This Research proposes a new set of microstrip antennas (MSA) with improved performances for wireless communications by combining the fractal and metamaterial concepts without compromising the miniaturized size. Microwave antenna is an ever active area of research because of its never ending demand in the modern communication era. What matters importantly in the demand is the profile of the antenna for modern wireless devices. Starting from large space occupying parabolic antenna, a variety of antennas have been invented, found in use and being investigated for improvements, all depending on the needs and intended areas of application.

However, due to the advancement of sophisticated technologies, the antennas need to shrink to fit smaller areas as the system itself has shrunk in size. Therefore, the increased demands on miniaturized antennas for robust communications with wireless devices, sensor networks, biomedical, implantable, automotive, wearable and radio frequency identification systems are never ending. The conventional MSA belongs to the miniature antenna category providing low profile such as planar, thin, less space occupancy, simpler, less expensive to manufacture and more compatible with printed-circuit technology. However, the MSA lacks multiband or broadband coverage and suffers from single resonance and low gain unless arranged to form stacking and arrays for enhancement which are against its low profile.

Fractal concept enables certain performances not previously possible with conventional MSAs. Two important self-similar and space
filling properties of fractal antenna (FA) increase the effective electrical length, reduce the size and make it frequency independent or provide multiband resonances. Recent research trends focus their attention on the metamaterials (MTM) for performance enhancement. The MTM means a negative refractive index material which does not exist by itself in nature and not formed from any chemical composition but prepared artificially with the structure of the substrate material on which the antenna pattern can be printed. Since the use of implantable medical devices (IMDs) for therapeutic and diagnostic purposes is found attractive, the need for suitable implantable antenna (IA) becomes more important. The preparation of IA for such purposes needs care in the design for sufficient amount of return loss, resonant frequency, gain and radiation properties.

In this Research, the investigations on the performances of some MTM loaded novel FAs in terms of return loss, resonance properties, bandwidth, gain and radiation pattern have been carried out. A third order microstrip low pass filter (LPF) has also been considered for optimum design using artificial neural networks (ANN) and its performance has been numerically verified. The same filter has also been loaded with a new MTM structure to experience the performance improvement.

Initially various novel FA shapes have been tried out including square and triangular indentations along the perimeter of a conventional rectangular and square MSAs. A multiple slip ring resonator (MSRR) with square patterns has been initially developed on a substrate material and later a complementary of this MSRR called complementary slip ring resonator (CSRR) has been created. The existence of negative medium properties for
both the MTMs has been verified using Nicolson Ross Wier (NRW) parameter retrieval method. Then two of the proposed FAs have been loaded with MSRR and CSRR MTMs to obtain improved performances.

A few of the antennas have been designed and simulated using Zealand IE3D electromagnetic (EM) simulation tool and the rest using ANSYS HFSS 3D EM simulation software. Finally some of the simulated antennas have been fabricated using photolithographic technique and the performances have been measured using Network Analyzer and Anechoic Chamber. The simulation and experimental results are in good agreement and showing reduction in return loss, multiple resonances, large bandwidth, enhanced gain and improved radiation pattern. A comparison of performances with the results presented already by various other investigators in the literature is also included at appropriate places.

The designed antennas and filter are suggested for applications in wireless communication and implantable devices in various frequency bands ranging from 1-20 GHz. An ANN trained and HFSS linked optimization algorithm has also been used to present the best design possibilities of the mainly proposed square fractal antenna (SFA) for the optimized results yielding broad band resonances with lower return loss in the microwave frequency spectrum of 1-12 GHz to meet out all the wireless standards specified in this range. The results of this Research work have been published in various International Journals and Conferences.