

Different Approaches of Integration of Antenna and Filter for RF Applications

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Abstract : In this paper various approaches of antenna and filter integration are presented for size reduction and for impedance bandwidth enhancement. Instead of using 50 ohm impedance at the interface, the impedance between the antenna and the filter is optimized to improve the performance. Single band, dual band, ultra wide band and reconfigurable filtering antennas are presented, which provide good desired frequency selectivity and out of band rejection.

IndexTerms - Integration, Antenna, Filter, Reconfigurable, Interface.

I. INTRODUCTION

This paper presents different approaches of integration of antenna and filter for size reduction. Miniaturization and low cost are the two most fundamental demands for RF receiver front-ends. One way to miniaturize an RF front-end is to embed its passive circuitries and interconnects into a package, which is called system-in package (SIP). Another way is to integrate required multiple functional circuitries into one device without the 50Ω (or 75Ω) constraints, referred to as co-design. The co-design method can change the structure of the circuit, improve the performance of the circuits, and simplify the connections between different components.[1] Antenna and filter are the most important components for RF Front end design. Antennas have a crucial effect on the overall size and performance of wireless systems. For instance, the efficiency of the antenna plays an important role to determine the overall efficiency of the wireless system because the antenna is the first to receive the signal in the receiver and the last to send out the signal in the transmitter. Therefore the integration of the antenna directly into the FEM package is required to optimization the size, cost and performance of the FEM. Integrating the antenna requires miniaturizing the antenna, which is another intricate task since the gain and bandwidth of the antenna are bounded by the fundamental limits depending on the size of the antenna. The so called Antenna-Filter devices have been attempted in the past by using the multilayer technology and combination of high permittivity ceramic materials and foam substrates for the filter and antenna layers, respectively [2]. Moreover, the specific design proposed in [2] fails to implement the filter part in a single layer and uses an additional thin film microstrip and the connecting via holes to implement parts of the filter. In this paper different approaches are proposed for Antenna-Filter integration.

II. ANTENNA FILTER INTEGRATION

In First approach of integration, antenna and filter, both the components are connected in cascade. This is traditional design approach and took large substrate size as shown in figure 1(a). The impedance at the interface is restricted to be 50 ohm in traditional design approach. In co-design approach of integration a notch antenna is connected with a hairpin filter and a common ground plane is sandwiched between the two as shown in figure 1(b). Both are connected vertically by a metallic via hole and arranged to have parallel currents so that electromagnetic interference is reduced [6]. In co-design approach of integration the size of the substrate is reduced because both the components share common ground plane and connected by a via hole

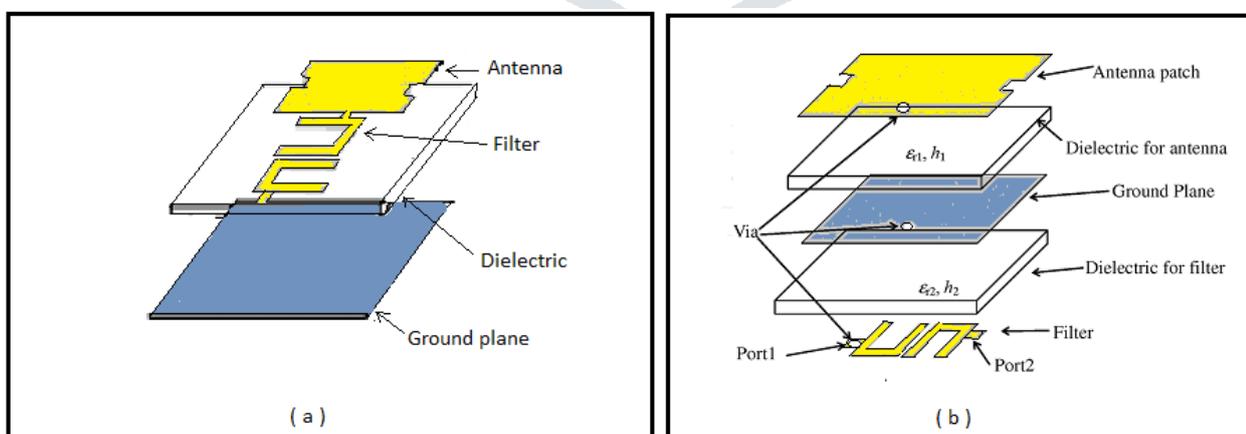


Figure1. Antenna-Filter (a) Traditional Version (b) Co-design Version [6].

The coupling between the antenna and filter, and via hole and ground provides resonance at two frequencies and due to this the bandwidth increases. Figure 2 shows the measured and simulated S11 parameters for the co-designed and traditional antenna-filters. The measured pass-band is located at 4.03–4.14 GHz (110MHz) for the traditional version and 4.06–4.26 GHz (the impedance bandwidth is 200MHz) for the co-designed version.

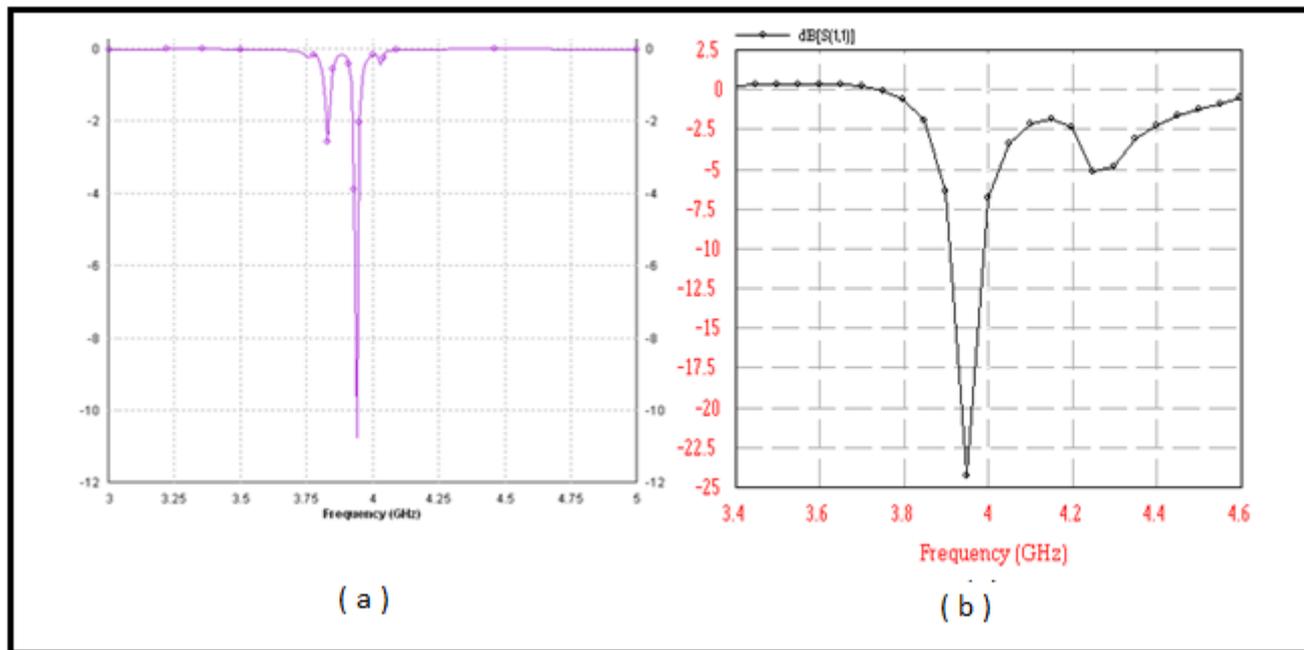


Figure 2. Return loss with, (a) Traditional Version, (b) Co-design Version.

In second design approach, a loop loaded dual band monopole radiator and a microstrip dual-band pseudo-interdigital bandpass Filter are integrated on a common ground plane. First of all, the loop loaded dual band monopole antenna and a dual band pseudo interdigital band pass filter is designed separately on the same substrate. Both are designed for same frequency i.e. 2.45GHz and 5.2GHz. The monopole frequencies are obtained, higher frequency i.e. 5.2GHz is due to small inductive loop at the top of the resonator and lower frequency i.e. 2.45GHz is due to capacitive loop of the monopole. The Bandpass filter is designed using two stepped impedance resonators. Then author designed both on a common ground plane as shown in Figure3 (a). The design is carefully integrated and the proposed antenna-filter provides good selectivity and rejection in out of band regions and Omni-directional radiation patterns within the two desired bands [3].

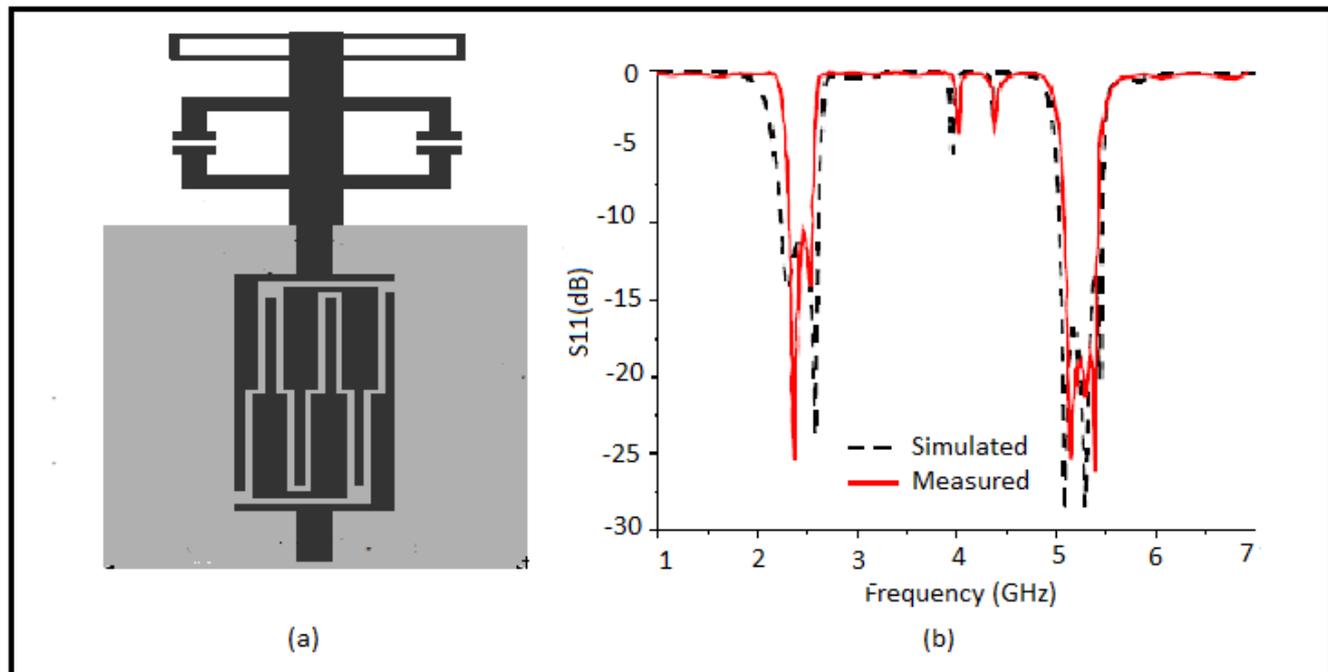


Figure3. (a)Co-design of compact Dual Band Filtering Antenna, (b) Simulated and Measured S11 for Antenna-Filter [3].

In Third approach of integration, a compact dual-band filtering antenna incorporating a PIN diode for 2.45/5.2GHz wireless local area network is designed shown in figure 4. A monopole radiator and a microstrip dual band bandpass filter is designed on a common substrate and ground plane with PIN diode shown in Figure4 [4]. The diode is incorporated between the coupling resonators of the filter. When diode is in off state (state 1) it acts as a series capacitor and provides high isolation between the resonators and gives return losses as shown in figure 5(a). When diode is in on state (State 2) it acts as a series resistor and change the current path and both the frequencies shifts towards lower frequency band and provides higher bandwidth, shown in figure 5(b). So reconfigurability is introduced in terms of bandwidth improvement.

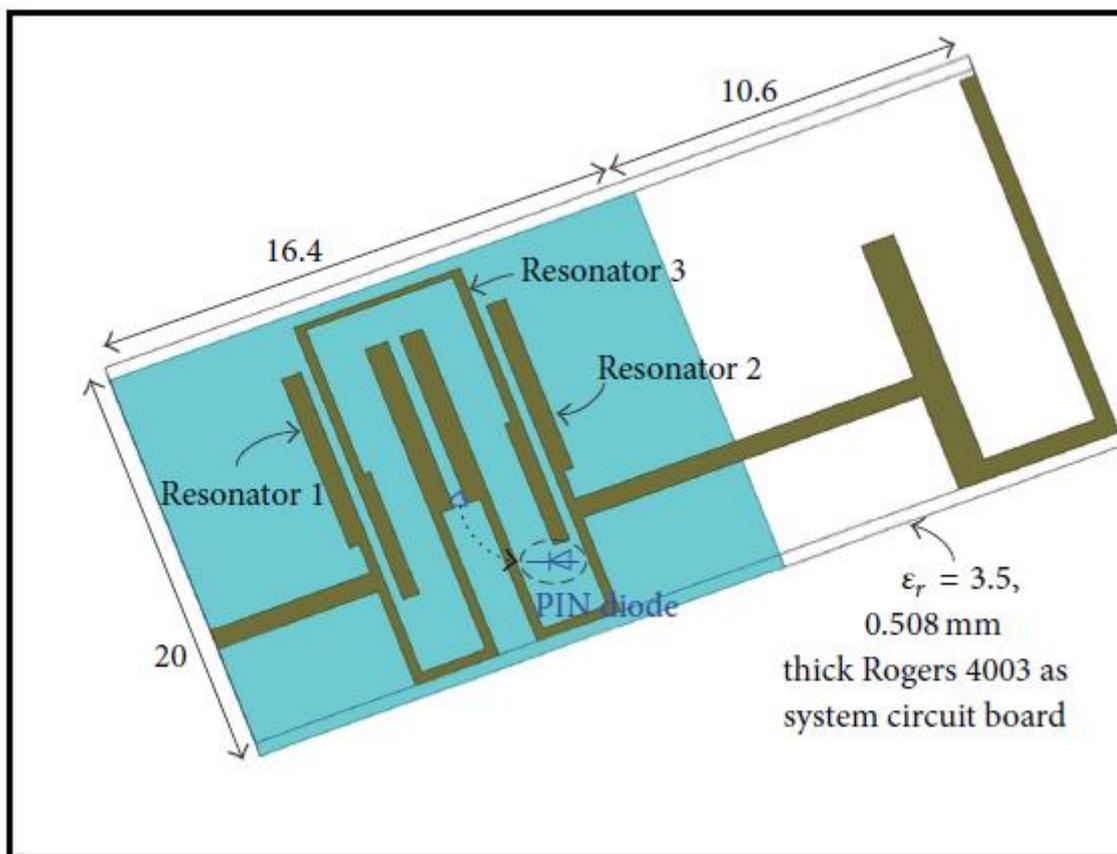


Figure 4. Dual Band Integrated Antenna Filter With PIN Diode.

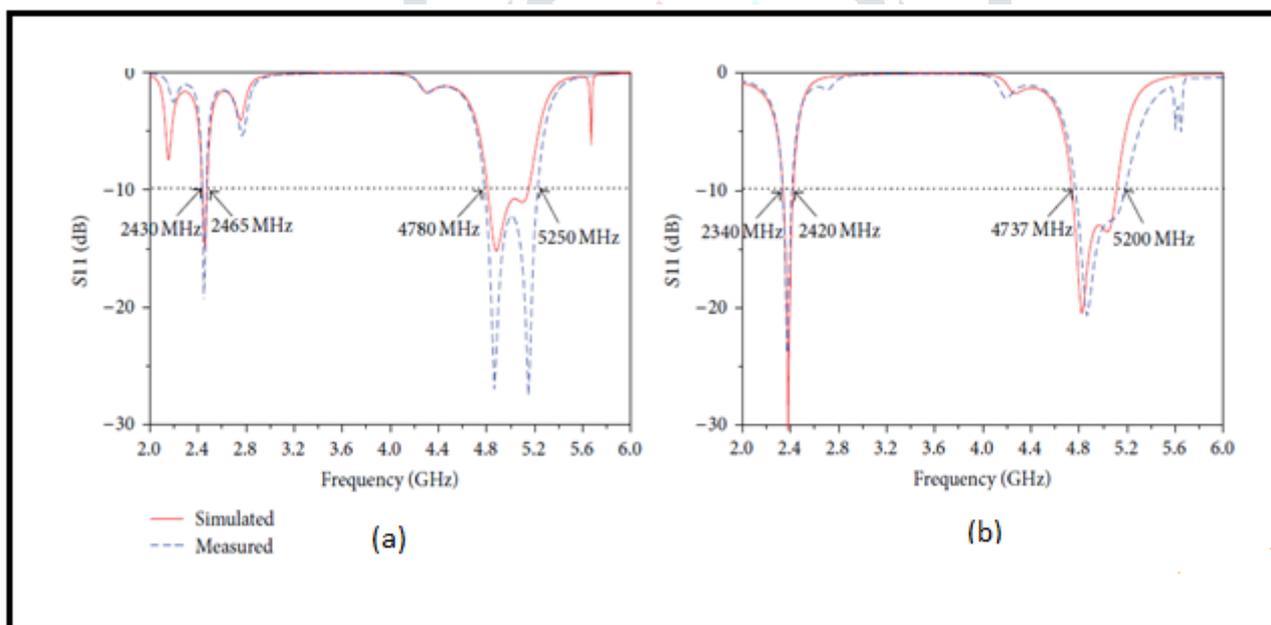


Figure 5. Simulated and Measured Reflection Coefficients against frequency, (a) for state 1, (b) for state 2.

In fourth approach, an UWB circular monopole microstrip antenna and UWB filter are cascaded on the same layer to obtain ultra Wide Band frequency band. Filter is obtained by integrating stepped impedance LPF and quarter wave short circuited stubs acting as HPF. The two are embedded together to form a BPF. The configuration and return loss of Co-design is shown in figure 6[5].

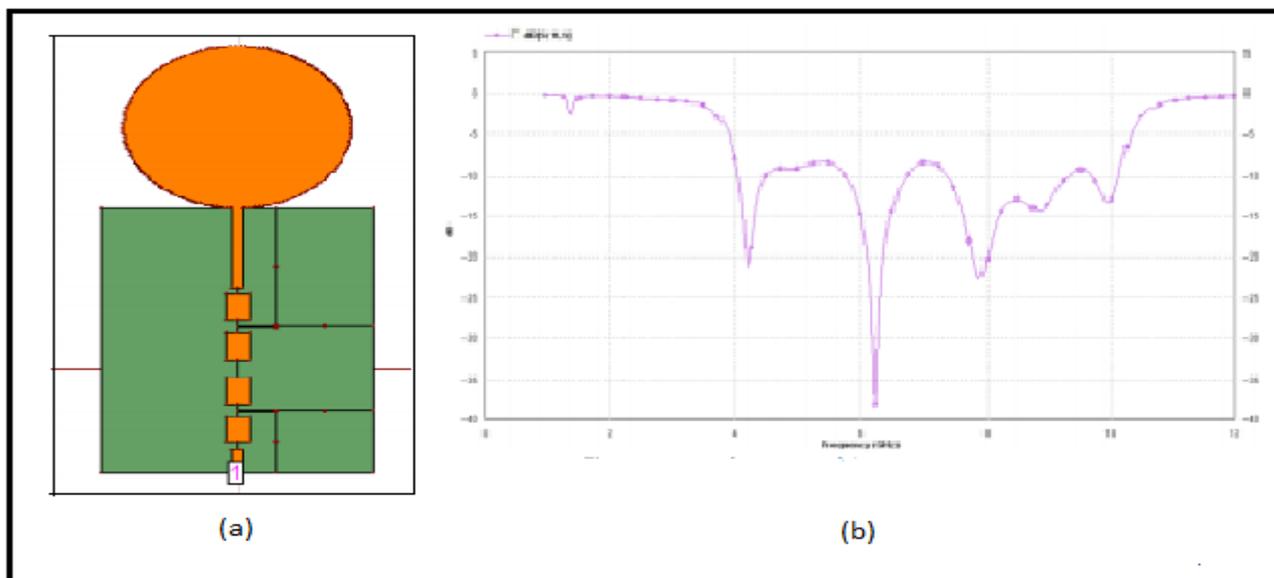


Figure 6. (a) Configuration and (b) Return Loss S_{11} for Antenna-Filter Co-design [5].

In fifth approach, a simple rectangular patch and defected ground plane, which act as a bandstop filter is used for design purpose. A PIN diode is used for frequency switch ability. A DGS almost similar to dumbbell shape is incorporated in the ground plane and a PIN diode along with four surface mount capacitors are introduced in the DGS, shown in figure 7. When diode is forward bias, 5.6GHz frequency is achieved and when it is reversed bias 2.4GHz and 5GHz frequency is achieved, as shown in figure 8.

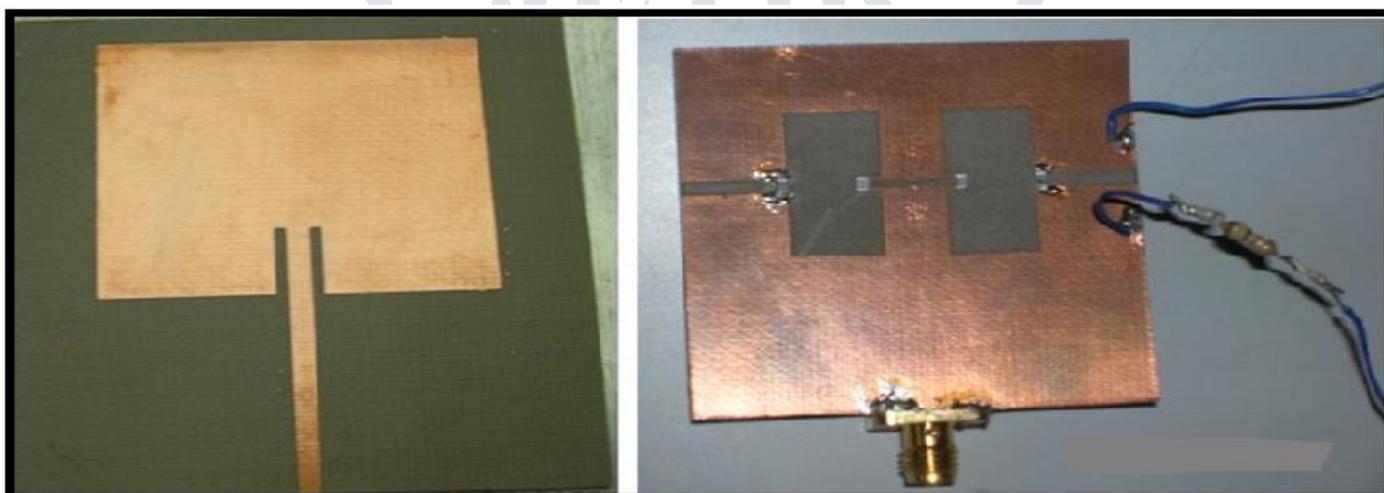


Figure 7. Fabricated prototype of Reconfigurable Filtenna

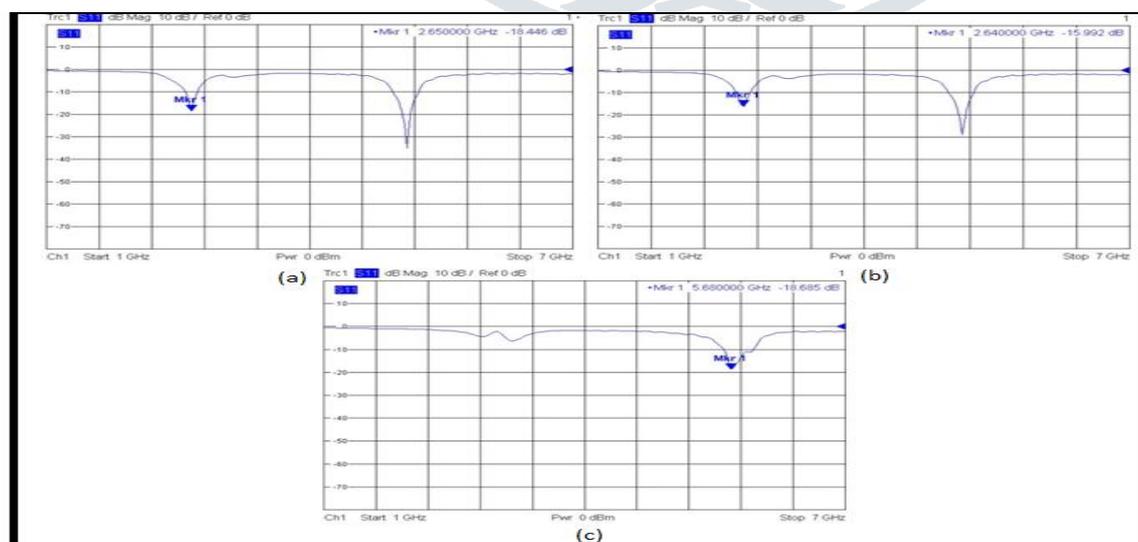


Figure 8. (a) No Biasing, (b) Off State, (c) On State

I. CONCLUSION

In this paper, various approaches of antenna-filter integration for RF applications is proposed. Single band is obtained by applying co-design method of integration on notch antenna and hairpin filter by sand witching ground plane between the two. Dual band availability for WLAN using loop loaded monopole integrated with band select filter and ultra Wide band availability by integrating circular monopole with UWB bandpass filter is achieved and frequency switch ability is also obtain by introducing DGS in the ground plane of rectangular patch.. The impedance matching between antenna and filter is optimized to improve the performance without restricting it to 50 ohm .It provides good selectivity, size reduction and rejection in out of band regions.

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