Application Note

Cisco – Understanding Access Point Antenna Designs (Comparing 9136 and 9166 antenna systems)

Application question:

Could you do some internal digging and help me understand the rationale for the lower gain antennas on the 9166 versus the 9136, Conscious decision or legitimate technical benefit?

Application answer:

A common misconception is that the overall peak antenna gain should be factored into the purchasing decision when comparing access point specifications. While it is a datapoint, the reality is peak antenna gain is just one factor in the overall design of the Access Point and its antenna system.

When discussing antenna systems, it is a lot more than simply one antenna element and its overall peak gain. It is a total design of the array – number of elements in the near field, polarity and isolation, power tables in the chipset design and of course many other factors. Let's take a brief look at the 9136's antenna system.

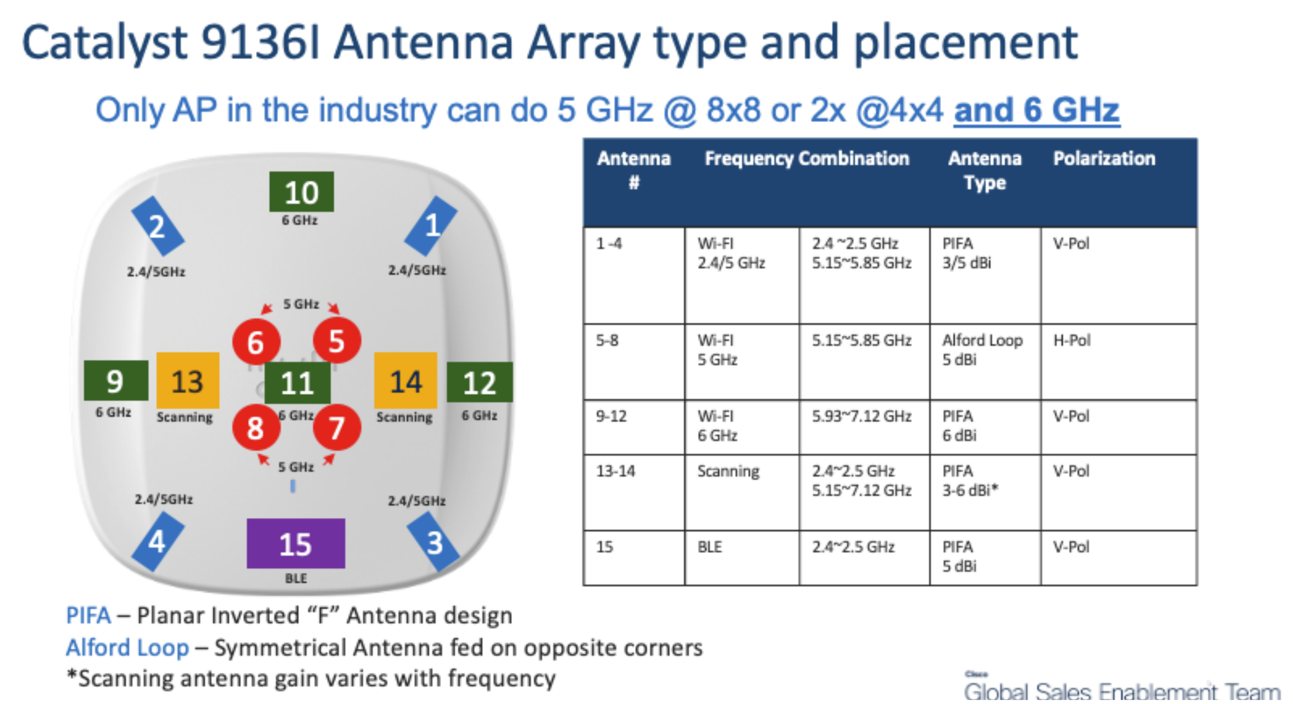
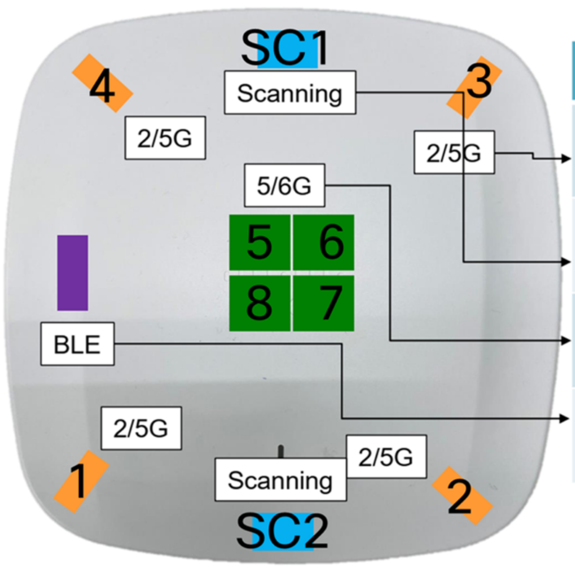


Figure 1 – CW9136 antenna system (note dedicated 6 GHz elements in green)

Looking at the 6 GHz elements on the 9136, (they only need to cover 6 GHz) 5.93-7.12 GHz is the span or range of that element. The other dual band elements (in blue) cover 5.15-5.85 GHz - they do not cover 6 GHz

It would be helpful now to examine the antenna system on the CW9166

Cisco Catalyst CW9166I Antenna type and placement



Frequency combination		ANT Type	Polarization
Wifi2/5G	2.4~2.5GHz 5.15~5.85GHz	Folded monopole (30 x 17 x 8.5 mm)	Vertical
Scanning (2/5/6G)	2.4~2.5GHz 5.15~7.125GHz	PIFA (30 x 20 x 8.0 mm)	Mixed
Wifi5/6G	5+6GHz (5.15~7.125GHZ)	H-POL Alford loop (30 x 30 x 0.8 mm)	Horizontal
BLE	2.4GHz	PIFA (30 x 14 x 8.6 mm)	Mixed

Figure 2 – CW9166 antenna system 4 less antennas and dual band has wider spread

Unlike the 9136, the 9166 lacks the ability (in hardware) to run an additional 4x4 radio allowing for 8x8 @ 5 GHz, as it has 4 antennas less than the 9136, in addition, the elements 5-8 (green) operate at a wider frequency range of 5.15-7.125 GHz.

Now let's talk about individual antenna elements, each discrete antenna element regardless of its design, Planar Inverted F Antenna "PIFA" or Alford Loop design or any design for that matter even those used by say a competitor….

During characterization of the antenna, the antenna element is going to "PEAK OUT" at max gain somewhere in the spectrum because somewhere in that spectrum range there is going to be areas in the spectrum where the antenna will be truly resonant (the most ideal performance and highest peak gain).

This is true in single band antennas, and it gets a bit more complex when the antenna elements also support dual or triband (2.4 & 5 GHz, / 5 & 6 GHz, or 2.4 & 5 and 6 GHz) modes.

A simple answer to the question at the start of this paper (why does 9136 have higher gain) could have been the use of a single band antenna at 6 GHz (like the 9136) is "easier" to get a higher gain when you don't have to stretch the antenna performance across a wider spectrum to include 2.4, 5 and 6 GHz.

Note: That is **NOT** the answer, but I am going to break that down a bit…

Figure 3 – An example of a PIFA and an Alfred loop design

Once you have an antenna design (of any kind) then the question becomes (where does the "peak" occur in these bands)? Can you get it consistent (not just one element)? but in the case of the AP all 4 elements uniform in pattern

Figure 4 – Ideally you want the antennas peak gain consistent over the desired bandwidth

Even if you get the antenna to peak in say the center of the 6 GHz band its gain will be somewhat diminished in each end of the 6 GHz band as 1,200 MHz is a long stretch for the antenna to remain resonant across the entire spectrum at the same gain.

That said in multi-band antennas is not always possible to have a "single peak gain" meaning, you may find the antenna is covering two or three frequency bands and there may only be two peaks say one at (2.4 and 5-7 GHz) in that case the peak gain could be lower in say 5 or 6 GHz – Note: when you are not designing your own antenna elements (and many competitors do not) they may simply use reference off the shelf elements and they tend to either characterize that antenna element "by itself in free space" assuming they characterize it at all as some just use the 3rd party vendors spec sheet. Additionally, oftentimes they do not design the antenna (characterizing it) with the other antenna elements in the near field.

Therefore, the published peak gain in a specification sheet could be misleading and certainly should not be the main factor in a purchasing decision. It is also not unheard of for a vendor to post a higher that realistic gain by using the PEAK in one band as the PEAK gain for the entire antenna element in all bands or by using data not taken from the completed design with all the other elements in place.

Cisco is very conservative on the posting of Peak antenna gain and we do not design Access Points for the "highest peak gain" but rather each antenna array is designed expressly for the Access Point being designed.

Figure 5 – Antennas are custom designed for each model Access Point

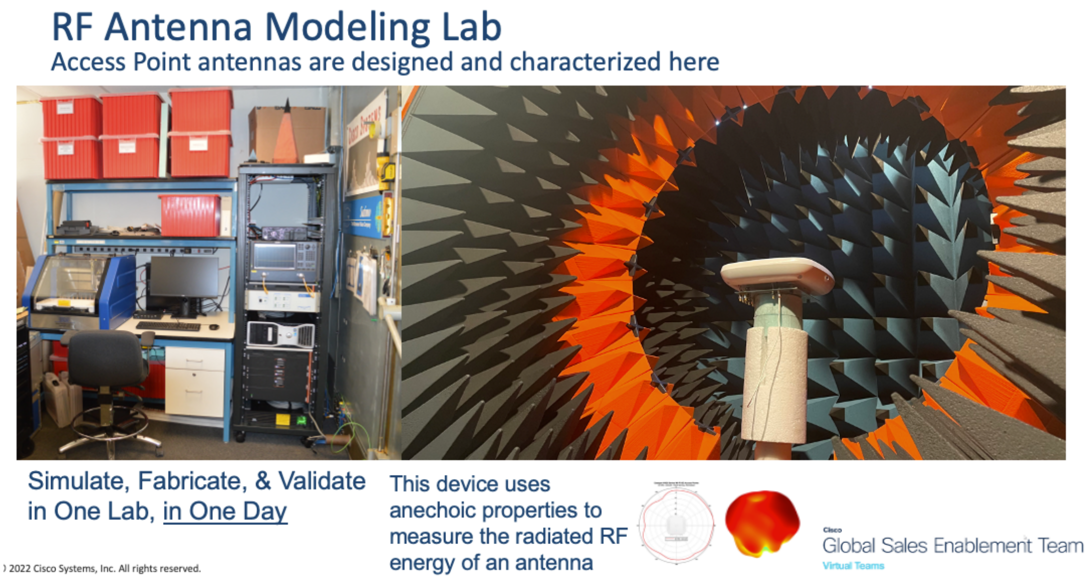


Figure 6 – CW9136/66 antennas are designed and modeled at Cisco's Richfield Ohio Facility (USA)

For more on this characterization chamber see the following URL:
https://www.mvg-world.com/en/case-study/cisco-picks-up-pace-of-antenna-innovation-with-mvgs-starlab

Rather than focusing on peak gain of a particular antenna element in a particular band, Cisco's approach is designed to cover many aspects of RF performance including…

1. Does the antenna and AP design offer similar coverage as previous products – Customer expects to replace existing product and not have to redo a site survey again or expect things to change – meaning the Access Point's RF performance should be uniform and coverage areas similar and certainly not degraded in any way from the product that is being upgraded. Note: You should find the performance and coverage of the 9136 and 9166 to be very close in coverage and overall performance.

2. With an internal antenna design, each antenna element is in the near field of other antenna elements – the more elements in the design the more difficult it is to maintain a uniform pattern and not degrade the gain and performance of the other elements in the antenna system.

3. The RF power tables and chipsets being used in each AP (can be different) and are factored into the overall antenna design for max EIRP and performance (sometimes out of band emissions or power in the sub-bands or other factors will change antenna design from one AP to another) as each Cisco antenna design is uniquely crafted to maximize the use capabilities of each AP's unique hardware design.

4. In the 9136-antenna design (due to the extra 4 antenna elements), it was designed differently from the 9166 (slight polarization changes) were used to get to the needed isolation between all the discrete antenna elements - sometimes at a slight detriment to overall MIMO EIRP. However, the 9136 has the extra hardware capability to enable dual 5 GHz in 4x4 while concurrently permitting a 6 GHz 4x4 radio to also be active, one of a few features the 9166 does not support.

5. The 9166 using less antenna elements (does not have the 5 GHz 8x8 support) of the 9136 but the 9166 was designed more holistically for overall best coverage <versus posted dBi gain> it is interesting to note… When we designed the 9166 (we used what we learned in the 9136) to improve upon our vector summation method of expressing the combination antenna gain which results in a lower gain expression (in dBi) but allows us to slightly increase power in the sub-bands where typical regulations would hold us back a bit.

The design and placement of the antenna elements along with other antenna elements in the near field determines how well those antenna elements will perform uniformly in each area.

Both the 9136 and 9166 antenna designs factor into account the strengths of each model – Both models will perform similar in coverage and performance.

To close… the differences in each model should not be judged simply by peak gain, or other misconceptions such as the higher gain of one product over another allows for the energy to be focused for higher density applications etc. Both products are positioned as enterprise class for ceiling mount installations.

Cisco offers a wide range of Access Point models that can address all your needs.

Figure 7 – Many of the patents on this wall are Access Point and antenna related designs

Figure 8 – One of the many engineering facilities Cisco has worldwide.