**Circuit`s topology optymalisation focused on performance improvement as a way of power loss reduction**

In this Chapter it is shown that realization of circuit`s topologies and design techniques focused on circuit`s performance improvement also leads to reduction of total power loss. The approach is studied on an example of directional filters and couplers for which performance improvement is obtained allowing for either circuit size reduction of more optimal operation. The results of the conducted research have been a subject of three journal papers: one submitted for *IEEE Transactions on Microwave Theory and Techniqes* andtwo published in *IEEE Microwave and Wireless Components Letters* as well as two conference papers presented at *International Symposium on Antennas and Propagation ISAP`15* and *International Conference on Microwave, Radar and Wireless Communications MIKON`16*, both under auspice of *Institute of Electrical and Electronics Engineers,* which constitute the Chapter.

A new design of miniaturized coupled-line directional filter multiplexer allowing for band separation in UWB antenna systems has been proposed. To achieve small size of the directional filters, hence entire multiplexer, directional couplers constituting the filter have been miniaturized following the approach, in which the coupler is realized as a connection of tightly coupled and uncoupled lines. Moreover, sections of quarter-wave-long transmission lines have been designed with quasi-lumped elements approach, which allows for further miniaturization of the structure. Theoretical analysis of the circuit has been provided. Moreover, performance of the presented approach has been verified by the design and measurement of an exemplary single directional filter multiplexer covering ISM 2.4 GHz band.

Following, a new design of a traveling wave loop directional filter allowing for realization of transmission zeroes has been proposed. In order to introduce transmission zeroes to bandpass branch of the filter, two loops have been cascaded using transmission line sections. Theoretical analysis of the circuit has been provided giving the insight into behavior of the appearing transmission zeroes related to electrical lengths of the loops’ connecting segment. Performance of the presented approach has been verified by the design and measurements of an exemplary cascaded single-loops directional filter with two symmetrically placed transmission zeroes covering ISM 2.4 GHz band. The obtained results prove the usefulness of the presented approach.

Furthermore, a novel approach to the design of directional filters based on differential bandstop filter and delay lines is proposed. It is shown, that utilization of a phase inverter and reference line as a mode converting phase shifter allows for obtaining theoretically ideal bandpass to bandstop channels isolation over an infinite bandwidth. The presented theoretical analysis is confirmed by realization of an exemplary low-loss directional filter with defected ground type phase inverter covering Industrial, Scientific and Medical 2.4 GHz band. The obtained measurement results show insertion loss as low as 1.1 dB and almost flat isolation response, better than 27 dB up to 6 GHz proving the validity of the presented approach.

Additionally, a novel topology of a traveling-wave directional filter allowing for selectivity enhancement without increasing filter’s order is proposed. Additional loose cross coupling introduced between #(n-1)th loop resonator and isolated port of the nth-order directional filter allows for generating transmission zeros in the bandpass branch. Moreover, electrical length of the cross-coupling connecting transmission line allows for adjusting the location of transmission zeros and realizing symmetric or asymmetric frequency response. The presented approach is theoretically analyzed and experimentally verified. Exemplary second- and third-order directional filters with symmetrically placed transmission zeros were designed to operate at f0 = 1 GHz, manufactured and measured. The obtained results prove correctness and applicability of the presented approach.

Finally, A new type of broadband 3-dB tandem coupler has been proposed featuring frequency characteristics of the resulting coupling similar to those of a classic 3-dB two-section asymmetric coupled-line directional coupler. The coupler is composed of two loosely-coupled-line sections having electrical length close to quarter-wavelength connected by right-handed and left-handed transmission line sections. Theoretical analysis and design equations have been presented with exemplary realization. Measurements of the manufactured tandem coupler operating at f0 = 1 GHz having wide operational bandwidth have been shown to validate the presented analysis.