PREFACE

The focussing ability of microwave energy has aroused considerable research interest in its bio-medical applications including hyperthermia for many years. Hyperthermia is one of the therapeutic modalities considered for cancer treatment. To-date, different types of antenna applicators at microwave frequencies such as waveguides/horn antennas/conformal antennas have been reported in the literature for hyperthermia. Researchers are continuing to refine the existing waveguide/horn/conformal antenna applicators and devise better applicators so that these systems can provide enhanced heating depth in the medium to treat tumors at greater depth.

The present work is motivated in part by the need to design and develop efficient, practical, non-invasive, direct-contact horn antennas/conformal antenna as hyperthermia applicators, which can provide greater penetration depth (PD) in bio-medium/bio-media, have the focusing ability and/or remain compatible remain with the curved portion of the human body. The simulation, experimental, and/or theoretical investigations of the fields, SAR and temperature distributions in a bio-medium/bio-media owing to water-loaded diagonal horns/conformal antenna applicators carried out during the course of the research work are described in six chapters.

A brief introduction and review of waveguide/horn and planar antennas already investigated by researchers for hyperthermia applications at microwave frequencies are given in chapter 1.

Conventional metal diagonal horn (MDH) has attractive radiation properties such as reasonable gain as well as beamwidth, and its radiation pattern in the far field possesses almost perfect circular symmetry so that the 3, 10 and 20 dB beamwidths are very closely equal, not only in the principal E- and H-planes, but also in the 45^{o} and 135^{o} planes, which would result in circularly symmetric field distribution in the bio-medium/bio-media. Due to these characteristics, conventional MDH has the potential to be used as hyperthermia applicator for the treatment of spherical (near spherical) tumors in superficial region of the body.

Chapter 2 provides simulation, theoretical and/or experimental studies on water-loaded conventional MDHs terminated in a bio-medium/bio-media without/with tumor for hyperthermia application at 2450 and 915 MHz. It has been found through the study of SAR and temperature distributions in the bio-medium/bio-media that although the horn studied in chapter 2 provides circularly symmetric heating pattern, the PD in the bio-medium/bio-media is not good enough.

In chapter 3, water-loaded improved MDHs are investigated through simulation, theoretically and/or experimentally for hyperthermia application at 2450 and 915 MHz. An improved MDH is obtained by introducing two pairs of conducting pins at appropriate locations near the aperture of conventional MDH. Due to presence of conducting pins, the resultant field over the aperture of each of the improved MDH antennas designed at 2450 and 915 MHz and terminated in a bio-medium/bio-media corresponds to a combination of TE_{10}, TE_{30}, TE_{01}, and TE_{03} modes which are significant. Hence, field distribution over the aperture of each improved MDH is a closer approximation to the uniform distribution that may ensure uniform absorbed-power distribution in the bio-medium/bio-media and prevent steep power gradient in bio-media. It is determined through the study that water-loaded improved MDHs described in this chapter provide circularly symmetric heating patterns and effective field size (EFS) almost identical to those due to respective conventional MDHs (chapter 2) but values of PD in the bio-medium/bio-media without/with tumor due to the proposed improved horns are higher.

In chapter 4, water-loaded metal-dielectric wall diagonal horn (MDWDH) applicators are investigated through simulation and experimentally at 2450 MHz and through simulation at 915 MHz. A new form of diagonal horn is proposed in which the central portions of all the four walls of the respective conventional MDHs are replaced by Perspex dielectric ($\varepsilon_r' = 2.59$) while remaining wall portions are made of metal, considering the region of the antenna from throat to aperture. It is determined through the study that water-loaded MDWDHs presented in this chapter provide circularly symmetric heating patterns. Further, values of EFS and PD in the bio-medium/bio-media due to these horns are higher as compared to their conventional counterparts studied in chapter 2.

Applicators studied in chapters 2–4 are horn applicators. The disadvantages of waveguide/horn applicators are that these applicators are heavy, large in size and have fixed form of aperture. Therefore, an effort was made to design and develop a compact microstrip slot antenna for hyperthermia application at 2450 MHz. However, slot antenna has bidirectional radiation, which would expose the operator of the hyperthermia applicator to hazardous level of microwave. Keeping this aspect in view, a new conformal slot antenna integrated with a novel and compact artificial magnetic conductor (AMC) was studied for hyperthermia application and is described in chapter 5.

The major findings of the entire investigations are summarized in chapter 6. Furthermore, some of the future investigations associated with the present study are also described in this chapter.

The amplitude coefficients of the modes for determining the aperture electric field distribution for water-loaded conventional and improved MDHs employed in chapters 2 and 3 are obtained through theoretical analysis as given in Appendix-A.

The formulas for computing reflection coefficient at the interface between water-loaded conventional/improved MDH and the bio-media used in chapters 2 and 3 are derived in Appendix-B.

Experimental procedure for the determination of dielectric property of the prepared biological phantom (muscle) is given in Appendix-C.

Methods used for determination of dielectric property of the Perspex material used in fabrication of the horn presented in chapter 4 are given in Appendix-D.