Chipless RFID Tag based on Meandered Line Resonator

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***Abstract*— A meandered microstrip transmission line resonator is proposed for the design of chip-less RFID tag. The 6 bit resonator is operates from 3 to 5 GHz. The tag consists of a micro strip open stub resonators and two Ultra-wide Band (UWB) monopole antennas. The 30 mm x 35 mm chip-less RFID tag is designed on Taconic substrate with permittivity of 2.75. The modification technique from the straight line of micro strip open stub toward meandered line is introduced.**

Keywords—component; chipless RFID tag, microsrip open stub, UWB antenna

I. INTRODUCTION

Radio Frequency Identification (RFID) uses wireless radio frequency system to transfer data for identifying purposes and tracking of tag activities. The RFID system has been implemented for various applications such as in payment systems, access control and asset tracking [1]. The RFID system elements consists of active reader which transmit encoded signal to interrogate the tag, transponder (tags), and subsequently store the ID information in integrated circuit that stores and processes the radio-frequency signal. However, production of RFID tag is high in cost due to the presence of Application Specific Integrated Circuit (ASIC) chip. Recently, researchers are focusing in designing a compact and low cost chip less RFID system without the implementation of ASIC.

The chip-less RFID system specification is based on the transponder which uses the electromagnetic properties and design of various structure to perform data encoding without the need of ASIC chip [2]. There are two types of transponder which are the time domain reflectometry (TDR) such as surface acoustic wave (SAW) tag [3] and spectral signature such as capacitive tuned dipole [4], space filling curves [5] and LC resonant. However, the aforementioned technique cannot be applied on fully printable material such as bank note and postage stamp due to the piezoelectric nature of SAW tag. The Chip-less RFID tags is based on LC resonant has been proposed using spit-wheel, microstrip open stub and spurline techniques[6-8].

In this project, passive chip-less RFID system is proposed by using amplitude spectral signature of a multi-resonator. The tag consists of 6 bit multi-resonators which integrated with wideband monopole antennas. The antenna is designed to encode 111111 and 010101 IDs. The operating frequency of RFID system is from 3 to 4.5 GHz. The chip-less RFID system is designed on Taconic substrate with thickness, permittivity, and loss tangent of 1 mm, 2.75, 0.0003 respectively.

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II. TAG DESIGN

The chip-less tag RFID design is designed and simulated using CST Microwave Studio 2013. The 6-bit chip-less tag contains spectral signature with 63 ID information. To obtain transmission line impedance of 50 ohm, the stub length 18 mm and width 7 mm is designed and optimized as shown in Fig. 1 The insertion loss of microstrip transmission line is consistent at approximate0 dBi as shown in Fig. 2. In the design of chip-less tag, $\tau_g/4$ open circuited stub which acts as multi-resonator is connected to the centre of 50 ohm microstrip transmission line, where τ_g is the guided wavelength which corresponds to the operating frequency. Each line of stub represents one bit. The connection between microstrip line and stub line represent “0” for unconnected (open) or “1” bit for connected (short) as shown in Fig. 3. Both of the tag design structures incorporated with straight line or meandered line stub. The design parameter of chipless RFID system are shown in Fig. 4 and Fig. 5. The gap between the stubs is optimized to obtain the minimum possible coupling between each of the stub element. The microstrip line is then integrated with two circular monopole antenna which functions is to receive and transmit the interrogated signal.

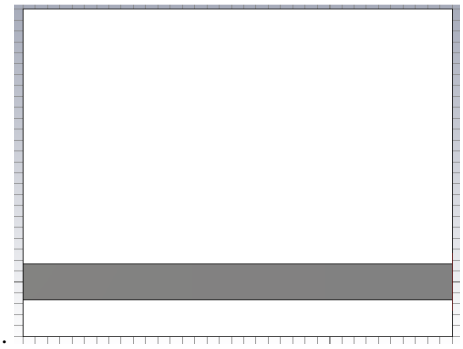

Fig. 1. Microstrip Transmission Line

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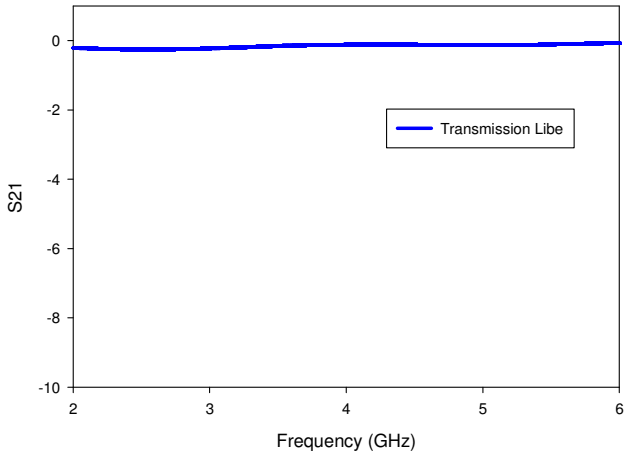

Fig 2. Simulated Insertion Loss for Transmission Line

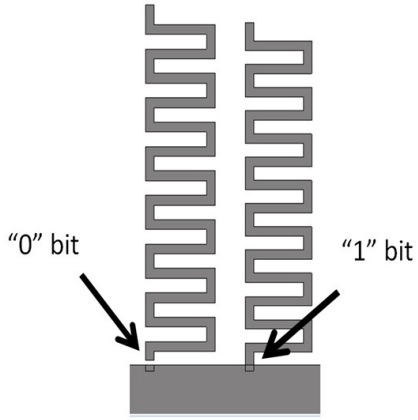

Fig 3. Two State Condition of Bit; Opening Stub ("0" bit) and Shorting Stub("1"bit)

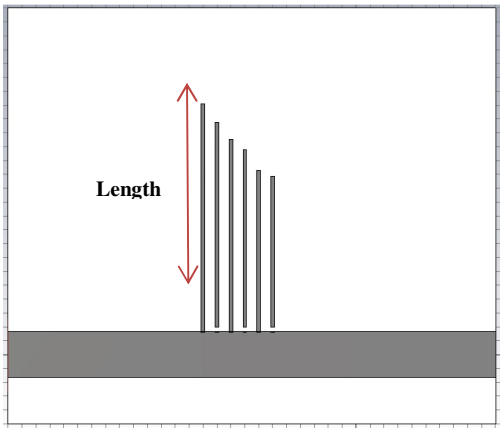

Fig. 4. Straight Line Microstrip Stub, Each with Width of 0.25 mm And Stub Gap Of 0.75 mm

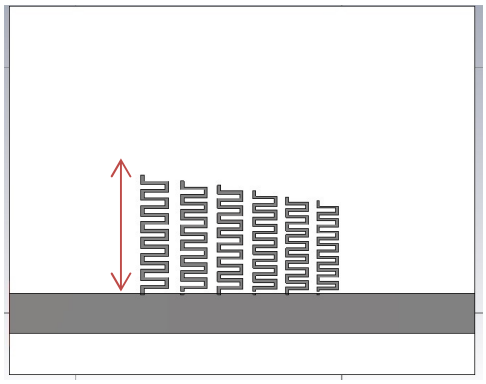

Fig. 5. Meandered Line Microstrip Open Stub, (from left) with width of first stub = 0.26 mm, width of second stub = 0.21 mm, gap between first stub and second stub= 0.9 mm, gap between fifth and sixth stub = 0.6 mm

A CPW fed UWB antenna [9] operating from 3 to 12 GHz is introduced to be integrated with chip-less tag as transmitter and receiver of interrogated signal as shown in Fig. 6. The antenna has a high average gain between 3 – 4.3 dBi in the range of 2.5 to 5 GHz. The radiation pattern is near omni-directional pattern which will ensures good transmission and reception of signal in all directions in one plane. The simulated reflection coefficient of antenna is well performed from 2.5 to 5.5 GHz as shown in Fig. 7.

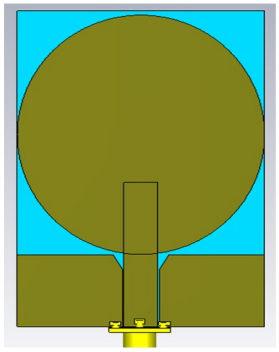

Fig. 6. CPW fed UWB Antenna with overall dimension of 66mm x 40mm

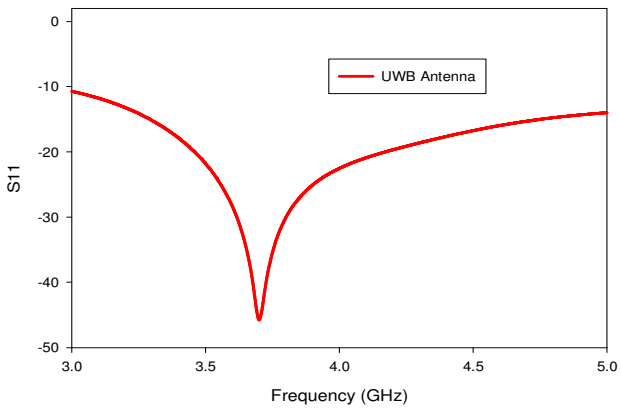

Fig. 7. Simulated Reflection Coefficient of CPW fed UWB Antenna

III. RESULT AND DISCUSSION

Two types of open stub microstrip; straight line and meandered are compared and analyzed. Meandered line technique can be implemented to minimize the space consumption for chip-less tag application. However, the S_{21} performance of straight line is more stable than meandered line stub. The simulated result of meandered line and straight line stub are compared as shown in Fig. 8. All six frequency signature are represent bit "1", which are used to encode "111111". Straight line stub with "1" bit resonate at different frequency of 3.0, 3.3, 3.6, 3.9, 4.2 and 4.5 GHz. Meandered line Stub reduces the stub length in average of 33 – 42% as compared to the straight line as depicted in Table 1.

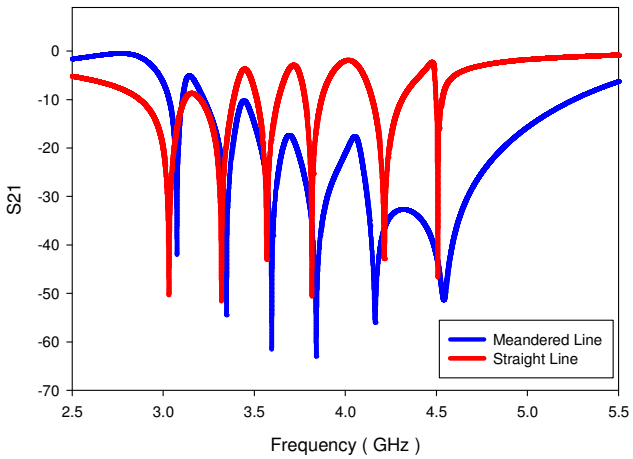

Fig 8. Simulated Insertion Loss Comparison between Meandered Line and Straight Line Stub of ID 111111

TABLE 1: Length and Operating Frequency of Straight Line and Meandered Line Stub

Stub Type	**Straight Line**		**Meandered Line**		
Bit	Length	Freq (GHz)	Length	Freq (GHz)	Length reduction (%)
1st	16.50	3.03	9.62	3.07	41.6
2nd	15.15	3.32	9.15	3.35	39.6
3rd	13.95	3.57	8.78	3.60	37.1
4th	13.20	3.82	8.33	3.84	36.9
5th	11.70	4.22	7.82	4.16	33.2
6th	11.25	4.51	7.50	4.54	33.3

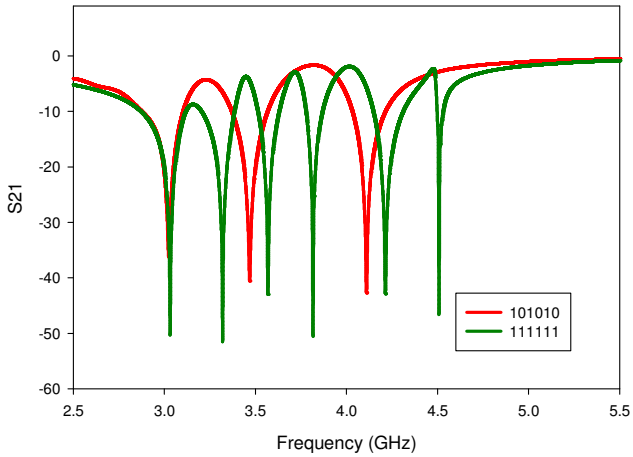

Fig. 9. Simulated Insertion Loss for Straight Line Stub of ID 1010101 and 111111

Open or shorted the three straight line stub changes the bit representation from "111111" to "101010" which shifted the resonances to the lower frequency as shown in Fig. 9. The resonance frequency is shifted for bit 1 of 3rd and 5th digit from 3.57 to 3.46 GHz and from 4.2 to 4.1 GHz. However, the resonance of 1st digit of stub maintain at 3.05 GHz. In Fig 10, the all resonances are shifted out when the bit switches from "111111" to "101010" of meandered line stub . However, shifting of the frequency based on the shorting and opening stub will not deteriorate signal detection because the reader is capable to estimate the corresponding spurious response.

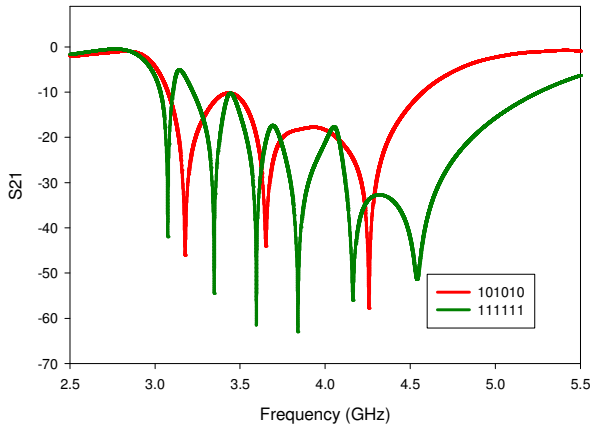

Fig. 10. Simulated Insertion Loss for Meandered Line Stub of ID 1010101 and 111111

IV CONCLUSION

The chip-less antenna using microstrip open stub based on meandered line which operate at 3 to 4.5 GHz with 6 bits of data have been analyzed and designed. The concept of meandered line is proposed to minimize the length of the stub to reduce space consumption for chip-less RFID application. The integration between UWB antenna, microstrip stub line

and transmission line to form chip-less RFID is presented and discussed.

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