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IoT Smart Fridge

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Abstract— **The new market research reports state that the smart appliances market is estimated to reach about USD 37.2 Billion by 2020, at a CAGR of 15.4% between 2015 and 2020.Smart refrigeration with the help of a smart fridge is a concept that finds its place in smart kitchens. The Internet of Things (IoT) is the recent communication paradigm that envisions a near future, in which the objects of everyday life will become an integral part of the Internet. This paradigm indeed finds applications in many different domains, such as home automation, where smart appliances are used. Existing systems use barcode or RFID scanning to keep track of the stock. The products currently available are expensive. The Smart Fridge module can be embedded into any existing refrigerator to provide food using sensors. The smart refrigerator is capable of sensing and monitoring its contents and is also able to remotely notify the user about scarce products via SMS (Short Message Service) and email using a GSM module. It also facilitates the purchase of scarce items by providing a link of the online website for purchase of that particular item.**

The core functionality of the smart fridge is food management with the help of sensors by assessing qualitatively, quantitatively and based on shelf life, the contents of the refrigerator. As a result, the user is notified every time a replacement or restocking needs to be done. This assessment is done with the help of LDR and micro switches employed as pressure sensors (quantity management), odour sensor (quality management) and RFID (shelf life management). The overall food management is done based on coding done using Keil software for the same purpose.

***Index Terms*—IoT, Food management, Keil, Sensors.**

I. INTRODUCTION

Home automation aims to make our daily life more comfortable. In addition to this, communication between people and machines would make life easier. There is a significant demand for the remote control and monitoring of any system. Both Research and Industry have focused on the development of the Smart Home Environment. Developing smart appliances is necessary to develop a Smart Home environment. It is a critical factor in the realization of the smart home environment. Kitchen is an important place of consideration for a Smart home as it consists of many appliances which provide better services to the household.. The area of interest is the smart fridge. Many smart refrigerator variants have been developed, none of which has been cost effective. Some of the developments were from Samsung and LG and are discussed below. These refrigerators were an unsuccessful because the consumers had seen them as an unnecessary product and due to the high cost (more than $20,000) and the problems solved were obscure. Recently, several commercial models of smart fridges have been developed or are under development. The "LG Internet Refrigerator" has a thin-film transistor-liquid crystal display screen with TV functionality and also has a Local Area Network (LAN) port. It includes a LCD information window that has the features like electronic pen, data memo, video messaging and provides information, such as inside temperature, the freshness of stored foods, nutrition information and recipes. Features included are a webcam that is used as a scanner and tracks what is inside the refrigerator, a MP3 player and an automatic icemaker. Samsung's Home Pad refrigerator has a large 15-inch LCD (liquid crystal display) panel on the front door. Via the touch panel, users can access the Internet to surf the Web, send and receive e-mail or watch television. In addition, other audio/visual devices, such as DVD (digital versatile disc) or VHS players, can be attached. In addition, it comes equipped with device control interfaces.

Electrolux's Screenfridge is equipped with a computer and touch screen built into the refrigerator door and does not consume existing storage space. This refrigerator is also connected to the Internet. Aside from using the refrigerator to send e-mails or to surf the Internet, the homeowner can also use it to select, buy and order food without leaving the kitchen. In addition, there is a built-in library of recipes. The refrigerator is equipped with speakers, a microphone and a small video camera, for users to leave video messages for each other. All the functions are available through a touch screen and a virtual keyboard. There's also a built-in television and radio, so the owner can watch the morning news or listen to music while cooking. The fridge will ultimately include a "reader" able to use the electronic tagging found on all food and liquid packaging in the future. This way, the refrigerator can keep stock of food that has been bought or to be purchased. The modern living in a fast paced environment doesn't allow the user to keep a track of the food items inside the fridge.

Although efforts have been put to develop the smart refrigerator, the current or the existing technology is still not cost effective. The smart fridge or the internet refrigerator, is used to monitor the items inside it and notify about scarce

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product. The idea of connecting home appliances to the internet is regarded as the next big thing.
Food wastage due to lack of monitoring and timely usage of refrigerated foods is a common problem.
United Nations Development Program states that about 40% of food is wasted in India. About 20% of food bought ends up being thrown away.
Food management in homes as well as restaurants, with the help of a SMART FRIDGE that monitors the quantity, quality and shelf life of the stored food and generates user alerts, hence proactively controls wastage all through the comfort of your phone.
A hardware prototype is to be developed which senses the contents inside the refrigerator, triggers when the contents inside is below a certain threshold or are on the verge of spoilage or are about to exceed shelf life.
In such cases, this trigger is sent to the users mobile and eventually to his email id through an android application.
The message comes with information about the product which is low on quantity inside the fridge and comes with a predefined link which facilitates online purchasing. The links that facilitate online purchase can be customized according to the preference of the user to place online orders.

II. OBJECTIVES

Refrigerator food management and wastage prevention by:

1. **Quantity monitoring**: Assess the quantity and provide timely updates and reminders of immediate usage or restocking.
2. **Quality monitoring**: Quality of vegetables and fruits can be monitored and alerts can be generated on the onset of spoilage.
3. **Shelf life monitoring**: Packaged products can be monitored for expiry date.

The user can be alerted of the updates on his phone and can take steps to prevent food wastage or can place orders to restock the food in the fridge.

III. METHODOLOGY

The system comprises of sections where the sensors are placed. Light dependent Resistors (LDR) sensors, odour sensors and pressure sensors are placed along with a counter which can be used to sense the quality and quantity of contents. They can be used to detect the level of milk and soft drinks in the container and to sense the presence of vegetables in the refrigerator. ASIC RFID transmitter and receiver are used to monitor shelf life of contents. Whenever the contents inside the refrigerator goes below the predetermined threshold values or are degraded in quality, or if the product is on the verge of expiry, a trigger is generated which is being transmitted in the form of message to the user.
SENSORS: These sensors are fitted in Refrigerator compartments. They sense objects, shelf life and quality of objects and if no object is found or if any quality degradation is sensed, they produce NO Object signal or NO Quality signal or NO shelf life signal which is fed to further stages.
INTERFACING STAGE: As microprocessor needs TTL compatible level signals at its input port, interfacing stage must be introduced .
POWER SUPPLY UNIT: A specially designed power supply unit provides all necessary voltages for the system.

IV. DESIGN AND CONSIDERATIONS

1. Design

The module could be seen to be composed of sub-modules namely:
1. *Sensing module*: LDR, MQ3 Sensor, Pressure Sensor, ASIC RFID Transmitter and Receiver
2. *Control module:* ARM*7* LPC 2148 Microcontroller, Power Supply Unit
3. *Transmission module*: LCD Module, GSM Module

These modules work together to determine contents status inside the refrigerator and notify the user about the products via an SMS or e-mail.

2. Considerations

The following constraints must be kept in mind while developing the design:

- Power supply should be cut off when module not in use.
- Module has to be installed in a place where there is availability of strong network for notifications.
- The food items have to be placed in their respective slots.
- The design must be applicable any existing refrigerator.
- 'Embedded C' was the effective option among others and is chosen as programming language.
- The output is shown on a circuit board which consists of the smart refrigeration module. LED's are placed at various places to indicate the flow of execution.
- The possible source of error include replacing of food items without using them leading false notification. To recover from such an error, the module could be reset or dedicated application could be developed.

V. SMART FRIDGE MODULE

For the first application i.e. quantity monitoring in the refrigerator, an LDR and pressure sensor are used to keep track of the contents in the compartment. A photo resistor or LDR (Light Dependent Resistor), is a light-controlled variable resistor. The resistance of a LDR reduces with increasing incident light intensity or exhibits photoconductivity. Hence, when the product is low in quantity, the light incident on the LDR through the product container increases, when a refrigerator compartment is taken into account. This causes change in resistance of LDR, therefore the output voltage varies. This change is monitored and detected and compared with thresholds to send user updates.
Pressure sensor on the other hand, has an output voltage that varies with the applied pressure. This change in voltage is monitored and detected by the microcontroller and it is compared with thresholds that are set and accordingly, user alerts are generated. In this implementation as soon as the vegetables or the soft drinks are used, the user is notified.
The quality and shelf life application involves the use odour sensors and RFID respectively, for sensing items inside the refrigerator which are placed inside specific compartments.

MQ-3 is used to determine the quality of contents in the refrigerator. MQ-3 gas sensor has high sensitivity to gas, and

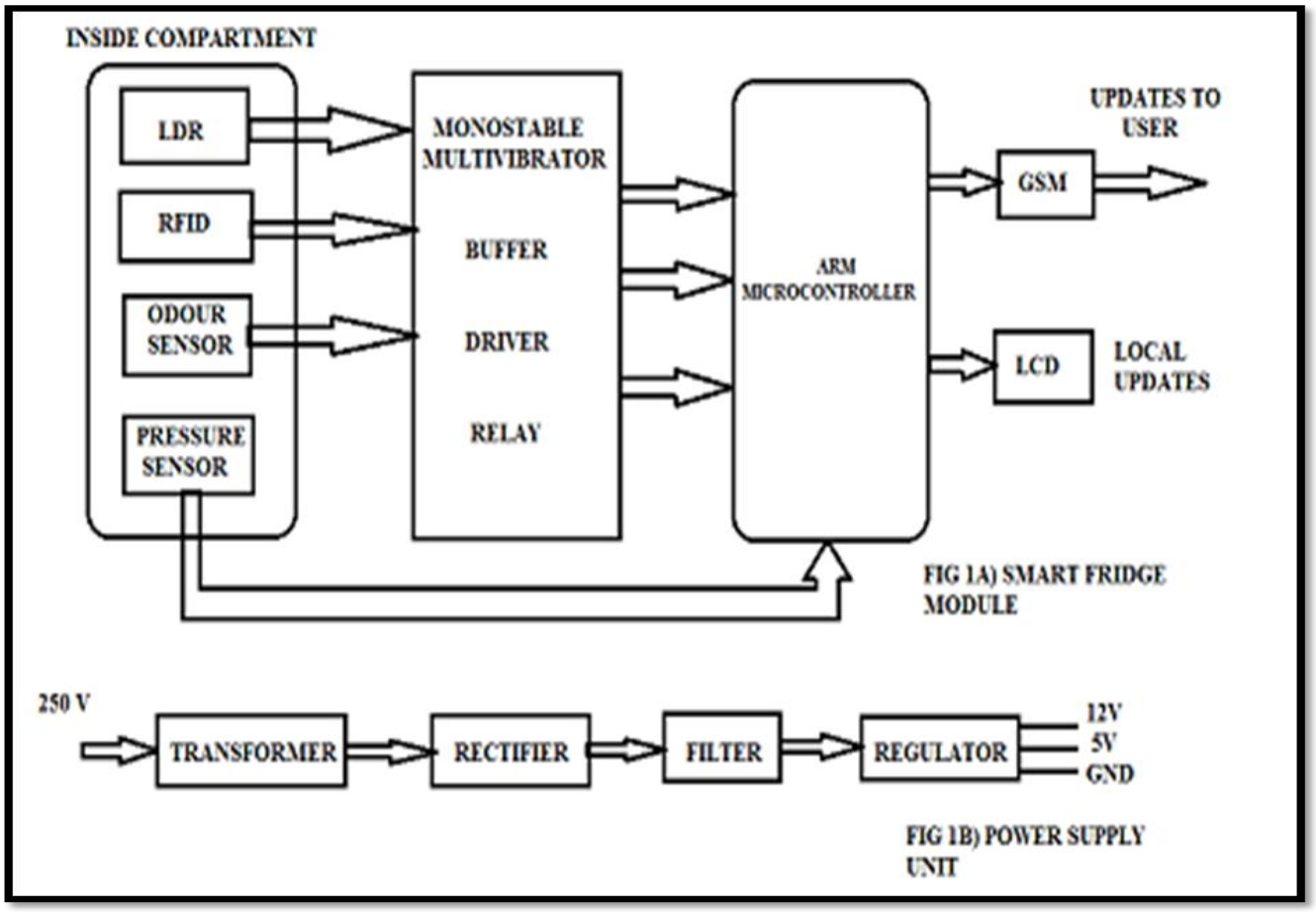

FIGURE 1: 1A) IoT based smart fridge module 1B) Power supply unit

has good resistance to disturb of gasoline, smoke and vapour. The sensor could be used to detect leakage of vapour with different concentration, it is with low cost and suitable for different applications. Here, it finds its application in detecting the smell of spoilt food. The output voltage of this sensor is monitored for variations based on set thresholds and accordingly, user updates are sent.

The RF transmitter and receiver module is built around the ASIC and common passive and active components, which are very easy to obtain from the material shelf. When a product is about to expire, the user may set a reminder using this module to place an online order before the product expires or depletes. The transmitter module may be placed in the vicinity of the compartment having the product and on pressing of switch on the transmitter module by the user, timely alerts can be generated to remind the user about purchase or restocking or immediate usage. The receiver module connects to the microcontroller where appropriate alert generation is determined.

Placing of sensors is to be done according to the requirement of the user or threshold level required. Note that the output voltages of the sensors are constantly monitored by the microcontroller to detect changes to generate updates via the GSM.

The GSM module that is connected to the microcontroller is used to send updates to the user in the form of SMS or E-mail with the use of android application. The user is alerted about the status of the refrigerator contents on his mobile phone and is provided with appropriate links to access online sites to place orders for depleted or expired products. LCD module connected to microcontroller, is used for local alerts. Module needs two voltages to work : +12 V & +5 V. Hence specially designed power supply unit as seen in figure 1B, is constructed to get regulated power supplies. Buffers do not change the logical state of a digital signal and are used to provide extra current drive at the output and regularize the logic present at an interface. Drivers are used to drive the relay where the output is complement of input which is applied to the drive and current will be amplified. An electromagnetic device is used to drive the load connected across the relay and the output of relay can be connected to controller.

The Keil Software LPC2148 development tools are used to compilation and assembly of the C code. µVision for Windows™ is an Integrated Development Environment that is used for implementation of code. These are the tools that are used to write and implement an embedded C code that is used to monitor the sensors and compare their voltage outputs to the predetermined thresholds and if values cross these thresholds, user alerts are generated via GSM.

VI. TESTING

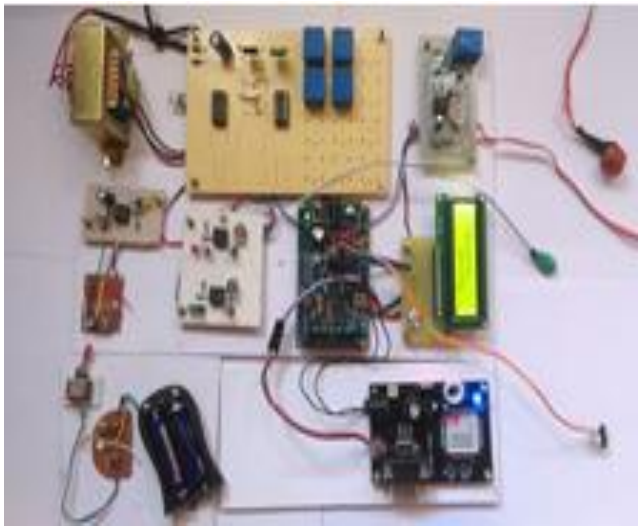

Figure 2: IoT Smart Fridge Module

Testing was done in a room with normal daylight. The temperature during testing was recorded to be 30°C.

A .Testing of Sensor module- LDR

LDR is placed in the compartment with containers having beverages. Light is continuously incident on the container. When the limit of the beverage in the container reduces, the intensity of light falling on the LDR is more than the threshold limit. There is variation in the output voltage of the LDR due to this. This variation is sensed by the microcontroller as it constantly monitors the LDR. The microcontroller hence triggers the GSM to send a message to the user alerting him of the restocking by providing the user with the link of the website to place an online order.

B. Testing of the Sensor module – Pressure sensor

The pressure sensor can be used to monitor the quantity of vegetables. In this smart fridge module, this concept is demonstrated by applying varying pressure on the pressure sensor. When the pressure applied is less than the threshold value, the output voltage of the pressure sensor varies. This variation is detected by the microcontroller, which in turn triggers the GSM to send an alert to the user with a link to place an online order for the vegetables. Many pressure sensors can be used in different compartments for monitoring of multiple vegetables.

C. Testing of Sensor module- Odour sensor

Food substances liberate odour on the onset of spoilage .The odour sensor is used for qualitative monitoring of products in the refrigerator. In this module, the MQ-3 sensor is used to demonstrate this concept. When any alcohol content is detected by the sensor, its output voltage varies. This is detected by the microcontroller and it triggers the GSM to send appropriate messages to the used to place online orders.

D. Testing of sensor module- ASIC RFID transmitter and receiver

RFID module is used for tracking the expiry date of packaged products like insulin that are stored in the refrigerator .The RFID transmitter is placed in the vicinity of the refrigerator compartment where products with expiry date are placed. The user has to merely press 'on' a switch at the time of placing the product in the fridge. A timer is set in the microcontroller and when the timer expires, the user is alerted before the time of expiry of the product (few days before expiry) regarding the usage or restocking of the product. Appropriate links are provided where user can place online orders .For demonstrative purposes, the timer is set for a few seconds after which alerts will be sent to the user.

VII. CONCLUSION

The Smart Refrigerator module is able to remotely notify the user about the low contents inside the refrigerator. It also facilitates purchase of the scarce food items from an online vendor. The link to the online vendor is incorporated inside the notification that is sent to the user via SMS (Short Message Service) and email. This module helps to prevent wastage of food as the user is constantly aware of the contents in the refrigerator and can proactively take measures to prevent wastage.

VIII. ACKNOWLEDGEMENT

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