DELTALINK ELECTRONICS.

- How to reach maximum throughput in MIMO
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CHAPTER 1:

Understanding the MIMO technology

1 – Introduction

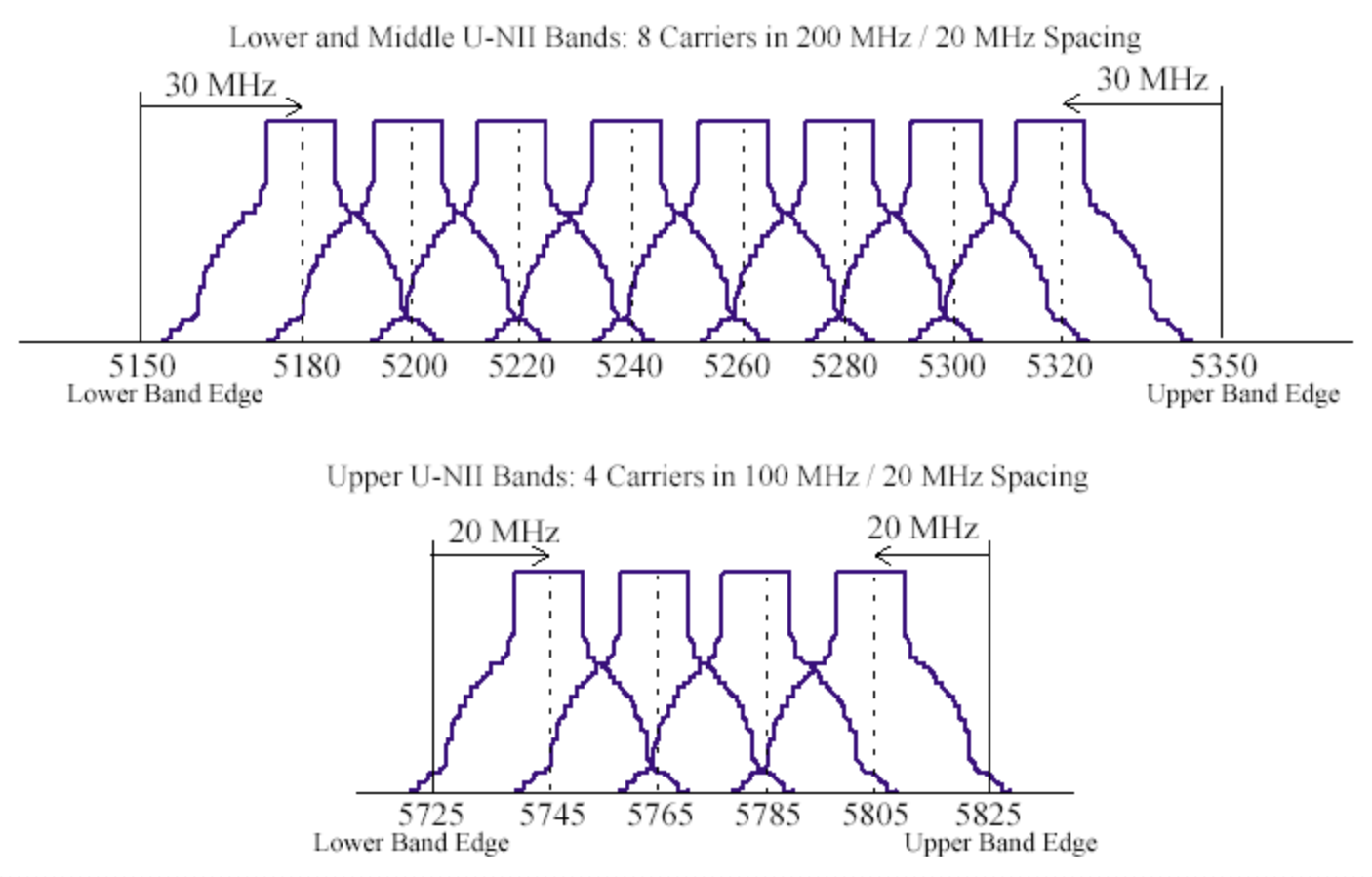
- Throughput:

Carrier efficiency x channel width x bit/symbols x FEC = Throughput

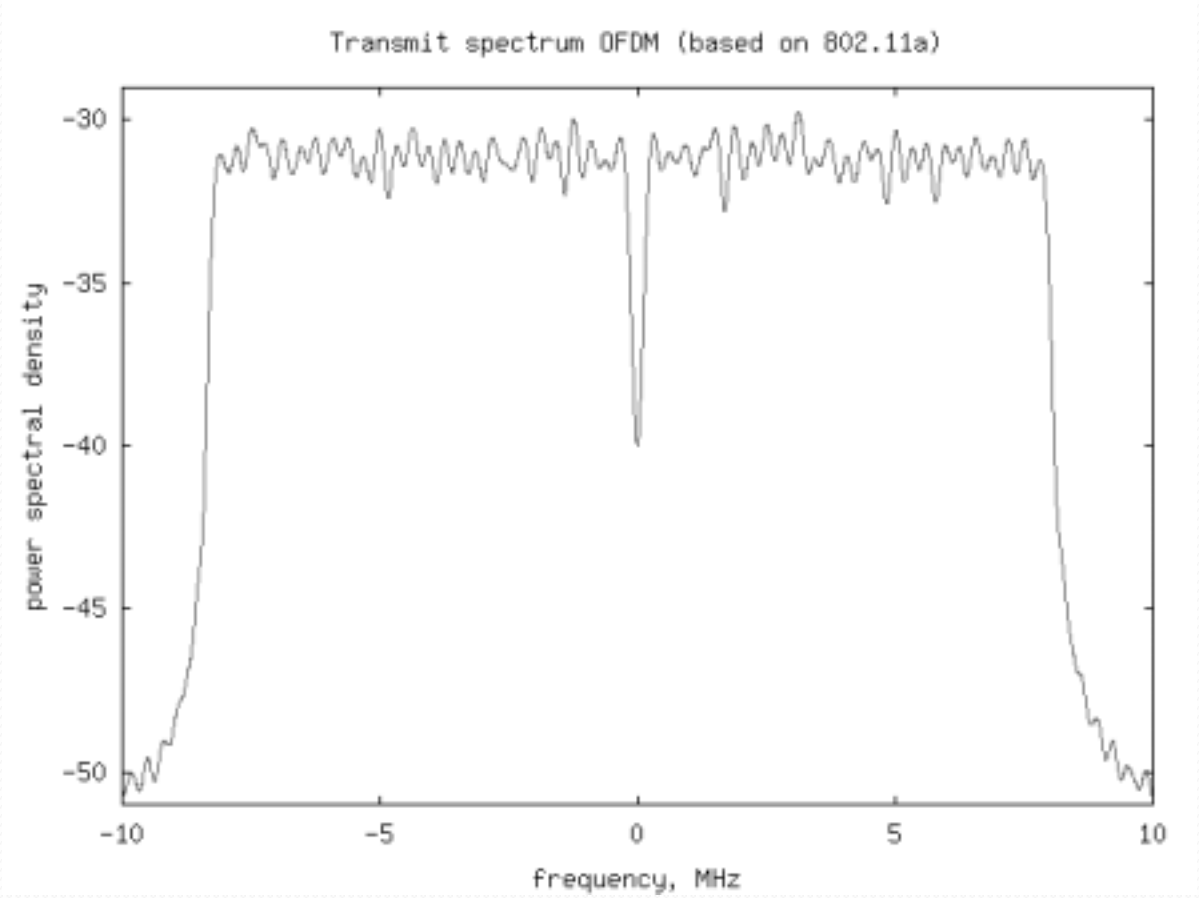
0.6	x	20 MHz	x	1(BPSK)	x	½	=	6 Mbps
0.6	x	20 MHz	x	1(BPSK)	x	¾	=	9 Mbps
0.6	x	20 MHz	x	6(64QAM)	x	¾	=	54 Mbps
0.6	x	40 MHz	x	6(64QAM)	x	¾	=	108 Mbps
0.75	x	40 MHz	x	6(64QAM)	x	¾	=	135 Mbps
0.75	x	40 MHz	x	6(64QAM)	x	5/6	=	150 Mbps

2- Carrier & Subcarriers

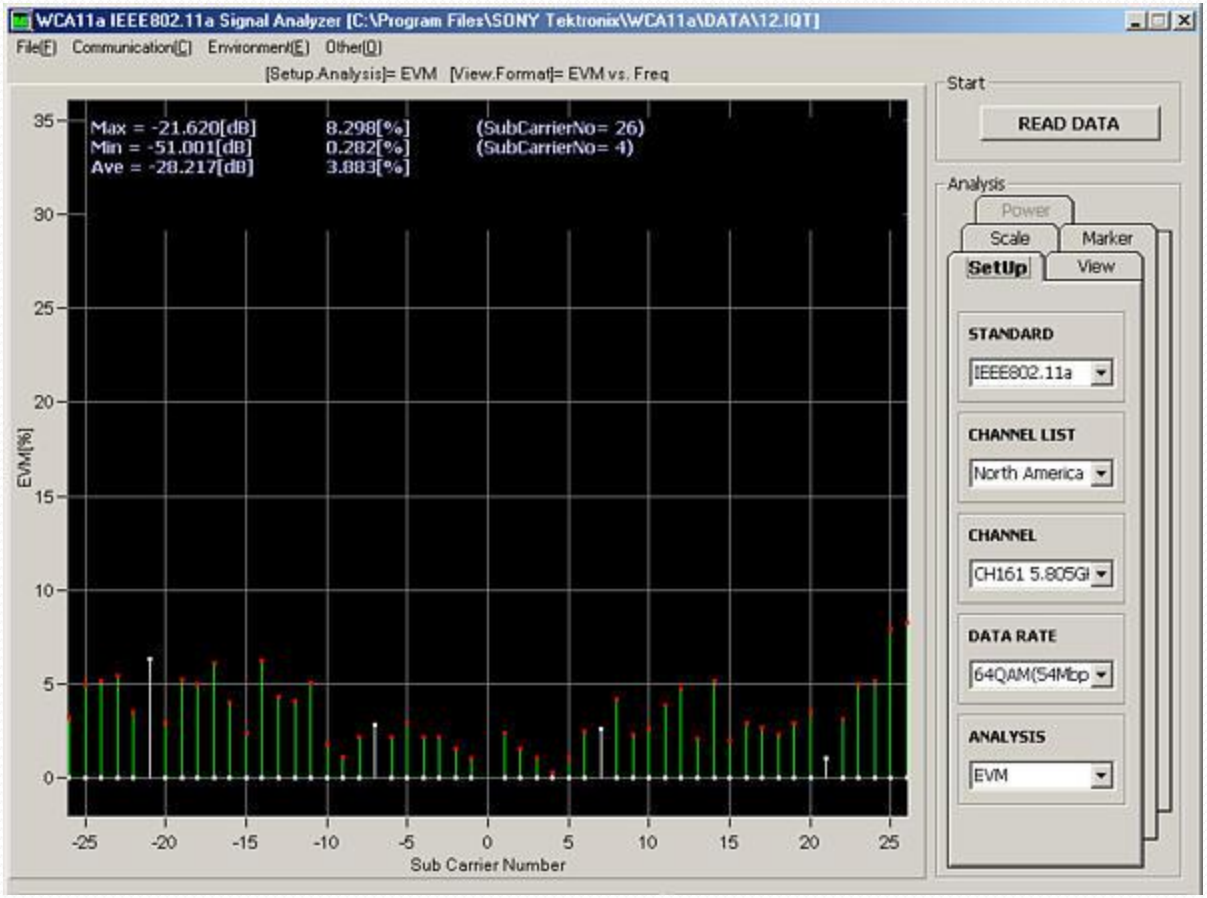
- Lower, Middle and Upper U-NII Bands Carriers :



- Closer look in to a 20 MHz Carrier :

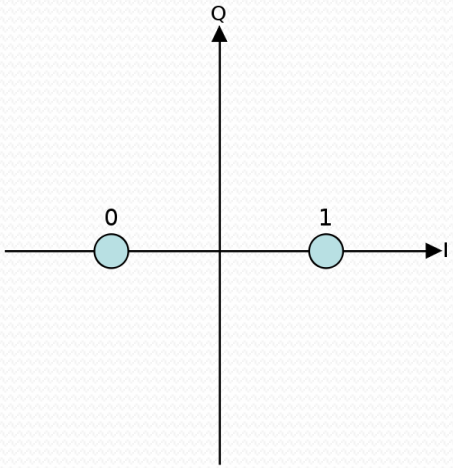


- Subcarriers (48 Subcarriers + 4 Pilots 312.5 KHz each in a 20 MHz Carrier)

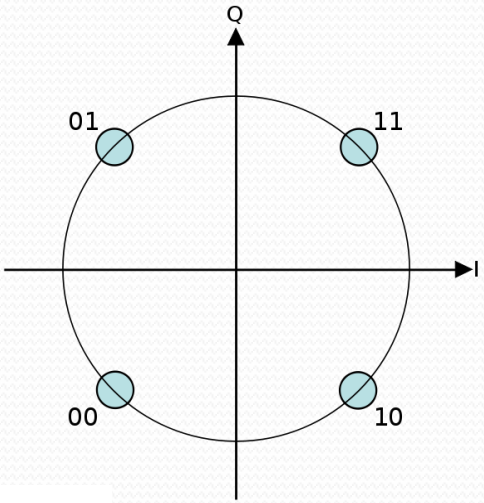


3- Modulation

- Phase Shift keying (BPSK, QPSK)

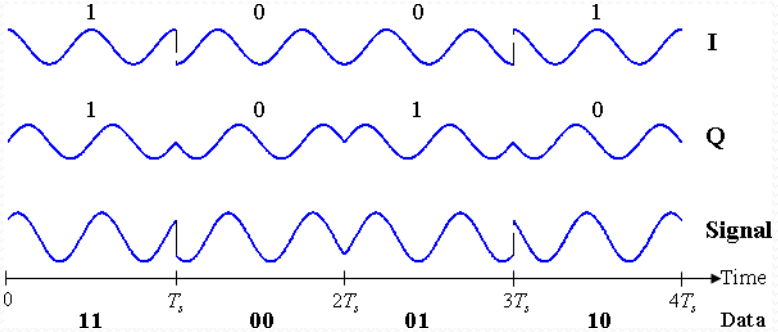


BPSK

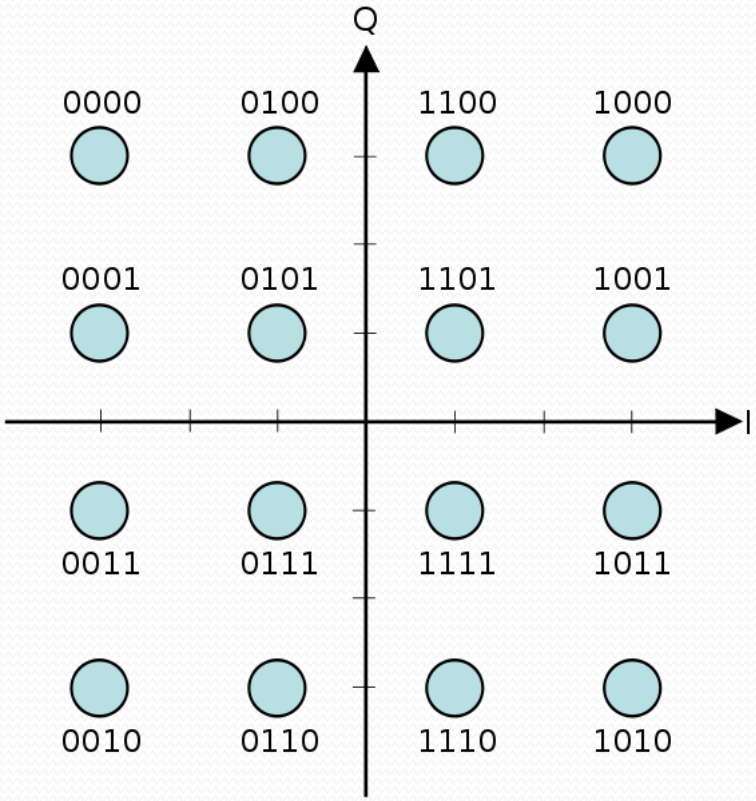


QPSK

QPSK

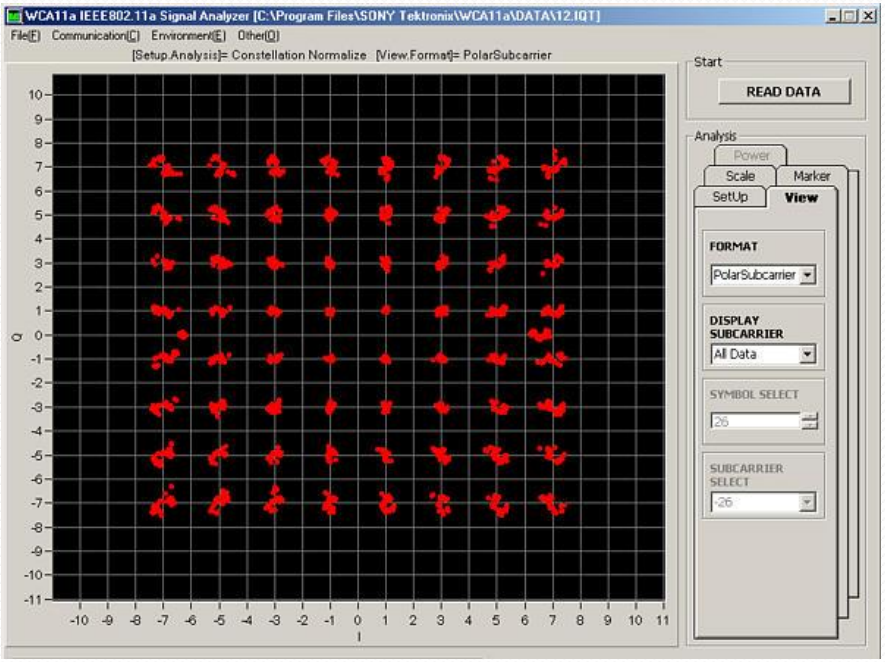


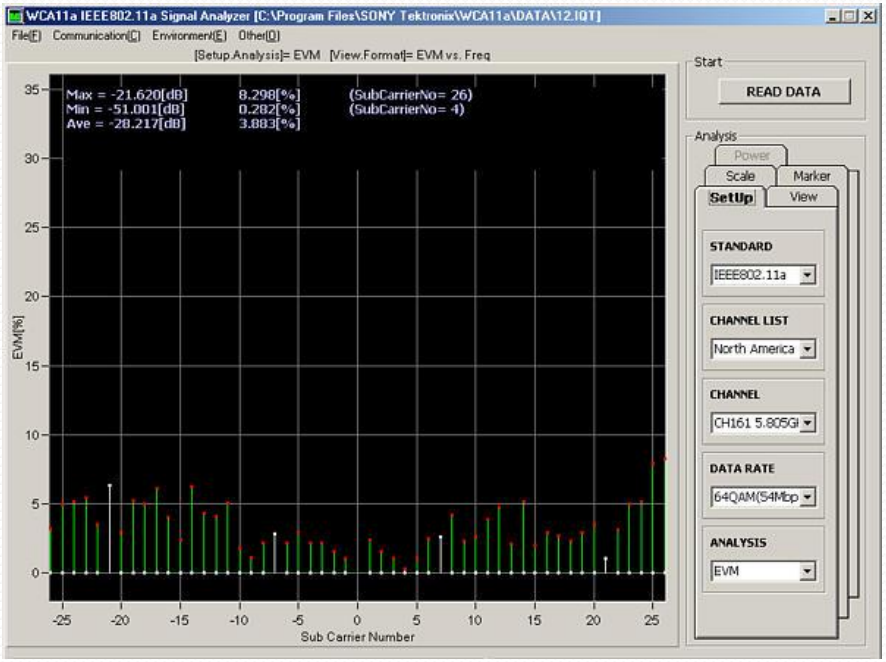
- QAM (Quadrature Amplitude Modulation)



16-QAM

- QAM (Quadrature Amplitude Modulation)





64-QAM

4- FEC (Forward Error Correction)

- Understanding the object :

Triplet received	Interpreted as
000	0 (error free)
001	0
010	0
100	0
111	1 (error free)
110	1
101	1
011	1

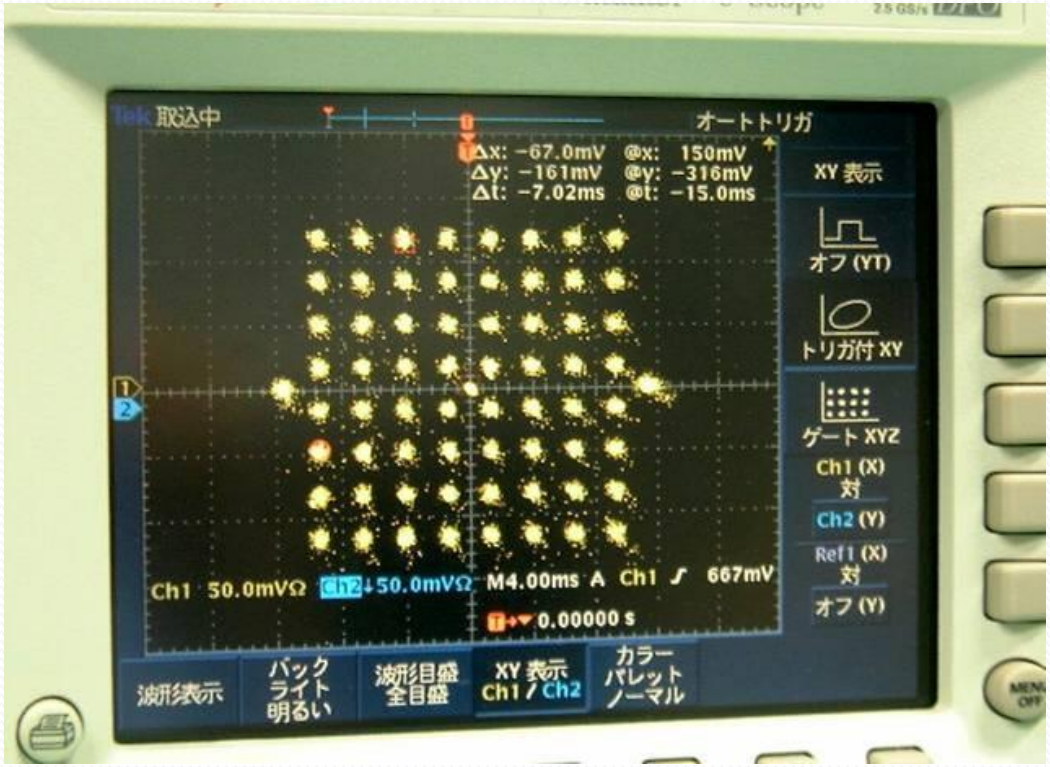
FEC= 1/3

Throughput

- With Higher Data rates we will always have better performance ?

- Why No !!??

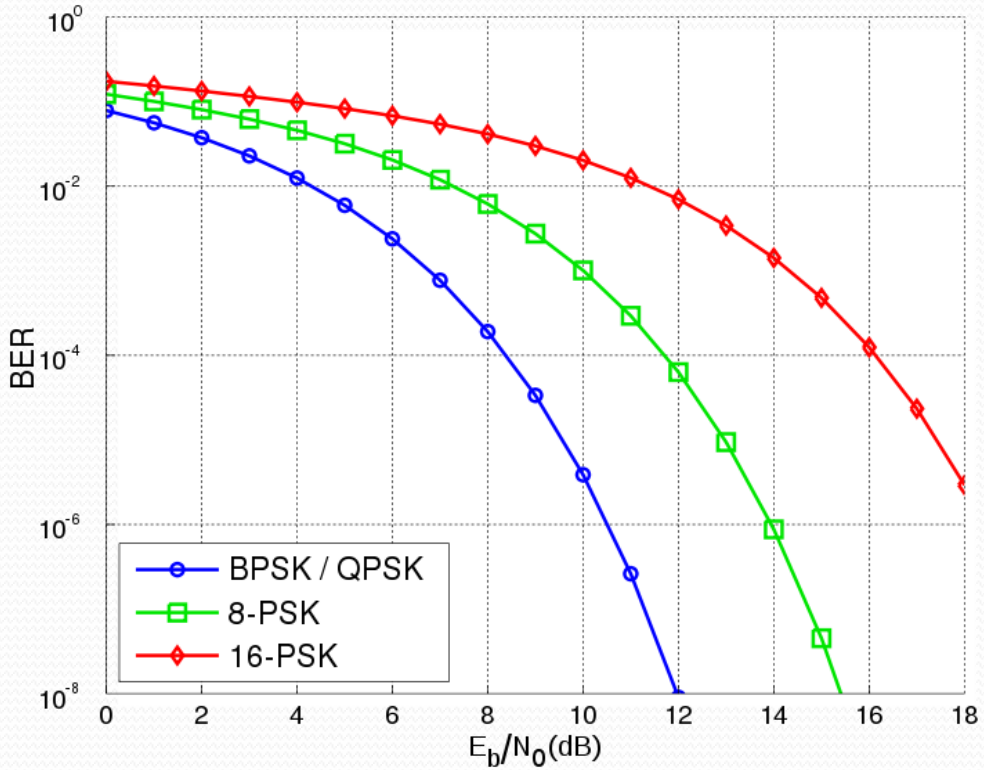
In this Picture the RX signal is -35



- Why No !!??

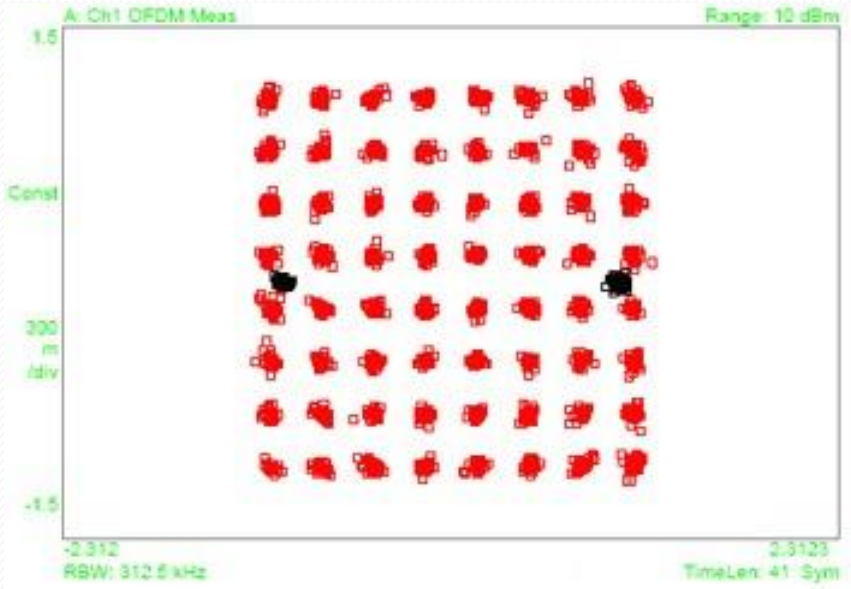
In this Picture the RX signal is -65

- when we have Noise or low RX level the BER(Bit Error Rate) will be maximized and the lost data will be more than Slower data rates in this case our throughput will be minimized and very unstable.

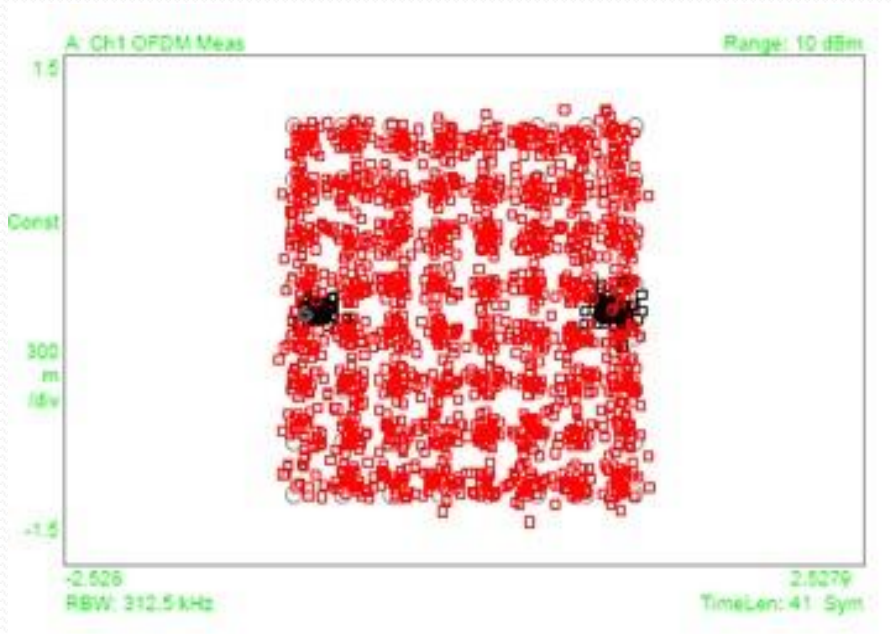


- Maximizing the transmit power is help us to reach the better performance ?

- in the right picture the output power is set to maximum and the left one the output power is 6 dBm lower you can see the results by your self and its up to you to decide.



18 dBm



24 dBm

Now we Know :

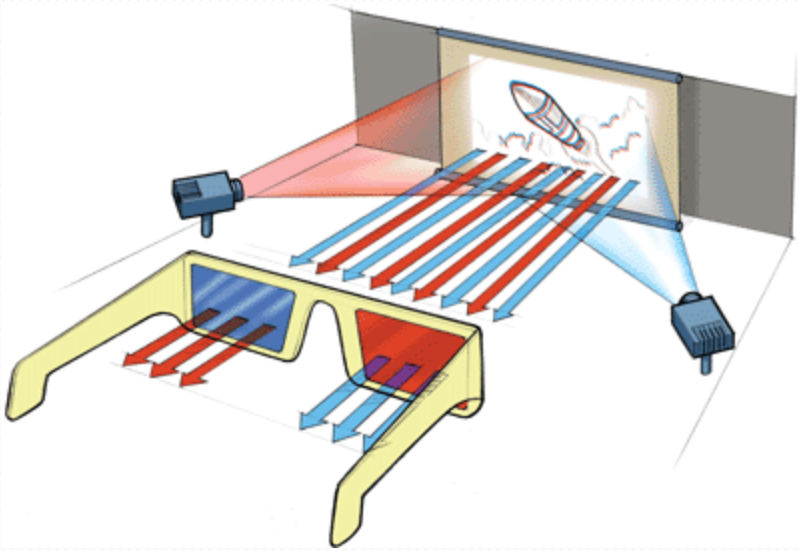
0.75 x 40 MHz x 6(64QAM) x 5/6 = 150 Mbps

Efficiency Carrier Width Modulation FEC Data rate

- In the real world we should always remember BER(Bit Error Rate) could effect our throughput and decrease it.

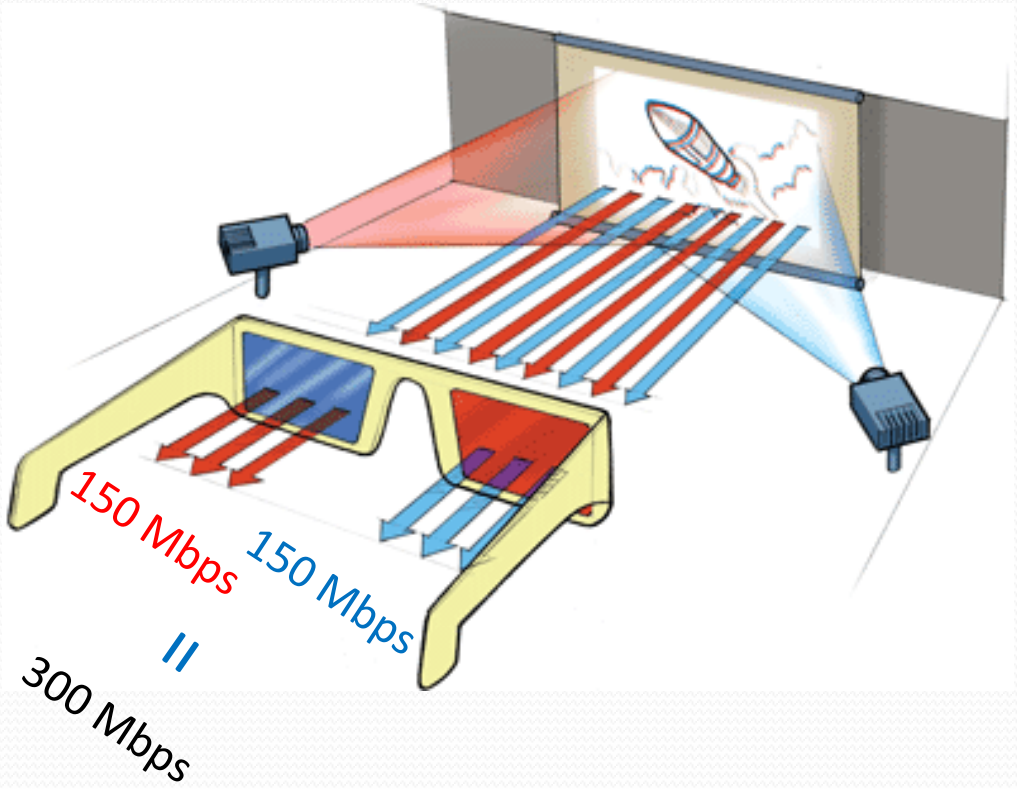
- The question is how its possible to reach 300 Mbps or more by keeping this parameters unchanged ???

- 3D Movies is the KEY !!???

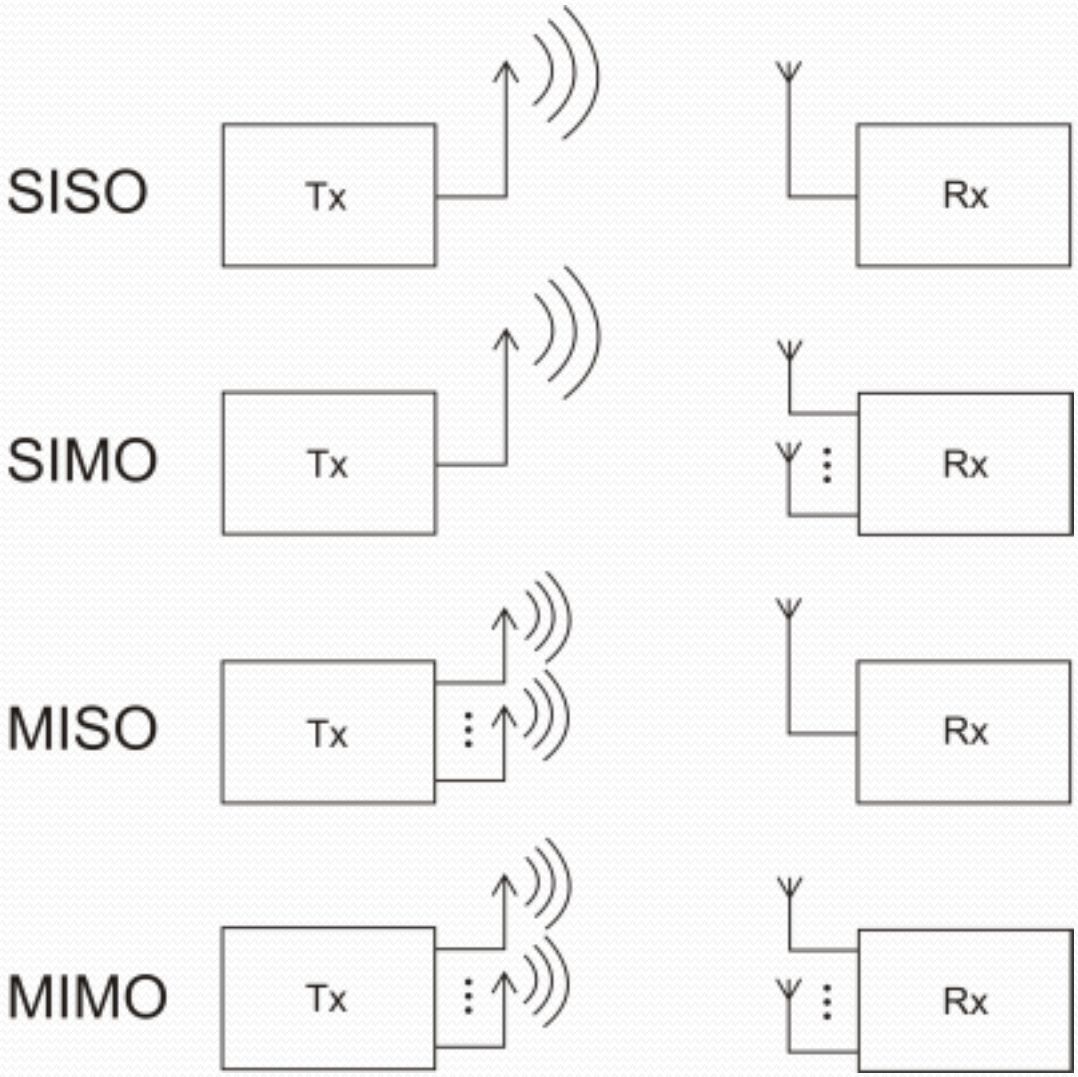


Throughput

- 3D Movies is the KEY !!???



MIMO(Multiple In Multiple Out)



- MIMO Data rates :

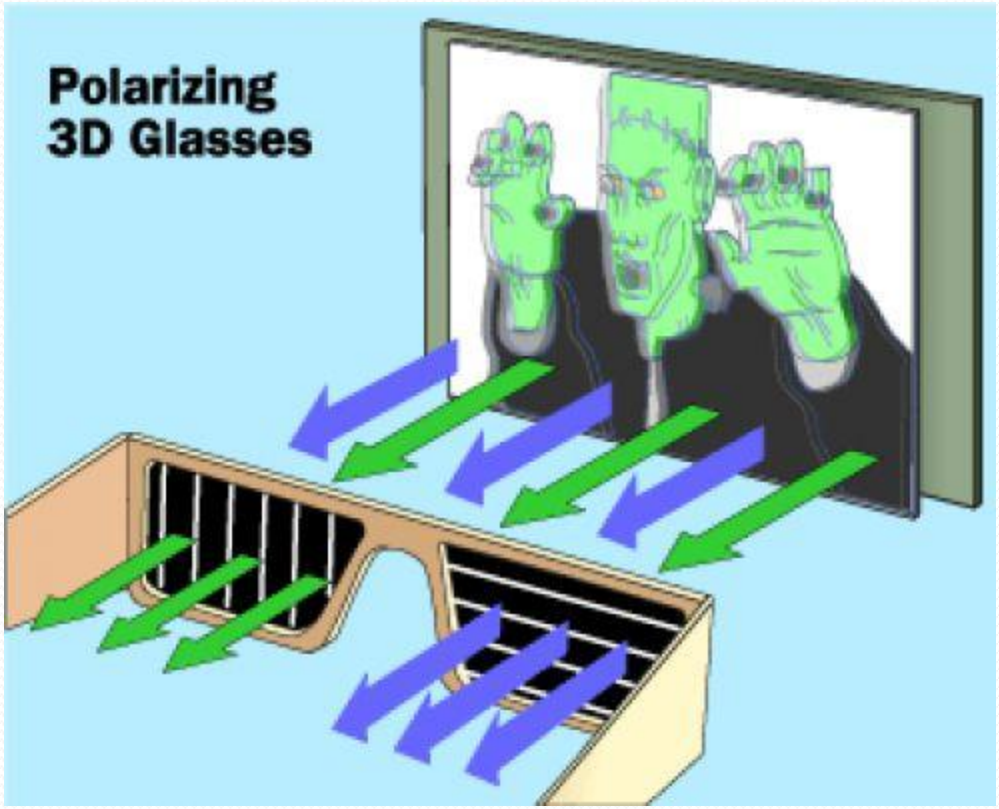
MCS Index	Spatial Streams	Modulation Type	Coding Rate	Data Rate Mbit/s			
				20 MHz channel		40 MHz channel	
				800ns GI	400ns GI	800ns GI	400ns GI
0	1	BPSK	1/2	6.50	7.20	13.50	15.00
1	1	QPSK	1/2	13.00	14.40	27.00	30.00
2	1	QPSK	3/4	19.50	21.70	40.50	45.00
3	1	16-QAM	1/2	26.00	28.90	54.00	60.00
4	1	16-QAM	3/4	39.00	43.30	81.00	90.00
5	1	64-QAM	2/3	52.00	57.80	108.00	120.00
6	1	64-QAM	3/4	58.50	65.00	121.50	135.00
7	1	64-QAM	5/6	65.00	72.20	135.00	150.00
8	2	BPSK	1/2	13.00	14.40	27.00	30.00
9	2	QPSK	1/2	26.00	28.90	54.00	60.00
10	2	QPSK	3/4	39.00	43.30	81.00	90.00
11	2	16-QAM	1/2	52.00	57.80	108.00	120.00
12	2	16-QAM	3/4	78.00	86.70	162.00	180.00
13	2	64-QAM	2/3	104.00	115.60	216.00	240.00
14	2	64-QAM	3/4	117.00	130.00	243.00	270.00
15	2	64-QAM	5/6	130.00	144.40	270.00	300.00

CHAPTER 2:

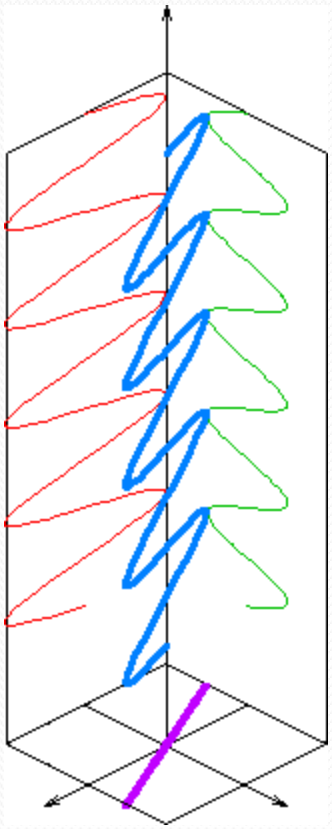
Antenna Parameters witch involved in throughput

Antenna cross polarization :

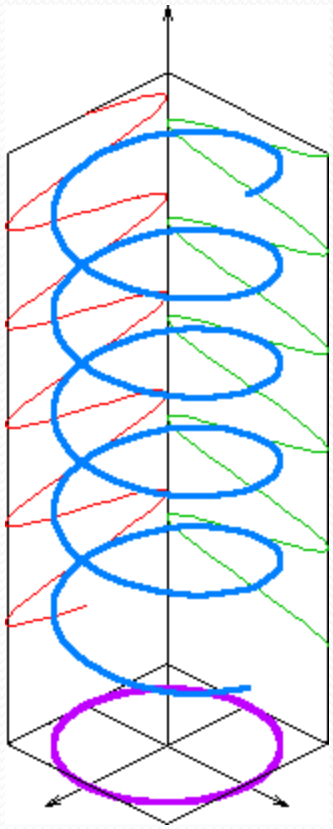
- To understanding the importance of the Antenna Cross polarization lets go back to the 3D Cinema



- What is the antenna polarization ?



Linear



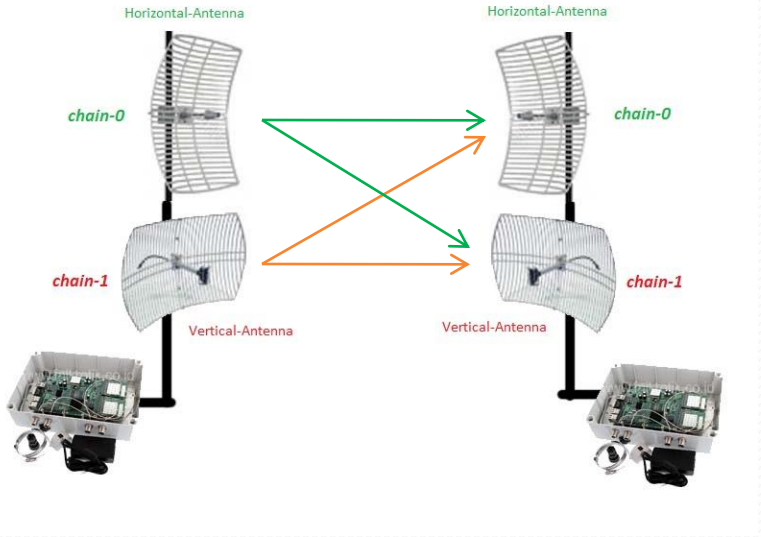
Circular

- Mismatch Loss(for Linear Polarization)

Polarization Mismatch Loss (dB) = 20 log (cos θ)

Orientation Angle	Polarization Mismatch (dB)
0.0 (aligned)	0.0
15.0	0.3
30.0	1.25
45.0	3.01
60.0	6.02
75.0	11.74
90.0 (orthogonal)	∞

- So if we use 2 Antennas for transmit signal in Linear Polarity and 2 Antennas for receive Signal and rotate 1 of the antenna in the both sides 90 digress we will have:



RX chain1(TX chain1) = -45dBm
RX chain1(TX chain0) = -45dBm – 25dBi(RX Antenna Cross Pol.) = -70 dBm

RX chain0(TX chain0) = -45dBm
RX chain0(TX chain1) = -45dBm – 25dBi(RX Antenna Cross Pol.) = -70 dBm

- for Chain-0 the incoming signal from Chain-1 is unwanted and its like Noise for it we should try to Fade it out.

To fade out the opposite chain signal we have 2 options

1- minimize the output power :

RX chain1(TX chain1) = -45dBm
RX chain1(TX chain0) = -45dBm – 25dBi(RX Antenna Cross Pol.) = -70 dBm

If we decrease 10dBm of the transmitter output power we will have :

RX chain1(TX chain1) = -55dBm
RX chain1(TX chain0) = -55dBm – 25dBi(RX Antenna Cross Pol.) = -80dBm

2- Choose a better antenna with higher cross polarization :

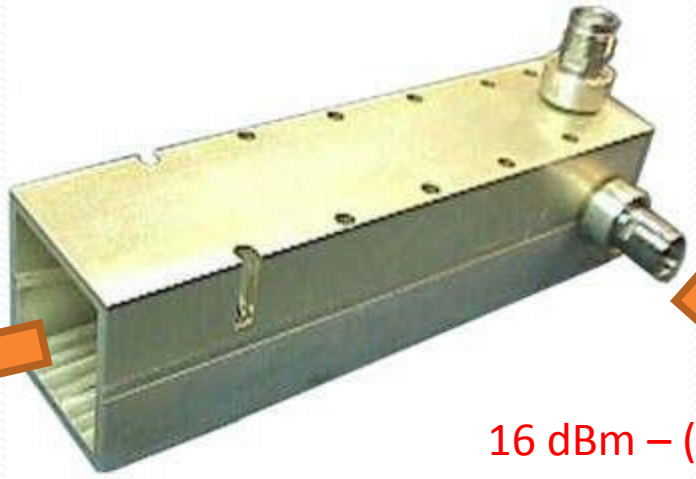
Here we use a better antenna with 35dBi cross polarization

RX chain1(TX chain1) = -45dBm
RX chain1(TX chain0) = -45dBm – 35dBi(RX Antenna Cross Pol.) = -80 dBm

Port to Port Isolation:

- In a MIMO Radio the generated signal could damage the neighbor port signals or even hardware if the signal could easily pass from the antenna ports we should be sure about the Port to Port Isolation

Output signal from chain0
16 dBm



16 dBm + 12dBi = 28 dB
EIRP

Go back to chain1

16 dBm – (Antenna Port to Port Isolation)

Return Loss:

- The return signal from the antenna to the transmitter port could damage the port we should always be sure that we use an antenna with return loss better than -10dB in the frequency we use

16 dBm

16dBm – 10 (RL) = 6dBm

16 dBm + 12dBi = 28 dB EIRP

- Impedance mismatching and VSWR

VSWR = Voltage Standing Wave Ratio

Start From : (1 : 1) Perfectly Mach 50Ω in 50Ω system

Acceptable : (2 : 1) up to 73Ω in 50Ω system

Up to : (∞ : 1) totally mismatch

- VSWR and Return Loss

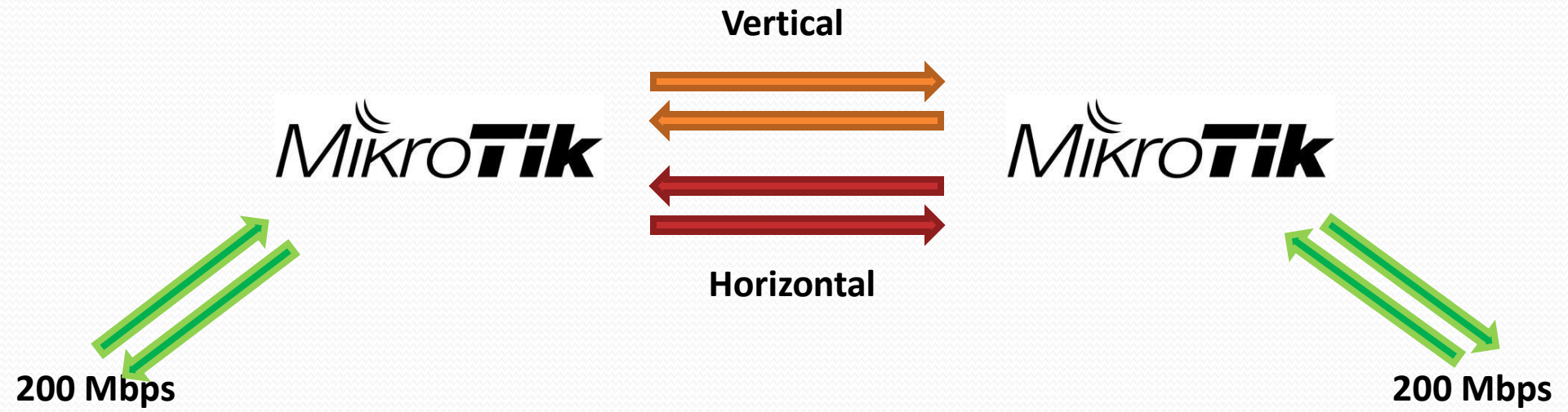
Return Loss = Power of return signal to the transmitter in dB

$$RL = 20 \log((VSWR+1) / (VSWR-1))$$

VSWR 2:1 → RL: -9.54

VSWR 1.01:1 → RL: -46

Know you have enough knowledge about this technology to mix it with your experience, buy 2 Mikrotik Routerboards and wireless MiniPCI adapters, Choose right antennas and enjoy 200Mbps Real TCP throughput.



For more information please contact me at:
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