Arduino and Bluetooth based Smart Diaper Sensing System

BS Thesis Report

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Area of Work: **IoT-based Smart Sensing Systems**
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1 Abstract

The idea of this project is to equip the *elders* and *infants* with IoT-based smart diapers that would help to prevent the health problems of itches and rashes, arising due to the prolonged usage of wet diapers.

Most disposable diapers available in the market today contain phthalates, a chemical when placed in contact with wet skin poses a susceptible risk to cause irritations and rashes.

The proposed idea is to use smart sensing to be able to alert the care-givers whenever the diaper reaches a critical level of moisture.

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2 Introduction:

With the ever growing ease of living standards, busy schedules and disease-prone lifestyle of ours in the modern world, there arises the growing need of equipping the highest of standards in personal hygiene as well as time management, be it in the transportation sector or the health sector.

The prototype is developed using Arduino Uno microcontroller, HC-05 Bluetooth sensor, Soil Moisture Sensor and TCS 3200 photochromatic sensors, along with open-source Bluetooth applications.

2.1 Sensors used:

1. **Soil Moisture Sensor:** Wetness Sensor *LM-393 IC*.
2. **TCS 3200:** Photochromatic Sensor *Diaper wetness based colour changing indicator*.
3. **HC-05:** Bluetooth Tx-Rx Sensor.

2.2 Connectivity Protocol used:

Bluetooth 5.0 (*Frequency:* 2.402- 2.480 GHz)

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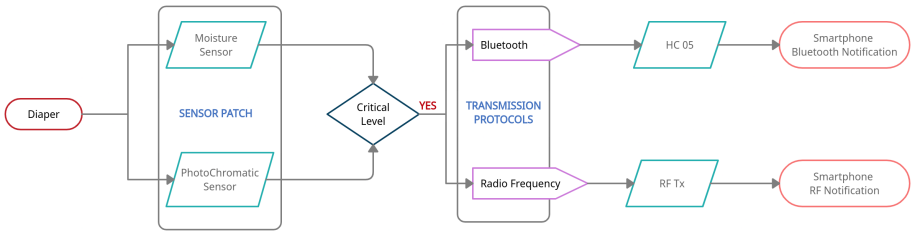
3 Block Diagram:



- Start Node: Diaper
- Input Nodes: Sensor Patch (Moisture + Photochromatic Sensors) and Transmission Protocol (Bluetooth + RF)
- Logical Nodes: Critical Level
- Output Nodes: (HC-05, RF Tx)
- Termination Node: Smartphone Notifications

4 Prototype:

4.1 Logic:

The Arduino Uno microcontroller is programmed on the basis of input analog signals generated from the Soil Moisture Sensor, w.r.t. the moisture (wetness) value of the diaper.

The Soil Moisture Sensor gives output values in the range of (0,1024). A critical limit of 600 is found to be suitable on the basis of several experimentation that can serve a logical level for distinguishing between 'wet' and 'dry' states of the diaper.

The idea of using photochromatic sensors to detect the moisture level of the diaper is based on the fact that most avaialable diapers in India provide a chemical indicator strip attcahed to the diaper, that changes color based on the level of moisture present. The Photochromatic Sensor gives output values as a function of frequencies of the ambient light. It was found that whenever a yellow light is sensed (frequency of BLUE sensed being highest) it corresponds to an almost 'wet' diaper. Correspondingly, whenever a blue light is sensed (frequency of RED sensed being highest) it reflects a relatively 'dry' diaper.

4.2 Working Video:

The working video of the prototype developed till now can be found at: ***Video Link***.

5 Sensors:

The prototype developed utilised the following sensors:

5.1 Soil Moisture Sensor:

Specifications of the Soil Moisture Sensor:

1. Required Voltage: 5 V
2. Required Current: <20 mA
3. Interface: Analog
4. Required Working Temperature: 10°C 30°C

Pin Configuration for the Sensor:

1. Vcc pin: Power
2. A0 pin: Analog Output
3. D0 pin: Digital Output
4. GND pin: Ground Pin

Working Principle:

Soil Moisture Sensor works on the principle of utilising capacitance to gauge the water/moisture content of the surroundings (on the basis of Dielectric Permittivity).

5.2 HC-05 Bluetooth Sensor:

Specifications of the Bluetooth Sensor:

1. Required Voltage: 3.3 V
2. Interface: IEEE 802.15.1 Bluetooth protocol
3. Range: <100 m
4. Default Baud Rate: 9600bps(data mode), 38400bps(command mode)

Pin Configuration for the Sensor:

1. KEY pin: Describes the mode of operation (Slave/Master)
2. Vcc pin: Power
3. RXD pin: Serial Data Receiver
4. TXD pin: Serial Data Transmitter
5. GND pin: Ground Pin
6. STATE pin: Describes whether the module is connected or not

Working Modes:

HC-05 module has two modes of operation:

1. Data Mode: Exchange of data between devices.
2. Command Mode: It uses AT commands which are used to change setting into either the Slave Mode or the Master Mode.

5.3 TCS 3200 Photochromatic Sensor:

Specifications of the Photochromatic Sensor:

1. Required Voltage: 2.7V - 5.5V
2. Interface: TTL Logic-level output
3. Range: <22 mm
4. Default Baud Rate: 9600bps

Pin Configuration for the Sensor:

1. OE pin: Output Enabler pin
2. Vcc pin: Power
3. OUT pin: Output TTL level square wave
4. S0 pin: Frequency Scaling selector
5. S1 pin: Frequency Scaling selector

6. S2 pin: Color Array selector
7. S3 pin: Color Array selector

Working Principle:

TCS3200 sensor contains white LEDs that illuminate the surface of the object, whose color has to be detected. The intensity of the light reflected back by the object is calculated. A frequency proportional to the intensity is produced by the converter, using which the microcontroller (Arduino) predicts the color of the object.

For detection of different colors, filters sensitive to different wavelengths are used by the photochromatic sensor.
Red color is detected for wavelength 580nm.
Green color is detected for wavelength 540nm.
Blue color is detected for wavelength 450nnm.

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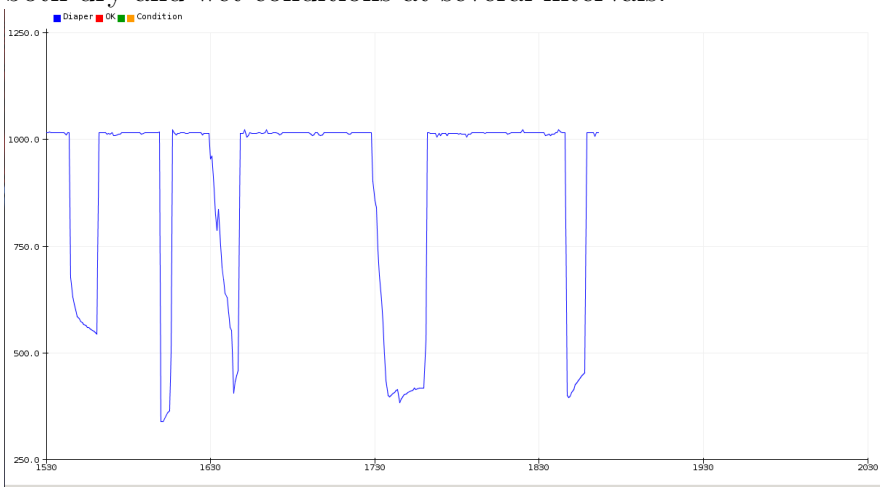
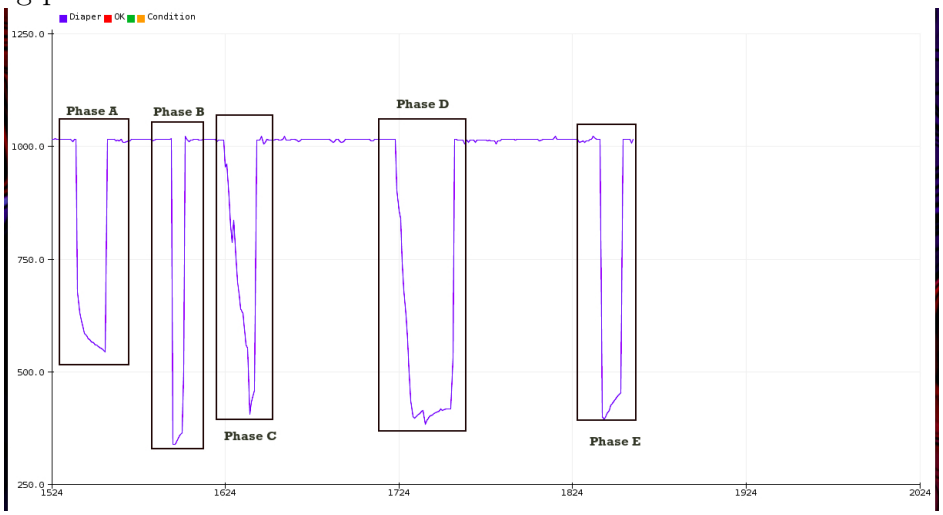
6 Plots:

The following plot was obtained by subjecting the prototype model to both dry and wet conditions at several intervals:



This plot can be divided into 4 subsections, as denoted by the following plot:



The four phases in the above plot can be described as:

1. **Phase A**: This phase was observed when the soil moisture sensed moisture for the very first time.
2. **Phase B**: This phase was observed when the soil moisture sensor encountered moisture for a very short duration of time.

3. **Phase C**: This phase was observed when the soil moisture sensor encountered a gradual wetting of the diaper, as seen by the gradual downward spikes occuring along the slope of the curve.

4. **Phase D**: This phase was observed when the prototype was subjected to moisture first and then gradually the moisture content was decreased, as shown by the spikes present in the bottom half of the curve.

5. **Phase E**: This phase was observed when the prototype was subjected to a relatively small duration of yellow light, as a test for the photochromatic sensor.

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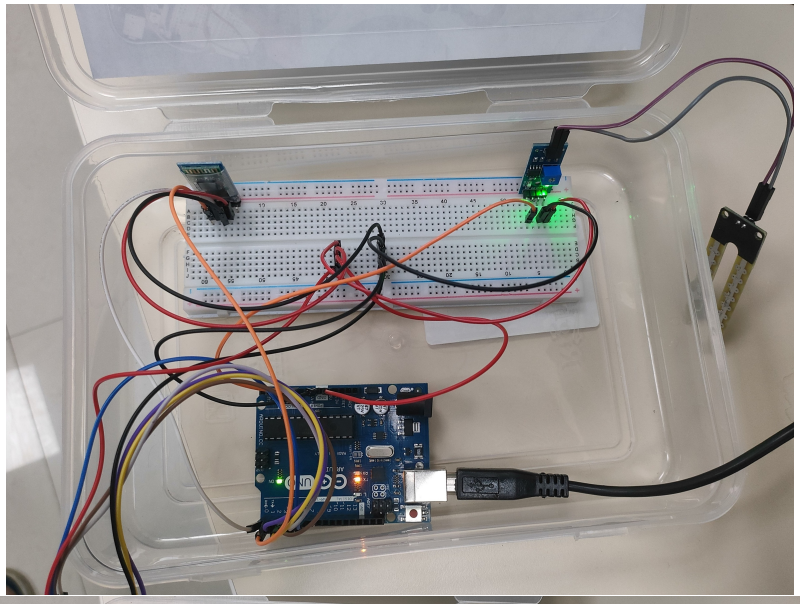
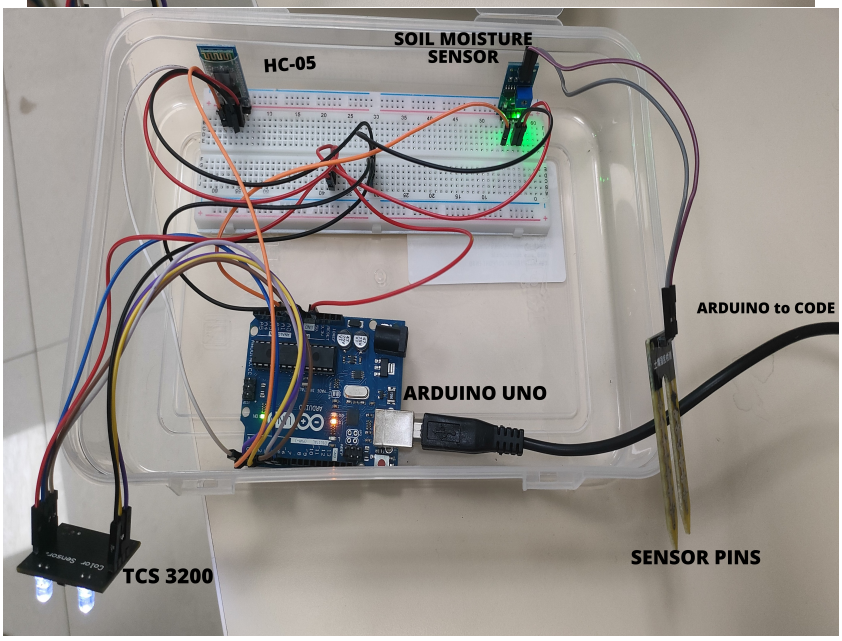
7 Images:




HC-05
SOIL MOISTURE SENSOR
ARDUINO to CODE
ARDUINO UNO
SENSOR PINS
TCS 3200

8 Issues:

The prototype developed faced the following issues:

1. RF transmission protocol had to be dropped due to the inability to synchronise the Receiver antenna at the smartphone end, due to manufacturer's accessibility and security concerns.
2. Analog outputs from the Soil Moisture Sensor displayed a delay of 180-220 ms in real time monitoring.
3. The TCS 3200 photochromatic sensor displayed a delay of 90-120 in real-time monitoring.

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9 Abbreviations:

Abbreviations used in the report include:

1. IoT: Internet of Things
2. Tx: Transfer Mode
3. Rx: Receiver Mode
4. w.r.t.: with respect to
5. ADC: Analog to Digital Converter
6. RF: Radio Frequency

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10 GitHub Repository:

The project and associated codes can be found at: ***Github-link***.

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11 Acknowledgements:

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Shirshakk Purkayastha

References

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