CERAGON

Datasheet

FibeAir IP-20N

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High-availability, split-mount, modular multicore aggregation node

The FibeAir IP-20N is a highly-flexible aggregation node that delivers multi-Gbps radio capacity at a very large scale. Now available with multicore technology and new radio units, IP-20N features high modularity and flexibility and supports up to 8 radio links with an exceptionally wide variety of line interfaces via pluggable modules, in a wide range of network topologies - making it the preferred node for your transport network's aggregation sites.

The FibeAir IP-20N operates within the entire microwave and millimeter-wave spectrum, offering high spectral efficiency across licensed and license-exempt frequency bands (4-86 GHz). It also supports all high-speed data interfaces (10G/1G/FE) and a wide variety of TDM interfaces (E1, STM-1); operates with a wide variety of multicore, standard and high power radios; and accommodates various network configurations including 1x 8+0, 4x 2+0, and 8x 1+0.

Note: For exact feature availability, contact your Ceragon representative. In case of discrepancy between this Datasheet and the Technical Description for the product, the Technical Description prevails.

General

Assembly options

1RU Chassis – 5x Universal slots;

2RU Chassis –10x Universal slots

Redundant TCC slots (2RU chassis only)

Radio

Supported Frequency Range

Standard Power: 6-42 GHz, 71-76 GHz, 81-86 GHz

High Power: 4-11 GHz

Supported RFUs

RFU-D – High-capacity MultiCore radio

RFU-D-HP – High-capacity, high-power MultiCore radio

RFU-E – High capacity E-band radio

RFU-S – High-capacity radio

RFU-C – High-capacity radio

1500HP/RFU-HP – High-capacity, high-power radio

Typical Radio Configurations

N+0 (up to N=8), 1x 8+0, 2x 4+0, 4x 2+0, 8x 1+0, 1+1, 2+2

Split Mount (Standard Power, High Power)

All Indoor (High Power)

Radio Features

Multi-Carrier Adaptive Bandwidth Control (up to 8+0)

Protection and Diversity: HSB, SD (BBC and BBS)

High spectral utilization: BPSK to 4096 QAM w/ACM

Channel bandwidth:

- 4-42 GHz: up to 112 MHz
- E-Band: up to 500 MHz

XPIC

Multiband (with IP-50E/IP-20E)

Advanced Space Diversity (ASD)*

Field Replaceable Diplexers/ Field Replaceable Channel Filters

Ethernet

Ethernet Interfaces

1RU/2RU Traffic Interfaces - Up to 10 x 1000Base-T (RJ-45) or 1000base-X (SFP)

Up to 2 x 10Gbase-X (SFP+)

Management Interfaces - 2 x 10/100 Base-T (RJ-45)

SFP Types - Optical 1000Base-LX (1310 nm) or SX (850 nm)

Ethernet Features

MTU – 9600 Bytes

Quality of Service

- Multiple Classification criteria (VLAN ID, P-bits, IPv4 DSCP, IPv6 TC, MPLS EXP)
- 8 priority queues per port
- Deep buffering (configurable up to 64 Mbit per queue)
- WRED
- P-bit marking/remarking

4K VLANs

VLAN add/remove

MSTP, ERP (ITU-T G.8032)

Frame Cut Through – controlled latency and PDV for delay sensitive applications

Header DeDuplication – Capacity boosting by eliminating inefficiency in all layers (L2,MPLS, L3,L4, Tunneling – GTP for LTE, GRE)

Y.1731 Ethernet OAM

Y.1731 Ethernet Bandwidth Notification (ETH-BN)

* Planned for future release.

TDM

TDM Interfaces

1RU Chassis: 80 x E1s; 5 x ch-STM-1s, 4 x STM-1s

2RU Chassis: 160 x E1s; 10 x ch-STM-1s, 8 x STM-1s

TDM Features

Native TDM services and TDM PWE using the same hardware

Integrated ch-STM-1 MUX (VC12)

XC capacity – 512 VCs

Timing options – Loop timing, system clock, recovered clock

1+1 / 1:1 path protection

Clear-channel STM-1 (RST)

Management Protocols

SNMP

REST

SDN Support:

- NETCONF/YANG

Synchronization

Synchronization Distribution

Sync Distribution over any traffic interface (GE/FE, E1, STM-1)

Dedicated In/Out synch interface (E1/2 MHz)

SyncE (ITU-T G.8261, G.8262)

SSM/ESMC Support for ring/mesh applications (ITU-T G.8264)

SyncE Regenerator mode, providing PRC grade (ITU-T G.811) performance for smart pipe applications

IEEE-1588

Optimized Transport for reduced PDV

IEEE-1588 TC

IEEE-1588 BC

Standards

MEF

Carrier Ethernet 2.0 (CE 2.0)

Supported Ethernet Standards

10/100/1000base-T/X (IEEE 802.3)

10G Base-LR (802.ae)

Ethernet VLANs (IEEE 802.3ac)

Virtual LAN (VLAN, IEEE 802.1Q)

Class of service (IEEE 802.1p)

Provider bridges (QinQ – IEEE 802.1ad)

Link aggregation (IEEE 802.3ad)

Auto MDI/MDIX for 1000baseT

RFC 1349: IPv4 TOS

RFC 2474: IPv4 DSCP

RFC 2460: IPv6 Traffic Classes

Supported E1 Standards

ITU-T G.703, G.736, G.775, G.823, G.824, G.828, ITU-T I.432, ETSI ETS 300 147, ETS 300 417

Supported STM-1 Standards

ITU-T G.703, G.775, G.813, G.825, EN 300 386 V1.2.1, ES 201 468; V1.1.1 :2000-03, ES 201 468 V1.2.1 :2002-09, EN 61000 4-3

TDM Pseudowire Standards

SAToP – RFC 4553

Security

Radio Encryption – AES 256

Secured protocols:

- HTTPS
- SNMPv3
- SSH
- SFTP

RADIUS authentication and authorization

TACACS+ Authentication, Authorization, and Accounting (session-based)

Standards Compliance

Radio Spectral Efficiency: EN 302 217-2-2

EMC: EN 301 489-4, EN 301 489-1, FCC 47 CFR, part 15, class B

Safety: EN 60950-1, IEC 60950-1, UL 60950-1, CSA-C22.2 No.60950-1, EN 60950-22, UL 60950-22, CSA C22.2.60950-22

Ingress Protection:

- RFU-D: IP67
- RFU-D-HP: IP67
- RFU-E: IP67
- RFU-S: IP67
- RFU-C: IP66
- 1500HP/RFU-HP: IP56

Storage: ETSI EN 300 019-1-1 Class 1.2

Transportation: ETSI EN 300 019-1-2 Class 2.3

Technical Specifications

Mechanical Specifications

1RU Chassis – 44.5mm(H), 444.3mm(W), 245mm(D), 3kg (empty);

2RU Chassis – 88mm(H), 444.3mm(W), 245mm(D), 6kg (empty)

Plugin Card Weights: 0.3kg – 1.5kg

RFU-D – 230mm(H), 233mm(W), 98mm(D), 6.5kg (includes diplexer unit)

RFU-D-HP– 319mm(H), 286mm(W), 107mm(D), 12kg (includes diplexer or OCU unit)

RFU-E – 220mm(H), 198mm(W), 75mm(D), 3kg

RFU-S – 217mm(H), 210mm(W), 85mm(D), 4kg

RFU-C – 200mm(H), 200mm(W), 85mm(D), 4kg

1500HP/RFU-HP – 490mm(H), 144mm(W), 280mm(D), 7kg(W) (excluding Branching)

1500HP/RFU-HP OCB Branching (Split Mount and Compact All-Indoor) – 420mm(H), 110mm(W), 380mm(D), 7kg per carrier

Environmental Specifications

IDU: -5° to +55°C (-25°C to +65°C extended);
RFU: -33°C to +55°C (-45°C to +60°C extended)

Power Input Specifications

IDU Standard Input: -48 VDC

IDU DC Input range: -40 to -60 VDC, with maximum current of up to 15A (1RU chassis) or 30A (2RU chassis)

Dual-feed power support

Power Consumption Specifications

TCC – 25W; RMC – 17W; RIC-D – 12W; 1X10G LIC – 12W; 4XGE LIC – 9W; 16XE1 LIC – 17W; ch-STM-1 LIC – 25W; STM-1 – 9W

Fans (1RU/2RU) – 6/30W max (4/6W-25°C)

RFU-D (2+0) – 6-11 GHz: 65W; 13-42 GHz: 48W

RFU-D-HP (2+0) – 130W

RFU-E – 43W

RFU-S – 43W

RFU-C – 6-26 GHz (1+0/1+1): 22W/39W; 28-42 GHz (1+0/1+1): 26W/43W

RFU-HP (6-8 GHz) – Max Bias: 73W; Mid Bias: 48W; Min Bias: 34W; Mute: 18W

RFU-HP (11 GHz) – Max Bias: 74W; Mid Bias: 64W; Mute: 21W

1500HP – Max Bias: 85W; Mid Bias: 72W; Mute: 29W

Product Images

IDU

IP-20N 1RU Chassis

IP-20N 2RU Chassis

Modules

Radio Modem Cards (RMCs)

Radio Interface Cards (RICs)

Traffic Control Cards (TCCs)

Ethernet LIC with 1 Combo and 3 Electrical or Optical Interfaces

Ethernet LIC with a Single 10G Optical Interface

TDM LICs

Radio Units

RFU-E

RFU-D

RFU-D-HP

RFU-S

RFU-C

1500HP/RFU-HP

Radio Specifications

Capacity and Maximum Number of E1s – Microwave Bands

Notes: BPSK and 4096 QAM modulations require RFU-D, RFU-D-HP, or RFU-S. For details about supported scripts, frequencies, and channels per RFU, refer to the Release Notes for the relevant CeraOS version.

	Capacity (Mbps)	Capacity De-Dup	Max. No. of E1s	Capacity (Mbps)	Capacity De-Dup	Max. No. of E1s	Capacity (Mbps)	Capacity De-Dup	Max. No. of E1s
Modulation	3.5 MHz			7 MHz			14 MHz		
BPSK	–	–	–	–	–	–	6-8	7-25	4
QPSK	3-4	4-13	2	8-10	9-32	3	17-20	17-63	8
8 QAM	–	–	–	13-16	13-48	5	26-32	28-100	12
16 QAM	8-10	9-32	4	18-22	19-69	8	38-46	39-143	17
32 QAM	11-14	12-43	5	24-30	26-92	10	50-62	53-192	23
64 QAM	14-17	15-54	6	30-37	32-114	112	63-77	66-238	28
128 QAM	17-21	18-65	7	36-44	38-137	15	76-93	80-290	33
256 QAM	19-24	20-74	8	42-51	44-158	17	87-107	92-333	38
512 QAM	–	–	–	45-54	47-169	18	97-119	102-369	42
1024 QAM Strong	–	–	–	48-58	50-182	19	103-126	108-391	45
1024 QAM Light	–	–	–	51-62	53-194	21	109-133	115-415	47
	28 MHz			40 MHz			56 MHz		
BPSK	18-22	19-68	9	26-31	27-97	12	40-49	42-153	18
QPSK	40-49	42-152	18	55-67	58-209	24	84-103	88-320	37
8 QAM	59-72	62-225	26	83-102	87-317	36	124-151	130-471	54
16 QAM	84-103	89-321	37	114-140	120-435	50	173-212	182-658	74
32 QAM	112-137	118-426	49	152-185	159-577	65	229-280	240-870	98
64 QAM	139-170	146-527	60	187-228	196-710	80	281-344	296-1026	120
128 QAM	167-205	176-637	72	227-277	238-862	97	341-416	358-1026	145
256 QAM	193-236	203-734	83	244-298	256-927	104	394-481	414-1026	168
512 QAM	206-251	216-782	88	267-327	281-1016	114	424-518	445-1026	180
1024 QAM Strong	225-274	236-854	96	303-371	319-1026	130	461-564	484-1026	196
1024 QAM Light	238-291	250-906	102	323-394	339-1026	138	490-599	515-1026	208
2048 QAM	260-318	273-989	111	349-427	367-1026	149	531-649	558-1026	226
4096 QAM	277-339	291-1026	118	369-451	388-1026	156	547-668	574-1026	232
	80 MHz			112 MHz					
BPSK	55-67	57-208	24	80-97	84-303	35			
QPSK	111-136	117-424	48	163-200	172-622	70			
8 QAM	159-195	167-606	69	244-299	256-929	104			
16 QAM	228-279	240-869	98	333-407	350-1026	142			
32 QAM	301-367	316-1026	128	439-536	461-1026	187			
64 QAM	369-451	387-1026	157	539-659	566-1026	229			
128 QAM	436-533	458-1026	186	652-797	685-1026	277			
256 QAM	502-614	528-1026	214	746-912	784-1026	317			
512 QAM	552-675	580-1026	235	810-990	851-1026	344			
1024 QAM Strong	601-735	631-1026	255	879-1037	923-1026	373			
1024 QAM Light	638-780	670-1026	271	933-1037	980-1026	396			
2048 QAM	676-826	710-1026	287	1002-1037	1002-1026	427			

Capacity and Maximum Number of E1s – RFU-E

	Capacity (Mbps)	Capacity De-Dup	Max. No. of E1s	Capacity (Mbps)	Capacity De-Dup	Max. No. of E1s
Modulation	14 MHz			28 MHz		
BPSK	9-11	10-36	3	20-26	21-70	8
QPSK	19-24	20-76	8	43-52	45-162	17
8 QAM	29-36	31-115	12	62-76	65-236	24
16 QAM	–	–	–	87-107	92-332	35
32 QAM	–	–	–	115-140	121-437	46
64 QAM	–	–	–	141-173	149-538	56
128 QAM	–	–	–	170-208	179-648	68
256 QAM	–	–	–	196-239	206-745	78
512 QAM	–	–	–	209-255	219-794	83
Modulation	62.5 MHz			125 MHz		
BPSK	42-51	44-160	19	90-110	94-341	41
QPSK	93-114	98-355	42	188-230	197-715	85
8 QAM	139-170	146-528	63	279-341	293-1062	127
16 QAM	188-230	198-716	85	379-463	398-1443	172
32 QAM	247-302	259-939	112	499-610	524-1898	227
64 QAM	301-368	316-1145	137	612-748	643-2329	278
128 QAM	362-442	380-1377	165	737-900	774-2500	335
256 QAM	412-504	433-1569	187	838-1025	880-2500	381
512 QAM	453-554	476-1724	206	923-1128	969-2500	420
1024 QAM	505-617	530-1920	230	–	–	–
Modulation	250 MHz			500 MHz		
BPSK	180-221	189-687	82	362-442	–	165
QPSK	377-461	396-1435	171	755-923	–	343
8 QAM	559-683	587-2128	254	1119-1368	–	509
16 QAM	759-928	797-2500	345	1520-1858	–	512
32 QAM	998-1220	1048-2500	454	1998-2442	–	512
64 QAM	1225-1497	1286-2500	512	2451-2500	–	512
128 QAM	1474-1802	1548-2500	512	–	–	–
256 QAM	1653-2021	1736-2500	512	–	–	–

Transmit Power – Microwave Bands

RFU-D

Modulation	Frequency (GHz)	6	7	8	11	13	15	18	23	26	28-32	38	42
BPSK - QPSK		28	28	28	28	24	24	22	20	21	18	22	15
8 QAM		28	28	28	28	24	24	22	20	21	18	22	15
16 QAM		28	27	27	28	23	24	22	20	20	17	21	15
32 QAM		28	27	26	28	23	24	22	20	19	16	21	14
64 QAM		28	26	26	27	23	24	22	20	19	16	20	13
128 QAM		27	26	26	26	22	24	22	20	19	16	20	13
256 QAM		27	26	26	26	21	22	20	20	17	14	19	13
512 QAM		27	25	24	26	21	22	20	20	17	14	19	11
1024 QAM		25	24	24	25	20	20	20	18	16	13	18	11
2048 QAM		25	23	22	24	20	20	18	17	15	12	18	10
4096 QAM		23	21	20	22	18	18	16					

RFU-D-HP

Modulation	Frequency (GHz)	4	5	6	7	8	11
BPSK		35	35	38	38	37	36
QPSK – 8 QAM		35	35	37	37	37	36
16 – 32 QAM		35	35	37	37	37	35
64 QAM		34	34	36	36	35	34
128 QAM		34	34	36	35	35	33
256 QAM		33	33	35	34	33	32
512 QAM		33	33	34	33	33	32
1024 QAM		32	32	33	32	32	31
2048 QAM		31	31	33	31	31	31
4096 QAM		30	30	31	29	29	29

RFU-S

Modulation	Frequency (GHz)	6	7	8	11	13	15	18	23	26	28-38	42
BPSK - 8 PSK		28	27	27	28	27	24	23	24	23	18	15
16 QAM		28	27	27	28	27	24	23	24	23	17	15
32 QAM		27	27	26	28	26	24	23	24	23	16	14
64 QAM		27	26	26	27	24	23	23	23	23	16	13
128 QAM		27	26	26	27	24	23	22	23	23	16	13
256 QAM		27	26	26	27	24	22	22	22	21	14	13
512 QAM		25	25	25	27	24	22	22	22	21	14	11
1024 QAM		25	24	24	25	22	20	19	21	20	13	11
2048 QAM		23	23	24	24	21	20	17	20	18	12	10
4096 QAM		21	21	22	22	19	18	15	–	–	–	–

RFU-C

Transmit Power	Frequency	6-8	11-15	18-23	24	26	28	36	38	42
QPSK/8 PSK		26	24	22	0	21	14	12	18	12
16 QAM		25	23	21	0	20	14	11	17	12
32 QAM		24	22	20	0	19	14	10	16	12
64 QAM		24	22	20	0	19	14	10	16	12
128 QAM		24	22	20	0	19	14	10	16	12
256 QAM		22	20	18	0	17	12	8	14	11
512 QAM		22	20	18	-1	17	9	10	14	11
1024 QAM		21	19	17	-3	16	8	9	13	10
2048 QAM		19	17	15	0	14	6	7	11	8

RFU-HP 1RX

Modulation	Frequency (GHz)	6L&H	7	8	11
QPSK – 16 QAM		33	33	33	30
32 QAM		33	33	33	29
64 QAM		32	32	32	29
128 QAM		31	31	31	29
256 QAM		30	30	30	27
512 QAM		28	28	28	25
1024 QAM		27	27	27	24
2048 QAM		25	25	25	22

RFU-HP 2RX (1500HP)

6L&H	7	8	11
33	33	33	30
33	33	33	29
32	32	32	29
32	32	32	29
30	30	30	27
28	28	28	25
27	27	27	24
25	25	25	22

Transmit Power – RFU-E

Modulation	Channel Bandwidth (MHz)	14	28	62.5	125	250	500
BPSK		18	18	18	18	18	15
QPSK		18	18	18	18	18	15
8 QAM		18	18	18	18	16	11
16 QAM		–	17	17	17	15	10
32 QAM		–	17	17	17	15	10
64 QAM		–	16	16	16	14	9
128 QAM		–	16	16	16	14	–
256 QAM		–	15	15	15	13	–
512 QAM		–	14	14	14	–	–
1024 QAM		–	–	13	–	–	–

Receiver Threshold (RSL) – Microwave Bands

Notes: BPSK and 4096 QAM modulations require RFU-D, RFU-D-HP, or RFU-S.

RFU-D and RFU-S

14 MHz / Frequency (GHz)	6	7-8	10	11	13	15	18	23	24	26	28-31	32	38	42
BPSK	-91.5	-91.0	-90.5	-91.5	-90.5	-89.5	-91	-90.0	-89.5	-89.5	-89.5	-89.0	-89.0	-88.5
QPSK	-90.5	-90.0	-89.5	-90.5	-89.5	-88.5	-90	-89.0	-88.5	-88.5	-88.5	-88.0	-88.0	-87.5
8 PSK	-84.5	-84.0	-83.5	-85.5	-83.5	-82.5	-84	-83.0	-82.5	-82.5	-82.5	-82.0	-82.0	-81.5
16 QAM	-83.5	-83.0	-82.5	-83.5	-82.5	-81.5	-83	-82.0	-81.5	-81.5	-81.5	-81.0	-81.0	-80.5
32 QAM	-80.5	-79.5	-79.5	-80.5	-79.0	-78.5	-79.5	-79.0	-78.5	-78.5	-78.0	-78.0	-77.5	-77.0
64 QAM	-77.5	-76.5	-76.5	-77.0	-76.0	-75.5	-76.5	-76.0	-75.5	-75.5	-75.0	-75.0	-74.5	-74.0
128 QAM	-74.0	-73.5	-73.0	-74.0	-73.0	-72.0	-73.5	-72.5	-72.0	-72.0	-72.0	-71.5	-71.5	-71.0
256 QAM	-71.5	-70.5	-70.5	-71.0	-70.0	-69.5	-70.5	-69.5	-69.0	-69.5	-69.0	-69.0	-68.5	-68.0
512 QAM	-68.5	-68.0	-67.5	-68.5	-67.5	-66.5	-68.0	-67.0	-66.5	-66.5	-66.5	-66.0	-66.0	-65.5
1024 QAM Strong	-65.5	-65.0	-64.5	-65.5	-64.5	-63.5	-65.0	-64.0	-63.5	-63.5	-63.5	-63.0	-63.0	-62.5
1024 QAM Light	-65.0	-64.0	-64.0	-64.5	-63.5	-63.0	-64.0	-63.5	-63.0	-63.0	-62.5	-62.5	-62.0	-61.5
28 MHz														
BPSK	-88.5	-88.0	-87.5	-88.5	-87.5	-86.5	-88.0	-87.0	-86.5	-86.5	-86.5	-86.0	-86.0	-85.5
QPSK	-87.5	-87.0	-86.5	-87.5	-86.5	-85.5	-87.0	-86.0	-85.5	-85.5	-85.5	-85.0	-85.0	-84.5
8 PSK	-83.0	-82.5	-82.0	-83.0	-82.0	-81.0	-82.5	-81.5	-81.0	-81.0	-81.0	-80.5	-80.5	-80.0
16 QAM	-81.0	-80.5	-80.0	-81.0	-79.5	-79.0	-80.5	-79.5	-79.0	-79	-79.0	-78.5	-78.0	-78.0
32 QAM	-77.5	-77.0	-76.5	-77.5	-76.0	-75.5	-77.0	-76.0	-75.5	-75.5	-75.5	-75.0	-74.5	-74.5
64 QAM	-74.5	-74.0	-73.5	-74.5	-73.0	-72.5	-74.0	-73.0	-72.5	-72.5	-72.5	-72.0	-71.5	-71.5
128 QAM	-71.5	-70.5	-70.5	-71.0	-70.0	-69.5	-70.5	-69.5	-69.0	-69.5	-69.0	-69.0	-68.5	-68.0
256 QAM	-68.5	-67.5	-67.5	-68.0	-67.0	-66.5	-67.5	-66.5	-66.0	-66.5	-66.0	-66.0	-65.5	-65.0
512 QAM	-66.0	-65.0	-65.0	-66.0	-64.5	-64.0	-65.0	-64.5	-64.0	-64.0	-63.5	-63.5	-63.0	-62.5
1024 QAM Strong	-63.0	-62.5	-62.0	-63.0	-61.5	-61.0	-62.5	-61.5	-61.0	-61.0	-61.0	-60.5	-60.0	-60.0
1024 QAM Light	-62.0	-61.5	-61.0	-62.0	-60.5	-60.0	-61.5	-60.5	-60.0	-60.0	-60.0	-59.5	-59.0	-59.0
2048 QAM	-58.5	-58.0	-57.5	-58.5	-57.0	-56.5	-58.0	-57.0	-56.5	-56.5	-56.5	-56.0	-55.5	-55.5
4096 QAM	-55.5	-55.0	-54.5	-55.5	-54.0	-53.5	-55.0	–	–	–	–	–	–	–
40 MHz														
BPSK	-87.0	-86.5	-86.0	-87.0	-86.0	-85.0	-86.5	-85.5	-85.0	-85.0	-85.0	-84.5	-84.5	-84.0
QPSK	-86.0	-85.5	-85.0	-86.0	-85.0	-84.0	-85.5	-84.5	-84.0	-84.0	-84.0	-83.5	-83.5	-83.0
8 PSK	-81.0	-80.5	-80.0	-81.0	-79.5	-79.0	-80.5	-79.5	-79.0	-79.0	-79.0	-78.5	-78.0	-78.0
16 QAM	-79.5	-79.0	-78.5	-79.5	-78.0	-77.5	-79.0	-78.0	-77.5	-77.5	-77.5	-77.0	-76.5	-76.5
32 QAM	-76.0	-75.0	-75.0	-75.5	-74.5	-74.0	-75.0	-74.0	-73.5	-74.0	-73.5	-73.5	-73.0	-72.5
64 QAM	-73.0	-72.0	-72.0	-73.0	-71.5	-71.0	-72.0	-71.5	-71.0	-71.0	-70.5	-70.5	-70.0	-69.5
128 QAM	-70.0	-69.0	-69.0	-70.0	-68.5	-68.0	-69.0	-68.5	-68.0	-68.0	-67.5	-67.5	-67.0	-66.5
256 QAM	-67.0	-66.0	-66.0	-66.5	-65.5	-65.0	-66.0	-65.0	-64.5	-65.0	-64.5	-64.5	-64.0	-63.5
512 QAM	-64.0	-63.5	-63.0	-64.0	-62.5	-62.0	-63.5	-62.5	-62.0	-62.0	-62.0	-61.5	-61.0	-61.0
1024 QAM Strong	-61.5	-61.0	-60.5	-61.5	-60.0	-59.5	-61.0	-60.0	-59.5	-59.5	-59.5	-59.0	-58.5	-58.5
1024 QAM Light	-60.5	-60.0	-59.5	-60.5	-59.5	-58.5	-60.0	-59.0	-58.5	-58.5	-58.5	-58.0	-58.0	-57.5
2048 QAM	-58.0	-57.0	-57.0	-58.0	-56.5	-56.0	-57.0	-56.5	-56.0	-56.0	-55.5	-55.5	-55.0	-54.5
4096 QAM	-55.0	-54.0	-54.0	-55.0	-53.5	-53.0	-54.0	–	–	–	–	–	–	–

56 MHz Frequency (GHz)	6	7-8	10	11	13	15	18	23	24	26	28-31	32	38	42
BPSK	-85.5	-85.0	-84.5	-85.5	-84.0	-83.5	-85.0	-84.0	-83.5	-83.5	-83.5	-83.0	-82.5	-82.5
QPSK	-84.5	-84.0	-83.5	-84.5	-83.0	-82.5	-84.0	-83.0	-82.5	-82.5	-82.5	-82.0	-81.5	-81.5
8 PSK	-80.0	-79.0	-79.0	-79.5	-78.5	-78.0	-79.0	-78.0	-77.5	-78.0	-77.5	-77.5	-77.0	-76.5
16 QAM	-77.5	-77.0	-76.5	-77.5	-76.0	-75.5	-77.0	-76.0	-75.5	-75.5	-75.5	-75.0	-74.5	-74.5
32 QAM	-74.0	-73.0	-73.0	-73.5	-72.5	-72.0	-73.0	-72.0	-71.5	-72.0	-71.5	-71.5	-71.0	-70.5
64 QAM	-70.5	-70.0	-69.5	-70.5	-69.5	-68.5	-70.0	-69.0	-68.5	-68.5	-68.5	-68.0	-68.0	-67.5
128 QAM	-68.0	-67.0	-67.0	-67.5	-66.5	-66.0	-67.0	-66.0	-65.5	-66.0	-65.5	-65.5	-65.0	-64.5
256 QAM	-64.5	-64.0	-63.5	-64.5	-63.5	-62.5	-64.0	-63.0	-62.5	-62.5	-62.5	-62.0	-62.0	-61.5
512 QAM	-62.5	-62.0	-61.5	-62.5	-61.5	-60.5	-62.0	-61.0	-60.5	-60.5	-60.5	-60.0	-60.0	-59.5
1024 QAM Strong	-59.0	-58.5	-58.0	-59.0	-58.0	-57.0	-58.5	-57.5	-57.0	-57.0	-57.0	-56.5	-56.5	-56.0
1024 QAM Light	-58.0	-57.5	-57.0	-58.0	-57.0	-56.0	-57.5	-56.5	-56.0	-56.0	-56.0	-55.5	-55.5	-55.0
2048 QAM	-55.5	-54.5	-54.5	-55.0	-54.0	-53.5	-54.5	-53.5	-53.0	-53.5	-53.0	-53.0	-52.5	-52.0
4096 QAM	-52.5	-51.5	-51.5	-52.0	-51.0	-50.5	–	–	–	–	–	–	–	–
80 MHz														
BPSK	-85.0	-85.0	-84.5	-85.5	-84.5	-83.5	-85.0	-84.0	-83.5	-83.5	-83.5	-83.0	-83.5	-82.5
QPSK	-82.5	-82.5	-82.5	-83.0	-82.0	-81.5	-82.5	-81.5	-81.0	-81.5	-81.0	-81.0	-81.0	-80.0
8 PSK	-79.0	-79.0	-78.5	-79.5	-78.5	-77.5	-79.0	-78.0	-77.5	-77.5	-77.5	-77.0	-77.5	-76.5
16 QAM	-76.0	-76.0	-75.5	-76.5	-75.0	-74.5	-76.0	-75.0	-74.5	-74.5	-74.5	-74.0	-74.0	-73.5
32 QAM	-72.5	-72.5	-72.0	-73.0	-71.5	-71.0	-72.5	-71.5	-71.0	-71.0	-71.0	-70.5	-70.5	-70.0
64 QAM	-69.0	-69.0	-69.0	-70.0	-68.5	-68.0	-69.0	-68.5	-68.0	-68.0	-67.5	-67.5	-67.5	-66.5
128 QAM	-66.5	-66.5	-66.0	-67.0	-66.0	-65.0	-66.5	-65.5	-65.0	-65.0	-65.0	-64.5	-65.0	-64.0
256 QAM	-63.5	-63.5	-63.0	-64.0	-63.0	-62.0	-63.5	-62.5	-62.0	-62.0	-62.0	-61.5	-62.0	-61.0
512 QAM	-61.0	-61.0	-61.0	-62.0	-60.5	-60.0	-61.0	-60.5	-60.0	-60.0	-59.5	-59.5	-59.5	-58.5
1024 QAM Strong	-58.0	-58.0	-57.5	-58.5	-57.5	-56.5	-58.0	-57.0	-56.5	-56.5	-56.5	-56.0	-56.5	-55.5
1024 QAM Light	-57.0	-57.0	-57.0	-58.0	-56.5	-56.0	-57.0	-56.5	-56.0	-56.0	-55.5	-55.5	-55.5	-54.5
2048 QAM	-54.5	-54.5	-54.5	-55.5	-54.0	-53.5	-54.5	-54.0	-53.5	-53.5	-53.0	-53.0	–	–
112 MHz														
BPSK	-82.0	-81.5	-81.0	-82.0	-80.5	-80.0	-81.5	-80.5	-80.0	-80.0	-80.0	-79.5	-79.0	-79.0
QPSK	-81.0	-80.5	-80.0	-81.0	-79.5	-79.0	-80.5	-79.5	-79.0	-79.0	-79.0	-78.5	-78.0	-78.0
8 PSK	-76.5	-75.5	-75.5	-76.0	-75.0	-74.5	-75.5	-74.5	-74.0	-74.5	-74.0	-74.0	-73.5	-73.0
16 QAM	-74.0	-73.5	-73.0	-74.0	-72.5	-72.0	-73.5	-72.5	-72.0	-72.0	-72.0	-71.5	-71.0	-71.0
32 QAM	-70.5	-69.5	-69.5	-70.0	-69.0	-68.5	-69.5	-68.5	-68.0	-68.5	-68.0	-68.0	-67.5	-67.0
64 QAM	-67.0	-66.5	-66.0	-67.0	-66.0	-65.0	-66.5	-65.5	-65.0	-65.0	-65.0	-64.5	-64.5	-64.0
128 QAM	-64.5	-63.5	-63.5	-64.0	-63.0	-62.5	-63.5	-62.5	-62.0	-62.5	-62.0	-62.0	-61.5	-61.0
256 QAM	-61.0	-60.5	-60.0	-61.0	-60.0	-59.0	-60.5	-59.5	-59.0	-59.0	-59.0	-58.5	-58.5	-58.0
512 QAM	-59.0	-58.5	-58.0	-59.0	-58.0	-57.0	-58.5	-57.5	-57.0	-57.0	-57.0	-56.5	-56.5	-56.0
1024 QAM Strong	-55.5	-55.0	-54.5	-55.5	-54.5	-53.5	-55.0	-54.0	-53.5	-53.5	-53.5	-53.0	-53.0	-52.5
1024 QAM Light	-54.5	-54.0	-53.5	-54.5	-53.5	-52.5	-54.0	-53.0	-52.5	-52.5	-52.5	-52.0	-52.0	-51.5
2048 QAM	-52.0	-51.0	-51.0	-51.5	-50.5	-50.0	-51.0	-50.0	-49.5	-49.5	-49.5	-49.5	–	–

RFU-D-HP

	28 MHz					40 MHz					56 MHz				
Frequency (GHz)	4-5	6	7	8	11	4-5	6	7	8	11	4-5	6	7	8	11
BPSK	-91.9	-91.6	-91.8	-91.2	-91.3	-90.6	-90.3	-90.5	-89.9	-90.0	-89.1	-88.8	-89.0	-88.4	-88.5
QPSK	-88.9	-88.6	-88.8	-88.2	-88.3	-87.4	-87.1	-87.3	-86.7	-86.8	-85.9	-85.6	-85.8	-85.2	-85.3
8 PSK	-85.0	-84.7	-84.9	-84.3	-84.4	-83.4	-83.1	-83.3	-82.7	-82.8	-81.8	-81.5	-81.7	-81.1	-81.2
16 QAM	-82.0	-81.7	-81.9	-81.3	-81.4	-80.5	-80.2	-80.4	-79.8	-79.9	-78.9	-78.6	-78.8	-78.2	-78.3
32 QAM	-78.7	-78.4	-78.6	-78.0	-78.1	-77.1	-76.8	-77.0	-76.4	-76.5	-75.6	-75.3	-75.5	-74.9	-75
64 QAM	-75.7	-75.4	-75.6	-75.0	-75.1	-74.0	-73.7	-73.9	-73.3	-73.4	-72.6	-72.3	-72.5	-71.9	-72.0
128 QAM	-72.6	-72.3	-72.5	-71.9	-72.0	-71.0	-70.7	-70.9	-70.3	-70.4	-69.7	-69.4	-69.6	-69.0	-69.1
256 QAM	-69.5	-69.2	-69.4	-68.8	-68.9	-68.7	-68.4	-68.6	-68.0	-68.1	-66.5	-66.2	-66.4	-65.8	-65.9
512 QAM	-66.7	-66.4	-66.6	-66.0	-66.1	-65.9	-65.6	-65.8	-65.2	-65.3	-63.9	-63.6	-63.8	-63.2	-63.3
1024 QAM Strong	-63.8	-63.5	-63.7	-63.1	-63.2	-62.4	-62.1	-62.3	-61.7	-61.8	-60.6	-60.3	-60.5	-59.9	-60.0
1024 QAM Light	-63.1	-62.8	-63.0	-62.4	-62.5	-61.7	-61.4	-61.6	-61.0	-61.1	-59.7	-59.4	-59.6	-59.0	-59.1
2048 QAM	-60.6	-60.3	-60.5	-59.9	-60.0	-59.4	-59.1	-59.3	-58.7	-58.8	-57.9	-57.6	-57.8	-57.2	-57.3
4096 QAM	-56.6	-56.3	-56.5	-55.9	-56.0	-56.3	-56.0	-56.2	-55.6	-55.7	-54.0	-53.7	-53.9	-53.3	-53.4

	80 MHz					**112 MHz**				
Frequency (GHz)	4-5	6	7	8	11	4-5	6	7	8	11
BPSK	-86.8	-86.5	-86.7	-86.1	-86.2	-85.4	-85.1	-85.3	-84.7	-84.8
QPSK	-84.5	-84.2	-84.4	-83.8	-83.9	-83.0	-82.7	-82.9	-82.3	-82.4
8 PSK	-80.8	-80.5	-80.7	-80.1	-80.2	-79.0	-78.7	-78.9	-78.3	-78.4
16 QAM	-77.8	-77.5	-77.7	-77.1	-77.2	-76.1	-75.8	-76.0	-75.4	-75.5
32 QAM	-74.4	-74.1	-74.3	-73.7	-73.8	-72.7	-72.4	-72.6	-72.0	-72.1
64 QAM	-71.5	-71.2	-71.4	-70.8	-70.9	-69.7	-69.4	-69.6	-69.0	-69.1
128 QAM	-68.5	-68.2	-68.4	-67.8	-67.9	-66.8	-66.5	-66.7	-66.1	-66.2
256 QAM	-65.8	-65.5	-65.7	-65.1	-65.2	-63.8	-63.5	-63.7	-63.1	-63.2
512 QAM	-63.1	-62.8	-63.0	-62.4	-62.5	-61.4	-61.1	-61.3	-60.7	-60.8
1024 QAM Strong	-59.9	-59.6	-59.8	-59.2	-59.3	-58.4	-58.1	-58.3	-57.7	-57.8
1024 QAM Light	-59.5	-59.2	-59.4	-58.8	-58.9	-57.7	-57.4	-57.6	-57.0	-57.1
2048 QAM	-56.6	-56.3	-56.5	-55.9	-56.0	-55.1	-54.8	-55.0	-54.4	-54.5

RFU-C

3.5 MHz	Frequency	6	7-10	11-15	18	23	24	26	28	31-42
QPSK		-97.5	-97.0	-97.5	-96.5	-96.0	-93.0	-95.0	-93.0	-94.0
16 QAM		-91.0	-90.5	-91.0	-90.0	-89.5	-86.5	-88.5	-86.5	-87.5
32 QAM		-88.0	-87.5	-88.0	-87.0	-86.5	-83.5	-85.5	-83.5	-84.5
64 QAM		-84.5	-84.0	-84.5	-83.5	-83.0	-80.0	-82.0	-80.0	-81.0
128 QAM		-81.0	-80.5	-81.0	-80.0	-79.5	-76.5	-78.5	-76.5	-77.5
256 QAM		-77.5	-77.0	-77.5	-76.5	-76.0	-73.0	-75.0	-73.0	-74.0
7 MHz										
QPSK		-95.0	-94.5	-95.0	-94.0	-93.5	-90.5	-92.5	-90.5	-91.5
8 PSK		-89.0	-88.5	-89.0	-88.0	-87.5	-84.5	-86.5	-84.5	-85.5
16 QAM		-88.5	-88.0	-88.5	-87.5	-87.0	-84.0	-86.0	-84.0	-85.0
32 QAM		-85.0	-84.5	-85.0	-84.0	-83.5	-80.5	-82.5	-80.5	-81.5
64 QAM		-82.0	-81.5	-82.0	-81.0	-80.5	-77.5	-79.5	-77.5	-78.5
128 QAM		-79.0	-78.5	-79.0	-78.0	-77.5	-74.5	-76.5	-74.5	-75.5
256 QAM		-75.5	-75.0	-75.5	-74.5	-74.0	-71.0	-73.0	-71.0	-72.0
512 QAM		-73.5	-73.0	-73.5	-72.5	-72.0	-69.0	-71.0	-69.0	-70.0
1024 QAM Strong		-70.0	-69.5	-70.0	-69.0	-68.5	-65.5	-67.5	-65.5	-66.5
1024 QAM Light		-69.5	-69	-69.5	-68.5	-68.0	-65.0	-67.0	-65.0	-66.0
14 MHz										
QPSK		-92.0	-91.5	-92.0	-91.0	-90.5	-87.5	-89.5	-87.5	-88.5
8 PSK		-86.0	-85.5	-86.0	-85.0	-84.5	-81.5	-83.5	-81.5	-82.5
16 QAM		-85.0	-84.5	-85.0	-84.0	-83.5	-80.5	-82.5	-80.5	-81.5
32 QAM		-82.0	-81.5	-82.0	-81.0	-80.5	-77.5	-79.5	-77.5	-78.5
64 QAM		-79.0	-78.5	-79.0	-78.0	-77.5	-74.5	-76.5	-74.5	-75.5
128 QAM		-75.5	-75.0	-75.5	-74.5	-74.0	-71.0	-73.0	-71.0	-72.0
256 QAM		-73.0	-72.5	-73.0	-72.0	-71.5	-68.5	-70.5	-68.5	-69.5
512 QAM		-70.0	-69.5	-70.0	-69.0	-68.5	-65.5	-67.5	-65.5	-66.5
1024 QAM Strong		-67.0	-66.5	-67.0	-66.0	-65.5	-62.5	-64.5	-62.5	-63.5
1024 QAM Light		-66.5	-66.0	-66.5	-65.5	-65.0	-62.0	-64.0	-62.0	-63.0
28 MHz										
QPSK		-89.0	-88.5	-89.0	-88.0	-87.5	-84.5	-86.5	-84.5	-85.5
8 PSK		-84.5	-84.0	-84.5	-83.5	-83.0	-80.0	-82.0	-80.0	-81.0
16 QAM		-82.5	-82.0	-82.5	-81.5	-81.0	-78.0	-80.0	-78.0	-79.0
32 QAM		-79.0	-78.5	-79.0	-78.0	-77.5	-74.5	-76.5	-74.5	-75.5
64 QAM		-76.0	-75.5	-76.0	-75.0	-74.5	-71.5	-73.5	-71.5	-72.5
128 QAM		-72.5	-72.0	-72.5	-71.5	-71.0	-68.0	-70.0	-68.0	-69.0
256 QAM		-69.5	-69.0	-69.5	-68.5	-68.0	-65.0	-67.0	-65.0	-66.0
512 QAM		-67.5	-67.0	-67.5	-66.5	-66.0	-63.0	-65.0	-63.0	-64.0
1024 QAM Strong		-64.5	-64.0	-64.5	-63.5	-63.0	-60.0	-62.0	-60.0	-61.0
1024 QAM Light		-63.5	-63.0	-63.5	-62.5	-62.0	-59.0	-61.0	-59.0	-60.0
2048 QAM		-60.0	-59.5	-60.0	-59.0	-58.5	-55.5	-57.5	-55.5	-56.5

40 MHz	Frequency	6	7-10	11-15	18	23	24	26	28	31-42
QPSK		-87.5	-87.0	-87.5	-86.5	-86.0	-80.5	-85.0	-83.0	-84.0
8 PSK		-82.5	-82.0	-82.5	-81.5	-81.0	-75.5	-80.0	-78.0	-79.0
16 QAM		-81.0	-80.5	-81.0	-80.0	-79.5	-74.0	-78.5	-76.5	-77.5
32 QAM		-77.5	-77.0	-77.5	-76.5	-76.0	-70.5	-75.0	-73.0	-74.0
64 QAM		-74.5	-74.0	-74.5	-73.5	-73.0	-67.5	-72.0	-70.0	-71.0
128 QAM		-71.5	-71.0	-71.5	-70.5	-70.0	-64.5	-69.0	-67.0	-68.0
256 QAM		-69.0	-68.5	-69.0	-68.0	-67.5	-62.0	-66.5	-64.5	-65.5
512 QAM		-66.5	-66.0	-66.5	-65.5	-65.0	-59.5	-64.0	-62.0	-63.0
1024 QAM Strong		-63.5	-63.0	-63.5	-62.5	-62.0	-56.5	-61.0	-59.0	-60.0
1024 QAM Light		-62.5	-62.0	-62.5	-61.5	-61.0	-55.5	-60.0	-58.0	-59.0
2048 QAM		-59.0	-58.5	-59.0	-58.0	-57.5	-52.0	-56.5	-54.5	-55.5
56 MHz										
QPSK		-85.5	-85.0	-85.5	-84.5	-84.0	-81.0	-83.0	-81.0	-82.0
8 PSK		-81.5	-81.0	-81.5	-80.5	-80.0	-77.0	-79.0	-77.0	-78.0
16 QAM		-79.0	-78.5	-79.0	-78.0	-77.5	-74.5	-76.5	-74.5	-75.5
32 QAM		-75.5	-75.0	-75.5	-74.5	-74.0	-71.0	-73.0	-71.0	-72.0
64 QAM		-72.5	-72.0	-72.5	-71.5	-71.0	-68.0	-70.0	-68.0	-69.0
128 QAM		-69.5	-69.0	-69.5	-68.5	-68.0	-65.0	-67.0	-65.0	-66.0
256 QAM		-66.5	-66.0	-66.5	-65.5	-65.0	-62.0	-64.0	-62.0	-63.0
512 QAM		-64.5	-64.0	-64.5	-63.5	-63.0	-60.0	-62.0	-60.0	-61.0
1024 QAM Strong		-61.0	-60.5	-61.0	-60.0	-59.5	-56.5	-58.5	-56.5	-57.5
1024 QAM Light		-60.0	-59.5	-60.0	-59.0	-58.5	-55.5	-57.5	-55.5	-56.5
2048 QAM		-55.5	-55.0	-55.5	-54.5	-54.0	-51.0	-53.0	-51.0	-52.0

RFU-HP

	14 MHz		28 MHz		40 MHz		56 MHz	
Frequency (GHz)	6 GHz	7-11 GHz	6 GHz	7-11 GHz	6 GHz	7-11 GHz	6 GHz	7-11 GHz
QPSK	-91.5	-91.0	-88.5	-88.0	-87.0	-86.5	-85.5	-85.0
8 PSK	-86.5	-86.0	-83.5	-83.0	-82.0	-81.5	-80.5	-80.0
16 QAM	-85.0	-84.5	-82	-81.5	-80.5	-80.0	-79.0	-78.5
32 QAM	-81.5	-81.0	-78.5	-78.0	-77.0	-76.5	-75.5	-75.0
64 QAM	-78.5	-78.0	-75.5	-75.0	-74.0	-73.5	-72.0	-71.5
128 QAM	-75.0	-74.5	-72.5	-72.0	-71.0	-70.5	-69.5	-69.0
256 QAM	-72.0	-71.5	-69.5	-69.0	-68.5	-68.0	-66.5	-66.0
512 QAM	-69.5	-69.0	-67	-66.5	-66.0	-65.5	-64.0	-63.5
1024 QAM Strong	-66.5	-66.0	-64	-63.5	-63.0	-62.5	-61.0	-60.5
1024 QAM Light	-65.5	-65.0	-63.5	-63.0	-62.0	-61.5	-60.0	-59.5
2048 QAM	–	–	-59.5	-59.0	-58.5	-58.0	-56.5	-56.0

1500HP

	14 MHz		28 MHz		40 MHz	
Frequency (GHz)	6 GHz	7-11 GHz	6 GHz	7-11 GHz	6 GHz	7-11 GHz
QPSK	-91.0	-91.0	-88.0	-88.0	-86.5	-86.5
8 PSK	-86.0	-86.0	-83.0	-83.0	-81.5	-81.5
16 QAM	-84.5	-84.5	-81.5	-81.5	-80.0	-80.0
32 QAM	-81.0	-81.0	-78.0	-78.0	-76.5	-76.5
64 QAM	-78.0	-78.0	-75.0	-75.0	-73.5	-73.5
128 QAM	-74.5	-74.5	-72.0	-72.0	-70.5	-70.5
256 QAM	-71.5	-71.5	-69.0	-69.0	-68.0	-68.0
512 QAM	-69.0	-69.0	-66.5	-66.5	-65.5	-65.5
1024 QAM Strong	-66.0	-66.0	-63.5	-63.5	-62.5	-62.5
1024 QAM Light	-65.0	-65.0	-63.0	-63.0	-61.5	-61.5
2048 QAM	–	–	-59.0	-59.0	-58.0	-58.0

Receiver Threshold (RSL) – RFU-E

Channel Bandwidth (MHz)	14	28	62.5	125	250	500
BPSK	-90.5	-87.5	-83.0	-80.0	-77.0	-74.0
QPSK	-87.2	-84.6	-79.5	-76.5	-73.5	-70.5
8 QAM	-83.1	-80.6	-75.5	-72.5	-70.0	-67.0
16 QAM	–	-77.4	-73.0	-69.5	-67.0	-64.0
32 QAM	–	-73.9	-69.0	-66.0	-63.0	-60.0
64 QAM	–	-70.8	-66.0	-63.0	-60.0	-57.0
128 QAM	–	-67.6	-63.0	-60.0	-57.0	–
256 QAM	–	-64.6	-59.5	-57.0	-54.0	–
512 QAM	–	-62.4	-57.0	-54.0	–	–
1024 QAM	–	–	-54.0	–	–	–

Note: Feature availability and specifications are subject to change without prior notification.