PMP 320 Link Budget Details

Version	Date	Description	Author
Ver 2.0	May 11, 2010	Release includes all supported channel bandwidths and DL/UL ratios.	Emilio Di Benedetto Basman Dahleh

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Overview

The following tables reflect a guideline for the PMP320 performance in varying RF conditions reflecting changing RSSI and CINR. This is a guideline only and the information must be used in conjunction with prior experience in deploying wireless solutions. The focus of the information below is the product's RF performance, and therefore, for all tests, UDP traffic was utilized to characterize throughput over varying conditions. A separate paper is available from Motorola that provides guidelines to achieve maximum TCP and UDP throughput for a PMP320 system.

For each channel bandwidth and downlink/uplink ratio that is supported, this document provides tables that show the typical throughput that can be achieved, the coverage (in miles) and the CINR that is required. This information is listed for each modulation and coding state (MCS). The received signal strength indicator (RSSI) levels that are shown are representative of what will be required in a noise-free environment although external sources of in-band noise, at the AP or CPE, can require this RSSI to be higher. Therefore, for coverage planning purposes, CINR and RSSI should be used together.

This data was collected in a lab environment using connectorized radios. Extensive testing has been performed in an outdoor environment to validate these lab data points.

The PMP320 supports MIMO B and MIMO A technology in the downlink via its two transmitters on the AP and two receivers on the CPE. The uplink operates in SISO mode and employs receive diversity. It uses one transmitter on the CPE and two receivers on the AP. MIMO B provides increased throughput by sending independent data streams over the main and diversity paths. On the other hand, MIMO A provides an increased level of link robustness by sending the same data stream over the two paths (transmit diversity).

When the CPE switches from MIMO B to MIMO A, the downlink will achieve some additional gain due to the redundant data streams (DL transmit diversity) and this will be reflected by an improved CINR reported on the CPE GUI. At this transition point, the CPE's RSSI will not show a similar improvement because, per the WiMax standard, the CPE's RSSI measurement is only based off of the AP's pre-amble. The AP only transmits the pre-amble on the main port. Therefore, the MIMO A (downlink) transmit diversity that occurs with data does not occur with the pre-amble. (Although the pre-amble is not transmitted with diversity, per the WiMax standard, it is transmitted at about 4dB increased power relative to the data. Measured average data indicates that this is typically 3.5 dB.)

In some cases where QAM 64 5/6 and MIMO B are used in the downlink, the AP's aggregate downlink throughput capability exceeds the capacity of an individual CPE. In these cases, the tables only list the single-CPE downlink throughput but a note is added, indicated by an asterisk (*), stating the total sector downlink throughput available when multiple CPEs are used. For example, when using 10 MHz channel bandwidth and a 75/25 downlink/uplink ratio, the maximum downlink single-CPE throughput is 25.8 Mbps but the maximum downlink sector throughput is about 40 Mbps.

In the lab setup, a traffic generator was used to create uplink/downlink traffic and variable attenuators were used to incrementally vary the attenuation so that radio performance could be characterized from very strong-signal conditions down to sensitivity.

RF cables were used to connect the AP's MAIN RF port to the CPE's MAIN RF port via RF attenuators. Similarly, the AP's DIVERSITY RF port was connected to the CPE's DIVERSITY RF port via RF attenuators. There was no Main-to-Diversity path coupling. In real field deployments with rich LOS multipath that can be converted to MRC gain, the PMP 320's dual-receiver architecture can achieve the same level of performance at greater distances since the RSSI and CINR levels at the radios can better by 3dB or more than those listed in the table, which was measured in an environment with no multipath. Note that the CINR required for a given MCS state will remain constant.

The tables also include four estimates of the coverage (in miles) that can be achieved. One column lists the coverage in a line-of-sight (LOS) environment with the AP and CPE antennas pointing directly at each other and at near equal height. The other three estimates increase the assumed level of obstruction with the same alignment described above: near line-of-sight (nLOS, 5dB obstruction), Non line-of-sight (NLOS1: assuming a 15dB obstruction) and severe Non-Line-of-Sight (NLOS2: 25dB obstruction).

The column labeled "Link Budget Margin to Sensitivity" indicates how much margin (dB) remains before the link will be dropped.

AP Ant Gain (dB)	16.5	**AP max TX (dBm)**	25
CPE Ant Gain (dB)	14.5	**CPE max TX (dBm)**	27
Antenna Cable Losses (dB)	0.7	**Preamble/data (dB)**	3.5

10MHz CHANNEL BANDWIDTH (75% Downlink / 25% Uplink)

Maximum Supported Distance (km) 11
Maximum Supported Distance (miles) 6.9

UPLINK

MCS	Throughput (Mbps)	Minimum Required UL CINR (dB)	Minimum Required AP Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6	5.0	25	-73	130.3	21	6.90	6.90	2.46	0.78
qam64-ctc-3/4	4.5	22	-75	132.3	19	6.90	6.90	3.10	0.98
qam64-ctc-2/3	4.0	21	-77	134.3	17	6.90	6.90	3.90	1.23
qam64-ctc-1/2	3.0	19	-78	135.3	16	6.90	6.90	4.37	1.38
qam16-ctc-3/4	3.0	17	-81	138.3	13	6.90	6.90	6.18	1.95
qam16-ctc-1/2	2.0	14	-84	141.3	10	6.90	6.90	6.90	2.76
qpsk-ctc-3/4	1.5	11	-87	144	7	6.90	6.90	6.90	3.90
qpsk-ctc-1/2	1.0	5	-93	150.3	1	6.90	6.90	6.90	6.90
Sensitivity	1.0	4	-94	151.3	0	6.90	6.90	6.90	6.90

DOWNLINK

MCS	Throughput (Mbps)	Minimum Required CPE Zone CINR (dB)	**Minimum Required CPE Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6 MIMO B	* 25.8	28	-69	127.5	25	6.90	5.62	1.78	0.56
qam64-ctc-5/6	21.5	27	-71	130.2	23	6.90	6.90	2.42	0.77
qam64-ctc-3/4	19.4	25	-74	132.4	20	6.90	6.90	3.13	0.99
qam64-ctc-2/3	17.2	24	-75	134.2	19	6.90	6.90	3.87	1.22
qam64-ctc-1/2	13.0	20	-79	137.4	15	6.90	6.90	5.58	1.77
qam16-ctc-3/4	13.0	19	-80	138.4	14	6.90	6.90	6.28	1.99
qam16-ctc-1/2	8.6	15	-83	142.2	11	6.90	6.90	6.90	3.06
qpsk-ctc-3/4	6.5	12	-86	145.3	8	6.90	6.90	6.90	4.35
qpsk-ctc-1/2	4.3	6	-93	151.8	1	6.90	6.90	6.90	6.90
Sensitivity	1.6	5	-94	152.8	0	6.90	6.90	6.90	6.90

ALL DISTANCE ESTIMATES SHOWN ASSUME AP and CPE at equal elevation with 0 degree azimuth
nLOS - used additional 5dB of loss
NLOS1 - used additional 15dB of loss
NLOS2 - used additional 25dB of loss

*** DL T-put shown to one CPE. MIMO-B to multiple CPEs can produce 43.0Mbps**
All values shown are typical as measured measured in a lab environment with no MRC or Rx Diversity gain included.
In a field deployment, MRC / Diversity gains can improve the Minimum Required Rx levels by 3dB.

10MHz CHANNEL BANDWIDTH (65% Downlink / 35% Uplink)

Maximum Supported Distance (km) 11
Maximum Supported Distance (miles) 6.9

UPLINK

MCS	Throughput (Mbps)	Minimum Required UL CINR (dB)	Minimum Required AP Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6	8.4	25	-74	131.3	21	6.90	6.90	2.76	0.87
qam64-ctc-3/4	7.5	22	-75	132.3	20	6.90	6.90	3.10	0.98
qam64-ctc-2/3	7.1	21	-76	133.3	19	6.90	6.90	3.47	1.10
qam64-ctc-1/2	5.0	19	-79	136.3	16	6.90	6.90	4.91	1.55
qam16-ctc-3/4	5.0	17	-82	139.3	13	6.90	6.90	6.90	2.19
qam16-ctc-1/2	3.3	14	-85	142.3	10	6.90	6.90	6.90	3.10
qpsk-ctc-3/4	2.5	11	-88	145.3	7	6.90	6.90	6.90	4.37
qpsk-ctc-1/2	1.7	5	-94	151.3	1	6.90	6.90	6.90	6.90
Sensitivity	0.04	4	-95	152.3	0	6.90	6.90	6.90	6.90

DOWNLINK

MCS	Throughput (Mbps)	Minimum Required CPE Zone CINR (dB)	**Minimum Required CPE Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6 MIMO B	* 25.2	28	-68	126.9	26	6.90	5.26	1.66	0.53
qam64-ctc-5/6	17.2	27	-71	129.9	23	6.90	6.90	2.35	0.74
qam64-ctc-3/4	15.5	25	-74	132.8	20	6.90	6.90	3.29	1.04
qam64-ctc-2/3	13.7	24	-76	134.7	18	6.90	6.90	4.08	1.29
qam64-ctc-1/2	10.4	20	-79	137.8	15	6.90	6.90	5.82	1.84
qam16-ctc-3/4	10.4	19	-80	138.9	14	6.90	6.90	6.61	2.09
qam16-ctc-1/2	6.9	15	-84	142.7	10	6.90	6.90	6.90	3.26
qpsk-ctc-3/4	5.2	12	-87	145.8	7	6.90	6.90	6.90	4.63
qpsk-ctc-1/2	3.4	6	-93	151.8	1	6.90	6.90	6.90	6.90
Sensitivity	3.4	5	-94	152.8	0	6.90	6.90	6.90	6.90

ALL DISTANCE ESTIMATES SHOWN ASSUME AP and CPE at equal elevation with 0 degree azimuth
nLOS - used additional 5dB of loss
NLOS1 - used additional 15dB of loss
NLOS2 - used additional 25dB of loss

*** DL T-put shown to one CPE. MIMO-B to multiple CPEs can produce 34.6 Mbps**
All values shown are typical as measured measured in a lab environment with no MRC or Rx Diversity gain included.
In a field deployment, MRC / Diversity gains can improve the Minimum Required Rx levels by 3dB.

10MHz CHANNEL BANDWIDTH (55% Downlink / 45% Uplink)

Maximum Supported Distance (km) 11
Maximum Supported Distance (miles) 6.9

UPLINK

MCS	Throughput (Mbps)	Minimum Required UL CINR (dB)	Minimum Required AP Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6	8.7	25	-72	129.3	22	6.90	6.90	2.19	0.69
qam64-ctc-3/4	7.4	22	-75	132.3	19	6.90	6.90	3.10	0.98
qam64-ctc-2/3	7.2	21	-77	134.3	17	6.90	6.90	3.90	1.23
qam64-ctc-1/2	5.5	19	-79	136.3	15	6.90	6.90	4.91	1.55
qam16-ctc-3/4	6.0	17	-80	137.3	14	6.90	6.90	5.51	1.74
qam16-ctc-1/2	4.0	14	-84	141.3	10	6.90	6.90	6.90	2.76
qpsk-ctc-3/4	2.6	11	-89	146.3	5	6.90	6.90	6.90	4.91
qpsk-ctc-1/2	2.0	5	-93	150.3	1	6.90	6.90	6.90	6.90
Sensitivity	2.0	4	-94	151.3	0	6.90	6.90	6.90	6.90

DOWNLINK

MCS	Throughput (Mbps)	Minimum Required CPE Zone CINR (dB)	**Minimum Required CPE Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6 MIMO B	* 25.4	28	-68	126.9	27	6.90	5.29	1.67	0.53
qam64-ctc-5/6	14.4	27	-72	131.1	23	6.90	6.90	2.68	0.85
qam64-ctc-3/4	13.0	25	-74	132.8	21	6.90	6.90	3.28	1.04
qam64-ctc-2/3	11.5	24	-76	135.0	19	6.90	6.90	4.25	1.34
qam64-ctc-1/2	8.6	20	-79	137.7	16	6.90	6.90	5.75	1.82
qam16-ctc-3/4	8.6	19	-80	139.0	15	6.90	6.90	6.68	2.11
qam16-ctc-1/2	5.8	15	-84	142.8	11	6.90	6.90	6.90	3.27
qpsk-ctc-3/4	4.3	12	-87	145.8	8	6.90	6.90	6.90	4.63
qpsk-ctc-1/2	2.9	6	-94	152.8	1	6.90	6.90	6.90	6.90
Sensitivity	0.1	5	-95	153.8	0	6.90	6.90	6.90	6.90

ALL DISTANCE ESTIMATES SHOWN ASSUME AP and CPE at equal elevation with 0 degree azimuth
nLOS - used additional 5dB of loss
NLOS1 - used additional 15dB of loss
NLOS2 - used additional 25dB of loss

*** DL T-put shown to one CPE. MIMO-B to multiple CPEs can produce 28.8 Mbps**
All values shown are typical as measured measured in a lab environment with no MRC or Rx Diversity gain included.
In a field deployment, MRC / Diversity gains can improve the Minimum Required Rx levels by 3dB.

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AP Ant Gain (dB)	16.5	AP max TX (dBm)	25
CPE Ant Gain (dB)	14.5	CPE max TX (dBm)	27
Antenna Cable Losses (dB)	0.7	Preamble/data (dB)	3.5

7MHz CHANNEL BANDWIDTH (75% Downlink / 25% Uplink)

Maximum Supported Distance (km) 16
Maximum Supported Distance (miles) 10

UPLINK

MCS	Throughput (Mbps)	Minimum Required UL CINR (dB)	Minimum Required AP Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6	3.3	25	-74	131.3	22	10.00	8.73	2.76	0.87
qam64-ctc-3/4	2.9	22	-77	134.3	19	10.00	10.00	3.90	1.23
qam64-ctc-2/3	2.5	21	-78	135.3	18	10.00	10.00	4.37	1.38
qam64-ctc-1/2	2.0	19	-79	136.3	17	10.00	10.00	4.91	1.55
qam16-ctc-3/4	1.6	17	-83	140.3	13	10.00	10.00	7.78	2.46
qam16-ctc-1/2	1.3	14	-85	142.3	11	10.00	10.00	9.79	3.10
qpsk-ctc-3/4	0.8	11	-89	146.3	7	10.00	10.00	10.00	4.91
qpsk-ctc-1/2	0.6	5	-95	152.3	1	10.00	10.00	10.00	9.79
Sensitivity	0.6	4	-96	153.3	0	10.00	10.00	10.00	10.00

DOWNLINK

MCS	Throughput (Mbps)	Minimum Required CPE Zone CINR (dB)	**Minimum Required CPE Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6 MIMO B	* 24.9	28	-69	127.5	27	10.00	5.64	1.78	0.56
qam64-ctc-5/6	13.0	27	-73	131.5	23	10.00	8.97	2.84	0.90
qam64-ctc-3/4	11.7	25	-75	133.4	21	10.00	10.00	3.54	1.12
qam64-ctc-2/3	10.4	24	-76	135.3	20	10.00	10.00	4.36	1.38
qam64-ctc-1/2	7.8	20	-80	138.4	16	10.00	10.00	6.28	1.99
qam16-ctc-3/4	7.8	19	-81	139.5	15	10.00	10.00	7.09	2.24
qam16-ctc-1/2	5.2	15	-85	143.5	11	10.00	10.00	10.00	3.54
qpsk-ctc-3/4	3.9	12	-89	147.8	7	10.00	10.00	10.00	5.83
qpsk-ctc-1/2	2.6	6	-95	153.8	1	10.00	10.00	10.00	10.00
Sensitivity	0.1	5	-96	154.8	0	10.00	10.00	10.00	10.00

ALL DISTANCE ESTIMATES SHOWN ASSUME AP and CPE at equal elevation with 0 degree azimuth
nLOS - used additional 5dB of loss
NLOS1 - used additional 15dB of loss
NLOS2 - used additional 25dB of loss

*** DL T-put shown to one CPE. MIMO-B to multiple CPEs can produce 26.0 Mbps**
All values shown are typical as measured measured in a lab environment with no MRC or Rx Diversity gain included
In a field deployment, MRC / Diversity gains can improve the Minimum Required Rx levels by 3dB

7MHz CHANNEL BANDWIDTH (65% Downlink / 35% Uplink)

Maximum Supported Distance (km) 16
Maximum Supported Distance (miles) 10

UPLINK

MCS	Throughput (Mbps)	Minimum Required UL CINR (dB)	Minimum Required AP Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6	5.0	25	-73	130.3	22	10.00	7.78	2.46	0.78
qam64-ctc-3/4	4.5	22	-77	134.3	18	10.00	10.00	3.90	1.23
qam64-ctc-2/3	4.0	21	-78	135.3	17	10.00	10.00	4.37	1.38
qam64-ctc-1/2	3.0	19	-79	136.3	16	10.00	10.00	4.91	1.55
qam16-ctc-3/4	3.0	17	-81	138.3	14	10.00	10.00	6.18	1.95
qam16-ctc-1/2	2.0	14	-85	142.3	10	10.00	10.00	9.79	3.10
qpsk-ctc-3/4	1.5	11	-88	145.3	7	10.00	10.00	10.00	4.37
qpsk-ctc-1/2	1.0	5	-94	151.3	1	10.00	10.00	10.00	8.73
Sensitivity	0.9	4	-95	152.3	0	10.00	10.00	10.00	9.79

DOWNLINK

MCS	Throughput (Mbps)	Minimum Required CPE Zone CINR (dB)	**Minimum Required CPE Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6 MIMO B	22.8	28	-69	127.3	27	9.79	5.51	1.74	0.55
qam64-ctc-5/6	11.5	27	-72	131.3	23	10.00	8.72	2.76	0.87
qam64-ctc-3/4	10.3	25	-74	133.2	21	10.00	10.00	3.45	1.09
qam64-ctc-2/3	9.2	24	-76	135.2	19	10.00	10.00	4.35	1.37
qam64-ctc-1/2	6.9	20	-79	138.1	16	10.00	10.00	6.07	1.92
qam16-ctc-3/4	6.9	19	-80	139.3	15	10.00	10.00	6.91	2.19
qam16-ctc-1/2	4.6	15	-84	143.3	11	10.00	10.00	10.00	3.46
qpsk-ctc-3/4	3.4	12	-87	146.2	8	10.00	10.00	10.00	4.85
qpsk-ctc-1/2	2.3	6	-94	152.8	1	10.00	10.00	10.00	10.00
Sensitivity	0.8	5	-95	153.8	0	10.00	10.00	10.00	10.00

All values shown are typical as measured measured in a lab setup.
nLOS - used additional 5dB of loss
NLOS1 - used additional 15dB of loss
NLOS2 - used additional 25dB of loss

All values shown are typical as measured measured in a lab environment with no MRC or Rx Diversity gain included
In a field deployment, MRC / Diversity gains can improve the Minimum Required Rx levels by 3dB

7MHz CHANNEL BANDWIDTH (55% Downlink / 45% Uplink)

Maximum Supported Distance (km) 16
Maximum Supported Distance (miles) 10

UPLINK

MCS	Throughput (Mbps)	Minimum Required UL CINR (dB)	Minimum Required AP Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6	6.6	25	-74	131.3	22	10.00	8.73	2.76	0.87
qam64-ctc-3/4	5.9	22	-77	134.3	19	10.00	10.00	3.90	1.23
qam64-ctc-2/3	5.3	21	-78	135.3	18	10.00	10.00	4.37	1.38
qam64-ctc-1/2	4.0	19	-79	136.3	17	10.00	10.00	4.91	1.55
qam16-ctc-3/4	4.0	17	-81	138.3	15	10.00	10.00	6.18	1.95
qam16-ctc-1/2	2.7	14	-86	143.3	10	10.00	10.00	10.00	3.47
qpsk-ctc-3/4	2.0	11	-88	145.3	8	10.00	10.00	10.00	4.37
qpsk-ctc-1/2	1.3	5	-95	152.3	1	10.00	10.00	10.00	9.79
Sensitivity	0.3	4	-96	153.3	0	10.00	10.00	10.00	10.00

DOWNLINK

MCS	Throughput (Mbps)	Minimum Required CPE Zone CINR (dB)	**Minimum Required CPE Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6 MIMO B	17.2	28	-69	128.2	27	10.00	6.12	1.93	0.61
qam64-ctc-5/6	8.6	27	-72	131.3	24	10.00	8.70	2.75	0.87
qam64-ctc-3/4	7.8	25	-74	133.2	22	10.00	10.00	3.45	1.09
qam64-ctc-2/3	6.9	24	-76	135.0	20	10.00	10.00	4.24	1.34
qam64-ctc-1/2	5.2	20	-80	139.0	16	10.00	10.00	6.71	2.12
qam16-ctc-3/4	3.9	19	-81	140.0	15	10.00	10.00	7.53	2.38
qam16-ctc-1/2	3.0	15	-85	144.0	11	10.00	10.00	10.00	3.78
qpsk-ctc-3/4	2.6	12	-88	147.3	8	10.00	10.00	10.00	5.49
qpsk-ctc-1/2	1.7	6	-95	153.8	1	10.00	10.00	10.00	10.00
Sensitivity	1.6	5	-96	154.8	0	10.00	10.00	10.00	10.00

All values shown are typical as measured measured in a lab setup.
nLOS - used additional 5dB of loss
NLOS1 - used additional 15dB of loss
NLOS2 - used additional 25dB of loss

All values shown are typical as measured measured in a lab environment with no MRC or Rx Diversity gain included
In a field deployment, MRC / Diversity gains can improve the Minimum Required Rx levels by 3dB

MOTOROLA

AP Ant Gain (dB)	16.5	AP max TX (dBm)	25
CPE Ant Gain (dB)	14.5	CPE max TX (dBm)	27
Antenna Cable Losses (dB)	0.7	Preamble/data (dB)	3.5

5MHz CHANNEL BANDWIDTH (75% Downlink / 25% Uplink)

Maximum Supported Distance (km) 11
Maximum Supported Distance (miles) 6.9

UPLINK

MCS	Throughput (Mbps)	Minimum Required UL CINR (dB)	Minimum Required AP Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6	2.3	25	-76	133.3	21	6.90	6.90	3.47	1.10
qam64-ctc-3/4	1.9	22	-79	136.3	18	6.90	6.90	4.91	1.55
qam64-ctc-2/3	1.7	21	-80	137.3	17	6.90	6.90	5.51	1.74
qam64-ctc-1/2	1.5	19	-81	138.3	16	6.90	6.90	6.18	1.95
qam16-ctc-3/4	1.4	17	-83	140.3	14	6.90	6.90	6.90	2.46
qam16-ctc-1/2	0.8	14	-87	144.3	10	6.90	6.90	6.90	3.90
qpsk-ctc-3/4	0.7	11	-89	146.3	8	6.90	6.90	6.90	4.91
qpsk-ctc-1/2	0.4	5	-96	153.3	1	6.90	6.90	6.90	6.90
Sensitivity	0.4	4	-97	154.3	0	6.90	6.90	6.90	6.90

DOWNLINK

MCS	Throughput (Mbps)	Minimum Required CPE Zone CINR (dB)	**Minimum Required CPE Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6 MIMO B	21.5	28	-71	129.8	26	6.90	6.90	2.33	0.74
qam64-ctc-5/6	10.8	27	-74	132.9	23	6.90	6.90	3.32	1.05
qam64-ctc-3/4	9.7	25	-76	134.7	21	6.90	6.90	4.07	1.29
qam64-ctc-2/3	8.6	24	-78	136.8	19	6.90	6.90	5.22	1.65
qam64-ctc-1/2	6.5	20	-82	140.8	15	6.90	6.90	6.90	2.62
qam16-ctc-3/4	6.5	19	-83	142.3	14	6.90	6.90	6.90	3.10
qam16-ctc-1/2	4.3	15	-87	145.9	10	6.90	6.90	6.90	4.67
qpsk-ctc-3/4	3.2	12	-90	148.9	7	6.90	6.90	6.90	6.62
qpsk-ctc-1/2	2.1	6	-96	154.8	1	6.90	6.90	6.90	6.90
Sensitivity	0.0	5	-97	155.8	0	6.90	6.90	6.90	6.90

ALL DISTANCE ESTIMATES SHOWN ASSUME AP and CPE at equal elevation with 0 degree azimuth
nLOS - used additional 5dB of loss
NLOS1 - used additional 15dB of loss
NLOS2 - used additional 25dB of loss

All values shown are typical as measured measured in a lab environment with no MRC or Rx Diversity gain included.
In a field deployment, MRC / Diversity gains can improve the Minimum Required Rx levels by 3dB.

5MHz CHANNEL BANDWIDTH (65% Downlink / 35% Uplink)

Maximum Supported Distance (km) 11
Maximum Supported Distance (miles) 6.9

UPLINK

MCS	Throughput (Mbps)	Minimum Required UL CINR (dB)	Minimum Required AP Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6	4.1	25	-74	131.3	23	6.90	6.90	2.76	0.87
qam64-ctc-3/4	3.6	22	-77	134.3	20	6.90	6.90	3.90	1.23
qam64-ctc-2/3	3.3	21	-78	135.3	19	6.90	6.90	4.37	1.38
qam64-ctc-1/2	2.5	19	-81	138.3	16	6.90	6.90	6.18	1.95
qam16-ctc-3/4	2.0	17	-85	142.3	12	6.90	6.90	6.90	3.10
qam16-ctc-1/2	1.6	14	-87	144.3	10	6.90	6.90	6.90	3.90
qpsk-ctc-3/4	1.2	11	-89	146.3	8	6.90	6.90	6.90	4.91
qpsk-ctc-1/2	0.8	5	-95	152.3	2	6.90	6.90	6.90	6.90
Sensitivity	0.57	4	-97	154.3	0	6.90	6.90	6.90	6.90

DOWNLINK

MCS	Throughput (Mbps)	Minimum Required CPE Zone CINR (dB)	**Minimum Required CPE Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6 MIMO B	17.5	28	-71	130.2	26	6.90	6.90	2.44	0.77
qam64-ctc-5/6	8.6	27	-74	133.1	23	6.90	6.90	3.40	1.08
qam64-ctc-3/4	7.8	25	-76	135.1	21	6.90	6.90	4.29	1.36
qam64-ctc-2/3	6.9	24	-78	137.0	19	6.90	6.90	5.32	1.68
qam64-ctc-1/2	5.2	20	-81	140.2	16	6.90	6.90	6.90	2.42
qam16-ctc-3/4	5.2	19	-82	141.2	15	6.90	6.90	6.90	2.73
qam16-ctc-1/2	3.4	15	-86	145.2	11	6.90	6.90	6.90	4.34
qpsk-ctc-3/4	2.4	12	-90	149.2	7	6.90	6.90	6.90	6.88
qpsk-ctc-1/2	1.7	6	-96	155.1	1	6.90	6.90	6.90	6.90
Sensitivity	1.4	5	-97	156.1	0	6.90	6.90	6.90	6.90

ALL DISTANCE ESTIMATES SHOWN ASSUME AP and CPE at equal elevation with 0 degree azimuth
nLOS - used additional 5dB of loss
NLOS1 - used additional 15dB of loss
NLOS2 - used additional 25dB of loss

All values shown are typical as measured measured in a lab environment with no MRC or Rx Diversity gain included.
In a field deployment, MRC / Diversity gains can improve the Minimum Required Rx levels by 3dB.

5MHz CHANNEL BANDWIDTH (55% Downlink / 45% Uplink)

Maximum Supported Distance (km) 11
Maximum Supported Distance (miles) 6.9

UPLINK

MCS	Throughput (Mbps)	Minimum Required UL CINR (dB)	Minimum Required AP Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6	4.8	25	-75	132.3	22	6.90	6.90	3.10	0.98
qam64-ctc-3/4	3.8	22	-78	135.3	19	6.90	6.90	4.37	1.38
qam64-ctc-2/3	3.5	21	-80	137.3	17	6.90	6.90	5.51	1.74
qam64-ctc-1/2	2.9	19	-81	138.3	16	6.90	6.90	6.18	1.95
qam16-ctc-3/4	2.5	17	-84	141.3	13	6.90	6.90	6.90	2.76
qam16-ctc-1/2	1.9	14	-86	143.3	11	6.90	6.90	6.90	3.47
qpsk-ctc-3/4	1.4	11	-89	146.3	8	6.90	6.90	6.90	4.91
qpsk-ctc-1/2	1.0	5	-96	153.3	1	6.90	6.90	6.90	6.90
Sensitivity	0.2	4	-97	154.3	0	6.90	6.90	6.90	6.90

DOWNLINK

MCS	Throughput (Mbps)	Minimum Required CPE Zone CINR (dB)	**Minimum Required CPE Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6 MIMO B	14.4	28	-72	131.2	25	6.90	6.90	2.73	0.86
qam64-ctc-5/6	7.2	27	-76	134.3	22	6.90	6.90	3.90	1.23
qam64-ctc-3/4	6.5	25	-77	136.3	20	6.90	6.90	4.89	1.55
qam64-ctc-2/3	5.8	24	-79	137.3	19	6.90	6.90	5.51	1.74
qam64-ctc-1/2	4.4	20	-82	141.1	15	6.90	6.90	6.90	2.71
qam16-ctc-3/4	3.5	19	-83	142.3	14	6.90	6.90	6.90	3.10
qam16-ctc-1/2	2.5	15	-87	146.3	10	6.90	6.90	6.90	4.89
qpsk-ctc-3/4	2.2	12	-91	150.2	6	6.90	6.90	6.90	6.90
qpsk-ctc-1/2	1.4	6	-96	154.8	1	6.90	6.90	6.90	6.90
Sensitivity	1.3	5	-97	155.8	0	6.90	6.90	6.90	6.90

ALL DISTANCE ESTIMATES SHOWN ASSUME AP and CPE at equal elevation with 0 degree azimuth
nLOS - used additional 5dB of loss
NLOS1 - used additional 15dB of loss
NLOS2 - used additional 25dB of loss

All values shown are typical as measured measured in a lab environment with no MRC or Rx Diversity gain included.
In a field deployment, MRC / Diversity gains can improve the Minimum Required Rx levels by 3dB.

MOTOROLA

AP Ant Gain (dB)	16.5	AP max TX (dBm)	25
CPE Ant Gain (dB)	14.5	CPE max TX (dBm)	27
Antenna Cable Losses (dB)	0.7	Preamble/data (dB)	3.5

3.5MHz CHANNEL BANDWIDTH (75% Downlink / 25% Uplink)

Maximum Supported Distance (km) 16
Maximum Supported Distance (miles) 10

UPLINK

MCS	Throughput (Mbps)	Minimum Required UL CINR (dB)	Minimum Required AP Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6	1.6	25	-77	134.3	21	10.00	10.00	3.90	1.23
qam64-ctc-3/4	1.4	22	-79	136.3	19	10.00	10.00	4.91	1.55
qam64-ctc-2/3	1.1	21	-81	138.3	17	10.00	10.00	6.18	1.95
qam64-ctc-1/2	0.9	19	-84	141.3	14	10.00	10.00	8.73	2.76
qam16-ctc-3/4	1.0	17	-85	142.3	13	10.00	10.00	9.79	3.10
qam16-ctc-1/2	0.8	14	-87	144.3	11	10.00	10.00	10.00	3.90
qpsk-ctc-3/4	0.4	11	-91	148.3	7	10.00	10.00	10.00	6.18
qpsk-ctc-1/2	0.3	5	-97	154.3	1	10.00	10.00	10.00	10.00
Sensitivity	0.3	4	-98	155.3	0	10.00	10.00	10.00	10.00

DOWNLINK

MCS	Throughput (Mbps)	Minimum Required CPE Zone CINR (dB)	**Minimum Required CPE Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6 MIMO B	13.0	28	-71	129.9	26	10.00	7.44	2.35	0.74
qam64-ctc-5/6	6.5	27	-74	132.9	23	10.00	10.00	3.31	1.05
qam64-ctc-3/4	5.8	25	-76	134.8	21	10.00	10.00	4.12	1.30
qam64-ctc-2/3	5.2	24	-78	136.8	19	10.00	10.00	5.17	1.64
qam64-ctc-1/2	3.9	20	-81	139.9	16	10.00	10.00	7.39	2.34
qam16-ctc-3/4	3.9	19	-82	140.9	15	10.00	10.00	8.29	2.62
qam16-ctc-1/2	2.5	15	-87	145.9	10	10.00	10.00	10.00	4.67
qpsk-ctc-3/4	1.9	12	-90	148.9	7	10.00	10.00	10.00	6.60
qpsk-ctc-1/2	1.3	6	-96	154.8	1	10.00	10.00	10.00	10.00
Sensitivity	1.3	5	-97	155.8	0	10.00	10.00	10.00	10.00

ALL DISTANCE ESTIMATES SHOWN ASSUME AP and CPE at equal elevation with 0 degree azimuth
nLOS - used additional 5dB of loss
NLOS1 - used additional 15dB of loss
NLOS2 - used additional 25dB of loss

All values shown are typical as measured measured in a lab environment with no MRC or Rx Diversity gain included
In a field deployment, MRC / Diversity gains can improve the Minimum Required Rx levels by 3dB

3.5MHz CHANNEL BANDWIDTH (65% Downlink / 35% Uplink)

Maximum Supported Distance (km) 16
Maximum Supported Distance (miles) 10

UPLINK

MCS	Throughput (Mbps)	Minimum Required UL CINR (dB)	Minimum Required AP Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6	2.4	25	-76	133.3	22	10.00	10.00	3.47	1.10
qam64-ctc-3/4	2.2	22	-78	135.3	20	10.00	10.00	4.37	1.38
qam64-ctc-2/3	1.9	21	-79	136.3	19	10.00	10.00	4.91	1.55
qam64-ctc-1/2	1.5	19	-82	139.3	16	10.00	10.00	6.93	2.19
qam16-ctc-3/4	1.4	17	-84	141.3	14	10.00	10.00	8.73	2.76
qam16-ctc-1/2	0.8	14	-89	146.3	9	10.00	10.00	10.00	4.91
qpsk-ctc-3/4	0.6	11	-91	148.3	7	10.00	10.00	10.00	6.18
qpsk-ctc-1/2	0.5	5	-97	154.3	1	10.00	10.00	10.00	10.00
Sensitivity	0.1	4	-98	155.3	0	10.00	10.00	10.00	10.00

DOWNLINK

MCS	Throughput (Mbps)	Minimum Required CPE Zone CINR (dB)	**Minimum Required CPE Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6 MIMO B	10.0	28	-73	131.7	25	10.00	9.12	2.88	0.91
qam64-ctc-5/6	5.6	27	-76	134.7	22	10.00	10.00	4.09	1.29
qam64-ctc-3/4	5.2	25	-78	136.6	20	10.00	10.00	5.10	1.61
qam64-ctc-2/3	4.6	24	-80	138.6	18	10.00	10.00	6.40	2.02
qam64-ctc-1/2	3.4	20	-83	141.7	15	10.00	10.00	9.12	2.88
qam16-ctc-3/4	3.4	19	-84	142.6	14	10.00	10.00	10.00	3.22
qam16-ctc-1/2	2.3	15	-88	146.7	10	10.00	10.00	10.00	5.14
qpsk-ctc-3/4	1.7	12	-91	149.7	7	10.00	10.00	10.00	7.25
qpsk-ctc-1/2	1.1	6	-97	156.3	0	10.00	10.00	10.00	10.00
Sensitivity	1.1	5	-98	156.7	0	10.00	10.00	10.00	10.00

ALL DISTANCE ESTIMATES SHOWN ASSUME AP and CPE at equal elevation with 0 degree azimuth
nLOS - used additional 5dB of loss
NLOS1 - used additional 15dB of loss
NLOS2 - used additional 25dB of loss

All values shown are typical as measured measured in a lab environment with no MRC or Rx Diversity gain included
In a field deployment, MRC / Diversity gains can improve the Minimum Required Rx levels by 3dB

3.5MHz CHANNEL BANDWIDTH (55% Downlink / 45% Uplink)

Maximum Supported Distance (km) 16
Maximum Supported Distance (miles) 10

UPLINK

MCS	Throughput (Mbps)	Minimum Required UL CINR (dB)	Minimum Required AP Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6	3.0	25	-77	134.3	21	10.00	10.00	3.90	1.23
qam64-ctc-3/4	2.9	22	-79	136.3	19	10.00	10.00	4.91	1.55
qam64-ctc-2/3	2.3	21	-81	138.3	17	10.00	10.00	6.18	1.95
qam64-ctc-1/2	2.0	19	-82	139.3	16	10.00	10.00	6.93	2.19
qam16-ctc-3/4	1.6	17	-85	142.3	13	10.00	10.00	9.79	3.10
qam16-ctc-1/2	1.1	14	-88	145.3	10	10.00	10.00	10.00	4.37
qpsk-ctc-3/4	1.0	11	-90	147.3	8	10.00	10.00	10.00	5.51
qpsk-ctc-1/2	0.6	5	-97	154.3	1	10.00	10.00	10.00	10.00
Sensitivity	0.2	4	-98	155.3	0	10.00	10.00	10.00	10.00

DOWNLINK

MCS	Throughput (Mbps)	Minimum Required CPE Zone CINR (dB)	**Minimum Required CPE Rx (dBm)	Link Budget (dB)	Link Budget Margin to Sensitivity (dB)	LOS distance (miles)	nLOS distance max (miles)	NLOS1 distance max (miles)	NLOS2 distance max (miles)
qam64-ctc-5/6 MIMO B	8.0	28	-73	131.7	25	10.00	9.09	2.88	0.91
qam64-ctc-5/6	4.3	27	-76	134.6	22	10.00	10.00	4.06	1.28
qam64-ctc-3/4	3.9	25	-78	136.6	20	10.00	10.00	5.10	1.61
qam64-ctc-2/3	3.4	24	-80	138.6	18	10.00	10.00	6.40	2.02
qam64-ctc-1/2	2.6	20	-83	141.6	15	10.00	10.00	9.05	2.86
qam16-ctc-3/4	2.6	19	-84	142.6	14	10.00	10.00	10.00	3.21
qam16-ctc-1/2	1.7	15	-88	146.7	10	10.00	10.00	10.00	5.12
qpsk-ctc-3/4	1.3	12	-91	149.7	7	10.00	10.00	10.00	7.26
qpsk-ctc-1/2	0.8	6	-97	156.2	0	10.00	10.00	10.00	10.00
Sensitivity	0.8	5	-98	156.6	0	10.00	10.00	10.00	10.00

ALL DISTANCE ESTIMATES SHOWN ASSUME AP and CPE at equal elevation with 0 degree azimuth
nLOS - used additional 5dB of loss
NLOS1 - used additional 15dB of loss
NLOS2 - used additional 25dB of loss

All values shown are typical as measured measured in a lab environment with no MRC or Rx Diversity gain included
In a field deployment, MRC / Diversity gains can improve the Minimum Required Rx levels by 3dB

MOTOROLA