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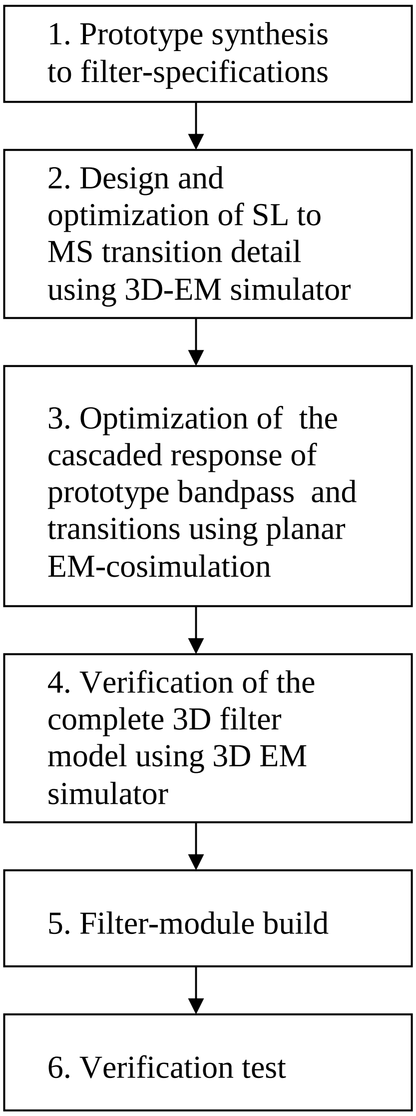
Low-cost Stripline SMD-Filter for the Ku-band

At Microwave frequencies Stripline-Filters offer a rather inexpensive and compact alternative to more complex types like Cavity-, Waveguide- or Dielectric Resonator-Filters although they cannot match the superior insertion loss properties of the other types.
The example filter shown below is a 5th order Chebyshev approximation edge-coupled bandpass filter at 16.6 GHz centre-frequency and 1 GHz bandwidth. The stop-band attenuation at 1 GHz offset from the centre is more than 30 dB.

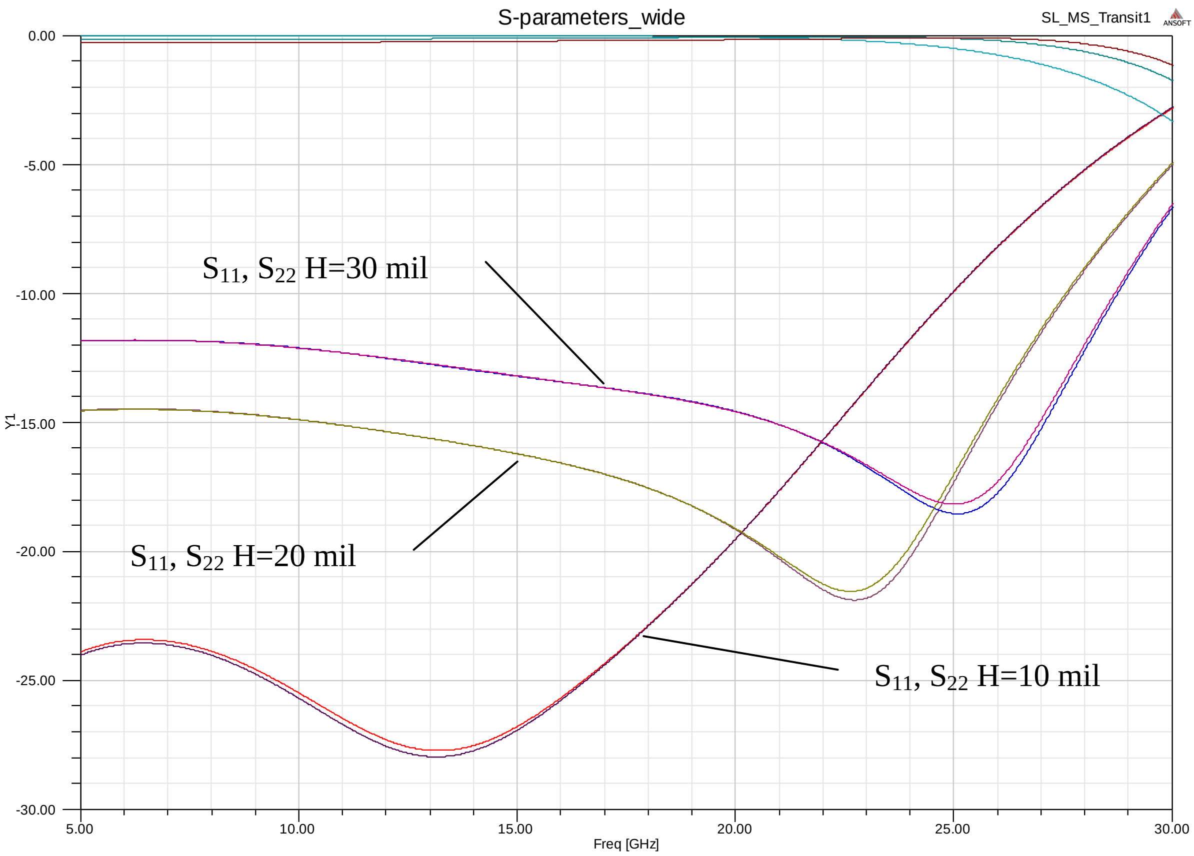
The general design flow for such kind of filter is shown below:



Synthesis, simulation and optimization are done using state-of-the-art EDA tools.

The design of the transitions to the Microstrip carrier should take the needs for reliable manufacturability and placement on the carrier board into account. Since this restriction is contrary to the desired minimal reflectivity at maximum bandwidth, a compromise has to be found.

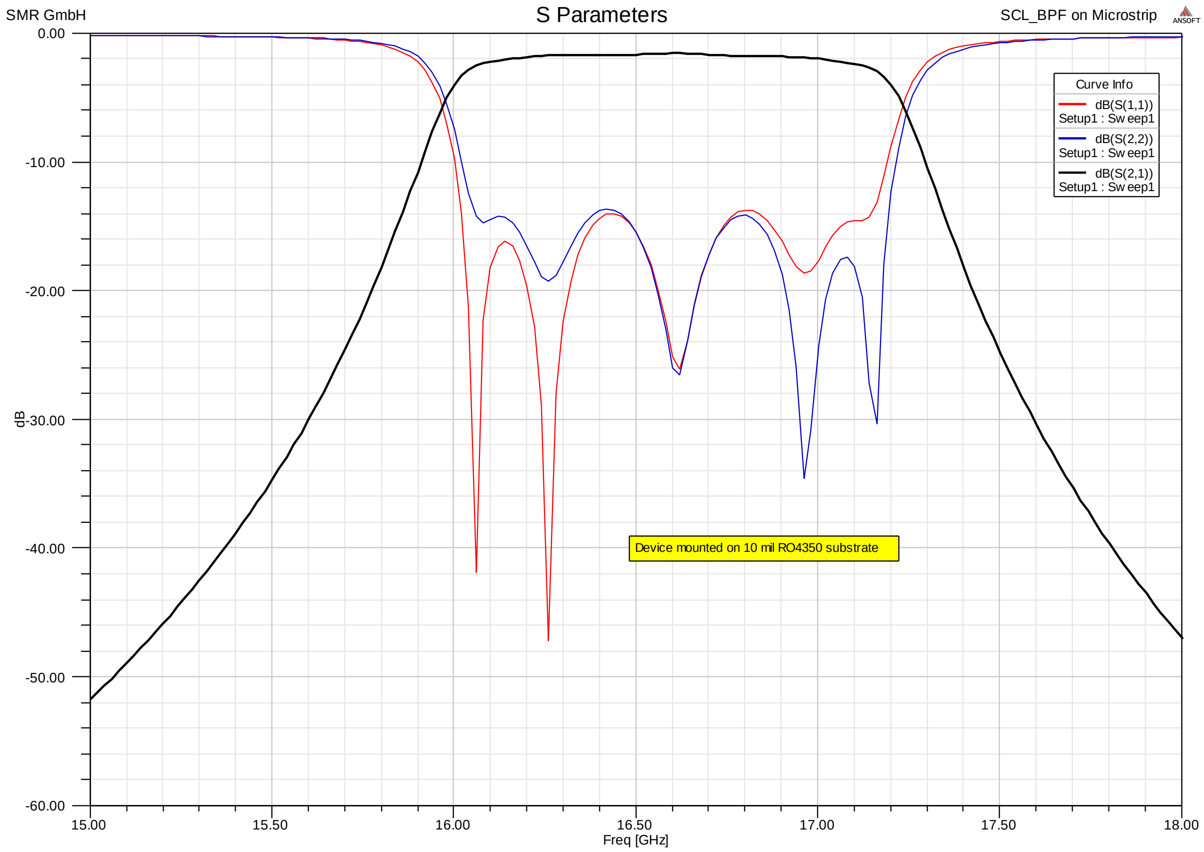
The lateral dimensions of the transition are optimized to yield minimal reflectivity for the specific carrier substrate - in this case 10 mil RO4350 - while maintaining solderability. For other substrates a reduced return loss at the transitions has to be accepted which in turn may reduce the overall performance.



Picture 1: Impact of carrier PCB height on interconnect reflectivity

Following the optimization of the transition detail the filter itself is being optimized taking the cascaded S-parameters of the transitions into account. This is done using circuit- and planar EM-cosimulation techniques. The optimized filter design is then extruded to 3D and a complete 3D filter model assembled together with the already prepared transition details. This step is simplified and accelerated by using a fully parameterized 3D model for a specific shape of the filter.

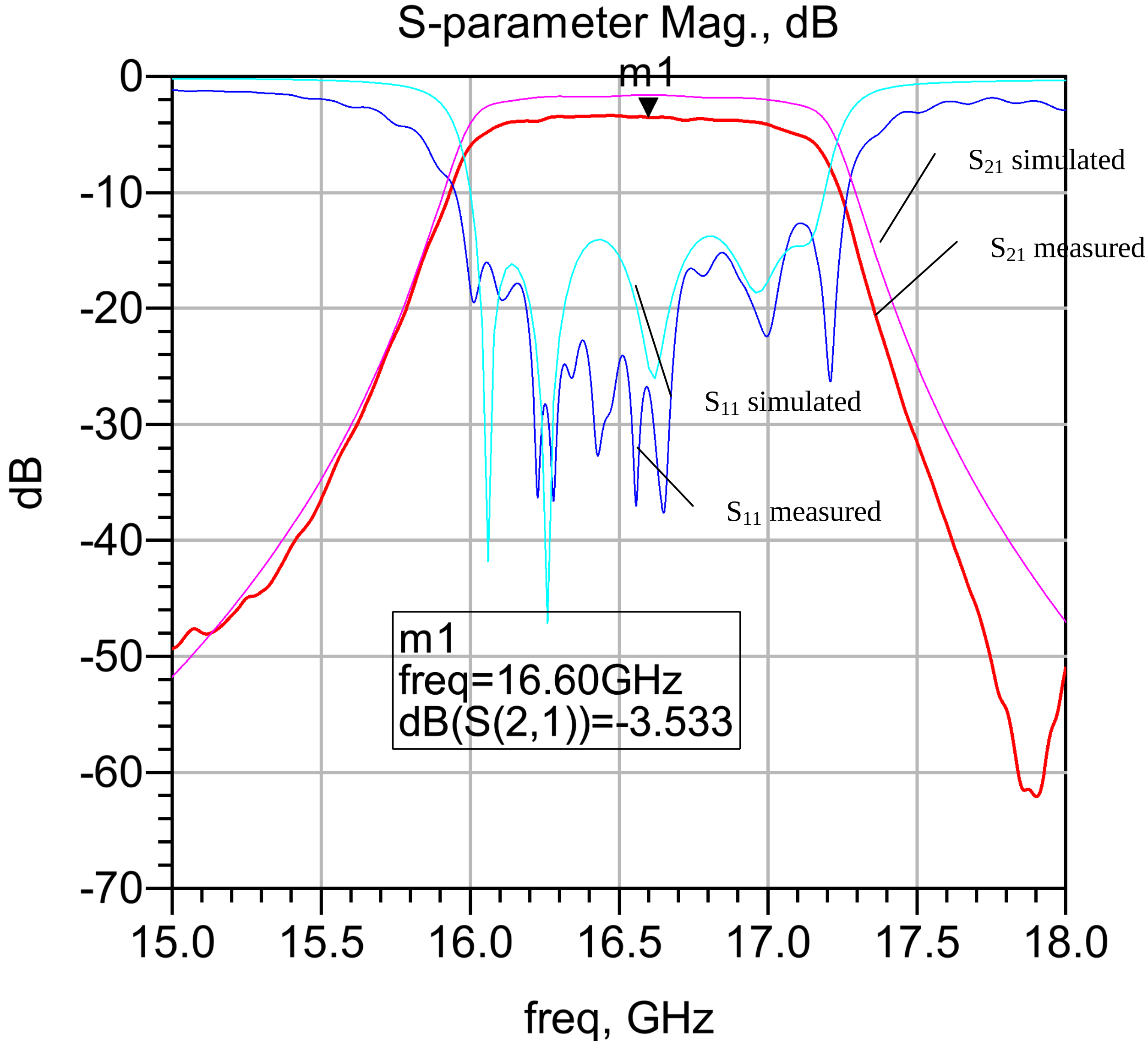
The simulation of the complete 3D model requires more computational effort than the previous steps and therefore a more powerful computing platform is needed to perform the task.
The simulation results are shown in the next picture below



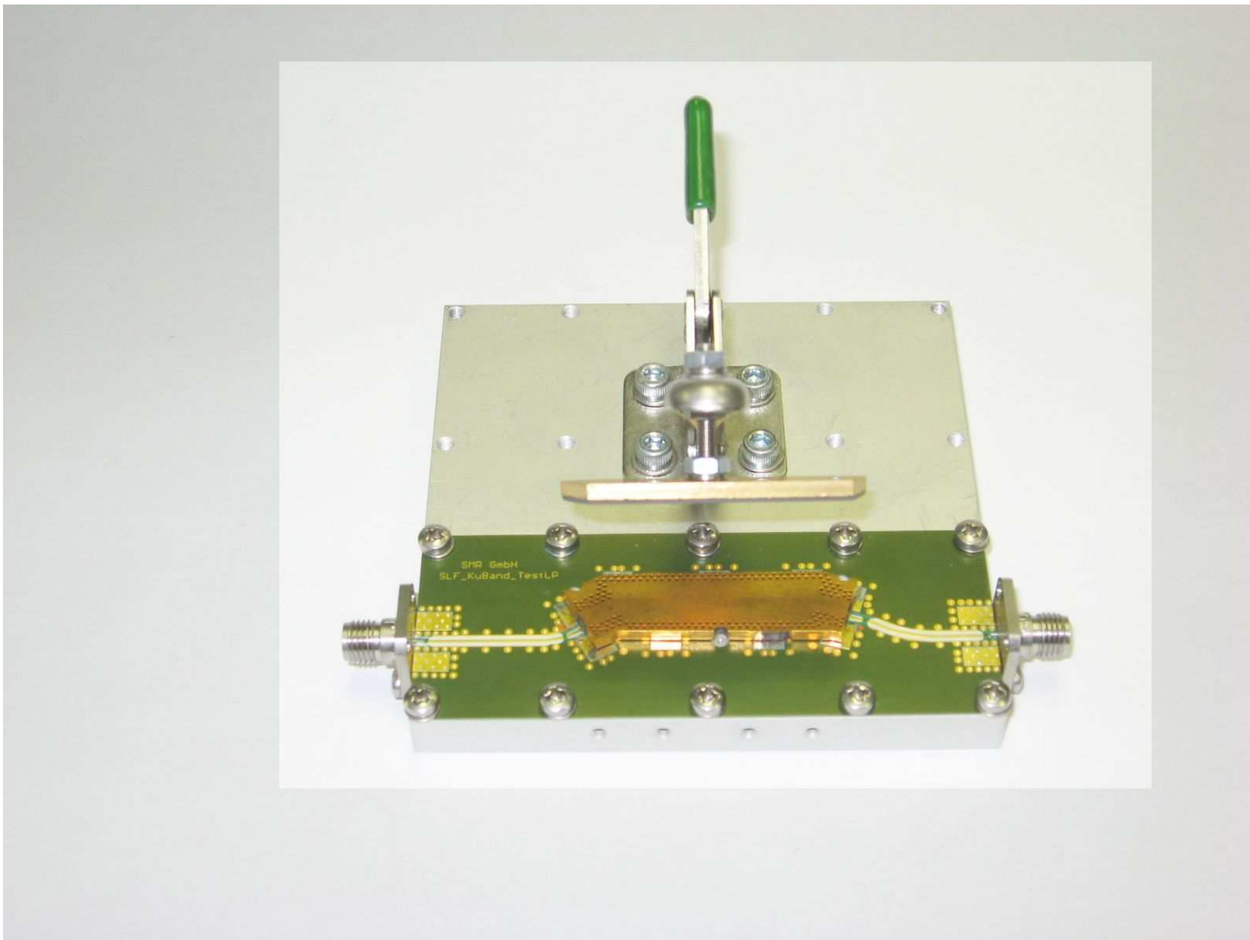
Picture 2: Simulated S-parameters of the complete filter-module

After successful verification of the filter in the simulator production data is generated for the assembly of filter samples.

The data of the real filter measured in a test-fixture is shown below (no deembedding of test-fixture). The expected loss due to the feed lines is 1-2 dB. Surface wave excitation on the carrier may affect the stop-band characteristic to some degree.



Picture 3: Measured and simulated filter S-parameter data



Picture 4: View of the filter in the test-fixture

It should be noted however, that at higher frequencies even well below the unavoidable re-entrance-mode of the filter itself the stop-band characteristic of the filter gets more and more spoiled by parasitic transmission modes (see picture below). Therefore additional lowpass-filtering may be required to extend the stop-band to higher frequencies. For the reasons explained above the useful range of operation for this type of filter is up to Ku-band at a fractional bandwidth down to 0.05. For applications at lower frequencies high frequency laminates with higher permittivity as well as alternative filter topologies like hairpin, interdigital or stub for higher fractional bandwidths up to 0.7 may be used in order to keep the structure small. The time required from specification to a prototype is about 3 to 4 weeks depending on frequency range and bandwidth.

Additional holes on the circumference of the device aid in positioning so that a misalignment between the pads on the motherboard and on the module's bottom side can be largely avoided. The module is mounted by using a standard reflow process.

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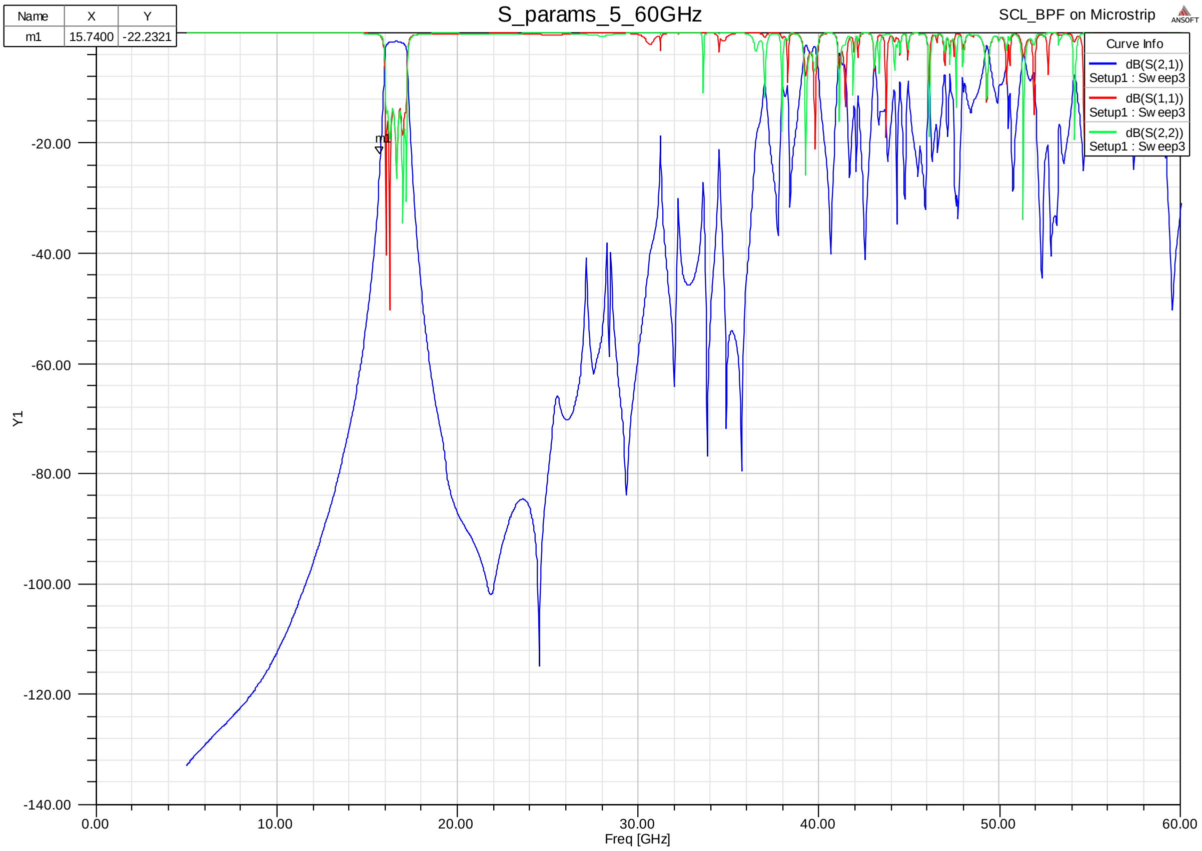

Picture 5: Wideband simulated S-parameter plot of the filter

Summary

A low-cost Stripline SMD filter-module operating at Ku-band is presented. The basic design flow for the filter and its necessary interconnects to the motherboard is shown. Results for a real filter are presented and restrictions pointed out.
This kind of filter offers a low-cost alternative to more complex high-cost bandpass-filter types up to Ku-band and down to a fractional bandwidth of 5% but at a slightly increased insertion loss.

Filter Specifications:	
Centre Frequency Range:	4...20 GHz (C To K_u Band)
Bandwidth:	5...70%
Insertion Loss:	depending on frequency and bandwidth 1...3.5 dB
Max. Ripple:	+/- 0.5 dB
VSWR:	< 2:1
Temperature range:	-35...+85℃
Centre-Frequency drift (-35...+85℃):	±0.6%
Max. Input Power:	30 dBm
Size:	depending on frequency and bandwidth