Direct Digital Manufacturing of a 2.45 GHz Phased Array

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Direct digital manufacturing (DDM) is an emerging technology that is finding its place across a wide array of industries and applications, as a cost effective solution for low volume and customizable production. One of the promising applications for DDM is structural electronics, where light weight printed plastics provide mechanical support as a fixture, package or structural member and also host the electrical interconnects and devices, all in a contiguous fashion. Microwave structural electronics is a specific class of such systems for which the printing resolution and electrical and surface properties of the materials are especially important. This paper describes a 2.45 GHz phased array antenna that is designed as part of an airborne platform and is fabricated using a multi-material, multi-layer DDM process. The antenna stack-up is 4.7 mm thick and comprised of 7 acrylonitrile butadiene styrene (ABS) thermoplastic substrate layers, with 7 silver paste conductive layers. The ABS layers are formed using fused deposition modeling and the conductive traces are deposited using micro-dispensing; both processes are on an integrated platform on an nScrypt 3Dn series tool. The antenna element is a bow-tie dipole that is backed by a multi-layer high impedance surface (HIS) with overlapping plates to increase the coupling capacitance between HIS unit cells. The electronics for each phased array element include a digital phase shifter, band-pass filter, LNA/PA module with TX/RX switches, and a balun to feed the dipole; a 1x4 Wilkinson divider is used at the array input. The simulated and experimental performance of a single phased array element and a 4-element array are presented, with a detailed analysis of the impact that substrate roughness and silver paste conductivity have on the high frequency performance.