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DESIGN OF AN IOT SMART CURRENT CONTROL SYSTEM BASED ON GOOGLE ASSISTANT

Ali Abduljabbar
Master of Science in Computer Network, Assistant Lecturer*
Omar Alsaydia
Corresponding author
Master of Science in Computer Network, Assistant Lecturer*
E-mail: omar.alsaydia@uoninevah.edu.iq
Aya Mahfoodh
Bachelor of Science in Computer and Information Engineering*
Rushd Mohammed
Bachelor of Science in Computer and Information Engineering*
*Department of Computer and Information
Ninevah University, College of Electronics Engineering
Al Majmoaa str., Mosul, Iraq, 41001

In locations where power is restricted, such as off-grid, solar, and generator-powered houses, considering the capacity of the power source is critical for the effectiveness of home automation systems. During regular power system outages, millions of houses all over the globe are reliant on a fixed current power supply to keep their lights on. In such circumstances, prioritizing and arranging the home's workload is essential. The goal of this paper is to decrease the amount of effort required by the user to manually control a gadget. To connect with the Raspberry Pi and the users, this system makes use of Google Assistant Software Development Kit (SDK), which is offered by Google. Users use voice commands to manage the devices in their homes, check the amount of current available, and chat to the Google Assistant to turn on/off the smart switch. This paper suggests using a sensor, Message Queuing Telemetry Transport (MQTT) protocol, a controller (OpenHAB open source), and an actuator in conjunction with each other (smart switch) has the capability of measuring and monitoring the entire power that is available and making choices based on that knowledge. Finally, the usage of Google Assistant as an artificial intelligence system makes end-user engagement with the smart home more pleasant. The proposed network was executed in both unlimited and limited power or electrical current modes to compare the standard unlimited smart home setup and our current control design. The system was programmed to function based on the proposed algorithm, with a 10 Ampere as a maximum available current. The water heater was considered a low priority load in this trial as a heavy load. In this system's run, the smart controller was continuously monitoring the load, and when the total load reaches 10 Amperes or above it turns off the low priority loads. Thus, preventing the power supply overload

Keywords: home automation, electrical current control, OpenHAB, MQTT, Google assistant, NodeMCU, power control

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1. Introduction

A person's preferred location after a long and tiring day is his or her own house. Many people get home exhausted after a hard day at work [1]. After they've fallen on their sofa, couch, or bed, some folks are so fatigued that they can't budge from their position. Any little item or technology that enables people to control their surroundings with their voice, such as turning on or off their lights, playing their favorite music, or doing anything else, will make their environment more comfortable [1, 2].

Home automation is the intelligent monitoring and control of household items to ensure that they are used efficiently. Everyday products should be digitally linked and provide data to enable them to operate at peak efficiency. With the combination of home automation and the Internet of Things (IoT), it is possible to have more flexibility when monitoring and managing household goods. A significant number of smart houses will be linked together, allowing for more efficient resource usage over a greater geographical area [3].

Before the invention of artificial intelligence, the affluent employed human employees such as housekeepers to keep their houses in order. Even today, when technology has evolved enough, only a few groups of well-off people in society have access to these new smart home gadgets, owing to the high cost of such devices. However, not everyone has the financial means to purchase a personal assistant or a smart home package. This has resulted in an ongoing growth in the need for a low-cost, efficient electrical current or power management, intelligent helper for typical households [4].

Even to this day, while technology is useful enough, only the well-off members of society are blessed with new smart home gadgets such as Amazon Echo, Google Home, and so on, because the costs of these devices are rather high. However, not everyone is rich enough to buy a personal assistant or a smart home kit. As a result, the need for a low-cost, intelligent assistant for average families continues to increase [5, 6].

Therefore, studies that are devoted are necessary to be conducted to improve the situations in the smart home in the upcoming years in terms of Electrical current management. This can be achieved by monitoring and controlling the available electrical current in real time and remotely.

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2. Literature review and problem statement

In the literature, the Current Control System topic received considerable attention from the researcher in the field to analyze and optimize different systems. The researchers in [7] focus on developing a smart wireless home automation system that can be controlled remotely by the user over the Internet. Furthermore, it may be used to identify trespassers via a network of sensors. The advantage that this system has over comparable current systems is that the information sent to the connected microcontroller monitoring device may be notified to the individual user on his or her phone from any remote place, regardless of whether his or her phone is connected to the internet or not. The microcontroller utilized in the present prototype is a NodMCU, which has an integrated microcontroller and an integrated Wi-Fi shield, via which all of the linked electrical equipment in the home may be managed. A smartphone application known as If This Then That (IFTTT) is used to interconnect the module and only monitor the home devices via various communication modes but the power control of home appliances and management is still unresolved. It has been decided to put in place a smart energy system in [8] an intelligent energy-efficient smart control system is proposed that can access and control home equipment from any location on the planet, regardless of time or place of the day. A connection is made between the main supply unit of the home system and an Internet access module, which is then accessible over the Internet. When communicating wirelessly, the Internet Protocol (IP) Address is used. This home automation is built on the foundation of a versatile application that can be controlled either by a voice recognition command sent via Google assistant or a web-based application. This system does not take into consideration the priority of dissipation and management of the current between different home appliances. According to [9], the researcher studied a notion for an Internet of Things-based smart home automation system with a remote-control device for disabled folks that was developed using voice commands. It is possible to operate electrical items in the house, such as televisions (TVs), fans, and lights, using just voice control instructions and without having to move to turn on or off electrical devices, thanks to intelligent monitoring systems. For electrical equipment in the room or at home, the Google Assistant software installed on mobile phones is utilized to recognize spoken commands. When the accent is right, voice instructions will be sent to the Google Assistant software. Voice commands for Internet of Things (IoT)-based Smart Homes are more convenient to use than typing text messages. When compared to texting, consumers gain from the convenience of using a computer. As a result of the transmitted power of the Internet service, a favorable performance device will be generated at various times such as the Google Assistant Response Time, System Processing Response Time, activating and deactivating Electrical Devices. However, the amount of available electrical current and the priority are not considered and are only monitored without controlling the electrical items. The researcher in [10] provides a novel of controlling household appliances with human voices in many languages, as demonstrated by the multilingual capability. The setup manages home items such as a Bluetooth speaker, a light bulb, a fan, and a charging connector. The Raspberry Pi is used to communicate with the appliances in this design, and the Blynk server is remotely linked to the setup. IFTTT technology was deployed as a bridge between Google Assistant and the Android application app. The Google Assistant allows the user to issue commands in the language of their choice. However, this system only on/off the household appliances without any concert to the power usage and available electrical current and power management, and this paper does not use the MQTT protocol.

In recent years, there has been an increase in interest in home automation and smart home. It is an interesting topic in which intelligent home appliances are linked via a network and may communicate with one another to give the consumer the ultimate in comfort and luxury. The suggested concept in [11] brings this advantage to the less wealthy segments of society. This study wants to make a gadget that acts as a bridge between typical appliances and the user, optimizing the operation based on the user's preferences. In this experiment, the study takes three different types of light bulbs and controls them using voice commands, hinting at our eventual objective of the previously stated mediation device. This system only makes a bridge between home devices and users for monitoring and controlling only remotely but not automatically depending on the status of the home environment, also this system does not using google assistant. The framework and model of an intelligent earth system are provided in [12]. This system uses the Raspberry pi, which contains a built-in Wi-Fi module that allows to operate your device over the Internet, which is the most crucial feature. It is compatible with a wide range of earth tools, including energy management systems. Furthermore, the program is designed so that the user may control the gadget using Google Assistant. The IoT project also intends to create a wireless home security system that will employ the ESP32 camera Node MCU module to send warnings to owners if someone snaps a photo of the door and transmits it to the homeowner. However, this system does not take into consideration the priority of dissipation and management of the current between different home appliances and does not use the MQTT protocol for controlling.

The IoT project in [7] aims on developing a smart wireless home automation system that the unique owner may operate remotely over the Internet. Furthermore, a collection of sensors may be used to identify trespassers. This system has comparable to current systems in that the information sent to the microcontroller-managed system may be notified to the individual user on his or her phone from any remote place, regardless of whether his or her smartphone is connected to the internet or not. The microcontroller utilized in the present prototype is a Node MCU, which has an embedded microprocessor and an inbuilt Wi-Fi shield, via which all of the linked electrical equipment in the home may be managed. This paper does not focus on the availability of the amount of current and does not utilize google assistant for voice command control.

The main problem or issue noticed from the literature is that some works are handling the monitoring and switch on/off for home appliances but are not focused on the availability of the current and the priority of using the home devices depending on the current available. Also, does not use the benefit of using the MQTT protocol for the smart home environment.

3. The aim and objectives of the study

The aim of the study is to design a smart home controller that can be used in environments with limited available supplied electrical power. Additionally, this smart home controller should be capable of receiving verbal instructions from the user to execute an action or change the controller's setting.

To achieve this aim, the following objectives are accomplished:

– to develop a concept for the functioning of an electrical current controller that can function in a limited accessible power environment. the proposed controller should monitor the system's power usage in real time by using sensors and control the operation of the electrical utilities based on the power availability and predefined priority maps;

– to propose a system for conversational interactions between the controller and the user, Google Assistant as an A. I system was linked to the controller. Custom routines were needed in Google assistant to overcome the lack of action flexibility.

4. Materials and methods of research

4. 1. Object and hypothesis of the study

In this paper, a mechanism of this kind is postulated. The Google Assistant, the Raspberry PI has an inbuilt WIFI that allows the user to connect, monitor, and control the electronic appliance via the home network and Internet. The most important components are the MQTT protocol, OpenHAB, a smart switch, and the NodeMCU. This allows to receive information from several sensors and make choices based on what is happening in the system [5]. Protocol bindings are responsible for triggering events on the event bus. Any sensor input may cause a change in the state of the object being monitored. The information from your home's sensors is sent to you through the protocol bindings that you create. Additionally, smart switches and other devices can influence change to connect via the use of this protocol [5, 6]. Natural language voice commands are supported for controlling the Google Assistant [5, 6]. Combining Google Assistant artificial intelligence with the power cognizant smart home controller broadens the horizon of this technology and its future applications. Enabling people with access to limited power supplies to use smart home controllers through a user friendly interface. And this technology will have a huge influence on society.

The study was conducted using physical hardware, not in a simulation environment. To compare the outcomes of the proposed design against the available commercial solutions in its real environment. Many physical modifications were made to the hardware and code alterations to the open-source software.

Tests were made in the normal operation of a smart home controller without any limitation to the supplied electrical power, to investigate the behavior of the such system in conditions where the available power is limited.

Ten amperes alternating electrical current were chosen as a benchmark for the system performance as it is the average private generator subscription in Iraq. Also, it represents a realistic actual sustained capacity of many solar/batteries off-grid systems.

4. 2. Node Micro Controller Unit (NodeMCU)

It's an open platform and a programmable board with Internet of Things (IoT) features that allow things to connect and interact with one another through the Internet. The ESP8266 shield is used in this project. In terms of length and breadth [13–15], the NodeMCU board measures 47 mm in length and 26 mm in width.

4. 3. Open Home Automation Bus (OpenHAB)

Using OpenHAB, your smart home can be at the heart of an open-source, technology-agnostic home automation platform. It is the capacity to work with a wide range of different devices and systems. Various home automation systems, smart gadgets, and other technologies are included in OpenHAB as one comprehensive solution. A standard user interface and an approach to automation rules throughout the whole system, independent of the number of manufacturers and sub-systems involved, are needed. OpenHAB gives the most adaptable technology available to realize virtually any home automation dream.

It's impossible to talk about the OpenHAB without bringing up Google Assistant, as previously discussed.

Keep in mind that OpenHAB is nothing more than a piece of software code. Unless you explicitly instruct it to do anything, the computer will not act on your instructions. OpenHAB has a wide range of pre-configured solutions that are simple to use. On the other hand, the more you insist on everything looking and working precisely how you want it, the more effort you will have to do. It is possible to make OpenHAB your own, but it will take time to work on your part [6, 16].

4. 4. Google Assistant Action

Google Assistant is Google's virtual personal assistant, and it leverages Actions on Google as a platform for "Acts" (programmers) to enhance the Google Assistant's capability. Users converse with Google Assistant to accomplish tasks such as controlling various electronics and household items. You may use the fully approved openHAB Action for Google Assistant to simply manage and control your home automation through conversational interactions with your openHAB smart home powered by voice control. You may use the Action to control your openHAB things by speech, and it supports lights, plugs, switches, and thermostats. The openHAB Action is available in a variety of languages, including English, German, and French [6].

4. 5. Message Queuing Telemetry Transport (MQTT) protocol

In the Internet of Things, MQTT is a protocol that works very well for M2M connections between a small number of IoT devices. It is also advantageous to have a very short header with just 2 KB of data since it reduces network overhead in terms of latency and throughput over a Transmission Control Protocol/Internet Protocol (TCP/IP) network. It is necessary to use an intermediate third-party provider when a sender broadcasts messages to many topics and a subscriber is compliant with multiple topics and the same protocol for messages to be delivered to the destination. Two standard ports, 1883 and 8883, are used by MQTT clients, and both have been approved by the Internet Assigned Numbers Authority (IANA). A TCP/IP network uses port 1883 for standard MQTT transmission, whereas port 8883 is used for MQTT data that has been authenticated via TLS. The benefits of using MQTT above all other protocols are that it is throughput efficient in terms of bit rate, that it makes effective use of power consumption, and that it allows for the creation of customized solutions owing to the server-client architecture [16–18].

4. 6. Google Assistance and OpenHAB

Google Assistant is the company's virtual personal assistant, and it makes use of Actions on Google as a platform for "Actions" to increase its capability. And uses the OpenHAB cloud service myopenhab.org to connect to the smart home controller. Lights, plugs, switches, thermostats, and many more OpenHAB "things" are supported by the Action, which allows voice control of OpenHAB devices [19].

In other words, OpenHAB was designed to permit connection to Google Assistance and accepts actions regarding things that are exposed to Google Assistance. However, this paper aims to achieve actions beyond simple switching ON/OFF devices by OpenHAB using Google's voice commands. And as stated by [20], routine is the technique that Google Assistant uses to accomplish multiple tasks automatically. Yet, these routines are simply sets of actions triggered by a condition and are still not sophisticated enough to accept simple programming conditions such as if/then.

On the other hand, OpenHAB supports several programming languages that may be used to write advanced rules. And although built-in Blockly is incredibly strong and comparatively simple to use, there are certain details or use cases that it cannot handle [21].

This paper used JavaScript scripting language in OpenHAB as an add-on to implement the proposed algorithm. OpenHAB will gather its environment variable using the sensors and accept actions provided by customized Google Assistant, then consult the algorithm to make its decisions.

The sensor, controller (OpenHAB), and actuator are all shown in the block diagram of the proposed system in Fig. 1 (smart switch).

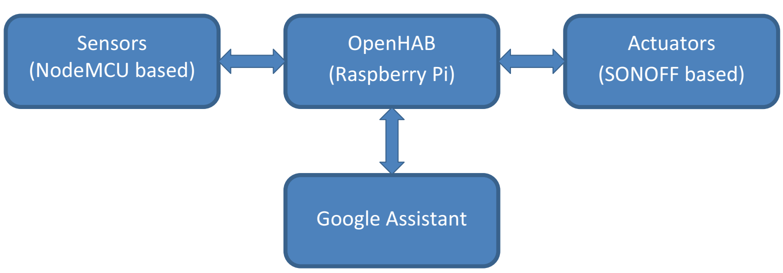

Fig. 1. The block diagram of the proposed system

In addition, this system may be controlled remotely by Google Assistant on smartphones using voice commands.

4. 7. Practical implementation

For the sake of testing purposes, a test-bed network is created. Which is composed of three different loads and three levels of priority. For each load, there are a load sensor and actuators. Multiple operation scenarios were tested to evaluate the system response.

Referring to Fig. 2, 3 the implementation is divided into two stages (phases), the sensors in the system are structured using the NodeMCU board in addition to the ACS712 chip, which is a Hall effect current sensor that can function on AC as well as DC.

As for the actuators, The Sonoff basic comes with an ESP8266 chip, power supply, relay switch, a push button, and light-emitting diode (LED) in a small case. As the factory firmware is not flexible enough to accept custom commands, the firmware on the ESP8266 chip was replaced by a modified one. Writing on the chip requires using the 3.3 V, Transmitter (Tx), Receiver (Rx), and Ground (GND) by soldering points on the printed circuit board (PCB), and provisioning of the Future Technology Devices International (FTDI) USB-to-Serial converter.

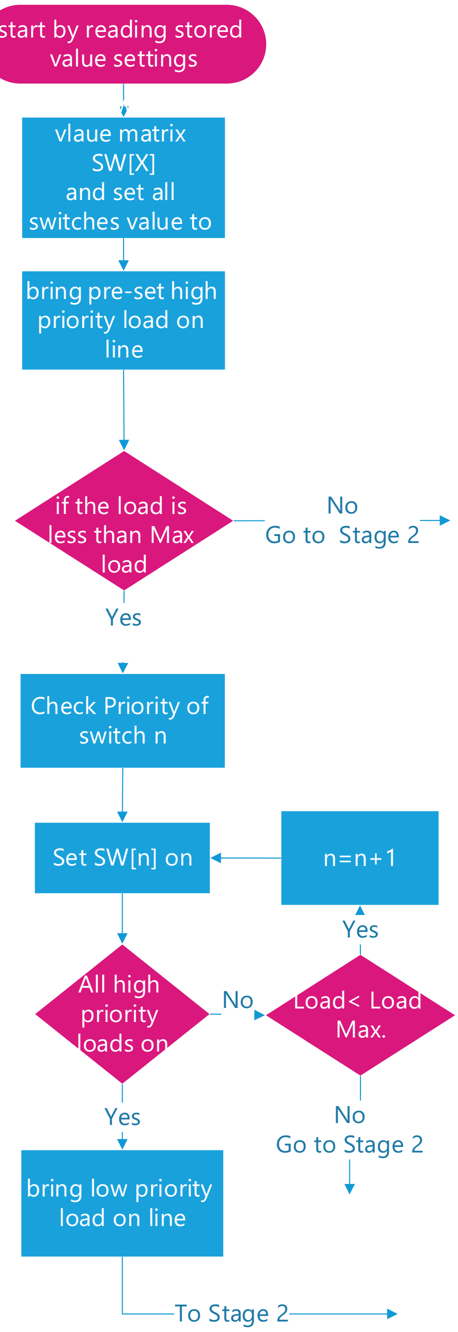

Fig. 2. The first stage

Each sensor and actuator communicates with the smart home controller using a separate topic of the MQTT protocol.

In the center of the system, there is the OpenHAB controller to make the decisions. Users can interact directly with the controller graphical interface or Google Assistance.

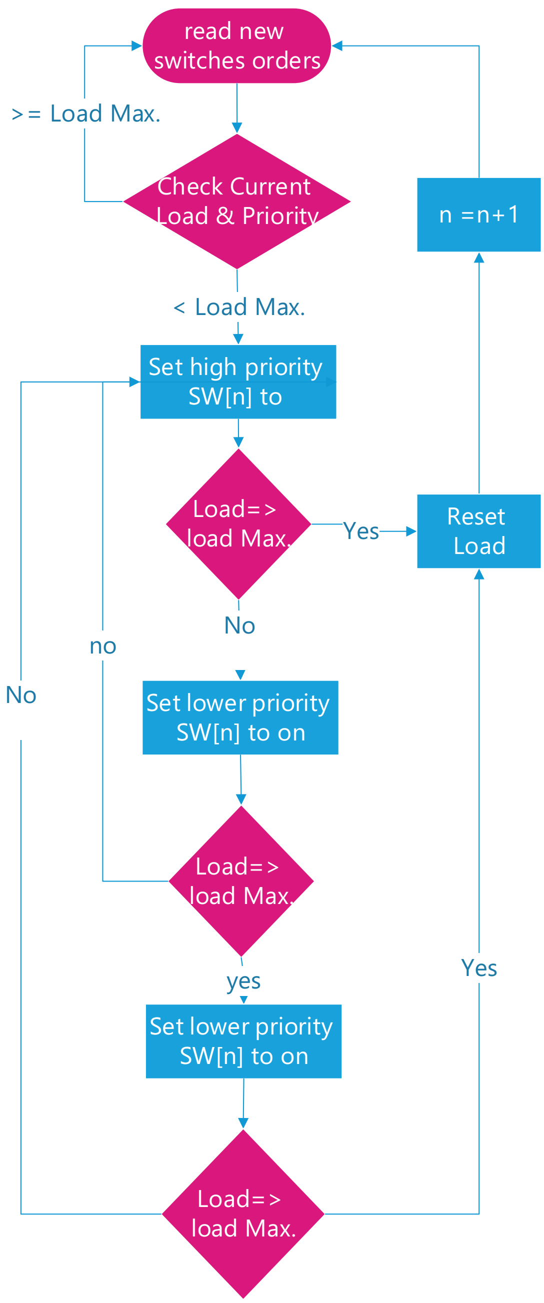

Fig. 3. The second stage

A basic implementation of the proposed power-aware smart home controller was accomplished using the built-in rules in the OpenHAB controller. In this scenario, the code of rule depends on the availability of 50 Amp (which represents the total available electrical current), and the switch needs 15 Amp to be run. Before the switch can be turned on, the instantaneous in-use electrical current for the entire system should be 35 Amp or less, and this shows the role of the OpenHAB will check whether amps are enough to run or not by the current measurement sensor (ESP) after that switch will be run or not. Fig. 4, 5 show the code for adding things and adding items.

Fig. 6 show the code for adding the sitemap: and the code of the rule.

This arrangement can prevent overloading the power supply when a new load is introduced through the controller at any given time. However, it does not measure the power supply load after that during the normal operation.

The typical domestic electricity usage has a fluctuating nature where loads can be switched on or off at any time either by users or by loads that contain a thermostat or internal timer etc.

A proposed algorithm was introduced to the controller to make the system usable in such an anticipated power-constrained challenging environment. In which, the controller will go through two main phases.

The first one is the initialization phase in which it will load the initial configuration, which contains the total available electrical current and the priority of each electrical device (load).

Then proceeds to put ON designated high priority loads online, while measuring the load on every step, low priority loads will be switched ON if there is any remaining available power. The figure below shows the flow chart of this phase.

The second phase is the main loop, where the program continuously monitors the system loads and waits for any new ON/OFF commands. ON designated Low priority loads will be turned ON if there is available power after satisfying all the ON designated high priority loads.

If the load on the power supply exceeded the maximum threshold allowed by the power supply, the controller shall turn OFF the ON designated low priority loads until the allowed maximum electrical current is achieved.

```
Bridge mqtt: broker : mosquitto "Mosquitto" [host="127.0.01", secure=false, clientID="openHAB2"]
{
    Thing topic test_sonoff "test_sonoff switch" @ "kitchen"
{
    Channels:
    Type string : reachable "reachable"     [stateTopic="tele/sonoff1/LWT"]
    Type switch : Power     "Power"         [stateTopic="stat/sonoff1/POWER", commandTopic="cmnd/sonoff1/POWER"]
    Type number : rssi      "WiFi Singnal Strenth" [stateTopic="tele/sonoff1/STATE", transformationPattern="JSONPATH:$.WiFi.RSSI'
    Type switch : power2    "Power2"        [stateTopic="stat/sonoff1/POWER", commandTopic="cmnd/sonoff1/POWER"]
}
Thing topic Ac_current "mesure AC current" @ "kitchen"
{
    Channels:
    Type number : total_current     "total mesured current" [stateTopic="AC-current/MainCurrent/A"]
}
}
```

Fig. 4. Sample of creating things in OpenHAB

```
Kitchen_vent    "Light" <vent>  (Kitchen)          ["Switchable"]  {channel="mqtt:topic:mosquitto:test_sonoff:power"}
total_current   "main"  <energy> (Kitchen, energy)  ["Temperature"] {channel="mqtt:topic:mosquitto:Ac_current:total_current"}
Garage_vent     "Light" <vent>   (Kitchen)         ["Switchable"]   {channel="mqtt:topic:mosquitto:test_sonoff:power2"}
```

Fig. 5. Sample of items on OpenHAB

```
sitemap myhous label="MyHouse" {
    Frame
    {
        Group item=Kitchen
        Group item=Garage
        Group item=Living
        Group item=Bedroom1
        Group item=Bedroom2
        Group item=bath
    }

}
```

Fig. 6. Adding the sitemap to OpenHAB

5. Results of Electrical current Control and Google Assistant

5. 1. Electrical current control result

The testbed network was executed in both unlimited and limited current modes to compare the standard unlimited smart home setup and our current controlled design.

In both executions, there were three loads. One with a Direct Current (DC) of 1.5 Ampere was programmed to alter on and off status every 15 minutes to simulate a domestic refrigerator. The second load represents domestic various loads like lights and utilities. The NodeMCU was configured to provide random numbers to the OpenHAB equivalent to 2 to 6 Amperes. Finally, the last load simulates a load of domestic water geyser with a reading of 6 A. The load will be on and off in a random time manner.

Referring to Fig. 7, 8, in this test, the controller was configured to run in unlimited current mode to replicate the behavior of commercial smart home controllers. The total load current at any given time is the sum of the three loads.

Fig. 8 shows the distribution of electrical loads to prevent power supply overload (max. 10 Amps).

In Fig. 8, the smart controller was programmed to function based on our proposed algorithm, with a 10 Ampere as a maximum available current. the water heater, as a heavy load, was considered a low priority load in this trial. In this system's run, the smart controller was continuously monitoring the load, and when the total load reaches 10 Amperes or above it turns off the low priority loads. Thus, preventing the power supply overload.

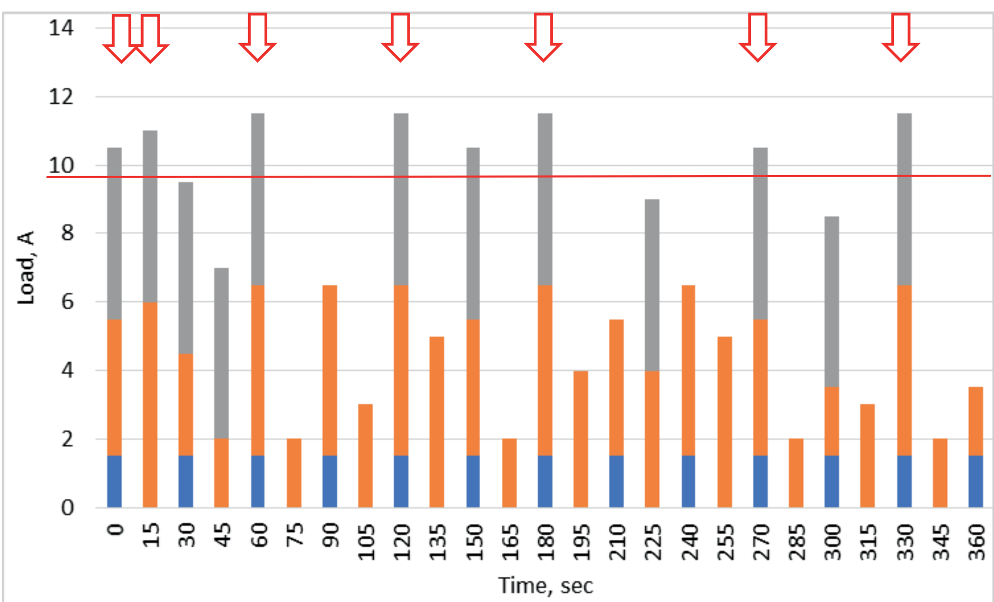

Fig. 7. Potential power outage points

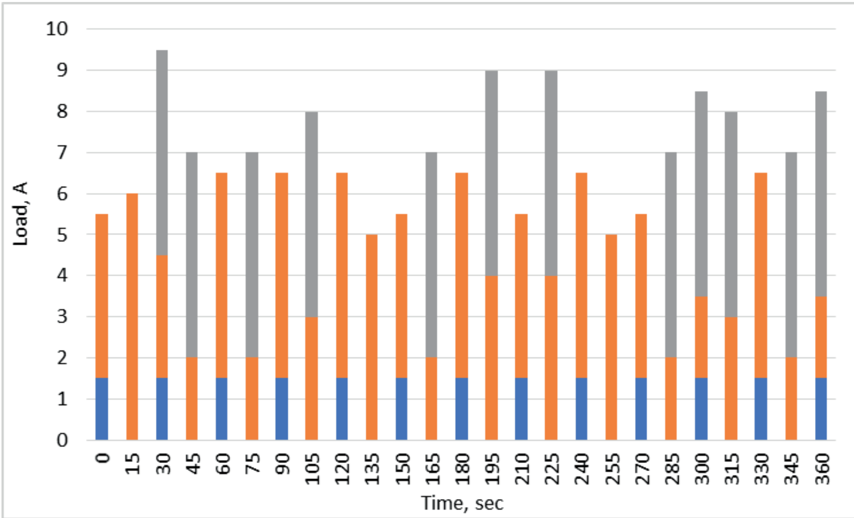

Fig. 8. Electrical loads were distributed to prevent power supply overload (max 10 Amps)

5. 2. Google assistant result

As mentioned earlier, Google assistant acts as an intermediate agent between the smart home controller and the end-user. Its uses can be as simple as receiving orders of turning ON/OFF the loads as in Fig. 9 by creating switchable items in OpenHAB and linking them to google assistance.

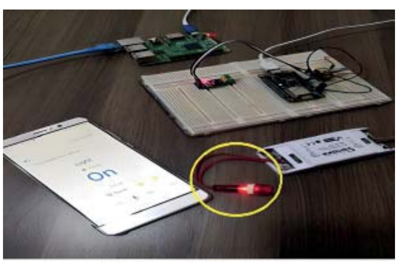

Fig. 9. Google assistant turning ON/Off

Also it can switch the priority map of the system in more complex environments with various types of loads and priorities by utilizing google assistance routines.

Fig. 10 shows the load graph after using the keyword "urgently" to turn on the heater.

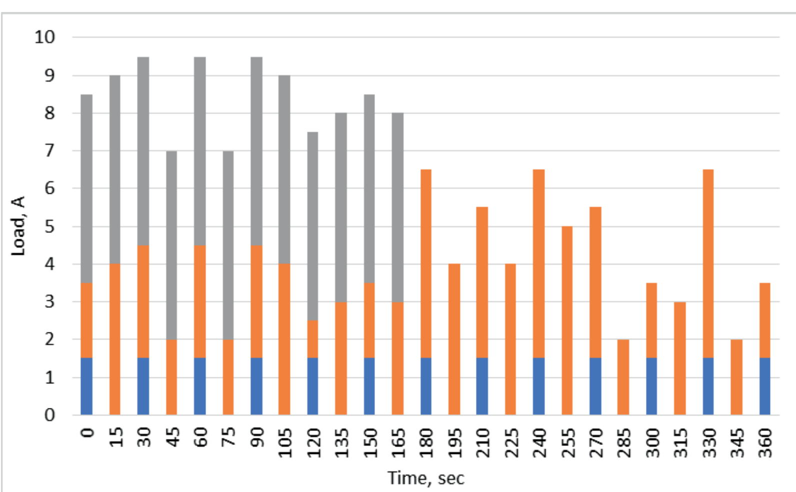

Fig. 10. The load graph after using the keyword to alter the priority map

Here the controller gave a high priority to the heater load as well as for the fridge. The remaining available power was allocated to the remaining load until the high priority load was satisfied.

6. Discussion of the experimental results of the proposed system

As shown in Fig. 7, there is load fluctuation between a minimum of 2 Amps to a maximum of 1.5 Amps which is normal household load behavior. However, if this controller were used in an environment where the total available electrical current was capped to 10 Ampere, as most of the households in Iraq have when running on commercial generators during a national electrical grid outage, there will be multiple electrical disconnections as indicated by the arrows in Fig. 7. This happens since almost all the electrical grids in the world are designed to charge customers based on the consumed energy. And, from the results, this model will cause several power outages in environments where the power at a given time is restrained like in off-grid sites.

As shown in Fig. 8 it's important to note that while the smart controller controls the power supplied to loads, some of these loads have internal switches and will not be ON all the time. For example, the refrigerator load in the test was treated as a high-priority load and was always ON by the controller but the actual drawn current was as shown in Fig. 8. Therefore, the algorithm was designed to continually monitor the total supplied electrical current status and make the power available to the loads with less priority whenever the power supply is not fully loaded.

The results demonstrate that the proposed methods if properly configured will greatly decrease the possibility of power supply overloading in limited power environments such as off grid and generators. The result also shows how the proposed method used Google assistant to change the system settings by using key phrases to trigger the Google assistant's routines which in turn trigger the priority map changes in the smart home controller.

Although Google Assistant artificial intelligence added the possibility of verbal communication between the end user and the smart home controller. The commercial nature of Google assistant itself is one of the main drawbacks of this study. As Google company has the exclusive right to modify or withdraw this product.

It is worth mentioning that the limitation of this study is the complexity of the system when increasing the number of controlled devices in order to take into consideration the priority of these devices. Also, the system depends on the processor speed for implementation. Software must be powerful in terms of capacity and processing speed in order to improve the system.

7. Conclusions

1. The proposed system successfully prevented overloading the power supply as an electrical current control system by allocating power to utilities based on priorities given by the user and power availability. By constantly monitoring the supplied power and granting power to the low priority more demanding loads during off-peak times, the proposed system successfully avoided power disruption. The open source software used in the proposed solution provided a suitable platform in which some codes were modified and others were added. Unfortunately, highly customizable software makes them sometimes difficult to use for non-specialized users.

2. Google assistance was successfully integrated with the proposed solution. Authorized users were able to give verbal orders to the home automation system using Google powered devices including mobile phones. Google Assistant was successfully used by the system not only to switch ON/OFF items but to alter the overall pre-set priority map using the pre-defined keywords.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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