DELTALINK ELECTRONICS.

- What is 802.11ac
- By : Ahmad Mortazavi

PITTSBURGH, USA (2014)

CHAPTER 1:

Understanding the 802.11ac technology

1 – Introduction

Where did Data rates come from ??

Data rates

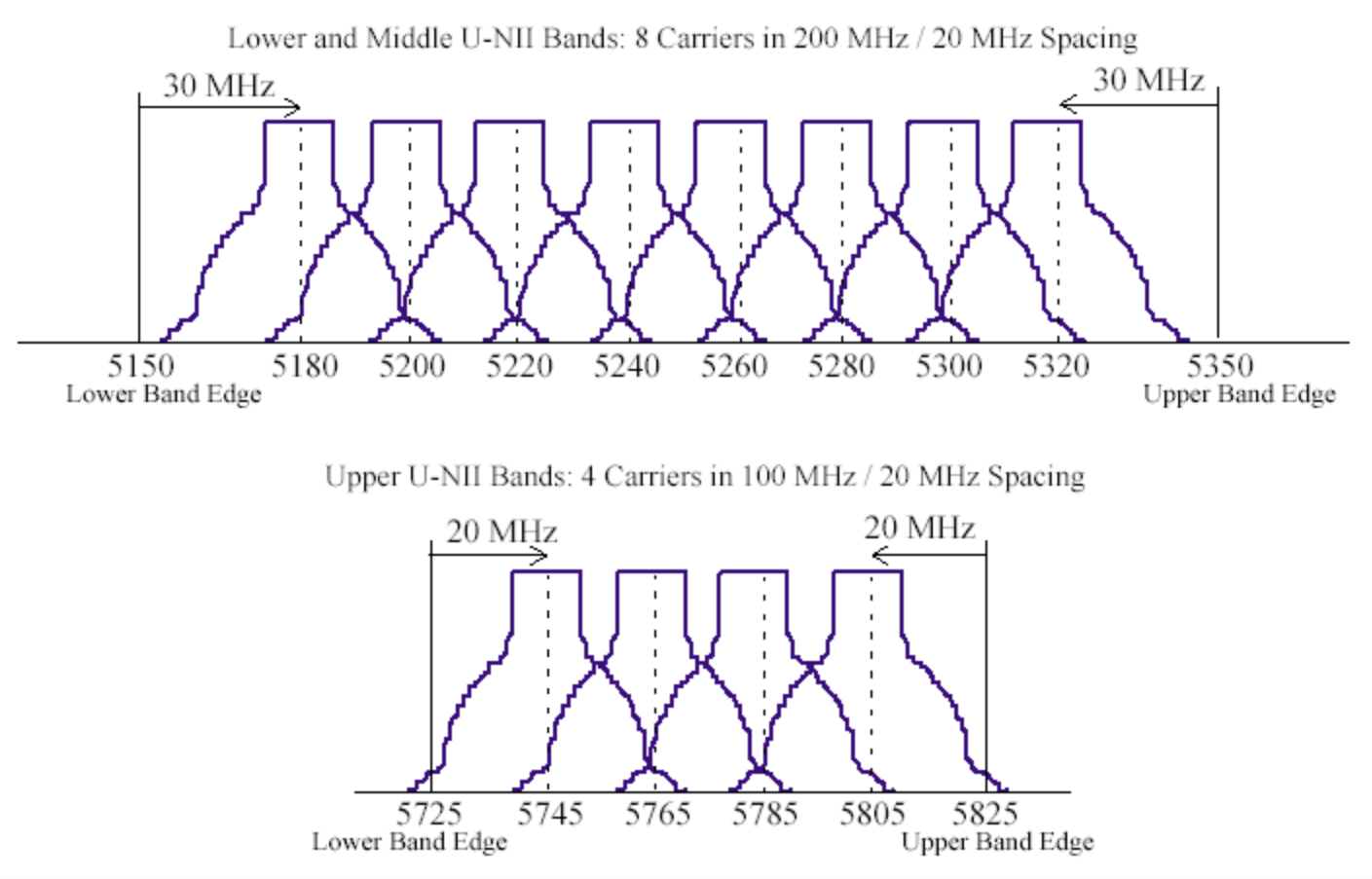
- Where did Data rates come from ??

Carrier efficiency x channel width x bit/symbols x FEC

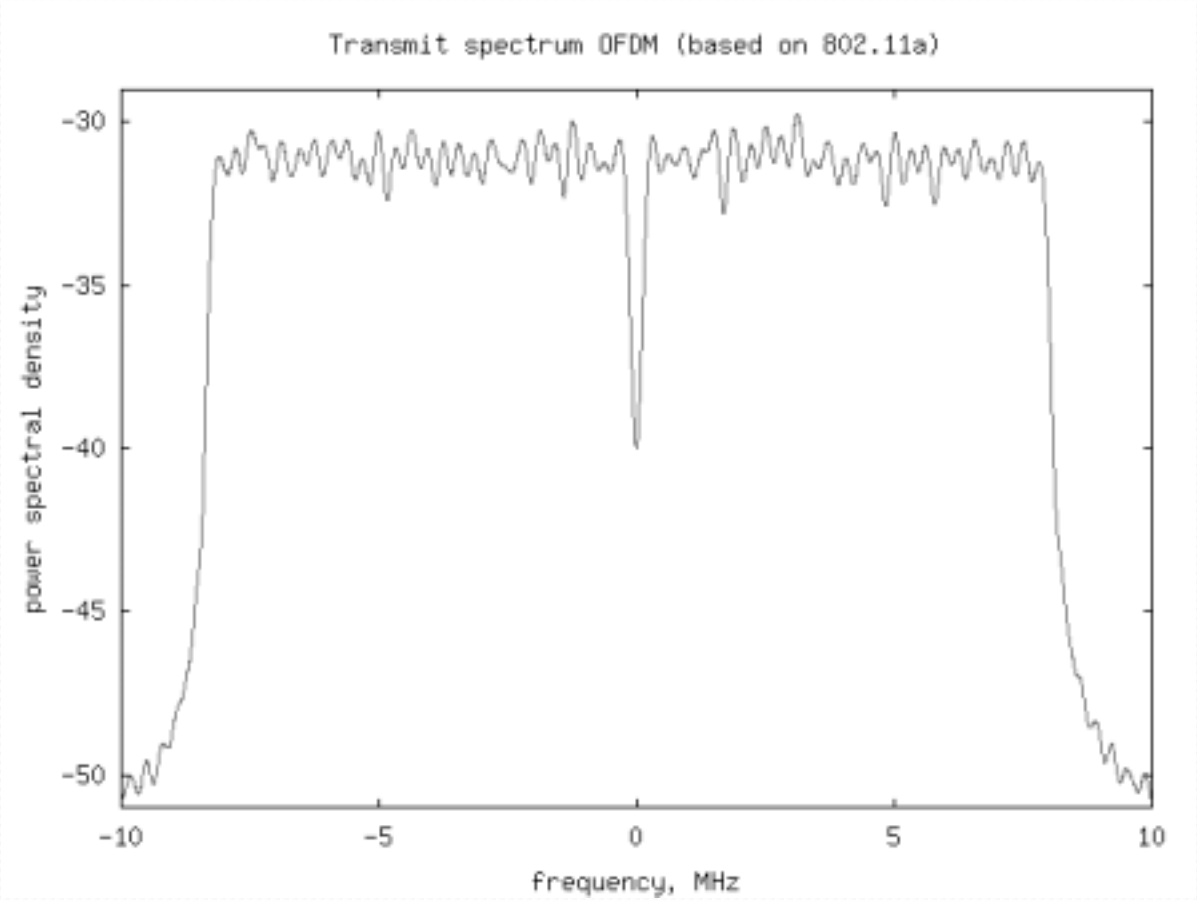
Data rate

Carrier & Subcarriers

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

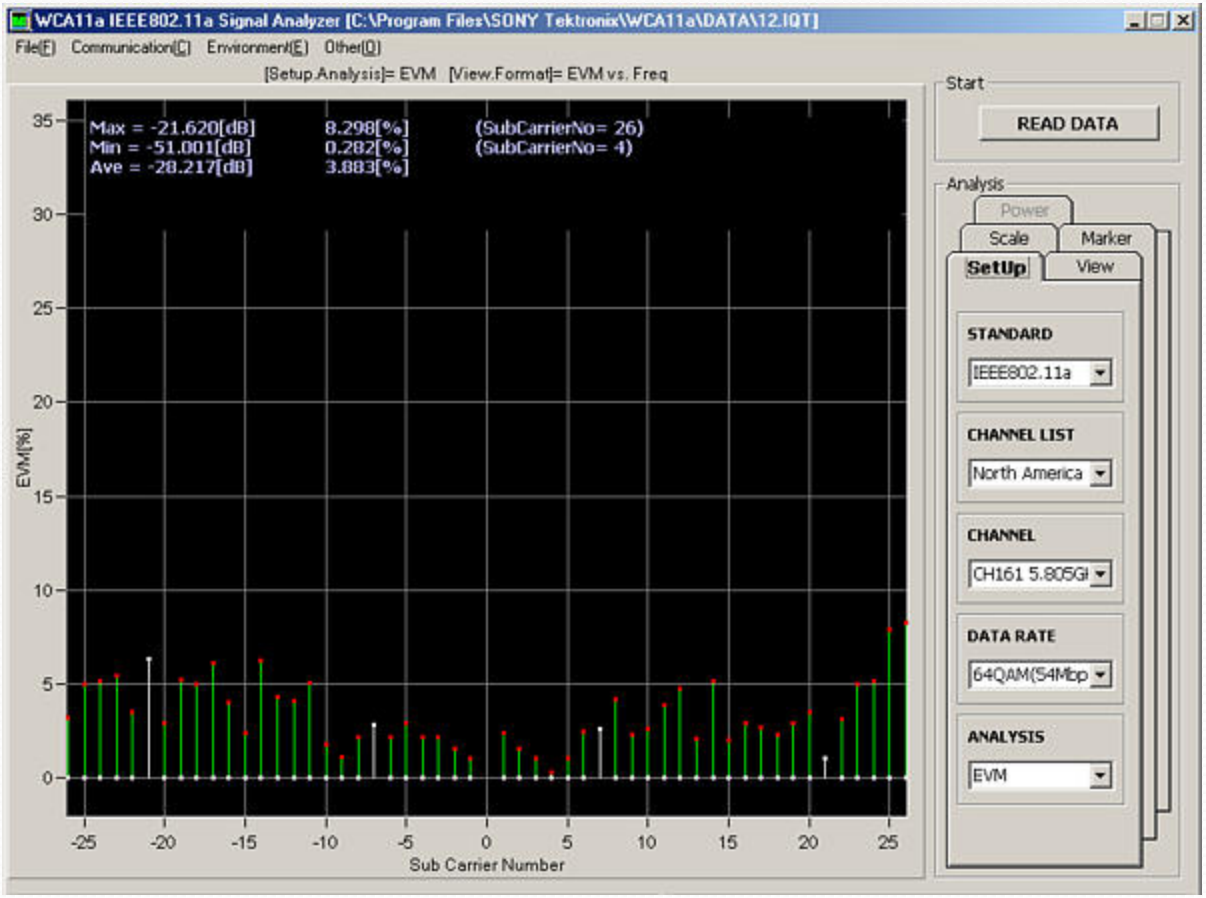


- Closer look in to a 20 MHz Carrier :



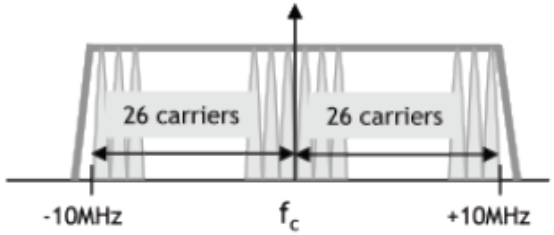
- **802.11 a/g Subcarriers**

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

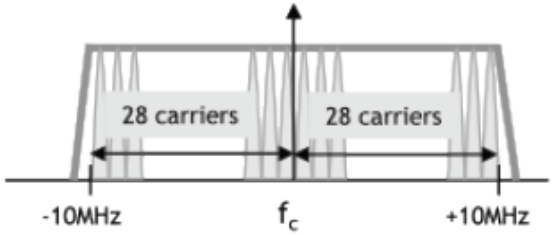


Carrier & Subcarriers

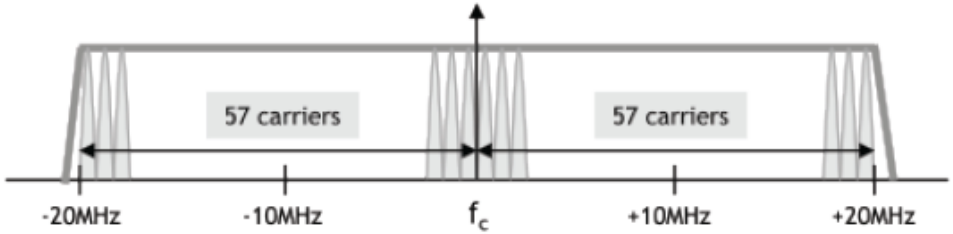
OFDM SUBCARRIERS USED IN 802.11A, 802.11N AND 802.11AC



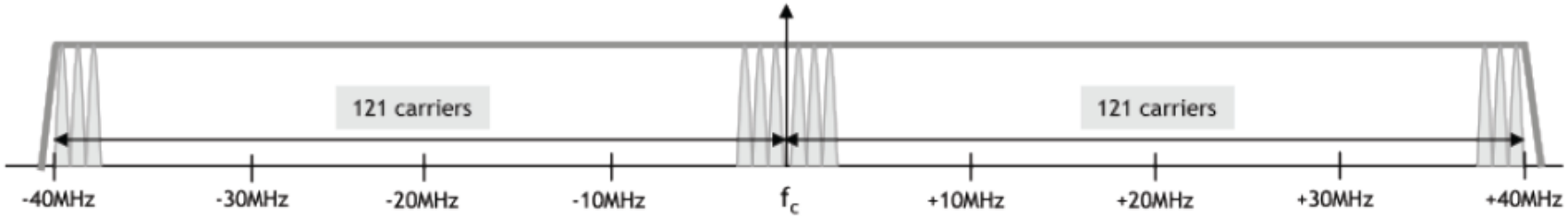
52 subcarriers (48 usable) for a **20 MHz non-HT** mode (legacy 802.11a/g) channel



56 subcarriers (52 usable) for a **20 MHz HT** mode (802.11n) channel



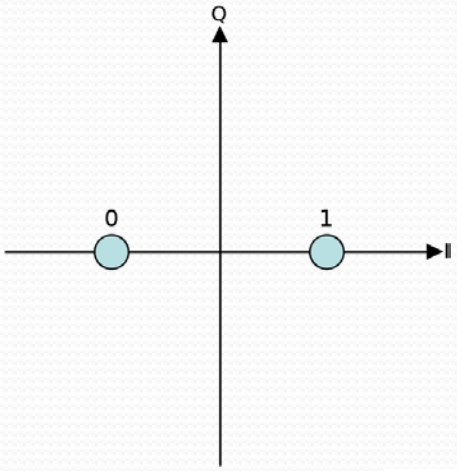
114 subcarriers (108 usable) for a **40 MHz HT** mode (802.11n) channel



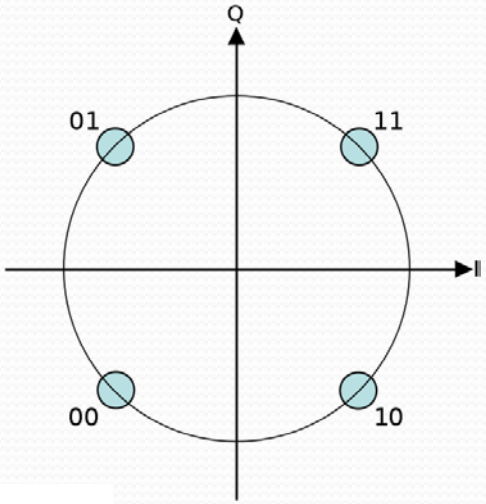
242 subcarriers (234 usable) for a **80 MHz VHT** mode (802.11ac) channel
An 80+80MHz or 16MHz channel is exactly two 80MHz channels, for 484 subcarriers (468 usable)

Modulation

- Phase Shift keying (BPSK, QPSK)

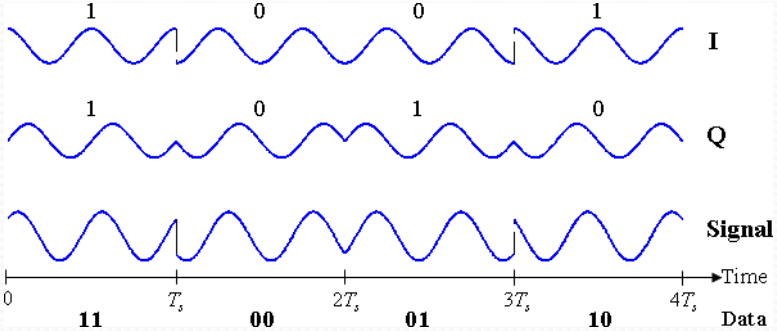


BPSK

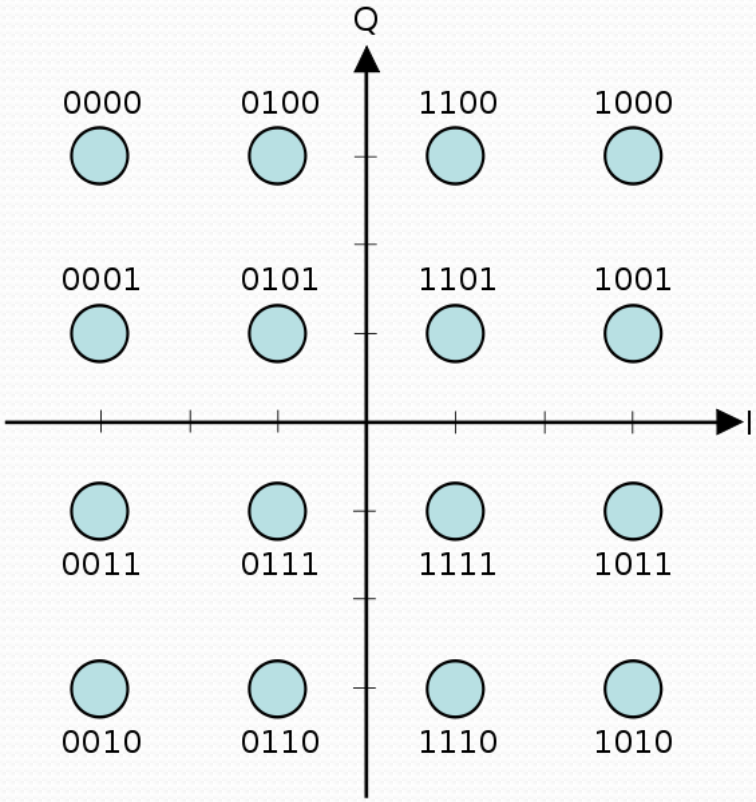


QPSK

QPSK

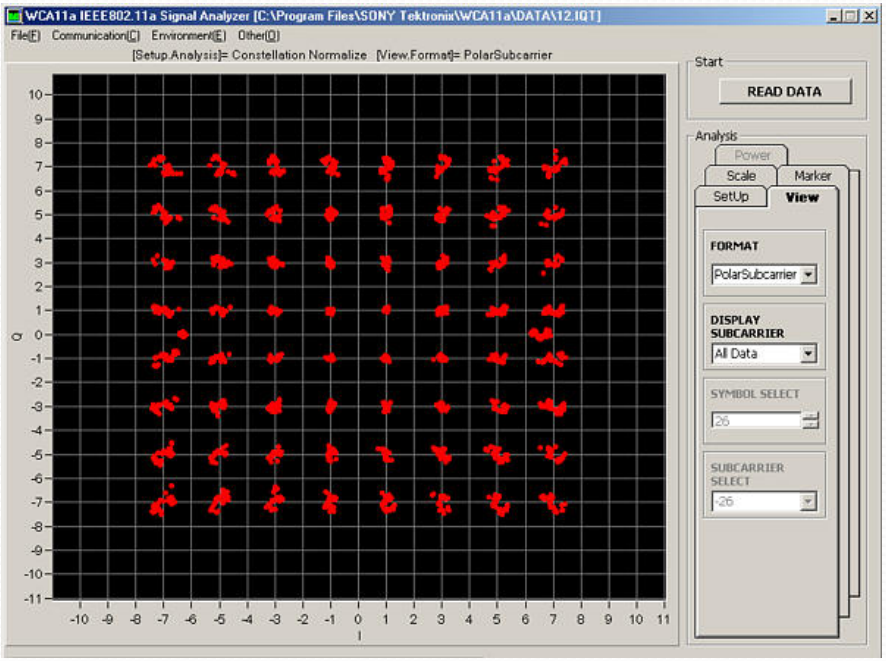


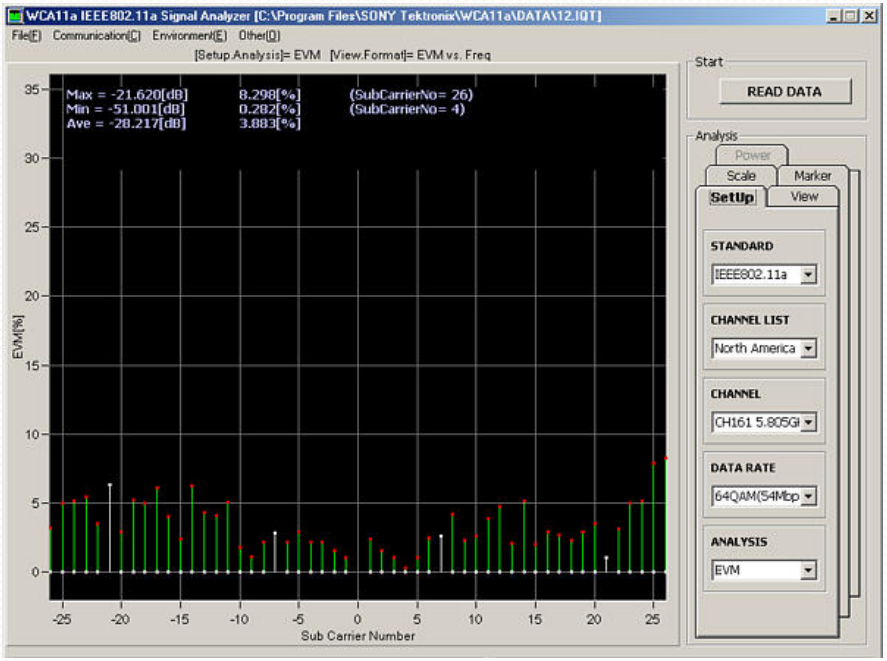
- QAM (Quadrature Amplitude Modulation)



16-QAM

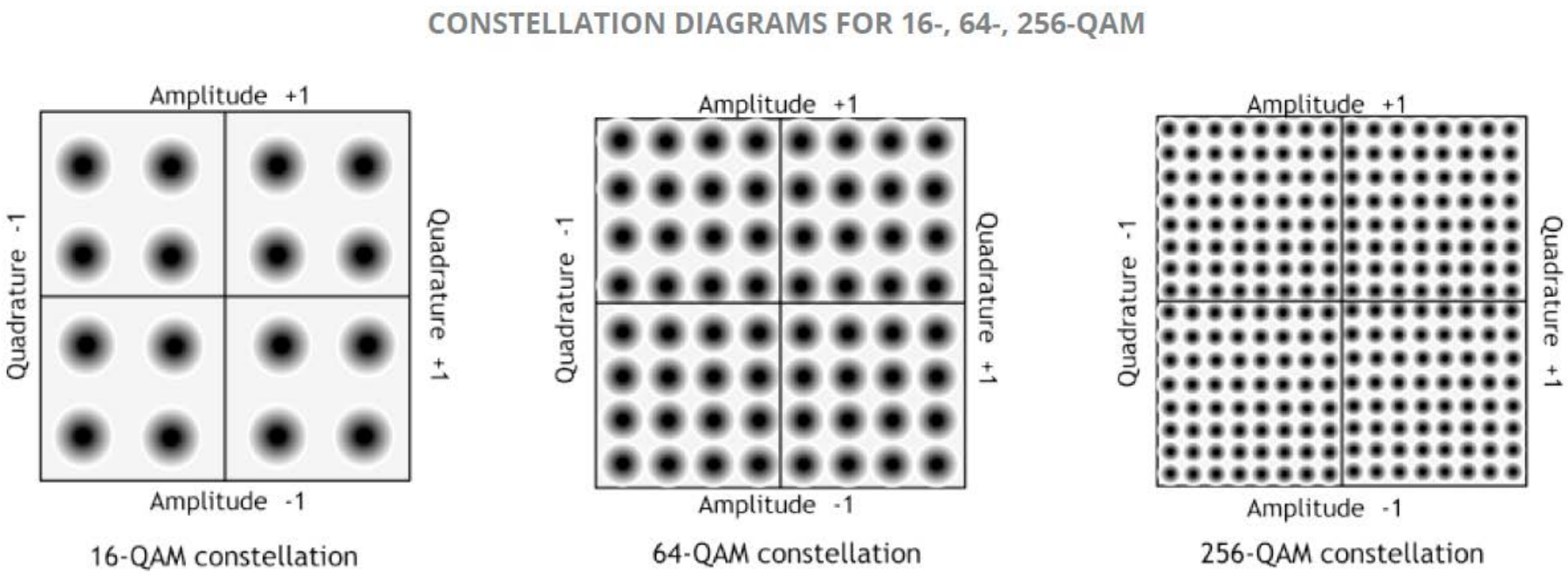
- QAM (Quadrature Amplitude Modulation)





64-QAM

Bits per symbols



Each symbol Means 4 Bits in 16 QAM for example (1101)

Each symbol Means 6 Bits in 64 QAM for example (110101)

Each symbol Means 8 Bits in 256 QAM for example (11010100)

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

Now we Know where the data rates come from :

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

Efficiency	Carrier Width	Modulation (bits per symbol)	FEC	Data rate

- 802.11ac Data rate:

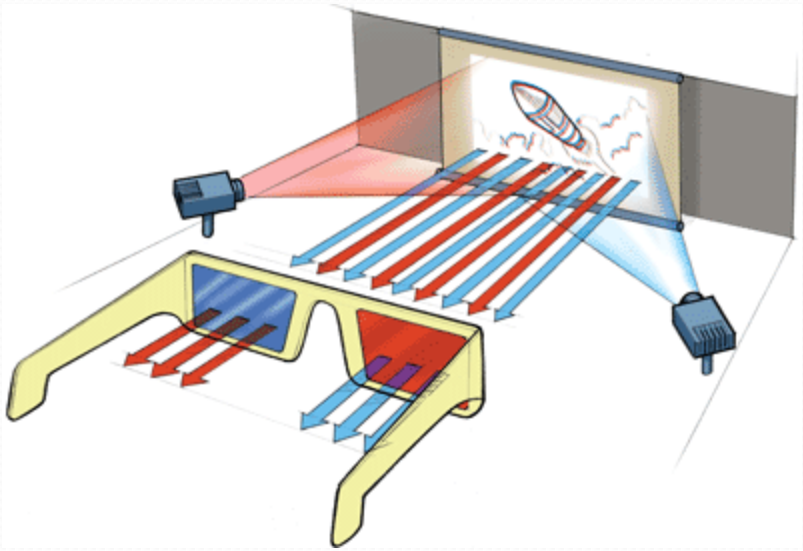
Carrier efficiency x channel width x bit/symbols x FEC = Data Rate

802.11a/g → 0.6 x 20 MHz x 6(64QAM) x ¾ = **54 Mbps**

802.11n → **0.75** x **40 MHz** x 6(64QAM) x **5/6** = **150 Mbps**

802.11ac → **0.812** **x** **80 MHz** **x 8(256QAM)** x 5/6 = **433.3 Mbps**

What is MIMO ?

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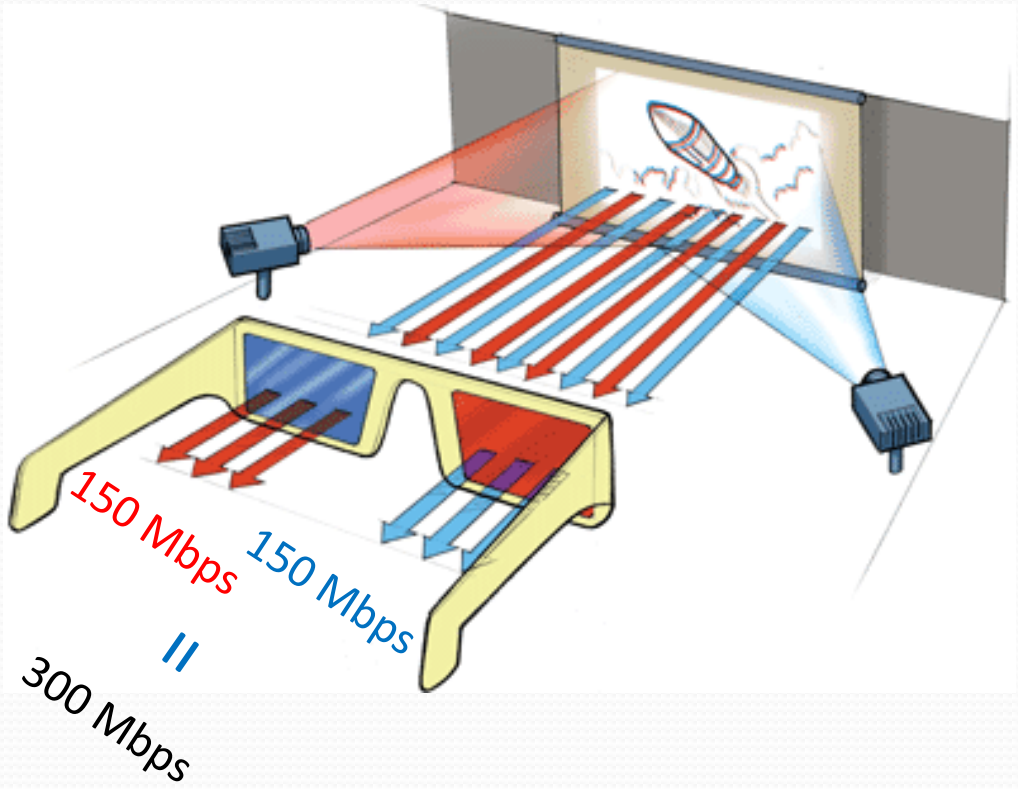
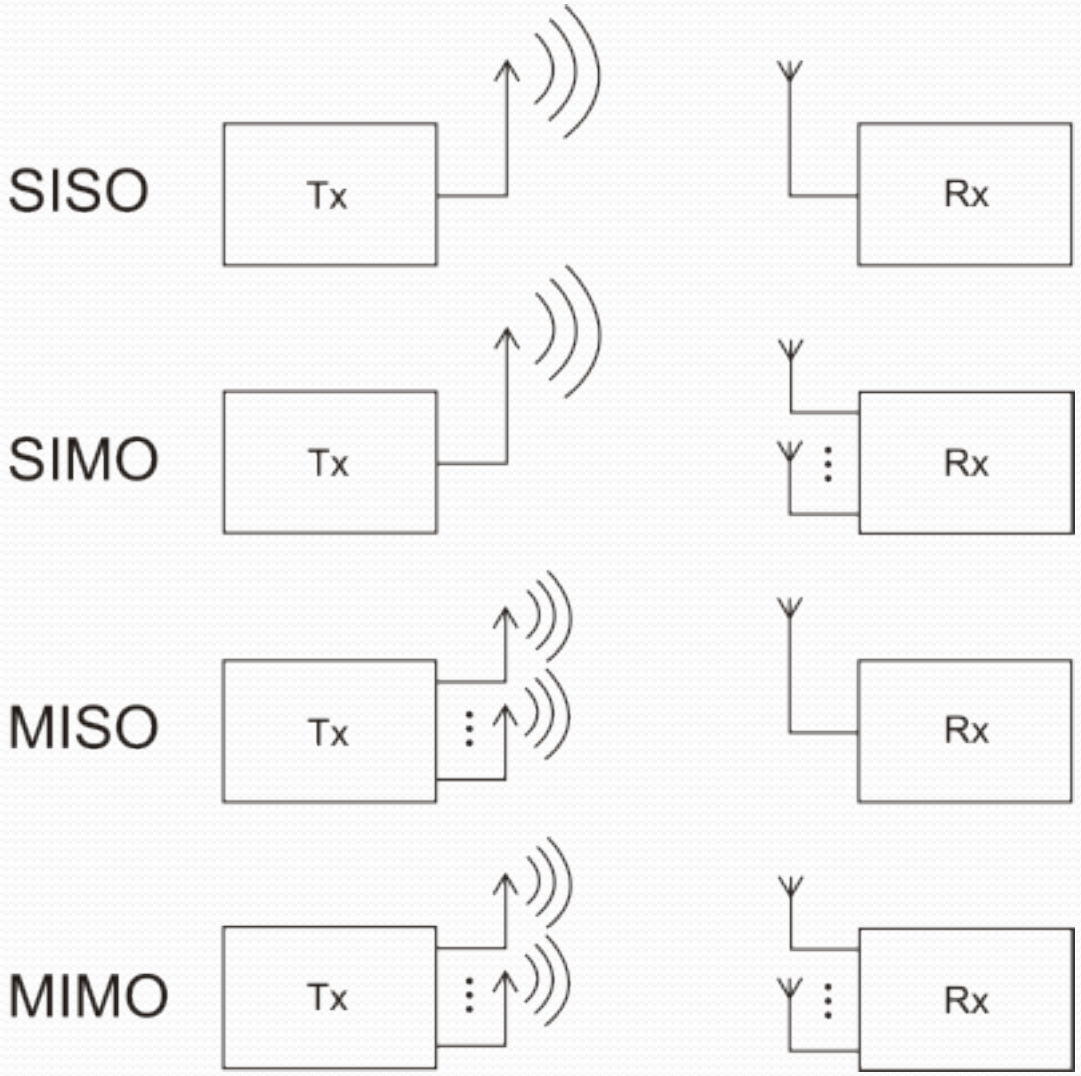
- 3D Movies is the KEY !!???



MIMO(Multiple In Multiple Out)



Throughput

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

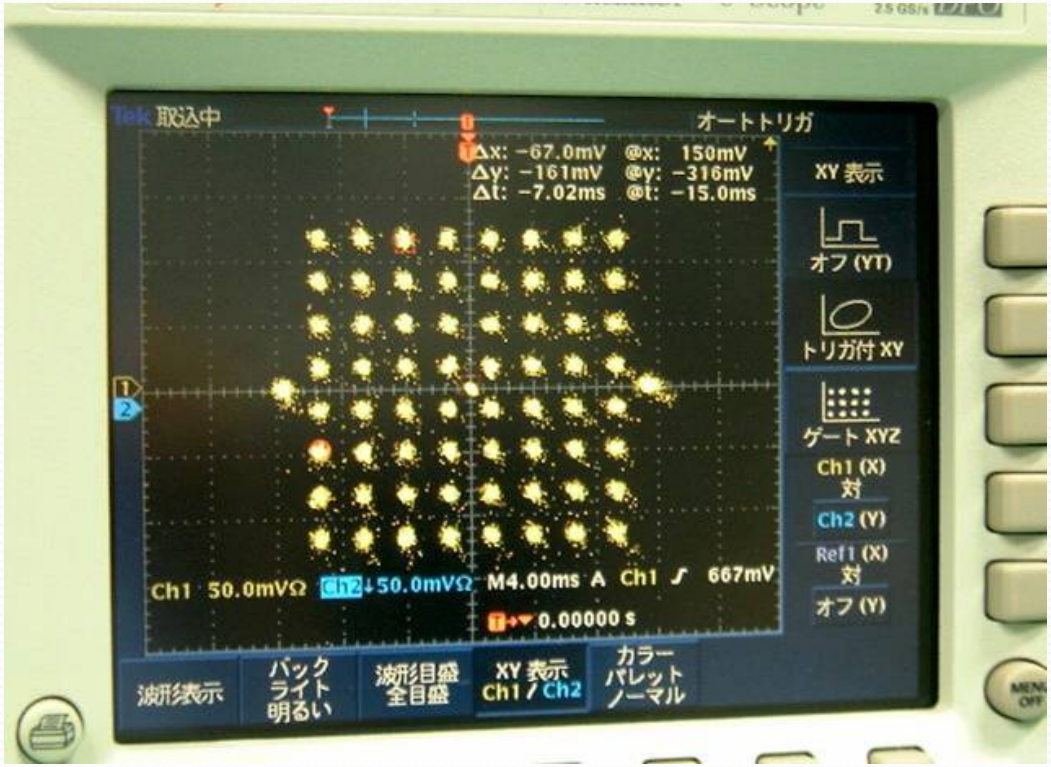
- 802.11ac Data rates :

SELECTED 802.11AC RATES IN MBPS (SHORT GUARD INTERVAL, 1, 2, 3, 4, 8 SS)

MCS	Modulation & Rate	20 MHz 1x SS	20 MHz 2x SS	20 MHz 4x SS	20 MHz 8x SS	40 MHz 1x SS	40 MHz 2x SS	40 MHz 4x SS	40 MHz 8x SS	80 MHz 1x SS	80 MHz 2x SS	80 MHz 4x SS	80 MHz 8x SS	160 MHz 1x SS	160 MHz 2x SS	160 MHz 4x SS	160 MHz 8x SS
0	BPSK 1/2	7.2	14.4	28.9	57.8	15.0	30.0	60.0	120.0	32.5	65.0	130.0	260.0	65.0	130.0	260.0	520.0
1	QPSK 1/2	14.4	28.9	57.8	115.6	30.0	60.0	120.0	240.0	65.0	130.0	260.0	520.0	130.0	260.0	520.0	1040.0
2	QPSK 3/4	21.7	43.3	86.7	173.3	45.0	90.0	180.0	360.0	97.5	195.0	390.0	780.0	195.0	390.0	780.0	1560.0
3	16-QAM 1/2	28.9	57.8	115.6	231.1	60.0	120.0	240.0	480.0	130.0	260.0	520.0	1040.0	260.0	520.0	1040.0	2080.0
4	16-QAM 3/4	43.3	86.7	173.3	346.7	90.0	180.0	360.0	720.0	195.0	390.0	780.0	1560.0	390.0	780.0	1560.0	3120.0
5	64-QAM 2/3	57.8	115.6	231.1	462.2	120.0	240.0	480.0	960.0	260.0	520.0	1040.0	2080.0	520.0	1040.0	2080.0	4160.0
6	64-QAM 3/4	65.0	130.0	260.0	520.0	135.0	270.0	540.0	1080.0	292.5	585.0	1170.0	2340.0	585.0	1170.0	2340.0	4680.0
7	64-QAM 5/6	72.2	144.4	288.9	577.8	150.0	300.0	600.0	1200.0	325.0	650.0	1300.0	2600.0	650.0	1300.0	2600.0	5200.0
8	256 QAM 3/4	86.7	173.3	346.7	693.3	180.0	360.0	720.0	1440.0	390.0	780.0	1560.0	3120.0	780.0	1560.0	3120.0	6240.0
9	256-QAM 5/6	-	-	-	-	200.0	400.0	800.0	1600.0	433.3	866.7	1733.3	3466.7	866.7	1733.3	3466.7	6933.3

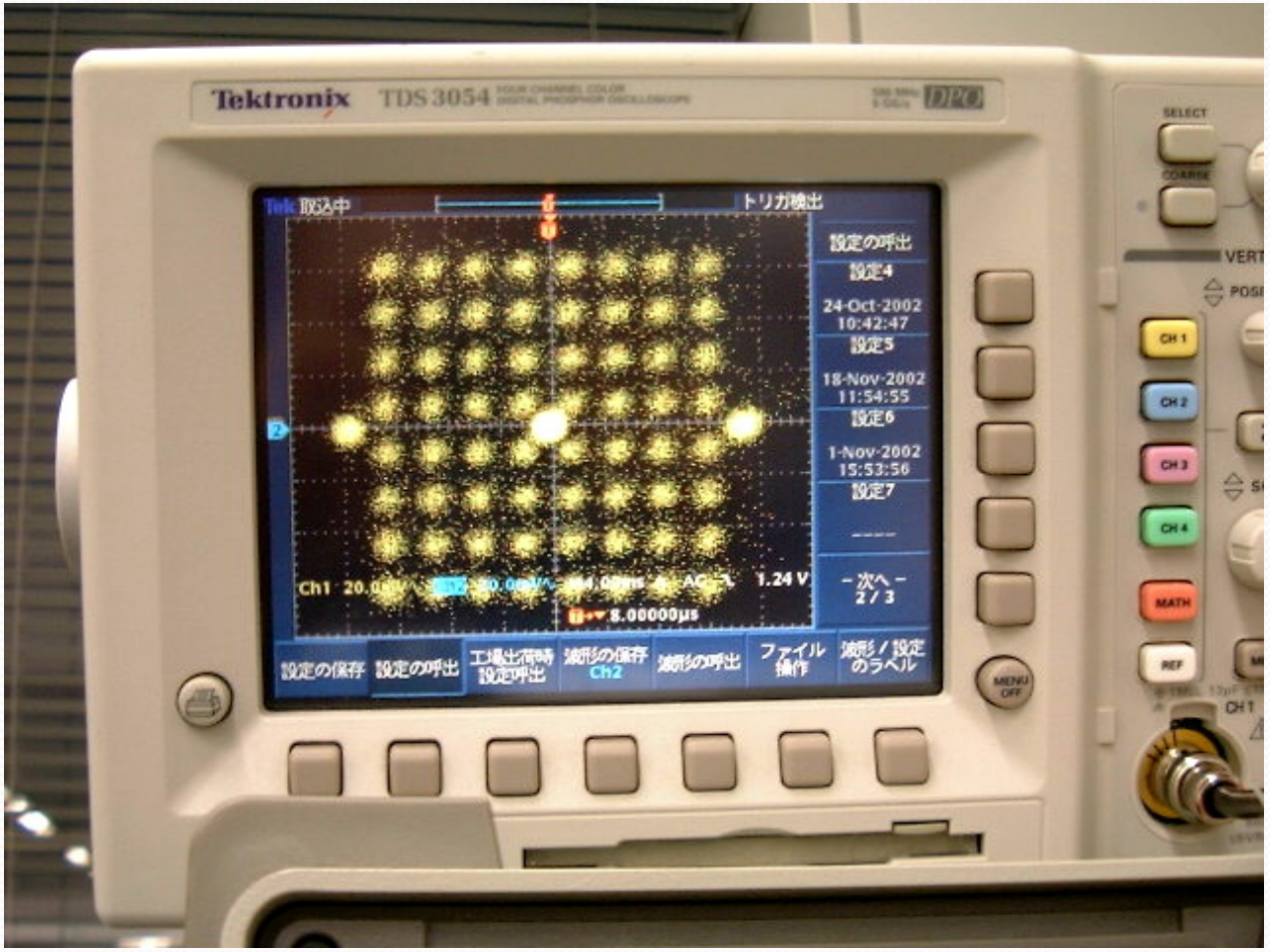
- Why No !!??

64 QAM In this Picture the RX signal is -35

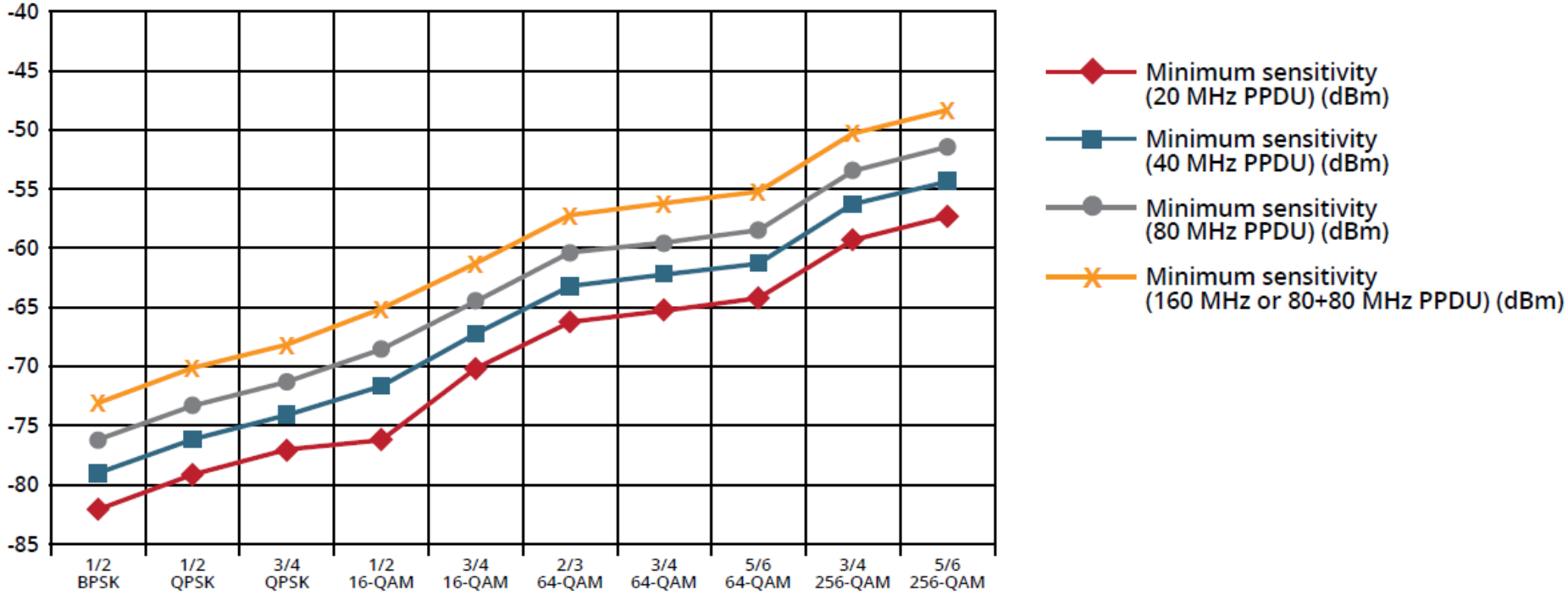


- Why No !!??

64 QAM In this Picture the RX signal is -65



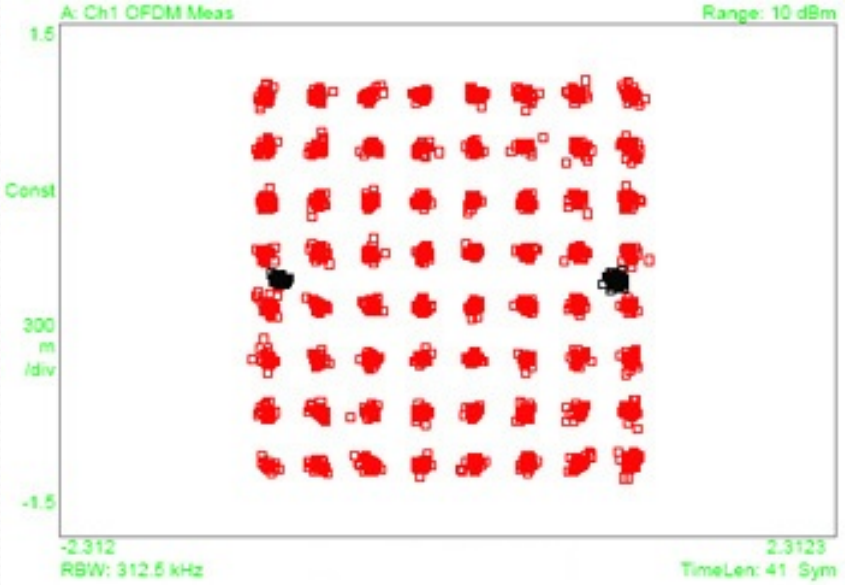
- when we have Noise or low RX level the BER(Bit Error Rate) will be maximized and the lost data will be more than Slower data rates in this case our throughput will be minimized and very unstable.



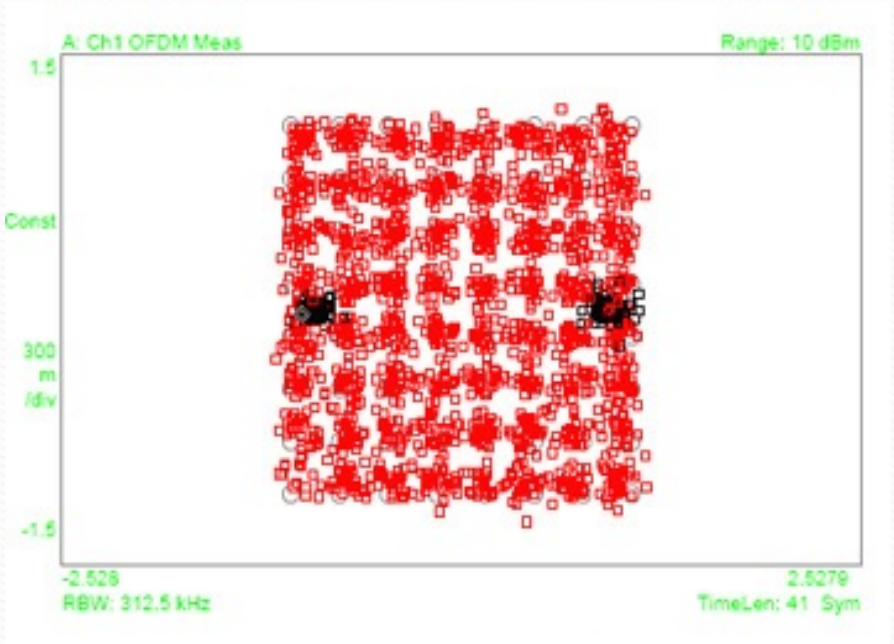
Required receive sensitivity for different modulation and coding rates channel, and to -49 dBm for the top rate (866 Mbps) in a 160-MHz channel

- 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



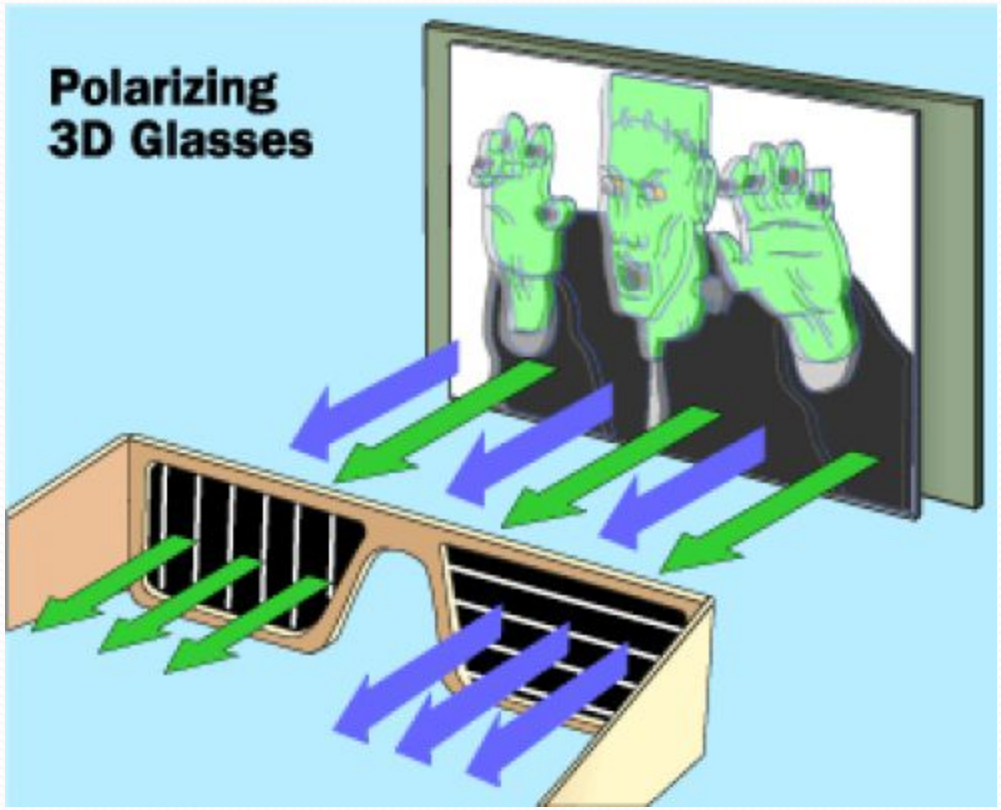
24 dBm

CHAPTER 2:

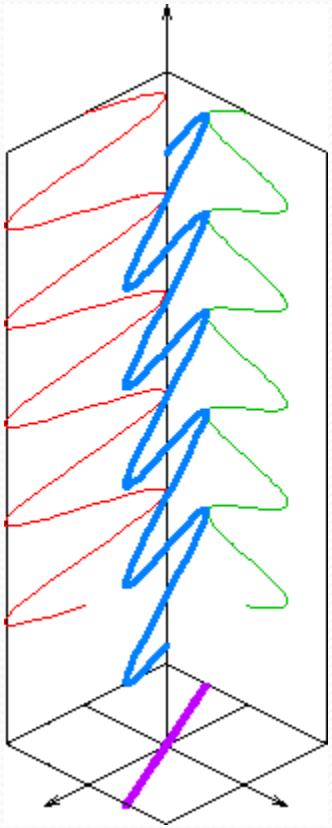
Antenna Parameters witch involved in throughput for outdoor MIMO

Antenna cross polarization :

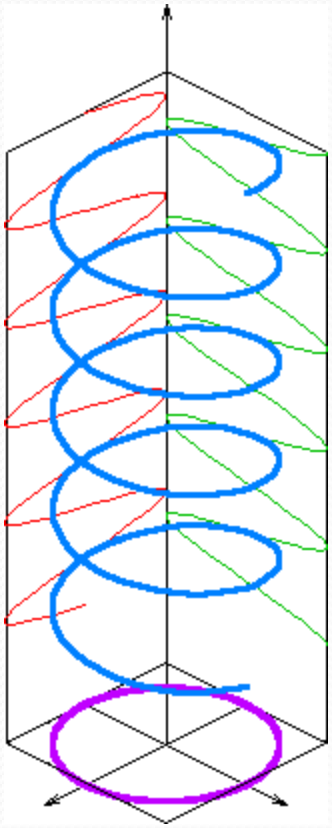
- To understanding the importance of the Antenna Cross polarization lets go back to the 3D Cinema



- What is the antenna polarization ?

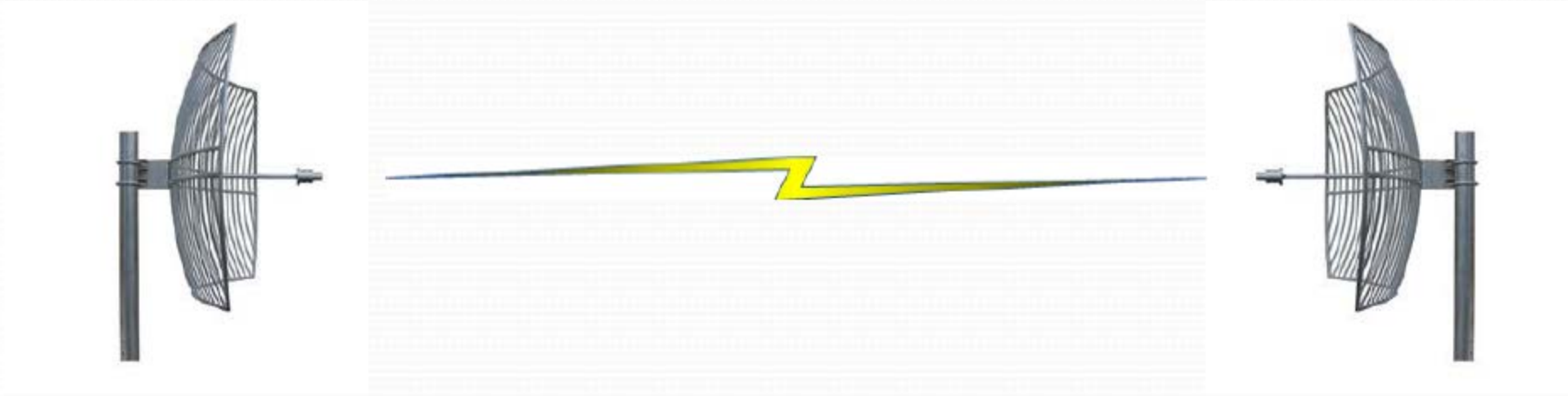


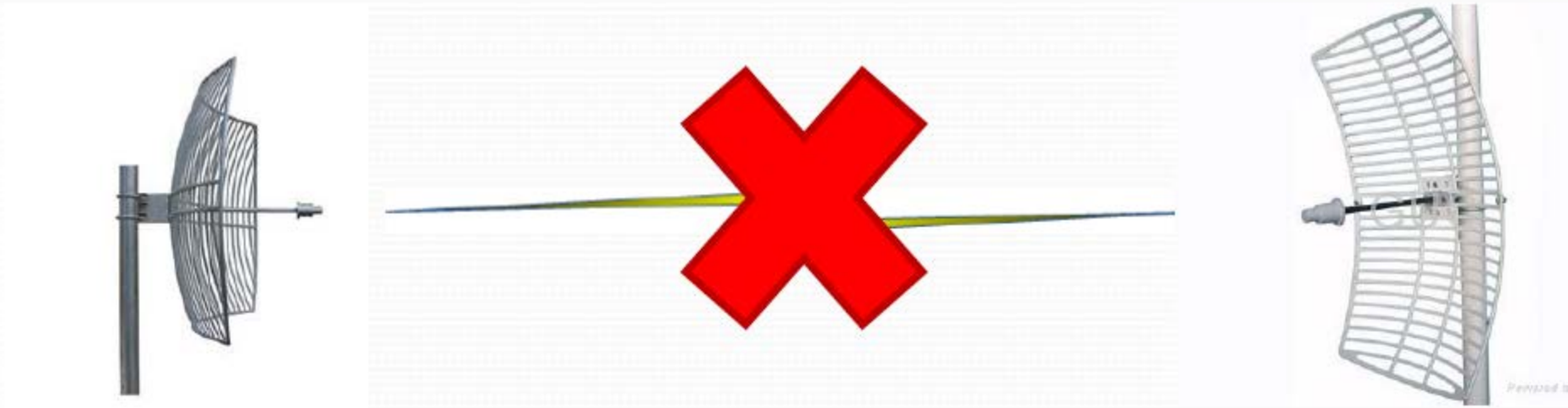
Linear



Circular

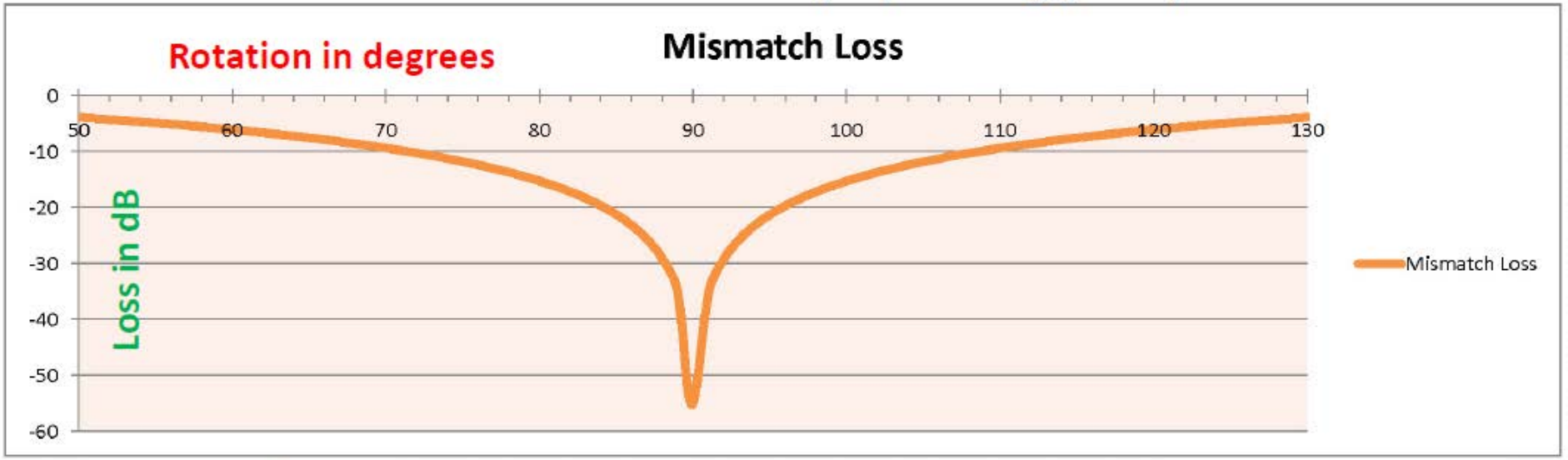
- Mismatch Loss(for Linear Polarization)

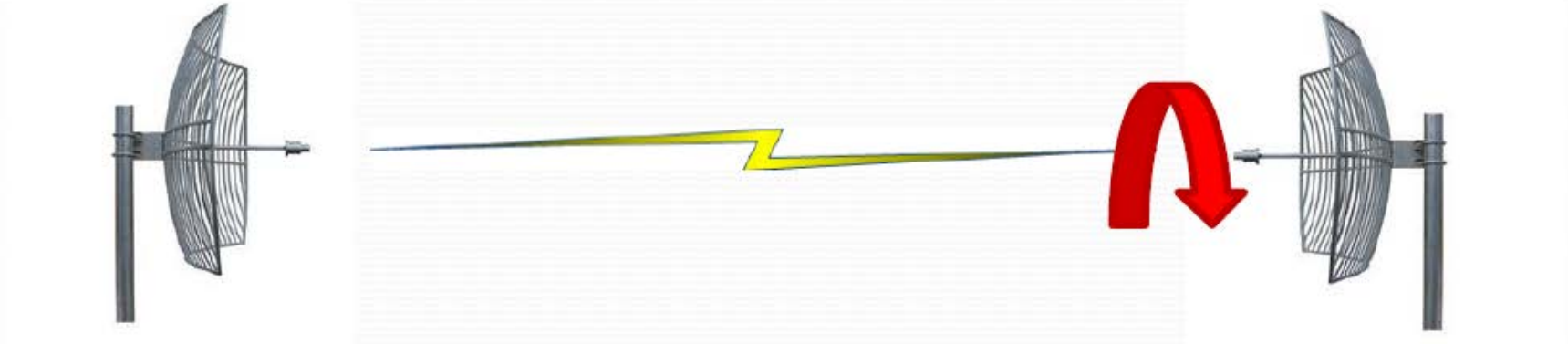




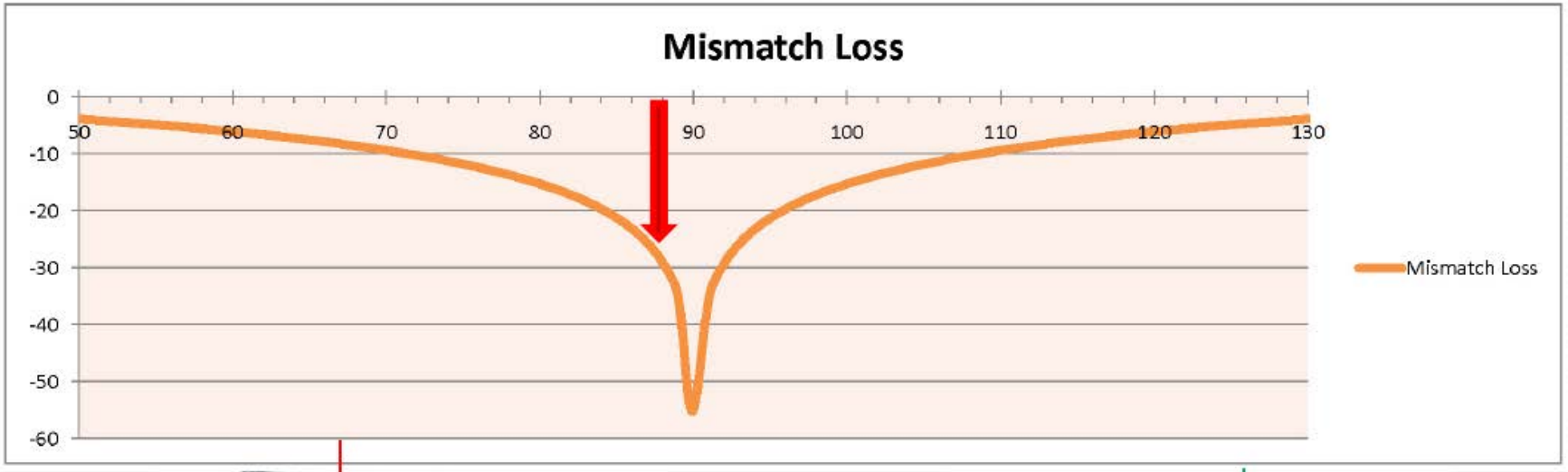
- Mismatch Loss(for Linear Polarization)

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





- To maximize the Cross polarization **Always Level Your Antennas**



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

ERIP
Antenna Gain + Output Power

Go back to chain1

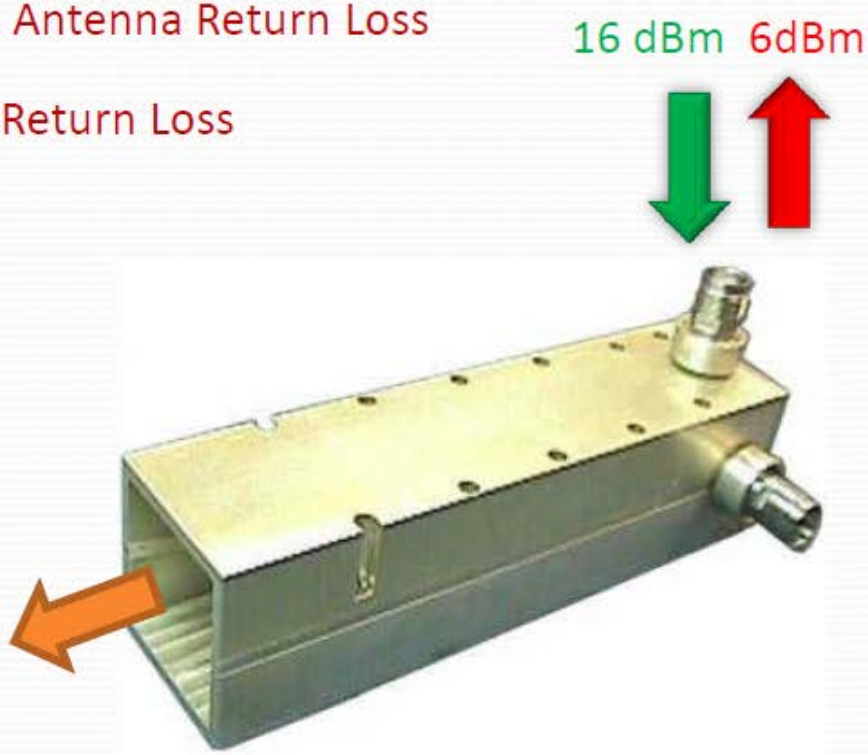
16 dBm – (Antenna Port to Port Isolation)

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

Transmitted Signal – Returned Signal = Antenna Return Loss

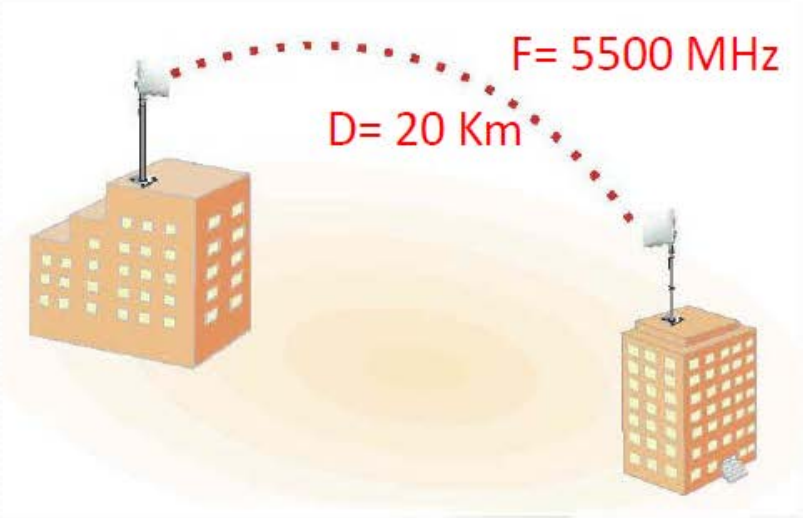
16 dBm – 6 dBm = Antenna Return Loss



Antenna Gain:

- Always the question is what antenna Gain I need for my link. You can calculate the antenna gain this how :

First you have to Calculate the path loss :



Path Loss(LOS) = 20 log (distance in mile) + 20 log (frequency in MHz) + 36.6

Path Loss(20 Km) = 20log(20km/1.61 = Mile) + 20 log (5500) + 36.6

Path Loss(20 Km) = 21.9 + 74.8 + 36.6 ➔ 133.3 dB

- Second based on your desire RX level Calculate the Antenna Gain that you have to use:

Path loss =133.3 dB

RX Signal = TX power – Cable loss + TX Antenna gain – Path loss + RX Antenna gain – Cable Loss

Check Your MiniPCI wireless adapter RX level @ MCS7 or MCS 15

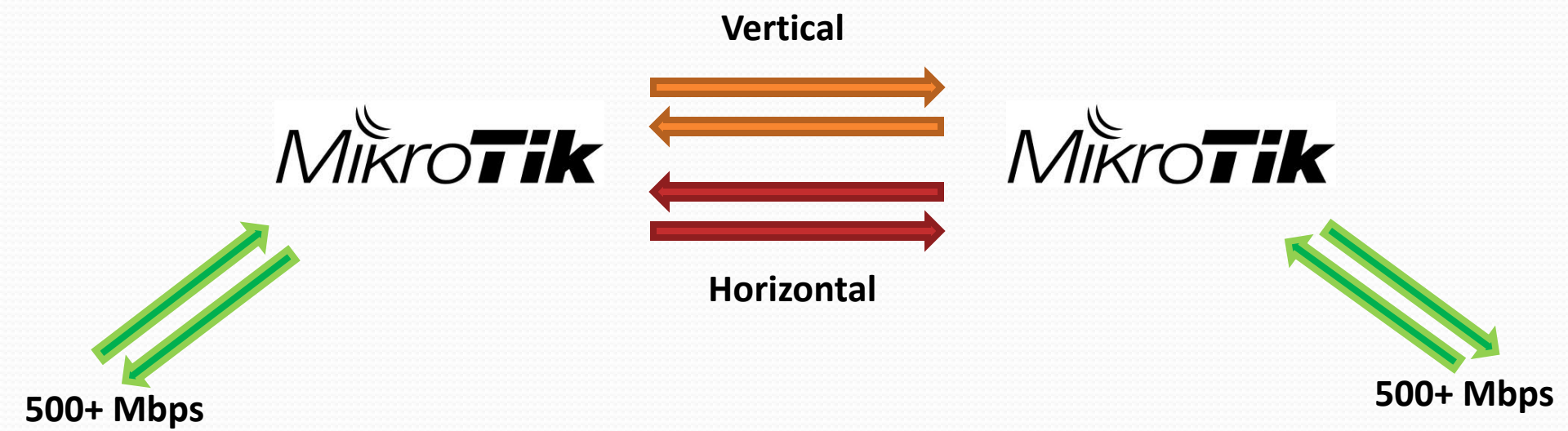
Check Your MiniPCI wireless adapter maximum TX power @ MCS7 or MCS 15

-65 = +19 – (Jumper + Pigtail loss) 2 + Antenna gain – 133.3 + Antenna gain – 2

-2(Antenna gain) = 65 +19 – 2 – 133.3 – 2

Antenna gain = 53.3 / 2 ➔ 26.6 dBi (Minimum Antenna that you need to reach -65 RX)

Know you have enough knowledge about this technology to mix it with your experience, buy 2 Mikrotik Routerboards and Choose right antennas and enjoy 500+ Mbps Real TCP throughput.



For more information please contact me at:
ahmad@deltalin.com.tr