**Smart IoT Hand Sanitizer Dispenser: A Project in Modern Prototyping**

**Abstract**

This document details the recreation of a smart, touchless hand sanitizer dispenser, with a primary focus on leveraging modern design and fabrication technologies. While the core function of the device is to automatically dispense sanitizer, the main objective of this project was to serve as a comprehensive learning exercise. The project encompasses the end-to-end product development lifecycle, starting with the mechanical design of a custom enclosure using Autodesk Fusion 360, followed by its fabrication via 3D printing. The electronic foundation is a custom-designed Printed Circuit Board (PCB) created in KiCad. Finally, the device is brought to life with an Internet of Things (IoT) implementation, enabling it to monitor sanitizer levels, track usage, and send real-time notifications to a smartphone, including estimates on how long the current supply will last.

**1. Introduction: Reimagining a Classic Project with Modern Tools**

Many engineers begin their journey with simple electronics projects. This project is a deliberate effort to revisit one such foundational concept—an automatic sanitizer dispenser—and re-engineer it from the ground up using industry-standard tools and methodologies. The goal was not simply to build a functional device, but to master the complete workflow from digital design to physical prototype to smart, connected product.

The key motivations for this project were:

* **To learn and apply Autodesk Fusion 360** for 3D mechanical design, moving beyond generic project boxes to create a custom-fit, aesthetically pleasing, and functional enclosure.
* **To gain proficiency in KiCad** for electronic circuit and PCB design, transitioning from temporary breadboard setups to a permanent, reliable, and professional-grade electronic system.
* **To implement a practical IoT solution** that adds significant value to the device, providing useful, real-time data to the end-user.

By integrating these three pillars—mechanical design, electronic engineering, and software development—this project serves as a case study in modern product prototyping.

**2. System Architecture and Design Workflow**

The architecture of the dispenser is a synthesis of custom-designed mechanical parts, a bespoke electronic circuit, and intelligent firmware.

**2.1 Mechanical Design: Fusion 360 and 3D Printing**

The physical body of the dispenser was designed entirely in Autodesk Fusion 360. The design process focused on creating a compact and robust enclosure that would securely house all electronic components while being easy to assemble and refill. Key design considerations included:

* A dedicated mounting point for the ESP32 microcontroller and the custom PCB.
* Precisely placed openings for the IR sensor (for hand detection) and the ultrasonic sensor (for level measurement).
* An integrated bracket to hold the sanitizer bottle and the dispensing pump securely.
* A modular design that allows for easy access to the electronics and the sanitizer reservoir.

Once the design was finalized in Fusion 360, all parts were exported as STL files and fabricated using a 3D printer. This allowed for rapid prototyping and the creation of a perfectly tailored physical form.

**2.2 Electronic Design: KiCad and Custom PCB**

To ensure reliability and a clean internal layout, a custom PCB was designed using KiCad. This moved the project beyond the limitations of jumper wires and breadboards. The circuit schematic includes:

* An **ESP32 Microcontroller** as the brain of the system, chosen for its built-in Wi-Fi capabilities.
* An **IR (Infrared) Sensor** to detect the presence of a hand under the nozzle.
* An **Ultrasonic Sensor** positioned above the sanitizer liquid to measure its level.
* A **Motor Driver Circuit** to control the small pump that dispenses the sanitizer.
* Power regulation circuitry to supply the correct voltage to all components.

Designing the PCB in KiCad involved creating the schematic, laying out the components, routing the traces, and generating the Gerber files required for manufacturing.

**2.3 Operational Workflow**

The device operates in a simple, automated sequence:

1. A user places their hand beneath the dispenser's nozzle.
2. The IR sensor detects the hand and sends a signal to the ESP32.
3. The ESP32 activates the pump for a predetermined duration, dispensing a single dose of sanitizer.
4. After each dispense, the ESP32 records the usage event.
5. Periodically, the ultrasonic sensor measures the distance to the sanitizer's surface, and the ESP32 calculates the remaining volume.
6. The ESP32 connects to the local Wi-Fi network to transmit this data to a cloud service.

**3. IoT Implementation and Smart Features**

The IoT functionality transforms the dispenser from a simple automated device into a smart, connected tool.

* **Usage Monitoring and Notifications:** Every time the dispenser is used, it sends a notification to a companion smartphone app or a cloud dashboard (e.g., Blynk, Home Assistant). This allows for real-time tracking of usage frequency, which is particularly useful for monitoring hygiene compliance in public or commercial spaces.
* **Sanitizer Level Estimation and Alerts:** The system uses the data from the ultrasonic sensor to maintain a real-time status of the sanitizer level. Based on the average daily usage, it can project how many days of supply are remaining. When the sanitizer level drops below a user-defined threshold (e.g., 20%), the system automatically sends a "Low Sanitizer" alert to the user's phone, ensuring a timely refill and preventing downtime.

**4. Conclusion**

This project successfully achieved its primary objective of redeveloping a smart hand sanitizer dispenser through the lens of modern design and fabrication tools. The final product is a fully functional, touchless dispenser with valuable IoT features. More importantly, this endeavour served as a practical and intensive learning experience in **Autodesk Fusion 360** for mechanical modelling, **KiCad** for professional PCB design, and the overall integration of an **IoT ecosystem**. It stands as a testament to the power of combining these disciplines to turn a simple concept into a polished and intelligent real-world product.