Fully Textile Slot Linear Array Antenna with Curvature and Crumple Analysis

M. A. A Majid, M. K. A. Rahim, N. A. Murad, N.A.Samsuri, N. F. A. Elias, M. H. Mokhtar.
Communication Engineering Department, Faculty of Electrical Engineering,
Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia.
mafiq23@gmail.com, mkamal@fke.utm.my, asniza@fke.utm.my, asmawati@fke.utm.my, norfae89@gmail.com,
mhazmi3@live.utm.my

Abstract - **This paper presented the investigation of wearable textile slot linear array (TSLA) antenna under flat, curvature and crumple conditions in free space designed for body worn communication application. The antenna substrate is made of 0.78 mm denim fabric with conducting monopole and ground plane is made of 0.17 mm shieldit fabric. The antenna is designed at resonant frequency of 2.45 GHz Industrial Scientific Medical (ISM) band. Simulated results show that the antenna curve and crumple significantly detuned the antenna resonance frequency and altered the antenna radiation pattern while decreased realized gain value.**

Index Terms — **Textile linear slots antenna; wearable antenna; fabric substrate; conductive textile; curvature analysis.**

I. INTRODUCTION

The wearable antenna intends to be used as integral part of clothing [1]. It attractive due to it's able to attach with wireless wearable technology applications and does not limit the possible antenna placement onto body. The most common requirement for wearable antenna is inexpensive, light weight, zero maintenance and no damage from obstacle [2]. The study on antenna with fully ground plane in bend and crumple position has been published in [3]–[5]. In this paper, the author aimed to investigate the possibilities of curvature and crumple conditions for wearable TSLA antenna. The TSLA antenna is suitable for applications that need uniform coverage on body communication such as smart clothing where 360 degree coverage is required.

II. METHODOLOGY AND SIMULATION SETUP

A. Textile Slot Linear Array Antenna Design (TSLA)

The proposed TSLA antenna is composed of monopole feed line place at the top of denim fabric and L slot ground plane beneath substrate material. The substrate which is denim fabric has a permittivity of 1.7, tangent loss of 0.025 and thickness of 0.78 mm at 2.45 GHz. The overall size TSLA antenna is 154 mm x 89 mm. Fig. 1 shows the proposed antenna design configuration. Based on parametric study, the dimensions of TSLA antenna are obtained. The value of a=14mm, b=48mm, c=23.07mm, d=9mm, e=23.86mm and f=5.36mm. The L slot ground plane is designed using half wavelength equation. Position of the slot is off center to the monopole feed line in order to achieved

better reflection coefficient. The slot is bent downward to achieve compact structure. The antenna radiating elements are feed with corporate feed network and quarter-wave transformer method is used to match the impedance of monopole element with the transmission line. The width of the feed line is designed at 3 mm to match with SMA port.
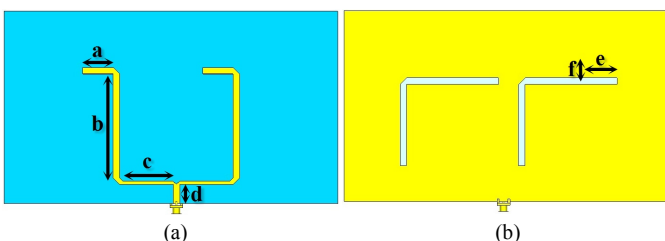

(a)   (b)
Fig. 1. Antenna dimensions. (a) Front view. (b) Back view.

B.   Simulation Setup

The proposed TSLA antenna is investigated at two conditions: curvature and crumple. Fig. 2(a) shows curvature descriptions. For curvature position: horizontal convex and horizontal concave is studied. For each curvature cases, the antenna is curve along the principle of H-plane with three curvatures: 30, 35 and 40 mm. The results will be compared with the flat condition (no curvature). For crumple position: vertical crumple and horizontal crumple is studied. Fig. 2(b)-2(d) show crumple description. The height of crumple is fixing at H=15mm while the length, L is vary with three crumples: 10mm, 20mm, and 40mm. The results will be compared with flat condition. The antenna length reduces as the TSLA antenna crumples down to L=10mm.

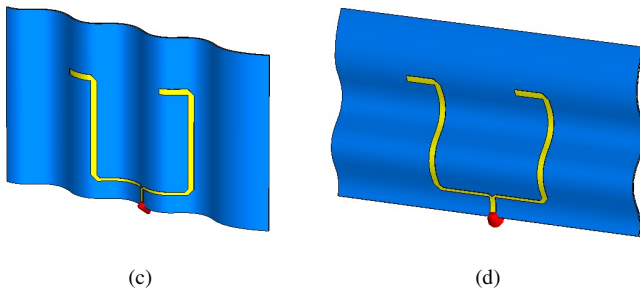(a)   (b)
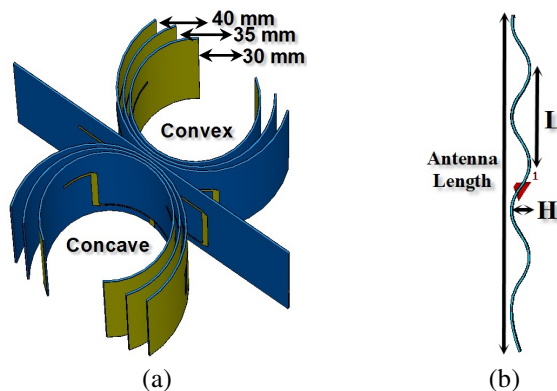
Fig. 2. The TSLA simulation descriptions. (a) Curvature concave and curvature convex. (b) Vertical crumple. (c) Horizontal crumple.

III. RESULT AND DISCUSSION

A. The Curvature Result

Fig. 3(a) shows the simulated reflection coefficient of the flat and curvature TSLA antenna. The TSLA is operating at 2.44 GHz with a return loss of -53.38 dB in flat condition (no curvature). It is noticed that the curvature of the antenna has caused a slight shift of the antenna resonant frequency and reduced the return loss value for all curving cases investigated except concave 40mm.

Fig. 3(c) and Fig. 3(d) show the simulated radiation pattern of the curvature TSLA antenna. It is apparent that the antenna curvature has significantly distorts the radiation pattern in the H-plane and E-plane. The results have showed that the amount of curvature affect the antenna radiation by changing pattern to omnidirectional. It can be said that the shape deformation affect the mutual coupling between two radiating slot.

B. The Crumpling Result

Fig. 3(b) shows the simulated reflection coefficient of the flat and crumple TSLA antenna. It is noticed that the crumple of the antenna has caused a slight shift of the antenna resonant frequency investigated. It is noticed that the horizontal crumple obtained good return loss compared with vertical crumple.

Fig. 3(e) and Fig. 3(f) show the simulated radiation pattern of the crumpling TSLA. It is apparent that the antenna crumple maintaining bidirectional pattern with little change in the realized gain.

IV. CONCLUSION

This paper demonstrates the capabilities of TSLA to be used in curvature and crumpling conditions. From the results above, it can be concluded that the curvature and crumpling structure slightly detune the resonant frequency to higher frequency. For curvature conditions, the radiation pattern distort by changing from directional (flat condition) to omnidirectional while for crumple conditions, the pattern remain the same. It observed that the TSLA antenna's performance is still acceptable under crumpling and curvature except high crumple and high curvature.
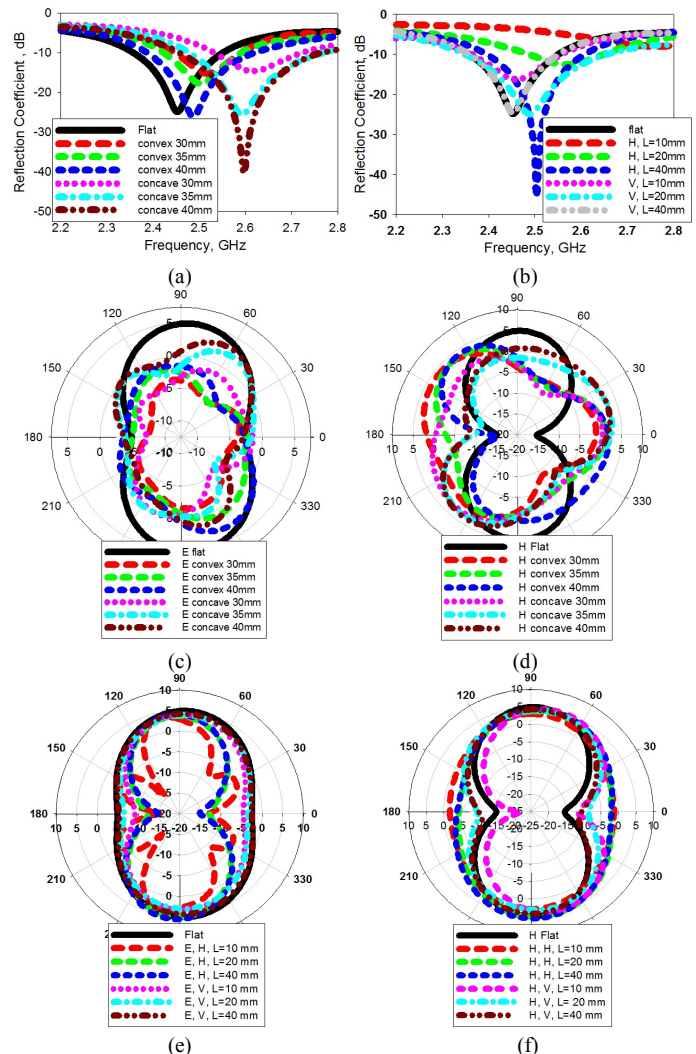
Fig. 3. Simulation results. (a) Reflection coefficient of curvature. (b) Reflection coefficient of crumpling. (c) E-plane of curvature. (d) H-plane of curvature. (e) E-plane of crumpling. (f) H-plane of crumpling

REFERENCES

[1] Nurul, H. M R; Malek, F.; Soh, P.J.; Vandenbosch, G.A.E.; Volski, V.; Ooi, S.L.; Adam, I., "Evaluation of a wearable hybrid textile antenna," Antennas and Propagation Conference (LAPC), 2010 Loughborough , vol., no., pp.337,340, 8-9 Nov. 2010

[2] Rahmat-Samii, Y., "Wearable and Implantable Antennas in Body-Centric Communications," Antennas and Propagation, 2007. EuCAP 2007. The Second European Conference on , vol., no., pp.1,5, 11-16 Nov. 2007

[3] Ismail, M.F.; Rahim, M.K.A.; Hamid, M.R.; Majid, H.A., "Circularly polarized textile antenna with bending analysis," RF and Microwave Conference (RFM), 2013 IEEE International , vol., no., pp.460,462, 9-11 Dec. 2013

[4] Qang Bai; Rigelsford, J.; Langley, R., "Crumpling of Microstrip Antenna Array," Antennas and Propagation, IEEE Transactions on , vol.61, no.9, pp.4567,4576, Sept. 2013

[5] Jalil, M.E.; Rahim, M.K.A.; Samsuri, N.A.; Ayop, O.; Abdullah, M.A.; Ismail, M.F., "Investigation the performance of Koch fractal multiband textile antenna for on-body measurement," Microwave Conference Proceedings (APMC), 2012 Asia-Pacific , vol., no., pp.1373,1375, 4-7 Dec. 2012