The Creation of a Deformation Sensor Using “Smart” Fabrics: Applications to In Vivo Monitoring of Pregnant Women

S. Herbert1, D. Patron2, K. Dandekar2, A. Fontecchio2, T. Kurzweg2, O. Montgomery3, G. Dion4

1Department of Mechanical Engineering, Drexel University, Philadelphia PA; 2Department of Electrical Engineering, Drexel University, Philadelphia PA, 3College of Medicine, Drexel University, Philadelphia PA; 4Shima Seiki Haute Technology Laboratory, Drexel University, Philadelphia PA

The Problem

• Current Fetal Monitoring Devices (Fig. 1) possess many inadequate features:
  • Cumbersome, uncomfortable and invasive
  • Restrict movement of the pregnant woman
  • Do not offer consistent 24/7 monitoring
  • Can leave physical damage on both the mother and child
• Four million US pregnancies a year results in this being a widespread issue

Antenna Design and Simulation

• A patch antenna was designed with a center frequency of 4.5 GHz
• Simulations on the return loss and radiation patterns of this antenna were determined in HFSS (High Frequency Structural Simulator) for experimental comparison (Fig. 3)

Knitting Simulation

• The design of the Smart Fabric Bellyband was created using Shima Seiki simulation software, shown in Fig. 4
• These simulations allow for FEA analysis of the strain placed on the fabric when in use

Antenna Fabrication

• These designs were developed in the Shima Seiki Knitting Software, as seen in Fig. 5a
• The program was executed with the Shima Seiki SSV knitting machine (Fig. 6), using silver-coated and wool fibers. The resulting antenna is seen in Fig. 5b

Test Methods and Procedure

• The fabric antennas were secured into an adjustable test fixture, seen in Fig. 7
• The antenna was connected to a network analyzer to measure its return loss, radiation patterns, and change in central frequency as the fabric is deformed in millimeter increments

Results and Conclusions

The radiation patterns and return loss of the antenna at rest were compared to the simulated results. The results are shown in Fig. 8. While not ideal, these results show that knitting is an effective means of creating a working antenna.

Acknowledgements

The authors gladly acknowledge the support from the Coulter Foundation, the ExCITE Center, Shima Seiki Haute Technology Laboratory, and Drexel University.