
# DEVELOPMENT AND LABORATORY IMPLEMENTATION OF SUPERVISORY CONTROL AND DATA ACQUISITION(SCADA) SYSTEM FOR SMART GRID AT RESIDENTIAL LOADS LEVEL

**BY**

**Eng. Safaa Said Sayed**

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**

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**Approved by the Examining Committee**

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FACULTY OFENGINEERING,CAIRO UNIVERSITY
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**Title of Thesis:-**

**Development and Laboratory Implementation of Supervisory Control and Data Acquisition (SCADA) System for Smart Grid at Residential Loads Level**


**Key Words:**

**SCADA; SG; Demand Response (DR); SM; WAN**


**Summary:**


This work presents the development and laboratory implementation of a SCADA system for the Smart Grid at the residential loads level. SW packages, smart metering & control devices and wireless data communication network (Wide Area Network WAN) have been used in the implementation of the Smart Grid. Load electrical variables are collected and stored in a PLC , and sent via WAN to Utility Center, where SCADA SW has been configured for the real time visualization of the load variables , archiving , generation of reports and billing. Demand response events are generated from SCADA and sent via WAN to the control unit to control load power. Experimental results are presented for different loading conditions and based on DR events.

# Dedication

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: Safaa said sayed Date:../3/2019

Signature: Safaa said

# Dedication

I dedicate this thesis to my family for their dedicated partnership for success in my life.

# Acknowledgments

I would like to express my sincere gratitude to **PROF.AHAMAD BAHGAT** for his interesting to finish this thesis in a good manner in the laboratory of control system section. My sincere thanks also go to **PROF. HASSAN M**. **RASHAD** for helped me to enhance my knowledge in my research continuous support of my thesis study. Also I thank **DR. AHMED BESHEER** for his effort with me to finalize and modify thesis comments and. He has a lot of papers in Smart Grid and related researches; he also has a good practice experience in control system and its industrial applications. Thanks for all of you, And for each one help to make this thesis done. Finally, I consider my thesis a love message for my parents who supported me to complete my master degree with my difficult career work condition. Finally, I must express my very profound gratitude to **Eng. Sarah El-fishawy** who provided me with unfailing support throughout my work in laboratory.

# Table of Contents

# List of Tables

# List of Figures

# Nomenclature

## Symbols

| | |
|---|---|
| %I | Represents a discrete input bit. |
| %IW | Represents an analog input word register. |
| %M | Represents a memory bit. |
| %MW | Represents a memory word register. |
| %Q | Represents a discrete output word register. |
| %QW | Represents an analog output word register. |
| %S | Represents a system bit. |
| %SW | Represents a system word register. |
| %KW | Represents a memory constant word register. |

## Abbreviations

| | |
|---|---|
| **A** | |
| ASCII | American Standard Code for Information Interchange. |
| AMI | Advanced Meter Infrastructure |
| AMM | Advance Metering Management. |
| AMR | Automatic Meter Reading |
| AENS | Average Energy Not Supplied |
| ASAI | Average Service Availability Index |
| ASUI | Average Service Unavailability Index |
| ASK | Amplitude shift keying |
| **B** | |
| Bps | Bits per second. |
| B.W | Band Width. |
| **C** | |
| CAN | Controller area network. |
| CSMA/CA | Collision senses multiple access /collision avoidance. |
| CSMA/CD | Collisions sense multiple access /collision detection. |
| CAS | Central acquisition system. |
| CPU | Central Processing Unit. |
| CRC | Cyclic Redundancy Checksum. |
| COM | Component Object Mode. |
| CDMA | Code Division Multiple Access. |
| CAIDI | Customer Average Interruption Duration Index. |
| CPP | Critical Peak Pricing. |
| **D** | |
| DAQ | Data acquisition. |
| DB | Data Base |
| DCS | Distributed Control System. |
| DINT | Double Integer. |
| DLC | Direct load control. |
| DNP3 | Distributed Network Protocol Version 3. |
| DR | Demand Response. |

| | |
|---|---|
| DRMS | Demand Response Management System. |
| DSM | Demand side management. |
| **E** | |
| EBOOL | Extended Boolean. |
| EF | Elementary Function. |
| EDS | Electrical Distribution System. |
| ENS | Energy Not Supplied. |
| EMCU | Energy Management Control unit. |
| EMR | Energy Management Report. |
| **F** | |
| FDDI | Fiber Distributed Data Interface. |
| FDM | Frequency -division Multiplexing. |
| FTP | File Transfer Protocol. |
| FB | Function Block. |
| FBD | Function Block Diagram. |
| FLC | Fuzzy logic controller. |
| FSK**G** | Frequency shift keying. |
| **G** | |
| GMRP | Generic Attribute Registration Protocol. |
| GUI | Graphics user interface. |
| GHEMS | Global home energy management system. |
| GPRS | General packet radio service. |
| GSM | Global System for Mobile. |
| **H** | |
| HAN | Home area network. |
| HART | Highway Addressable Remote Transducer. |
| HF | High Frequency. |
| HMI | Human-machine interface. |
| HTTP | Hypertext Transfer Protocol. |
| HSSP | Homeland Security Standards Pane. |
| HEMS | Home Energy Management System. |
| **I** | |
| ICT | Information and Communication Technologies. |
| INT | Integer. |
| IP | Internet protocol. |
| IPX/SPX | Inter Packet exchanged/Sequential Packet exchanged. |
| ISDN | Integrated Services Digital Network. |
| ISO | International Standards Organization. |
| **L** | |
| LED | Light emitting diode. |
| LRC | Longitudinal redundancy check. |
| LAN | Local area network. |
| LHEMS | Local home energy management system. |
| **M** | |
| MAC address | Media access control address. |
| MAST | Master. |
| MAS | Multi-agent systems. |
| MTU | Master terminal unit. |
| MILP | Mixed integer linear programming. |
| **N** | |

| | |
|---|---|
| NetBIOS | Network Basic Input Output System. |
| NetBEUI | NetBIOS Extended User Interface. |
| NMC | Network management center. |
| NTP | Network time protocol. |
| NCS | Networked Control System. |
| **O** | |
| OSI model | Open Systems Interconnection model. |
| ODBC | Open Database Connectivity. |
| OEM | Original Equipment Manufacturer. |
| **P** | |
| PAR | Peak to Average Ratio. |
| PLC | Programmable logic controller. |
| PLCC | Power Line Carrier Communication. |
| PING | Packet Internet groper. |
| PBM | Pulse-Burst-Modulation. |
| PM | Power meter. |
| PSK | phase shift keying |
| PSN | Public switch network. |
| PTM | Point to Multipoint. |
| PTP | Point to Point. |
| **Q** | |
| QI | Quality index. |
| QOP | Quality of Performance. |
| QOS | Quality of Service. |
| **R** | |
| RTU | Remote Terminal Unit. |
| RAD Graphics | (Rapid Application Development)Graphics. |
| RAS | Remote Access Service. |
| RDBMS | Relational Database Management System. |
| REMS | Residential energy management systems. |
| RTP | Real Time Pricing. |
| **S** | |
| SCADA | Supervisory Control and Data Acquisition. |
| SH | Smart home. |
| SM | Smart meter. |
| STDM | Statistical time division multiplexer. |
| SQL | Structured Query Language. |
| SAIFI | System Average Interruption Frequency Index. |
| SAIDI | System Average Interruption Duration Index. |
| **T** | |
| TAP | Transmission Access Point. |
| TCP/IP | Transmission Control Protocol/Internet Protocol. |
| TDM | Time-division Multiplexing. |
| TFE | Transparent factory Ethernet. |
| TFTP | Trivial File Transfer Protocol. |
| TOS | Time of use. |
| **U** | |
| UDP | User datagram protocol. |
| UHF | Ultra-High Frequency. |
| USB | Universal serial bus. |