



بسم الله الرحمن الرحيم

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مسئولية عن محتوى هذه الرسالة.

ملاحظات:

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**DESIGN AND IMPLEMENTATION OF A HOME  
ENERGY MANAGEMENT SYSTEM WITH DEMAND  
RESPONSE CAPABILITIES USING IOT TECHNIQUE**

By

**Sarah Osama Mohamed Elfishawy**

A Thesis Submitted to the  
Faculty of Engineering at Cairo University  
in Partial Fulfillment of the  
Requirements for the Degree of  
**MASTER OF SCIENCE**  
In  
**Electrical Power and Machines Engineering**

FACULTY OF ENGINEERING, CAIRO UNIVERSITY  
GIZA, EGYPT  
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Approved by the Examining Committee

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**Title of Thesis:**

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**Key Words:**

Home energy management system; Demand response; Internet of things; MQTT

**Summary:**

The increasing demand for electricity and the emergence of smart grids have presented new opportunities for a home energy management system (HEMS) that can reduce energy usage. The HEMS incorporates a demand response (DR) tool that shifts and curtails demand to improve home energy consumption. This thesis presents the implementation of a proposed HEMS system using microcontroller. The system includes:

- Microcontroller based actuators (smart plugs) that measure and can switch loads,
- HEMS main controller that implements a load management algorithm that can incorporate demand response actions.
- Wifi Network communication based on MQTT between controller and actuators.
- User Interface to monitor the HEMS and to enable the user to customize the controller operation by assigning load priorities and required comfort level.

## **Disclaimer**

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Sarah Osama Mohamed Elfishawy

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# **Dedication**

I dedicate this thesis to my family and my friends for their partnership of success in my life.

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# Nomenclature

## Abbreviations

### A

AC Air conditioner

### C

CB Consumption based

CD Cloth dryer

CE Cost of energy

CPP Critical Peak Price

### D

DR Demand Response

DS Delayed Scheduling

### E

EM Electromagnetic waves

EMS Energy management system

ESS Energy storage system

EV Electric vehicle

### G

GUI Graphical user interface

### H

HAN Home-area network

HEM Home Energy management

HEMS Home Energy management system

HTTP Hypertext Transfer Protocol

### I

ICT Information and Communication Technology

IoT Internet of Things

IP Internet Protocol

IBR Inclining block rate

### M

MQTT Message queuing telemetry protocol

### L

LE	Low Energy
<b>O</b>	
OSI	Open System Interconnect
<b>P</b>	
PWM	Pulse Width Modulation
PV	Photovoltaic
<b>R</b>	
RES	Renewable energy sources
RP	Reward price
RTP	Real Time Price
<b>S</b>	
SFP	Single Fixed Price
SHA	Shiftable home appliance
SHEMS	Smart Home Energy Management System
SSID	Service Set Identifier
<b>T</b>	
TBD	Time based discomfort
TCP	Transmission control protocol
TOU	Time of use
<b>W</b>	
WH	Water heater
WSM	Weighted sum method