7: Summary and Conclusion

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

The thesis described the application of 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 absorbers viz. single/dual/triple band absorbers consist of one/two/three metallic wire elements for single/dual/triple band absorption, are designed and characterized. These metallic wires are printed on lossy metal back FR4 sheet. The proposed absorbers were polarization-insensitive due to four-fold rotational symmetry.

Taking advantage of WBA resonant frequency relation with wire element length, the bandwidth-enhanced polarization-sensitive WBA was designed. The design comprised of multiple wires printed on metal grounded lossy FR4 substrate. The improved bandwidth was attributed to the overlap of the absorption peaks of individual wires. The achieved bandwidth corresponding to 10dB return loss was 0.5 GHz.

The WBA was capped with a dielectric absorber for further bandwidth improvement. Two resonating modes (WBA and dielectric absorber) were tailored by optimizing 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 presented 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) was achieved for –10 dB reflections in the proposed absorber. The enhanced bandwidth was attributed to the overlapping of λ/4 resonance and square patch induced coupling mode.

The bandwidth of the conventional Salisbury Screen Microwave Absorber (SSMA) was improved using the square patch and WBA. Theoretically, the maximum fractional bandwidth of the SSMA for FR4 substrate with an optimum sheet resistivity of 308 Ω/sq for -10 dB reflection is nearly 42.1%. The bandwidth for square patch-based SSMA was 59.7% with the same thickness. The design comprises of square patches of the SSMA placed periodically on the metal sheet. The square patches consist of FR4 substrate and a 200 Ω/sq resistive sheet. The overlapping of the λ/4 mode and the additional coupling mode due to square patch, resulted 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 absorber comprises of, wire element printed on FR4 substrate, placed on the top of the SSMA. The SSMA consists of 50 Ω/sq resistive sheet placed on the metal-backed dielectric spacer. 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.

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The thesis described the bandwidth enhancement of multilayer absorbers using engineered planar structures viz. metallic square patch. The square patches were considered as capacitive element due to enhance coupling between the nearby patches. The resonant frequency of the metallic square patches can be tuned by changing the patch size, thickness and material parameters of the substrate. The capacitive element based absorber offers enhanced bandwidth in comparison to low capacitive elements viz. cross, square loop.

The work explored the Triple-layer Microwave Absorbers (TLMA) consisted of a metal sheet, FR4 substrate, a resistive sheet of 100 Ω/sq and FR4 substrate. The fractional bandwidth for -10 dB reflection of the TLMA with the thickness of 6.13mm was 9.7 GHz (7 GHz-16.7 GHz). In comparison, the fractional bandwidth for -10 dB reflections for square patch-based TLMA is 11.2 GHz (5.6 GHz -16.8 GHz). The improved bandwidth of the designed absorber was achieved with almost the same thickness as TLMA.

As future work, new opportunities in terms of bandwidth enhancement of existing absorbers with engineered planar structures can be explored. The physical insight of the absorbers is revealed by simulating field quantities. The equivalent circuit can be modelled as future work to visualize the factors affecting the performance of the proposed absorbers. The work presented in this thesis has used dielectric absorbers. The combination of magnetic absorbers with engineered planar structures can be explored for bandwidth improvement with reduced thickness. The minimum thickness requirement for dielectric absorbers indicates that a similar analysis can be carried out for the proposed absorbers. The unit cell with resistive sheet/different absorbing materials of different thickness can be designed as future work for further improvement of the bandwidth.

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