Wide scan angle transmit array antenna

The role of the Transmitarray Antenna (TA) is to focus the radiation energy in one direction by transforming a spherical wave into a plane wave. It's composed of unit-cells allowing controlling the phase shift of the electromagnetic wave.

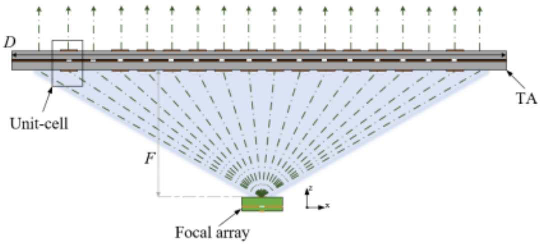


Figure 1 : Schematic diagram

The phase shift distribution is optimized by using discrete phase shift value. To obtain good performance, 8 values (each 45°) has been chosen. The following figure shows the phase shift distribution obtained in the case of an unifocal transmitarray.

- TA with 20×20 unit-cells (50×50 mm^2)
- Ratio F/D = 0.4 (edge tapering -11 dB)

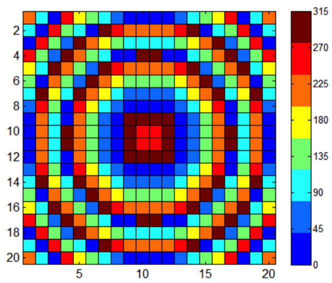


Figure 2 : Phase shift distribution

The transmitarray antenna has been tested and validated from radiation pattern measurement. The primary source is the 2X2 patch array presented in **M5HESTIA 60GHz-FI downconverter** part.

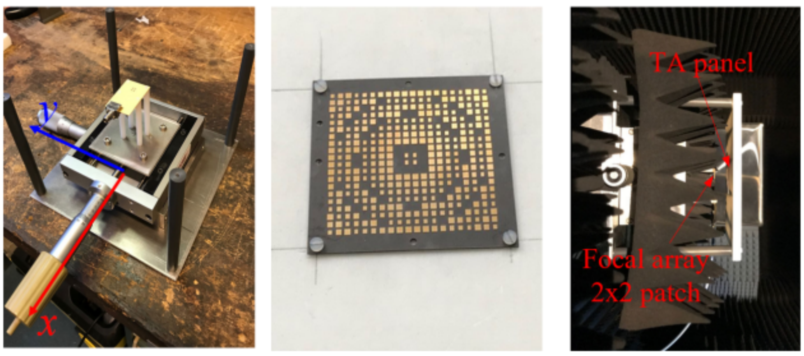
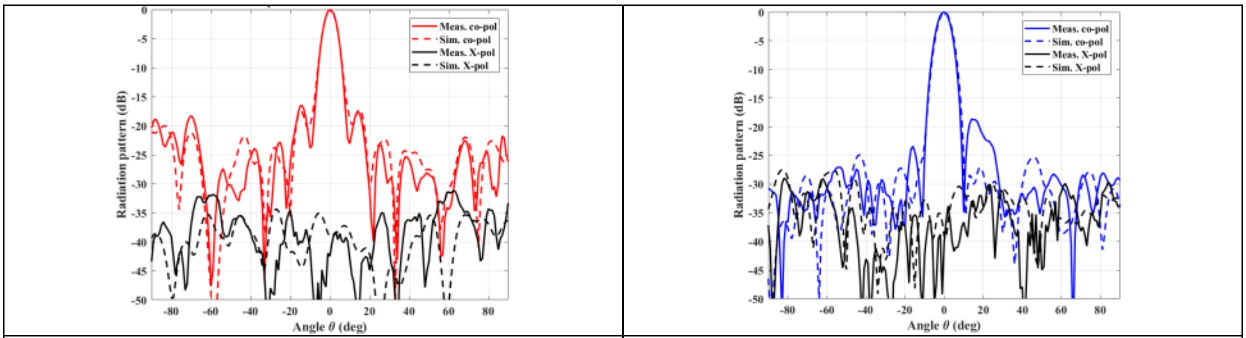


Figure 3 : radiation pattern test bench



E plane 60GHz	H plane 60GHz

Figure 4: Radiation antenna measurement

- Side lobe level (SLL) is < -16/-18 dB (E-/H-plane)
- Cross polarization is < -30/-28 dB (E-/H-plane)
- Full half power bandwidth is 8° in E-&H-plane

The beam scanning is obtained by moving the primary source

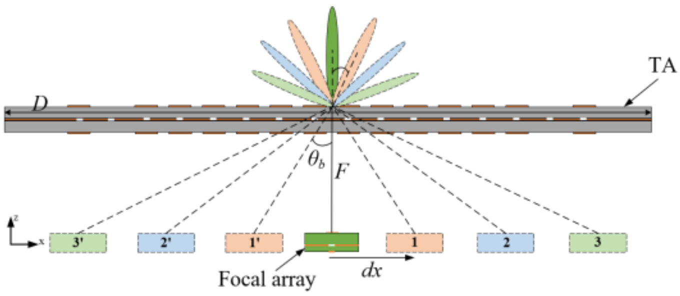
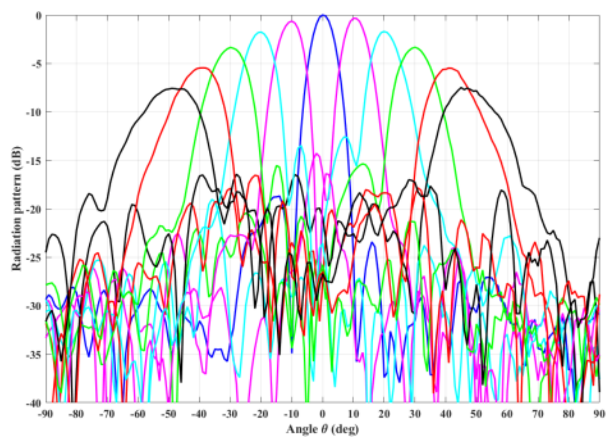


Figure 5: schematic diagram of the beam scanning



dx (mm)	θmax (°)	Gain (dBi)	SLL (dB)	HPBW (°)
0	0°	21.2	-18	7.7°
±3	10°	20.8	-15	8.2°
±9	20°	19.5	-11	9.5°
±12	30°	17.9	-13	11.9°
±18	40°	15.6	-14	13.8°

Figure 6: Radiation pattern of the unifocal TA in H-plane at 60 GHz

Unifocal means that the phase error in the aperture is minimum for one primary source position (usually at the centre corresponding to a 0° beam direction).

To improve the beam scanning performance, the principle is to design a multi-focal transmitarray antenna. Usually two symmetric primary source position are defined where the phase error will be minimized (figure). In our case, the focal position corresponds to a 33° beam direction.

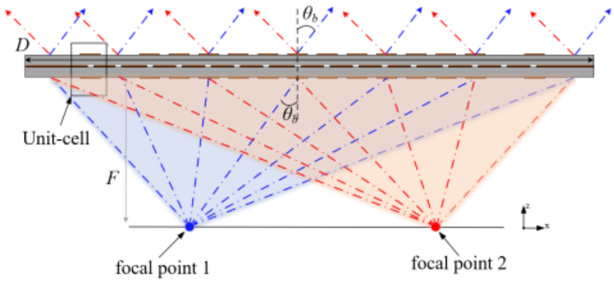
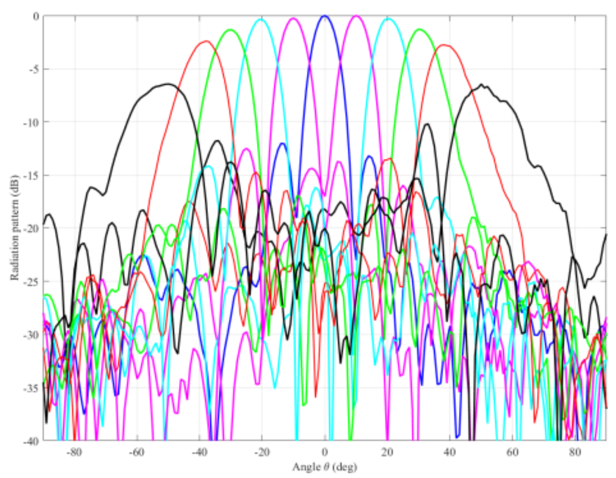


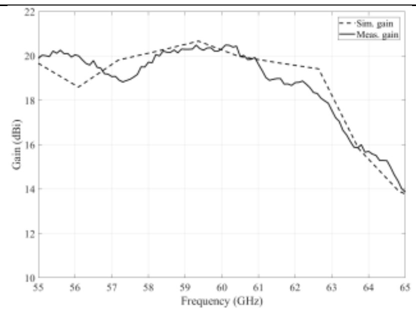
Figure 7: Schematic diagram of a bifocal TA



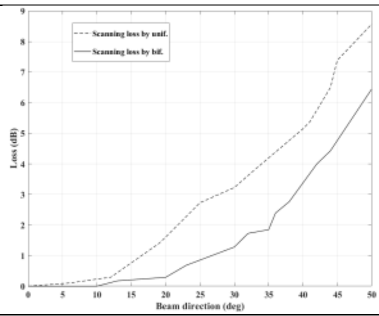
dx (mm)	θmax (°)	Gain (dBi)	SLL (dB)	HPBW (°)
0	0°	20.3	-13.5	8.2°
±4.5	10°	20.3	-14.4	8.6°
±9	20°	20	-16.2	8.8°
±13	30°	19.1	-16.4	10.8°
±16	40°	17.4	-10.7	13°

Figure 7: radiation pattern of the bifocal TA antenna in H-plane at 60 GHz

The scan loss is 2.9 dB at ±40° and the gain is around 20dBi.



Gain antenna



Scan loss for unifocal and bifocal TA

Figure 8: Gain antenna and comparison of the scan losses for unifocal and bifocal TA

In the case of a scan in both plane (azimuthal and elevation), it's possible to design a quadrifocal TA (figure 9).

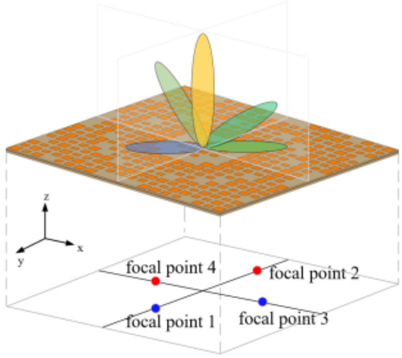
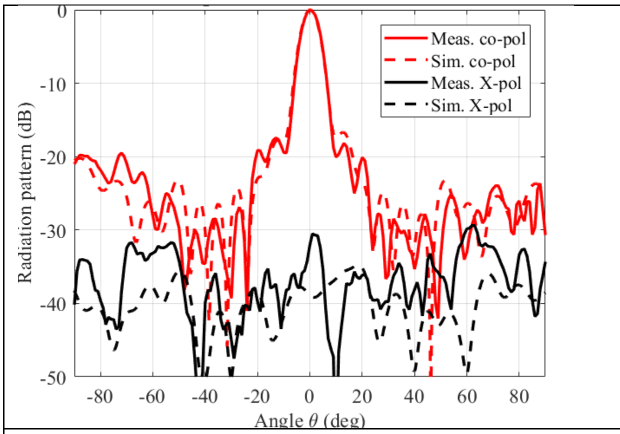
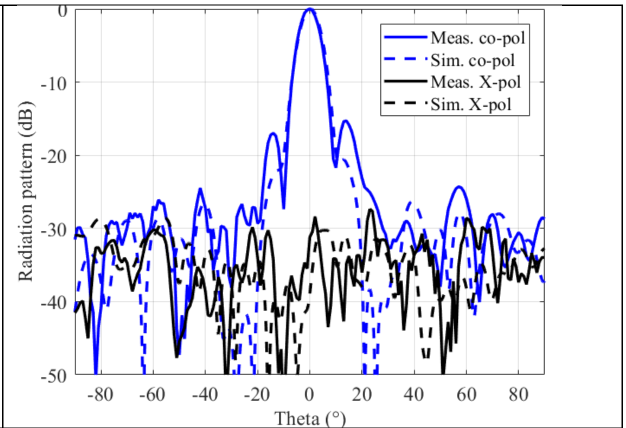


Figure 9: a quadrifocal TA

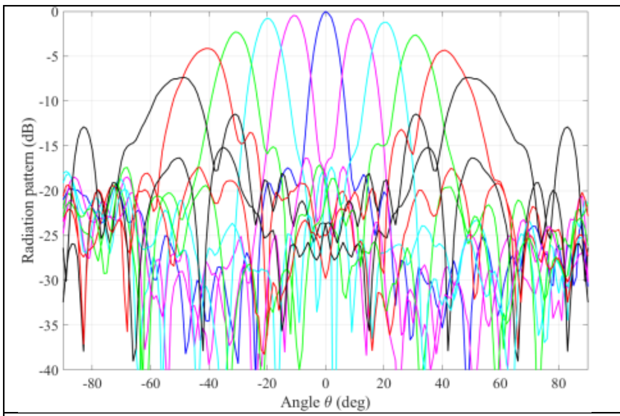


Quadrifocal TA 0° beam in the E plane

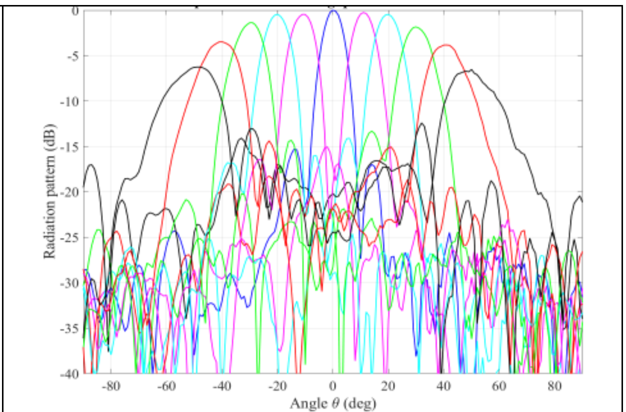


Quadrifocal TA 0° beam in the H plane

Figure 10: Comparison simulation- measurement of the radiation pattern of the quadrifocal TA



Measurement beam scanning in the E-plane at 60GHz



Measurement beam scanning in the H-plane at 60GHz

Figure 10: Measurement of the radiation pattern of the quadrifocal TA

	Unifocal TA	Quadrifocal TA
Loss (dB)	Angle range (E/H plane)	Angle range (E/H plane)
1	±14°/±16°	±22°/±25°

2	±20.7°/±21.8°	±29.4°/±31°
3	±30.5°/±27.9°	±35.2°/±36.7°
4	±36.5°/±34.1°	±40°/±40.2°
5	±40.9°/±39.3°	±43°/±44°

The angular range with scan losses below 2dB are respectively of 40° for the unifocal TA and 60° for the quadrifocal TA.