A Reconfigurable Dual Sense Fluidic Antenna for Land Mobile Radios And GNSS

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Abstract—**Reconfigurable antennas, antennas that able to radiate more than one frequency or pattern or both are necessary in modern wireless communication systems. Reconfigurable antenna is a necessity because of the needs of size reduction requirement of multifunction wireless communication systems, the number of users of the similar spectrum increases causes the increases in probability of interference and the multitude of different standards in smart phones and mobile devices. Therefore, reconfigurable antenna technologies are highly desirable. This paper describes the design procedure of a reconfigurable antenna that operate in circular polarized (CP) and another in linear polarized (LP). The linearly polarized antenna operates in the Land Mobile Radio (LMR) band with frequency from 0.851 GHz to 0.869 GHz. While the circularly polarized antenna operates in Global Navigation Satellite System (GNSS) band with frequency between 1.559 GHz to 1.610 GHz. The antenna is designed using CST MWS.**

Index Terms—**Reconfigurable antenna, Land Mobile Radio, Global Navigation Satellite System, wireless communication.**

I. Introduction

TO design an antenna with frequency and polarization reconfigurable using mechanically pumps liquid metal. Polydimethylsiloxane (PDMS) is use as the substrate of the antenna and it will contain channels for the liquid metal to flow in order to reconfigure the frequency and polarization of the antenna. The flow of the liquid metal will be control by micro pumps. Varying the flows generates two difference antennas, one operate in circular polarized (CP) and another in linear polarized (LP). The linearly polarized antenna operates in the Land Mobile Radio (LMR) band with frequency from 0.851 GHz to 0.869 GHz. While the circularly polarized antenna operates in Global Navigation Satellite System (GNSS) band with frequency between 1.559 GHz to 1.610 GHz. Simulation of the performance will be done using software and 3-D printing of mold will be use to fabricate the substrate of the antenna.

II. Antenna Design

From the previous researches that have been studied, a reconfigurable microstrip patch antenna will be designed according to the specification listed in Table 1.

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TABLE 1 DESIGN SPECIFICATION OF THE ANTENNA.

Parameter	Requirement
Frequency	LMR : 0.851-0.869 GHz GNSS : 1.559-1.610 GHz
Reflection coefficient	< -10 dB
Polarization	LMR : Linear polarization GNSS : Circular polarization
Axial ratio	< 3 dB
Substrate	PDMS
Substrate dielectric constant	2.7
Radiator	Galinstan & Copper (0.4mm)
Feeding technique	Coaxial probe feed
Coaxial port	50 Ω

A. Substrate Material

The substrate used for the antenna is PDMS, which belongs to a group of polymeric organosilicon compounds that are commonly refer to as silicones. The attractive features of PDMS is due to its mechanical stability. The properties of PDMS shown in Table 2.

TABLE 2 PROPERTIES OF PDMS.

Properties	Characteristic
Formula	$(C_2H_6OSi)_n$
Dielectric constant	2.7
Density (kg/m^3)	965
Thermal conductivity (W/(mK))	0.2
Temperature range of use (°C)	-115 to 315
Boiling point (°C)	200
Chemical resistance	Good, resistant against weak acids

B. Radiating elements

Liquid metal as radiating elements have been propose to facilitate the integration of tune ability and reconfigurability features in antennas. Historically, mercury has been use in industrial chemical, electrical, electronic applications and systems, while some medical thermometers, electromechanical relays are fill with mercury. However, mercury is extremely toxic for humans and for the environment and must be handle with care. Several types of alternative liquid metals are then consider such as EGaIn and Galinstan. Table 3 show its composition. In this research, liquid metal Galinstan is used.

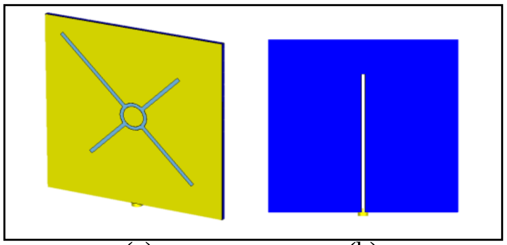
TABLE 3 COMPOSITION OF EGaIn AND Galinstan.

Liquid Metals	Composition	Amount (%)
EGaIn	Gallium	75.5
	Indium	24.5
Galinstan	Gallium	68.5
	Indium	21.5
	Tin	10.0

C. Geometry Design

In this project, a single-layer microstrip-fed configuration coupled to an annular-slot is design. The antenna should be reconfigurable by moving the fluid in the microstrip line from one to another. Fig. 1 illustrate the antenna design.

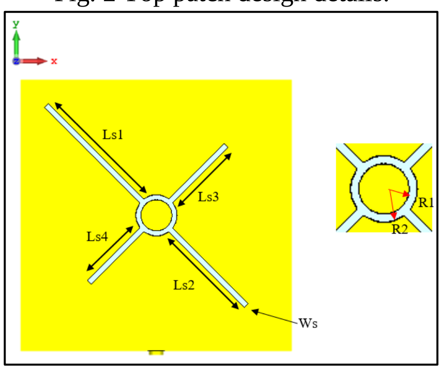
Fig. 1 (a) Top patch & (b) Microstrip line.



(a) (b)

The top patch of the antenna comprises of an annular slot and four orthogonal linear slot arms. The annular slot with inner radius, R1 and outer radius, R2. The four linear slot arm lengths are Ls1, Ls2, Ls3 and Ls4 with the same width of Ws. The frequency and polarization can be adjust by the key parameter, i.e. the R1, R2, Ls1, Ls2, Ls3 and Ls4 as in Fig. 2.

Fig. 2 Top patch design details.



III. Result

Parametric study done on the annular slot radius, length of the linear slot and the position of the entire slot in order to figure out the best combination for frequency and axial ratio. For example, fine-tuning done on parameter Ls1, Ls3 and Ls4 to investigate which parameter was infect, the tuning results are show in Fig. 3(a), 3(b) and 3(c). S1, 1 result in Fig. 4 summarizes the best combination of all parameter tuning for frequency requirement.

Fig. 3(a) Ls1 Tuning for S1, 1 plot.

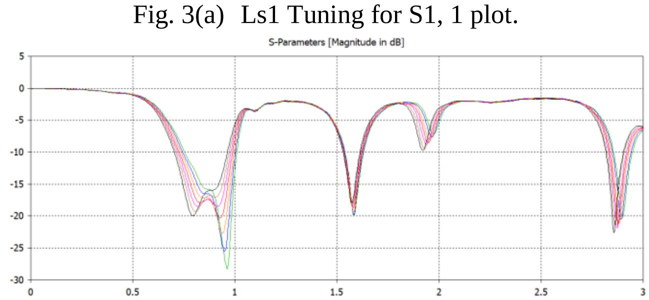


Fig. 3(b) Ls3 Tuning for S1, 1 plot.

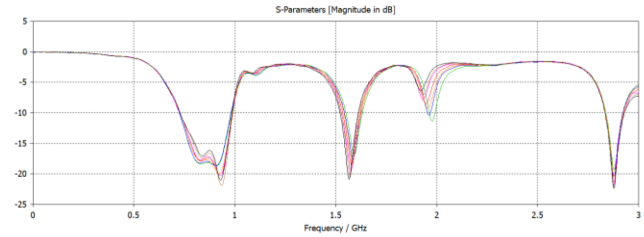


Fig. 3(c) Ls4 Tuning for S1, 1 plot.

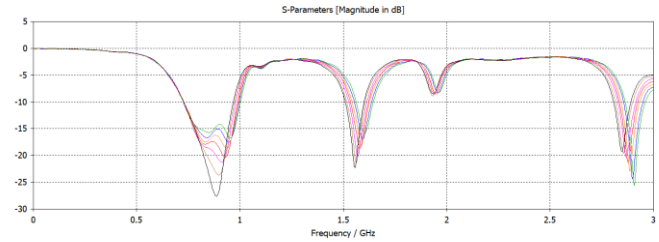
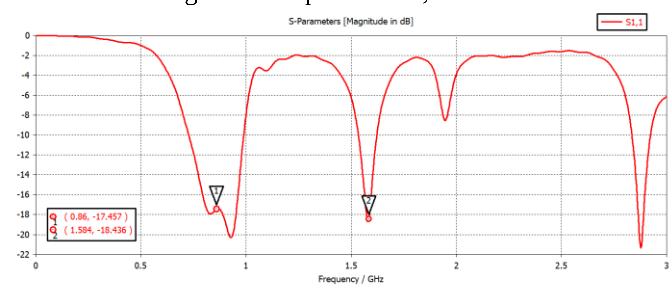


Fig. 4 The optimum S1, 1 result.



IV. Conclusion

In conclusion, s-parameter meets the requirement of -10 dB at 0.86 GHz and 1.584 GHz respectively. Further improvement should be done on axial ratio in order to get the antenna to function in circular polarization.

V. Acknowledgement and Next Plan

The IEEE MTT-S Undergraduate/Pre-Graduate Scholarship motivates me to pursue research in wireless communication although I am not a communication student. Furthermore, this inspires me to continue my study and career in microwaves field. Sincere gratitude to MTT-S for the undergraduate scholarship.

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