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Interdigital Filtering Antenna with a ± 15° Slant Polarization

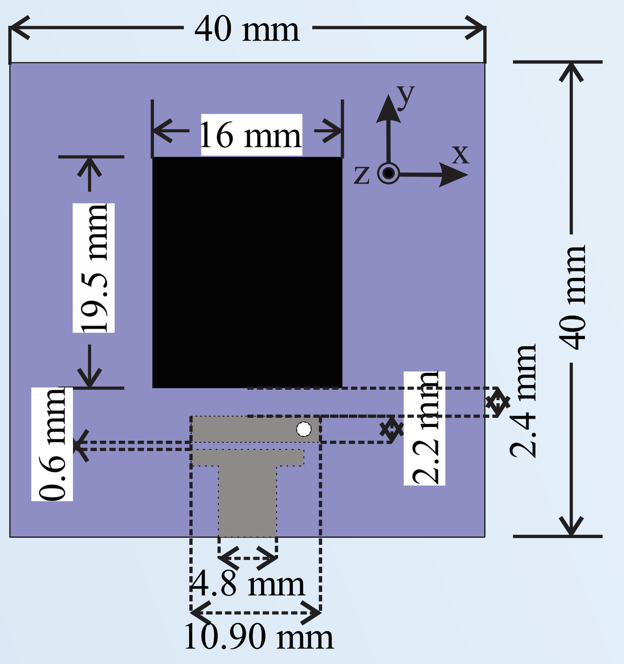
Dwi Astuti Cahyasiwi, Fitri Yuli Zulkifli, Eko Tjipto Rahardjo
Department of Electrical Engineering, Universitas Indonesia

Abstract - *The studies of the filtering antenna have performed many methods and type of resonators used in co-design between the filter and antenna. But none of the design using the interdigital resonator with a via through hole. Interdigital resonator with a via through hole has a unique characteristic for it is short-circuited at one end and open circuited at the other. This condition is expected to have an effect to the electric field and the surface current direction. This paper performs a second order of the interdigital filter co-design with a proximity fed rectangular patch antenna. The simulation shows that the interdigital resonator with a via through hole affects the polarization of the antenna from a vertical polarization alter to a slant polarization. The design is fabricated and measured, both the simulation and measurement show a good agreement with a bandwidth of 340 Mhz at 4.8 GHz resonance frequency, maximum gain of 8.2 dBi and a - 15° slant polarization.*

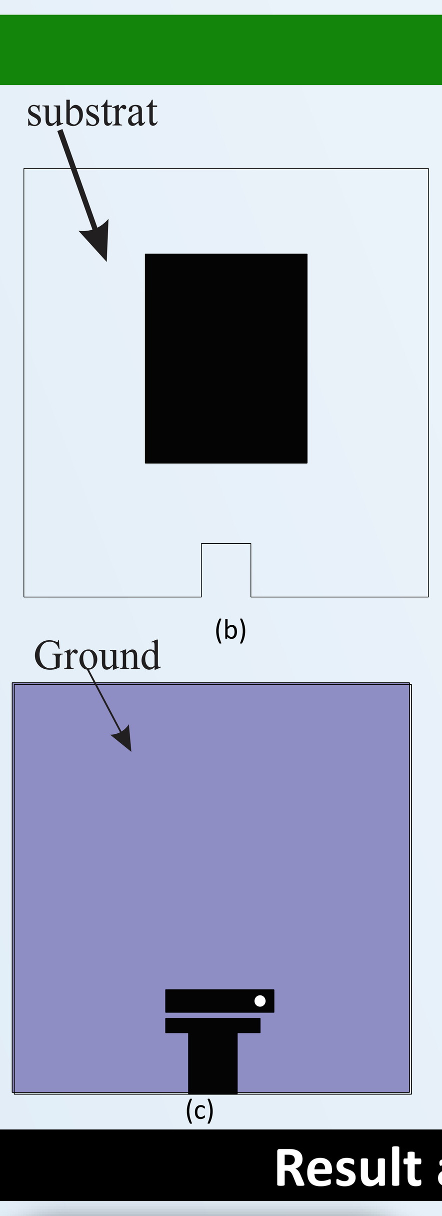
Introduction

Polarization is one of the parameters that often studied in a filtering antenna and many papers have shown the method to realize some types of the filtering antenna polarization such as circular polarization and dual linear polarization [1], [2]. There are other types of polarization that have never been presented in a filtering antenna, that is the slant polarization, which is proved to have a better gain diversity compare to dual linearly polarized antenna [3] in a multipath propagation condition. It also performed a lower Bit Error Rate compare to the horizontal/vertical polarization and has a higher channel capacity [4], [5]. This study proposed a novel co-design of the interdigital filter with a via through hole and rectangular patch antenna that performs an antenna that has a flat gain response along its bandwidth and also a slant polarization.

Design



(a)



(b)

(c)

In the first design, the via is placed on the right arm of the interdigital while for the second design the via is located at the opposite arm as can be seen in Fig 2.

Method

The proposed filtering antenna is shown in Fig. 1. The filtering antenna consists of two dielectric substrates which is printed on Roger Duroid 5880 with a dielectric thickness 1.575 mm, permittivity 2.2 and loss tangent 0.0009. The 40 x 40 mm² stacked interdigital filtering antenna consists of two layers, on the first layer as seen in Fig.1 (b) a rectangular patch radiator is proximity fed by the second layer. An interdigital resonator with 1.2 mm diameter via through hole on the left arm and 50 W transmission line on the second layer shown in Fig. 1 (c) fed the radiator above. The length of the interdigital is approximately a quarter wavelength at the operating frequency and the geometry of each layer is depicted in Fig. 1 (a) which has a geometrical symmetry at *yz* plane.

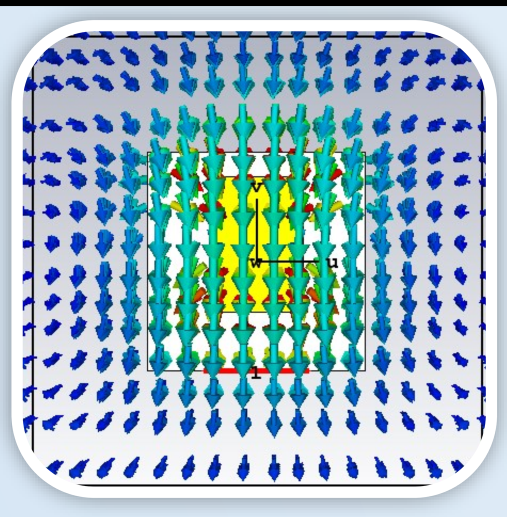

(a) (b)

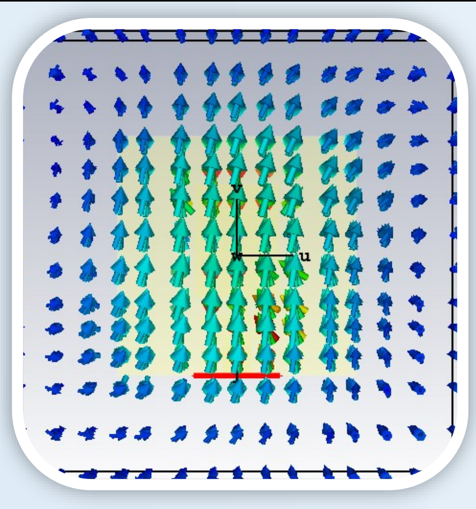
Fig. 2. Vias on the (a) right and (b) left arm of the Interdigital Resonator

The method to perform an alteration at the electrical field and surface current based on the position of the open and short circuited. It is predicted that the placement of the via through hole will result in the different inclination of the polarization.

As shown in Fig. 3, the electrical field simulation reveals that stacked Interdigital filtering antenna (SIFA) inclines the polarization in some degree to the right or to the left vertical (*+v*) axis compare to the conventional antenna with proximity coupling in Fig 3 (a). The via positioning on the interdigital arm affects the direction of the polarization inclination, if the via is at the right arm of the interdigital as illustrated in the structure in Fig. 3 (b) then the electrical field incline to the left side of the vertical ***+v*** axis, on the contrary if the via is located at the left arm, then the electrical field inclines to the right side of the vertical *+v* axis.

Result and Discussion


(a)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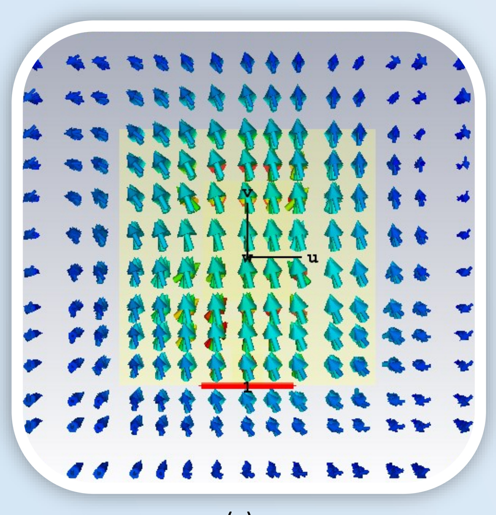
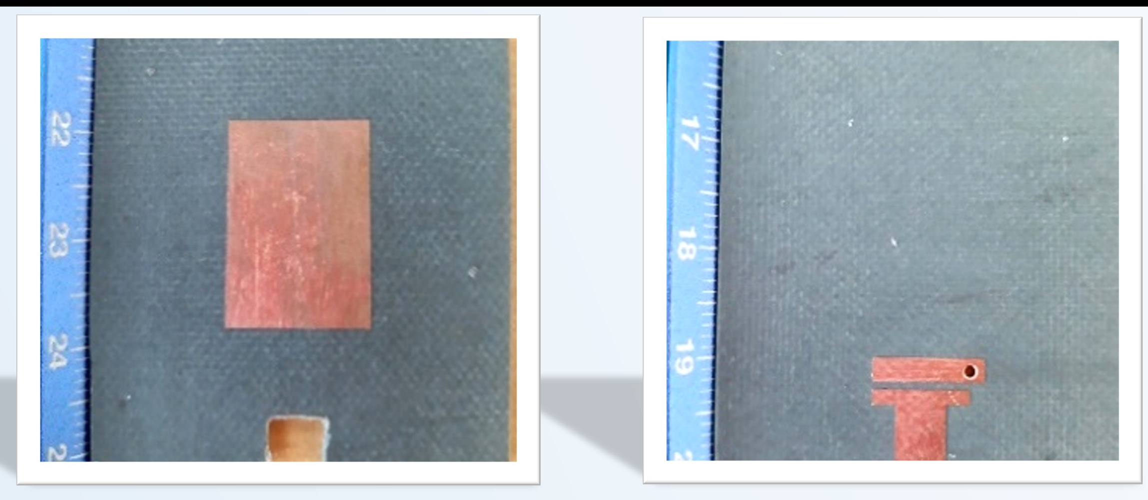

(c)

Fig. 3. Electrical Field (a) Conventional Antenna with proximity coupling (b) Interdigital Filtering Antenna with via on the right (c) Interdigital Filtering Antenna with via on the left


(a) (b)

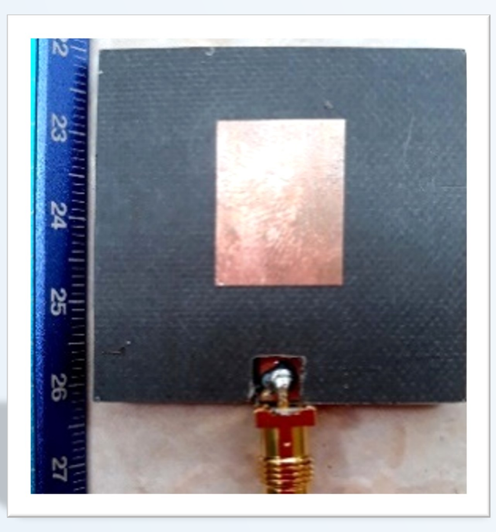
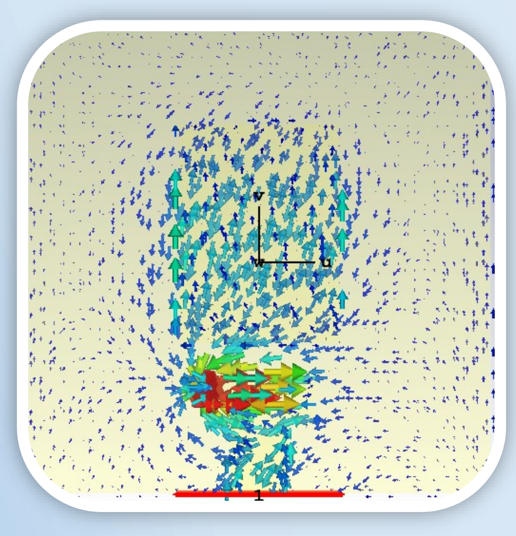
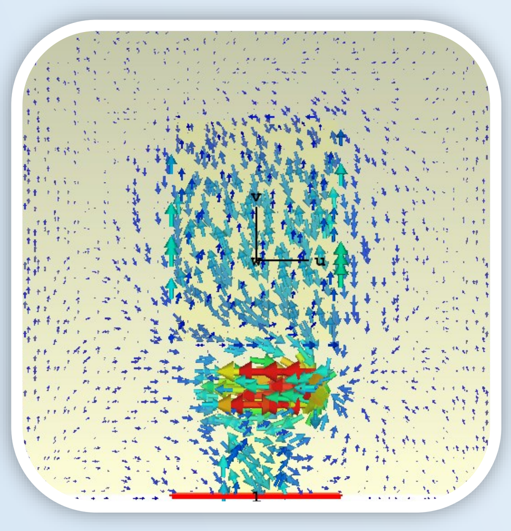

(c)

Fig. 6. The picture of prototype stacked interdigital filtering antenna (SIFA) (a) Rectangular radiator at the first layer (b) Interdigital resonator with via at the left arm at the second layer (c) Stacked Filtering Antenna.

The simulation results of the magnitude reflection coefficient can be observed in Fig. 7 (dash line) that SIFA has a 300 MHz bandwidth or 6.45% FBW at operating frequency of 4.65 GHz while the measured -10 dB reflection coefficient (solid line) has 340 MHz bandwidth (4.587 – 4.934 GHz) .

The comparison of the simulation and measurement based on the different θ along the frequency are shown in Fig 8 where at θ = -15° slant polarization (solid line) performs the highest value of gain compare to the vertical polarization or θ = -90° (dash line) and other different θ slant polarization. These measurements results verify that the SIFA polarization is at θ = -15° and we also can conclude that with the via positioned at the right arm of the resonator then the polarization will be +15° slanted. All the measurement result shows sharp shape of gain with the maximum value at 4.9 GHz, shifted 200 MHz to the higher frequency compare to the simulation.


(a)


(b)

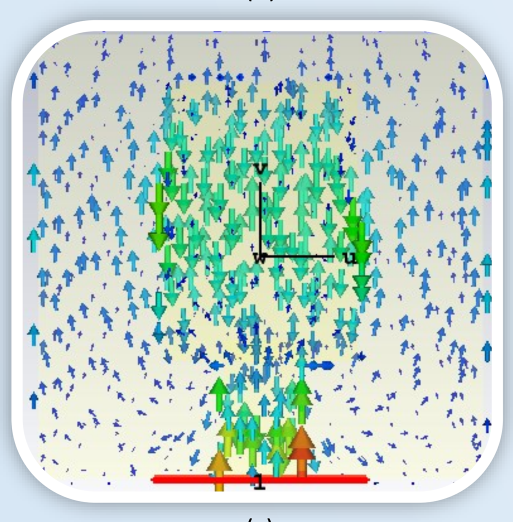

(c)

Fig. 4. Surface current (a) Interdigital Filtering Antenna with via on the right (b)Interdigital Filtering Antenna with via on the left (c) Conventional Antenna with proximity coupling

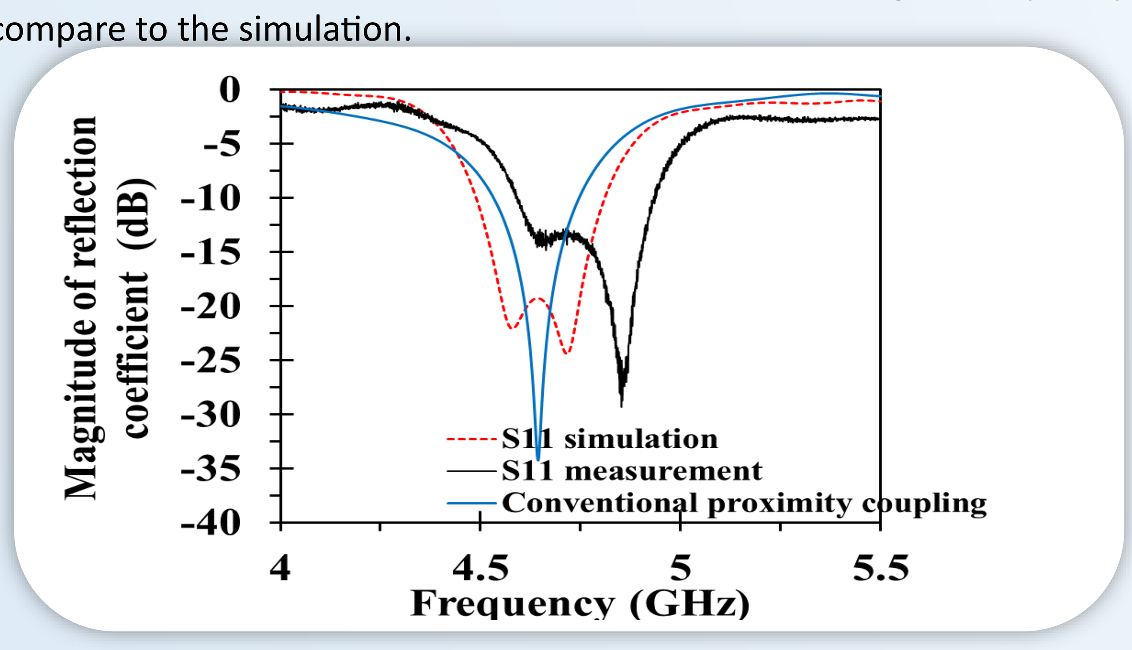


Fig. 7. Magnitude of reflection coefficient comparison between simulation and measurement.

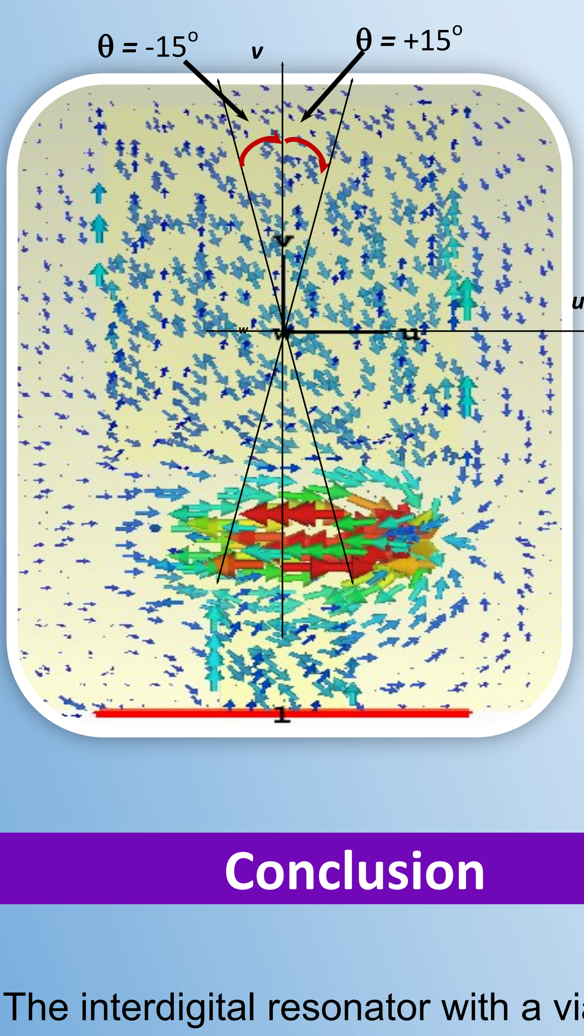


Fig. 5. Surface current projection of a ± 15° slanted polarization from the vertical polarization

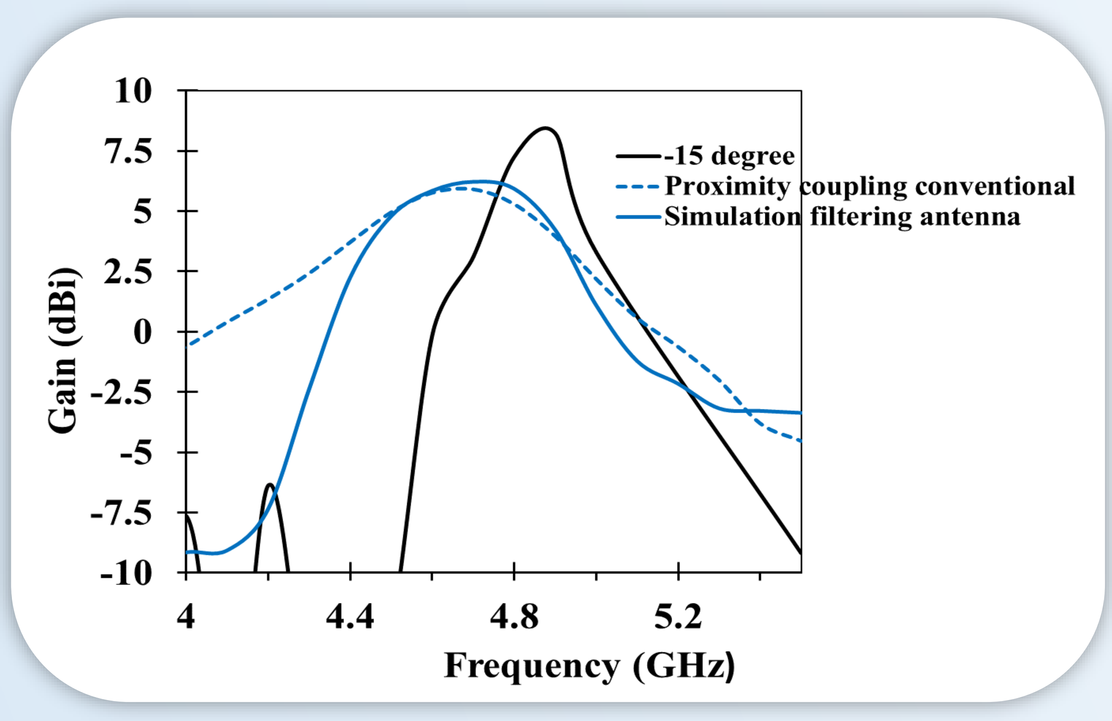


Fig. 8. Simulation and measurement result of SIFA Gain with ± 15° inclination of slant (q) polarization compare to the conventional antenna with proximity coupling.

Conclusion

The interdigital resonator with a via through hole that parallelly fed a rectangular patch radiator is proved to alter the polarization from the vertical to a slant polarization. The inclination of the polarization is controlled by the position of the via through hole in the interdigital resonator's arm. The design has been confirmed by measurement and a good agreement with the simulation is achieved. The stacked interdigital filtering antenna has 340 MHz bandwidth, 8.2 dBi gain at 4.9 GHz and -15° slant polarization.

References

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