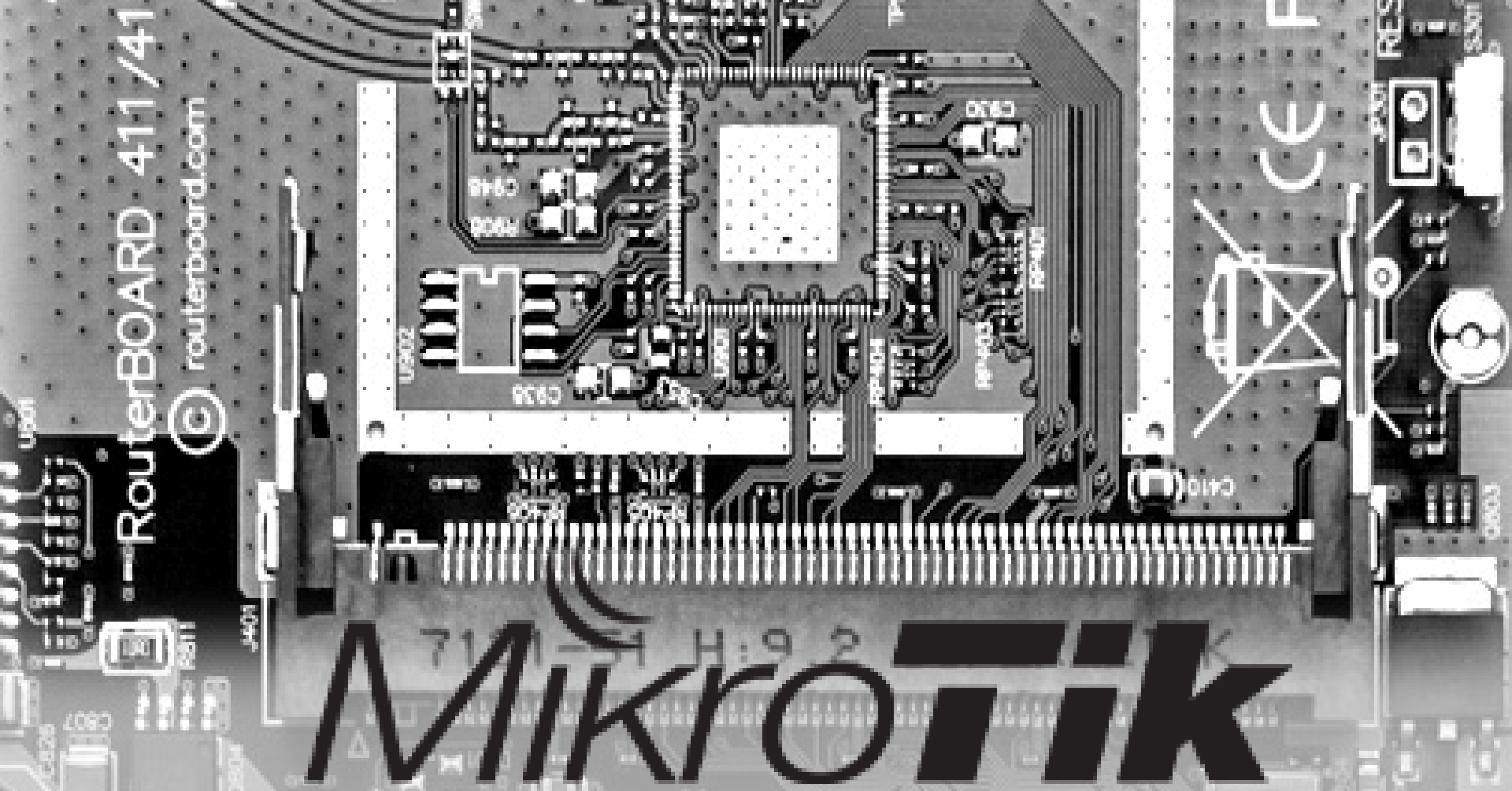

MikroTik

802.11 AC FEATURES

Casablanca- Morocco MUM June 1st 2015

Mani Raissdana

M.IT.S Co. www.mits-co.com

Mani Raissdana

- MikroTik Certified Trainer (since 2011)
- M.IT.S Co Founder & CTO

  (MikroTik Sales & Training Partner)
- Own a WISP (MikroTik Wireless Platform)
- Doing MikroTik projects in 5 African and 10 Asian Countries









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- MikroTik 802.11 ac implementation

IEEE

- Institute of Electrical and Electronics Engineers
- Professional association formed in 1963
- Educational and technical advancement of electrical and electronic engineering, telecommunication and computer engineering

Responsible to standardize technologies

1. Power and Energy
2. Biomedical and healthcare
3. Information technology and telecommunication

…and many more…

IEEE 802

- Refers to a family of standards dealing with LAN & MAN
- 802 is the date of first IEEE meeting (February 1980)
- 802 standards map to the lower 2 layers (physical and Data link layers)
- The most widely used standards are for the Ethernet family, Token Ring, Wireless LAN, Bridging and Virtual Bridged LANs

IEEE 802 (first 15) working groups

Name	Description	Note
IEEE 802.1	Bridging (networking) and Network Management	
IEEE 802.2	LLC	inactive
IEEE 802.3	Ethernet	
IEEE 802.4	Token bus	disbanded
IEEE 802.5	Defines the MAC layer for a Token Ring	inactive
IEEE 802.6	MANs (DQDB)	disbanded
IEEE 802.7	Broadband LAN using Coaxial Cable	disbanded
IEEE 802.8	Fiber Optic TAG	disbanded
IEEE 802.9	Integrated Services LAN (ISLAN or isoEthernet)	disbanded
IEEE 802.10	Interoperable LAN Security	disbanded
IEEE 802.11	Wireless LAN (WLAN) & Mesh (Wi-Fi certification)	
IEEE 802.12	100BaseVG	disbanded
IEEE 802.13	Unused[2]	Reserved for Fast Ethernet development[3]
IEEE 802.14	Cable modems	disbanded
IEEE 802.15	Wireless PAN	

IEEE 802.11

- Standards and specifications for implementing wireless local area network (WLAN) computer communication in the 2.4, 3.6, 5, and 60 GHz frequency bands
- The base version of the standard was released in 1997
- consists of a series of half-duplex over the air modulation techniques
- 802.11b was the first widely accepted one
- followed by 802.11a, 802.11g, 802.11n, and 802.11ac

Is the brand name of WLANs under 802.11 Standard

IEEE 802.11

802.11 network standards										
802.11 protocol	Release date	Freq (GHz)	Band-width (MHz)	Stream data rate[6] (Mbit/s)	Allowable MIMO streams	Modulation	Approximate range			
							Indoor		Outdoor	
							(m)	(ft)	(m)	(ft)
802.11-1997	Jun 1997	2.4	22	1, 2	N/A	DSSS, FHSS	20	66	100	330
a	Sep 1999	5	20	6, 9, 12, 18, 24, 36, 48, 54	N/A	OFDM	35	115	120	390
		3.7[A]					—	—	5,000	16,000[A]
b	Sep 1999	2.4	22	1, 2, 5.5, 11	N/A	DSSS	35	115	140	460
g	Jun 2003	2.4	20	6, 9, 12, 18, 24, 36, 48, 54	N/A	OFDM, DSSS	38	125	140	460
n	Oct 2009	2.4/5	20	7.2, 14.4, 21.7, 28.9, 43.3, 57.8, 65, 72.2 [B] (6.5, 13, 19.5, 26, 39, 52, 58.5, 65) [C]	4	OFDM	70	230	250	820[7]
			40	15, 30, 45, 60, 90, 120, 135, 150 [B] (13.5, 27, 40.5, 54, 81, 108, 121.5, 135) [C]			70	230	250	820[7]
ac	Dec 2013	5	20	7.2, 14.4, 21.7, 28.9, 43.3, 57.8, 65, 72.2, 86.7, 96.3 [B] (6.5, 13, 19.5, 26, 39, 52, 58.5, 65, 78, 86.7) [C]	8		35	115[8]		
			40	15, 30, 45, 60, 90, 120, 135, 150, 180, 200 [B] (13.5, 27, 40.5, 54, 81, 108, 121.5, 135, 162, 180) [C]			35	115[8]		
			80	32.5, 65, 97.5, 130, 195, 260, 292.5, 325, 390, 433.3 [B] (29.2, 58.5, 87.8, 117, 175.5, 234, 263.2, 292.5, 351, 390) [C]			35	115[8]		
			160	65, 130, 195, 260, 390, 520, 585, 650, 780, 866.7 [B] (58.5, 117, 175.5, 234, 351, 468, 702, 780) [C]			35	115[8]		
ad	Dec 2012	60	2,160	Up to 6,912 (6.75 Gbit/s) [9]	N/A	OFDM, single carrier, low-power single carrier	60	200	100	300
ah	Est. 2016[5]	0.9								
aj	Est. 2016[5]	45/60								
ax	Est. 2019[5]	2.4/5				MIMO-OFDM				
ay	2017	60	8000	Up to 100 (100 Gbit/s)	4	OFDM, single carrier,	60	200	1000	3000

IEEE 802.11

802.11 protocol	Freq	Band-width	Max data rate[6]	Allowable MIMO streams	Modulation	Approximate range			
						Indoor		Outdoor	
	(GHz)	(MHz)	(Mbit/s)			(m)	(ft)	(m)	(ft)
a	5	20	54	N/A	OFDM	35	115	120	390
						—	—	5,000	16,000
b	2.4	22	11	N/A	DSSS	35	115	140	460
g	2.4	20	54	N/A	OFDM, DSSS	38	125	140	460
n	2.4/5	20	72.2	4	OFDM	70	230	250	820
		40	150			70	230	250	820
ac	5	20	96.3	8		35	115		
		40	200			35	115		
		80	433			35	115		
		160	866.7			35	115		

IEEE 802.11ac

- Provides high throughput WLANs on 5 GHz
- was developed from 2011 through 2013 and approved in January 2014
- multi-station WLAN throughput at least 1 Gbps and a single link throughput at least 500 Mbps
- This throughput achieved by using:

1. Wider RF bandwidth (up to 160 MHz),
2. More MIMO spatial streams (up to eight),
3. Downlink multi-user MIMO (up to four clients),
4. high-density modulation (up to 256-QAM)

Differences with 802.11n

802.11 protocol	Freq (GHz)	Band-width (MHz)	Max data rate (Mbps)	Allowable MIMO streams	Approximate range			
					Indoor		Outdoor	
					(m)	(ft)	(m)	(ft)
n	2.4/5	20	72.2	4	70	230	250	820
		40	150		70	230	250	820
ac	5	20	96.3	8	35	115		
		40	200		35	115		
		80	433		35	115		
		160	866.7		35	115		

802.11ac Specifications

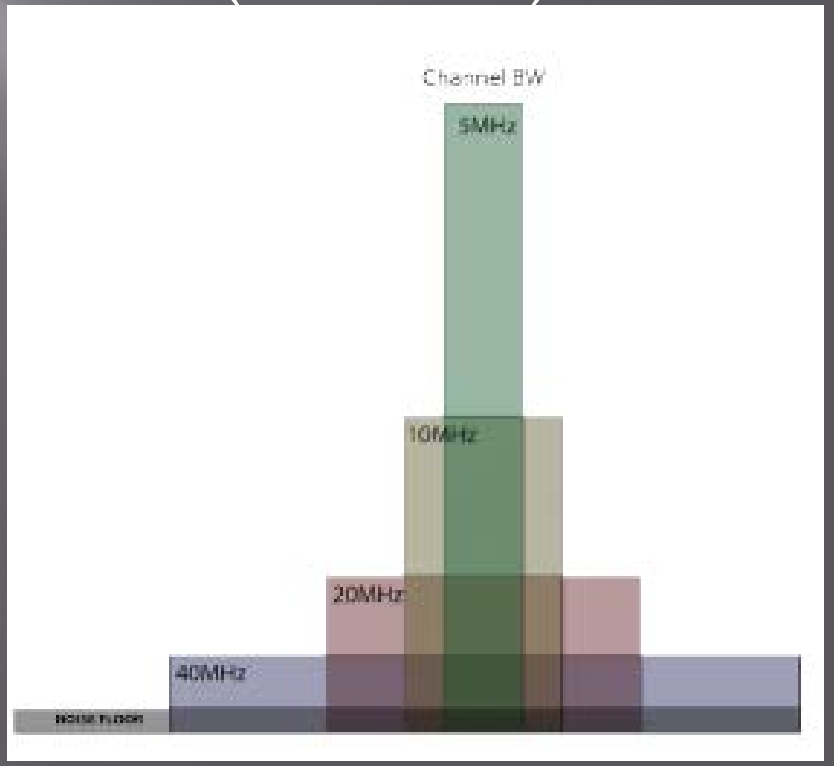
RF Bandwidth (Channel Width)

802.11ac can support up to 160 MHz Channel Width

Wider Channel Width=More Bandwidth

Wider Channel Width=Less Power (Distance)

Channel Width	RX Sensitivity	Data Rate
20MHz	Reference	Reference
40MHz	-3dB	X2
80MHz	-6dB	X4
10MHz	+3dB	1/2
5MHz	+6dB	1/4

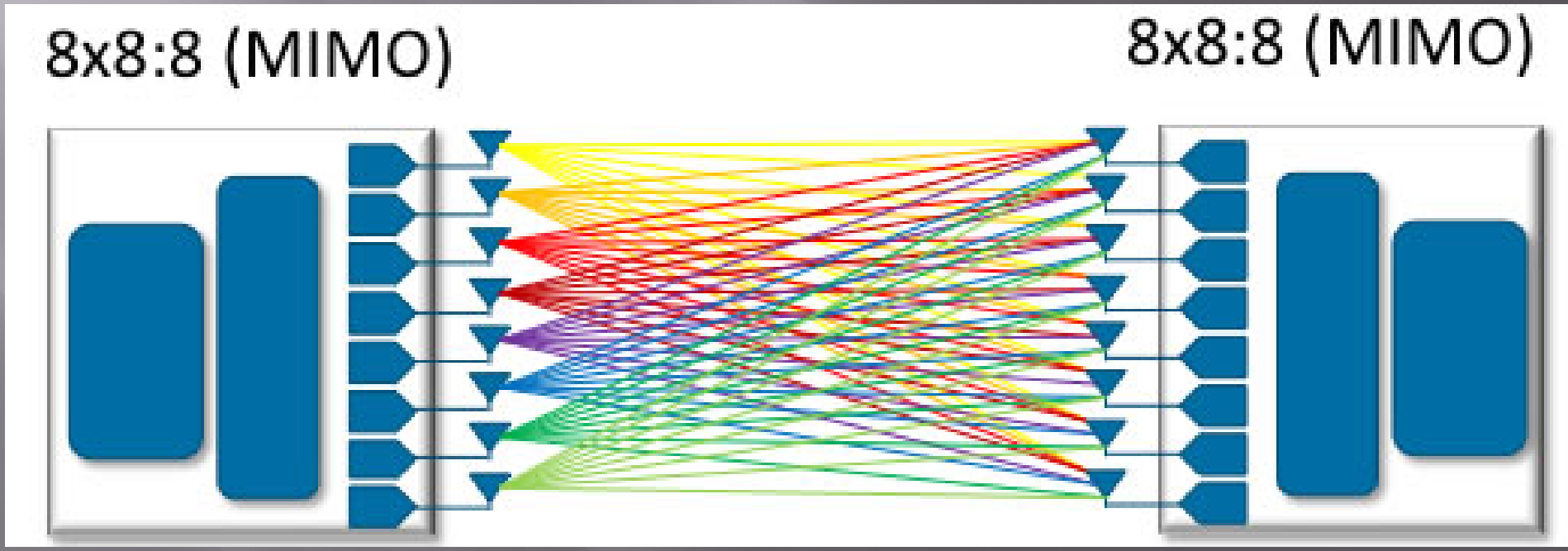


802.11ac Specifications

MIMO Special Stream

- 802.11ac can support up to 8x8 MIMO

More Stream=More data Rate



802.11ac Specifications

Modulation

- 256-QAM, rate 3/4 and 5/6, added as optional modes (vs. 64-QAM, rate 5/6 maximum in 802.11n)
- Some vendors offer a non-standard 1024-QAM mode, providing 25% more bandwidth compared to 256-QAM

Modulation

- Modulation is very, very important in Wireless transmission, specially to increase quality, Performance and throughput

But

What is Modulation actually?????

Modulation

In general:

modulation is the process of varying one or more properties of a periodic waveform (*carrier signal)*

with a modulating signal that typically contains information to be transmitted

In Telecommunication:

modulation is the process of conveying a message signal, for example a digital bit stream or an analog audio signal, inside another signal (*carrier signal)* that can be physically transmitted

Modulation

- The aim of **digital modulation** is to transfer a digital bit stream over an analog PassBand channel, for example over the public switched telephone network (PSTN)
- The aim of **digital baseband modulation** methods, also known as line coding, is to transfer a digital bit stream over a BaseBand channel, typically a non-filtered copper wire such as a serial bus or a wired local area network.

Modulation Methods

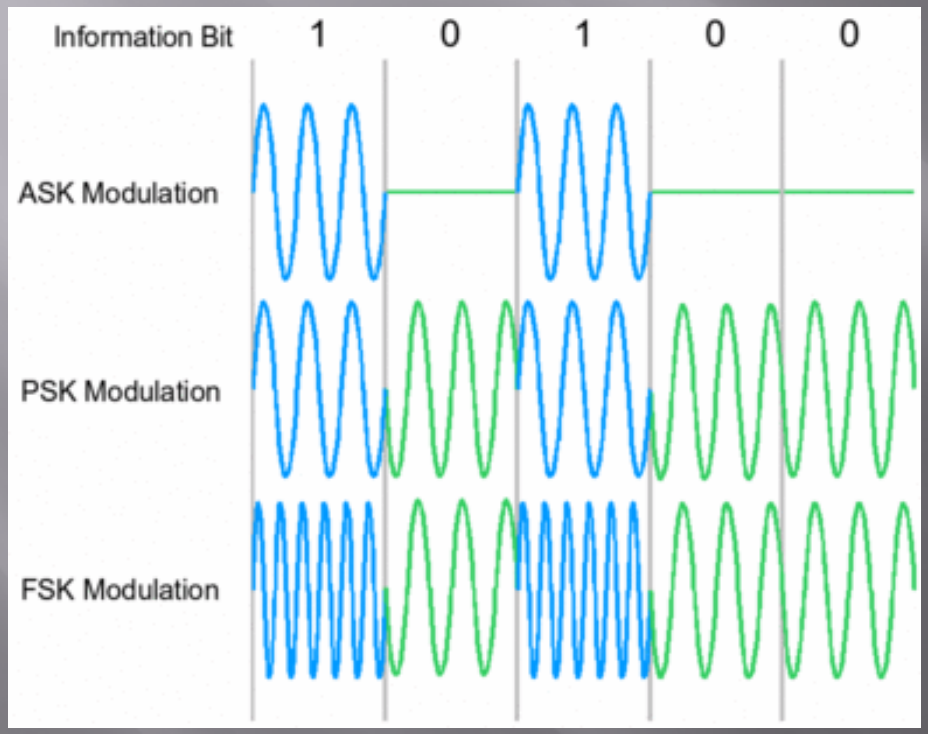
<table>
<tr><th colspan="4">Modulation Methods</th></tr>
<tr><th colspan="3">Analog</th><th>Digital</th></tr>
<tr><td rowspan="6">Amplitude Modulation</td><td rowspan="3">DSB</td><td>DSB-WC</td><td rowspan="2">PSK (phase-shift keying)</td></tr>
<tr><td>DSB-SC</td></tr>
<tr><td>DSB-RC</td><td rowspan="2">FSK (frequency-shift keying)</td></tr>
<tr><td rowspan="2">SSB</td><td>SSB-WC</td></tr>
<tr><td>SSB-SC</td><td rowspan="2">ASK (amplitude-shift keying)</td></tr>
<tr><td colspan="2">VSB</td></tr>
<tr><td rowspan="3">Angle Modulation</td><td colspan="2">QAM</td><td rowspan="3">QAM (quadrature amplitude modulation)</td></tr>
<tr><td colspan="2">FM</td></tr>
<tr><td colspan="2">PM</td></tr>
</table>

Digital Modulation

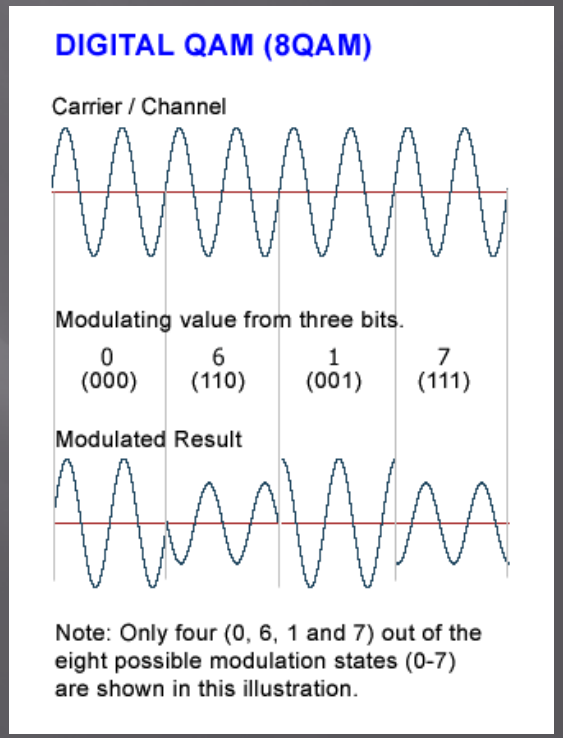
Digital Modulation techniques	
Phase-shift keying (PSK)	Binary PSK (BPSK), using M=2 symbols
	Quadrature PSK (QPSK), using M=4 symbols
	8PSK, using M=8 symbols
	16PSK, using M=16 symbols
	Differential PSK (DPSK)
	Differential QPSK (DQPSK)
	Offset QPSK (OQPSK)
	π/4–QPSK
Frequency-shift keying (FSK)	Audio frequency-shift keying (AFSK)
	Multi-frequency shift keying (M-ary FSK or MFSK)
	Dual-tone multi-frequency (DTMF)
Amplitude-shift keying (ASK)	
On-off keying (OOK), the most common ASK form	M-ary vestigial sideband modulation, for example 8VSB
Quadrature amplitude modulation (QAM) - a combination of PSK and ASK	**Polar modulation like QAM a combination of PSK and ASK**
Continuous phase modulation (CPM) methods	Minimum-shift keying (MSK)
	Gaussian minimum-shift keying (GMSK)
	Continuous-phase frequency-shift keying (CPFSK)
Orthogonal frequency-division multiplexing (OFDM) modulation	discrete multitone (DMT) - including adaptive modulation and bit-loading.
Wavelet modulation	
Trellis coded modulation (TCM)	
Spread-spectrum techniques	Direct-sequence spread spectrum (DSSS)
	Chirp spread spectrum (CSS) according to IEEE 802.15.4a CSS uses pseudo-stochastic coding
	Frequency-hopping spread spectrum (FHSS) applies a special scheme for channel release
	SIM31 (SIM) New digital Mode SIM31 SIM63 tks SWL Tunisian

Digital Modulation

ASK, PSK and FSK



QAM

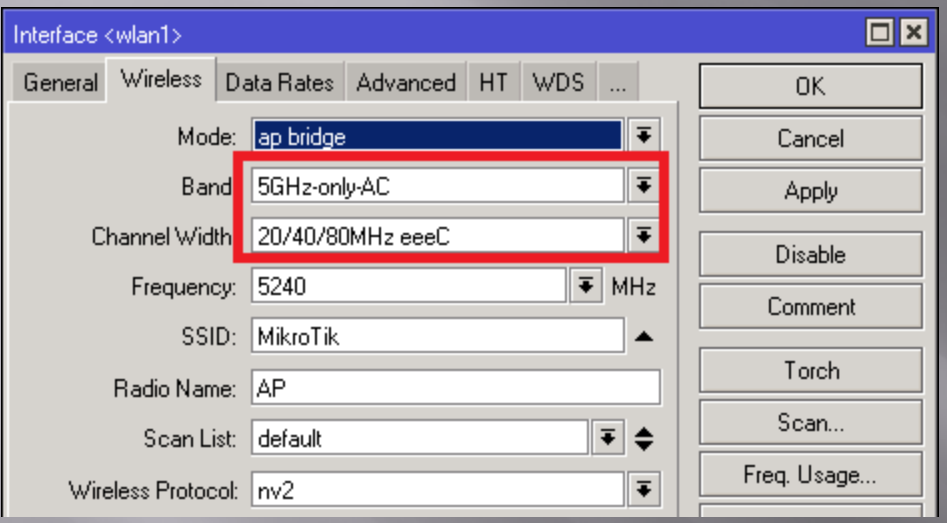


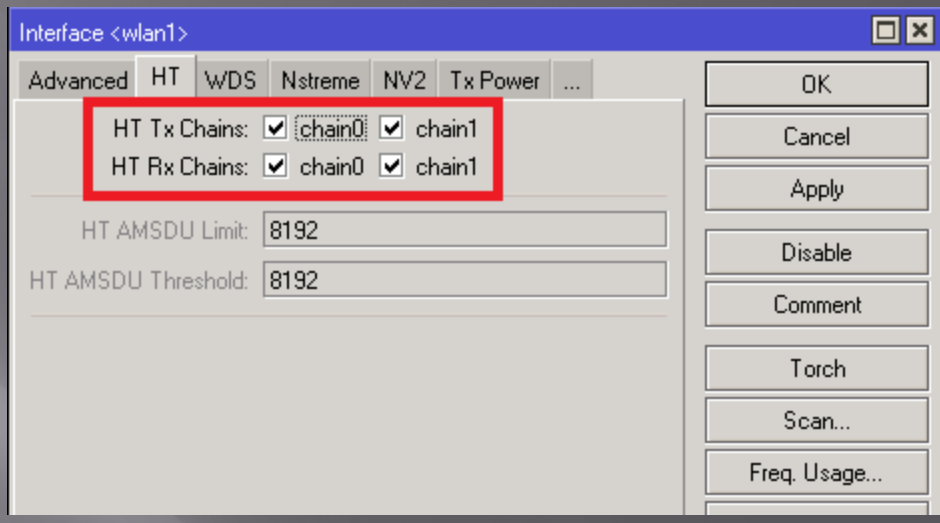
Data Rate Table

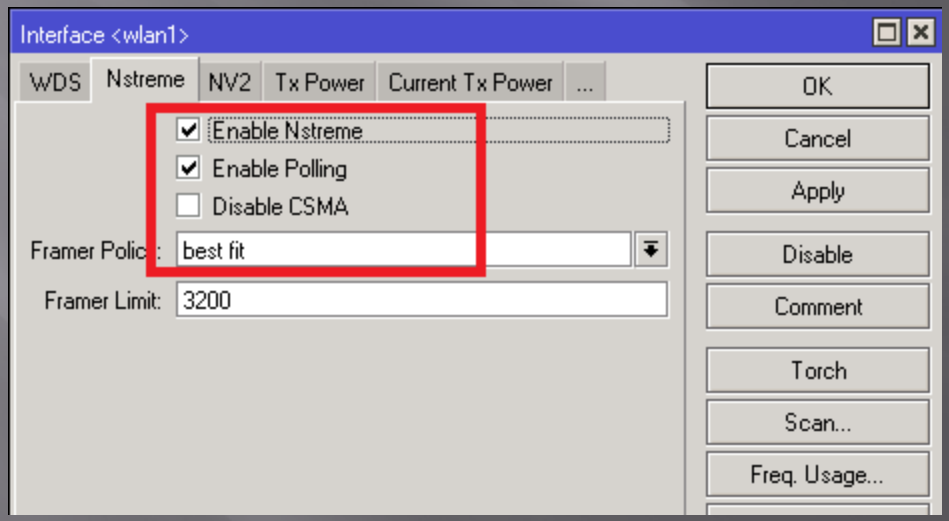
802.11ac OFDM Data Rates

MCS	Modulation	Bits per Symbol	Coding Ratio	20-MHz		40-MHz		80-MHz		160-MHz	
				800ns	400ns	800ns	400ns	800ns	400ns	800ns	400ns
1 Spatial Stream				**Data Rate (Mbps)**							
MCS 0	BPSK	1	1/2	6.5	7.2	13.5	15.0	29.3	32.5	58.5	65.0
MCS 1	QPSK	2	1/2	13.0	14.4	27.0	30.0	58.5	65.0	117.0	130.0
MCS 2	QPSK	2	3/4	19.5	21.7	40.5	45.0	87.8	97.5	175.5	195.0
MCS 3	16-QAM	4	1/2	26.0	28.9	54.0	60.0	117.0	130.0	234.0	260.0
MCS 4	16-QAM	4	3/4	39.0	43.3	81.0	90.0	175.5	195.0	351.0	390.0
MCS 5	64-QAM	6	2/3	52.0	57.8	108.0	120.0	234.0	260.0	468.0	520.0
MCS 6	64-QAM	6	3/4	58.5	65.0	121.5	135.0	263.3	292.5	526.5	585.0
MCS 7	64-QAM	6	5/6	65.0	72.2	135.0	150.0	292.5	325.0	585.0	650.0
MCS 8	256-QAM	8	3/4	78.0	86.7	162.0	180.0	351.0	390.0	702.0	780.0
MCS 9	256-QAM	8	5/6	*N/A*	*N/A*	180.0	200.0	390.0	433.3	780.0	866.7
2 Spatial Streams				**Data Rate (Mbps)**							
MCS 0	BPSK	1	1/2	13.0	14.4	27.0	30.0	58.5	65.0	117.0	130.0
MCS 1	QPSK	2	1/2	26.0	28.9	54.0	60.0	117.0	130.0	234.0	260.0
MCS 2	QPSK	2	3/4	39.0	43.3	81.0	90.0	175.5	195.0	351.0	390.0
MCS 3	16-QAM	4	1/2	52.0	57.8	108.0	120.0	234.0	260.0	468.0	520.0
MCS 4	16-QAM	4	3/4	78.0	86.7	162.0	180.0	351.0	390.0	702.0	780.0
MCS 5	64-QAM	6	2/3	104.0	115.6	216.0	240.0	468.0	520.0	936.0	1040.0
MCS 6	64-QAM	6	3/4	117.0	130.0	243.0	270.0	526.5	585.0	1053.0	1170.0
MCS 7	64-QAM	6	5/6	130.0	144.4	270.0	300.0	585.0	650.0	1170.0	1300.0
MCS 8	256-QAM	8	3/4	156.0	173.3	324.0	360.0	702.0	780.0	1404.0	1560.0
MCS 9	256-QAM	8	5/6	*N/A*	*N/A*	360.0	400.0	780.0	866.7	1560.0	1733.3
3 Spatial Streams				**Data Rate (Mbps)**							
MCS 0	BPSK	1	1/2	19.5	21.7	40.5	45.0	87.8	97.5	175.5	195.0
MCS 1	QPSK	2	1/2	39.0	43.3	81.0	90.0	175.5	195.0	351.0	390.0
MCS 2	QPSK	2	3/4	58.5	65.0	121.5	135.0	263.3	292.5	526.5	585.0
MCS 3	16-QAM	4	1/2	78.0	86.7	162.0	180.0	351.0	390.0	702.0	780.0
MCS 4	16-QAM	4	3/4	117.0	130.0	243.0	270.0	526.5	585.0	1053.0	1170.0
MCS 5	64-QAM	6	2/3	156.0	173.3	324.0	360.0	702.0	780.0	1404.0	1560.0
MCS 6	64-QAM	6	3/4	175.5	195.0	364.5	405.0	*N/A*	*N/A*	1579.5	1755.0
MCS 7	64-QAM	6	5/6	195.0	216.7	405.0	450.0	877.5	975.0	1755.0	1950.0
MCS 8	256-QAM	8	3/4	234.0	260.0	486.0	540.0	1053.0	1170.0	2106.0	2340.0
MCS 9	256-QAM	8	5/6	260.0	288.9	540.0	600.0	1170.0	1300.0	*N/A*	*N/A*

MikroTik 802.11ac Implementation







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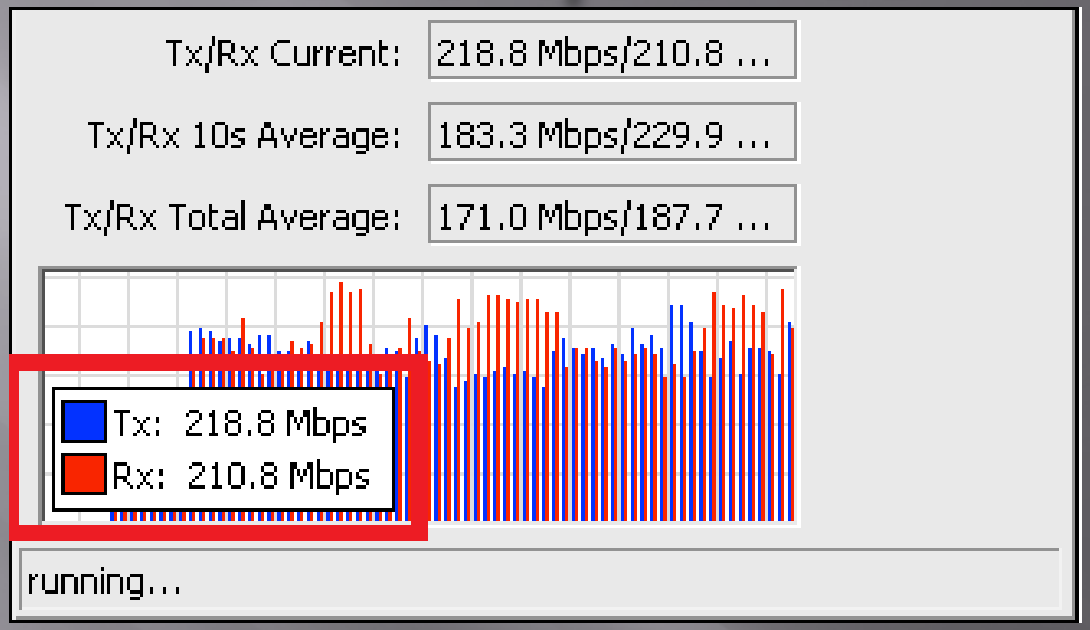

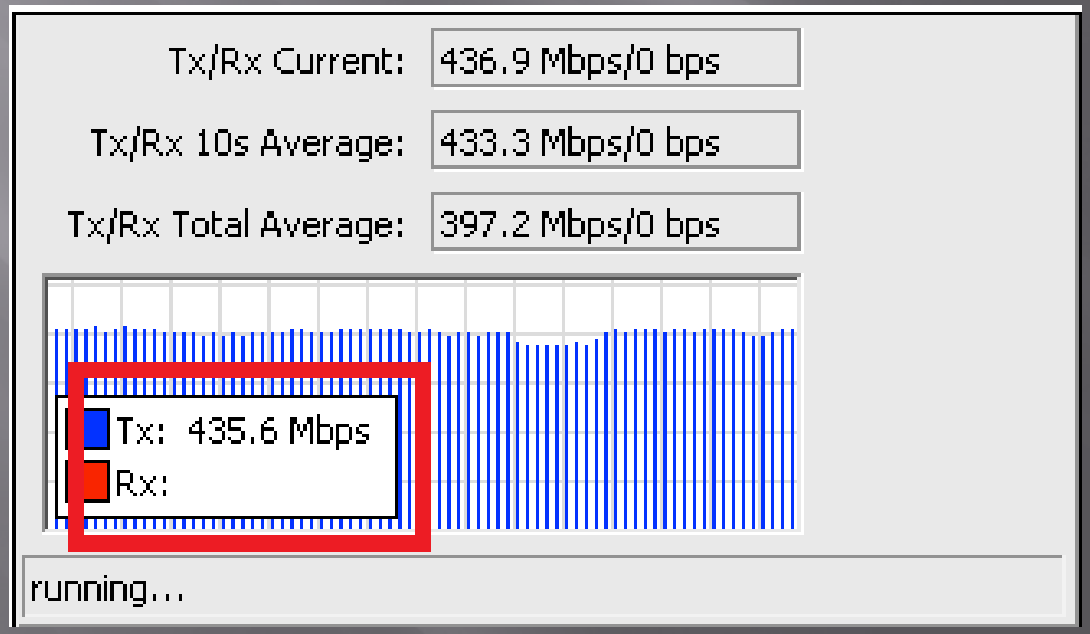

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Any Questions????????

Enjoy MUM

Good Luck