WHITE PAPER

Massive MIMO active antenna unit

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We recently developed a customizable reference design for a Massive MIMO antenna array with 16 dual polarized elements, operating at 2.5 GHz. In this paper read about our solution, approach and results, to understand if this solution is a good fit for your next product and can shorten your time to market.

Massive MIMO (Multiple-Input Multiple-Output), abbreviated as mMIMO in this article, is a fundamental technology for 5G and 4G/LTE. It provides significantly higher data rates per user, greater cell capacity (simultaneous users) and potentially increased cell range compared to traditional macrocell technologies.

The increased performance is possible because mMIMO combines the radio and antenna into a single active antenna unit. The unit is equipped with a large number of antenna elements i.e.16, 32, 64, or 96. This enables the transmitted signal or beam to be steered to the user, reducing interference with surrounding users and improving overall performance. This is unlike traditional macrocell technologies where the transmitted beam is fixed over a 120-degree sector. The concept is illustrated in the diagram below.

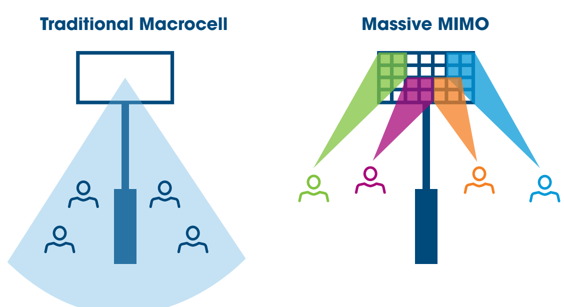

Figure 1: Traditional Macrocell vs Massive MIMO

According to Markets & Markets, the mMIMO market will grow rapidly to $21 billion by 2026 at 41% CAGR. This presents a huge opportunity for the industry as a whole.

mMIMO technology has been on the market for several years with the first products appearing in 2016. However, mMIMO units are several times more expensive to manufacture than traditional radio units. Based on our experience, this is due to the higher bill of materials cost (than traditional radios) and increased manual assembly effort during manufacturing. The manual assembly required to attach the 16-96 antenna elements onto the main antenna board produces lower yields, due to increased manual assembly.

Our solution

We realized that the high cost of manufacturing mMIMO units was a major challenge for our customers. That's why we developed and characterized a mMIMO prototype with 16 dual polarized antenna elements. We anticipate this design will reduce manual assembly effort by a factor of 5 times vs. traditional designs. This 16-element array can quickly be scaled to a 32, 64 or 96 element array in accordance with customer requirements.

mMIMO specification and description:

Table 1 describes the typical specifications of the mMIMO reference design. Each can be customized by our team to meet specific customer requirements.

Band	n41/B41 (2.5 GHz)
Antenna Bandwidth	200 MHz
Transmit Power	Up to 68 dBm EIRP
Antenna elements	16 (dual polarized)
Maximum Gain	17.5 dBi
Antenna Array Efficiency	67 %
3 dB beam width	18°
Return Loss	-15dB

Table 1: Massive MIMO Specifications

Figure 2 shows the mMIMO prototype unit and top/side view of the antenna array. The design team incorporated a capacitive coupling technique to transfer RF energy between the antenna and ground printed circuit boards (PCBs). The mMIMO unit includes built-in lighting protection through each patch which mitigates the need for a separate grounding solution.

Figure 3 shows a detailed view of the antenna and ground PCBs. The antenna PCB has antenna patches on the front and a L-probe feeding contact and DC grounding pin at the back. The front of the ground PCB has antenna feed pads, matching component placement and DC ground holds. At the back of the ground PCB, SMA connectors are soldered to test each antenna and verify their performance. The feeding method and grounding are designed to ensure the antenna and ground PCBs are separated by the specified distance.

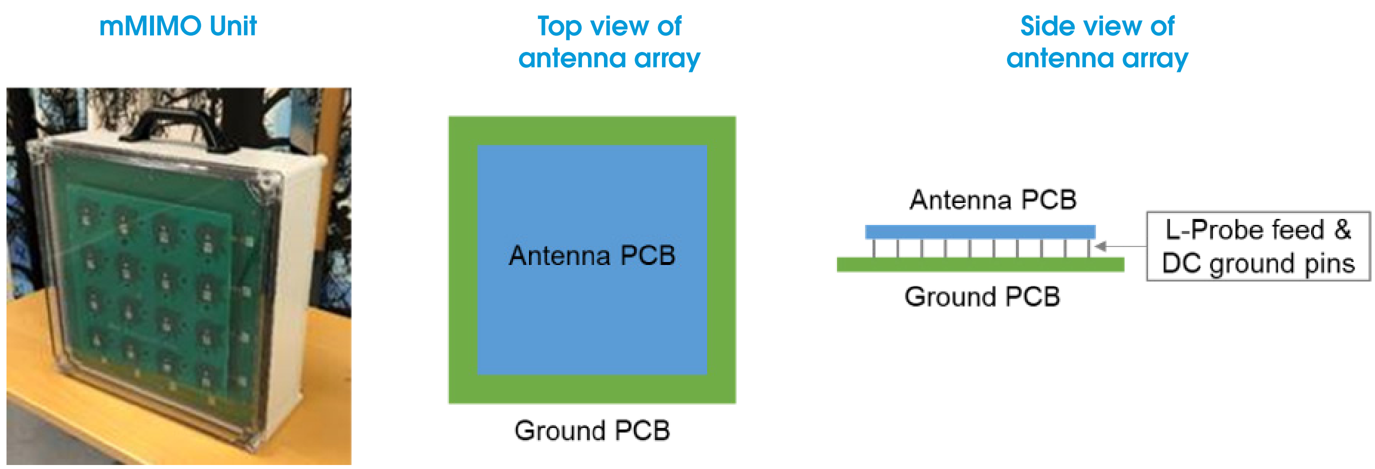

Figure 2: Massive MIMO antenna array with top and side views

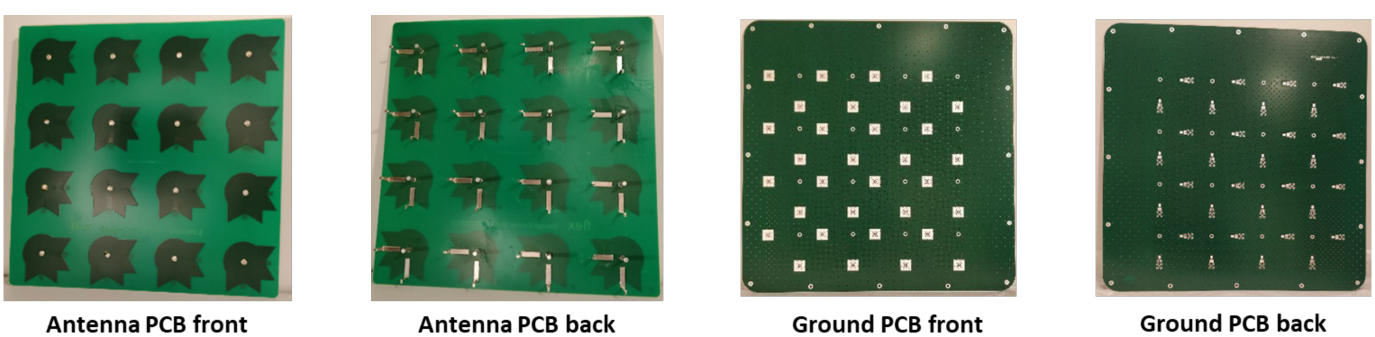

Figure 3: Front and back view of the antenna and ground PCBs

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Design process:

Figure 4 describes our overall process for designing the mMIMO unit, covering specification, modeling, simulation, construction, testing, optimization and acceptance. The design process is iterative and typically we will have 3 main design cycles if there are minimal changes to the initial specifications.

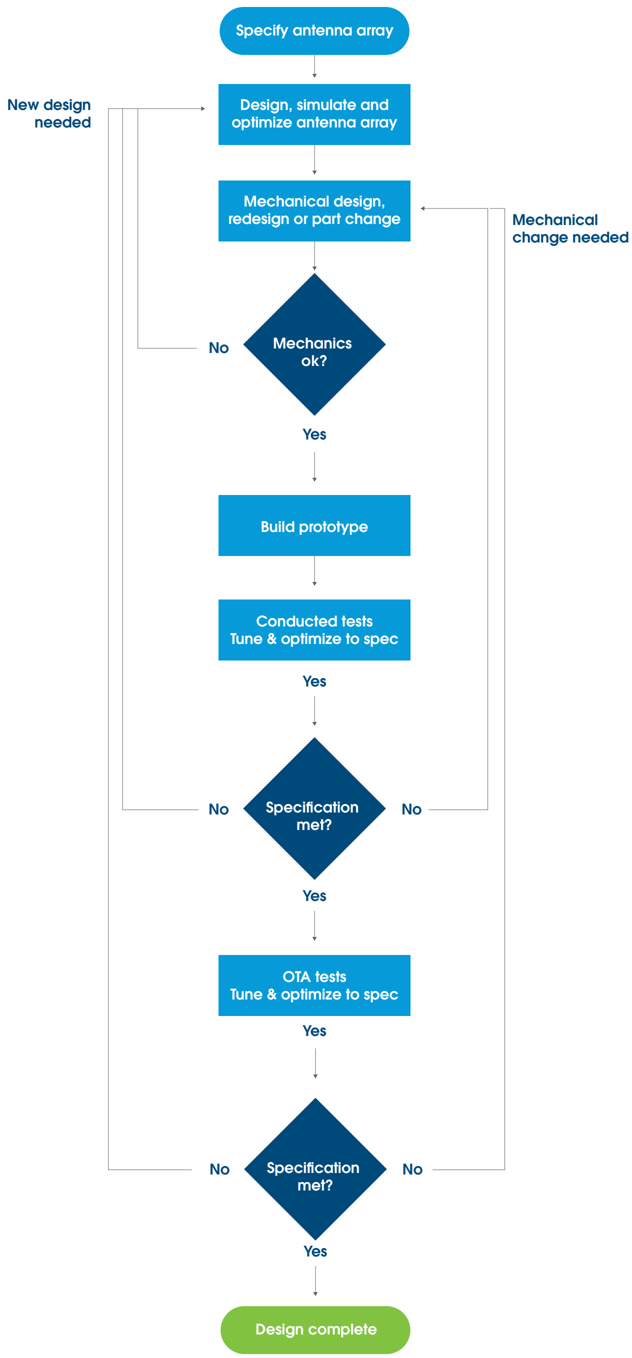

Figure 4: Massive MIMO antenna design process

Simulation results:

As described in the design process, a simulation study was done before making a prototype. Figure 5 shows the simulated results for the mMIMO unit at bore side at 2.6 GHz. Here the observed gain was 17.2 dBi and the 3 dB beamwidth was 18^0.

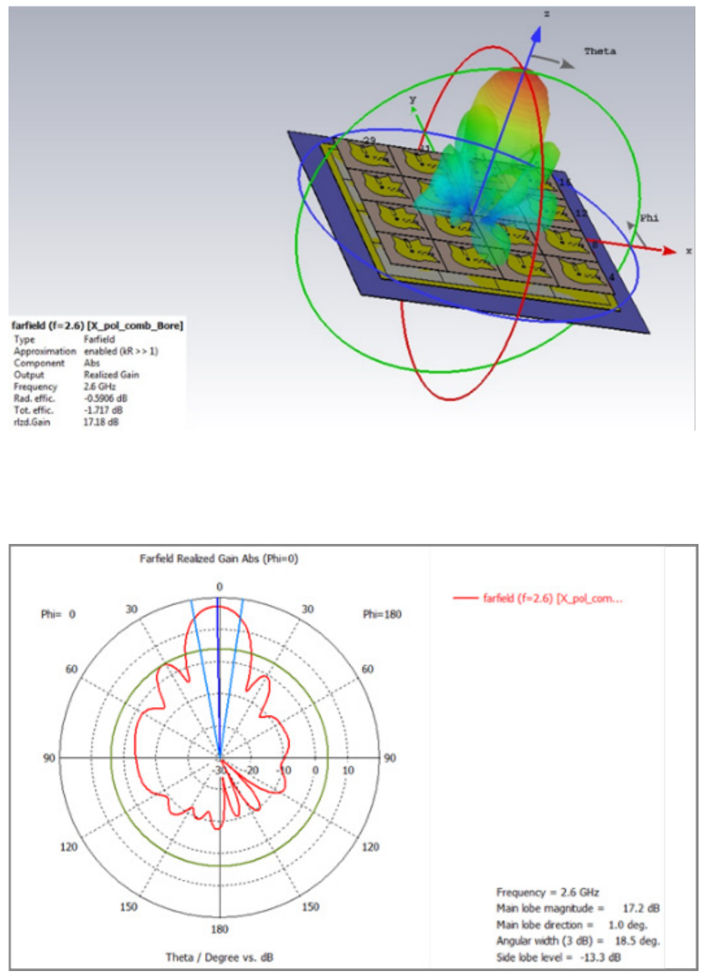

Figure 5: Simulation results

Lab & Over-the-Air testing

Flex constructed several prototypes of the mMIMO unit for testing purposes, one of which is shown in Figure 6. The design team performed extensive Over-the-Air (OTA) testing to fully characterize the unit, compare with simulation results and ensure alignment with the specification.

Conducted testing:

In conducted testing, all 32 antenna ports (16 dual polarized antenna elements) were tested to measure antenna input matching. Isolation tests, between antenna elements, were performed for the more critical cases where the antenna elements were close together for both polarizations. Measurements were conducted in a large empty room to avoid any reflection during measurement.

The majority of the antenna ports had -15dB input matching over the band. Isolation between ports with opposite polarization were in the -14 to -19 dB range in most of the cases.

OTA testing:

Figure 7 shows the OTA measurement performed in a full anechoic conical-cut chamber. Measurement data was collected in the near field using spherical scanning. The resulting complex value of near-field data was transformed to far-field using the spherical near to far-field transformation. Each antenna port was scanned separately. Beam pattern was formed by mathematically summing the resulting far-field patterns of the individual antenna ports, using known amplitude and phase weighting factor for each beam. The combined maximum gain at the center of the band was over 17 dBi for both polarizations at bore sight.

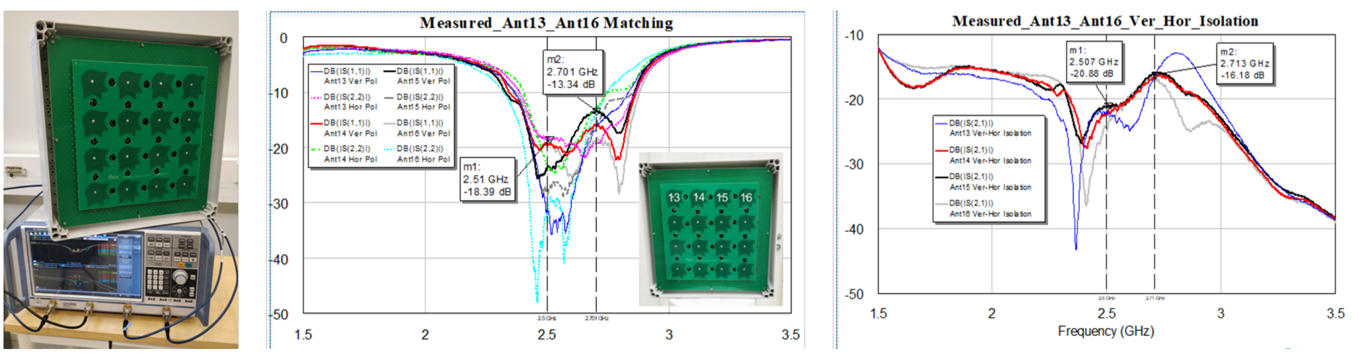

Figure 6: Conducted testing and results

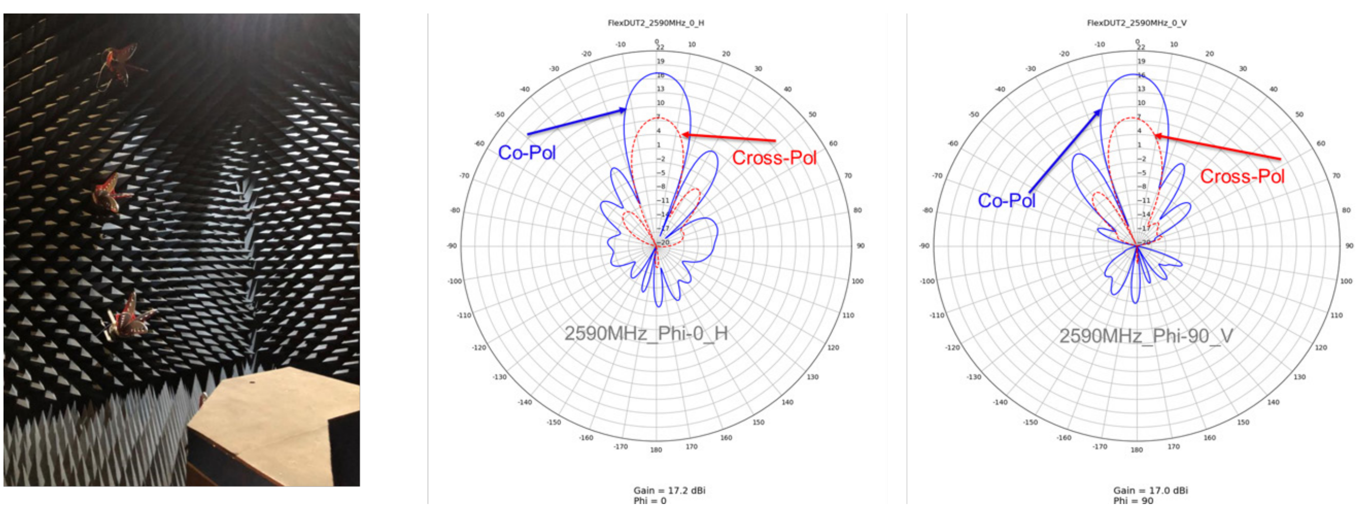

Figure 7: OTA testing and results

Partner with Flex

We develop new 5G products to support mMIMO and enhance existing products in preparation for mass production. Through a joint design and manufacturing (JDM) partnership, we can develop mMIMO units to meet your individual requirements.

Reduce your time to market and lower your investment costs by tapping into our mMIMO and broader 5G expertise. We'll share our knowledge of the design, development and manufacturing - and the materials and components you need to build them. We anticipate key components will be in high demand, so we've developed partnerships with major suppliers to make sure we have the components you need before you need them.

We also have deep expertise in related wireless communication products, such as base stations, remote radio units, small cells, mmWave phased arrays and microwave systems. We design and manufacture these products for many of the leading RAN infrastructure and Microwave OEMs. Our manufacturing expertise pairs with our strong supplier and partner network to make your ideas a reality.

About Flex

We are the Sketch-to-Scale® solutions provider that designs and builds intelligent products for a smart, connected world.

We deliver innovative design, engineering, manufacturing, real-time supply chain insight and logistics services to companies of all sizes in various industries and end-markets. With unrivalled expertise across every major industry, we empower leading companies to flawlessly develop and launch their next innovation at scale, from ideation, through design and development, to market – and beyond.

Flex is the global Sketch-to-Scale® solutions provider for intelligent products. We bring innovative design, engineering, manufacturing, supply chain and logistics services to companies of all sizes, across many industries and markets. Learn more at flex.com. Twitter: @Flexintl. Live Smarter™

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