DESIGN FOR THE STRUCTURAL SURFACE MATERIAL AT WHICH REFLECTION AND TRANSMISSION CHARACTERISTICS CAN BE CONTROLLED

SUMMARY

The rapid development of communication systems has leaded mobile applications to become widespread. Nevertheless, the radio spectrum is limited. The mutual interference among the adjacent wireless networks reduces communication speeds due to the extensive usage of unlicensed ISM bands in indoor environment. Secure personal communication within such wireless networks is also another important problem. Therefore, there is a growing need to control the propagation of electromagnetic waves within buildings.

These issues are becoming more and more important on each day and is being tried to solve by advanced signal processing techniques and antenna designs. Isolating the coverage areas of the wireless networks can be a useful solution for interference and security problems. Isolation can be achieved by converting indoor surfaces into band-stop frequency selective surfaces (FSSs). A small reduction in signal interference can increase the system performances significantly in mobile and wireless systems. An achievement of signal attenuation by 10 dB can reduce the separation required for frequency reuse by a factor of three. In addition, today's communications technologies demand FSSs of which their frequency selective characters can be changed to suit the purpose. Therefore, researches have been done on reconfigurable FSS that frequency response can be controlled actively. Therefore, the aim of this thesis is defined in order to control the transmission of extensively used 2.4 GHz and 5.8 GHz ISM bands.

Band-stop FSS characteristic is achieved by using periodic conducting arrays, which behaves as a filter for electromagnetic waves depending on its structure. The inclusion of lumped elements, such as varicaps, PIN diodes and etc. in specific locations within each unit cell of FSS allows control on the frequency response of FSS by changing the applied voltage bias. These surfaces are called as active or reconfigurable FSSs. Switching and tuning are two special features of these active surfaces.

In this thesis work, Ansoft HFSS v.15 software is used for analyzing the electromagnetic behavior of FSS. Equivalent circuit model is also used to determine the effects of the geometrical parameters of the FSS on the frequency characteristic of FSS.

In the first stage, multiple resonator structures are investigated for multiband passive FSS design. Multiple resonators are placed in a FSS unit cell either nested, hybrid or in a layered structure. An important issue is the mutual effect between each resonator in one unit cell. Mutual effect is highly dependent to wave incidence angle and may lead the optimization stage to be inadequate or time consuming. Therefore, novel design techniques are proposed in order to control mutual effect and whereat able to optimize each resonant frequency efficiently.

In the second stage, PIN and varactor diodes are integrated in specific locations within each unit cell of FSS to control the frequency response by changing the applied voltage bias. These surfaces are called as active FSSs. Electrical properties of PIN and varactor diodes can be controlled by applying bias voltages. Tuning and switching features are achieved by using varactor and PIN diodes respectively. In order to achieve desired tuning and switching performances, simple FSS geometries are modified using the information obtained from equivalent circuit model. Mutual effects between each resonator is also an important problem for active FSS designs. Same techniques, which have been proposed for passive FSS designs have been implemented in active FSS designs.

As a result of thesis works: Fourteen FSS designs are proposed. Four different conferences were attended. Five works have been sent to different journals. Four of them has been accepted and the other one is in review process. Two new works are also being prepared for the journals.

FSS designs:

1st design: The aim of this study is to proposeca FSS absorber design at the unlicensed 2.45 GHz ISM band. Absorber characteristic is achieved by placing a second FSS layer comprising lossy periodic FSS elements or placing lumped resistors on the conducting paths of periodic element geometries. HFSS software is used for simulation and design purposes. The minimum attenuation was obtained as 20dB on the transmission (S21) coefficient, while it was obtained as 10dB on the reflection (S11) coefficient, respectively.

2nd design: As a result of the enormous increase in mobile phone usage throughout the world, mobile phone base stations are located in almost everywhere nowadays. The globally recognized organizations have started to release maximum RF exposure levels that are regarded as safe. An efficient approach to decrease the RF exposure levels inside the buildings is to transform building walls to a frequency selective surface which filters out GSM signals but allows the others, such as radio and television signals. This work proposes a new multiband Frequency Selective Surface element geometry, which leads to a minimum 20 dB attenuation in 900 MHz, 1800 MHz and 2100 MHz mobile communication bands according to Swiss electromagnetic radiation prevention limit values (NISV, DEC 23 1990). Achieved results show that the proposed FSS element geometry has a stable frequency response with minimum 20dB of attenuation levels for TE and TM polarizations when the angle of incident wave is varied from 0^0 to 60^0.