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Comment on "Compact UWB Bandpass Filter Using Stub-Loaded Multiple-Mode Resonator"

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In the above letter [1], the authors present an ultra-wideband (UWB) bandpass filter with a wide upper stopband. The core piece of the circuit is a stub-loaded multiple-mode resonator (MMR) which provides four resonances as transmission poles to build up the passband and a zero to increase roll-off at the upper band edge. As in our study [2], an unloaded MMR must have a sufficiently large impedance ratio ($R \geq 5$) so that the leading three resonances have a relatively close proximity to form a broad passband. Therefore, at least two points are worth investigating from circuit design point of view. One is that the R value of the unloaded MMR in [1] is only 1.5, and the other is where the fourth resonance and the zero come from.

The MMR in [1] is loaded with an open stub of length ℓ_c in the middle and two symmetric side stubs of lengths ℓ_s. Fig. 1(a) investigates the resonant spectrum of the MMR versus $\ell_s/(\lambda/4)$ when $\ell_c = 0$, where λ is the wavelength of the unloaded MMR at its fundamental frequency $f_o = 4.4$ GHz. All resonances move down to lower frequencies as ℓ_s is increased and this implies circuit miniaturization. Note that the odd and even resonances of an unloaded MMR occur alternatively [2]. The third resonance of the stub-loaded MMR, f_3, however, goes down more rapidly than f_2, and $f_3 < f_2$ when $\ell_s/(\lambda/4) > 0.65$. Fig. 1(b) depicts the dependence of the resonances on $\ell_c/(\lambda/4)$ when $\ell_s = 0$. Only the even modes shift down to lower frequencies when ℓ_c is increased [1]. When $\ell_c/(\lambda/4) > 0.35$, f_4 becomes lower than f_3. Also, $f_2 < f_1$ when $\ell_c/(\lambda/4) > 1$. It can be deduced that the fourth resonance is one of the inherent resonant modes of the unloaded MMR and brought down into the passband by the shunt stubs.

It is interesting to note that zeros of both Fig. 1(a) and (b) have the same frequencies when $\ell_c = \ell_s$. From [3], the zero is the frequency at which ℓ_c is one quarter wavelength, since the tap point becomes virtual ground. One can see that $f_z = f_o$ when $\ell_c = \lambda/4$. Also, the zero f_z can be moved to either between f_2 and f_4 or to even lower than f_1 by adjusting ℓ_c or ℓ_s.
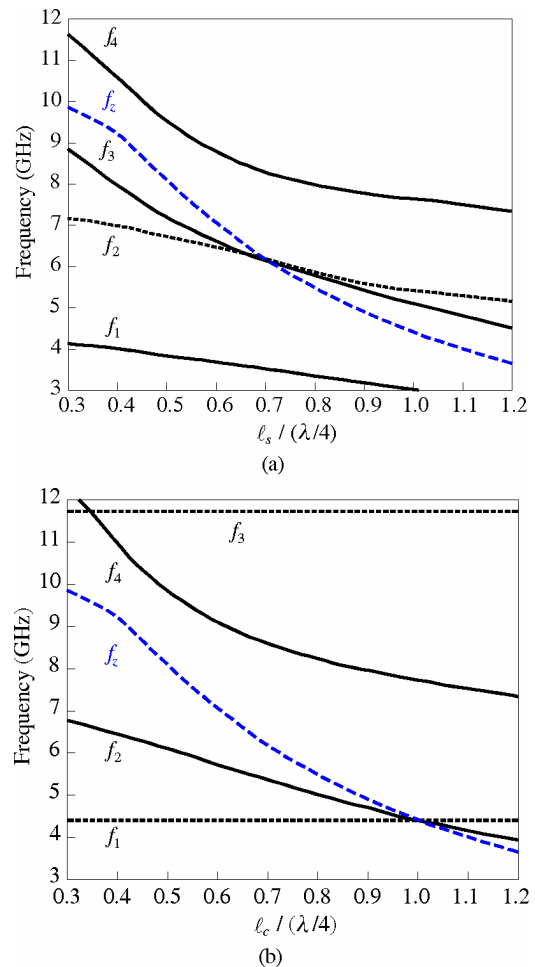
Fig. 1. Dependence of resonance modes and transmission zero on normalized stub length in [1]. (a) $\ell_c = 0$ mm. (b) $\ell_s = 0$ mm. f_z is the transmission zero and f_1, f_2, f_3, and f_4 represent, respectively, the first, second, third, and fourth resonant frequencies.

REFERENCES

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