# SYNTHESIS METHOD FOR MATCHING FILTERS

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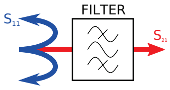
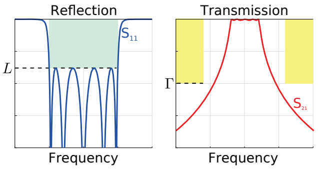
## 1. MICROWAVE FILTER

### *TRADITIONAL DESIGN*

Let through signals of a given frequency and reflect the rest



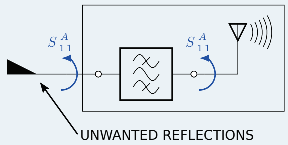

Minimize reflection in the passband & Maximize rejection in the stopband

***Tchebyshev filter***

## 2. MOTIVATION

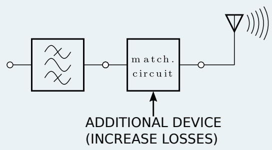
### *UNMATCHED ANTENNA*

Reflection of the antenna goes through the filter



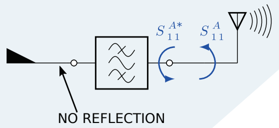

### *MATCHING CIRCUIT*

Reduce reflections but increase cost



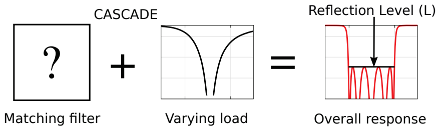

### *MATCHING FILTER*

Filter input signal & reject reflections




## 3. NEW CONCEPT: OVERALL DESIGN + DE-EMBEDDING

### *TARGET: OVERALL RESPONSE*

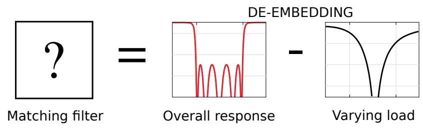



***CASCADE OPERATION:*** Connecting devices
***DE-EMBEDDING OPERATION:*** Unconnect devices

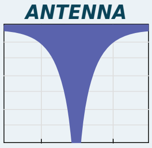
***CONSTRAINT OVER THE OVERALL RESPONSE***
(Interpolation conditions impossed by the antenna)

Nevanlinna-Pick Interpolation ➔ Positivity of Pick Matrix

### *METHOD: ANTENNA SUBTRACTION*

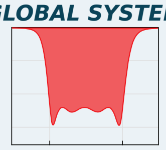



### *ANTENNA*



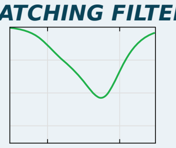
Reflection of the antenna limits the synthesis

### *GLOBAL SYSTEM*



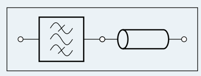
Best realizable response for the given antenna

### *MATCHING FILTER*



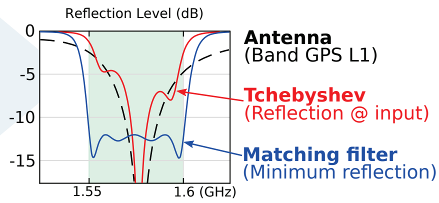
Deembedding to recover the matching filter

### *IMPLEMENTATION*



Filter response yields coupling matrix and transmission line

### *EXAMPLE*




## 4.DESCRIPTION

### *CONVEX SEMIDEFINITE PROGRAMMING*

Provides the best global response ensuring the extraction of the antenna by the positivity of $\mathbb{P}_A(P)$

$$\begin{aligned}
&\text{Find:} && \min_P L \\
&\text{Subject to:} && P(\omega) \leq L R(\omega) \quad L \geq 0 \quad \omega \in \text{Passband} \\
& && P(\omega) \geq \Gamma R(\omega) \quad \Gamma \geq 0 \quad \omega \in \text{Stopband} \\
& && \mathbb{P}_A(P) \succeq 0
\end{aligned}$$

$L$: Reflection level in the passband
$\Gamma$: Rejection level in the stopband
$P(\omega)$,$R(\omega)$: Positive polynomials
$\mathbb{P}_A(P)$: Pick matrix (depends on the antenna)

Reflection and transmission of the overall response:

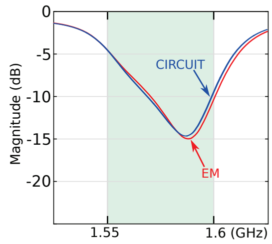
$$S_{11} = \left(1 + \frac{R(\omega)}{P(\omega)}\right)^{-1} \qquad S_{21} = \left(1 + \frac{P(\omega)}{R(\omega)}\right)^{-1}$$

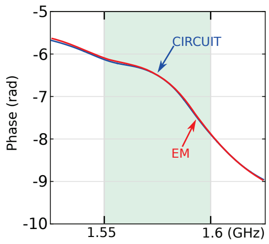
$\mathbb{P}_A(P) \succeq 0$ ➔ ***Convex Space*** ➔ ***Convex Problem!***

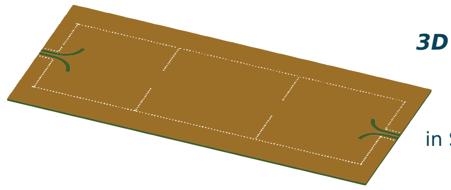
## 5. RESULTS

### *MATCHING FILTER*

Filter of degree 3 with antenna of degree 1
Target (CIRCUIT) and measured reflection (EM) after tuning:



### *3D STRUCTURE*

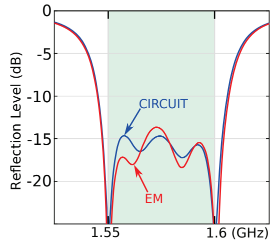
Matching filter implemented in SIW technology

### *OVERALL RESPONSE*

Response of degree 4 with filter of degree 3

***Improved efficiency & Reduced footprint***

Expected and measured global responses:




## 6. CONCLUSION

### *SYNTHESIS*

Synthesis with a requency-varing load is equivalent to the traditional synthesis

### *OPTIMALITY*

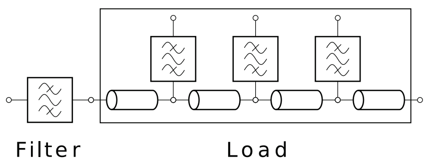
The optimal filter of degree N for a given antenna can be computed

## 7. ONGOING WORK

### *SYNTHESIS TOOL FOR MULTIPLEXERS*

Each filter needs to be matched to the rest of the multiplexer (including other filters)

The design involve several simultaneous matching problems

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