

**EFFECT OF RESIDENTIAL SOLAR PV PENETRATION
ON DISTRIBUTION NETWORK PROTECTION
SCHEMES**

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DECLARATION OF THE CANDIDATE & SUPERVISOR

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Abstract

Electricity generation from solar PV has been increasing due to many reasons including heavy environmental considerations, reduction of burning fossil fuels, fast developments in the solar technology and the industry, consequent reduction in investment costs etc. Especially in Sri Lanka, the government took lot of steps to encourage the consumer end to install roof top Solar PV's. As an initiation Government revised the tariff system and provided considerable financial support for the consumers to encourage PV generation. Especially, in the urban areas the number of rooftop solar PV connected to the LV distribution system (0.4 kV) has increased. Due to this heavy solar PV penetration, fault current seen by the grid side has been changing. Hence, it is required to analyze the changes in fault current levels and consequent impact on the protection coordination in the medium voltage (MV) distribution system.

The main objective of this research is to assess the impact of increasing solar PV penetration levels on the MV level protection coordination and to propose a methodology for revising the protection settings for proper relay coordination with the increasing solar PV levels.

For the analysis a MV feeder having high penetration of solar PV has been selected and simulated. Modelling of the low voltage (LV, 0.4 kV) distribution system with widely dispersed solar PV integration has been a key challenge in this research. As the protection coordination has been evaluated at the MV side, the total LV distribution system has been simulated as an equivalent system and the solar PV has been modelled as an equivalent voltage source inverter. The equivalent solar PV model has been validated using already verified built-in solar PV model in PSCAD/EMTDC version 4.5.

Initially, performance of the MV level protection coordination has been analyzed in the selected feeder without solar PV being integrated. Then, the performance of the protection system has been analyzed based on the present PV penetration levels and fault current variation for different fault locations considering all probable fault types. Analysis indicated that, with the present PV penetration levels, existing protection settings can still be used, as they effectively maintain the required protection coordination.

After analysing the system behaviour with increasing solar penetration levels, a generalized method has been proposed to evaluate the MV level protection system performance. If the any system relay parameters fail to perform the expected outcome, a technique has been proposed to identify a criterion to review the relay settings.

KEYWORDS: Equivalent system, Medium Voltage level (MV), PV-photovoltaic, Relay parameters.

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Table of Contents

Abstract	iv
Acknowledgement	v
List of Figures.....	ix
List of Tables.....	xiii
List of Abbreviations	xv
CHAPTER 1.....	1
1. INTRODUCTION	1
1.1. Importance of the Research.....	2
1.2. Main Objective of Research.....	3
1.3. Research Methodology	3
1.4. With Distributed Generation Probable Protection Issues	4
1.5. Over view of Thesis.....	6
CHAPTER 2.....	8
2. PROJECT OVERVIEW	8
2.1. Grid Connected PV inverters	8
2.1.1. Main components of the detailed model.....	8
2.2. Protection System Setting Philosophy.....	10
2.3. Protection Schemes used at MV level	11
2.4. Grading of Over current and Earth Fault Relays.....	12
2.4.1. Discrimination by Time	12
2.4.1. Discrimination by current	12
2.4.2. Discrimination Using both Current and Time.....	13
2.5. Statement of Problem.....	14

2.6.	Objectives of the Study.....	15
CHAPTER 3.....		16
3.	METHODOLOGY AND SYSTEM MODELING	16
3.1.	Component Modelling for the Simulation	17
3.1.1.	Average Solar PV Modelling	17
3.2.	The selected case studies for simulation and the system modelling using PSCAD.....	39
3.2.1	33kV Grid (Upper Network Equivalent)	40
3.2.2.	33kV distribution System Modelling.....	41
3.2.3.	Modelling Cu 240mm ² Cable with length of 2.4 km.....	42
3.2.4.	33/11kV Transformers.....	47
3.2.5.	33/11kV 11kV Network Equivalent Network.....	48
3.2.6.	11/0.4kV Transformers Represent as Equivalent Lumped transformer.	50
3.2.7.	11/0.4kV 33kV and 11kV levels Existing Relays and Protection Schemes	51
3.2.8.	Evaluate the Existing System Coordination for different Fault locations when solar PV Penetration neglected.	54
CHAPTER 4.....		59
4.	RESULTS	59
4.1.	Analysis of the Protection system performance Expect Theoretically.....	59
4.2.	Summary of table include Protection system performance as per simulation.	61
4.3.	With Solar PV penetration System modelling and Verify the Existing Protection system Performance	69
4.4.	Protection System performance verify for the 80% of PV penetration level.	81

4.5. Fault current contribution by solar PV and Grid with higher PV Penetration Level.	82
4.1. With high Resistive Faults, Fault current contribution and Relay discrimination time	91
4.2. Research Out come- Study Methodology of the impact from PV for any distribution feeder.....	92
CHAPTER 5.....	98
5. Conclusions.....	98
References	102

List of Figures

Figure 1-1: Solar PV Global Capacity Increase	2
Figure 2-1: Schematic of the Detailed Solar PV Model on PSCAD/EMTDC platform	9
Figure 2-2: IDMT Relay Characteristic for Over Current and Earth fault Protection	13
Figure 2-3: Definite Time Relay Characteristic	14
Figure 3-1: Overall Schematic Diagram for Simulation.....	16
Figure 3-2: PSCAD Model to obtain Measured Active and Reactive Power in PU Base.....	17
Figure 3-3: Obtain I _{base} value in simulation	18
Figure 3-4: Deriving Direct and Quadrature Axis Current Components for CSI	18
Figure 3-5: Deriving Phase current Components for the CSI	19
Figure 3-6: Deriving Phase Locked Loop Angle	19
Figure 3-8: Maintain Constant voltage for stabilizing the CSI output	20
Figure 3-7: Parameter Setting For PLL Block	19
Figure 3-10: Representation of PV source injects I _s current and P (Active Power) and Q (Reactive Power).....	21
Figure 3-9: Simulated System to model single PV equivalent as CSI.....	20
Figure 3-11: Deriving Measured PV Active and Reactive Power Reading Pu Values	24
Figure 3-12: Deriving VSI Voltage Waveform Angle and Magnitude	25
Figure 3-13: Driving Voltage Source Inverter Phase voltage values	25
Figure 3-14: Modeling Voltage Source Inverter using Direct and Quadratic Voltage values.	26
Figure 3-15: Deriving Phase Voltages Using Direct and Quadratic Voltage Values.	26
Figure 3-16: Solar VSI power, voltage current output waveforms at Steady State when the reference set point at 0.1 pu	28
Figure 3-17: Solar VSI power, voltage current output waveforms at Steady State when the reference set point at 0.5pu	29

Figure 3-18: Solar VSI power, voltage current output waveforms at Steady State when the reference set point at 1 pu	30
Figure 3-19: Output Active Power Variation of the Detailed Solar PV Model at 0.25reference Point.....	31
Figure 3-20: Output Active Power Variation of the Average model at 0.25pu reference point.....	31
Figure 3-21: Output Current Variation of the Detailed Solar PV Model at 0.25pu reference.....	32
Figure 3-22: Output Current Variation of the Average model at 0.25pu P_reference point	32
Figure 3-23: Output Voltage Variation of the Detailed Solar PV Model at 0.25pu P_reference point.....	33
Figure 3-24: Output Voltage Variation of the Average model at 0.25pu P_reference point	33
Figure 3-25: Output Reactive Power Variation of the Detailed Solar PV Model at 0.25pu P_reference point	34
Figure 3-26: Output Reactive Power Variation of the Average model at 0.25pu P_reference point.....	34
Figure 3-27: Output Active Power Variation for LG faults, of the Detailed Solar PV Model at 0.25pu Reference	35
Figure 3-28: Output Active Power Variation for LG faults, of the Average Solar PV Model at 0.25pu Reference	Error! Bookmark not defined.
Figure 3-29: Output Current Power Variation for LG faults, of the Detailed Solar PV Model at 0.25pu Reference	36
Figure 3-30: Output Current Power Variation for LG faults, of the, Average model at 0.25pu Reference	36
Figure 3-31: Output Active Power Variation for LLL faults, of the Detailed Solar PV Model at 0.25 Reference	37
Figure 3-32: Output Active Power Variation for LLL faults, of the Average Solar PV Model at 0.25 Reference	37
Figure 3-33: Output Current Variation for LLL faults, of the Detailed Solar PV Model at 0.25 Reference	38

Figure 3-34: Output Current Variation for LLL faults, of the Average model at 0.25 Reference.....	38
Figure 3-35: Overall Schematic with 11kV distribution Feeders.....	40
Figure 3-36:33kV Feeder as Source with finite Impedance.....	41
Figure 3-37: Cable Model and Cable Interfacing in PSCSD software.....	42
Figure 3-38: Underground cable Configuration.....	44
Figure 3-39: Physical Cross section of the simulated tower in Distribution Corridor	46
Figure 3-40:11/33kV Transformer Name Plate Data and Parameters for Simulation	47
Figure 3-41: Part of the Map of 11kV Network Used for Simulation.....	48
Figure 3-42: Table Used to obtain the equivalent impedance of the MV feeder	49
Figure 3-43: Existing Over Current Scheme-Relay Setting Parameters.....	51
Figure 3-44: Existing Over Current Characteristic.....	52
Figure 3-45: Existing Earth Fault Current Scheme-Relay Setting Parameters	53
Figure 3-46: Existing Earth Fault Current Characteristic	53
Figure 3-47: Schematic of the Selected Configuration Indicated with Fault Locations	54
Figure 3-48: Over Current Relay Parameters to simulate in PSCAD	55
Figure 3-49: Earth Fault Relay Parameters to simulate in PSCAD.....	56
Figure 3-50: Obtaining Harmonic Filtered Phase values similarly as in advanced Numerical Relays.....	57
Figure 3-51: SR Latch for Stabilizing the Breaker.....	58
Figure 4-1: Fault Locations in the general schematic of the Model with solar PV	59
Figure 4-2: Schematic of the Ladder Network.....	67
Figure 4-3: Schematic of the Simplified Ladder Network.....	67
Figure 4-4: Sequence Component Diagram for Unbalanced Fault Analysis.....	69
Figure 4-5: Summery of Existing System Performance for LG Faults at different locations	80
Figure 4-6: Summery of Existing System Performance for Non Earthed Faults at different locations	81
Figure 4-7: Summery of Existing System Performance for LG Faults at different locations with Solar PV penetration increased up to 80%.....	89

Figure 4-8: Summary of Existing System Performance for non Earthed Faults at different locations with Solar PV penetration increased up to 80%.....	90
Figure 5-0-1: Protection Philosophy for 33kV Feeder protection Setting Parameter Determination.....	94
Figure 5-0-2: Protection Philosophy for 11/33kV Transformer HV side protection Setting Parameter Determination.....	94
Figure 5-0-3: Protection Philosophy for 11/33kV Transformer LV side protection Setting Parameter Determination.....	95
Figure 5-0-4: Protection Philosophy for 11kV Feeder protection Setting Parameter Determination.....	95

List of Tables

Table 3–1: Comparison of Fault current contribution of Each Model	27
Table 3–2: 33kV Cable Parameters for Modeling	42
Table 3–3: Coaxial Cable Data for Simulation	43
Table 3–4: Cable Interfacing Configuration	44
Table 3–5: Parameters for Simulating Transmission Line	45
Table 3–6: Parameters to simulate Tower Configuration	45
Table 3–7: Ground Wire Configuration Data	46
Table 3–8: Equivalent 11kV feeder Impedance Table	49
Table 3–9: Equivalent Solar PV and Customer Loading for Existing System simulation	55
Table 4–1: The Protection Scheme Performance for LG faults at different fault Locations	61
Table 4–2: Protection Scheme Performance for LLG faults at different fault Locations	62
Table 4–3: Protection Scheme Performance for LL faults at different fault Locations	64
Table 4–4: Protection Scheme Performance for LLL faults at different fault Locations	65
Table 4–5: Arc Resistance Variation Based on the parameters as per Warrington formula	66
Table 4–6: Tripping Time Variation Based on the Fault Loop Impedance variation at different fault Locations	68
Table 4–7: Fault Current Contribution from the grid side and PV side and Relay Trip Times for 33kV Cable Start	73
Table 4–8: Fault Current Contribution from the grid side and PV side and Relay Trip Times for 33kV Cable End	74
Table 4–9: Fault Current Contribution from the grid side and PV side and Relay Trip Times for 11/33kV Transformer Internal Fault	75

Table 4–10: Fault Current Contribution from the grid side and PV side and Relay Trip Times for Outside Transformer at LV side	77
Table 4–11: Fault Current Contribution from the grid side and PV side and Relay Trip Times for 11kV Starting Point	78
Table 4–12: Fault Current Contribution from the grid side, PV side and Relay Trip Times for 11kV Feeder end	79
Table 4–13: The System Equivalent Loading and PV connected when PV penetration increased.	82
Table 4–14: Fault Current Contribution from the grid side and PV side and Relay Trip Times for 33kV Feeder Starting Point	82
Table 4–15: Fault Current Contribution from the grid side and PV side and Relay Trip Times for 33kV End Point	84
Table 4–16: Fault Current Contribution from the grid side and PV side and Relay Trip Times for 11/33kV Transformer Internal Fault	85
Table 4–17: Fault Current Contribution from the grid side and PV side and Relay Trip Times for outside 11/33kV Transformer LV side Fault	86
Table 4–18: Fault Current Contribution from the grid side and PV side and Relay Trip Times for outside 11kV Feeder Starting Point	88

List of Abbreviations

Abbreviation	Description
PV	Photovoltaic
MV	Medium Voltage
IEC	International Electro technical Commission
IEEE	Institute of Electrical and Electronic Engineers
kWh	Kilo Watt Hour
LECO	Lanka Electricity Company (pvt) Ltd
VSI	Voltage Source Inverter
CSI	Current Source Inverter
FL	Fault Level
OC	over Current
EF	Earth Fault
BCU	Trip Circuit Supervision
WECC	Eastern Electricity Coordination Council