Novel Dual-band Bandpass-to-Bandstop Filter Using Shunt PIN Switches Loaded on the Transmission Line

Yilong Zhu, Yuandan Dong*
yilong@std.uestc.edu.cn; ydong@uestc.edu.cn
University of Electrical Science and Technology of China, Chengdu, China
Outline

- Introduction
- Shunt switches and series switches
- Filter design and analysis
- Experimental results
- Conclusion
1. Introduction

• Filter configurability is becoming an active topic due to the development of cognitive radios, and the simplification of communication systems;
• Bandpass-to-bandstop (BP-to-BS) filters are highly desirable in the dynamic interference environment;
• Bandpass mode: lower interference environment;
• Bandstop mode: high interference environment;
1. Introduction

*BP-to-BS Tunable $f_c$ and bandwidth

*BP-to-BS Tunable $f_c$ with wide range

*BP-to-BS Tunable $f_c$ and response shape

All these works present single-band responses
1. Introduction

1) Only a few studies focus on Dual-band BP-to-BS filters;
2) Series switches are employed in all the reported filters;

*Tunable TZs and TPs;
*Variable Bandwidth;
*Tunable frequency
*Tunable frequency
2. Shunt switches and series switches

* Transmission line loaded by a **series** switch; the switch is equivalent to a capacitor (**switch off**)

* Transmission line loaded by a **shunt** switch; the switch is equivalent to an inductor (**switch on**)

Both the series and shunt switches are able to select the through or isolation mode of a TL.
3. Filter design and analysis

3.1 Configuration

- Four shunt PIN diodes are loaded on the main TL;
- Two pairs of SIRs with mixed electric and magnetic coupling;
- A thin isolation bar is placed between each pair of SIRs.
- The TL near D2 and D3 becomes narrow, which is for better impedance matching of the TL in the bandstop mode.

<table>
<thead>
<tr>
<th></th>
<th>D1-D4</th>
<th>D5-D6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandpass mode</td>
<td>Switch on</td>
<td>Switch off</td>
</tr>
<tr>
<td>Bandstop mode</td>
<td>Switch off</td>
<td>Switch on</td>
</tr>
</tbody>
</table>

SMP1320-079LF PIN diode from Skyworks

\[ L_s = 0.7 \text{nH}, \quad R_f = 0.75 \Omega, \quad C_j = 0.23 \text{pF}, \quad R_p = 0.4 \text{M}\Omega \]
3. Filter design and analysis

3.2 Coupling Topology

Bandpass:
D1-D4 (Switch on)
D5-D6 (Switch off)

Bandstop
D1-D4 (Switch off)
D5-D6 (Switch on)
3. Filter design and analysis

3.3 bandpass mode

1) Two passbands are generated due to the two pairs of SIRs;
2) the filter exhibits high selectivity with five TZs;
3) By increasing the gap $g_1$, TZ$_2$ and TZ$_3$: hide $\Rightarrow$ appear $\Rightarrow$ split;

Fig. Simulated transfer responses versus $g_1$
3. Filter design and analysis

3.4 Bandstop mode

1) The isolation bar: prevent intercouplings between the resonators;
2) By decreasing the bar length, TZ₂ gradually moves away from TZ₁: increased bandwidth and declined in-band rejection;
3) Little effect on the second stopband;

Fig. transfer responses under different isolation bar length \( L_1 \)
4. Experimental results

Central Frequencies: 1.2 / 2.31 GHz; Minimal IL: 2.57 / 2.46 dB;

Good agreement; High selectivity in both BP and BS modes;

Central Frequencies: 1.25 / 2.39 GHz; in-band rejection: >30 dB / ≈ 40dB
Table 1: Comparisons with counterparts

<table>
<thead>
<tr>
<th>Freq. band</th>
<th>SW.</th>
<th>T. $f_c$</th>
<th>T. BW</th>
<th>passband IL (in the bandstop mode)</th>
</tr>
</thead>
<tbody>
<tr>
<td>[5]</td>
<td>single</td>
<td>series</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>[7]</td>
<td>single</td>
<td>series</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>[8]</td>
<td>dual</td>
<td>series</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>[10]</td>
<td>dual</td>
<td>series</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>This work</td>
<td>dual</td>
<td>shunt</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SW.: switch, T. $f_c$: tunable central frequency, T. BW: tunable bandwidth

The passband IL is much smaller than that of other reported works using series switches.
5. Conclusions

- A new design method for BP-to-BS filters is demonstrated by using shunt switches loaded on the transmission line;
- A significant advantage by using shunt switches is that they do not cause extra passband IL in the bandstop mode;
- The loss introduced by the switches is actually transferred to the IL in the bandpass mode;
- A dual-band BP-to-BS filter with mixed electric and magnetic coupling is proposed and presented, verifying the design method;
THANK YOU!

Q & A