WIDE SPURIOUS FREE WAVEGUIDE BANDPASS FILTER DESIGN

Low insertion loss bandpass filters with wide spurious free stopband are usually realized by cascading a bandpass inductive iris-coupled TE_{101} mode cavity filter (BPF) and a broadband quasi-lowpass filter (LPF), such as waffle iron, corrugated, or ridged waveguide evanescent mode filter. While the BPF provides the filter selectivity on a relatively narrowband basis, by employing high Q-factor resonators, the quasi-LPF is used to reject the BPF's harmonics. Such a LPF employs relatively low Q-factor resonators and has a wide passband. In this way, the overall loss is the sum of the losses of the two cascaded filters. For receiving application, this could be not good enough to guarantee the required radio-link performance.

RS Microwave developed new non-conventional designs for high Q-factor waveguide BPFs that provide a wide spurious free stopband without needing a cascaded quasi-LPF, thus reducing the insertion loss performance with respect to the conventional approaches. The designs take into account also the rejection of the higher order modes.

Different concepts are implemented in the filter design:

- Capacitive irises instead of inductive irises: a capacitive iris is itself as a lowpass element and provides better spurious performance at high frequency;
- Wider cavities: the width of the cavities is dimensioned for suppression of low frequencies spurious (generated by the capacitive irises), and for moving most of the high frequency harmonics within prescribed frequency ranges. The width of the cavities can also change along the filter (inhomogenous approach).
- Input/output semi-lumped resonators: short sections of corrugated waveguide with associated input notch elements are used as first and last resonators of the filters. The input/output corrugated resonators provide significant harmonic suppression while do not affecting dramatically the filter insertion loss; the associated notch elements provide further suppression on prescribed frequency ranges.
- Reduced size waveguide sections: reduced size rectangular or ridged waveguide sections are used at the filter sides to reject higher order modes propagation and for further suppression of the dominant mode in the lower stopband.

Fig.1 shows the design of a bandpass filter assembly, including a 90 degree H-plane bend, at 20.7 GHz. The interfaces are standard WR-42. The filter order is six: the first and last cavities are semi-lumped corrugated resonators, while the other four cavities are TE_{101} mode resonators coupled through capacitive irises. Two E-plane stubs (notch elements) are associated with the first and last resonator. The H-plane 90 degree bend is interfaced with two reduced width waveguide sections that avoid the transmission of the TE_{20} mode within the required stopband.

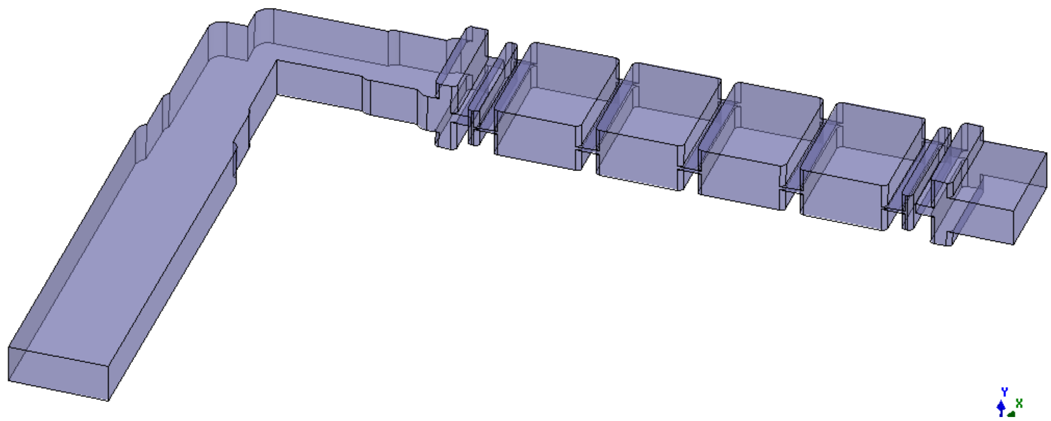


Fig. 1: Wide spurious free waveguide bandpass filter assembly (20.7 GHz).

Fig. 2 shows the HFSS simulation of the assembly. The pass band is 20.2 – 21.2 GHz. Concerning the stopband, not less than 60 dB rejection are simulated up to 47 GHz, that is 2.3 times the filter center frequency (1.6 is usually accomplished with ordinary waveguide bandpass filters). No lower stopband spurious are present above -50 dB transmission. The simulated pass band insertion loss considering ideal copper surfaces is about **0.2 dB**: an equivalent design employing a cascade of a conventional BPF and a quasi-LPF would lead to roughly 0.4 dB simulated insertion loss.

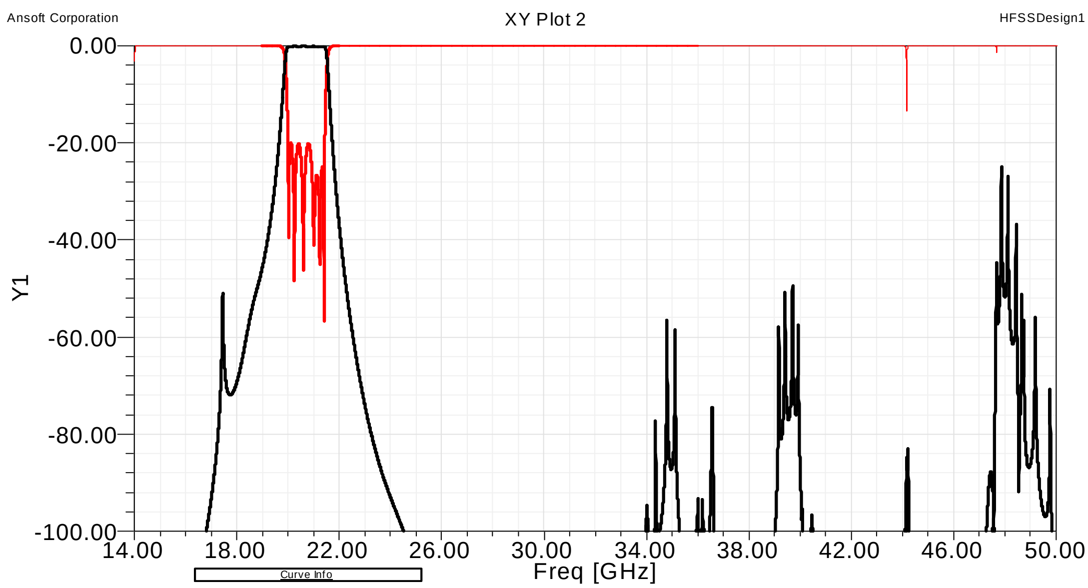


Fig. 2: HFSS simulation of the filter assembly of Fig. 1.

Fig. 3 shows a multimode HFSS simulation (TE_{01}, TE_{20}, and TE_{30} are considered) demonstrating that the higher order modes are suppressed as well below -50 dB transmission up to 47 GHz: this is of crucial importance when the filter is implemented within a complex waveguide assembly in which higher order modes can be excited and feed the filter.

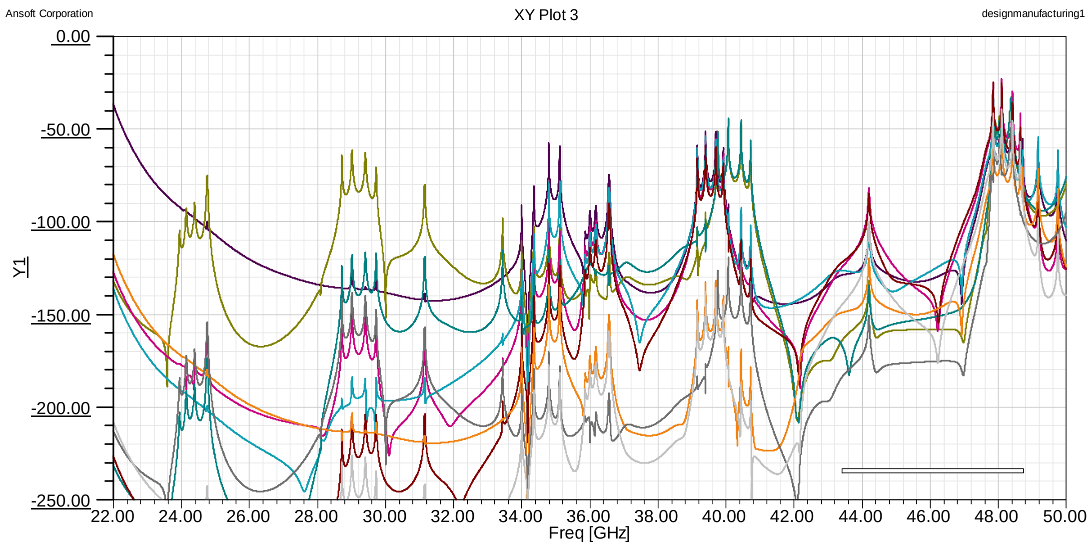


Fig. 3: Multimode HFSS simulation (TE_{01}, TE_{20}, and TE_{30} are considered) of the stopband of the filter assembly of Fig. 1.

Fig. 4 shows another example of wide spurious free bandpass filter at 30.7 GHz. The interfaces are standard WR-34. The filter order is four, and the structure is equivalent to the previous one. The main difference is that in this design two ridged waveguide sections are used at the filter sides to suppress the higher order modes. It is worth noting that it does not induce any resonance for the dominant mode into the ridged waveguide sections, and therefore such sections do not significantly affect the insertion loss of the structure.

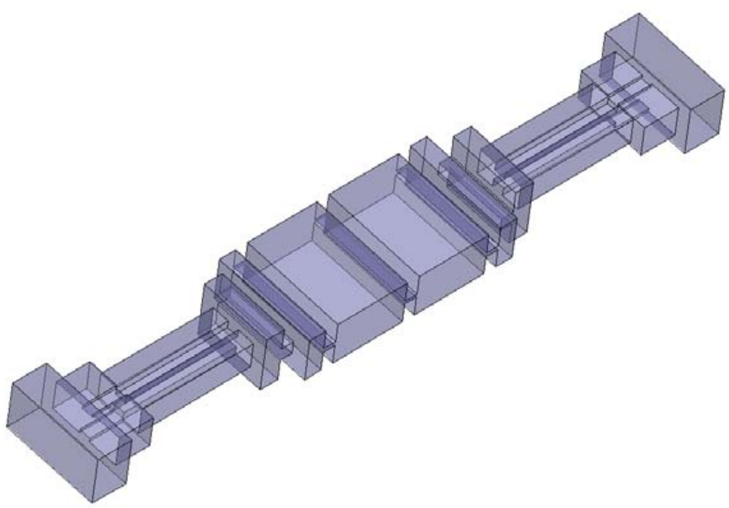


Fig. 4: Wide spurious free waveguide bandpass filter at 30.7 GHz.

Fig. 5 shows the HFSS simulation. The pass band is 30.2 – 31.2 GHz. Concerning the stopband, more than 60 dB rejection are simulated up to 65 GHz. No lower stopband spurious are present above -80 dB transmission. The simulated pass band insertion loss considering ideal copper surfaces is about **0.25** dB: an equivalent design employing a cascade of a conventional BPF and a quasi-LPF would lead to roughly 0.5 dB insertion loss.

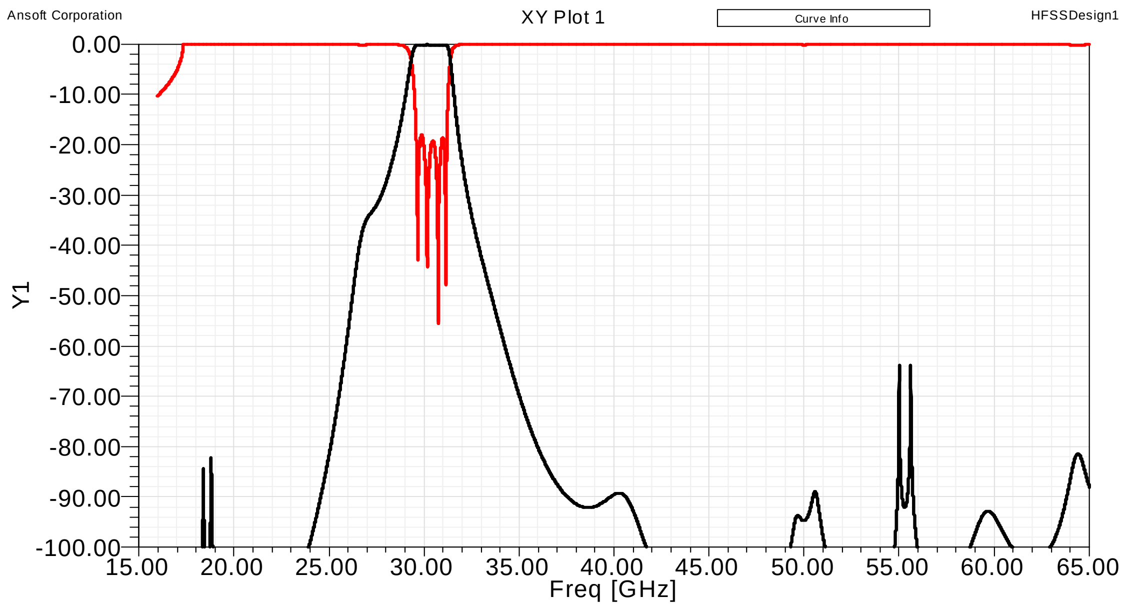


Fig. 5: HFSS simulation of the filter in Fig. 4.

The utility of the ridged waveguide section to avoid higher order mode spurious is demonstrated considering the filter embedded within a waveguide assembly as shown in Fig. 6: waveguide branches having H-plane and E-plane bends are present at both filter sides.

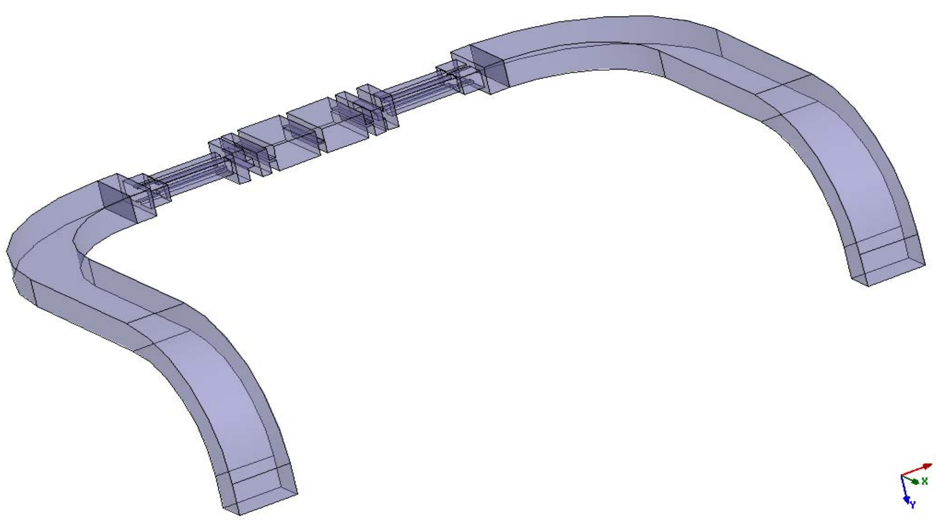
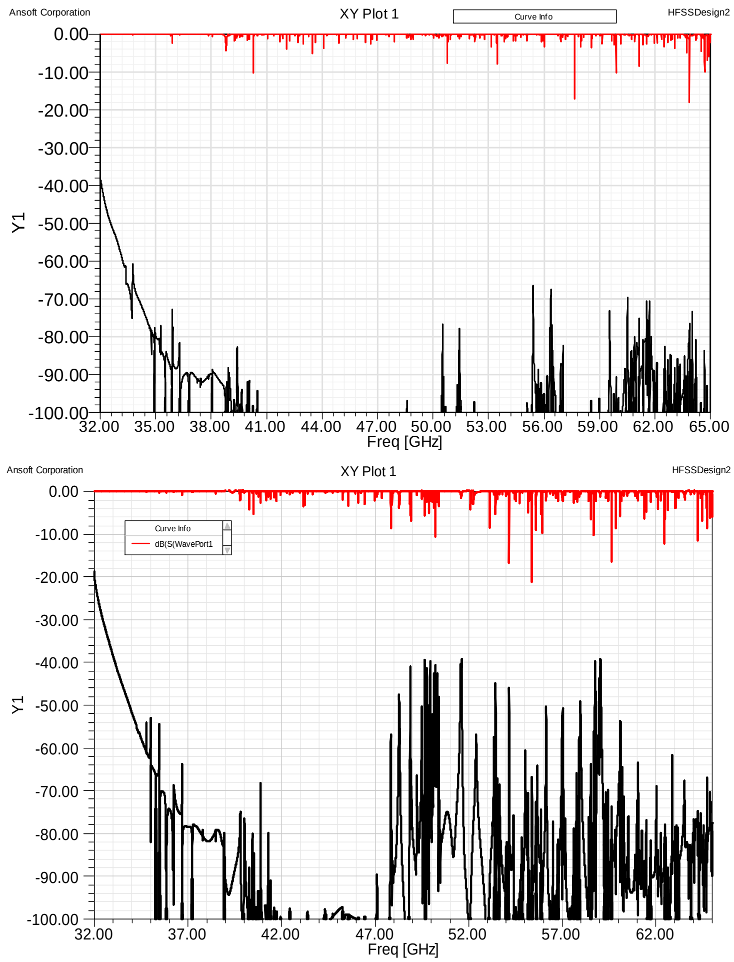


Fig. 6: Filter of Fig. 4 embedded within a possible waveguide assembly.

Fig. 7 shows the comparison between the full wave simulation of the structure in Fig. 6 when the filter includes the ridged waveguide section (Fig. 7a) and when such sections are not involved

(Fig. 7b): the spurious level significantly increases in the latter case due to the higher order modes excited by the assembly and passing through the filter.



(a)

(b)

Fig. 7: HFSS simulation of the assembly of Fig. 6: (a) filter with ridged waveguide sections; (b) filter without the ridged waveguide sections.