A Study of Wearable Loop Antenna for One Segment Broadcasting Reception

Takahiro Suzuki [1]and Hisao Iwasaki [1]
Shio Yamamoto[2], Eiji Hankui[2], Toru Taura[2],Takashi Harada[2] and Akio Kuramoto[2]

[1] Shibaura Institute of Technology
307 Fukasaku, Minuma-ku, Saitama, 337-8570, Japan
E-mail:m109049@sic.shibaura-it.ac.jp
[2] NEC Corporation,
Kanagawa, Japan

1. Introduction

Recently, many kinds of wearable fabric antennas for GPS reception have been developed [1][2]. On the other hand, the wideband antenna application for receiving digital television broadcasting wave from 470 MHz to 770 MHz in Japan is required for mobile terminals. Recently, many kinds of wearable fabric antennas have been developed to fulfil this requirement [3],[4],[5]. The wideband wearable antenna which is usable for multi-applications is one of the strong candidates for the next generation devices.

In this paper, a new wideband wearable fabric loop antenna for digital television (DTV) reception is proposed. Details of the simulated and measured results of the proposed antenna are presented and discussed.

2. Proposed Antenna Configuration

In general, one loop antenna can not obtained broadband characteristic. To obtain the broadband width from 470 MHz to 770 MHz, the antenna, which consisted of the dual loop elements, was considered at first. Fig.1 shows the dual loop antenna configuration. Fig.2 shows the simulated VSWR of this antenna as shown in Fig.1. Broadband characteristic was not obtained. To fulfil the wideband, we propose the novel antenna configuration which consisted of triple loop elements as shown in Fig.3. The feed point was the x-cross point of the mid-loop and outer loop element. The proposed antenna was fed by a coaxial cable

3. Simulated Results

Fig.4 shows the simulated VSWR as a parameter of the quarter length L5 of the inner loop element. In Fig.4, the VSWR less than 2 was obtained from 450MHz to 670MHz. It is necessary to move the high resonant frequency to higher frequency.

So, in order to clarify the working principle, the current distributions were simulated. The current distributions at low resonant frequency 470MHz and high resonant frequency 640MHz were shown in Fig.5 and Fig.6, respectively. The mid-loop and the outer loop elements was operated in low frequency. On the other hand, the mid-loop and the inner loop elements were operated in high frequency. The strong current distributions were obtained in X-axis direction. So, the three loop antenna was operating as two half-wave dipole antenna array.

Fig.7 shows the proposed modified the triple loop antenna. The new element was added in inner loop to move the high resonant frequency to high frequency. And to move the low frequency from 450 MHz to 470 MHz, which can be obtained VSWR less than 2, the antenna size was changed.

Fig.8 shows the simulated VSWR as a parameter of the space L6 of the cross intersection length. The red line shows the simulated VSWR in the case of L6=18mm. The black line shows the simulated VSWR in the case of L6=17mm. The VSWR less than 2 was obtained from 469.5MHz to 713.5MHz in L6=17mm. The VSWR less than 2 was obtained from 469.7MHz to 710.2MHz in L6=18mm. From these results, the optimized dimensions of cross intersection were spacing 2.7mm, L6 = 17mm. Therefore, it is necessary to adjust the spacing and the length of the cross intersection which are important design parameters to obtain broadband.

The simulated radiation patterns without the human body in x-y plane are shown in Fig.9. The proposed modified triple loop antenna was operating as the dipole antenna array from current distributions. And the simulated radiation patterns are similar to the dipole radiation patterns. The radiation patterns were omni-directional radiation patterns. The maximum gain was about 4dBi.

4. Measured results

Fig.10 shows the prototype of the triple loop antenna. This antenna was made of conductive fabric. Then, it was fixed on the dielectric cloth and fed by the coaxial cable.

The simulated and measured VSWR in the free space were shown in Fig.11. In the free space, between the measured and simulated results was agreed very well. So, similar VSWR characteristics were obtained. The VSWR less than 2 was obtained from 478MHz to 731MHz.

Fig.12 shows the measured VSWR when the antenna was located on the human body. The black line was result of upright. The red line was the result of the case of bend forward. Green line was the result of the case of bend backward. The VSWR of upright and bend backward were deteriorated compared with the VSWR in the space. Because the proposed modified three loop antenna was influenced by the human body. However, the VSWR in free space and in case of the antenna away from the human body were almost same results. From these results, The VSWR of high frequency was less affected by the human body. And the VSWR of low frequency was strongly influenced by the human body.

The digital television broadcasting wave in Japan was received by using the proposed modified three loop antenna in outside.

5. Conclusion

This paper describes the wearable fabric modified the triple loop antenna for receiving the digital television broadcasting wave.

The VSWR less than 2 was obtained from 478MHz to 731.5MHz without the human body using the prototype antenna. The measured VSWR was deteriorated on the human body. The VSWR in free space and in case of the antenna away from the human body were almost same results. On the other hand, the radiation patterns are omni-directional radiation patterns. The digital television broadcasting wave was received by using our proposed prototype three loop antenna.

As a next stage, it is necessary to improve the VSWR with the human body.

References

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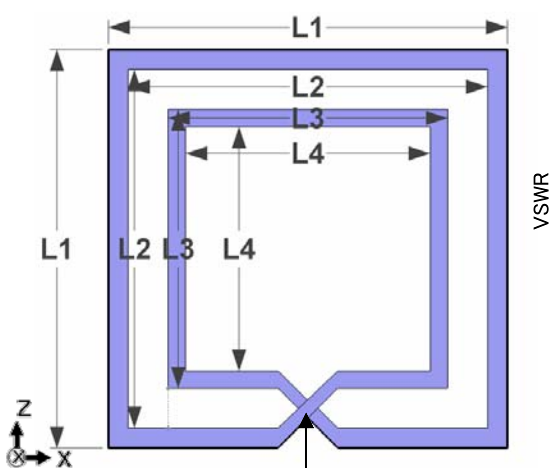


Fig.1 The dual loop antenna.
L1=187mm, L2=168mm, L3= 127mm
L4=111mm, Feed space = 5.3mm

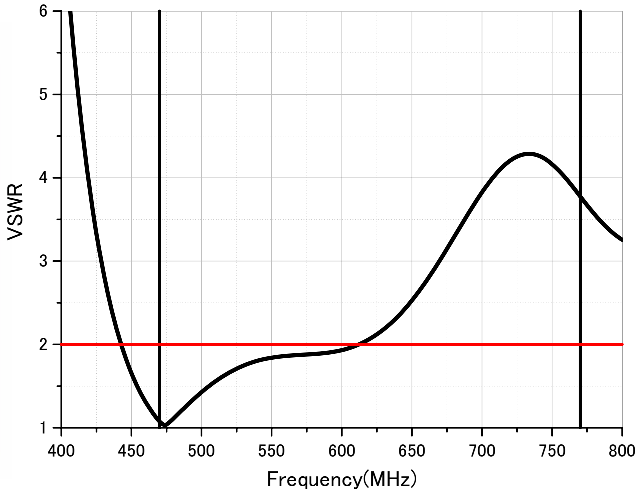


Fig.2 The simulated VSWR of the dual loop antenna.

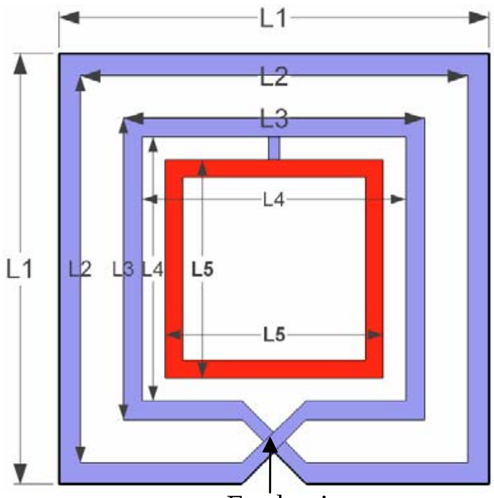


Fig.3 The triple loop antenna.
L1=187mm, L2=168mm, L3= 127mm
L4=111mm, L5=94mm, 104.5mm
Feed space = 5.3mm

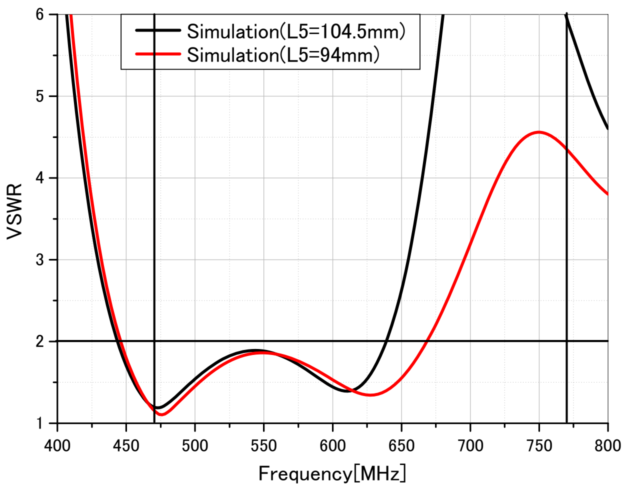
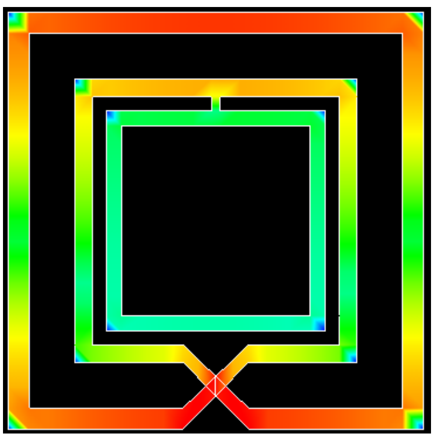
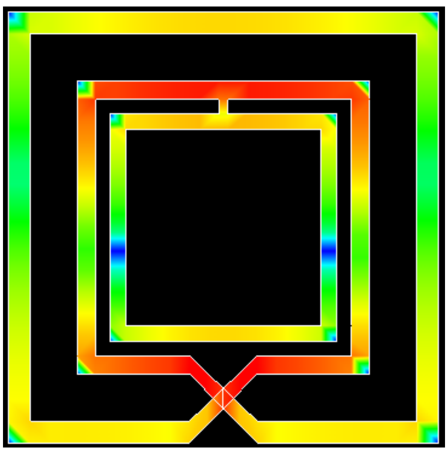


Fig.4 The simulated VSWR of the triple loop antenna.





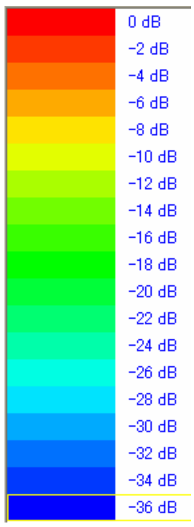


Fig.5 Simulated current distribution. (470MHz)

Fig.6 Simulated current distribution. (640MHz)

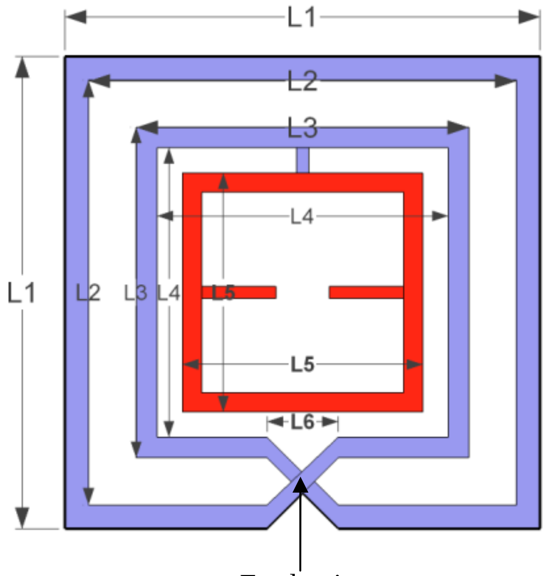


Fig.7 The proposed modified triple loop antenna.
L1=178mm, L2=160mm, L3= 121mm
L4=106mm, L5=94mm, L6=17mm
Feed space = 2.7mm

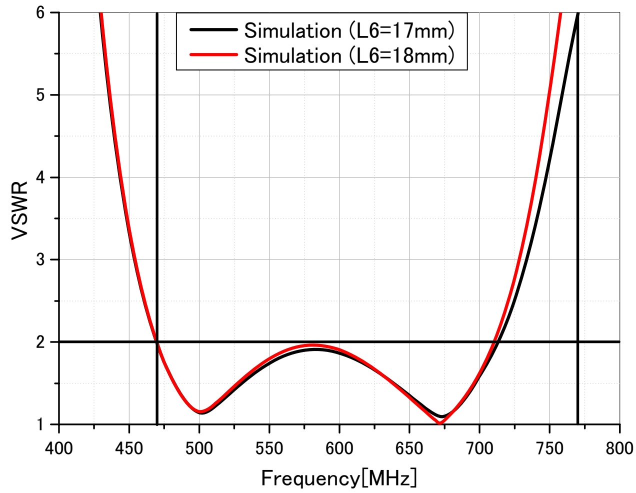


Fig.8 The simulated VSWR
modified triple loop antenna.

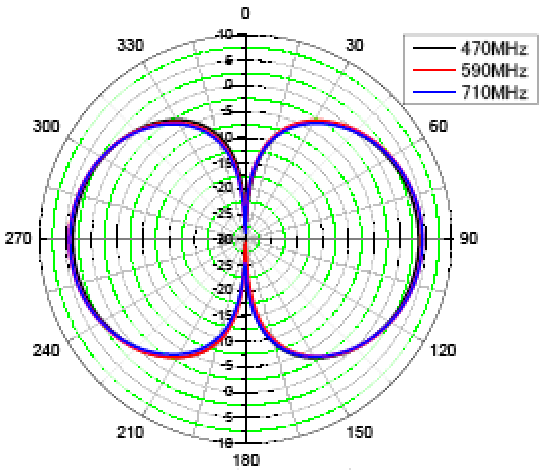


Fig.9 The simulated radiation patterns.
(x-y plane)

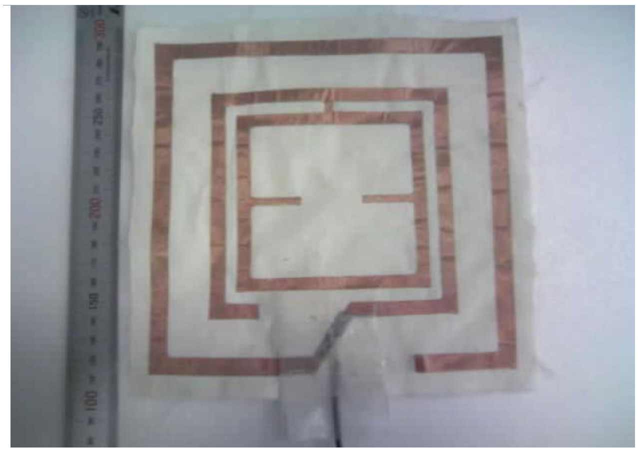


Fig.10 The photograph of the proposed loop antenna.

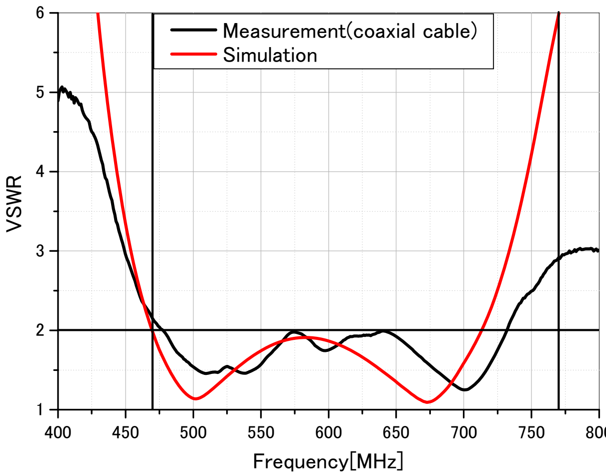


Fig.11 The simulated and measured VSWR
(in free space)

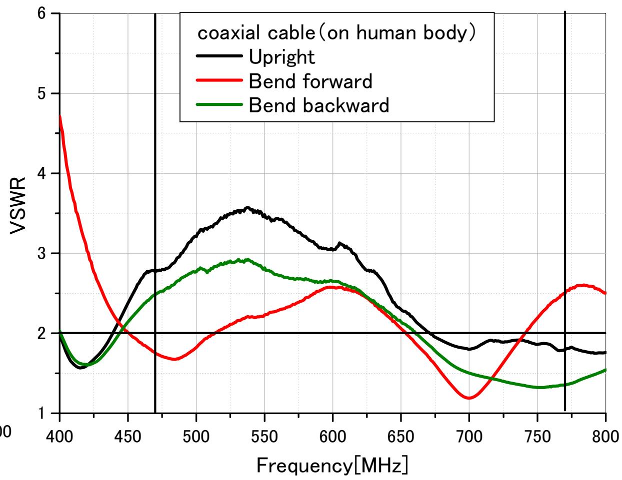


Fig.12 The measured VSWR
(on human body)