



**Datasheet**

# FibeAir IP-20N

REV. B | April 2018

## 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 (10GE/1GE/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, 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 (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

**Note:** 500 MHz channels are planned for future release.

XPIC

LoS 4x4 MIMO\*

Advanced Frequency Reuse (AFR)\*

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/translate

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

\* 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)

## 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

### 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: IEC 60529 IP56

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

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

## Technical Specifications

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### 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

RFU-D-HP – 319mm(H), 286mm(W), 107mm(D), 12kg

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; 1X10GE 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 – 75W

RFU-D-HP – 130W/180W

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 10GE 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
<b>Modulation</b>	<b>3.5 MHz</b>			<b>7 MHz</b>			<b>14 MHz</b>		
BPSK	1-2	2-4	–	5-7	5-16	2	9-12	10-34	3
QPSK	3-4	4-13	1	8-10	9-32	3	19-24	20-74	8
8 QAM	5-7	6-20	2	13-16	13-48	5	29-36	31-112	12
16 QAM	8-10	9-32	4	18-22	19-69	8	40-49	42-153	16
32 QAM	11-14	12-43	5	24-30	26-92	10	53-65	56-203	22
64 QAM	14-17	15-54	6	30-37	32-114	112	66-80	69-249	26
128 QAM	17-21	18-65	8	36-44	38-137	15	79-97	83-301	32
256 QAM	19-24	20-74	9	42-51	44-158	17	90-110	95-344	36
512 QAM	21-27	22-84	10	45-54	47-169	18	100-122	105-380	40
1024 QAM Strong	23-30	24-94	10	48-58	50-182	19	106-129	111-402	42
1024 QAM Light	–	–	–	51-62	53-194	21	112-137	118-426	45
2048 QAM	25-33	26-104	11	54-66	56-206	23	118-144	122-440	48
4096 QAM	27-36	28-114	12	57-70	58-217	24	124-150	126-455	50
	<b>28 MHz</b>			<b>40 MHz</b>			<b>56 MHz</b>		
BPSK	20-26	21-70	8	20-30	21-90	8	42-50	43-120	17
QPSK	43-52	45-162	17	54-66	57-206	22	83-101	87-314	33
8 QAM	62-76	65-236	24	83-101	87-315	34	123-150	129-468	49
16 QAM	87-107	92-332	35	117-144	123-447	46	167-205	176-637	67
32 QAM	115-140	121-437	46	156-191	164-595	62	220-269	231-838	88
64 QAM	141-173	149-538	56	185-226	194-704	74	270-331	284-1000	107
128 QAM	170-208	179-648	68	218-267	229-831	89	327-400	343-1000	130
256 QAM	196-239	206-745	78	247-302	259-939	98	374-457	393-1000	148
512 QAM	209-255	219-794	83	271-331	284-1030	110	406-496	426-1000	161
1024 QAM Strong	228-278	239-866	90	306-374	321-1164	122	441-540	464-1000	175
1024 QAM Light	241-295	253-917	96	318-388	334-1209	127	469-573	492-1000	185
2048 QAM	263-321	276-1000	105	330-400	340-1252	132	508-621	534-1000	201
4096 QAM	280-340	283-1080	112	340-410	345-1270	136	520-640	545-1000	208
	<b>80 MHz</b>			<b>112 MHz</b>					
BPSK	68-72	68-210	27	80-95	82-220	32			
QPSK	114-140	120-435	45	156-190	160-590	62			
8 QAM	162-198	170-618	64	230-283	240-880	92			
16 QAM	231-283	243-880	92	317-385	330-1200	126			
32 QAM	304-371	319-1000	121	415-508	435-1550	166			
64 QAM	371-454	390-1000	148	510-625	535-1650	204			
128 QAM	439-536	461-1000	175	615-755	645-1800	246			
256 QAM	505-618	531-1000	202	708-865	747-2000	283			
512 QAM	555-679	583-1000	222	769-938	800-2000	307			
1024 QAM Strong	604-738	634-1000	241	835-1020	875-2000	334			
1024 QAM Light	630-750	645-1000	252	889-1084	930-2000	355			
2048 QAM	673-795	675-1000	269	960-1175	1030-2000	384			
4096 QAM	705-820	710-1000	282	–	–	–			

## 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
<b>Modulation</b>	<b>14 MHz</b>			<b>28 MHz</b>		
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
<b>Modulation</b>	<b>62.5 MHz</b>			<b>125 MHz</b>		
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	-	-	-
<b>Modulation</b>	<b>250 MHz</b>			<b>500 MHz</b>		
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	-	-	-

**Note:** 500 MHz is planned for future release.

## Transmit Power – Microwave Bands

### RFU-D and RFU-S

Modulation	Frequency (GHz)	6	7	8	11	13	15	18	23	24	26	28-38	42
BPSK - 8 PSK		28	28	28	29	27	24	22	25	0	21	18	15
16 QAM		28	27	27	29	26	23	22	25	0	20	17	14
32 QAM		27	26	26	29	25	23	22	24	0	19	16	13
64 QAM		27	26	26	27	24	22	21	22	0	19	16	13
128 QAM		27	26	26	26	23	22	21	21	0	19	16	13
256 QAM		27	26	24	25	22	21	20	18	0	17	14	11
512 QAM		25	24	24	25	22	20	19	18	0	17	14	11
1024 QAM		25	24	24	24	20	20	18	17	0	16	13	10
2048 QAM		23	22	22	23	19	18	17	16	0	15	12	9
4096 QAM		21	20	20	21	17	16	15	13	0	13	10	7

### RFU-D-HP

Modulation	Frequency	4-5	6	7	8	11
BPSK – 64 QAM		35	36	34	32	33
128 QAM		32	36	34	32	33
256 QAM		32	35	33	31	32
512 QAM		31	34	33	31	31
1024 QAM		30	32	32	31	30
2048 QAM		30	32	32	30	30
4096 QAM		30	31	31	28	30

### RFU-C

Transmit Power (dBm)	Frequency (GHz)	6-8	11-15	18-23	24	26	28	31	32	36	38	42
QPSK/8 PSK		26	24	22	0	21	14	16	18	12	18	15
16 QAM		25	23	21	0	20	14	15	17	11	17	14
32 QAM		24	22	20	0	19	14	14	16	10	16	13
64 QAM		24	22	20	0	19	14	14	16	10	16	13
128 QAM		24	22	20	0	19	14	14	16	10	16	13
256 QAM		22	20	18	0	17	12	12	14	8	14	11
512 QAM		22	20	18	-1	17	9	12	14	10	14	11
1024 QAM		21	19	17	-3	16	8	11	13	9	13	10
2048 QAM		19	17	15	0	14	6	9	11	7	11	8

### RFU-HP 1RX

Modulation	Frequency (GHz)	6L&H	7	8	11
QPSK – 32 QAM		33	33	33	29
64 QAM		32	32	32	29
128 QAM		31	31	31	28
256 QAM		30	30	30	27
512 QAM		28	28	28	25
1024 QAM		27	27	27	25
2048 QAM		25	25	25	23

### RFU-HP 2RX (1500HP)

6L&H	7	8	11
33	33	33	29
33	33	33	29
32	32	32	28
31	31	31	27
29	29	29	25
28	28	28	25
26	26	26	23



## 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	–	–	–

**Note:** 500 MHz is planned for future release.

## Receiver Threshold (RSL) – Microwave Bands

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

### 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
2048 QAM		-62.0	-61.0	-61.0	-61.5	-60.5	-60.0	-61.0	-60.5	-60.0	-60.0	-59.5	-59.5	-59.0	-58.5
4096 QAM		-59.0	-58.0	-58.0	-58.5	-57.5	-57.0	-58.0	-57.5	-57.0	-57.0	-56.5	-56.5	-56.0	-55.5
<b>28 MHz</b>															
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	-54.0	-53.5	-53.5	-53.5	-53.0	-52.5	-52.5

40 MHz	Frequency (GHz)	6	7-8	10	11	13	15	18	23	24	26	28-31	32	38	42
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	-53.5	-53.0	-53.0	-52.5	-52.5	-52.0	-51.5
<b>56 MHz</b>															
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	-51.5	-50.5	-50.0	-50.5	-50.0	-50.0	-49.5	-49.0
<b>112 MHz</b>															
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	-50.0	-49.5	-49.5	-49.0	-48.5

### RFU-D-HP

	28 MHz		40 MHz		56 MHz		112 MHz	
Frequency (GHz)	4-6	7-11	4-6	7-11	4-6	7-11	4-6	7-11
BPSK	-92.0	-91.5	-90.5	-90.0	-88.5	-88.0	-82.5	-82.0
QPSK	-90.0	-89.5	-88.5	-88.0	-86.5	-86.0	-80.5	-80.0
8 PSK	-85.5	-85.0	-83.5	-83.0	-82.5	-82.0	-76.5	-76.0
16 QAM	-83.5	-83.0	-82.0	-81.5	-80.0	-79.5	-74.0	-73.5
32 QAM	-80.0	-79.5	-78.5	-78.0	-77.0	-76.5	-71.0	-70.5
64 QAM	-77.0	-76.5	-75.5	-75.0	-73.5	-73.0	-67.5	-67.0
128 QAM	-74.0	-73.5	-72.5	-72.0	-71.0	-70.5	-65.0	-64.5
256 QAM	-71.0	-70.5	-69.5	-69.0	-67.5	-67.0	-61.5	-61.0
512 QAM	-68.5	-68.0	-66.5	-66.0	-65.5	-65.0	-59.5	-59.0
1024 QAM Strong	-65.5	-65.0	-64.0	-63.5	-62.0	-61.5	-56.0	-55.5
1024 QAM Light	-64.5	-64.0	-63.0	-62.5	-61.0	-60.5	-55.0	-54.5
2048 QAM	-61.0	-60.5	-60.5	-60.0	-56.5	-56.0	-50.5	-50.0
4096 QAM	-59.0	-58.5	-58.5	-58.0	-54.5	-54.0	-48.5	-48.0

### 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
<b>7 MHz</b>										
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
<b>14 MHz</b>										
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	Frequency	6	7-10	11-15	18	23	24	26	28	31-42
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:** 500 MHz is planned for future release.

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