Transmit Power Control Based EDT for NB

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Background

- **ETSI 303687 v1.1.1 text**

The EDT is proportional to the equipment's maximum configured transmit power (P_{max}):

For $P_{max} \leq 14$ dBm:	EDT = -75 dBm/MHz
For 14 dBm < $P_{max} \leq 24$ dBm:	EDT = -85 dBm/MHz + (24 dBm - P_{max})
For $P_{max} \geq 24$ dBm:	EDT = -85 dBm/MHz

The EDT levels defined above are absolute levels that apply at all times.

The channel associated with an NB transmission is defined in clause 4.3.1.3.

- **The current ETSI rules have a fixed ED threshold of -75 dBm/MHz for all powers less than or equal to 14 dBm.**
- **In this work, we take a closer look at the -75 dBm/MHz value associated with 14 dBm, and propose a transmit power control (TPC) based ED threshold.**

Simulation Assumptions

- **802.11 with BW=80/160/320 MHz with 14 dBm TX Power**
- **802.15.4ab NB with 2.5 MHz BW with varying TX power**
- **AWGN Channel model with dbp = 5m (breakpoint) and fc =5.8 (UNII-3) or 6.4 (UNII-5) GHz**
- **“NB user” is trying to find lost “NB” device**
- **802.11 AP and STA 10m (typical) and 12m apart (typical “NLOS” case)**
  - RSSI level is ~-59dBm,-~62 dBm respectively when fc=6.4 GHz
- **Lost “NB” device, 802.11 AP/STA are stationary, and “NB user” is allowed to roam**
- **NB: 4 cases when 802.11 is transmitting**

RX Energy @ NB > EDT: No TX with 802.11 SINR < 4dB (success)

RX Energy @ NB > EDT: No TX with 802.11 SINR >= 4dB (lost opportunity)

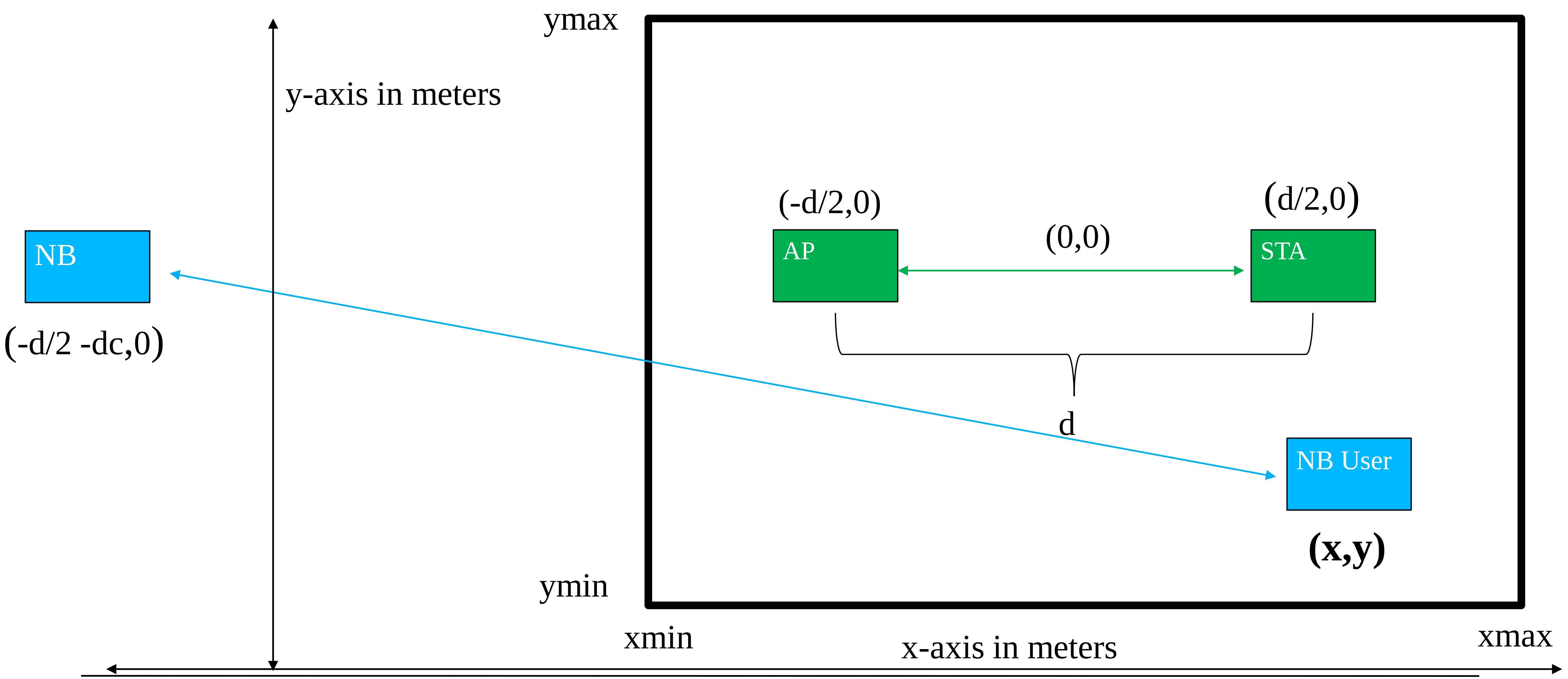
RX Energy @ NB <= EDT: TX with 802.11 SINR < 4 dB (802.11 irrecoverable interference)

RX Energy @ NB <= EDT: TX with 802.11 SINR >= 4dB (success)

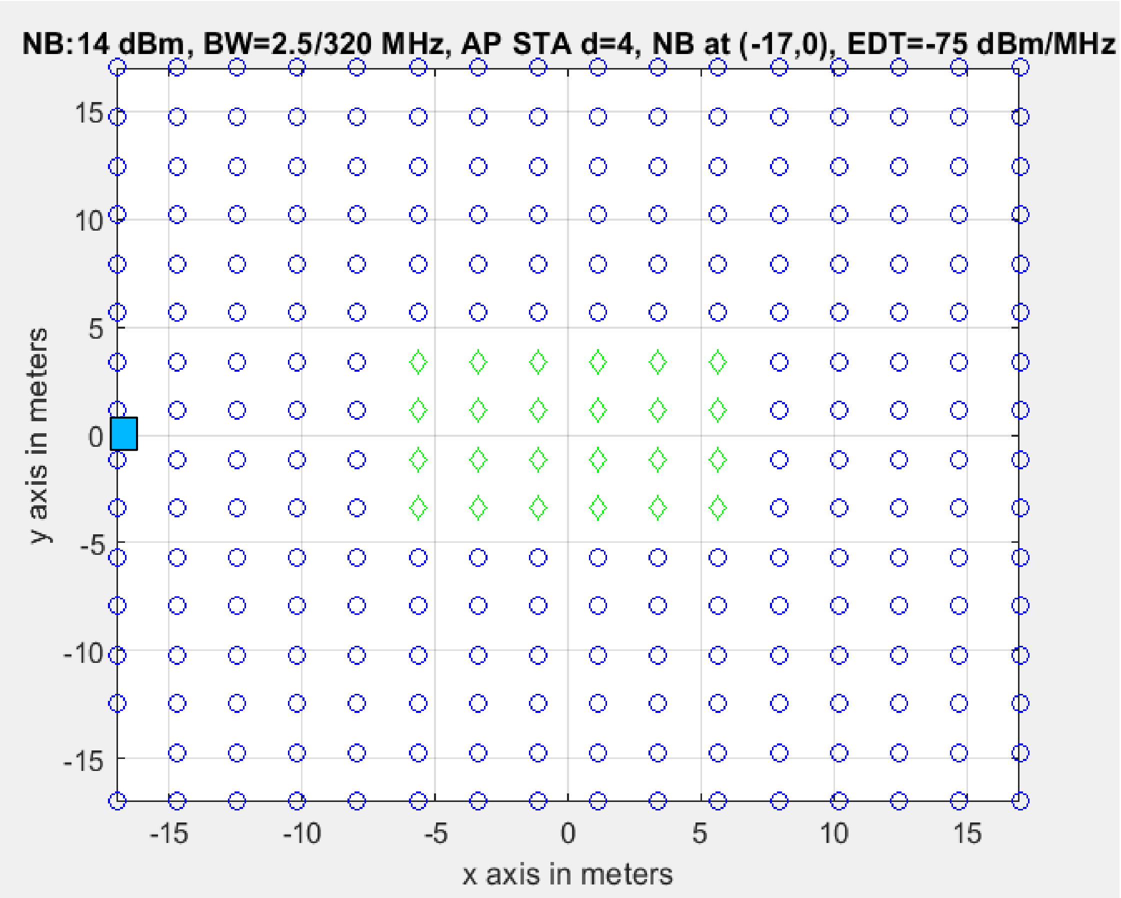
Simulation Assumptions

- **802.11 : 4 cases when NB is transmitting**
  - RX Energy @ 802.11 > -62 dBm: No TX with NB SINR < 10dB (success)
  - RX Energy @ 802.11 > -62 dBm: No TX with NB SINR >= 10dB (lost opportunity)
  - RX Energy @ 802.11 <= -62 dBm: TX with NB SINR < 10 dB (NB irrecoverable interference)
  - RX Energy @ 802.11 <= -62 dBm: TX with NB SINR >= 10dB (success)

Scenario 1 with lost "NB" to left of 802.11



Non typical example of d=4 case with 802.11 RSSI ~ -47 dBm

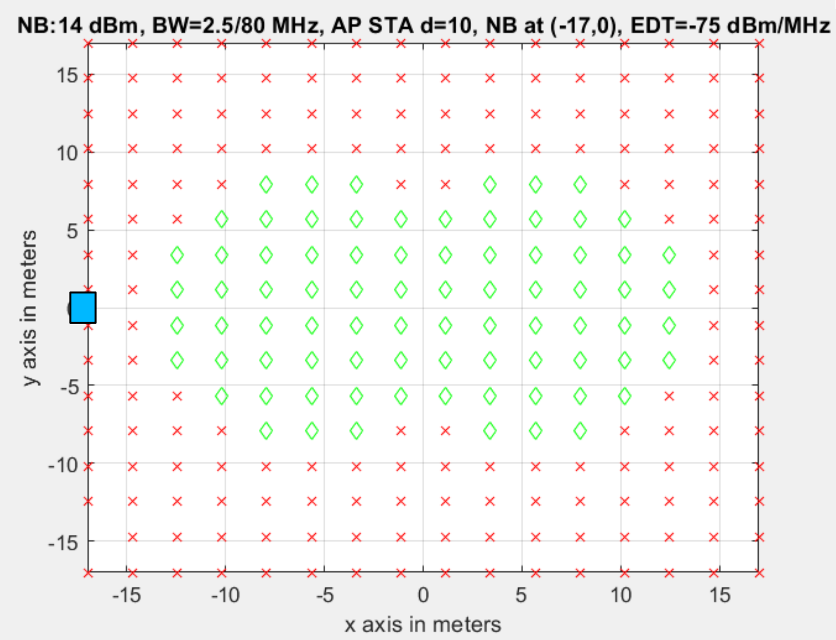


In this case, NB is a good neighbor to 802.11 and -75 dBm/MHz is optimal EDT

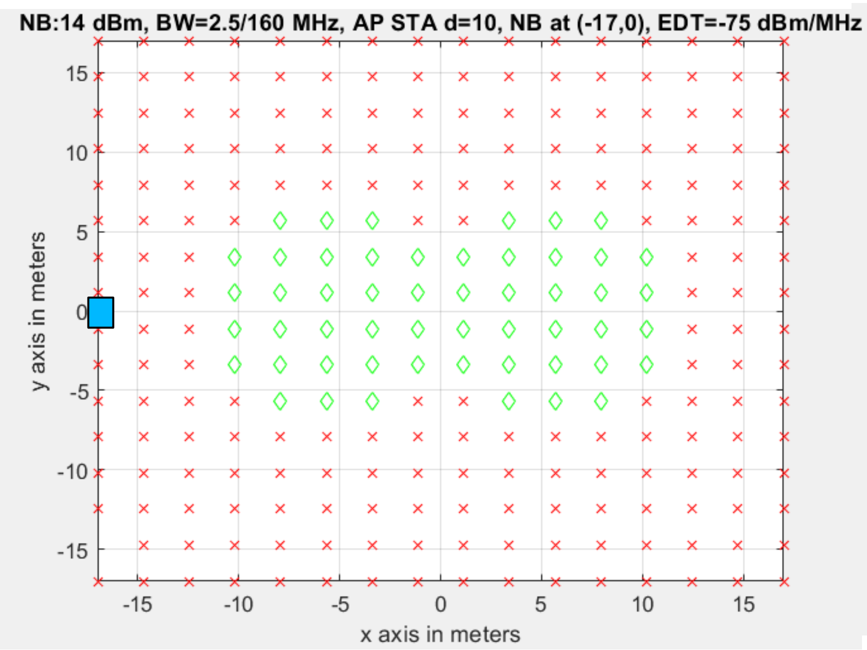
14 dBm, EDT=-75 dBm/MHz for 80, 160, 320 MHz with d= 10

Legend:
Deferral : No interference to 802.11 neighbor
Lost tx opportunity when 802.11 transmits
Irrecoverable interference to 802.11 neighbor
Tx because no interference caused

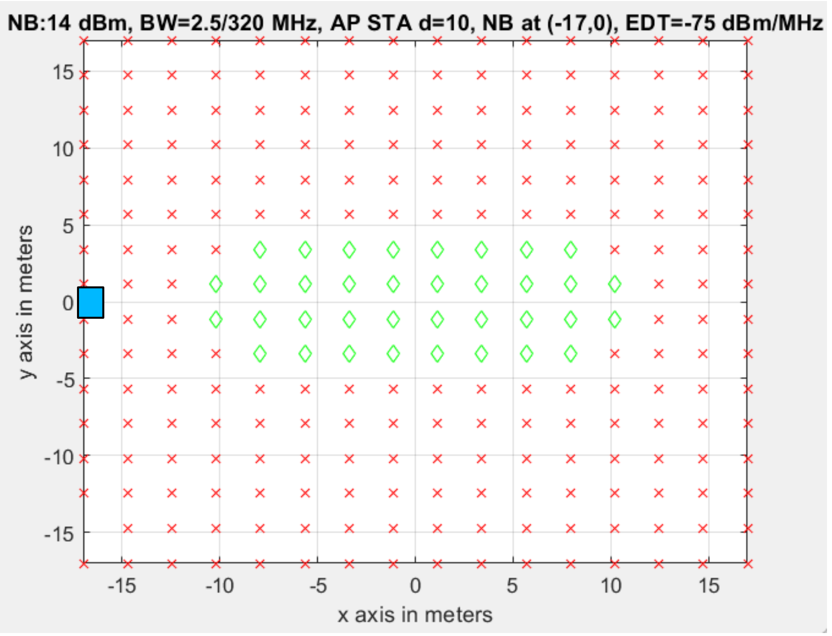
BW80



BW160



BW320

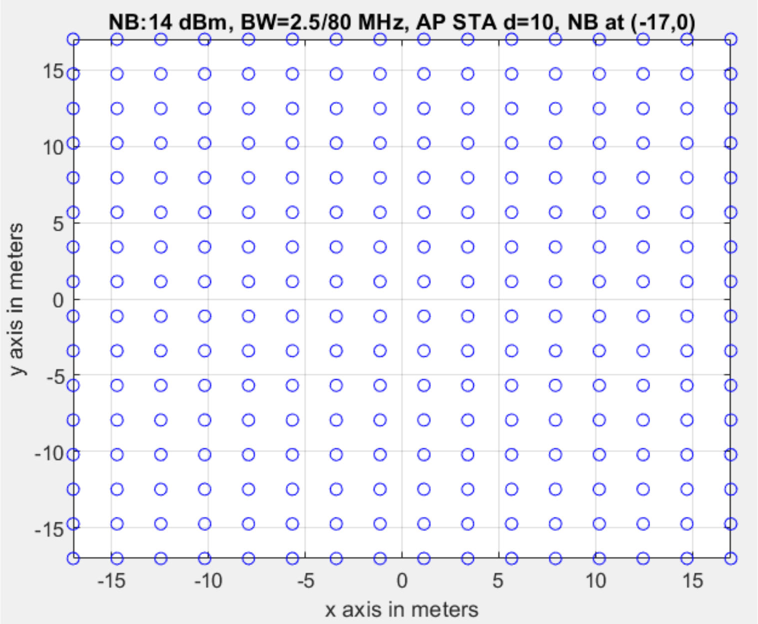


Irrecoverable interference to 802.11 get worse as 802.11 BW increases

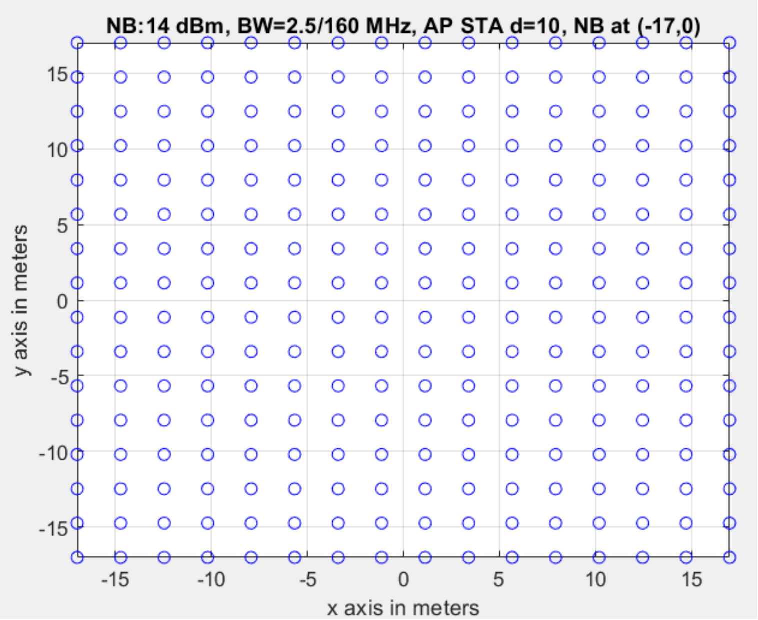
14dBm, lost “NB” at (-17,0) for 80, 160, 320 MHz with d= 10

Legend:
Deferral : No interference to NB neighbor
Lost tx opportunity when NB transmits
Irrecoverable interference to NB neighbor
Tx because no interference caused

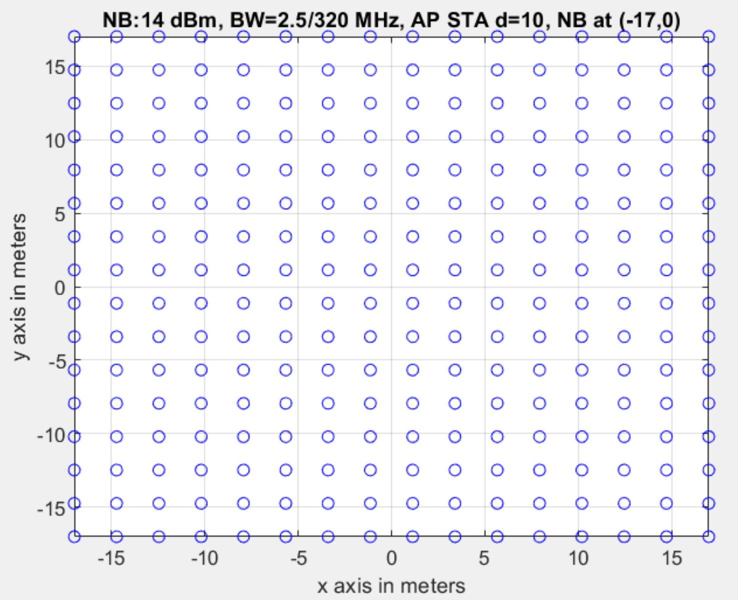
BW80



BW160



BW320

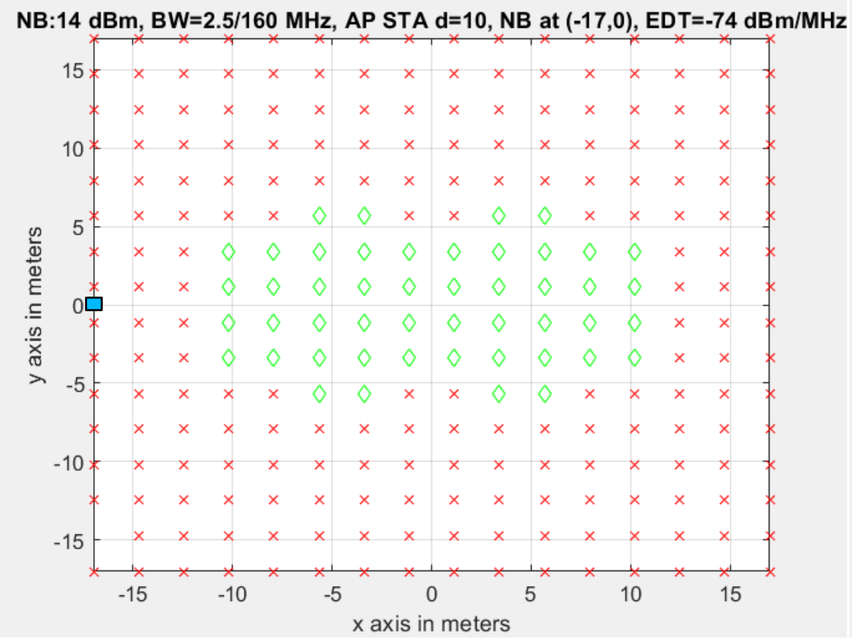


802.11 does not cause irrecoverable interference to NB

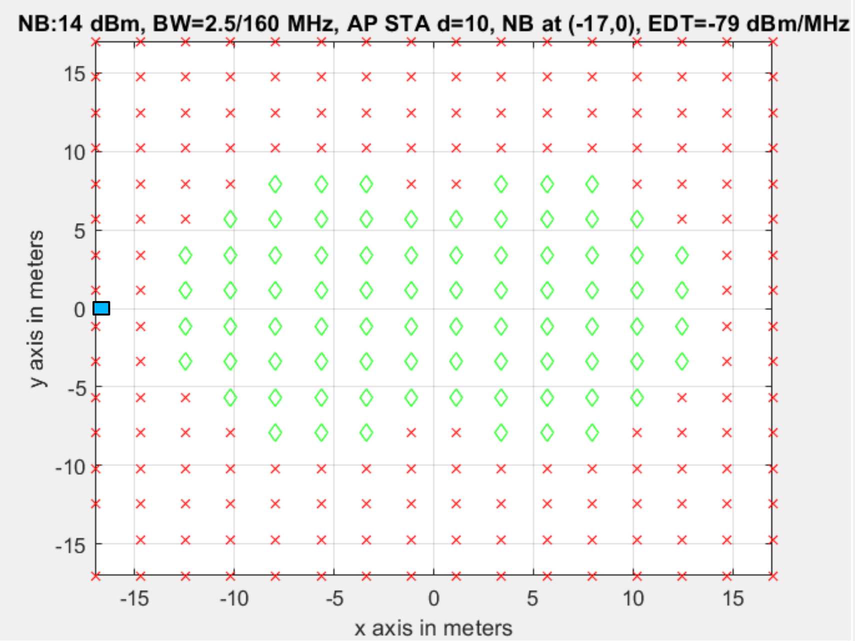
14 dBm, 160 MHz with d= 10

Legend:
Deferral : No interference to 802.11 neighbor
Lost tx opportunity when 802.11 transmits
Irrecoverable interference to 802.11 neighbor
Tx because no interference caused

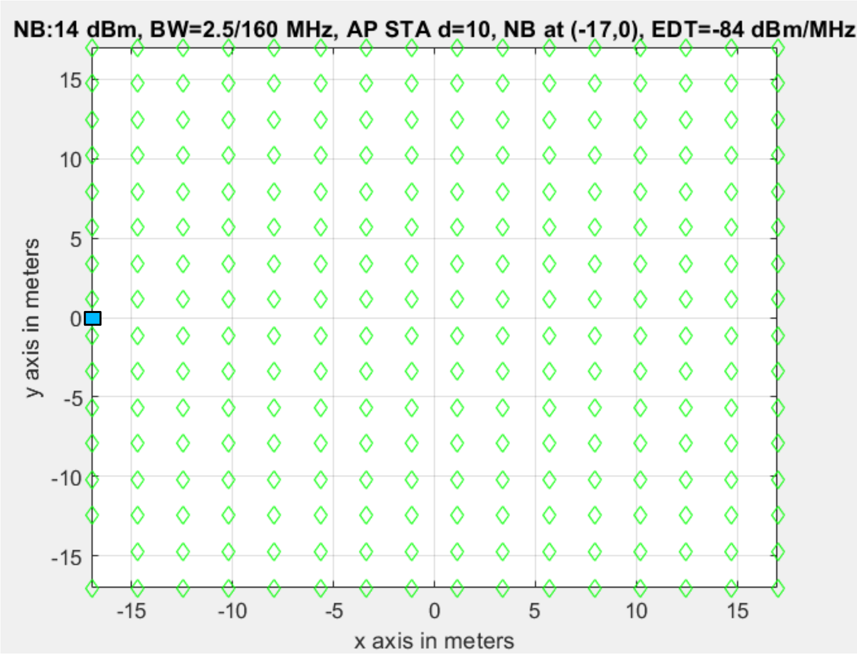
-74 dBm/MHz



-79 dBm/MHz



-84 dBm/MHz

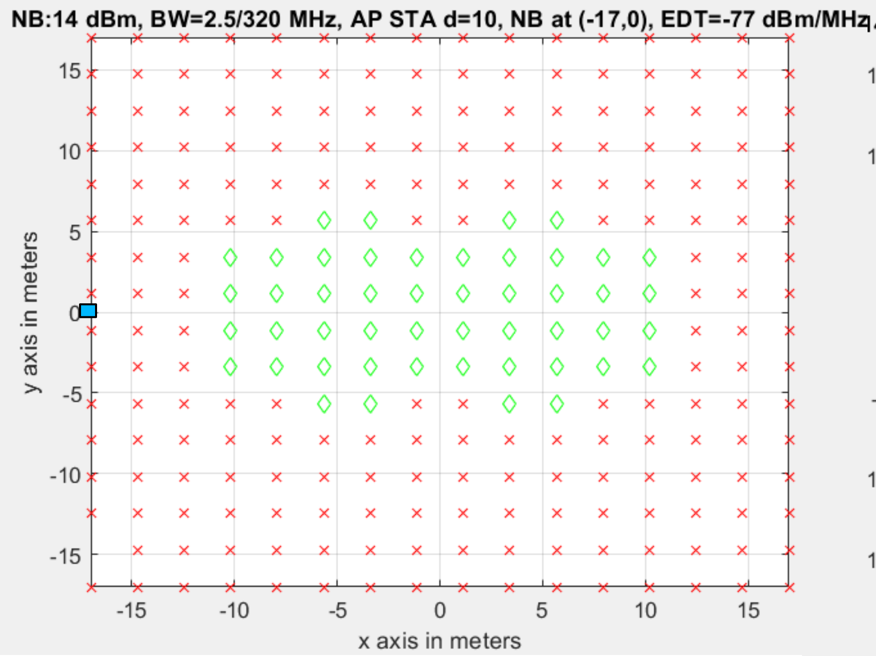


-84 dBm/MHz is optimal EDT

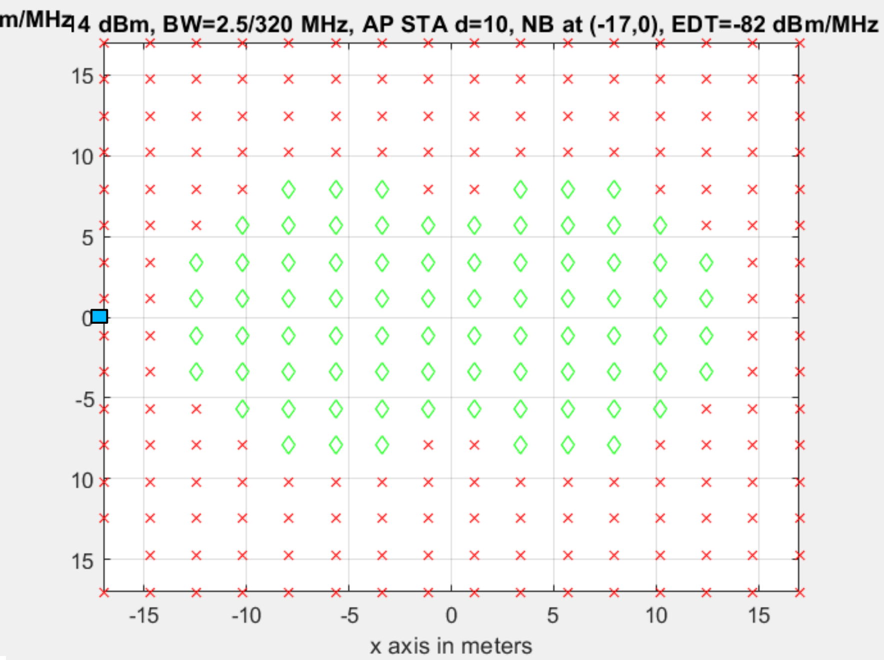
14 dBm, 320 MHz with d= 10

Legend:
Deferral : No interference to 802.11 neighbor
Lost tx opportunity when 802.11 transmits
Irrecoverable interference to 802.11 neighbor
Tx because no interference caused

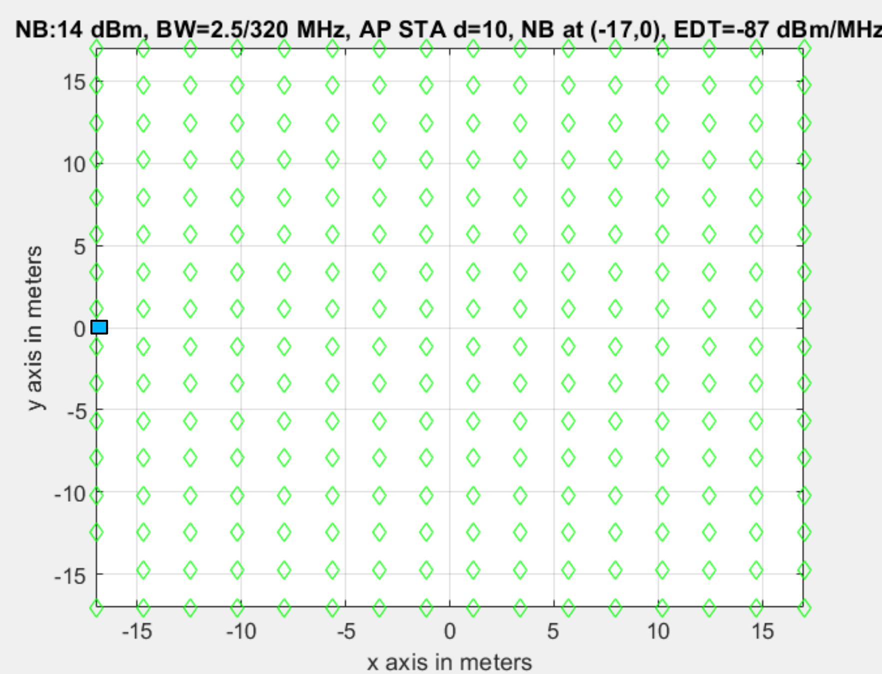
-77 dBm/MHz



-82 dBm/MHz

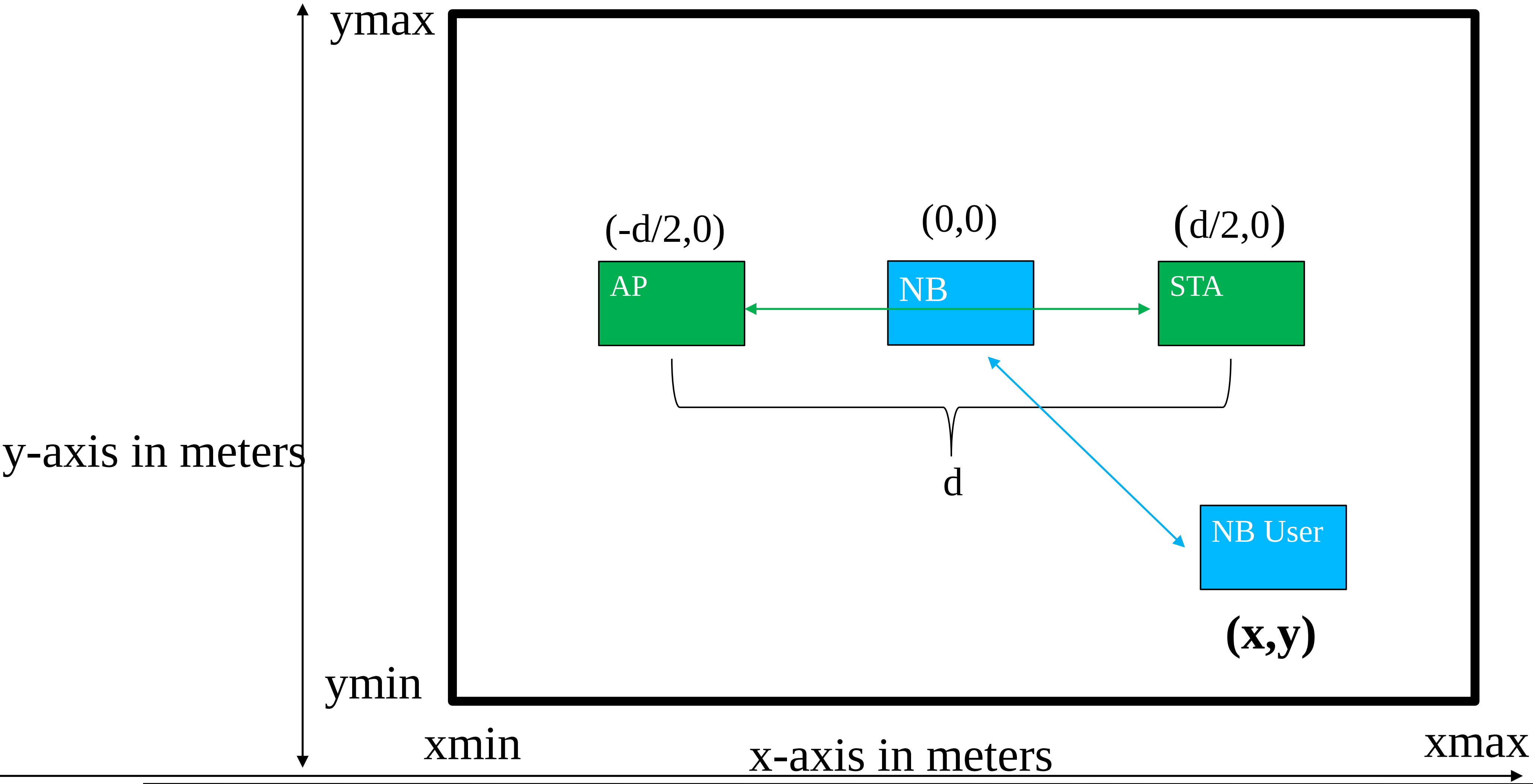


-87 dBm/MHz

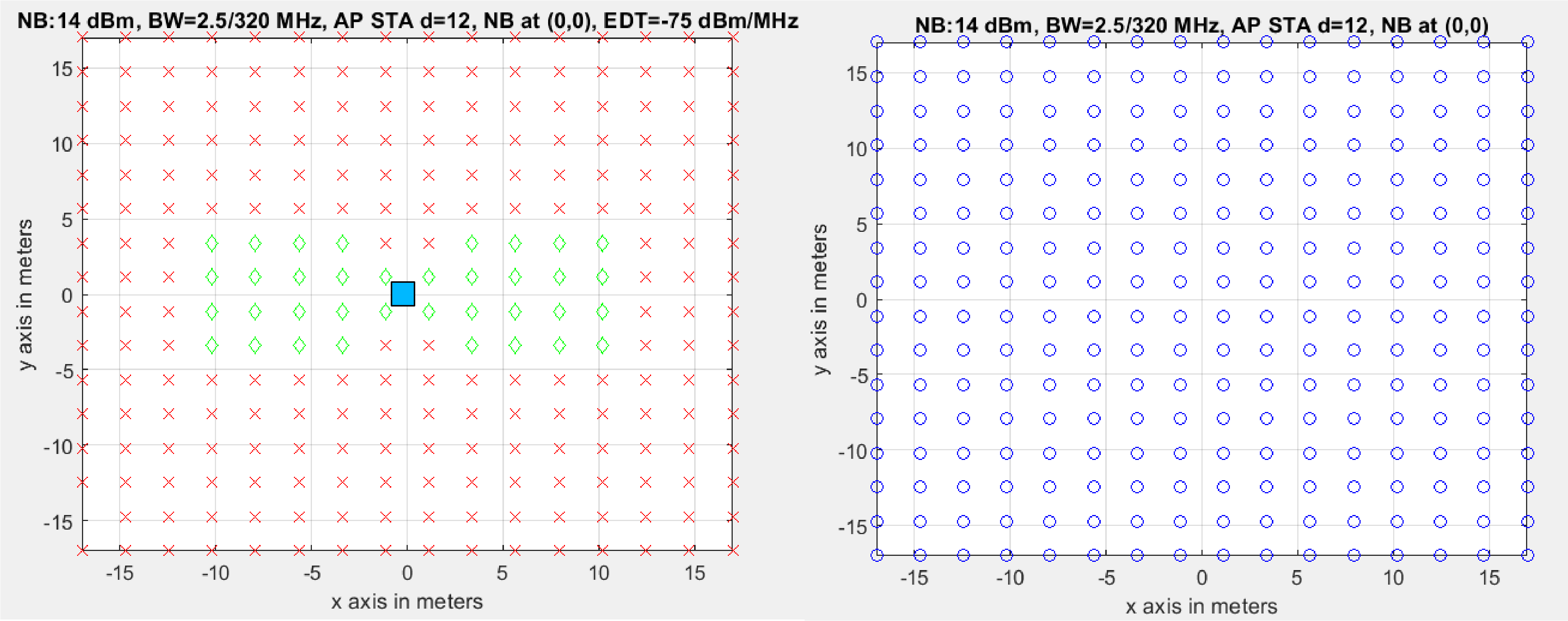


-87 dBm/MHz is optimal

Scenario 2 with lost “NB” in middle of 802.11



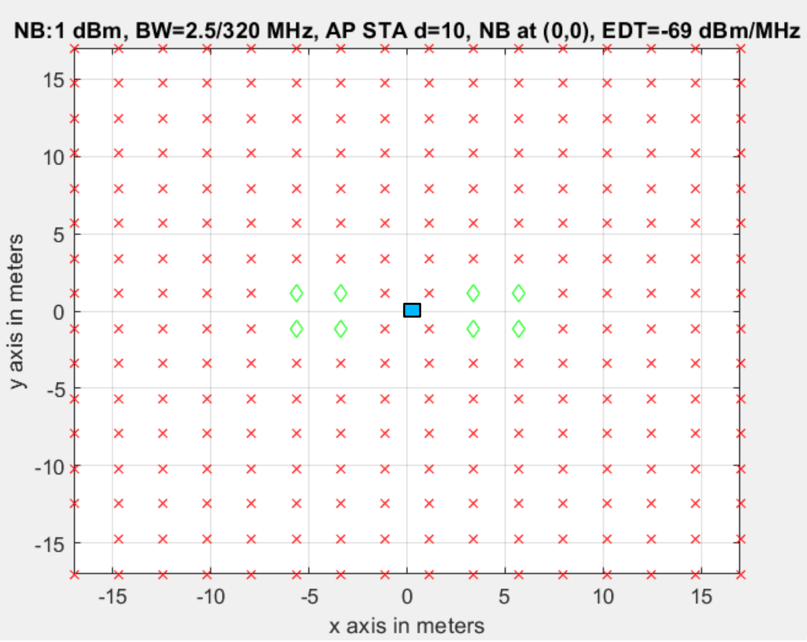
14 dBm, 320 MHz with d= 12



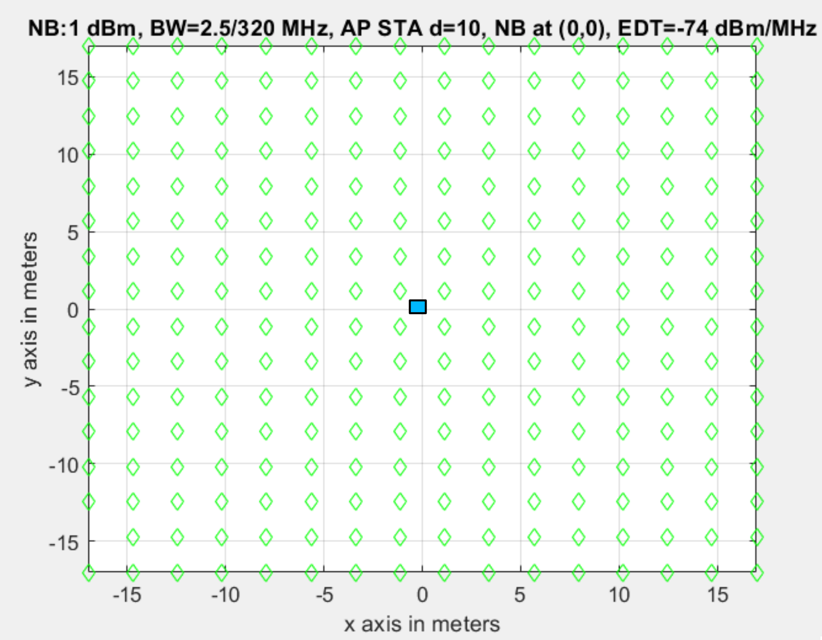
Here we see -75 dBm/MHz is too high, while again 802.11 is a good neighbor to NB

1 dBm, 320 MHz, d=10

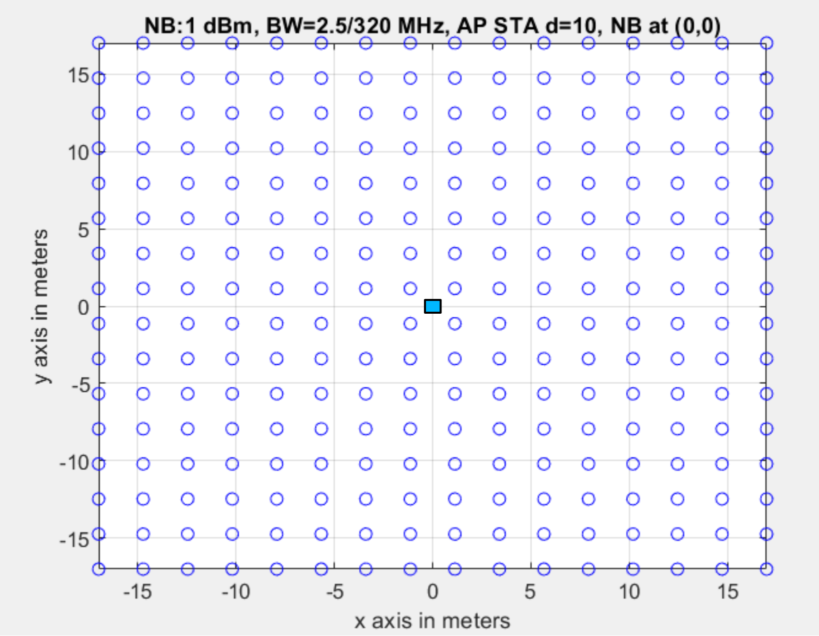
-69 dBm/MHz



-74 dBm/MHz



NB Metrics

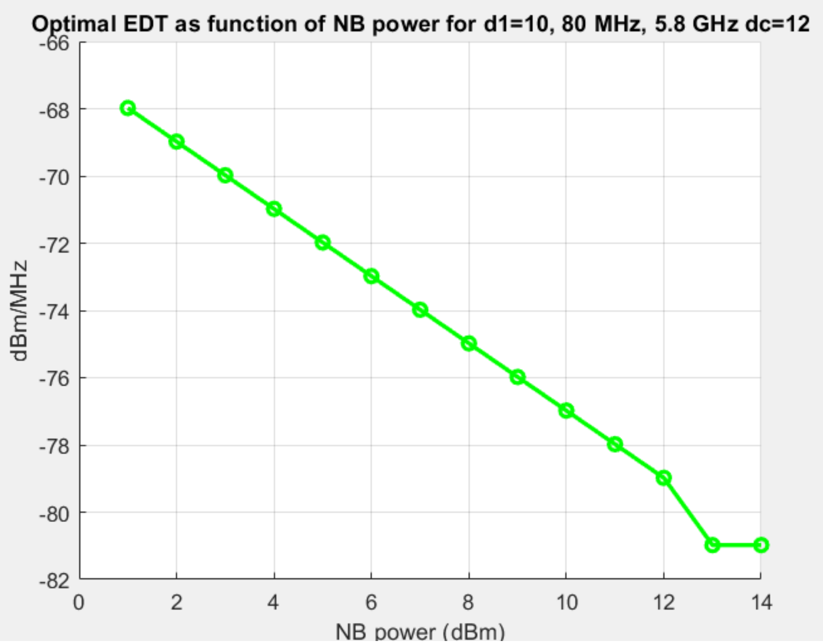


-74 dBm/MHz is optimal

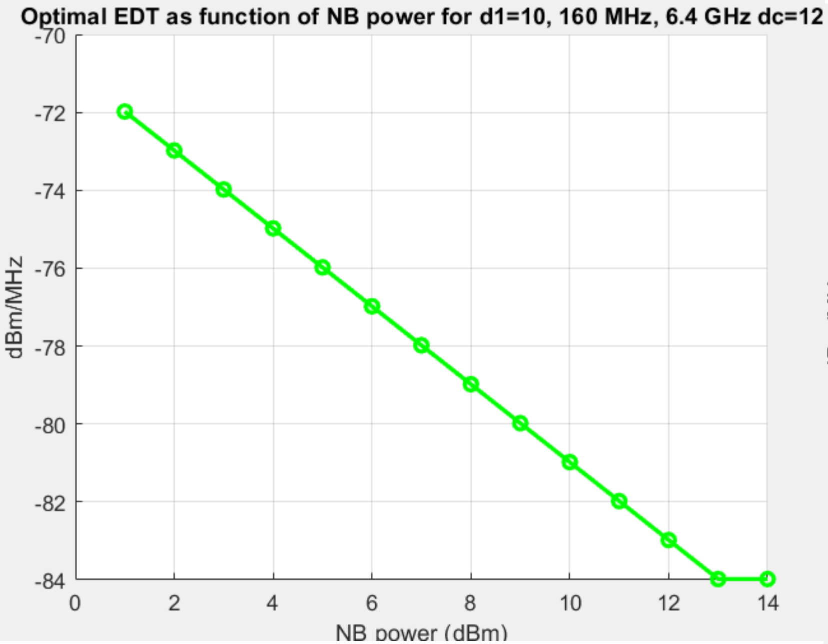
Simulation Results for d=10

Sweeping through various “lost” NB locations, EDT and NB powers, the optimal results for d=10 are shown below

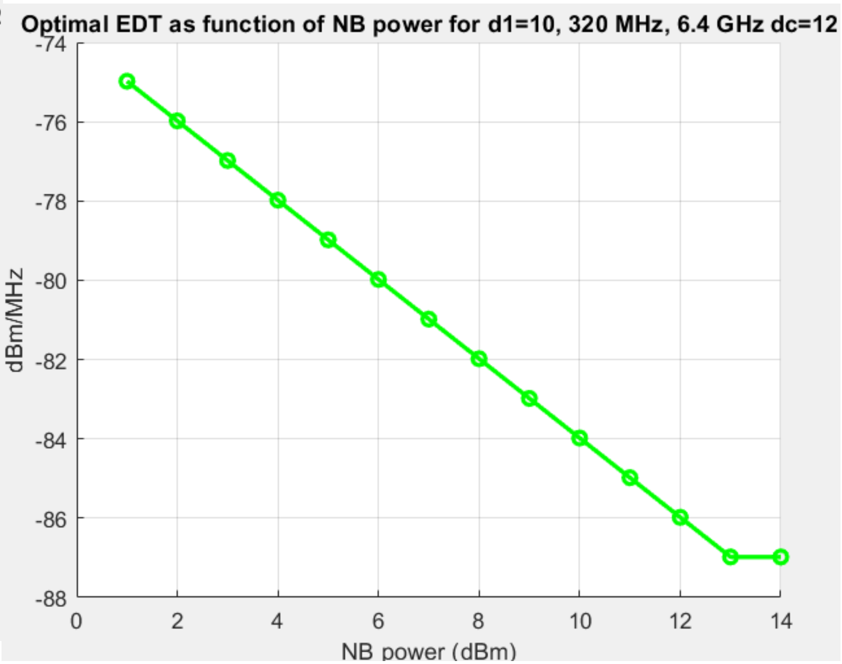
BW80 in UNII-3



BW160 in UNII-5



BW320 in UNII-5



EDT Proposal

- **For UNII-5, EDT = -74 dBm/MHz – Ptx where Ptx is the instantaneous power in dBm**
- **For UNII-3, EDT = -67 dBm/MHz - Ptx**

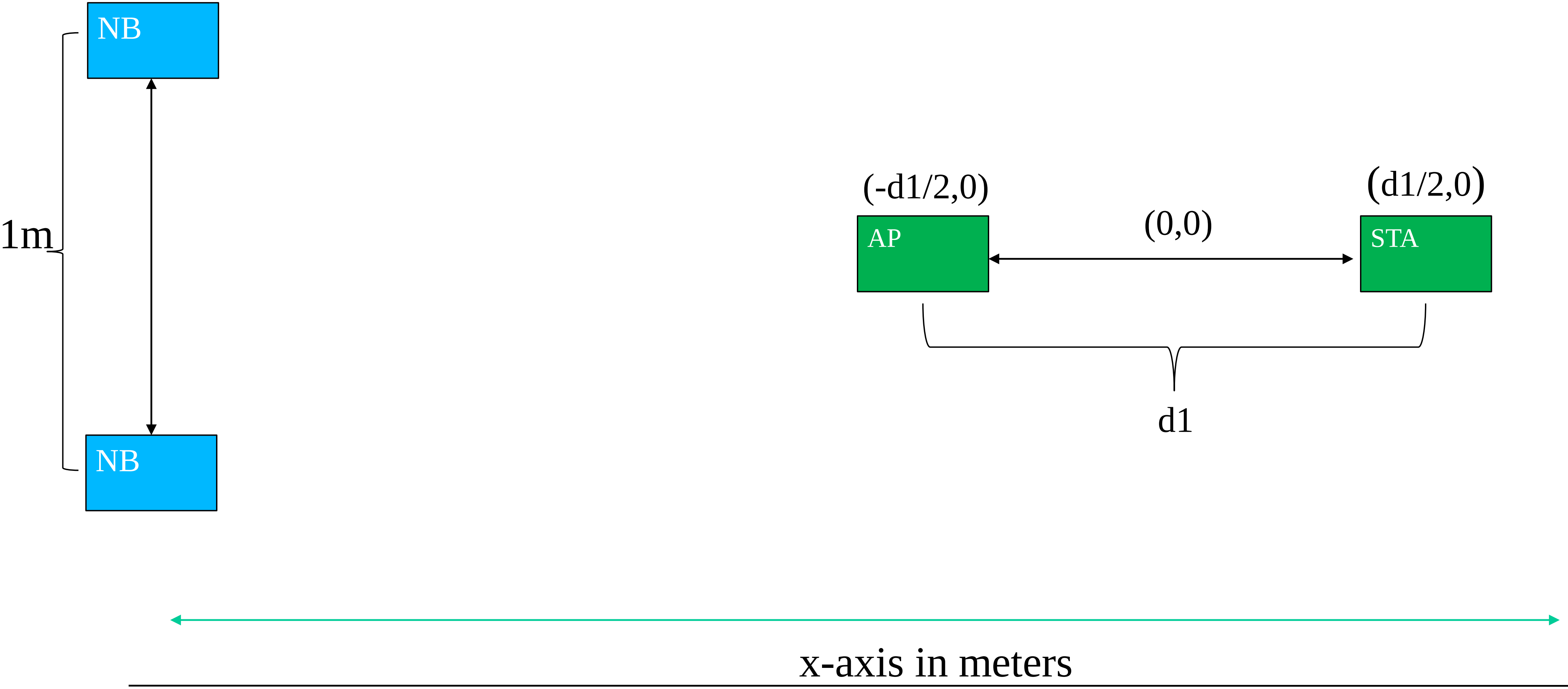
Implications

To achieve low latency results, NB devices can now map the RX CCA level to a desired transmit power and go ahead and transmit.

For example, in UNII-5, a measured CCA RX power by a 2.5 MHz wide 802.15.4ab NB device of -71 dBm (-75 dBm/MHz) corresponds to 1 dBm TX power.

Appendix

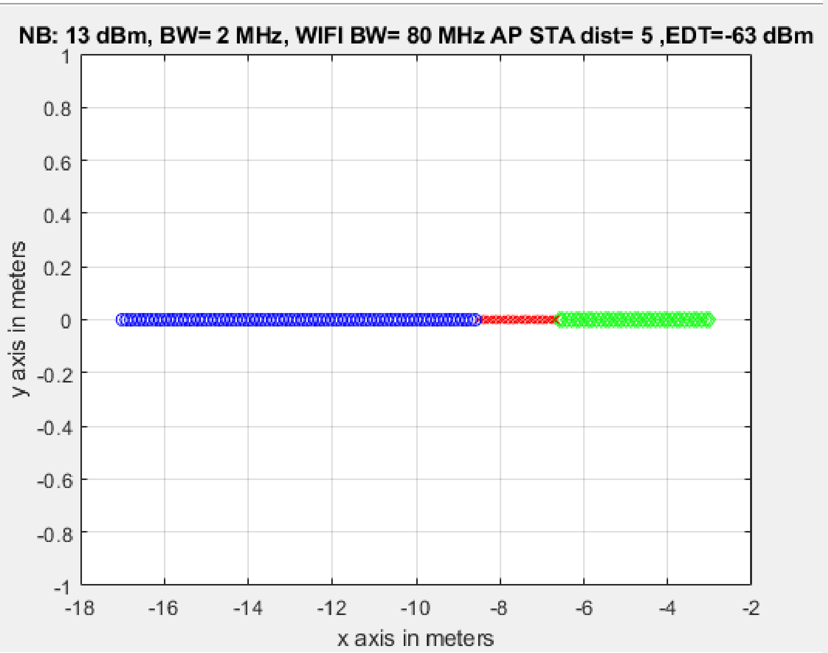
Bluetooth Scenario

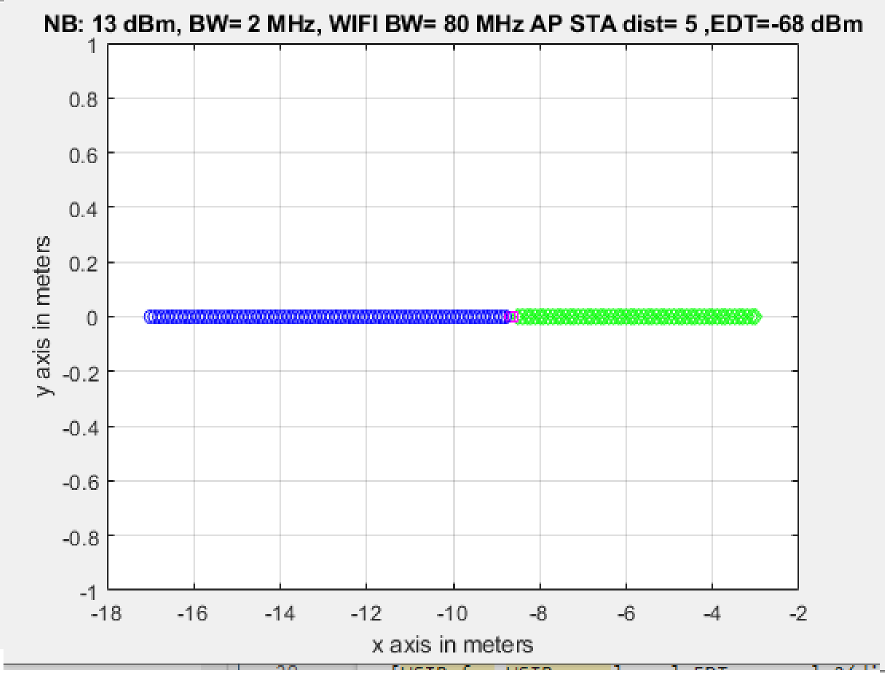


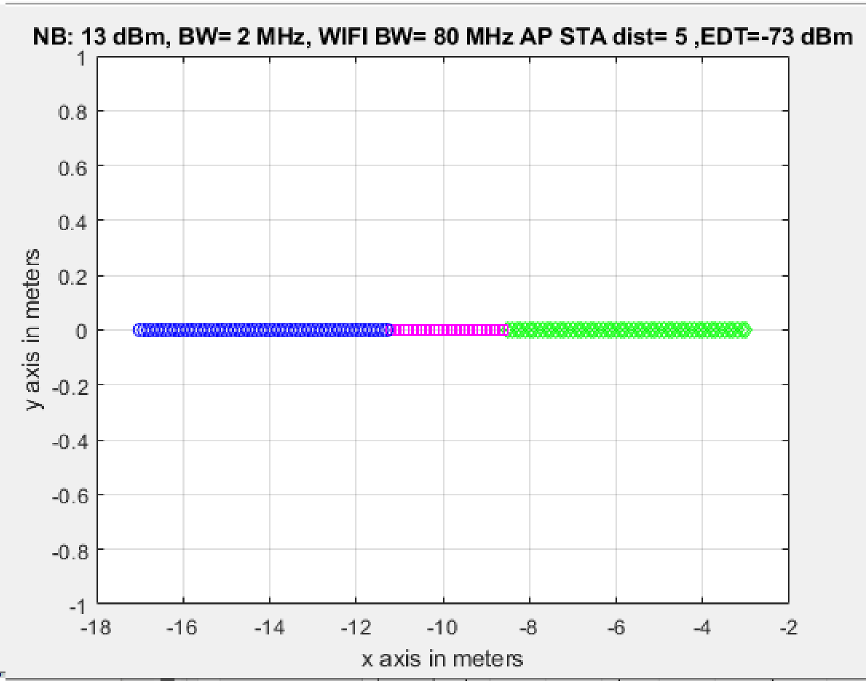
NB BW = 2 MHz

WiFi BW = 80 MHz
NB power = 13 dBm, d1=5

EDT= -63 dBm **-68 dBm (-71 dBm/MHz)** **-73 dBm**

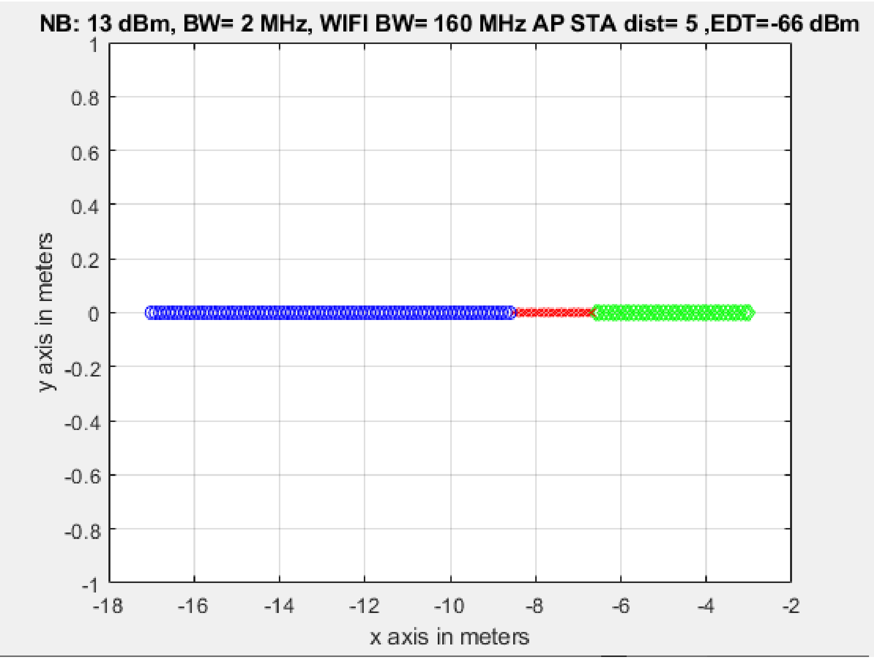


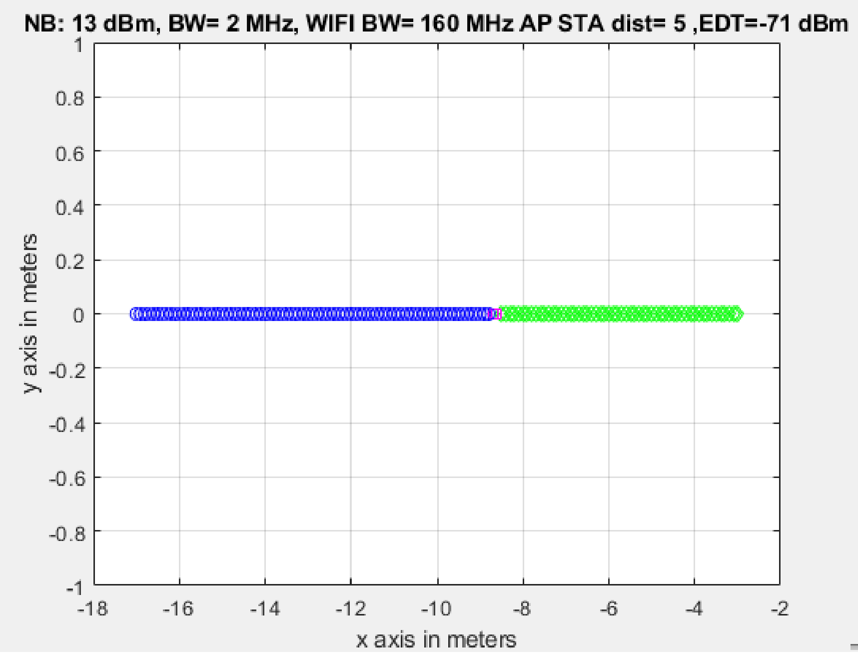


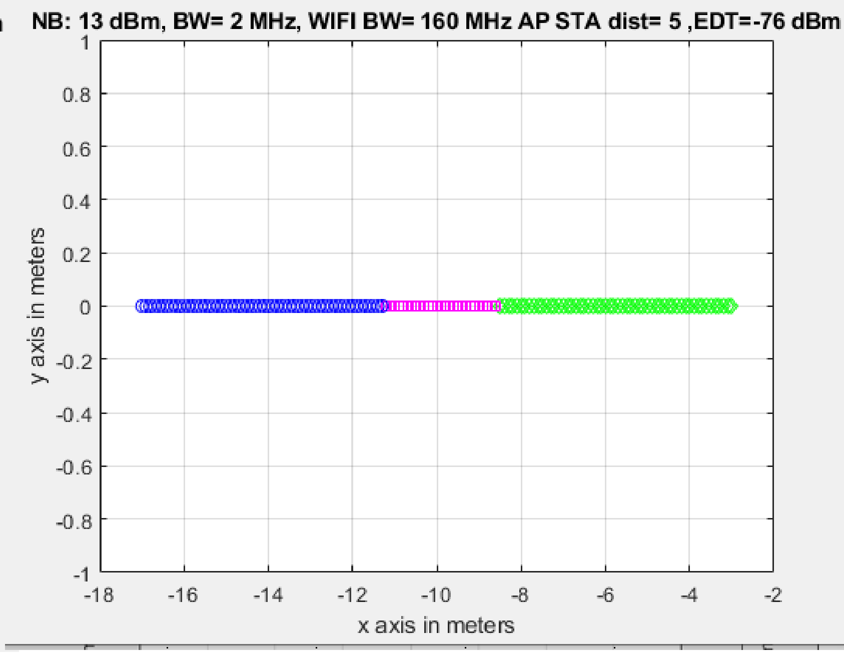


WiFi BW = 160 MHz NB power = 13 dBm, d1=5

EDT = -66 dBm **-71 dBm (-74 dBm/MHz)** **-76 dBm**

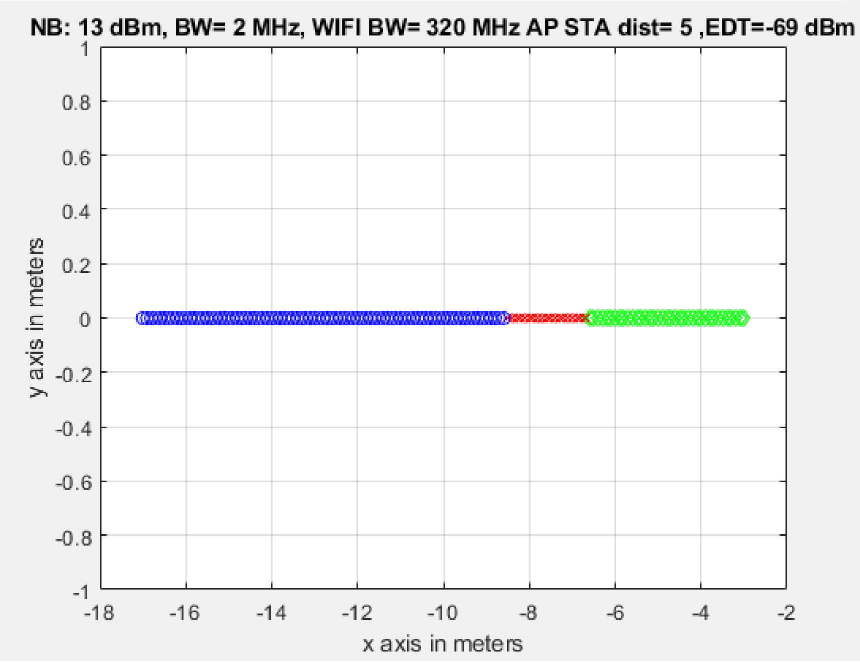


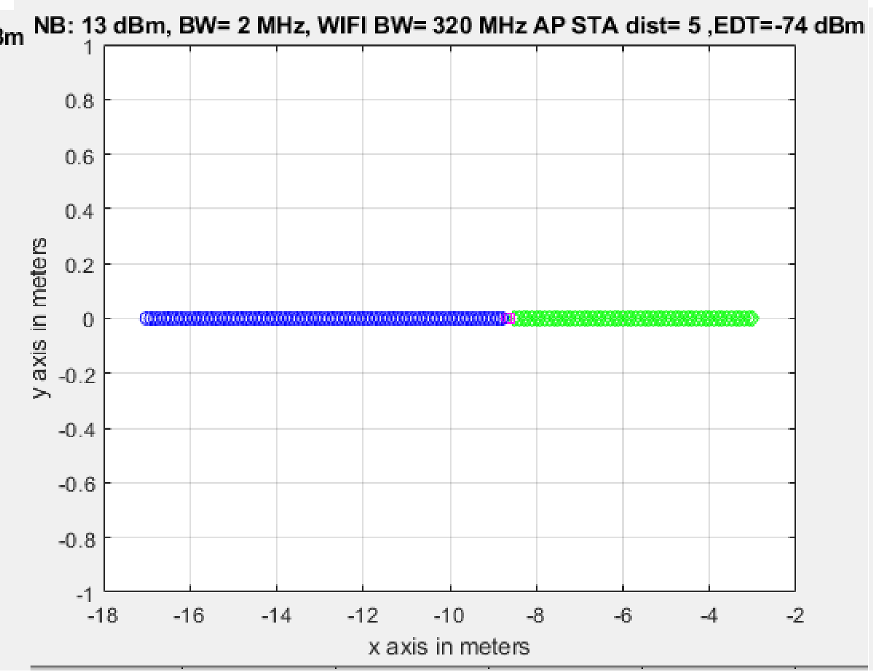


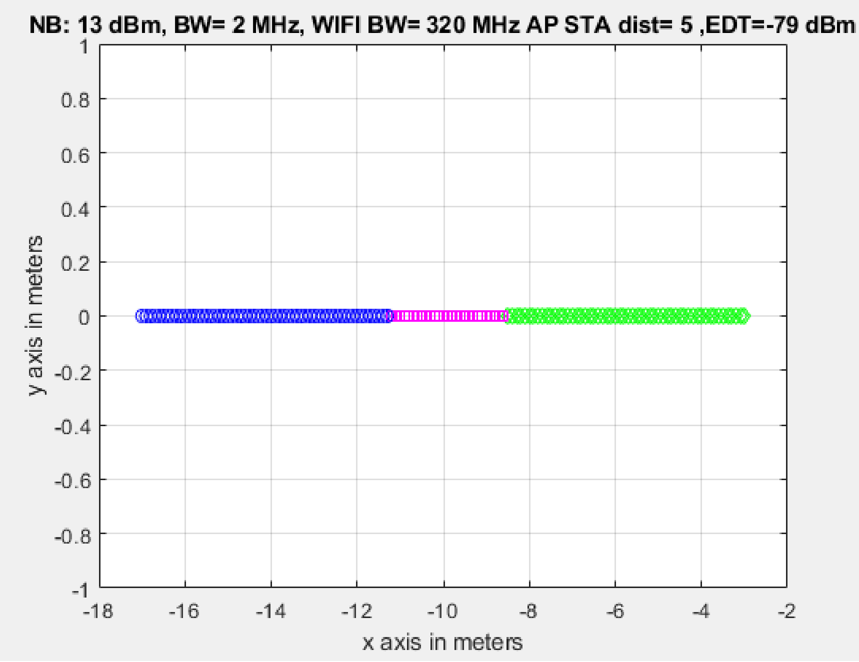


WiFi BW = 320 MHz
NB power = 13 dBm, d1=5

EDT = -69 dBm **-74 dBm (-77 dBm/MHz)** **-79 dBm**



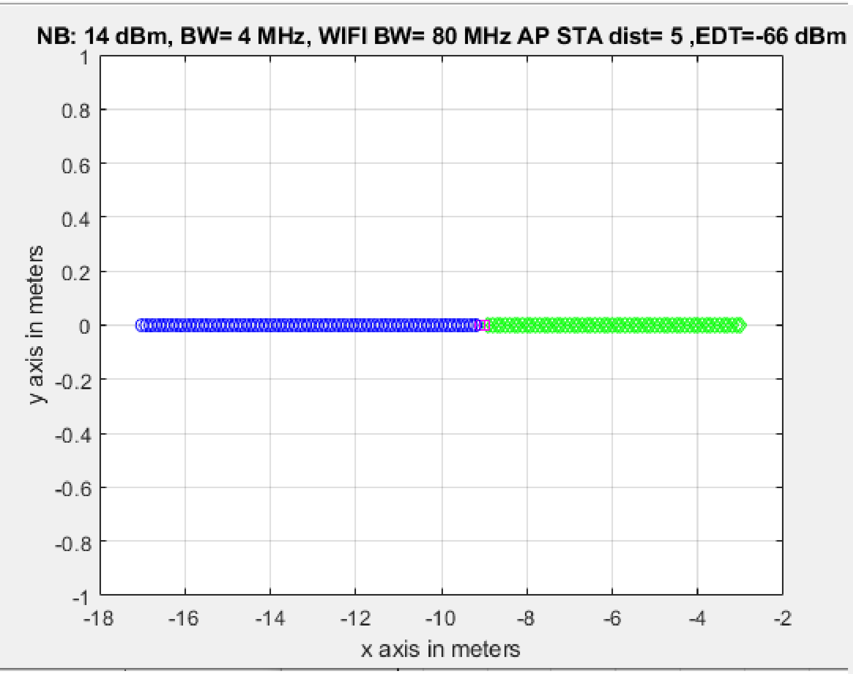


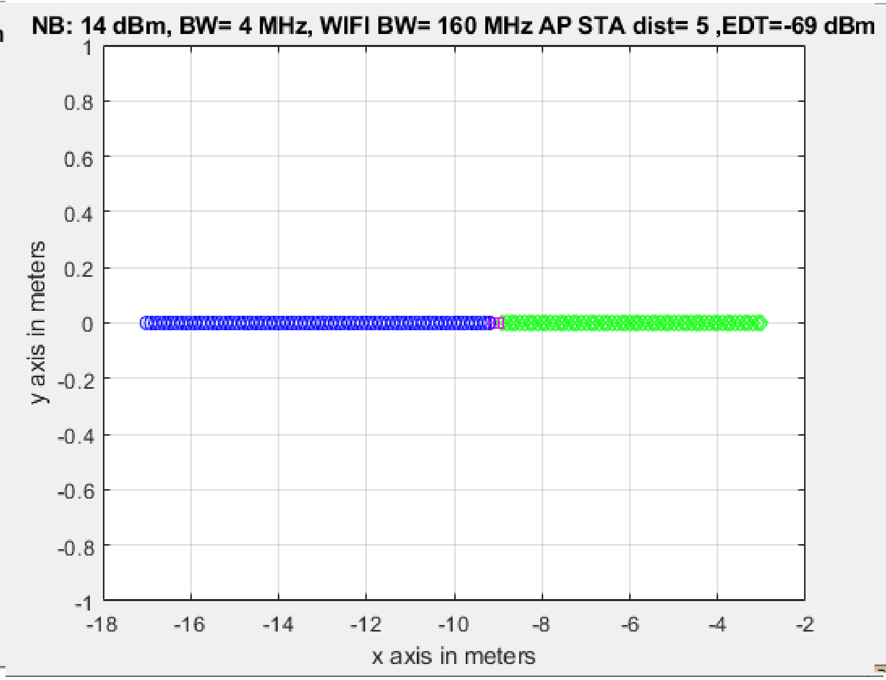


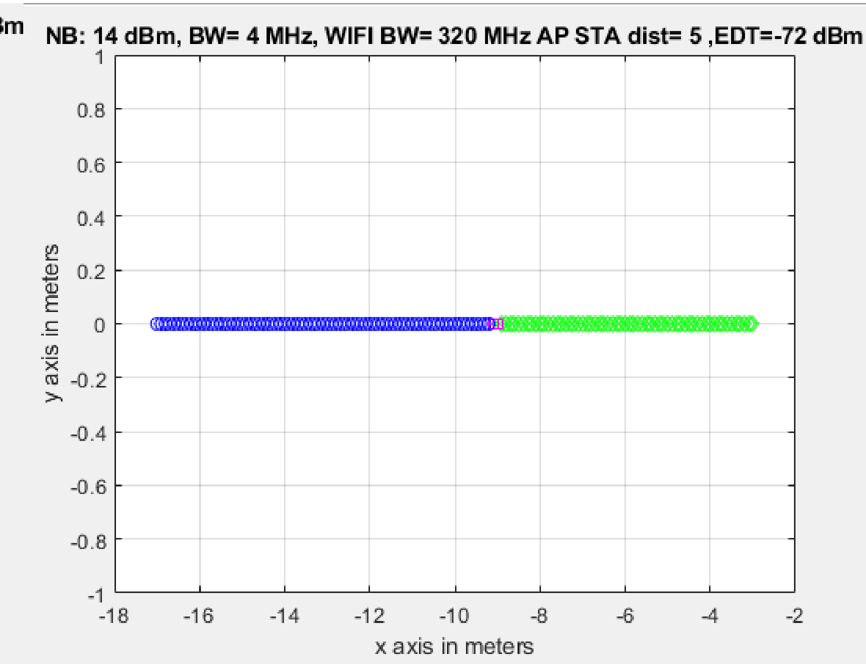
HOW ABOUT 4 MHz?

NB = 4 MHz, 14 dBm, d1=5

EDT: -72 dBm/MHz @ 80 MHz **-75 dBm/MHz @ 160 MHz** **-78 dBm/MHz @ 320 MHz**

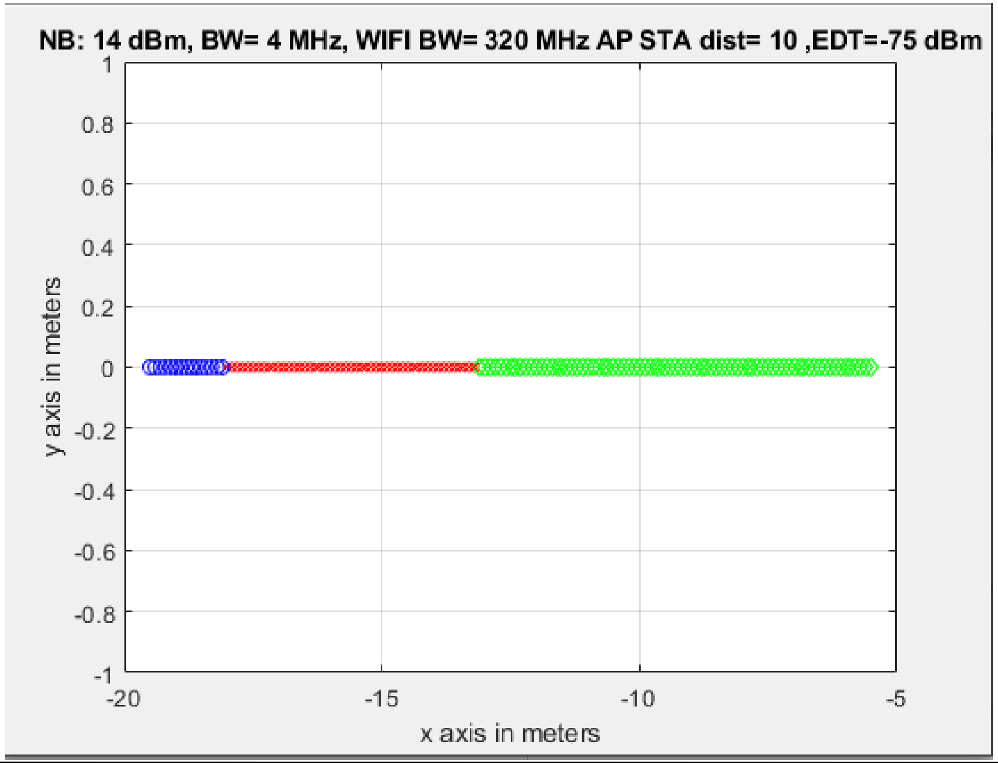


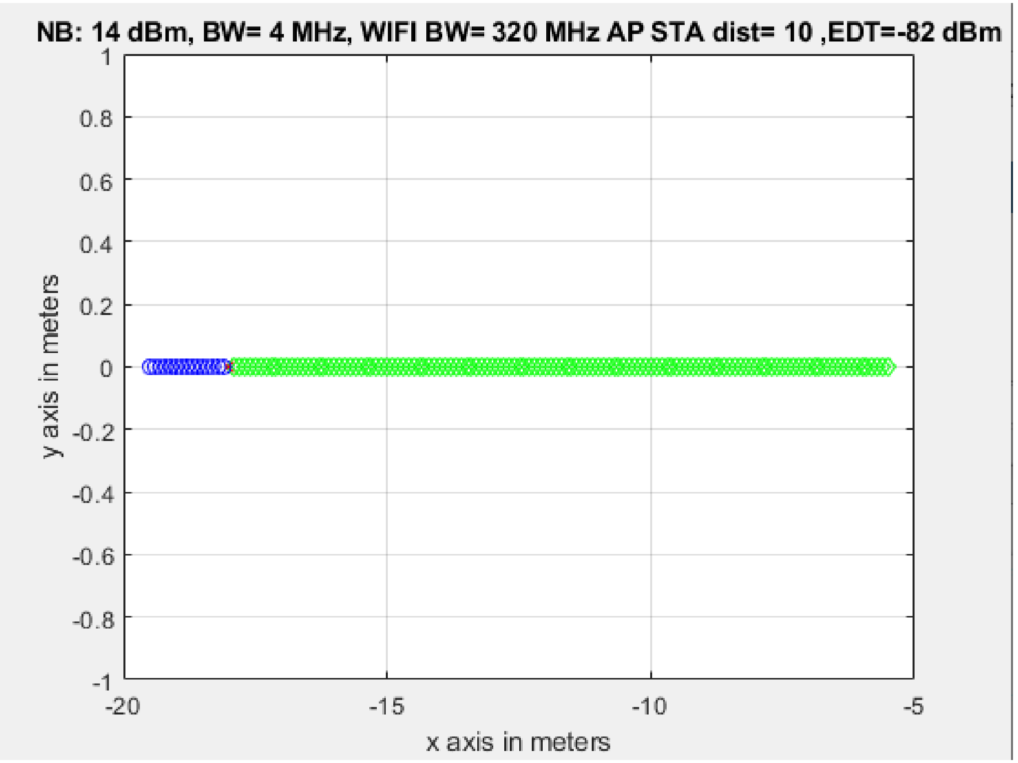




NB = 4 MHz, 14 dBm, d1=10

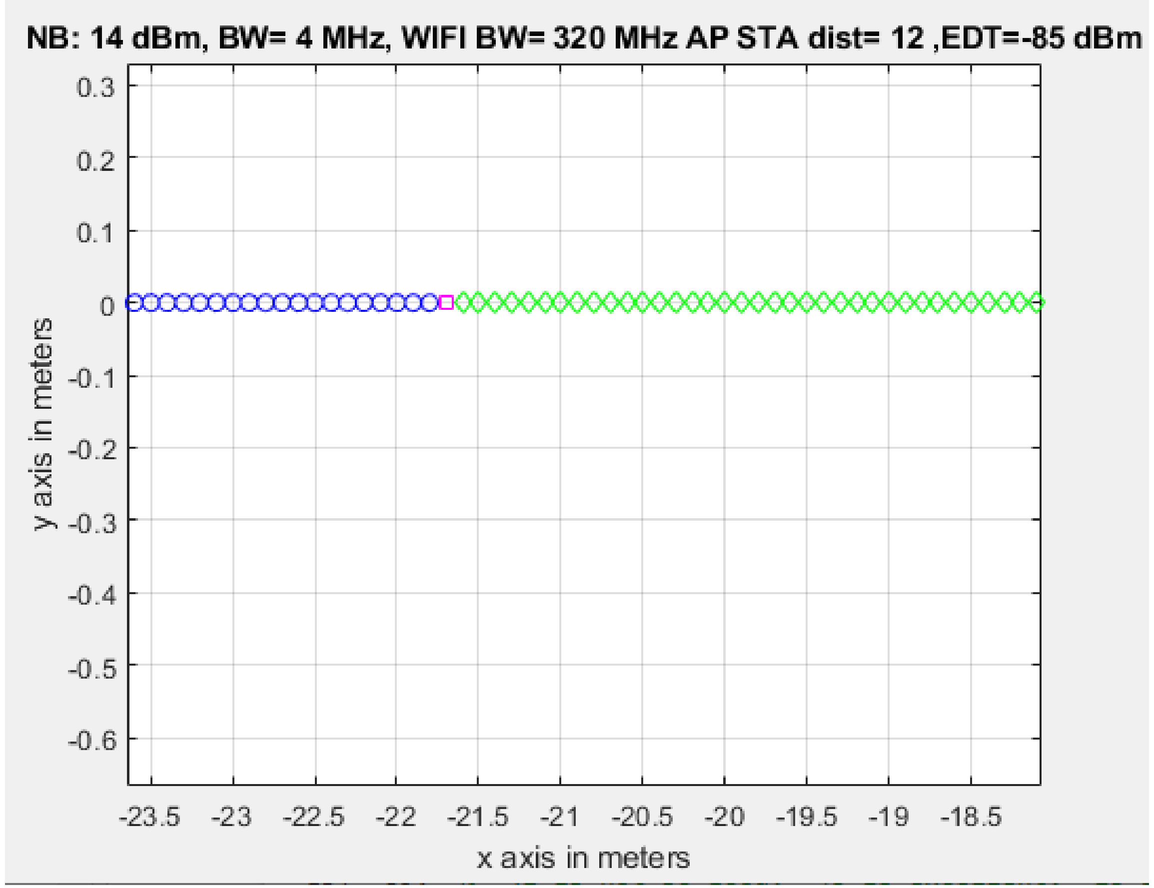
EDT = -82 dBm (-88 dBm/MHz) is optimal for this case (from -72 dBm when d1=5)





NB = 4 MHz, 14 dBm, d1=12

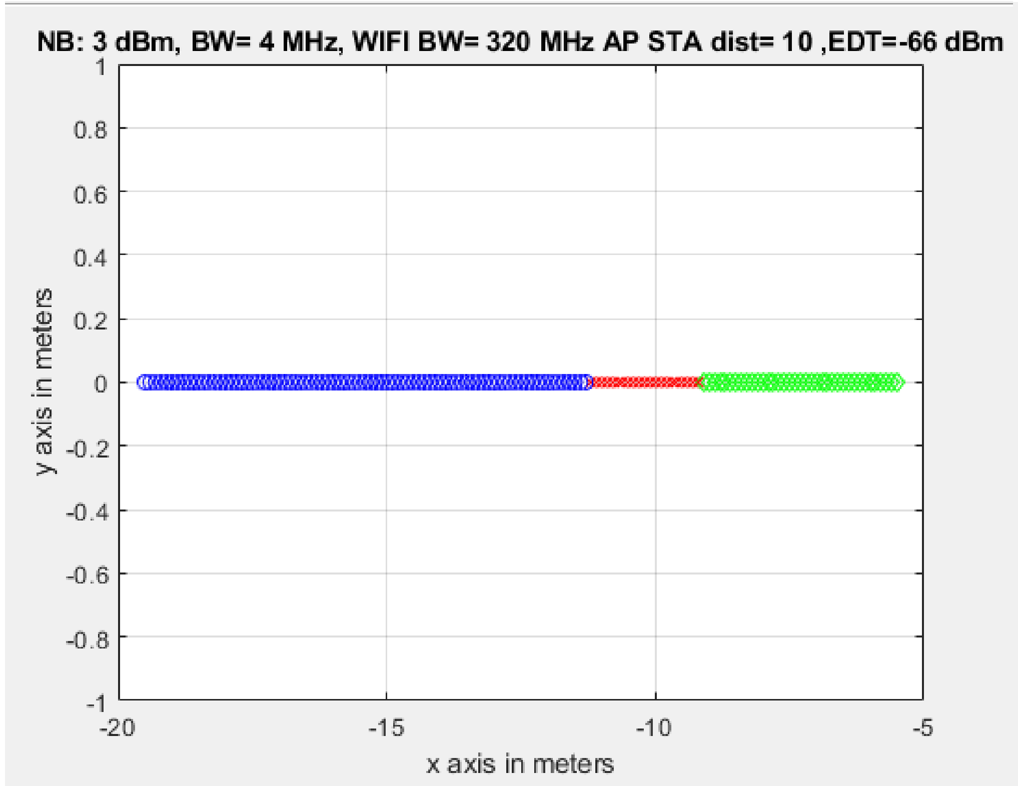
EDT : -85 dBm (-91 dBm/MHz) is optimal

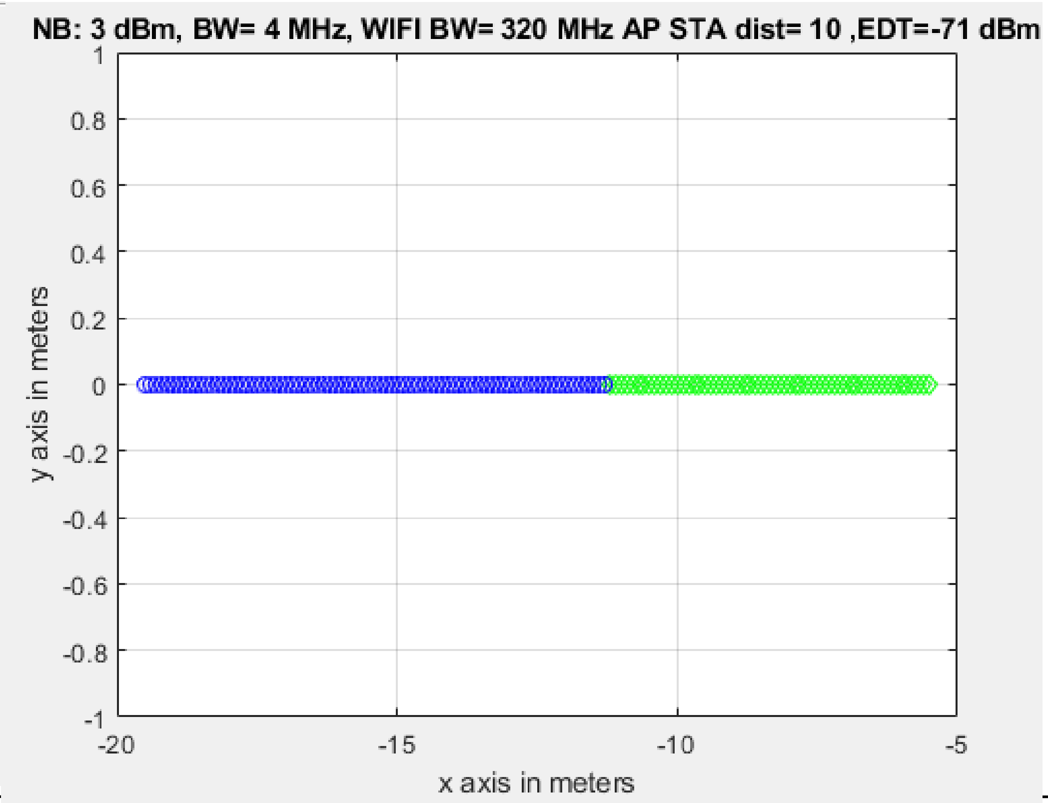


HOW ABOUT NB POWER CONTROL when d1=10?

NB = 4 MHz, 3 dBm, d1=10

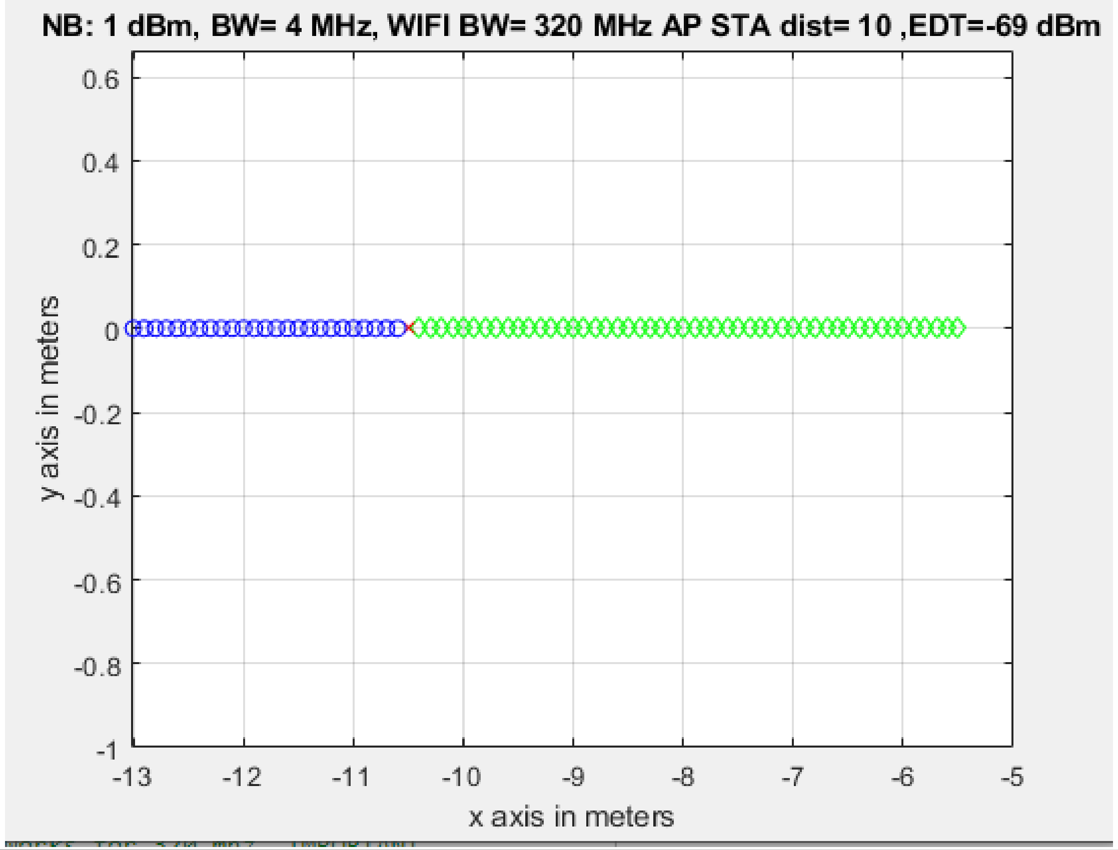
EDT = -71 dBm (-77 dBm/MHz) is optimal for this case (optimal was -82 dBm with 14 dBm)





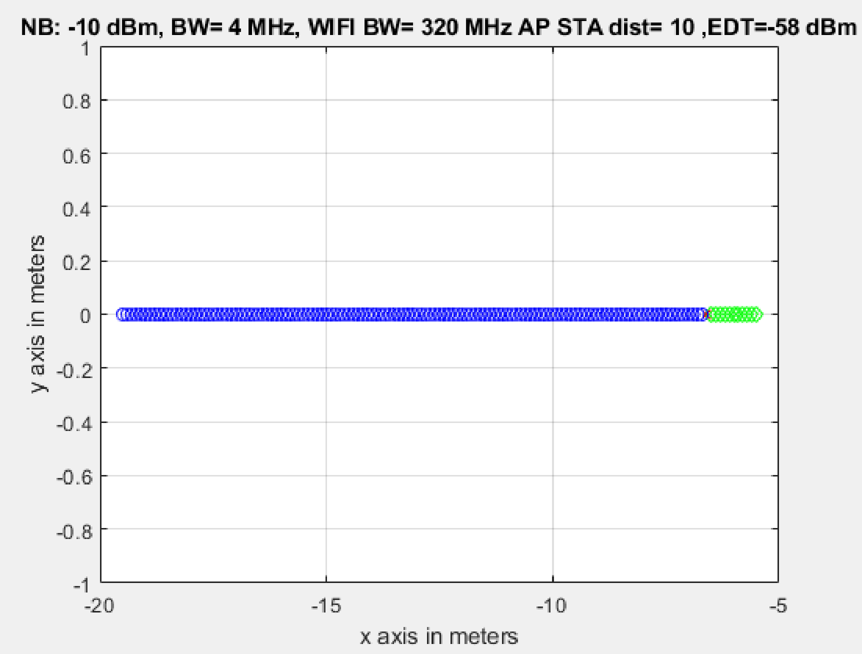
NB = 4 MHz, 1 dBm, d1=10

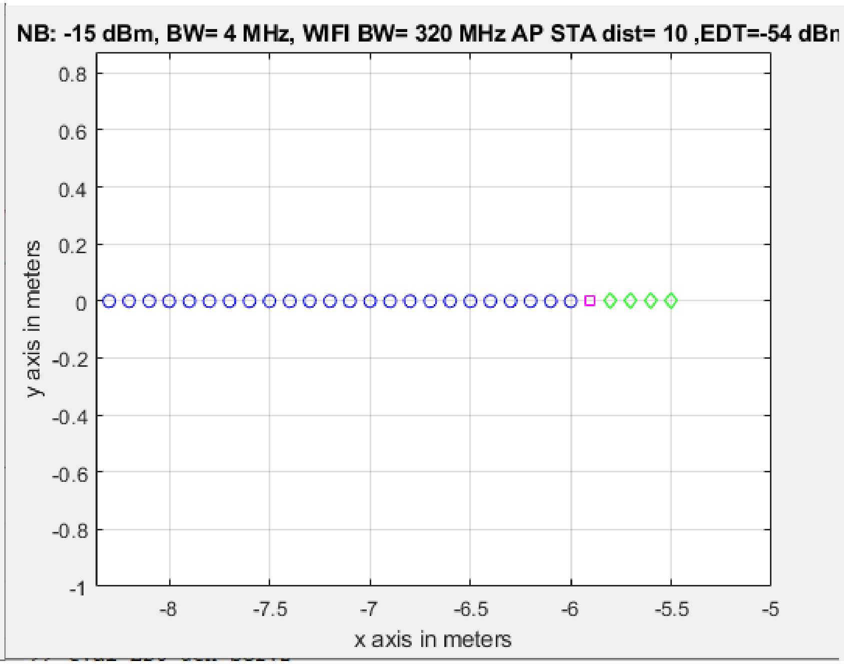
EDT = -69 dBm (-75 dBm/MHz) is optimal for 1dBm. This is a 13 dB offset from current 14 dBm value!

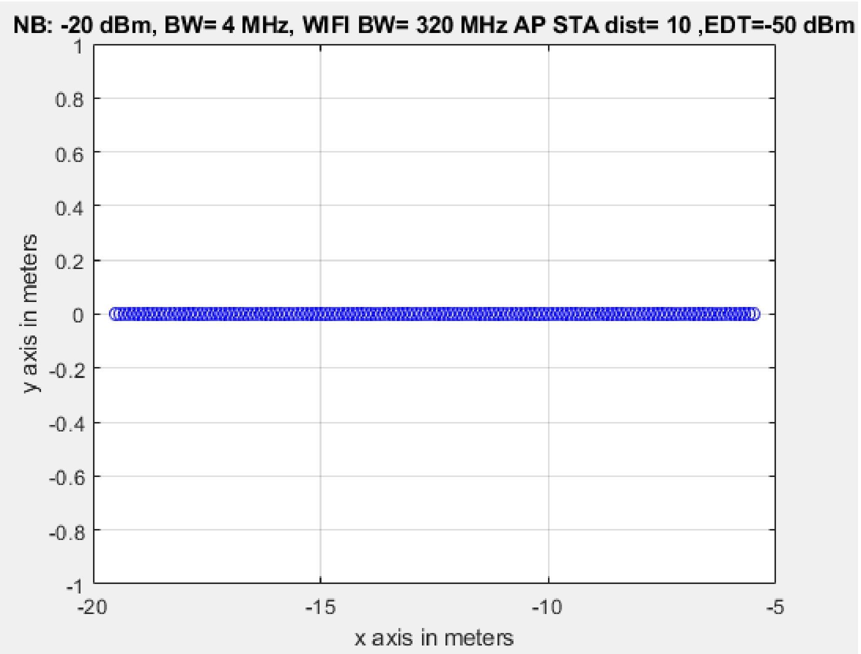


NB = 4 MHz, -10,-15,-20 dBm,d1=10

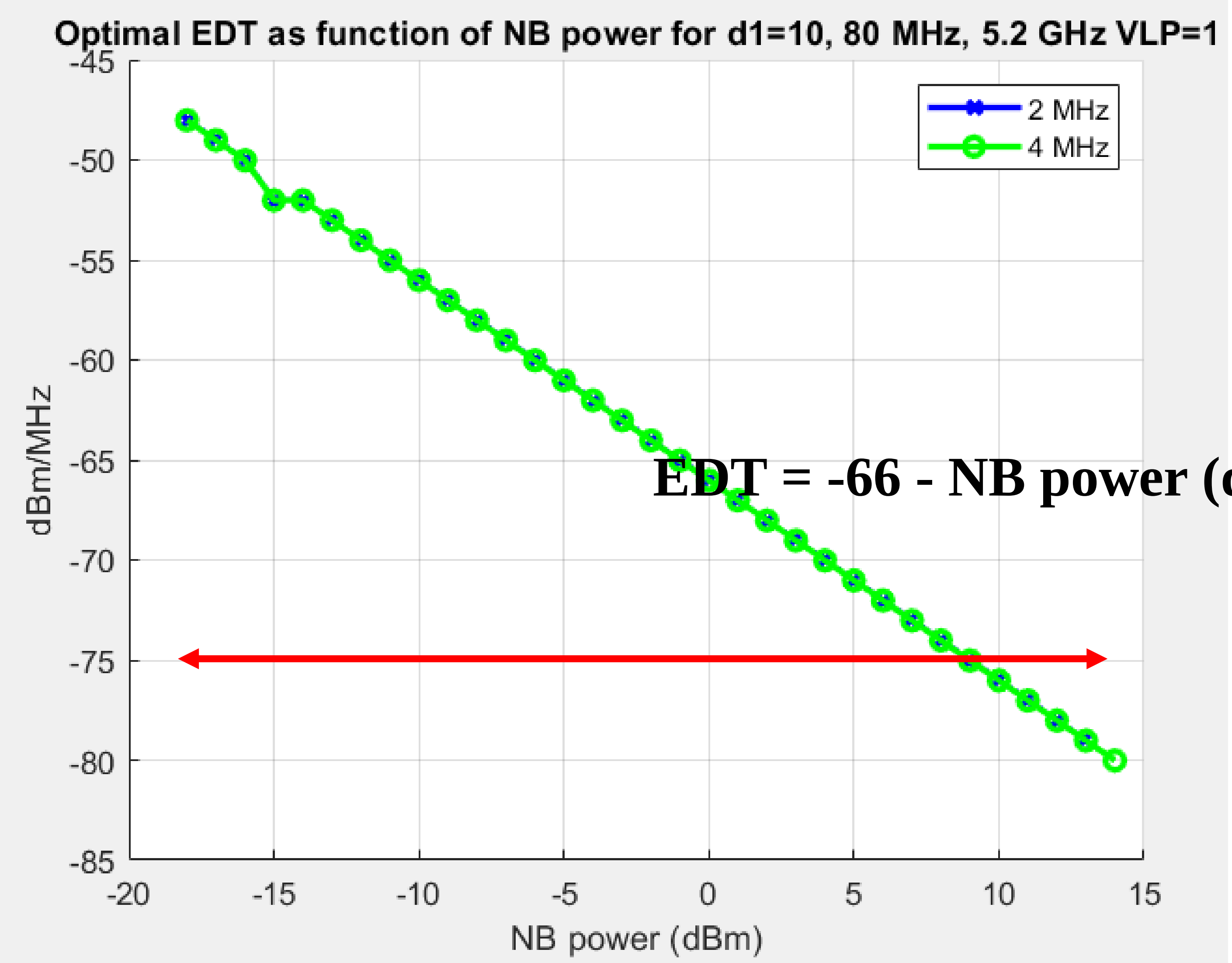
EDT = -58/-54/-50 dBm is optimal for -10/-15/-20 dBm







Summary of Results for 5.2 GHz (UNII-1), 80 MHz, d1=10

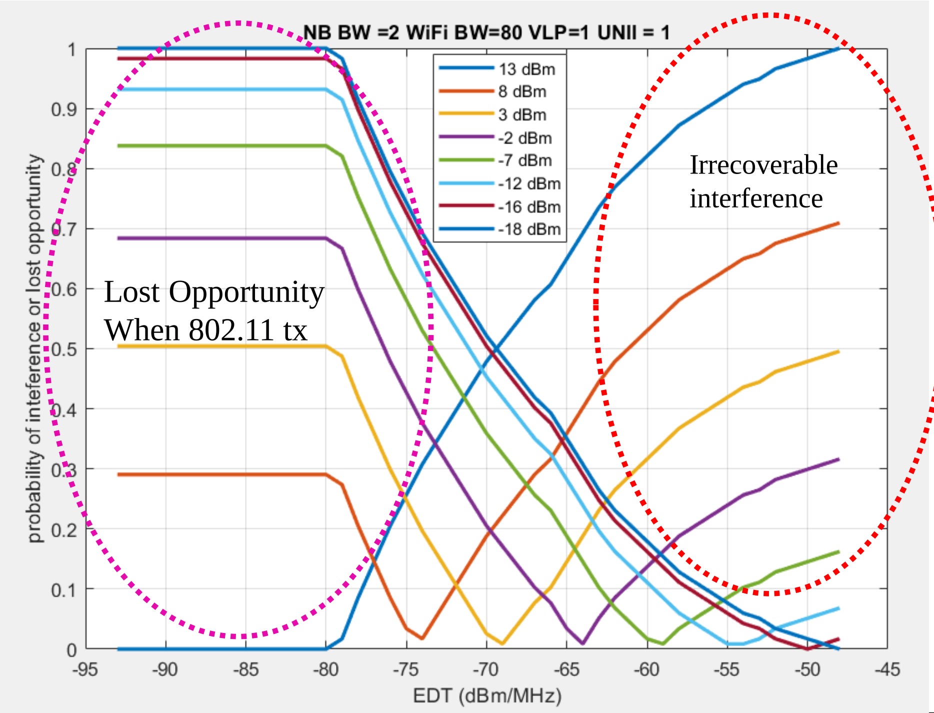


EDT = -66 - NB power (dBm)

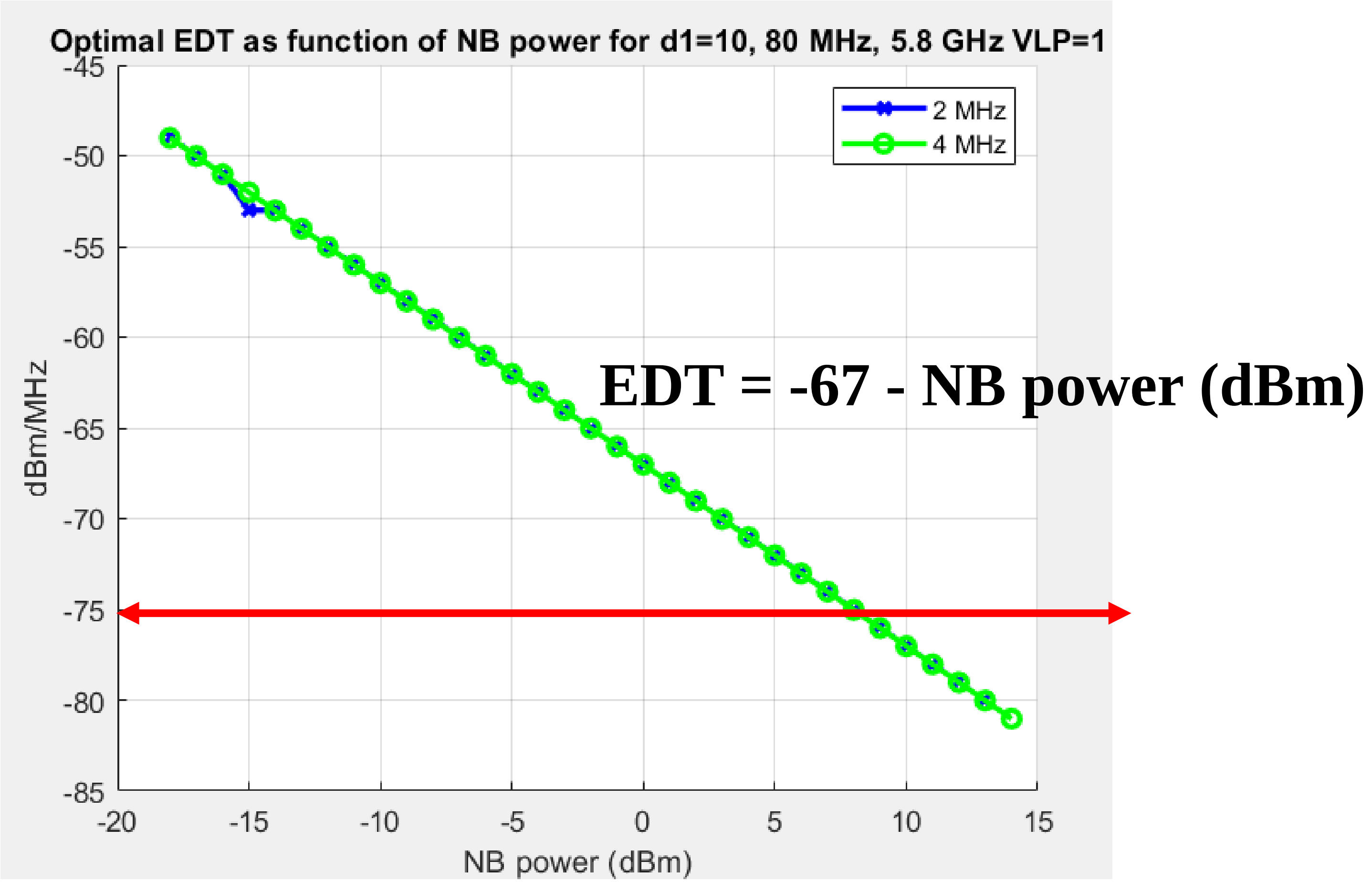
Sensitivity Plot for 80 MHz (UNII-1), d1=10

-75 dBm/MHz results in ~26% chance of irrecoverable interference for 13 dBm

For fixed -75 dBm/MHz, NB powers< 8 dBm have unnecessary lost opportunities when 802.11 transmits in the vicinity.



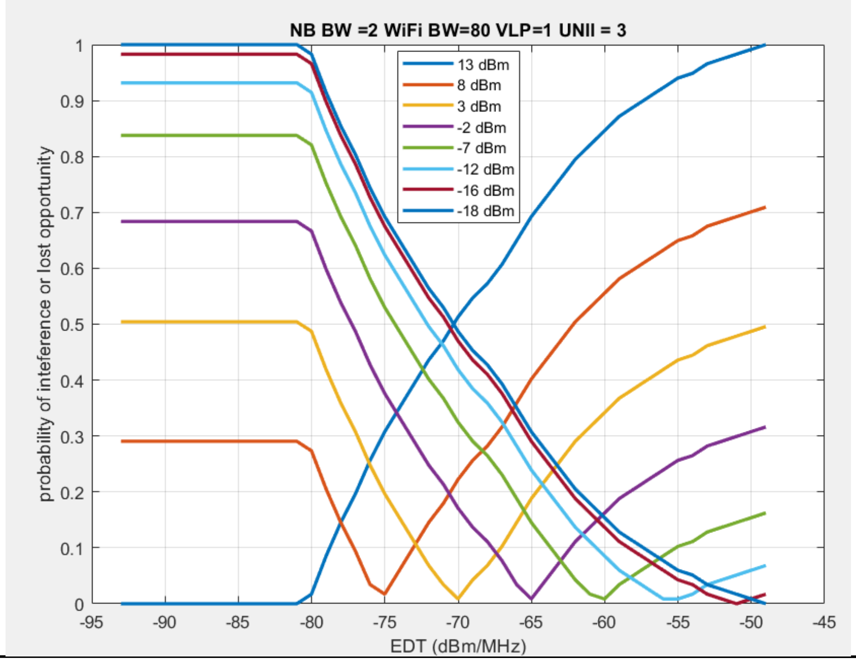
Summary of Results for 5.8 GHz (UNII-3/4), 80 MHz, d1=10



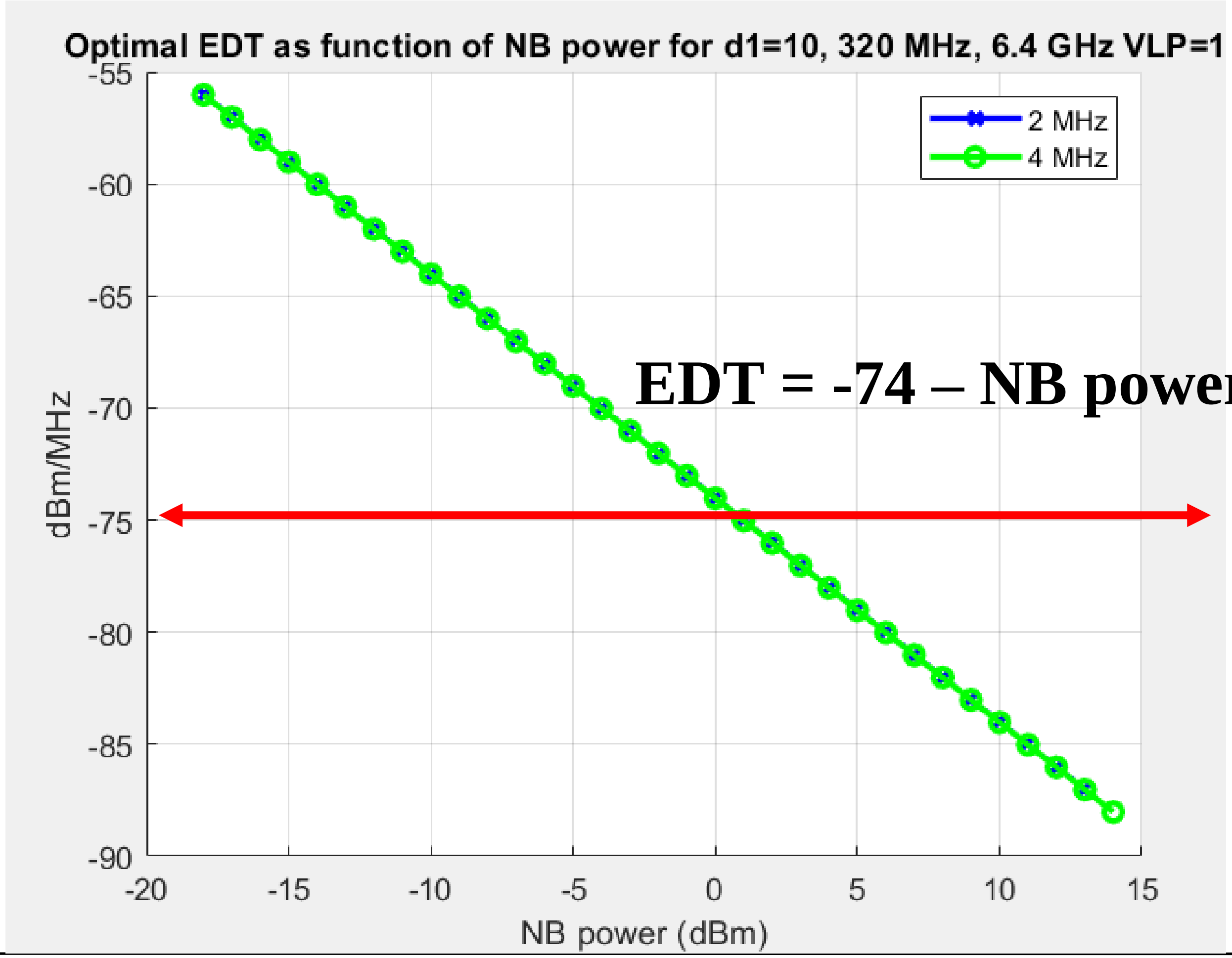
Sensitivity Plot for 80 MHz (UNII-3/4), d1=10

-75 dBm/MHz results in 30% chance of irrecoverable interference for 13 dBm

For fixed -75 dBm/MHz, NB powers< 8 dBm have unnecessary lost opportunities when 802.11 transmits in the vicinity.



Summary of Results for 6.4 GHz (UNII-5), 320 MHz, d1=10

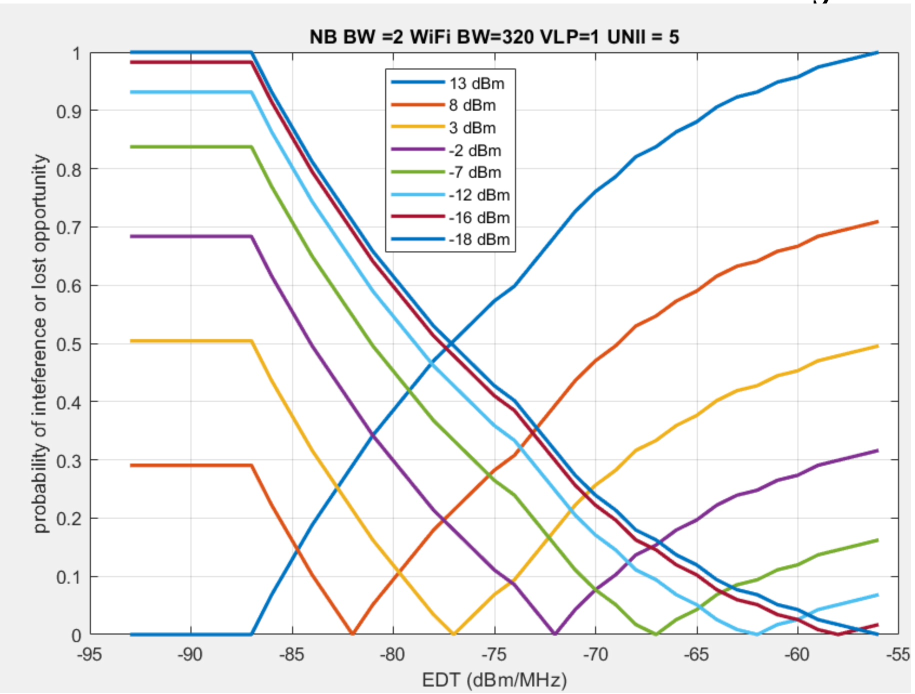


EDT = -74 – NB power (dBm)

Sensitivity Plot for 320 MHz (UNII-5), d1=10

-75 dBm results in ~60% chance of irrecoverable interference for 13 dBm

For fixed -75 dBm/MHz, NB powers< 1 dBm have unnecessary lost opportunities when 802.11 transmits in the vicinity.



Summary of NB ED Threshold Findings for d1=10

UNII-1	UNII-3/4	UNII-5
Pmax <=14 -66 dBm/MHz -Ptx	Ptx <=14 -67 dBm/MHz -Ptx	Pmax <=14 -74 dBm/MHz -Ptx

Observations

- Higher 802.11 BWs require lower NB ED threshold
- As the 802.11 AP and STA separate, the optimal NB ED threshold should be reduced further. NLOS case would require further EDT reduction.
- As NB power decreases from 14 dBm by x dB, the NB ED threshold can be increased by x dB.
- The optimal ED threshold is more sensitive as NB power increases
- For HB, the EDT starting point for 14 dBm TX power should be reduced from current -75 dBm/MHz value to reduce interference to a nearby 802.11 system.