CHAPTER-6

CONCLUSIONS AND FUTURE SCOPE

This chapter presents the conclusions and the summary of the investigations carried out on the low cross-polarized antenna system. Section 6.1 describes the conclusions and the important findings of the research. Some of the recommendations for further investigations are included in section 6.2.

6.1 CONCLUSIONS

In this thesis, a problem of suppressing the undesired high cross-polarization and removing the beam squinting effects of an offset parabolic reflector antenna was undertaken. After carrying out detailed literature survey, it was decided to solve the problem by optimizing the primary feed employing the conjugate field matching technique. Three such feeds (rectangular, cylindrical, and corrugated) have been designed, fabricated and tested with the offset parabolic reflector antenna. Development of three such feeds leads to the important technological development in the field of antenna design. The conclusions drawn from the investigations can be briefly summarized as follows:

- Matched feed effectively suppresses the unwanted high cross-polarization introduced by the offset geometry in an offset parabolic reflector antenna. It also removes the beam squinting when circular polarization is employed.
- In a matched feed, it is necessary that the tangential electric fields at the aperture of the primary feed should be complex conjugate to the focal plane fields of the offset reflector antenna. In order to achieve this matching, the primary feed should support the appropriate higher order mode(s), in addition
to the fundamental mode. Such modes in case of a smooth-walled cylindrical feed are TM$_{11}$ and TE$_{21}$ with the fundamental TE$_{11}$ mode, TE$_{11}$ mode with the fundamental TE$_{01}$ mode in a rectangular feed, and HE$_{21}$ mode with the fundamental HE$_{11}$ mode in a cylindrical corrugated feed.

- For satisfactory operation of the matched feed, it is necessary that the higher order mode(s) should be added in proper amplitude and the phase with respect to the fundamental mode. It has been observed that the amplitudes of the higher order modes strongly depend on the reflector geometry, i.e., F/D ratio and offset angle ($\theta_o$). For all the three matched feeds, it was noticed that only a specific proportion of the higher order mode results in the least peak cross-polarization in the secondary radiation pattern.

- In case of a rectangular matched feed, the higher order TE$_{11}$ mode should maintain a quadrature phase relation with the fundamental TE$_{01}$ mode. However, in a cylindrical structure, in-phase relationship is required between the TM$_{11}$ and TE$_{11}$ mode, while a quadrature phase relationship must be satisfied for the TE$_{21}$ mode with respect to the dominant TE$_{11}$ mode. Similarly, in a corrugated matched feed, the additional HE$_{21}$ mode should be -90° out of phase with reference to the principal HE$_{11}$ mode.

- It was observed that, the higher order asymmetric mode in the matched feed generates high cross-polarization in the Phi = 90° plane of the primary (feed) radiation pattern. However, this high cross-polarization of the feed counter balances the effect of high cross-polarization in the secondary radiation pattern of an offset reflector.
• During the study it was found that, to generate the higher order modes, the use of arc-shaped septums in place of the cylindrical posts, results in better return-loss performance of the feed.

• Through simulation study, it was proved that the use of matched feed in place of conventional feed, improves the beam efficiency of the offset reflector antenna. Thus, the matched feed can become the preferred option for the future remote sensing radiometer antennas where high beam efficiency is essential.

• During the fabrication of the feed, utmost care should be taken to maintain the specified fabrication tolerances. A slight variation in the feed dimension may degrade the performance of the reflector.

• While measuring the far-field radiation patterns of the reflector, it is very necessary to set the correct alignment of the feed with the reflector. A slight displacement of the feed from the focus of the reflector affects the performance of the feed and the reflector.

• Matched feeds are very suitable for offset reflector configurations having low F/D ratio. Therefore, in practical applications where the low F/D reflector is enforced due to space and weight constraints, the matched feed option can be more viable. Further, the feeds do not add any complexity or additional mass to the antenna structure as compared to the conventional feed.

• The cross-polar bandwidth should not be treated as the constraint for selection of matched feed as a primary feed for the offset reflector antenna. As discussed in Section 4.5, with a modified design of a tri-mode matched feed, it is possible to achieve more than 8 dB cross-polarization suppression over a 12 % bandwidth.
It is expected that, in near future, for many practical applications, including the beam-scanning, multiple spot beam generation, remote-sensing radiometers, monopulse tracking radars, etc. the matched feed will become the most preferred feed option with the offset parabolic reflector antenna.

6.2 **SCOPE FOR FUTURE WORK**

1. In the present thesis, the design and the experimental verifications of rectangular, cylindrical and corrugated matched feeds have been presented. Investigations on a multi-mode matched feed using elliptical wave guide structure may be carried out as an advancement of this work. This type of elliptical matched feed will be useful for an application where different beamwidths are required in both E and H planes, while maintaining the low cross-polarization in the secondary radiation pattern.

2. A modified design of a tri-mode matched feed with improved cross-polar bandwidth has been discussed in the thesis. Further investigations can be carried out to enhance the cross-polar bandwidth of a rectangular as well as a corrugated matched feed. In order to achieve the improvement in the cross-polar bandwidth, it will be necessary to maintain the required amplitudes and the phases of all the essential waveguide modes over a wide frequency range. This will be a challenging work and will need a new design concept and efficient modeling tools to implement the concept.

3. In the thesis, matched feed designs have been proposed for a single offset parabolic reflector antenna. A new matched feed can also be designed for a shaped offset reflector [21] in which the offset reflector profile is deformed to generate a contoured beam or a shaped beam.
4. The feed configurations (rectangular, cylindrical, and corrugated) considered in the present thesis fall under the category of waveguide feed structure. Considering the advantages of a planar structure (e.g., microstrip patch), the conjugate field matching concept can be employed to design a planar matched feed for the offset reflector antenna. However, for such a planar matched feed, one has to first find out the necessary feed excitation coefficients such that the fields radiated by the feed nullify the cross-polarization produced by the offset geometry.