Abstract

Microwaves play a vital role in communications systems viz. Mobile Phones, Bluetooth, Wi-Fi, and so on. Additionally, the microwaves find a wide range of applications in the radar systems for target detection and navigation, microwave ovens for cooking, environmental remote sensing for change and feature extraction, medical systems for the diagnosis of disease and medical treatment. In spite of the wide range of applications, there are certain limitations associated with microwaves viz. Electromagnetic Interference (EMI), dielectric heating effect, and so on. The microwave absorbers are invariably required for overcoming the limitations of microwaves viz. minimizing the EMI between the circuit components for the smooth functioning of the devices, minimizing the health risk by absorbing the unwanted radiations. Additionally, the microwave absorbers are required for lowering the Radar Cross Section (RCS) of the target for defence applications.

The thesis presents the design philosophy along with the limitations of different classes of microwave absorbers viz: Salisbury Screen Microwave Absorber, Jaumann Absorbers, Material Based Absorbers and Metamaterial Absorbers. Additional resonance modes can be induced using engineered planar structures to achieve bandwidth enhancement.

The thesis describes the application of engineered wire-based absorbers (WBA) for bandwidth improvement. The resonant frequency of WBA varies inversely with the length of the wire element. The cross-polarization of the WBA is almost nil owing to dipole behaviour. Additionally, WBA can be fabricated using a low-cost screen printing process. Multiband viz. single/dual/triple band and bandwidth-enhanced absorbers are designed and realized using engineered wire structure. The bandwidth of the WBA is further improved using capped dielectric absorber. Two resonating modes (WBA and dielectric absorber) are tailored by tuning the thickness of the dielectric layer and wire element length. The designed absorber offers the bandwidth of more than 6 GHz for 10dB return loss.

The thesis presents a design approach to improve the bandwidth of Dielectric Material Based Microwave Absorbers (DMBMA). The design comprises of planar square patches of DMBMA placed periodically on the metal-backed FR4 sheet. The bandwidth of 8 GHz (10-18 GHz) is achieved for –10 dB reflections in the proposed absorber. The enhanced bandwidth is attributed to the overlapping of $\lambda/4$ resonance and square patch induced coupling mode.

The bandwidth of the conventional Salisbury Screen Microwave Absorber (SSMA) is improved using the square patch and WBA. The bandwidth for square patch-based SSMA is 59.7%. The bandwidth of SSMA is 42.1% for the same thickness. The overlapping of the $\lambda/4$ mode and the additional coupling mode due to square patch, result in bandwidth improvement.

Using WBA in combination with the SSMA can improve the bandwidth to 53.5% (8.9-15.4 GHz) for -10 dB reflection. The FR4 substrate with the SSMA works as Jaumann configuration and introduces an additional resonance mode. The selective overlapping of resonant mode excited by wire element and the additional resonance mode enhances the bandwidth of the absorber.

The thesis describes the bandwidth enhancement of multilayer absorbers using engineered planar structures viz. metallic square patch. The fractional bandwidth for -10 dB reflection of the TLMA with the thickness of 6.13mm is 9.7 GHz. In comparison, the fractional bandwidth for -10 dB reflections for square patch-based TLMA is 11.2 GHz.