A Lightweight Broadband Dual Polarized Base Station Antenna for All Bands of UHF DVB-H Mobile TV, CDMA and GSM

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I- Introduction:
Base station antennas of mobile communications are required to generate narrow vertical beam widths and wide horizontal beam widths. They are also demanded to achieve two orthogonal polarizations. Arrays of crossed dipoles are commonly used as base station antennas for mobile communications [1]. However, they are heavy in weight, high in coast and they have a high wind resistance. Furthermore, they have limited frequency bandwidths which are not sufficient for recent expansions in mobile applications such as mobile TV and WiMax. In this research, a base station antenna that overcomes these problems has been developed using dual parabolic cylindrical reflectors [2]. The new base station antenna covers a frequency band ranging from 450 MHz to 960 MHz with 72% bandwidth. Thus, it can cover all the bands of 450 MHz WiMax (450 MHz-470 MHz), UHF mobile digital TV "DVB-H" (470-862 MHz), 700 MHz WiMax (698-806 MHz), CDMA/GSM800 (824-894 MHz) and E-GSM900 (880-960 MHz).

Fig.1 shows the geometry of a dual parabolic cylindrical reflector antenna. It consists of two parabolic cylinders S_1 and S_2 with focal lengths F_1 and F_2 and a feed F positioned on the focal line of S_2 [2]. Dual parabolic cylindrical reflector antennas can generate arbitrary horizontal and vertical beam widths with arbitrary ratios between them. However, conventional dual parabolic cylindrical reflector antennas have some serious problems when they are used as UHF base stations. They are heavy in weight and they have high wind resistance. Furthermore, no small size UHF feed antenna is available with a broad bandwidth that is sufficient for the above applications. UHF feed antennas are large in size and, therefore, they cause severe blockage for the sub-reflector and/or the main reflector [3]. A novel small size broadband dual polarized resonant feed is developed with the required bandwidth. The new feed antenna is used with a low-coast, lightweight grid dual parabolic cylindrical reflector antenna having a low wind resistance.

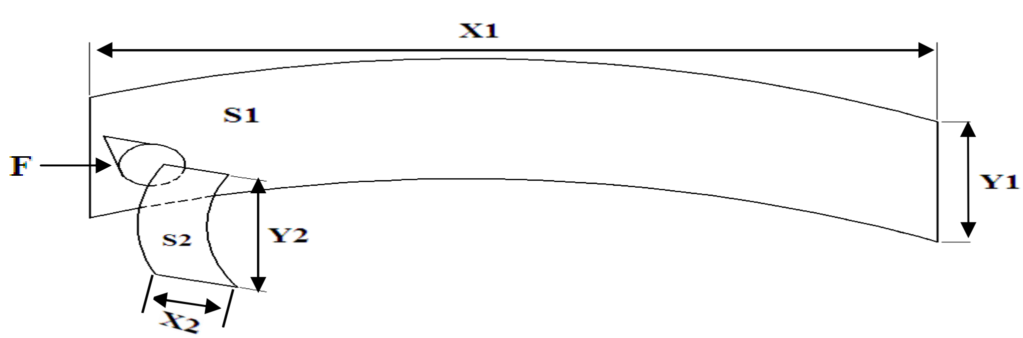

Fig.1 A dual parabolic cylindrical reflector antenna

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II- Geometry of the new wideband dual polarized resonant feed:

Fig.2 shows the geometry of the new broadband resonant feed antenna. It consists of two narrow printed metallic arms connected together by a short metallic strip. The length of the short arm is L_1 and its width is W_1 while the length of the long arm is L_2 and its width is W_2. The thickness of the antenna is T_a and the antenna is fed at a distance F_a from the shorted edge. Each arm has a set of slots having different shapes which are optimized in order to maximize the bandwidth of the antenna. The new antenna is completely self-contained and it does not need an additional ground plane, a matching circuit or any other component. Furthermore, the new feed antenna is made of a flexible material and it can be bent or folded in different forms.

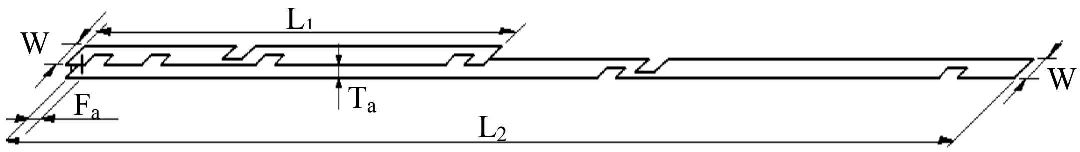

Fig.2 Geometry of the new feed antenna

A UHF prototype of the new broadband feed antenna is designed and manufactured as shown in Fig. 3. The dimensions of the antenna are: L_1 =11.5 cm, L_2 = 25 cm, W_1 = 2.6 mm, W_2 =3.5 mm and T_a = 2 mm. Thus, the overall size of the new UHF feed antenna is 25 x 0.35 x 0.2 = 1.75 cm^3. The performance of the new antenna is numerically calculated by a software packages that uses the moment method. It is also measured at IMST antenna labs in Germany [4]. The radiation patterns of the new antenna alone (without parabolic cylindrical reflectors) are omni-directional and they are sensitive to only one polarization as shown in Fig.3. To make the new feed antenna sensitive to two perpendicular polarizations, it is bent by 90°. Fig.4. shows a bent antenna and its measured dual polarized patterns at 700 MHz.

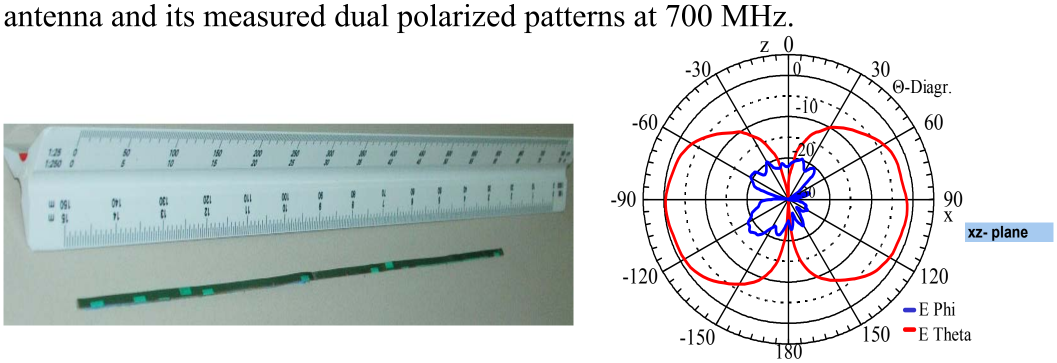

Fig.3 A straight feed antenna and its radiation patterns at 700 MHz

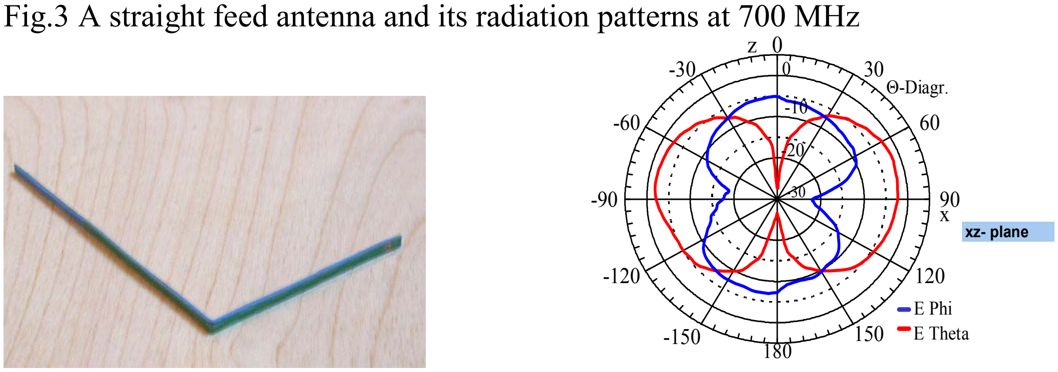

Fig.4 A bent feed antenna and its radiation patterns at 700 MHz

III- Grid dual parabolic cylindrical reflectors with the new feed:

A UHF prototype of dual parabolic cylindrical reflectors is designed and manufactured as shown in Fig.5. The Dimensions of the antenna are: F1=80 cm, F2 = 19 cm, X_1 = 210 cm, Y_1 = 30 cm, X_2 =32 cm and Y_2 = 30 cm. The reflectors are manufactured from 1 mm thick aluminum sheets. In order to significantly reduce the weight of the reflectors and also reduce the wind resistance, several holes are punched in the reflectors. The overall weight of the punched (grid) dual parabolic cylindrical reflector antenna is about 6 Kg. The new feed is located on the focal line of the sub-reflector [2]. Since the overall size of the new feed antenna is very small, it does not cause any considerable blockage for any of the reflectors.

Fig.5 A prototype of grid dual parabolic cylindrical reflectors

Fig.6 shows the measured return loss of the new feed antenna with the main reflector behind it. It is clear that the feed bandwidth covers all the above applications. On the other hand, the existence of the main reflector behind the feed antenna significantly modifies its radiation patterns. Fig.7 shows the calculated radiation patterns of the feed antenna with the main reflector behind it at 700 MHz. The gain of the feed antenna is about 9 dBi. The radiation patterns of the dual parabolic cylindrical reflector antenna with the new feed are calculated using GTD (geometrical theory of diffraction) [2]. A GTD software code was written for dual parabolic cylindrical reflectors with arbitrary feed patterns and its accuracy was verified experimentally [5]. Fig.8 shows the calculated radiation patterns of the new developed base station antenna with the new feed in two principal planes at 700 MHz. The gain of the antenna is about 15 dBi and the beam widths in two principal planes are about 105^o and 15^o.

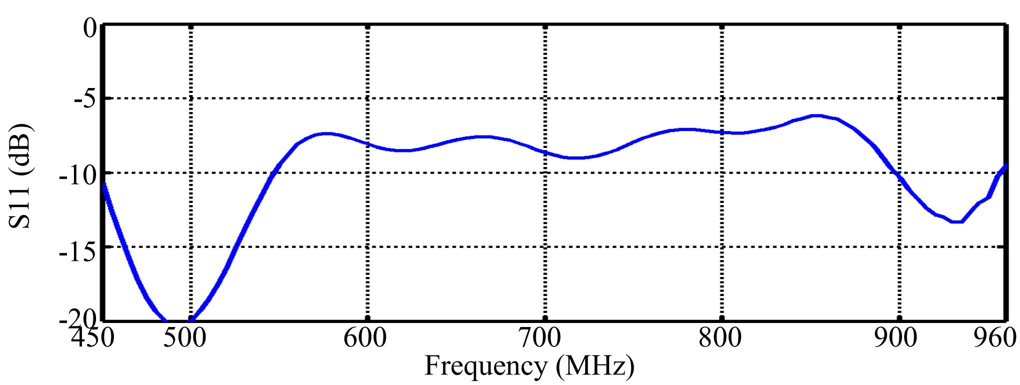

Fig.6 Measured return loss of the new feed with the main reflector behind it

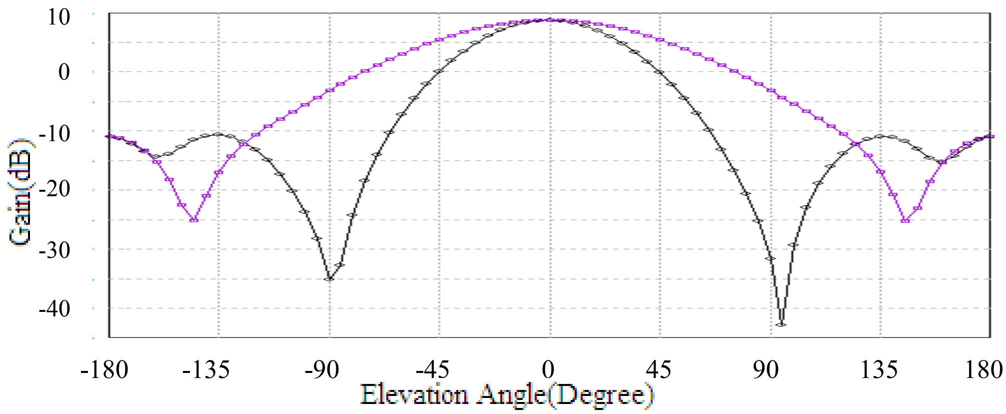

Fig.7 Radiation patterns of the new feed with the main reflector behind it

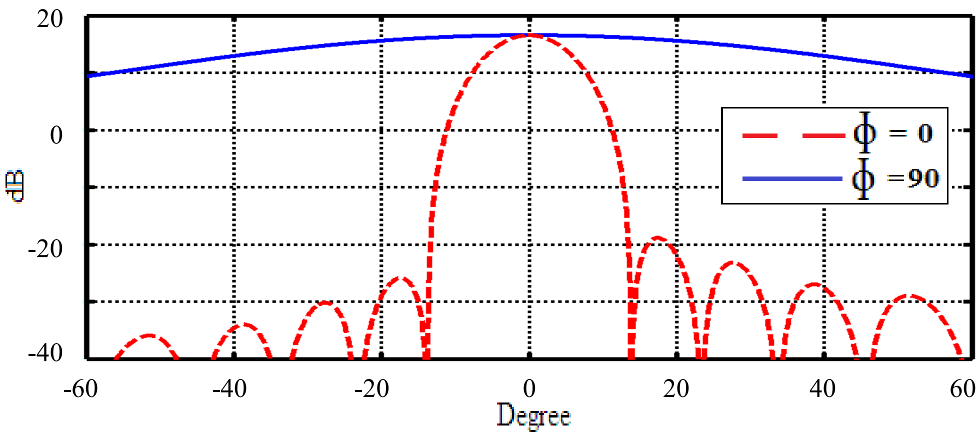

Fig.8 Radiation patterns of the new base station antenna at 700 MHz

IV- Conclusions:

A low-coast, lightweight grid dual parabolic cylindrical reflector antenna was developed with a novel broadband dual polarized resonant feed. The new base station antenna covered a frequency band ranging from 450 MHz to 960 MHz with 72% bandwidth. It could cover all the bands of 450 MHz WiMax (450 MHz-470 MHz), UHF DVB-H mobile digital TV (470-862 MHz), 700 MHz WiMax (698-806 MHz), CDMA/GSM800 (824-894 MHz) and E-GSM900 (880-960 MHz).

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