Available Online at www.ijecse.org ISSN- 2277-1956

A Review on Reconfigurable Low Pass Bandstop Filter Based on Technology, Method and Design

B. H. Ahmad and K. N. Minhad
Centrefor Telecommunication Research and Innovation, Faculty of Electronicsand Computer Engineering,
UniversitiTeknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya, 76100 Melaka, Malaysia.
E-mail:badrulhisham@utem.edu.my, M021110012@student.utem.edu.my

Abstract-Reconfigurable filter technology is in robustness development. Due on the tunable and reconfigurable capability will contribute a various advantages in wireless applications. This tuning selectivity consist a numerous method, for example using varactor, micromachines, and PINdiodes.This review paper discussed PIN diodes as a switching element. The design and development of different types of switching element were then described. This paper presents of reconfigurable low pass bandstop filter WLAN, UWB bands applications for the past few years that operatedbetween1 to 5.6GHz. Most of the studies were focus on Chebyshev filter because of the excellent selectivity and the response is easy to be analyzed. Different types of method have been introduced in reconfigurable low pass bandstop filter, design and performance of the filter will then be compared.

Keywords – Reconfigurable filter, low pass bandstop filter,PIN diode

I. Introduction

Few years back, RF microwave filters has been enormous development, especially in reconfigurable design. Rely on current demanding, RF system provide more reliable, efficient and adaptable to imply in multiband system. This paper intends to make some review on the technology, method and design approach.Moreover, new applications have evolving for multi-functional RF system, and even better with the huge demand in diverse condition for reconfigurable filter to permit the system reconfiguration from radar to communications. It is necessary for the future RF systems towards the commercialization, civil, aviation, marine and defence sector [1]. Recent years has shown rapid changes in RF techniques as well as technology. Many reconfigurable methods has been explored, however no matter what types of switching being used, they should be conserve their transmission and reflection coefficient over the tuning detailed.

The method and design of each filter is different. A number of tuning filter based on centre frequency has been studied and investigated [2-14]. The tunable process would occurred by adjusting the electrical length of each filter resonators [15-19] either in continuous or descreterealizations.Asstatedin conventional methods, varactor diode is proposedly as popular method emerging in Barium-Strontium-Titanate (BST) [15], piezoelectric [19], and semiconductor. In way to reconfigure the centre frequency, some of other method has been identified to implement discrete step PIN diode [20]. Nevertheless, new technology wasintroducing using micromechanical tuning switch, which can easily tune the centre frequency.

Reconfigurable filter is much more commercialize in the future due on the hasle frequency spectrum range. Furthermore in reconfigure filter, are more compact, implement in narrow or wideband, low insertion losses, and lots of realizable expandability. Figure 1 shows the basic third order of bandstopfilter with inverse chebyshev response. The circuit level will be transform to the distributed lumped element in Figure 2.

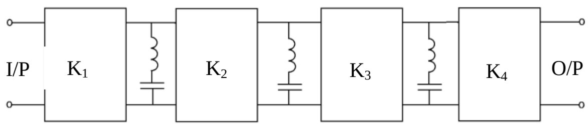

Figure 1. The basic schematic structure of circuit level

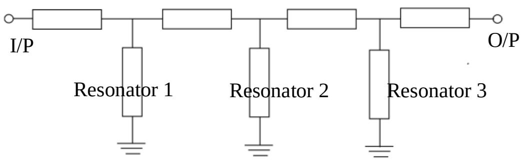

Figure 2. Distributed lumped element

Based on circuit level, it would be easy to identify the response after determine the inductor and capacitor value verified form the operational frequency and filter types [7], where f_o is the midband frequency of the bandstop filter and fractional bandwidth (FBW). The filter is normally designed to match 50Ω terminations, therefore Zo = 50Ω, to determine the electrical design paramaters for the filter network representation, it would be consider based on element values table [2],[21-23].

Previous studies has been conceal to develop and design the reconfigurable low pass bandstop filter based on the insertion loss, return loss, rejection loss, stopband rejection and method of the design will be discussed later on the next section. The physical layout in microstrip design as shown in Figure 3.

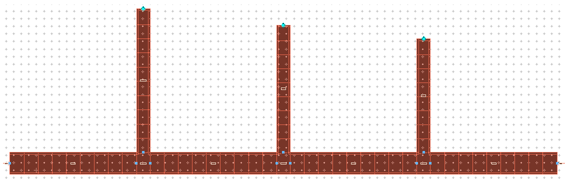

Figure 3. Physical layout in microstrip design

II.TECHNOLOGY, METHOD AND DESIGN

Developing ultra-wideband (UWB) and wireless technology requires the use of a wide radio spectrum. Furthermore, the frequency spectrum as a crucial resource is appreciated and limited, hence the spectrum is necessary for several purpose, which it may contain the unwanted signals when an operation for example of UWB, WLAN or WiMax is concerned.

To establish the configuration, in 2008 a solution have been introduce by using tunable or switchable narrow rejection band within the UWB bandpass filter [24-25]. Moreover, this application also suits for radar and electronic war systems. This paper report the bandpass filter in UWB using two identical notch structure with PIN diode is selected as the switching element. DC biasing circuit has been designed activate and deactivate the PIN diode without interrupting the filter response. Figure 4 shows the physical layout for the reconfigurable UWB with switchable notch.

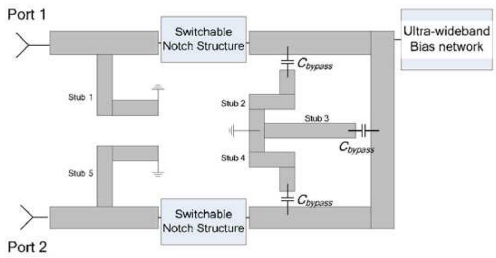

Figure 4.Physical layout for reconfigurable UWB with switchable notch structure [21].

Switchable notch structure with the PIN diode attached at the open end of embedded stub. When the PIN diode at the zero bias condition, it presents large impedance because of the very small capacitance junction whilst produce the open circuited stub that resonates. In order to investigate the accurate notch behaviour, two different schemes of switchable notch structure are demonstrated in figure 5. Based on the main principle of transmission line with and embedded stub, both of it represent width and length $W_1$and l_1,and electrical legth of l_1 is around 90° at the desired response notch frequency.

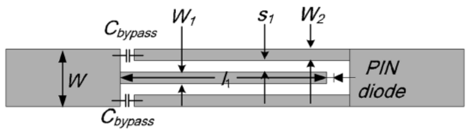

Figure 5. Switchable notch structure[21].

Filter performance has been analysed over the frequency range of 1 to 15GHz. The result shows the notch can be observed in on and off condition at the centre frequency about 5.1GHz, when it turning ON at 0 V bias, its gives rejection ratios more than 35dB. To switch the notch off, it is found that the filter performance is almost the same as when the PIN diode subjected to a forward bias between2.5 and 5 mA. The measured minimum insertion loss is 0.5 dB and the measured 3 dB bandwidth is 5.92 GHz. Some higher return loss may be attributed to the embedded switchable notch structure. Both of the simulation and measurement result has been compared as illustrated in Figure 6.

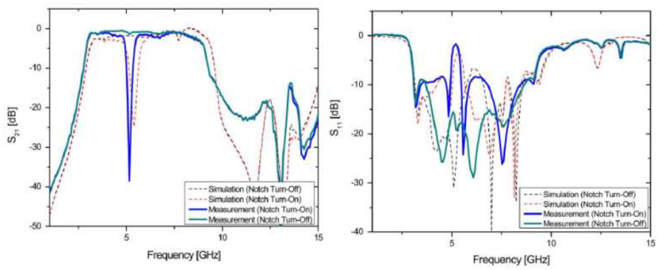

Figure 6: Comparison of simulation and measurement results [21].

In 2009, reconfigurable filter for wireless applications that has the operational frequency of 2.4GHzhas been applied. This filter has the ability to switch from UWB frequency to 2.4GHz using PIN diode. This technology development [25] was proposed to reconfigure from bandstop to bandpass at the same UWB spectrum. The filter consists of two bended open stubs short to the ground using PIN diode. Thus the switchable filter was developed by connecting half wavelength strip line resonator, when it's inparallel, nominally90° phase shift element and will optimized at active Q-factor. Figure 7 illustrated the layout of the reconfigurable filter.

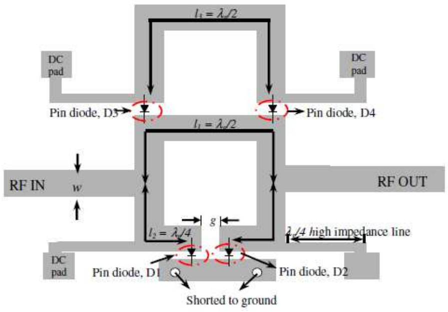

Figure 7.Schematic of reconfigurable filter [25].

As the PIN diode will be used in the switching element, it will operate in two conditions, when the switch is in ON state, the filter will turn to all pass response, while when the switch is in OFF state, it become to bandstopresponse.UWBbandpass filters are established [26] in order to achieve UWB passband with a 110% fractional bandwidth at the central frequency of6.85 GHz. Lately, a UWB based bandpass filter is stated with good rejection performance [27]. Bandstop filtersinmicrowave applications are considered using quarter-wave open-end stubs or short-end tubs or stepped impedance structures, but these circuits are typically narrow band [28].

These filter configuration can be operate in two conditions, considered the measurement results of the reconfigurable filter as shown in figure 8, enhancing the topology of the diode function when it turn to ON and OFF.

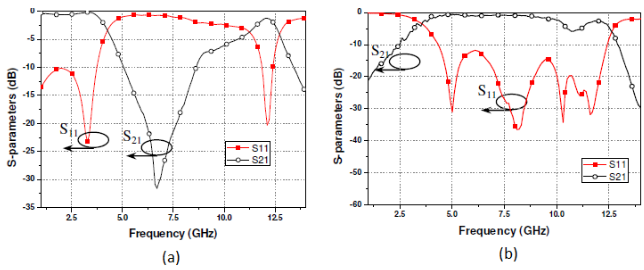

Figure 8. Measurement result for reconfigurable filter (a) PIN diode OFF, bandstop (b) PIN diode ON, bandpass[25].

To project the reconfigurable filter performance based on main characteristic, it has been short listed as in Table 1.For the UWB bandstop rejection level showed more than 30dB with the insertion loss of 1.9dB in the passband which is at 2.1GHz. Furthermore for switchable state at 2.4GHz, insertion loss depicted a lower than 0.9dB with a 3dB bandwidth of 400MHz. However, this is great execution in UWB 2.4GHz WLAN based system. Based on the following method that have been used, in 2010 [2], using different method to achieve the aimed to derive the better fractional bandwidth tuning range. The following methods are not really similar for low-pass filter, however, it can be implement to understand the filter behavior and tuning element concept theoretically.

Table 1- Measurement result based on filter performance [25].

Diode	Condition	f_0	Insertion Loss (dB)	Bandwidth	Rejection loss
D1,D2,D3 D4	OFF (Bandstop)	6.85GHz	1.9dB	20dB at 2.2GHz	>30dB
D1, D2	ON (Bandpass)	-	2.1dB	3dB at 7GHz	>25dB
D1,D2,D3 D4	ON (Switchable)	2.4GHz	0.9dB	3dB	-

In order to design the tunable cut-off frequency and wideband bandpass filters, the proposed circuit block may be useful. It consists of short circuit coupled lines and short circuit stubs with PIN diodes as tuning elements. Crucial part should be implemented to ensure the filter is reconfigurable, many methods have been used,it doesn't matter as long it can conserve the transmission zero and reflection-coefficient on tuning range. This reconfigurable filter mainly consists of short-circuited coupled lines and switchable short-circuited stubs which have an electrical length of 90°at centre frequency and an impedance transformer for impedance matching to obtain enough coupling. It may fix to odd or even mode impedances [25]. By altering the impedance stubs and the coupling, it will vary the bandwidth. Furthermore for the selectivity switching short-circuit, it may related to the ON and OFF or dependently alter the impedance of the stubs change the passband width. The actual filter design is as shown in Figure 7.

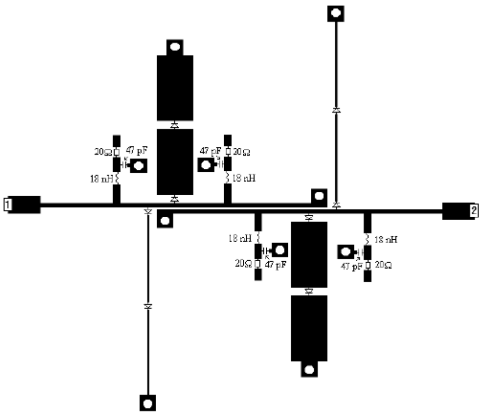

Figure 7. Combining both filter[1].

Each stub contain a different PIN diodes. This method proposed the no shifting in centre frequency because of the electrical length would be altered in way to distinguish appropriate shifts. Moreover, the insertion-loss will strongly accompanying with the narrowband are higher as the expected. The presence of the bias circuit components and diodes effects the losses of the circuit hence affecting the return loss permenantly. While this filter would allow four conditions, state 1 is when the all diodes OFF, state 2 wideband stubs ON and narrowband stubs OFF, state 3 is when the narrowband stubs ON and wideband stubs OFF, then the fourth stage is all diodes ON. Through out the simulation and measurement result, both response shows a good agreement in terms of insertion loss which has been inconsistence, whilst the centre frequency (f_0) and 3dB FBW are contribute to the tolerances of components and fabrication process. Figure 8 depicted the simulation response, Figure 9 shows the measurement response and table 2is the comparison for both results.

International Journal of Electronics and Computer Science Engineering
WWW.IJECSE.ORG

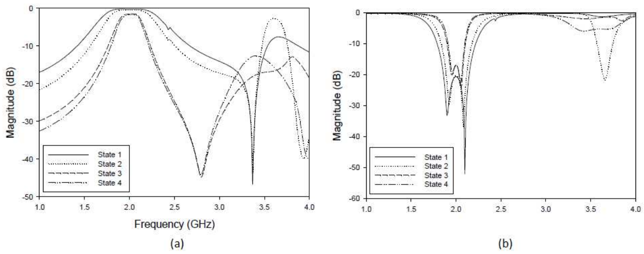

Figure 8. Simulated (a) insertion loss (S_{21}) and return loss (S_{11})[1].

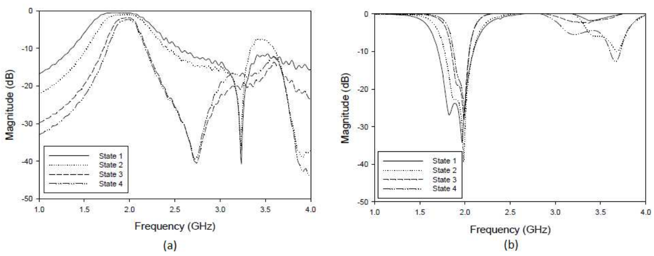

Figure 9. Measured (a) insertion loss (S_{21}) and return loss (S_{11})[1].

Table 1- Comparison for both simulation and measurement results [1].

		State I	State II	State III	State IV
Simulation performance	**FBW (3dB)**	34%	27%	15%	13.5%
	f_0	2GHz	2GHz	2GHz	2GHz
	Insertion Loss	-0.22dB	-0.45dB	-1.45dB	-1.66dB
Measurement performance	**FBW (3dB)**	33.5%	23.23%	14.65%	13.06%
	f_0	1.9GHz	1.9375GHz	1.945GHz	1.9525GHz
	Insertion Loss	-0.62dB	-1.07dB	-1.91dB	-2.5dB

In 2011, amethod of reconfigurable filter been disclosed using the matched bandstop [29]. This paper proposed a new method in matching bandstop filter using the switching configuration based on lossy all pass network. It accurately matched at all frequency selection. Generously it based on the half wavelengthλ/2 resonator together with gap coupling, parallel with all pass nominally 90°phase shift element. Realization involve the PIN diode towards two condition when its ON employ all pass and when it is in the OFF state it will be in OFF state. Filter prototype is as shown in Figure 9.

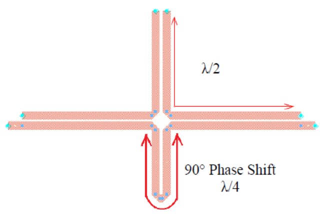

Figure 9: Filter prototype of twin resonator notch filter [29].

Notch filter topology is based on lossy resonator to matched bandstop response between S_{11} and S_{12} at one resonance frequency of 1GHz. The operation of this filter is based on the PIN diode. When it goes to OFF, the filter will be in a bandstop response, meanwhile when it was ON, it will obtained all pass response. As a switching element, the PIN diode will be connected to 8.8V in the bias circuit line. This design is expected to achieve return loss lower than -10dB ensuring to minimize the signal loss. Both of filter condition states has been collected and compared in Figure 10andTable 3.

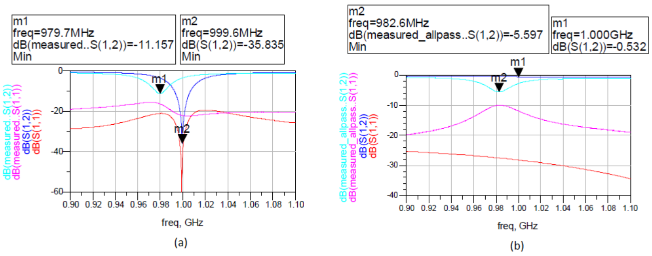

Figure 10. (a) Simulated (m1) and measured (m2) result when the PIN diode turned OFF,bandstop matching, (b) simulated (m1) and measured (m2) when the PIN diode ON, allpass response[29].

Figure 10 (a) shows that the response is shifted about 20 MHz. The attenuation for S_{12} gives -11.15 dB compared to the simulated result which is -35.83 dB. But from results explained the network is matched at all frequencies which means that the return loss is lower than -10 dB.Figure 10 (b), givesallpass response when the PIN diode is turned 'ON'. The simulation result gives the exact response but the measurement result is slightly having attenuation about -5.60 dB.

In the measured result, S_{12} cannot be improved to be lower than -3 dB. The possible root cause may bedueto parasitic inductance in PIN diodes during 'ON' state and theparasitic inductance of via hole between PIN diode to the groundlayer.This paper proved that the matched filter can be reconfigured by applying the PIN diode and provide a matched network at centre frequency of 1GHz.Meanwhile, there is some enhancement based on the same method design [30] using the dual-mode ring resonator. This paper intends to demonstrate reconfigurable dual-mode ring resonator matched the band stop filter behaviour. The technique been used by composed two degenerate modes and splitting resonant frequency using pertubing stub. Uttermost, this techniques drawn the advantages in term of size,which can reduce the filter size, and permit the better performance.

Dual-mode ring resonator method still using PIN diodes as a switching element. The filter can be reconfigure two states operation either in front-end to isolate frequency band and located within wide passband. Previous study showing the few method that been proposed, like using the match bandstop filter [31] which concern in high Q lossy resonator, tunable matched [32],[34-35]. Reconfigurable allpass to bandstop using the PIN diodes [29].The method that being chosen in this paper also referring to [29].

Approaching the filter design, energy differently reflected to realize frequency selectivity which limited by lossless. Dual-mode design taken [30] to determine the notch topology for dual-mode ring resonator bandstop filter. The filters with two resonators give two resonant frequency response, whichever in single response by adjusting the length. Figure 11 depicted in high notch with smaller size of filter circuit, and Figure 12 exposed the prototype of reconfigurable dual-mode ring resonator. Both ring resonator coupled thru-line while reacted in inductive and capacitive coupling, and parallel coupling line. Each of the coupler can shortly show the $\lambda/_4$ as the short circuit at resonator and perform in bandstop response.

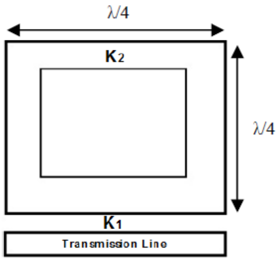

Figure 11. Notch topology design for dual-mode ring resonator [30]

ISSN: 2277-1956/V2N1-395-404

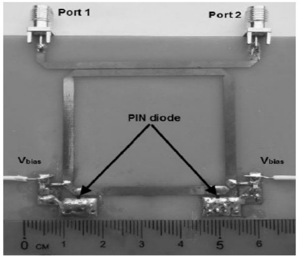

Figure 12. Prototype of reconfigurable dual-mode ring resonator matched bandstop filter at 1 GHz [30]

Moreover, based on the technology, method and design approch in this paper, it develop the best performance with the good agreement. Dual-mode ring resonator matched bandstop filter allows the structure of reconfigurable design by implement PIN diode as switching elements.

III. DISCUSSION

The review and analysis for reconfigurable lowpass bandpass and bandstop filter for the past few years has been done. The comparison and performance of the different method and design of every each design were presented in Table 3. Different method has been used in research area in order to develop the best performance of reconfigurable filter. Each of this method proposed has their own operational frequency, however the same method can be used to implement in other frequency range. As illustrated, an excellent filter should be low in losses while transmitting the signal, thus a lower insertion loss would be considered in design method.

Each of this method represent have their own advantages. For the circuit building block, the design can be simplify on diode arrangement. Whilst, the diode configuration can further down the stub to reduce the losses. However, this would cause some spike. Hence, to overcome this problem, few solution has been discovered by moving the diode halfway down between the losses and isolation of the spike being made. The demonstrated filter show a good agreement between measured and simulated result with reconfigurable bandwidths ranging from 16% to 37%. Furthermore, this design provide a potential simultaneous control the bandwidth and the centre frequency.

Besides that, by using the two bended open stub short to the ground can reconfigure the fiter behaviour act as a bandpass. It provides a different parametric, meaning the filter is switchable between 2.4GHz WLAN from UWB by conneting both stub lengthλ_g / 2. This type of method design enhance the conventional filter because a single filtercannot fullfill the requirement to operate at ultra-wide band (UWB) and wireless local area network (WLAN) hence using the multiple circuit will endure to the large surface area. Consequently, it generates compact size, low insertion loss and realiable performance filter. Matched filter method propose different design method but still using the PIN diode as the switching element. The filter has been rely on the allpass lossy network which can be matched at all frequency. Through the K inverter in topolgy which consist ofλ / 2 short circuit in transmission line and provide nominally 90° phase shift element between the resonator is able to use in any frequency selectivity. It shows the best matched bandstop reconfgurable filter. Moreover, the matched design got enhancement to improve the design quality in dual-mode ring resonator.

Table 3- Comparison of technology, method and design of reconfigurable lowpassbandstopfilter

Filter/ Year	**[21] 2008**	**[25] 2009**	**[1] 2010**	**[29] 2011**	**[30] 2012**
Method and design	Circuit block	Two bended open stub short to the ground	Circuit block	Matched bandstop filter	Dual-mode ring resonator
Technology	PIN diode	PIN diode	PIN diode	PIN diode	PIN diode
f_o(GHz)	5.1	6.85 & 2.4	2.0	1	1

ISSN: 2277-1956/V2N1-395-404

Fractional bandwidth, FBW (%)	-	10.1	13.5% - 34%	-	-
Insertion loss, IL (dB)	0.5	1.9, 2.1, 0.9	-0.45 -1.66	-11.15,-35.83	-10.161
Return loss, RL (dB)	Attribute to notch structure	>10	>10	-22.22, -59.98	-32.44
Stopband rejection (dB)	>35	>30 >25	>30	-	-
Size (mm^2)	9.4×0.75	9.3×10.30	26.85×10.0	90×110	60 × 100
Dielectric constant, ε_r	3.05	3.38	3	4.7	4.7

IV.CONCLUSION

The different methods of designing reconfigure low pass bandstop filter applications have been reviewed. The entire filter shows decent response for insertion loss and return loss. Besides, the size of the filter designed is small and compact as well easy to integrate. The fabrication process is done by using PCB which is beneficial to the low-cost manufacturing process.

V. REFERENCE

[1] Alexander Miller, Jia-Sheng Hong, "Wideband Bandpass Filter with Multiple Reconfigurable Bandwidth States", Microwave Conference (EuMC) 2010 Europian, pp 1273-1276, Sept 2010.

[2] J.-S. Hong, "Reconfigurable planar filters", IEEE Microwave Magzine, Vol.10, no.6, Oct. 2009, pp.73-83.

[3] I. C. Hunter and J. D. Rhodes, "Electronically tunable microwave bandpass filters," IEEE Trans. Microw. Theory Tech., vol. MTT-30, no.9, pp. 1353–1360, Sep. 1980.

[4] G. Torregrosa et al., "A simple method to design wide-band electronically tunable combline filters," IEEE Trans. Microw. Theory Tech., vol. 50, no. 1, pp. 172–177, Jan. 2002.

[5] Y.-H. Chun and J.-S. Hong, ''Electronically Reconfigurable Dual-Mode Microstrip Open-Loop Resonator Filter,'' IEEE Microwave and Wireless Components Letters, Vol. 18, No.7, pp. 449--451, July 2008.

[6] W. Tang and J.-S. Hong, "Tunable Microstrip Quasi-Elliptic Function Bandpass Filters", 39th European Microwave Conference, EuMC2009.

[7] Young-Hoon Chun, Jia-Sheng Hong, Peng Bao, Timothy J. Jackson,Michael J. Lancaster, "Tunable Bandstop filter Using BST Varactor Chips," Proceedings of the 37th European Microwave Conference, October 2007.

[8] Y.-H. Chun, J.-S. Hong, P. Bao, T. J. Jackson, and M. J. Lancaster, "Tunable Slotted Ground Structured Bandstop Filter with BST Varactors", IET Proceedings, Microwaves Antennas & Propagation, Vol.3, Issune 5, Aug. 2009, pp.870-876.

[9] Mahmoud Al-Ahmad, Richard Matz, and Peter Russer, "0.8 GHz to 2.4GHz Tunable Ceramic Microwave Bandpass Filters," Microwave Symposium, IEEE/MTT-S International, pp. 1615 – 1618, July 2007

[10] Y.-H. Shu, J. A. Navarro, and K. Chang, "Electronically switchable and tunable coplanar waveguide-slotline band-pass filters," IEEE Trans. Microwave Theory Tech., vol. 39, pp. 548–554, Mar. 1991.

[11] Cesar Lugo and John Papapolymerou, "Dual Mode ReconfigurableFilter with Asymmetrical Transmission Zeros and Center Frequency Control," IEEE Microwave and Wireless Components Letters, Vol. 16, No. 9, pp. 499 – 501, Sept 2006.

[12] Eric M. Prophet, Jurgen Musolf, Betty F. Zuck, Silverio Jimenez, Kenneth E. Kihlstrom and Balam A. Willemsen, "Highly-Selective Electronically-Tunable Cryogenic Filters Using Monolithic, Discretely- Switchable MEMS Capacitor Arrays," IEEE Transactions on Applied Superconductivity, Vol. 15, No. 2, pp. 956 – 959, June 2005.

[13] Kamran Entesari and Gabriel M. Rebeiz, "A 12-18 GHz Three-Pole RFMEMS Tunable Filter," IEEE Transactions On Microwave Theory andTechniques, Vol. 53, No. 8, pp. 2566-2571, August 2005.

[14] Jayesh Nath, Dipankar Ghosh, Jon-Paul.Maria, Angus I.Kingon, Wael Fathelbab, Paul D.Franzon, Michael B.Steer, "An Electronically Tunable Microstip Bandpass filter Using Thin-Film Barium-Strontium-Titanate (BST) Varactor," IEEE transactions on microwave theory and techniques, vol.53, no.9, Sep. 2009.

[15] Md. Fokhrul Islam, M.A. Mohd. Ali and Burhanuddin Yeop Majlis, "RF MEMS-Based Filter for X-Band Applications," Journal of Applied Sciences 8 (1): 189-191, 2008.

[16] Y.-H. Chun and J.-S. Hong, "Electronically reconfigurable dual-mode microstrip open-loop resonator filter," IEEE Microw. Wireless Compon. Lett., vol. 18, no. 7, pp. 449–451, Jul. 2008.

[17] J. Nath, D. Ghosh, J. - P. Maria, A. I. Kingon, W. Fathelbab, P. D. Franzon, and M. B. Steer, "An electronically tunable microstrip band-pass using thin-film barium-strontium-titanate (BST) varactors," IEEE Trans. Microw. Theory Tech., vol. 53, no. 9, pp. 2707–2712, Sep. 2005.

[18] M. A. Ahmad, R. Matz, and P. Russer, “0.8 GHz to 2.4 GHz tunable ceramic microwave bandpass filters,” in IEEE MTT-S Int. Micro. Symp. Dig., Jul. 2007, pp. 1615–1618.

[19] E. Pistono, M. Robert, L. Duvillaret, J.-M. Duchamp, A. Vilcot, and P. Ferrari, “Compact fixed and tune-all bandpass filters based on coupled slow-wave resonators,” IEEE Trans. Microw. Theory Tech., vol. 54, no. 6, pp. 2790–2799, Jun. 2006.

[20] Alexander Miller, Jia-Sheng Hong, “Wideband Bandpass Filter With Reconfigurable Bandwidth”, IEEE microwave and wireless components letters, vol. 20, no. 1, January 2010.

[21] Y.-H.Chun, H.Shaman, and J.-S.Hong , “ Switchable Embedded Notch Structure for UWB Bandpass Filter”, IEEE Microwave Wireless Components Lett. 18(9), 2008, 590-592.

[22] H.R. Arachchige, J-S.Hong, and Z.-C. Hao, “ UWB Bandpass flter with Tunable Notch on Liquid Crystal Polymer Substrate*,”Asia-Pacific Microwave Conference* , 2008 APMC, 4p, 16-20 Dec. 2008.

[23] R. Li and L. Zhu, “Compact UWB Bandpass filter using stub-loaded multiple-mode resonator,” IEEE Microw. Wireless Compon. Lett., vol. 17, no. 1, pp. 40–42, Jan. 2007.

[24] J. S. Hong and M .J. Lancaster, “Microstrip Filters for RF/Microwave Applications”, New York: Wiley, 2001. Ch. 8, pp. 235-271.

[25] M.F.Karim, Yong-Xin Guo, Z.N. Chen, L.C.Ong, “ Miniaturized Reconfigurable and Switchable Filter from UWB to 2.4GHz WLAN Using PIN Diodes ”, *Microwave Symposium Digest MTT'*, 2009*IEEE MTT-S International*, pp 509- 512, June 7-12th 2009.

[26] H. Ishida and K. Araki, “Design and Analysis of UWB Bandpass Filter with Ring Filter,” in IEEE MTT-S Int. Dig., Jun. 2004, pp.1307–1310.

[27] S. W. Wong, and L. Zhu, “EBG-embedded Multiple Mode Resonator for UWB Bandpass Filter with Improve Upper Stop band Performance, ” IEEE Wireless Component Lett., vol. 17, pp. 421-423, June 2007.

[28] A. Gorur, and C. Karpuz, “Uniplanar compact wide bandstop filter,” IEEE Wireless Component Lett., vol. 13, pp. 114-116, March 2003

[29] Zahari, M.K.; Ahmad, B.H.; Shairi, N.A.; Peng Wen Wong; , "Reconfigurable matched bandstop filter," *RF and Microwave Conference (RFM), 2011 IEEE International* , pp.230-233, 12-14 Dec. 2011

[30] Zahari, M. K.; Ahmad, B. H.; Shairi, N. A.; Peng Wen Wong; "Reconfigurable dual-mode ring resonator matched bandstop filter," *Wireless Technology and Applications (ISWTA), 2012 IEEE Symposium on* , pp.71-74, 23-26 Sept. 2012

[31] Guyette, A.C.; Hunter, I.C.; Pollard, R.D.; Jachowski, D.R.; , "Perfectly Matched Bandstop Filters using Lossy Resonators," MicrowaveSymposium Digest, 2005 IEEE MTT-S.

[32] Jachowski, D.R.;"Compact, Frequency-agile, Absorptive bandstopfilters," Microwave Symposium Digest, 2005 IEEE MTT-SInternational, vol., no., pp. 4 pp., 12-17 June 2005

[33] Peng Wen Wong; Hunter, I.C.; Pollard, R.D.;"Matched BandstopResonator with Tunable K-inverter," Microwave Conference, 2007European, vol., no., pp.664-667, 9-12 Oct. 2007.

[34] Jachowski, D.R.; Guyette, A.C.; , "Sub-octave-Tunable Microstrip Notch Filter,"Electromagnetic Compatibility,2009EMC2009IEEEInternational Symposium on, vol., no., pp.99-102, 17-21 Aug. 2009.

IJECSE
International Journal of Electronics and Computer Science Engineering
WWW.IJECSE.ORG