



Ain Shams University
Faculty of Engineering
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Design of PV System for Cathodic Protection Systems

A Thesis

Submitted in Partial Fulfillment of the Requirements of the Degree of
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STATEMENT

This thesis is submitted to Ain Shams University for the degree of Master of Science in Electrical Engineering.

The work included in this thesis was carried out by the author at the Electronics and Communications Engineering Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

No part of this thesis has been submitted for a degree or a qualification at any other university or institution.

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ABSTRACT

The corrosion is an electrochemical reaction between metal and the surrounding environment, such as: soil and water.

The cathodic protection system prevents corrosion of a metal surface by making the structure as a cathode while a block of metal is used as sacrificing anode. A current is passed from the sacrificing anode to the cathode using external power supply.

There are two different types of cathodic protection systems; galvanic system, and impressed current cathodic protection (ICCP).

Galvanic system (sacrificial anode) protects structures from corrosion by passing current from the sacrificial anode to protect structures. The galvanic system depends on the natural potential difference between sacrificing anode (higher potential) and the cathode (lower potential). The anode in Galvanic system is corroded. The galvanic system stops corrosion by impressing DC current. Increasing in DC current causes rapid corrosion of sacrificial anode and over protection of metallic structure. The DC supply may be obtained from a conventional source using rectifiers. The other alternative is to obtain DC supply from the PV solar system. The second alternative is discussed in details in this study. Also the hybrid system of using PV and diesel generator is considered. The criterion in deciding the optimum solution is the cost of produced kWh of the system.

Keywords:

Cathodic Protection (CP), Photovoltaic (PV), Array Factor (FA). State of Charge (SOC), Diesel Generator (DG), Impressed Current Cathodic Protection (ICCP), Galvanic System (GS), Array Factor the Ratio between PV Array sizes with Average Daily Power required operating Load. Load Voltage Regulator (LVR), Battery Voltage Regulator (BVR). Short Circuit (SC), High Silicon Cast Iron (HSCI), high silicon Chromium- Bearing Cast Iron (HSCBCI).

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SUMMARY

This thesis discusses systems focus on using renewable-energy source as PV solar-energy source discusses the calculation the voltage and the load current in different case. The case 1: Pipelines Require CP on The Surface of soil, The case 2: Pipelines Require CP totally buried in the Soil, The case 3: Immersed Tank in Water.

In remote areas Solution: PV +batteries (stand alone), PV + Two Diesel generators, PV+ Small batteries + 1 Diesel Generator, PV +Small batteries + 2 Diesel generators Also, Systems are simulated by a MATLAB Simulation program is based on: Climatic condition of Cairo, Array tilt angle equal to the latitude angle (30), Constant load 24 hours and Three consecutive cloudy days. Economics is calculated for each system.

Chapter one:

This Chapter discusses short introduction about CP system, Earliest practical use of CP and types of CP systems, Advantage and disadvantage of the Galvanic Cathode Protection system and Impressed cathodic protection system and properties of Galvanic system and ICCP system.

Chapter two:

This Chapter discusses the simulation model for photovoltaic, solar energy source as renewable – energy powering load and advantages and disadvantages of Grid PV System.

Chapter three:

This Chapter discusses the calculation the voltage and the load current in different case.

The case 1: Pipelines Require CP on The Surface of soil.

The case 2: Pipelines Require CP totally buried in the Soil.

The case 3: Immersed Tank in Water.

Chapter four:

It discusses CP system modules for different Case overall the year and simulation MATLAB program design for each system. With the effects of climatic conditions, solar irradiance, temperature, cloudy days, tilt angles and the energy output of the PV array. PV module characteristic is included in the simulation program and discusses overview economics calculations in US dollar (\$) for each system model according to mobile operator's requirements and international market prices.

Chapter five:

This chapter contains brief conclusion & future work.

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LIST OF ABBREVIATIONS

Item	Abbreviation
AC	Alternated Current
ATS	Automatic transfer switch
AUG	The authentication center
BER	Bit error rate
BFU	Battery fuse unit
BSC	Base Station Controller
BTS	Base Transceiver Station
CDMA	Code Division Multiple Access
DC	Direct current
DG	Diesel generator
DOD_{max}	Depth of Discharge maximum
DOU	Digital operation unit
EDGE	EnhancedData GSM Environment
EIR	Equipment Identity Register
GPRS	General Packet Radio Services
GSM	Global system for mobile communication
HLR	Home Location Register
HSPA	High Speed Packet Access
Kbps	Kilo byte per second
LTE	Long Term Evolution
MSC	Mobile Switch Center
NOC	National Occupational Classification
PDU	Power digital unit
PSU	Power supply unit
PV	Photovoltaic
PWM	Pulse-width modulation
RBS	Ericsson's cabinet version
SCU	Switch control unit
SOC	State of charge for battery strings
SOC_n	Previous value of charge for battery strings
TN	Traffic Node
TRX	Traction Rubber X-treme
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
VLR	Visitor Location Register