IMS2025 Student Design Competition

Rohde und Schwarz passives design competition - PCB based filter

Introduction

The growing number of smartphones, mobile video transmission, 5G and 6G networks and the Internet of Things (IoT) are causing a perceptible increase in mobile data traffic.

This is accompanied by a growing demand for powerful, compact and multifunctional communication devices. In order to meet these requirements, it is necessary to simultaneously increase the integration density of electronic systems.

PCB-based bandpass filters are an important component of wireless mobile systems and must meet a number of requirements. These include a small footprint, low costs, low losses and sufficient shielding to avoid radiation losses and cross talk.

It is particularly interesting to reduce the size of filters in the lower GHz frequency range, since these filters consume rather more PCB area than most of the other components.

Therefore the main part of the task is to build a passive PCB based filter with as small as possible footprint, without violating the electrical filter specifications.

Design specifications and rules

The designed filter will be evaluated by the following specifications:

- area used on PCB board panel
- insertion loss in pass band
- return loss in pass band
- insertion loss in stop band

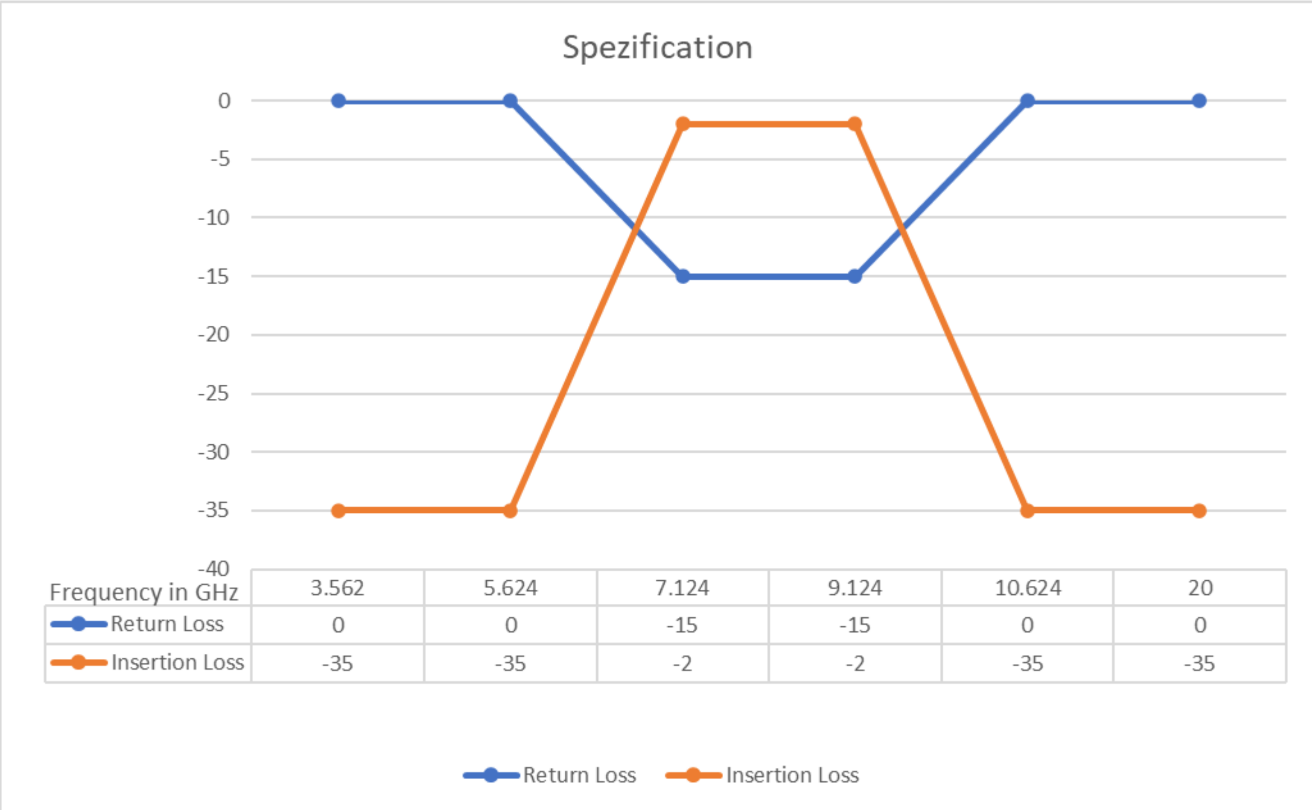
The decisive factor is the area required on a PCB board panel. It does not matter how many layers are used. Multilayer structures are therefore permitted. The connectors and signal traces to the DUT (see picture equipment information) are not part of this area.

In addition to the space required by the filter, hitting the specification also plays a role in determining the score. If the specification is not met, this leads to deductions in the score. However, bonus points can also be collected.

The further the filter edges are from the limits, the more this is rewarded. The same principle applies to the passband from 7.124 GHz to 9.124 GHz. If the defined passband is not adhered to, it will lead to deductions. This also applies to the return loss. Values above 15 dB are rewarded accordingly and those below are penalized.

The PCB-based bandpass filter to be developed should comply with the following specification:

Specification	frequency in GHz	S-Parameter in dB
Lower stop band (insertion loss)	3.562 - 5.624	≤ -35
Pass band (insertion loss)	7.124 - 9.124	≥ -3
Upper stop band (insertion loss)	10.624 - 20	≤ -35
Pass band (return loss)	7.124 - 9.124	≤ -15



Furthermore, a document (maximum 3 pages) containing the following information must be prepared for the competition:

- PCB layer structure of the DUT

- Manufacturing information (incl. design rules line/space, annular ring)

- Dimensioned illustration of the final model

It is also required that the filter can be measured via SMA sockets. Additionally, a thru-standard is required for the measurement. It is not allowed to connect your DUT with a separate DC power supply or a other supporting structure.

Scoring

The score is calculated using the following formula:

$$\textbf{score} = \frac{10^4 mm^2}{2*A} + x$$

$$x = RL + IL1 + IL2 + IL3 + IL4 + IL5$$

A: Area in mm²

x: Sum of the extra points

Calculation of the extra points:

Parameter	**Calculation**
M: measured value *The calculation of the extra points is dimensionless.*	
Return Loss	If the return loss is below 15 dB, points are deducted. The same principle applies to values above 15 dB. *M* corresponds here to the highest value in the pass band. *RL = (M − 15) × 2* For example: M = 14,3 dB → RL = (14,3 − 15) × 2 = -1.4 M = 17,8 dB → RL = (17,8 − 15) × 2 = +5.6
Insertion Loss (filter edges)	For the return loss at the filter edges, two specification values are crucial for the calculation of additional points or deductions: Stop band 1 (3.564 – 5.624 GHz) and Stop band 2 (10.624 – 20 GHz) *M* corresponds here to the highest value in the respective stop band. *Band 1: IL3 = (-35 − M) × 0.5* *Band 2: IL4 = (-35 − M) × 0.5* For example: M = -40 dB → *IL3 = [-35 − (-40)] × 0.5 = +2.5*
Insertion Loss (pass band)	If the insertion loss in the passband (7.124 GHz to 9.124 GHz) exceeds a value of -1.5 dB, 3 additional points are achieved. Deductions of points are given for values below -3 dB. *M* corresponds here to the lowest value in the respective pass band. *M ≥ -1.5 dB → IL5 = 3* *M ≥ -3.0 dB → IL5 = 0* *M ≥ -5.0 dB → IL5 = -3* *M ≥ -8.0 dB → IL5 = -7* *M ≥ -10.0 dB → IL5 = -10* *M ≥ -15.0 dB → IL5 = -40*

Name and number of supporting MTT-S Technical Committee

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TC-4 Microwave Passive Components and Transmission Line Structures Committee

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Equipment information

Participants must bring the thru-calibration standard and the developed filter (DUT), which can be measured via SMA connectors. The thru-calibration standard is a separate board with signal traces of equivalent length on the left and right side of the DUT for accurate calibration.

The complete measurement set up is taken care of by Rohde & Schwarz.