Circuit synthesis in antenna and RF optimization

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Optenni Lab - Circuit Synthesis Software for Antenna and RF Optimization

- Worldwide leading solution for circuit synthesis for antenna applications
- Filling a gap between existing electromagnetic and circuit simulators
 - Optimization of both antenna and circuit quantities
 - Design automation for eliminating repetitive design tasks
 - Offering solutions instead of building blocks
- Used by leading wireless companies worldwide
 - 7 out of the 10 largest technology companies in the world are our customers



Optenni Ltd was founded in 2009



Single port antenna matching synthesis

- Typical workflow:
 - Get impedance and efficiency data from electromagnetic simulators or from measurements
 - Select operation band from a list of wireless systems
 - Select number of components
 - Select inductor and capacitor series
 - Press OK
- Within second multiple optimized topologies are generated

Add	d Operation Frequency Band	
Frequ	iency band	
Sele	ect wireless system 🔻 💽 Both	upli
	User-defined frequency bands	•
	GSM	•
	WCDMA	•
	3GPP FDD bands	•
	3GPP TDD bands	•
	5G NR bands in FR1	•
	5G NR bands in FR2	•
	Satellite communication	•
	Satellite navigation	•
	Zigbee	•
	LoRa	•
	ISM	•
	Unlicensed Bands	•
	WLAN	•
	UWB HRP	•
	Misc	•
	NFC	

1120 (703-003 IVIL12, 1 D D) n29 (717-728 MHz, SDL) n30 (2305-2360 MHz, FDD) n34 (2010-2025 MHz, TDD) n38 (2570-2620 MHz, TDD) n39 (1880-1920 MHz, TDD) n40 (2300-2400 MHz, TDD) n41 (2496-2690 MHz, TDD) n46 (5150-5925 MHz, TDD) n47 (5855-5925 MHz, TDD) n48 (3550-3700 MHz, TDD) n50 (1432-1517 MHz, TDD) n51 (1427-1432 MHz, TDD) n53 (2483.5-2495 MHz, TDD) n54 (1670-1675 MHz, TDD) n65 (1920-2200 MHz, FDD) n66 (1710-2200 MHz, FDD) n67 (738-758 MHz, SDL) n70 (1695-2020 MHz, FDD) n71 (617-698 MHz, FDD) n74 (1427-1518 MHz, FDD) n75 (1432-1517 MHz, SDL) n76 (1427-1432 MHz, SDL)



Examples of generated circuits





Increase number of components (ideal case)





Effect of tolerances and losses





Optimization goals in antenna matching

Instead of minimizing S11, maximize antenna efficiency



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Simultaneous multiport antenna matching

- Enter efficiency targets for each port
- Select component type
- Press OK
- Multiple optimized topologies presented









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Efficiency in multiport antenna systems

- In a multiport antenna system, the radiation efficiency is a function of the termination and excitation of all ports
- The termination and excitation affects the near fields and the far fields
- If the complex radiation patterns of each port are known (one port excited at a time), the radiation efficiency for each termination and excitation condition can be found by a linear combination of the element patterns







Loss terms in multiport antenna matching



Goal: maximize minimum efficiency over all ports and all target frequencies



Tunable matching circuit design

- Define operation targets for multiple frequency configurations
- Insert a switch to the aperture port and set the switch state for each frequency configuration
- Set component types and synthesis settings



		Lucion larg							
ow	Mid	High							
nter o	optimiza	ation target	s for frequency	configuration	Low'				
Port	1 0	eneral tara	-						
		reneral tary	ets						
En	ter opti	mization ta	rgets for externa	l port 1					
En	ter opti	mization ta Id band	rgets for externa	l port 1 eq. End freq.	Туре	Target value		Name	
En	ter opti Ad	mization ta Id band stopband	rgets for externa Start fre 700 MH:	l port 1 eq. End freq. z 800 MHz	Type Eff passband port 1	Target value 0 dB	Low	Name	

Generic reactance component





Tunable results



Goal: maximize minimum efficiency over all frequency configurations (with different switch states)

Lesson learned: switch off-state capacitance as important as on-state resistance



Carrier aggregation optimization

- Challenge: multiple RF branches need to be active at the same time
- The different branches are loading each other
- Design example:
 - Receive branches for band 7, bands 1+3 and band 40
 - Any combinations for the three cases are allowed
 - A multithrow SP3T switch is used





Carrier aggregation setup

- Instead of optimizing all at once, it is more efficient to prematch the different branches first
- Final setup: define the pass and stop band targets for the 7 configurations





ost functio	n: -1.9						
CA B7	CA B1+B3	C/	A B40	CA B7+B1+B3	CA B7+B40	CA B1+B3+B40	CA B7+B1+B3+B40
Target type Freq. [GHz]		iHz]	Target			Value	
S31 passba	and 2.11 - 2.	17	0 dB	min/ave -1.7/-1.1	dB		
S41 passba	and 1.805 - 1	88.1	0 dB	min/ave -0.9/-0.5	dB		
S51 passba	and 2.3 - 2.4		0 dB	min/ave -1.9/-1.1	dB		



Carrier aggregation results









Conclusions and lessons learned

- Matching circuit synthesis can produce multiple broadband matching circuits which operate between two complex frequency dependent impedances
- Instead of minimizing reflected power, maximize power transfer
- When number of matching components is increased, matching circuit losses and tolerance problems may increase
- Simultaneous multiport antenna matching can produce a huge number of topology combinations. Optimize for best efficiency
- In tunable matching, pay attention to switch losses and off-state capacitance
- In carrier aggregation setups, it is useful to prematch parts of the RF chain and then fine-tune the total problem





ANNIVERSARY



15 years of innovation in antenna and RF design automation