Liquid Level Sensor for 3D Breast Imaging Device

Rafi Sufi, Shawn Patel, Adam Strebel, Derek Pitts
Client: Susan Hagness
Advisor: Beth Meyerand, BME

Abstract

Professor Susan Hagness is developing a 3-D microwave imaging technique that better suits higher risk women. The device, depicted in Figure 2, will be filled with a biocompatible liquid that allows the microwaves to propagate easier. The current procedure is manual and human intensive, causing the device to overflow. Professor Hagness requires a pump-sensor system that monitors the liquid level with very little human action. As a result, we propose the use of a capacitive sensor to measure the liquid level.

Background

- 1 in 8 women will develop breast cancer
- Breast cancer represents 30% of all cancer in women
- Women receive initial screening at 50 years
  - Mammogram
  - X-ray
- Mammogram is gold standard
- Leaves underserved population
  - Higher risk women
    - High breast density
  - Harder to screen
- Magnetic Resonance Imaging (MRI)
- 3D Microwave Imaging
  - Low cost
  - Low microwave power
  - Non-ionizing

Figure 1: Example of X-ray mammogram technology.

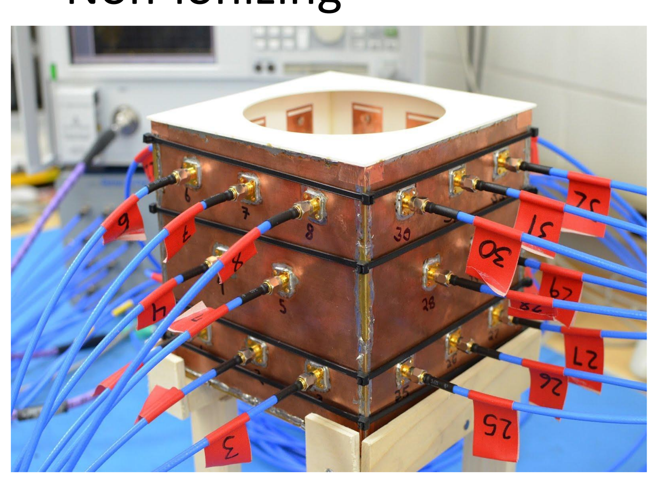

Figure. 2: Picture of 3D imaging device courtesy of Owen Mays.

Design Requirements

- •Device must detect fluid level in box
  - Substrate compatible
- •No Image distortion
  - No metallic substances inside box
  - Drilled holes < 1 cm
- •Ease of use
  - Mobile- Transferrable to similar devices
  - Automatic detection/shutoff
- •Device must fit in interstitial space of MR bed (Figure 3)

Figure 3: MR Bed with interstitial space circled

Final Design

- Miniature capacitive point level sensor (CLW)
- Able to fit along with dual band antennas
- Able to detect through ceramic substrate
- Contact-free measurement of liquid level
- Teachable measurement range
- Outputs 5 volts which can be used for automatic shutoff by pump via relay

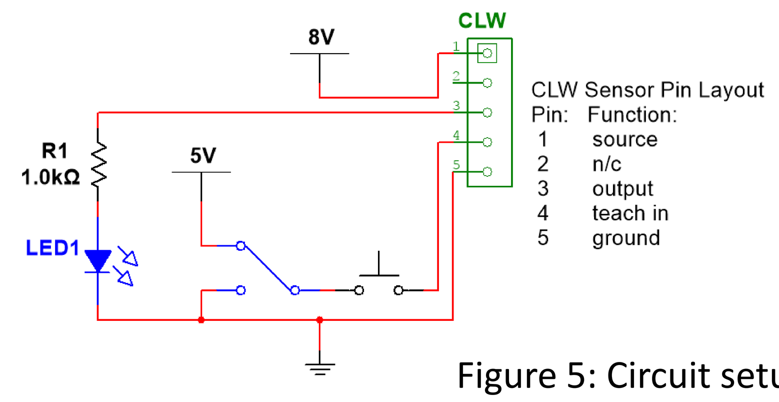

Figure 5: Circuit setup on breadboard

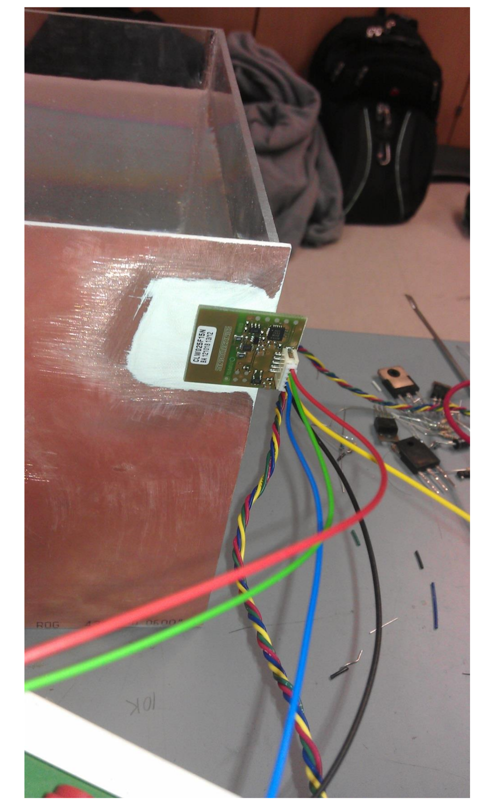

Figure 4: CLW sensor on substrate wall.

Prototype Creation

Model Microwave Array Box

- 3mm acrylic sheet purchased from Amazon
- Rogers 4360 copper-ceramic substrate donated by Rogers
- Acrylic cut and glued into four faces of box
- Rogers substrate cut and glued to finish box with one open face

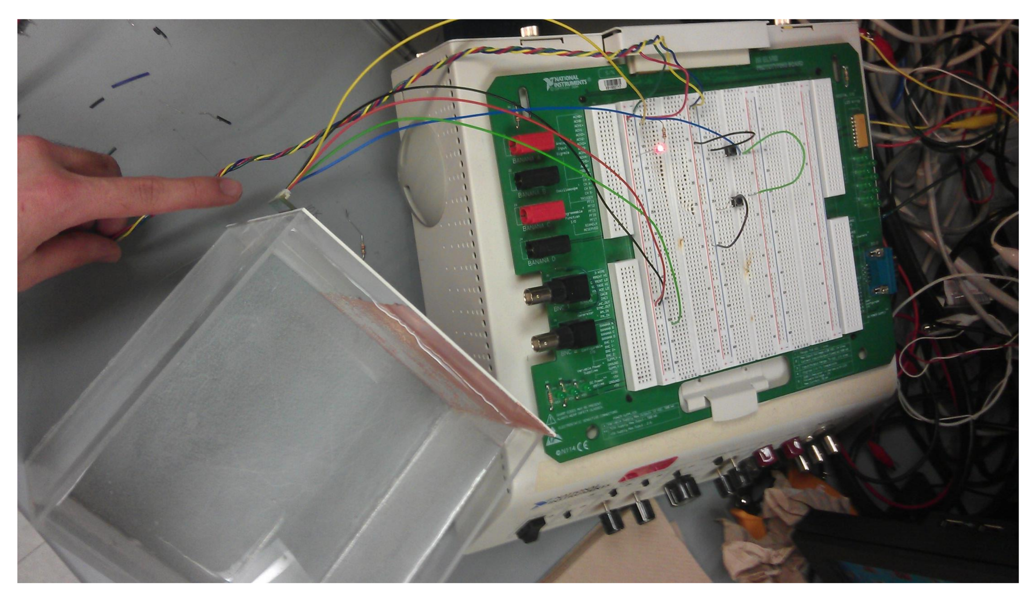

Figure 6: Final design with bread board, sensor and box.

CLW Capacitive Sensor

- Obtained CLW Capacitive liquid level sensor from Sensortechnics
- Copper plating on Rogers substrate sanded off in intended location of sensor
- Sensor applied to substrate with supplied adhesive
- Sensor wired to simple breadboard circuit with LED to represent pump switching on and off

Testing

Sensor Compatibility:

•Tested and verified with water, safflower oil and phantom

• CLW sensor detects liquid level through ceramic portion of substrate

• Any copper near the sensor turns the entire box and liquid into a large capacitive sensor, which breaks its functionality

Sensor Response:

•Accurately outputs high or low based on pre-programmed liquid level

- Output changes to low after a programmed “low” level is passed as the liquid level is falling
- Output changes to high after a programmed “high” level is passed as the liquid level is rising

•1.5 to 2 second delay in output change

- Should not be a problem because flow rate into the box is low through a 1cm hole

Budget

Total spent: $130

•Testing Materials: $25

- Acrylic, Acrylic Glue

•Design Elements: $105

- CLW Sensor, relay

•Remaining Budget: $470

- To be applied to pump, hosing ,and circuit components

Future Work

•Select a pump

- Centrifugal magnetic drive polypropylene, 1.1 GPM, 24 VDC

•Incorporate pump into sensor circuit

•Design pump hosing

•Test combined pump and sensor system

Acknowledgements

We would like to acknowledge and thank the following people:

•Beth Meyerand, Adviser

•Professor Susan Hagness, Client

•Owen Mays

•Matt Burfeindt