SIGNAL ANTENNA SYSTEMS

XFP-103019 X-Band Flat Panel Series Antenna versus Standard Gain Horn

Flat Panel Array (FPA) antenna technology is a novel approach to array antennas developed at Signal Antenna Systems (SAS). In this article an FPA antenna is presented. Both electrical and mechanical characteristics of the X-Band FPA antenna are discussed and compared to a conventional standard gain horn antenna.

For many applications requiring a directional antenna with medium gain, a horn antenna is the common choice. The horn antenna has been in a class of its own without much challenge from other types of antennas, but this usual approach is changing. FPA antennas allow radiational performance like horn antennas but do not require excessive depth of the horn, resulting in significant size and weight savings. Standard gain reference is the most common use of horn antennas; in a lab environment their extra size and weight are not significant considerations. In applications such as communications, radar, or telemetry the extra size and weight of a horn antenna can be a significant impediment to overall system size, weight, power and cost (SWaP-C).

Flat Panel Arrays have been developed with a focus on more demanding applications. FPAs typically offer 3:1 material volume saving when compared to a horn antenna of the same aperture area. As panels these antennas can be easily mounted to a flat surface with minimal protrusion or placed on a multi-axis gimbal with a minimal design effort. Being waveguide radiator type designs, FPAs have excellent power handling akin to horns. Unlike most horns, FPAs are designed with a low loss dielectric cover (“radome”) providing an environmental seal and allowing for internal pressurization when required. Additionally, FPA antennas can be combined into sub-arrays to realize a larger size array using external waveguide or coaxial combiners.

To illustrate antenna characteristics trade-offs, the XFP-103019 X-Band FPA antenna is compared to a pyramidal horn antenna, specifically L3 Narda ATM model # 90-442-6. The L3 Narda ATM model # 90-442-6 radiating aperture area is 4.87”x3.62”; for ease of comparison, it is modified to 3.6"x3.6" in this analysis. Horn length of 10.06” is maintained in this comparison. Both antennas are analyzed using CST Microwave Studio and antenna characteristics are summarized in Table 1.

TABLE 1: FP ARRAY and HORN ANTENNA COMPARISON

	FP Array Antenna (XFP-103019)	X-band Horn (Model # 90-442-6)
Frequency Band	8.5 - 11.5 GHz	8.2 - 12.4 GHz
Bandwidth	30.0 %	40.7 %
Directivity at 10 GHz	20.0 dBi	19.6 dBi
3-dB Beamwidth 10 GHz	E-Plane: 17.3 deg H-Plane: 17.5 deg	E-Plane: 16.6 deg H-Plane: 22.4 deg
Return Loss	-15 dB (typical)	-25 dB (typical)
Antenna Depth	0.8”	10.06”
Material Volume	1.8 in3	5.5 in3
Antenna Aperture Area	3.6"x3.6"x0.8"	3.6"x3.6"x10.06"

Owing to their non-resonant nature, horn antennas have wide operational bandwidth supporting the entire waveguide band. In contrast SAS Flat Panel Arrays are a special type of slotted array antenna which are inherently resonant. Nevertheless, FPAs achieve 30 percent operational bandwidth, which is adequate for many practical applications. The XFP-103019 X-Band FPA antenna has an operational bandwidth of 3.0 GHz at 10.0 GHz center frequency.

Figure 1 shows directivity of the XFP-103019 FPA versus the modified model # 90-442-6 horn antenna. The horn antenna linear directivity versus frequency, while the FPA has a flatter, band-optimized directivity curve. To a large extent the Flat Panel Array and the horn antenna have similar directivity and gain.

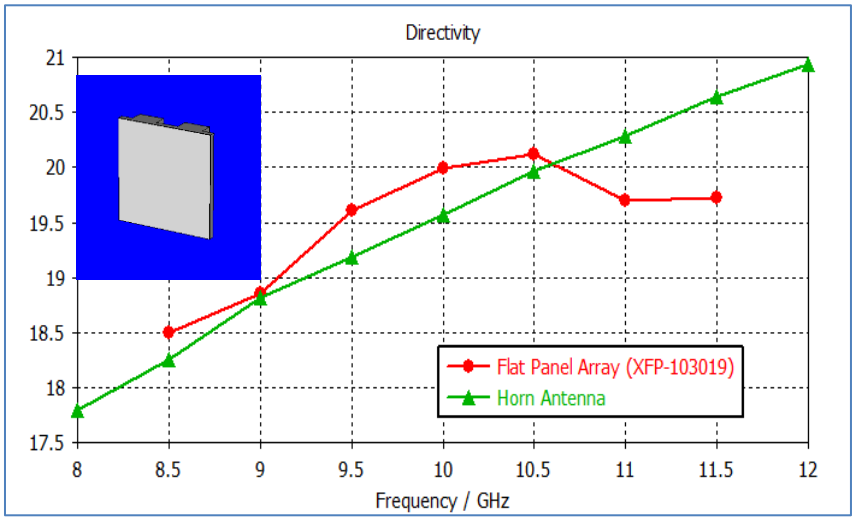
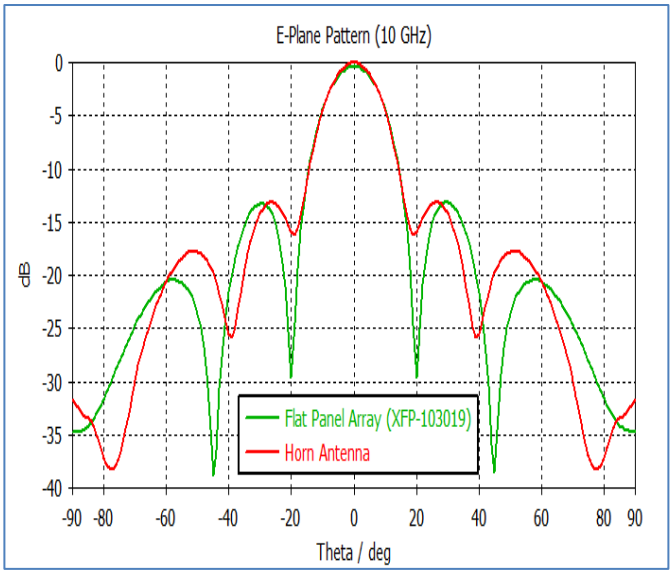


Figure 1: Directivity of FP Array (XFP-103019) and Horn Antenna (Modified Model # 90-442-6)

Next, comparing radiation pattern properties of two antennas, Figure 2 shows E and H plane radiation patterns of the two antennas at 10 GHz. Noting that both antennas have square size apertures, the Flat Panel Array has identical beamwidth in E and H planes while the horn antenna beamwidths are different between two planes. Due to wider H plane beamwidth, the horn antenna is typically designed with an asymmetrical (wider) aperture to compensate for beamwidth difference. Both antennas have similar beamwidth behavior over frequency as shown in Figure 3.

Direct comparison of sidelobes between two antennas is not practical. Horn antenna sidelobes are a function of antenna length and flare angle. FPA antenna sidelobes are defined by amplitude tapers across array dimensions. Typically, FPAs have uniform amplitude taper to maximize aperture gain; as a result sidelobes are typically around -12 dB in both planes. Lastly, input return loss of the two antennas is shown in Figure 4. The Flat Panel Array antenna has bandpass-type return loss behavior with typical return loss of -15 dB, while the horn antenna has broadband return loss behavior with typical value of -25 dB. In summary, electrical performance of the two antennas is highly comparable without significant trade-offs.

Turning to mechanical properties of the two antennas, the contrast is stark when it comes to overall depth. A horn antenna requires extended length (or depth) to maintain phase error which also limits maximum directivity of the horn. FPA antennas do not have phase error limitations and their depth is only a function of waveguide height. As a result, X-Band Flat Panel Array antenna depth is only 0.8 inches while a horn antenna depth is 10 inches.



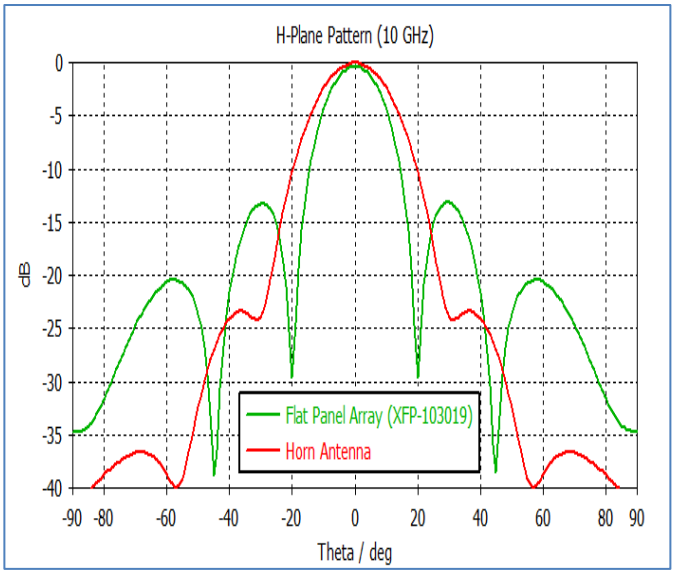


Figure 2: E and H Plane Radiation Patterns of FP Array (XFP-103019) and Horn Antenna (Modified Model # 90-442-6)

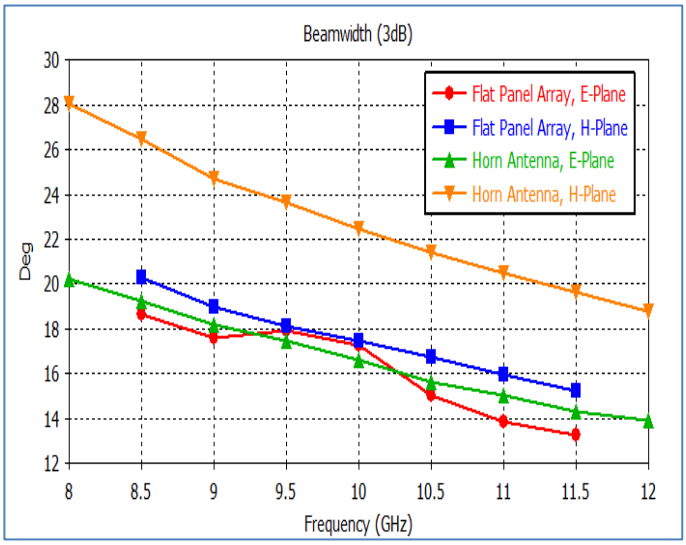


Figure 3: 3-dB Beamwidth versus Frequency for E and H Planes of FP Array and Horn Antenna

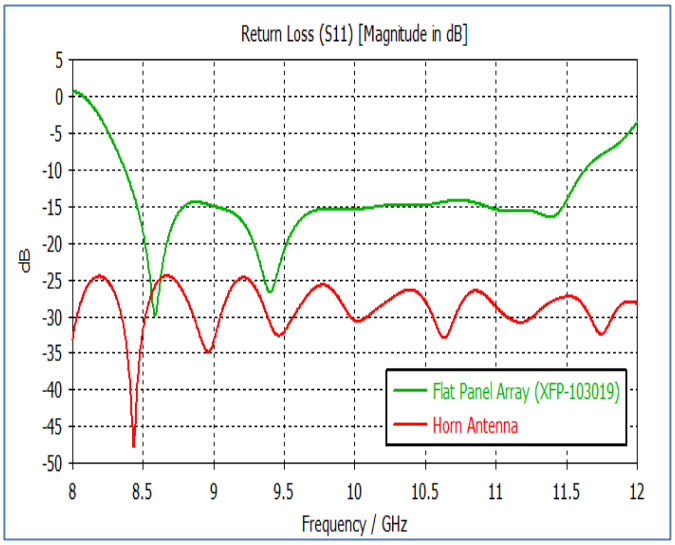


Figure 4: Return Loss of FP Array and Horn Antenna