Preface

This thesis represents a culmination of work and better learning that has taken place in the last couple of years. The transformation of the energy sector is looking for clean energy technology that is also suitable for baseload power generation. Terrestrial solar energy has many obstructions, so solar power from space without any hindrance has higher priority for adoption, and it is suitable for continuous energy supply in the future. Due to its high estimated space launching cost, it was suspended in earlier attempts, but Technological advancements and research are going on worldwide, and its practical implementation could be possible by 2030. For the feasibility of satellite solar power station (SSPS), High power wireless transmission for large distance via Microwave is the key issue, and many techniques have been developed. Besides others, research should focus on the reduction of space segment's components dimension and space vehicle dispatch cost. As SSPS total system cost reduction is desirable, and therefore an economic model of the system is required where it has interrelated parameters that can be optimized for the high efficiency and cost-effective performance. Furthermore, a cost minimization method is derived, and results are investigated for economically efficient SSPS prototype design. The Derived generalized mathematical Expressions are appropriate to evaluate the cost-effectiveness and performance of the microwave-based wireless power transfer system. The effect of transmitting antenna size is investigated for the desired power density on the receiving ground antenna. The Levelized cost of energy (LCOE) is also calculated for the space-based solar system.

In satellite solar power station (SSPS) and wireless power transfer (WPT), the rectenna (antenna and rectifier) is an elementary part for receiving radio frequency (RF) energy and converting RF energy into DC power. Design of an efficient cost effective rectenna is full of technical challenges, and many rectennas or rectenna arrays have been already developed. A linearized circuit model can be used for analyzing rectenna performance, and with some modification an enhanced rectenna can be developed. Unlike the traditional rectennas, a new circularly polarized (CP) microstrip antenna with embedded slots is proposed which can be connected to rectifying circuit without harmonics filter. The designed antenna is then connected to rectifying circuit in two ways. One is conventional single source fed rectenna (SSFR), and other is proposed differential source fed rectenna (DSFR). For the comparison, an SSFR and a DSFR are fabricated and tested. Furthermore an enhanced rectenna with differentially fed antenna array is developed. Firstly, a linear antenna array is designed considering its side lobes less than -20 dB. Two antenna array, one with a single feed and other with differential feed is designed to operate at 5.8 GHz. The two antenna array, one with a single feed and other with differential feed is tested for RF energy harvesting. It is observed that the differentially fed rectenna has higher output DC power than the single fed rectenna. Furthermore harmonic harvester Rectenna integrated power management circuitry for improving RF-DC power conversion efficiency is developed. The circuitry is designed for battery charging or energy storage application; resistance emulation method is used to realize a matching load resistance at output terminals. The proposed technique is useful for harvesting near maximum output power from the dual rectifiers (fundamental and harmonics) independently. Also, it delivers the combined maximal power to the energy storage cell. The power management module based on dual input buck-boost converter with simple open-loop control is utilized.

In this thesis, cost minimization strategy of SSPS is presented. Many new rectennas are designed, and circuitry is developed for energy storage application. The technologies are not only beneficial for point to point wireless power transmission but also they could have many applications in low power ambient RF energy harvesting / RFID.