



Cairo University

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

**FACULTY OF ENGINEERING, 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.

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Dedication

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

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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.
FSKG	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.