ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering
Vol. 2, Issue 5, May 2013

NEAR FIELD PATTERNS OF OFF FOCUS PARABOLOIDAL REFLECTOR AND OFFSET PARABOLOID

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Abstract: Radiation fields of the offset paraboloidal reflector illuminated by a prime focus feed and tilted feed employing the physical optics method. A set of curves generated by the optimum orientation of the axis of the feed for maximum antenna efficiency as a function of the offset angle β and the half angle α subtended by the reflector at its focus. A comparison on efficiency and side lobe levels is presented for different exiting angles of the feed.

Keywords: offset paraboloidal reflector, prime-focus, Side-lobe, Physical optics, cross polarization, rotational symmetric feed pattern, deviation angle.

I. INTRODUCTION

Some scientists [1] – [4] have explored the various aspects of the radiation characteristics of the offset paraboloids. In another publication [5] Rudge and Adatia presented a detailed survey in this topic. Jamnejad-Dailami and Rahmat-Samii [6] highlighted that the side-lobe levels in the symmetric plane could be improved by orienting the axis of the prime-focus feed along the direction of an incident ray, for which the reflected ray from the antenna passed through the center of the projected aperture. This improvement was found to be, to some degree, at the expense of the co-polar side-lobe levels and the peak cross polarization in the asymmetric plane. However the effect of feed orientation on the reflector efficiency was not indicated.

II. ANALYSIS

The geometry of the antenna is shown in Fig.1. For estimating the secondary fields, three Cartesian coordinate systems with their associate spherical coordinate [7].

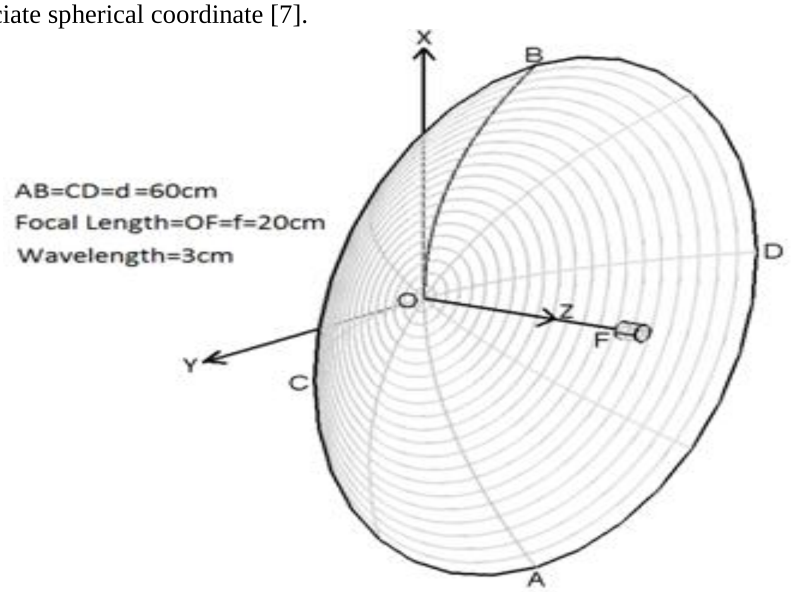

Fig. 1 Paraboloidal reflector designed for focal length of 20cm and wavelength of 3cm.

$$x = x' \cos\beta - z \sin\beta; \quad y = y'; \quad z = x' \sin\beta + z' \cos\beta. \tag{1}$$

A set of relationships can also be achieved between x,y,z and x', y',z' system by replacing x,y,z. with x',y',z' and β in (1). The reflector surface in the x,y,z system is given by

$$r = r\, 2F / (1 + \mathrm{cps}\,\theta \cos\beta - \sin\theta \sin\beta \cos\Phi) \tag{2}$$

Where F is the focal length of the parent paraboloid. The physical optics current method [8] is straightforward when the feed axis is different from the cone axis. The secondary electric field may therefore be obtained from

$$Es(\theta'.\Phi') = -j/\lambda r'(\exp\left(-jkr \int_0^{2x} \int_0^{\alpha}(n\, X\, \rho\, X\, Ei\right).\exp(jkr.r')ds \tag{3}$$

Where k=2Π/λ and n is the unit normal to the reflector surface. Where E_i is the incident electric field from the feed. A rotational symmetric feed pattern which produced a linearly polarized field along the x' axis is selected [9], and it is given by

$$Ei = cos^m \theta^n [\theta'' cos\phi'' - \phi'' sin\phi''] \exp(-jk!r!)/ !r! \quad 0^{o} < \theta'' < 90^{o} \tag{4}$$

Where m is a constant.

III. NUMERICAL RESULTS

From equation (3) the antenna efficiency was calculated numerically for different orientations of the feed. The optimum deviation angle of the feed axis from the cone one, to achieve the maximum efficiency, is plotted in Fig. 2

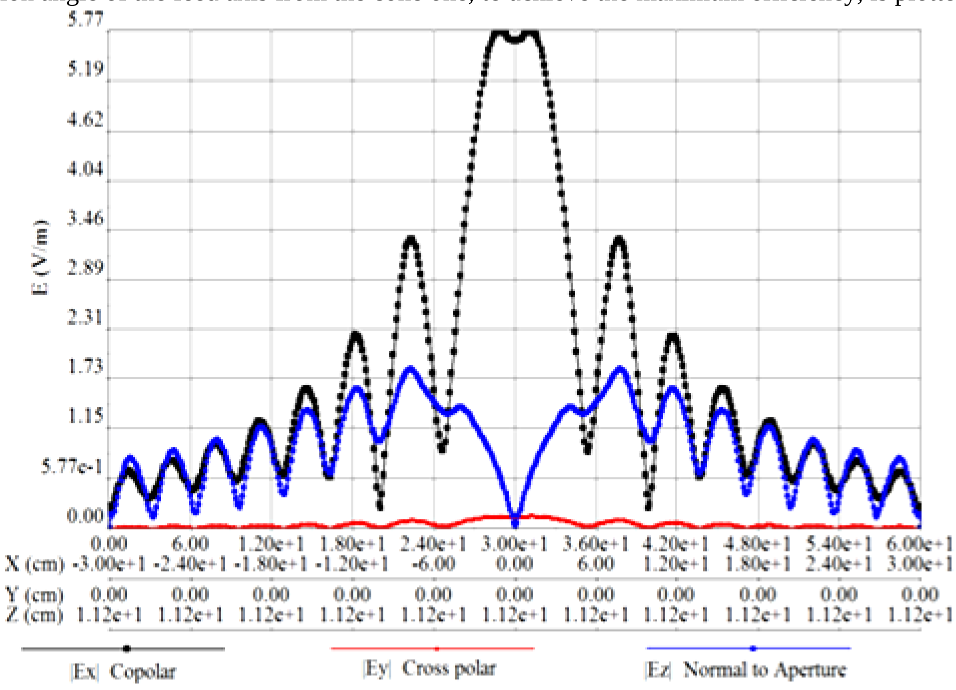

Fig. 2 Feed at Focus: E-Field variation along Line AB on the aperture plane.

As a function of half angle α for different offset angles β. Fig.2, Fig.3 & Fig.4 are the results of prime focus paraboloid (feed is at focus). For this case Directive Gain = 34.21 dB. Feeding is done such a way that the co-polar component of the aperture fields is in x-direction. Therefore the cross polar component of aperture fields are in Y-direction. The Z-directed fields on the aperture are non-radiating fields (not important field component).

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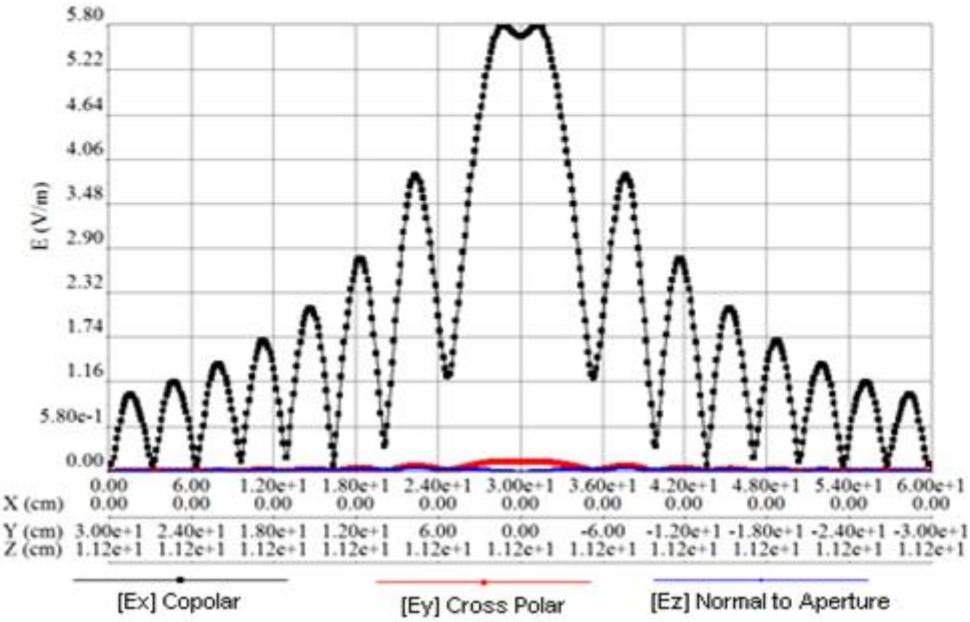

Fig. 3 Feed at Focul: E-Field variation along Line CD on the Aperture plane.

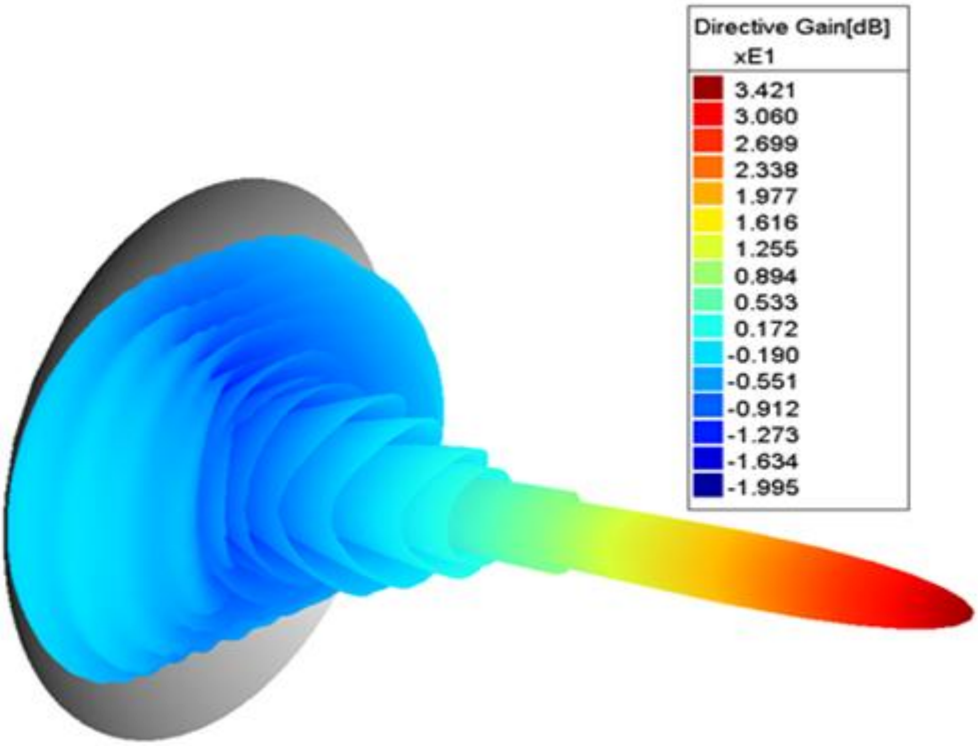

Fig. 4 Directive gain of prime focus paraboloid aperture diameter=60cm, Focal length=20cm Frequency of operation=10GHz.

Fig.5, Fig.6 & Fig.7 are results of feed lowered by 2cm. For this case Directive Gain = 30.11 dB. The co-polar fields (E_x) of Fig.2 and Fig.5 are shown in Fig.8 to highlight the effect of the feed displacement (E = plane, ϕ = 0 deg.).

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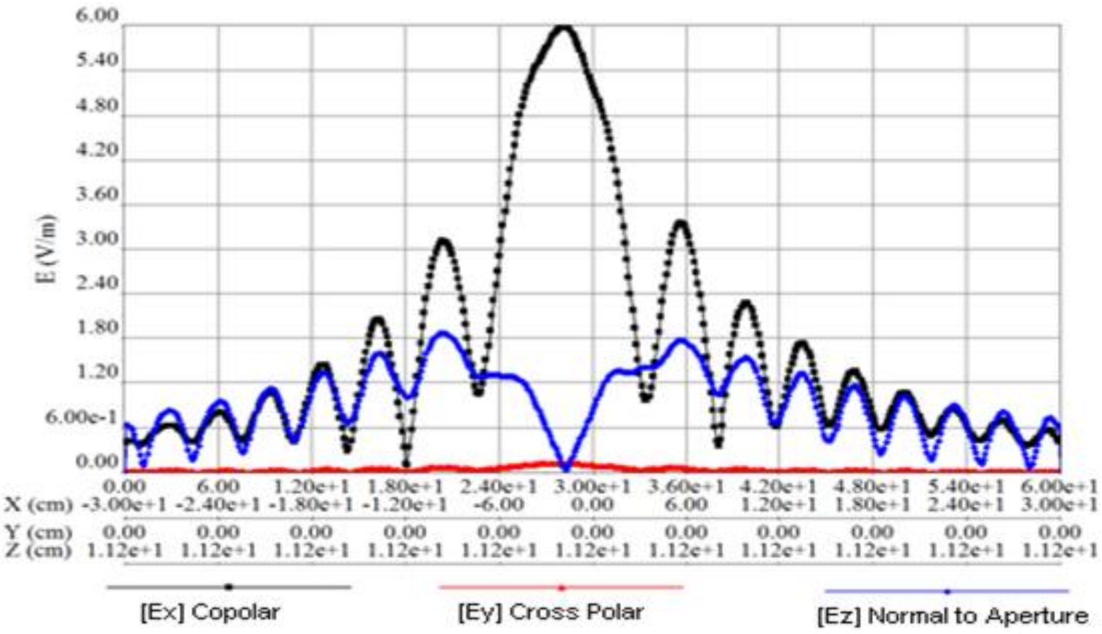

Fig. 5 Feed lowered by 2cm: E-field variation along line AB on the aperture plane.

The co-polar fields (E_x) of Fig.3 and Fig.6 are shown in Fig.9 to highlight the effect of the feed displacement (H = plane, ϕ = 90 deg). If we observe Fig.2, Fig.3 and Fig.5, Fig.6 the cross polar component fields (E_y) are very small compared to the co-polar fields (E_x).

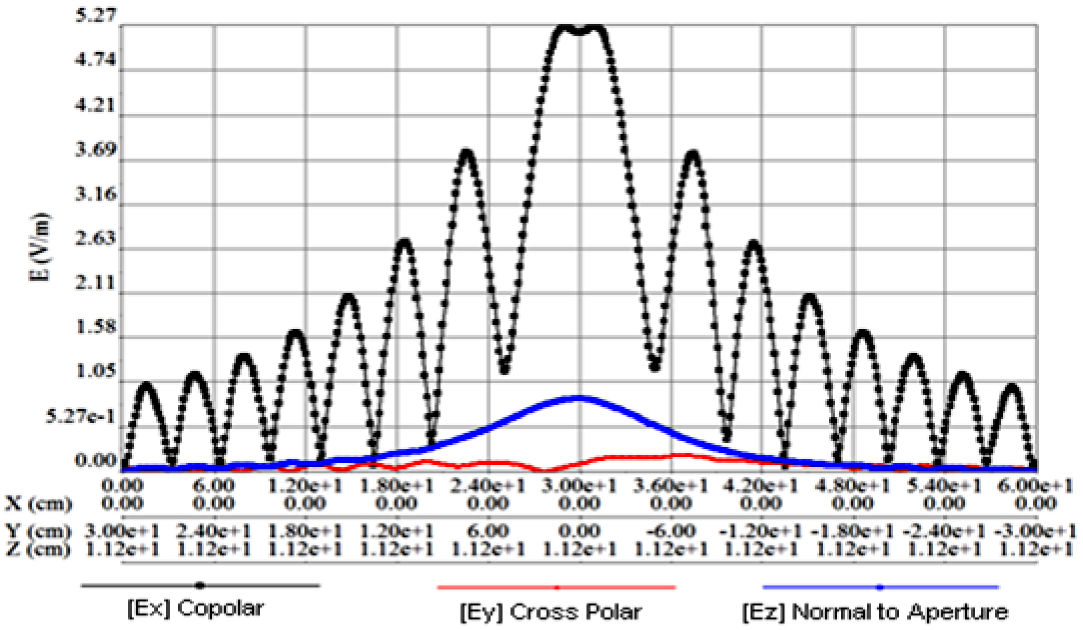

Fig. 6 Feed lowered by 2cm: E-Field variation along Line CD on the Aperture plane.

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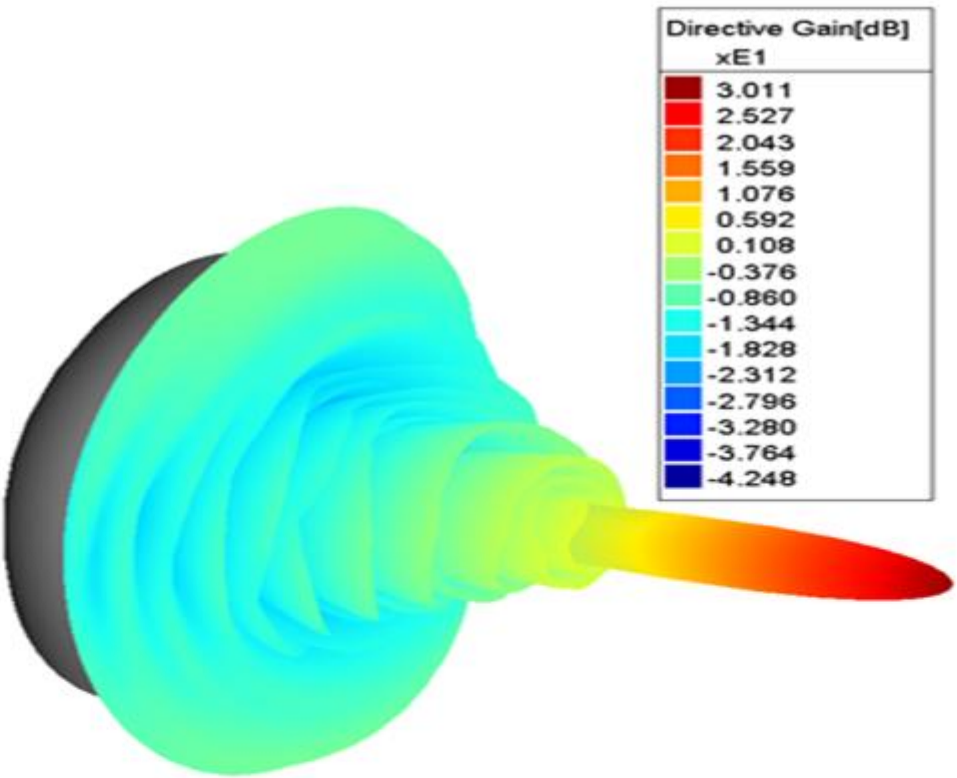

Fig. 7 Feed lowered by 2cm

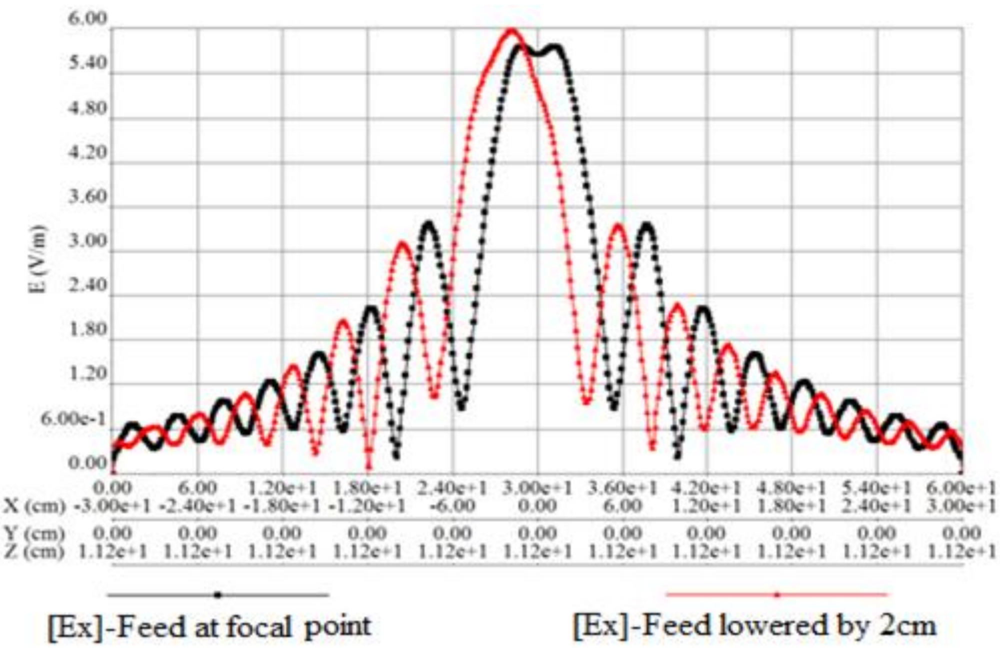

Fig. 8 Copolar component on the Aperture plane along Line AB

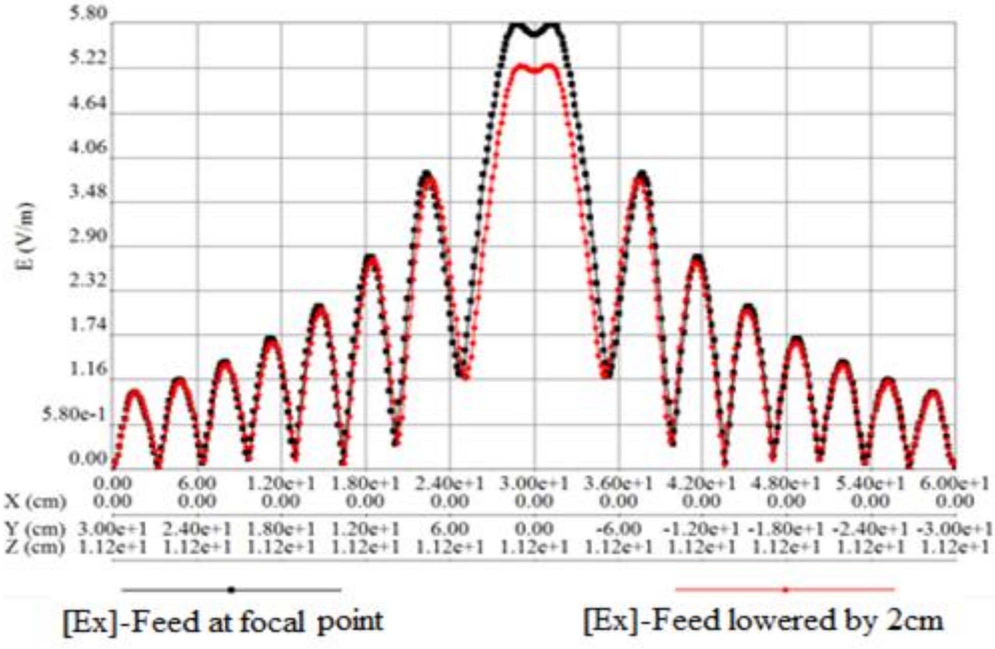

Fig. 9 Copolar Component on the Aperture plane along Line CD

IV. CONCLUSION

It can be concluded that among the three cases considered the reduction of side-lobes in the symmetric plane is more significant when the feed is along the central aperture direction. As pointed out in the optimum side-lobe levels in the symmetric plane. The maximum deterioration of the peak cross polar level, encountered in the asymmetric plane, is about 1.2dB in the different cases considered. The peak cross-polar level can be controlled by employing the matched field method. Therefore the optimum overall side-lobe level can be expected, especially for reflectors of smaller F/D ratio, by illuminating the reflector with a tilted matched feed.

ACKNOWLEDGMENT

We would like to express our thanks to the department of ECE and Management of KL University for their support and encouragement during this work. We also express out thanks to the department of ECE of CMJ University for providing facilities for the research work. Further author like to express sincere thanks to Prof. N. Venkatram, Associate Dean, Electrical Sciences, KL University for providing R&D facilities at KL University to carry out this work.

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