**Low-loss microwave circuits in strip transmission line technique.**

**Analysis, design and experimental investigations.**

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**Abstract:**

Currently observed an increasing demand for telecommunication systems' throughput and range results in the necessity of multiplication of transceivers in a compact form factor with code/frequency/spatial separation, employment of ultra-wideband systems, addition of de/multiplexers for bands` separation for further processing, increase of total transmitted power, etc., while keeping high systems' power efficiency. In order to fulfill these requirements, it is necessary to research for novel solutions and technologies that allow for the realization of compact and lightweight systems with a high level of components' integration and minimized power loss. One of the development directions is the application of strip transmission line technique. Circuits realized in such a technique are quasi-planar structures, what allows not only for relatively easy modeling and fast design but also for easy integration of passive and active, low- and high-frequency circuits and components into one board. Such an approach can reduce mechanical design complexity and allows for achieving very compact components as well as for reduction of the entire system's cost. However, such circuits suffer from relatively high power losses (which is mostly converted into heat) in comparison to e.g. all-metal waveguides, which is a result of a partial or full propagation of electromagnetic wave within lossy dielectric substrates (laminates) preventing such networks from application in high-power circuits.

This Thesis is dedicated to the analysis, design and experimental verification of microwave circuits in strip transmission line technique. The main goal of this work it to investigate the possibility of realization as well as development of new design methodologies and circuits' topologies of selected microwave circuits to feature minimized total power losses and high electrical performance. Among studied circuits are distributed filters, directional filters for multiplexing applications, as well as coupled-line directional couplers for power summation/division purposes. Propagating guided wave is attenuated along the transmission line length at the rate of attenuation constant for which two main contributors are conductor and dielectric losses. Therefore, to minimize total power loss within the circuit either total length of the lines or the influence of main loss sources needs to be reduced. In this work, the following issues are considered in the pursuit for low-loss circuits` realization:

* application of novel and alternative realization schemes and constitutive elements' topologies to improve performance of the circuit and obtain compact size, hence minimize total power loss;
* circuit power loss reduction by improving subcircuits' topology in terms of size and performance as well as altering realization technique to the ones with lower dielectric loss;
* circuit topology design focused on performance improvement leading to more efficient size to performance relationship as a way of power loss reduction;
* integration of various functionalities within the circuit as a way to reduce total power loss;
* introduction of novel materials and manufacturing technologies for the realization of low-loss circuits.

The Author have comprehensively investigated all the above-listed approaches and widely described them in the co-authored journal papers and conference proceedings, which are included in this Thesis. The result of a theoretical work as well as an experimental investigation is a variety of novel circuit solutions and design methodologies, including:

* realization of bandpass and bandstop filters utilizing a periodic structures approach, composed of identical, electrically short unit cells as well as the development of novel unit cells' topologies realized using coupled and uncoupled sections of transmission lines and lumped elements featuring bandpass and bandstop response together with their theoretical model and design methodology;
* realization of broadband bandpass filters employing a periodic structure approach in suspended stripline technique utilizing novel unit cells composed of solely coupled and uncoupled transmission line sections;
* development of novel topologies of directional filters allowing for selectivity improvement by introduction of transmission zeroes and topologies featuring enhanced isolation bandwidth;
* development of compact and selectivity improved frequency channels' multiplexers constructed out of directional filters;
* development of novel impedance transforming directional couplers with increased transformation ratio as well as development of bandwidth enhanced directional couplers in tandem configuration by introduction of appropriate phase shifters in-between;
* investigation on usability of various conductive and non-conductive filaments dedicated for the use with 3D printing technology for the realization of low-loss strip transmission line circuits;
* development of high-performance directional couplers in suspended stripline technique by introduction of 3rd dimension of structure's control enabled by the use of 3D printing technology;
* development of novel topology of directional-coupler-based impedance tuner with extended impedance range due to reduction of internal power loss enabling source-/load-pull measurement of a wide range of RF power transistors;
* development of an exemplary high power transceiver front-end, making use of the developed tuner to determine power stage transistor`s matching impedances for maximum power output.

All the developed methods and circuits have been experimentally verified proving their applicability and fulfillment of the stated goals. The obtained results presented in this Thesis will allow for better integration of particular blocks of transceiver front-ends of wireless telecommunication equipment as well as reduction of overall power loss, dimensions and weight by replacement of all-metal waveguide based components with uniform, integrated systems designed with the use of strip transmission line technique.