3D Plastic Printing and its Application to Radio Frequency Components and Structures

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Extended Abstract
Many radio frequency structures such as bandpass filters, resonant cavities, and antennae have been traditionally constructed from solid metal components. The design process [1], results in drawings or models being produced and instruction for manufacture generated. However, the advent of modern CAD systems, which include simulation tools, means that the component design can be taken directly to Numerically Controlled (NC) equipment for prototyping or volume 3D printing.

In this paper we present the design of a 1GHz interdigital band-pass-filter Figure 1, intended for receive only or low power transmission application implemented with a combination of printed Acrylonitrile Butadiene Styrene (ABS) and copper electroplating. The component is considered to be broadly within the range of radio frequencies that fabricated parts of this type would most likely use and is of moderate physical complexity, incorporating a number of tuned elements that are integral to the 3D moulding. We contrast this with other 3D printed Radio Frequency (RF) components such as horn antenna, waveguide section and reflector that are inherently wideband and not used for frequency determination [2][3].

For comparison a conventional RF bandpass filter was first constructed from aluminium and brass rod. Vector Network Analyser (VNA) and Spectrum Analyser/ Tracking Generator measurements were taken as reference. A Solidworks™ 3D CAD model was then closely adapted from this design, incorporating the resonant elements. All dimensions pertaining to the RF design intent, such as the tapping point positions for impedance matching, were strictly adhered to.

Experiments were carried out in order to prepare and electroplate the complex moulding. Graphite in solution, copper and nickel loaded paints using water-based (acrylic) and organic solvent bases were tested for adhesion to plastic, and the uniformity of pre and post electroplating resistivity across the material. To prevent granular and uneven copper deposition large donor copper-electrodes were used. This was achieved by using low electroplating current (< 200 mA) and the regular repositioning of parts in the electrolyte solution.

Figure 1. Three-pole interdigital band-pass filter and 3D printed variant during stages of electroplating.

Preliminary testing shows that the filter is capable of being tuned and matched. Improvements to electroplating uniformity and earth bonding are now being considered.

References

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[2] 3D polymer printing and metallization. Experimental test at 14~18 GHz." AEU - International Journal of Electronics and Communications Volume 73, March 2017, pp 119-128

[3] "Cassegrain Reflections – Producing and Testing 3D printed Cassegrain sub-reflectors" Alan Devlin, VK3XPD, Dubus (Magazine for Amateur Radio on VHF/UHF and Microwaves), vol 48, no 2, 2019, pp 22-34.