Assignment#02

Title:

Embedded Systems

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Detailed Breakdown of the Kitchen Ingredient Monitoring System

This project aims to create a smart system for monitoring the stock levels of common kitchen ingredients, such as flour and rice, and providing timely alerts when these levels are running low. The system will go beyond simple weight measurement by incorporating a mobile notification feature for enhanced convenience.

Project Objectives

The core functionality of the system revolves around continuously monitoring the weight of the ingredient stored in a container placed on a load cell. This weight data will be processed by an Arduino microcontroller to determine the current stock level.

The system will perform the following key actions:

1. **Real-time Weight Measurement:** A load cell, coupled with an HX711 amplifier, will accurately measure the weight of the ingredient in its container.

2. **Data Processing:** The Arduino will read the weight data from the HX711, perform necessary calibration and averaging to ensure accuracy, and convert the raw data into a usable weight reading (e.g., in grams or kilograms).

3. **Stock Level Monitoring:** The Arduino will continuously compare the measured weight against a pre-defined low-stock threshold (e.g., 500g). This threshold can be potentially adjusted in the code if needed in the future.

4. **Local Alerts:** When the weight falls below the defined threshold, the system will trigger local alerts:

   o **Visual Alert:** The LCD or OLED display will show a "Low Stock!" message, indicating the need to replenish the ingredient.

   o **Audible Alert (Optional):** An optional buzzer will sound to provide an immediate audible warning of the low stock level.

5. **Remote Mobile Notification:** In addition to the local alerts, the system will send a notification to a designated mobile phone when the stock level is low. This will require the integration of a Wi-Fi module with the Arduino and the use of a suitable platform or service for sending push notifications (e.g., IFTTT, Firebase Cloud Messaging). The notification will inform the user about which ingredient is running low.

Methodology

The system will achieve its functionality through the interaction of several hardware and software components:

1. **Weight Sensing:** The ingredient container will be placed on the load cell. As the quantity of the ingredient changes, the load cell will produce a corresponding change in electrical resistance.

2. **Signal Amplification and Conversion:** The HX711 amplifier module will take the small analog signal from the load cell and amplify it. It also contains an analog-to-digital converter (ADC) that will convert the amplified analog signal into a digital value that the Arduino can understand.

3. **Microcontroller Processing:** The Arduino will receive the digital weight data from the HX711. It will then execute a program (code) that will:

   o Read and process the raw data from the HX711.

   o Apply calibration factors to convert the raw data into accurate weight readings.

   o Implement a smoothing or averaging algorithm to reduce noise in the readings.

   o Compare the current weight against the pre-set low-stock threshold.

   o Control the LCD/OLED display to show the weight and "Low Stock!" messages.

   o Activate the buzzer (if included) when the stock is low.

   o Establish a connection to a Wi-Fi network using the Wi-Fi module.

   o Send a notification to the user's mobile phone via a chosen platform or service when the low-stock condition is met.

4. **User Interface:**

   o The LCD/OLED display will provide a visual indication of the current weight and alert messages.

   o The buzzer (optional) will provide an audible alert.

   o Mobile notifications will provide remote alerts and information.

5. **Power Supply:** A 5V power supply will provide the necessary power to the Arduino, HX711, and other components.

Project Components

Component	Purpose
Arduino Uno/Nano	Main controller for data processing and control
Load Cell (1kg or 5kg)	Measures the ingredient's weight
HX711 Amplifier Module	Amplifies and digitizes the load cell signal
16x2 LCD / OLED Display	Displays weight and stock alerts

Component	Purpose
Buzzer (Optional)	Provides an audio alert for low stock
ESP8266 / ESP32 Wi-Fi Module	Sends stock data via mobile notifications
Breadboard and Jumper Wires	Connects all components for prototyping
5V Power Adapter / Battery Pack	Powers the system
Container for Ingredient	Holds the ingredient on the load cell

In addition to the hardware, the project will require software in the form of Arduino code to control the components and implement the logic, as well as potentially configuration on a platform or service for sending mobile notifications.

Finalized Components and Their Selection Criteria

1. Arduino Nano

The Arduino Nano is a compact microcontroller built on the ATmega328P. It offers digital and analog I/O pins and a USB port for easy programming and power supply.
Why Chosen: Its small size makes it ideal for space-constrained environments like a kitchen shelf. Despite its size, it provides sufficient functionality to manage sensors, a display, and wireless communication. It's also a cost-effective alternative to the Arduino Uno.

2. 5kg Load Cell with HX711 Amplifier Module

The load cell functions as a sensor that converts weight into an electrical signal. The HX711 amplifier then amplifies this signal and provides accurate digital output to the microcontroller.
Why Chosen: A 5kg capacity is suitable for measuring common kitchen ingredients. The HX711 is specifically designed for weight measurement applications, offering high resolution and ease of integration with the Arduino.

3. 16x2 LCD Display with I2C Interface

This is a two-line character display module that uses I2C communication, which reduces wiring complexity by utilizing only two data lines.
Why Chosen: It provides a clear visual output of ingredient weight and stock status. The I2C interface also simplifies the circuit layout and frees up pins on the Arduino for other components.

4. Passive Buzzer

A small audio device that produces sound when driven by a signal from the microcontroller. Unlike active buzzers, passive ones require a signal to generate sound.

Why Chosen: It serves as an alert system for low-stock conditions. A passive buzzer allows custom tones and timing via programming, offering flexibility for future upgrades.

5. ESP8266 Wi-Fi Module (ESP-01)

A low-cost, compact Wi-Fi module capable of handling TCP/IP communication.
Why Chosen: This module enables the system to connect to a Wi-Fi network and send stock notifications to a mobile device. It's affordable, reliable, and easy to pair with the Arduino Nano.

6. Jumper Wires and Breadboard

Jumper wires and breadboards are essential prototyping tools used to make temporary and flexible electrical connections without soldering.
Why Chosen: They make it easy to build and modify the circuit during the testing and development phase. This helps in troubleshooting and making adjustments quickly.

7. 5V Power Supply (USB Adapter or Dedicated Supply)

A stable power source that provides 5V DC, necessary to operate most of the electronic components in the system.
Why Chosen: The Arduino Nano, load cell, and other modules require a 5V power supply. Using a USB adapter offers both convenience and reliability for powering the entire setup.

Detailed Build of Materials (BOM)

Sr. No.	Component Name	Part Number / Model	Specification / Details	Quantity	Estimated Cost (PKR)	Vendor / Source	Remarks / Notes
1	Arduino Uno (or Nano)	ATmega328P	Microcontroller Board, 5V Operation	1	600 – 800	Local electronics store / Online (Daraz.pk)	Main controller
2	Load Cell	5kg Load Cell	5kg Capacity, Aluminum Alloy Body	1	400 – 600	Local store / Online	Measures ingredient weight
3	HX711 Amplifier Module	HX711 IC Module	Analog to Digital Converter for Load Cells	1	300 – 400	Local store / Online	Interface between Load Cell and Arduino

Sr. No.	Component Name	Part Number / Model	Specification / Details	Quantity	Estimated Cost (PKR)	Vendor / Source	Remarks / Notes
4	16x2 LCD Display (with I2C)	PCF8574 (for I2C)	16 Characters x 2 Lines, I2C Communication	1	400 – 600	Local market / Online	Shows status messages
5	Buzzer	5V Active Buzzer Module	5V Rated Sound Buzzer	1	50 – 100	Local store	Audio alert for low stock
6	ESP8266 WiFi Module	ESP-01 / NodeMCU	WiFi Module for IoT Communication	1	400 – 600	Local store / Online	Sends notification to mobile
7	Breadboard	Standard MB-102	Medium Size, 830 Tie Points	1	300 – 400	Local market	Assembly without soldering
8	Jumper Wires	Male-to-Male / Male-to-Female	Set of 20–30 wires	1 set	100 – 150	Local market	For connecting components
9	5V Power Adapter	5V DC Charger	5V 1A Power Supply	1	200 – 300	Local mobile shop	Powering Arduino and modules

Total Estimated Budget:

Region	Approximate Total Cost
Pakistan (PKR)	~2200 – 3200 PKR

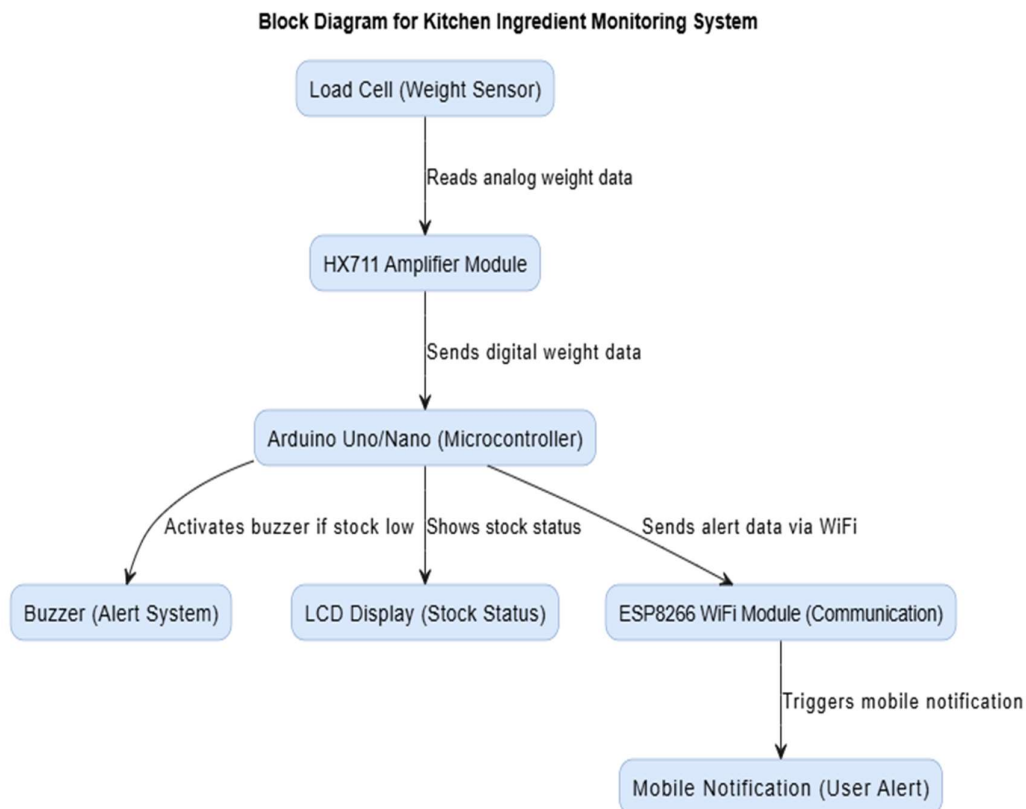🔔 *Costs may vary slightly depending on brand, seller, and quality.*

Notes:

➤ **Pricing:** The estimated costs are approximate and can vary based on the supplier, location (Rawalpindi, Pakistan), and whether we purchase online or from local electronics stores. It's always recommended to compare prices from different vendors.

➤ **Container:** The cost of the ingredient container is highly variable depending on the size, material (plastic, glass, etc.), and where we purchase it. We might already have a suitable container.

- ➢ **Supplier Recommendations:** Local electronics stores can be a good option for immediate availability, while online marketplaces often offer a wider selection and potentially lower prices, but may involve shipping time.
- ➢ **Clones vs. Original:** The BOM specifies an "Arduino Nano (Clone)" as they are generally more cost-effective and work well for most hobbyist projects. An official Arduino Nano would be more expensive.
- ➢ **Flexibility:** This BOM provides a solid foundation. We can adjust quantities or choose different brands based on your specific needs and budget. For instance, we might already have a suitable 5V power adapter.
- ➢ **Mobile Notification Components (Implicit):** While not explicitly listed as a separate hardware component beyond the ESP8266, remember that implementing the mobile notification feature will also involve:

  - **Software/Platform:** Utilizing a platform like IFTTT, Firebase Cloud Messaging, or a similar service, which might have free tiers suitable for this project.

  - **Mobile Application (Optional):** Depending on the chosen platform, we might need to install a companion app on our mobile phone.

Block Diagram and Flow Diagram

- ## Block Diagram Showing the Components Interconnection

Block Diagram for Kitchen Ingredient Monitoring System

Load Cell (Weight Sensor)
↓ Reads analog weight data
HX711 Amplifier Module
↓ Sends digital weight data
Arduino Uno/Nano (Microcontroller)
→ Activates buzzer if stock low → Buzzer (Alert System)
→ Shows stock status → LCD Display (Stock Status)
→ Sends alert data via WiFi → ESP8266 WiFi Module (Communication)
↓ Triggers mobile notification
Mobile Notification (User Alert)

- Flow Diagram

Flow Diagram for Kitchen Ingredient Monitoring System Working