RECTENNA ELECTROMAGNETIC COMPATIBILITY CONSIDERATIONS

FOR SOLAR-POWER SATELLITE SYSTEMS

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ABSTRACT

There are 4 categories of radiations from the rectenna. These are reflections of the powering wave, harmonic, intermodulation product and spurious emissions. The mechanisms for, and modelling of these radiations are discussed, and the conclusion is drawn that mitigation techniques are necessary for solar-power satellite systems. The integration of these techniques on a 'typical' rectenna site is described.

TEXT

The electromagnetic compatibility (EMC) of rectennas with other electronic equipment is a critical issue for solar-power satellite (SPS) systems. Its prediction requires models for the 4 categories of radiations from the rectenna array, namely reflections of the powering wave, radiations of harmonics, of intermodulation products and of spurious frequency components.

Except for a narrow edge region, rectenna elements behave in an identical fashion, and unit cell concepts may be used to show that 100 % beam collection efficiency is theoretically possible. In a practical system, however, the rectenna foreplane and reflector are never perfectly matched to the incoming powering wave. As a result, some reflection occurs at the fundamental frequency ω_P. The distribution of this reflected beam about the specular direction will depend on the size of the array, the degree of phase coherence of the incident wave and the amount of variation in rectenna diode parameters.

The second type of radiation is caused by the nonlinearity of the rectifying diodes. Owing to the non-ideal nature of the rectifier filters which surround the diode, some energy at the harmonics will reach the antenna of each element and be radiated. These harmonics are radiated in all directions in which the energy from each element adds in-phase.

For the third category, the powering wave, in switching the rectifier diode on and off, acts as a 'pump' or 'local oscillator', setting up close to ideal conditions for mixing. Any ambient (communications) signal ω_S will be converted to frequencies of the form $\pm n\,\omega_S \pm m\,\omega_P$ where n and m are integers.

The last type of radiation is caused by the nonlinear junction capacitance of the diode. The pumping of this capacitance can create a negative resistance which couples to LC (filter) circuits across the diode. Parametric oscillations and their mixed products with ω_P can be significant from VHF to well above the second harmonic of ω_P. In addition, parametric amplification of ambient signals can occur.

The modelling of these radiations is discussed further and representative radiation levels are given. The conclusion is drawn that mitigation techniques must be used for all categories. Reduction of reflections at the powering frequency would involve sensing the load resistance and beam amplitude on each sub-array and employing dynamic reconfiguration of the rectenna element interconnection for improved RF matching to the incident wave. Harmonic (and intermodulation product) radiations can be reduced by tailoring the frequency response of the antenna, diode parameters and input and output filters of the rectenna for any problem frequencies. In addition, by careful frequency planning and choice of rectenna location, harmonics and expected intermodulation products can often be well offset from essential communications links, radio astronomy observatories, etc. Harmonic frequencies would probably receive a status similar to Industrial, Scientific and Medical (ISM) frequencies, where interference is possible and to be tolerated. Spurious radiations can be prevented at source by the choice of a rectenna diode with high enough series resistance to 'damp out' the negative resistance causing the oscillations. Another technique involves the development of specific rectenna diodes with reduced capacitive nonlinearity. Both methods reduce the power conversion efficiency of the rectenna from optimum.

The integration of these and other mitigation techniques on a 'typical' rectenna site is described, and suggestions for further work made.