EQUIPPED



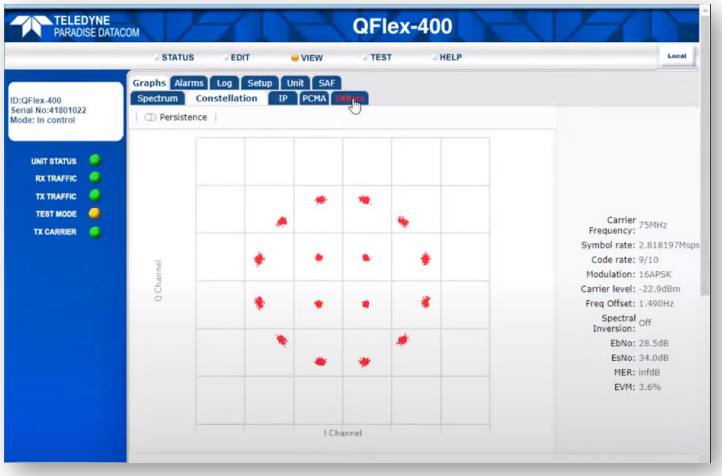
Transmitter
Fast:
- Up to 50Mbps CCSDS
- Output power: IF 0 to -25dBm; Standard L-Band 0 to -40dBm

Interface Ports
Convenient:
- 4 GB Ethernet ports, Layer 2 Bridge, Layer 3 router.
- Optional Serial EIA-530 interface
- Optional High-speed LVDS serial interface

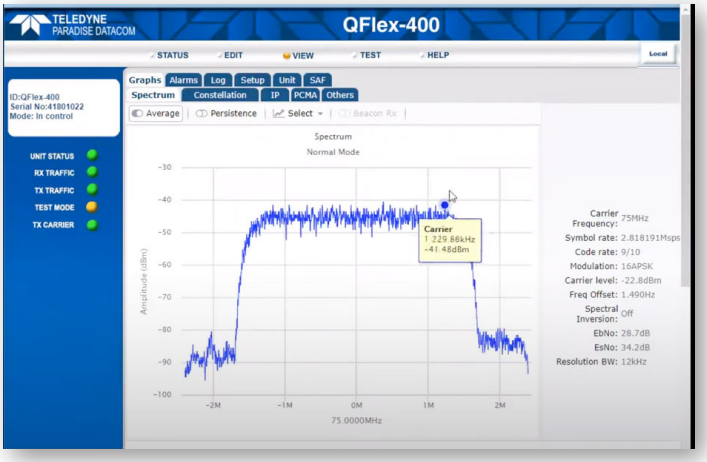
RF Stages
Future Proof:
- Transmit and Receive speeds field upgradeable, only pay for the capacity you need now
- Extended L-Band Transmit coverage from 950 to 2,450 MHz
- Wideband IF 50 - 180MHz

Receiver
Fast:
- Up to 50Mbps
- Extended L-Band receive coverage from 950 to 2,450MHz

Powerful Onboard Test Equipment



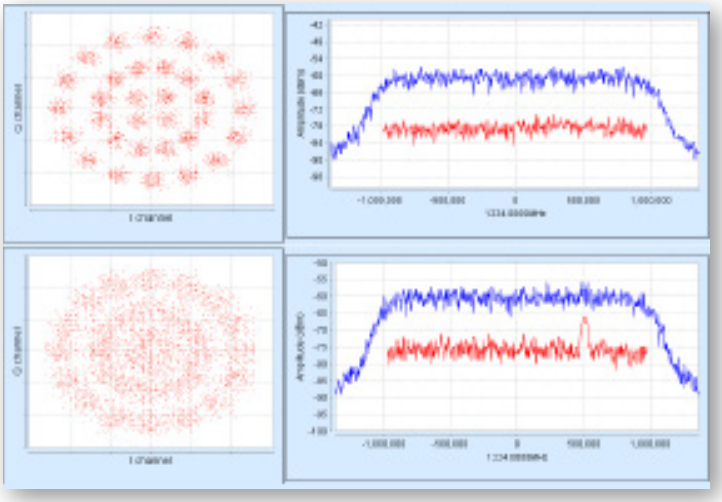
Constellation view: The Rx Constellation Monitor can be used to check for correct modem operation including checking for signal distortion and phase noise. The persistence mode is useful for showing any long-term effects due to phase noise and interference.



Spectral view: The Rx Spectrum Monitor is a powerful real-time spectrum analyser within the modem that is used to view the received signal spectrum. The monitor can not only display the wanted carrier but a Super Wide view allows checking for adjacent interfering carriers.

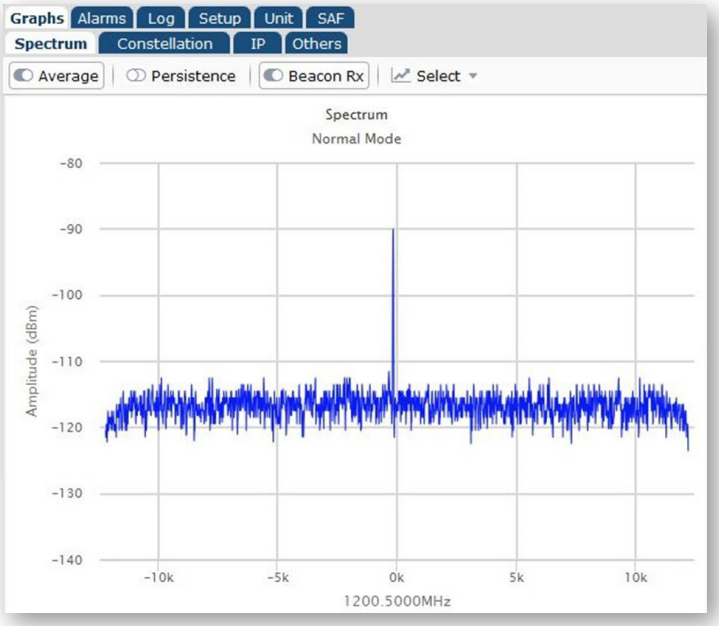
LinkGuard™ Interference Detection

Built-in Spectrum Analyser showing LinkGuard™ Signal-Under-Carrier interference detection without/with interferer present.



Beacon Receiver Function

QubeFlex detects satellite beacon transmissions down to very low signal levels. This helps with automatic antenna pointing and removes the need for a separate beacon receiver.

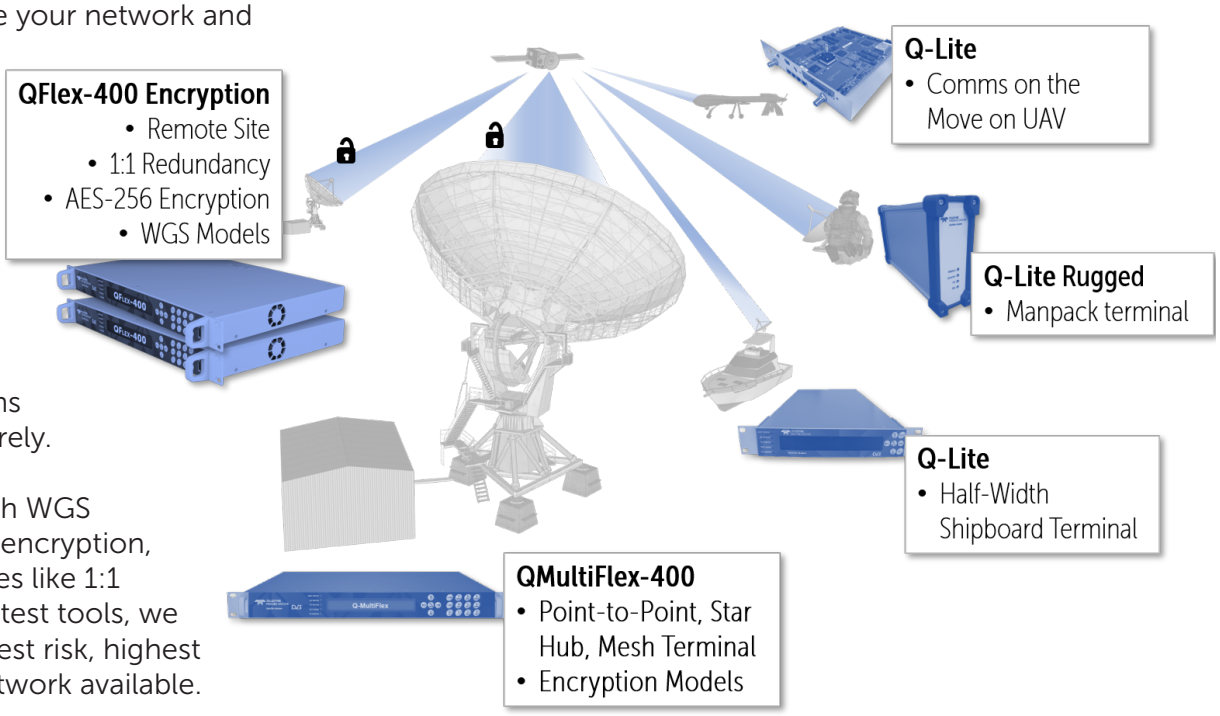


The Q-Net Family

Q-Net is a fabric that allows each of the Q-Series modems to seamlessly inter-operate giving you the ability to upgrade your network and re-use assets at will.

The different models have been thoughtfully designed to cover a wide variety of network situations flexibly and securely.

From models with WGS certification and encryption, to built-in features like 1:1 redundancy and test tools, we give you the lowest risk, highest return secure network available.



The Paradise Family of Secure SCPC Modems

Paradise SCPC Modems			Point-to-Point	Mesh	Point-to-MultiPoint, Star, Hybrid		Features of Note
					Hub	Remote Site	
Standard	1U 19" Rack	QFlex-400	✓			✓	PCMA+ enhanced carrier overlay available
		QMultiFlex-400	✓	✓	✓	✓	Optional Embedded Hub Canceller
		QFlex-400 P2MP	✓			✓	Configured remote
		QubeFlex	✓				Small Sat/LEO - support for CCSDS
		AXIOM-N (New)	✓			✓	IP-centric modem
Small Form Factor	Rack Mount Half Width	Q-Lite Half Width	✓			✓	Mountable side-by-side in 1U rack space
		AXIOM-C (New)	✓			✓	Compact IP-centric modem
	Rugged	Q-Lite Rugged	✓			✓	IP65 weatherproof outdoor modem
		AXIOM-R (New)	✓			✓	IP67 IP-centric modem
	OEM Card	Q-Lite Card	✓			✓	For OEM integration
		AXIOM-X	✓			✓	Our smallest modem

All modem models except QubeFlex are also available as **encrypted models**, capable of TCP/IP packet payload encryption using symmetric AES with 256-bit keys. Note that these models are export controlled.

Main Specifications

Frequency	**L-band (standard):** 950 to 2,450MHz (covering lower S-band also) (resolution 1Hz) **IF (standard):** 50 to 180MHz (resolution 100Hz) N-type connectors for Tx & Rx
Data Rates	**Standard:** 2.4kbps to 2,048kbps **Options:** 5, 10, 25, 50Mbps (CCSDS maximum is 50Mbps)
Symbol Rate Limits	2.4ksps to 40Msps (CCSDS Tx Max: 24.9Msps Viterbi +RS)
Operating Modes	**CCSDS** (CCSDS 131.0-B-1) Viterbi & Reed-Solomon **Intelsat** (IESS-308) Viterbi & Reed-Solomon
Scrambling	**CCSDS** (CCSDS 131.0-B-1) scrambler **Intelsat** V.35 scrambler
Impedance	50Ω
Return Loss	**L-Band:** 950MHz to 2GHz >16dB; 2GHz to 2.45GHz > 12dB **IF:** > 18dB

Traffic Interfaces

Standard	4-port Gigabit Ethernet switch for IP traffic and user control of the modem); Automatic conversion of all demodulated data to UDP unicast/multicast packets, with optional timestamp and link metadata. Includes explicit handling of CCSDS, these and all other formats can also be output in a 'pass through' mode as generic IP. Output is compatible with various off-the-shelf IP packet capture tools for onward computer processing and storage
Serial EIA-530 Interface	RS422, X.21, V.35 & RS232; 25-pin D-type female connector; maximum data rate for RS232 is 100kbps and for all the others is 10Mbps
High-speed Serial LVDS Interface	In serial mode, the demodulator acts as a transparent pipe, with no attempt being made to interpret the data following the error correction stage. 25-pin D-type female connector; maximum data rate is 50Mbps

Test Facilities & Alarm Outputs

Built-in Test Tools	As part of built-in web server: Rx constellation monitor; Rx spectrum analyser; **LinkGuard™** Signal-Under-Carrier interference detection; beacon receiver function that provides automatic detection of satellite beacon transmissions; time graphs for key performance indicators (IP throughput, Eb/No, etc.)

Mechanical/Environmental

Size	1U chassis, 285mm deep excluding front panel handles and rear panel connectors and fans
Weight	3kg
Power Supply	90 to 264VAC, 1A @ 100V, 0.5 A @ 240V, 47 to 63 Hz Fused IEC connector (live and neutral fused); 24V and 48V DC options
Compliance	FCC, CE and RoHS compliant
Safety Standards	EN 62368-1:2014
Emissions & Immunity	Emissions: EN 55032:2015 Class A Immunity: EN 55032:2017
Operating Temperature	0°C to +55°C
Storage Temperature	-20°C to +70°C (limits must not be exceeded)
Humidity	95% relative humidity, non-condensing
Design & Production Facility Certification	Both the design and production facilities are ISO9001 certified; the production facility is additionally AS9100 certified (giving parts traceability)

Optional Functionality

Modulator

Description	An integrated, optional, fully functional modulator mirrors the CCSDS operation of the demodulator in every respect; this may be useful for TT&C & bench/ satellite test purposes
Output Power (0.1dB steps)	**IF:** 0 to –25dBm (0.1 dB steps) **L-Band** (0.1 dB steps)**:** • 0 to -40dBm (950 to 2,150MHz) • 0 to –30dBm (2,150 to 2,450MHz)

Demodulator

Input Range (dBm)	**IF minimum:** -130 + 10 log (symbol rate) **L-band minimum:** -140 + 10 log (symbol rate) **IF/L-band maximum:** -68 + 10 log (symbol rate)
Doppler Limits	**Frequency shift:** up to ± 700kHz **Rate of change:** up to ± 9kHz/s
Frequency Sweep Width	± 1kHz to ± 255kHz (1kHz steps)
Maximum Composite	+10dBm
Wanted-to-Composite	**L-band:** -102 + 10 log (symbol rate)
Rx Spectral Roll-off	Root-raised cosine filter provides choice of 5% , 10%, 15%, 20%, 25%, and 35-60% in 1% steps. Larger roll-offs reduce the carrier peak-to-average power ratio, which reduces signal distortion, thereby substantially easing smallsat transmitter size, weight and power design constraints
LNB 10MHz Reference	Via IFL cable; 10MHz ± 0.01ppm; 2dBm ± 2dB (complies with both 0dBm ± 3dB and 3dBm ± 3dB)
LNB Voltage	Programmable 13V, 15V, 18V, 20V or 24V DC to LNB via IFL cable; maximum 0.75A

Included Network Management

Web browser user interface support provided standard. SNMP & command line interfaces support development of third-party user interfaces. The following network control application options is available

Q-NET™ Navigator	Allows all modems and third-party network devices to be fully controlled through a single application. It provides an easy-to-navigate site map, summary status reporting, etc. Provided as standard, free of charge

Ethernet: Standard Features

IPv4/IPv6	Dual IPv4/IPv6 TCP/IP supporting IPv4/ IPv6 bridging and routing
DHCP	DHCP client for automatic allocation of M&C IP address
SNMP	SNMP v1, v2c & v3
Web Server	Modem web server M&C interface (including built-in tools listed under Test Facilities)
IP Metrics	Tx, Rx throughput (bps, pps) graphs; dropped, errored packet counts
Ethernet MTU Size	All packets generated by the demodulator will conform to the standard MTU of 1500 bytes

Forward Error Correction

Note: Viterbi & Reed-Solomon can be used independently of each other as required

CCSDS-compliant Viterbi & Reed-Solomon	**Viterbi:** BPSK, QPSK & OQPSK 1/2, 2/3, 3/4,5/6, 7/8 **Reed-Solomon:** **Symbols per codeword:** 255 **Error correction values:** 8 & 16 Codes include (255, 223) & (255, 239) plus shortened codeblocks **Interleaver depth**: 1
Intelsat-compliant Viterbi & Reed-Solomon (including custom settings)	**Viterbi:** BPSK, QPSK & OQPSK 1/2, 3/4, 7/8 **Reed-Solomon:** A codeword consists of k data symbols + (n - k) parity symbols, where (n - k)/2 symbol errors per codeword can be corrected. **Value of n**: 60 to 255 symbols **Value of k**: 40 to 253 symbols in steps of 2 where the current range is restricted to between n - 2 and n - 20 **Interleaver depth**: 4 & 8

Ordering: QubeFlex Satellite Modem

Standard Features		Description
Base Modem	✓	2.4kbps to 2.048Mbps Tx/Rx CCSDS/Intelsat modem 4-port Gigabit Ethernet switch for modem control and satellite traffic; includes all features described under Ethernet Standard Features CCSDS & Intelsat Forward Error Correction as described under Forward Error Correction IF operation: 50 to 180MHz L-band/S-band operation (standard): 950 to 2450MHz; high-stability 10MHz reference Doppler limits (standard): ±255kHz, ±2.1kHz/s Carrier roll-offs (standard): 5%, 10%, 15%, 20%, 25%, 35% Test facilities: includes all features described under Test Facilities AC mains input
Optional Features		
Rx Only	○	A discount is applied when the modulator function is not required
Extend Data Rate	○	5Mbps data rate: Extends base operation to 5Mbps (CCSDS Viterbi/Reed-Solomon)
	○	10Mbps data rate: Extends 5Mbps operation to 10Mbps (CCSDS Viterbi/Reed-Solomon)
	○	25Mbps data rate: Extends 10Mbps operation to 25Mbps (CCSDS Viterbi/Reed-Solomon)
	○	50Mbps data rate: Extends 25Mbps operation to 50Mbps (Supports CCSDS Viterbi/Reed-Solomon to 50Mbps)
Terrestrial Interfaces	○	Serial EIA-530 interface: Supports RS422/X.21/V.35/RS232; 25-pin D-type female connector; maximum data rate for RS232 is 100kbps and for all the others is 10Mbps
	○	High-speed LVDS serial interface: 25-pin D-type female connector; maximum data rate is 50Mbps
Extended Doppler	○	Extends base modem Doppler limits from ±255kHz, ±2.1kHz/s to ±700kHz, ±9kHz/s
Extended Roll-offs	○	Extends base modem carrier roll-offs to include up to 60% roll-off (selectable in 1% increments)
DC Input	○	48V DC: K3025 48V DC primary power input (in place of 100 to 240V AC input)

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