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A NEW ISLANDING DETECTION SCHEME FOR GRID INTERFACED DISTRIBUTED GENERATION SYSTEM

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***Abstract*:**. Distributed generation (DG) is one of the most promising alternatives for generation of electric power in today's time. The need for DG is enhanced world-wide due to the restructuring of the electric power industry and the increase of electric power demand. Connecting DG to distribution network produces some problems, such as islanding. Islanding occurs when a DG and its local load become electrically isolated from the utility; meanwhile, the DG produces electrical energy and supplies the local load. Islanding creates many problems in power system, and the existing standards thus do not permit DGs to be utilized in islanding mode.

The work proposed in this dissertation involves simulation of distribution system with DG using simulation software. creation of islanding cases capturing of voltages and current data which further processed using wavelet transform for feature extraction. Machine learning classification model is created based on dataset generated. This classification model is used to detect islanding condition. System is tested on different Islanding & Non- Islanding Cases. Post analysis, experimental result shows that proposed system outperforms existing islanding detection techniques.

***Index Terms* – Machine Learning, KNN, SVM, MATLAB simulation ,Islanding etc**

I. Introduction

To meet the energy consumption demand of the world, all are looking towards the renewable DG. The research on the growth of DG systems and their utilization is increasing around the world because of their advantages and low pollution compared to the burning of fossil fuels. In the conventional power system, the power is received by the consumers, but in the DG connected smart grid, consumers can also produce the power. The small scale power generation systems such as photo voltaic, mini hydro, tidal, biomass connected to the grid at the consumer level are called DG.Islanding is the situation in which a distribution system becomes electrically isolated from the remainder of the power system, yet continues to be energized by DG connected to it. Islanding can either be intentional or unintentional. Intentional islanding is a purposeful isolation of a proportion of the grid during fault or disturbance in which can be designed to assist continuity supplying electrical energy to the load demand. In contrast, unintentional islanding is an uncontrollable operation which brings serious danger to the utility workers as well as the DG units in the island. The concern is mainly in regards to the fluctuation and variation of the voltage and frequency. Stability interference of the systems might cause complication for proper automatic grid reconnection and restoration [2]. Islanding causes the following adversities in a power system.

II. Problem Statements

Unintentional islanding in power systems is a serious concern since the introduction of micro grid. These interconnected networks, along with inverter-and non-inverter-based DG systems, multiple load, profile profiles, and a complex control mechanism possess a potential threat to their liability of power system networks. The history of mega blackouts and power system failures confirms the fact that the loss of utility has caused huge protection and economic crashes. Among these failures and losses, one of the main concerns is the formation of power system islanding. Many IdMs are available that utilize advanced mathematical and signal processing techniques as efficient capacity-building tools. However, there are still certain challenge in the field of islanding detection that need to be investigated, such as the performance of IdMs for simultaneous events ,i.e., fault followed by islanding for various DG systems, or the interaction among various DG systems equipped with anti-islanding protection when islanding occurs DG integration is becoming prevalent worldwide due to the increasing needs of power and energy, avoiding long transmission networks, or implementing resilient energy transitions.However, many challenges in the form of operation, protection, and control from mega to micro level energy transition are running behind. A power system island, if unintentionally formed, creates trouble and severe damage to the utilizing equipment as well system operators. In the current scenario, the main concern of utility operators is to provide efficient and economic anti-islanding protection solutions for integrated AC and DC micro grid networks. In addition, the researchers or analysts use various efficient models and management techniques to ensure well-secured and fast islanding detection operations for such networks.

III. Block Diagram of Proposed Methodology

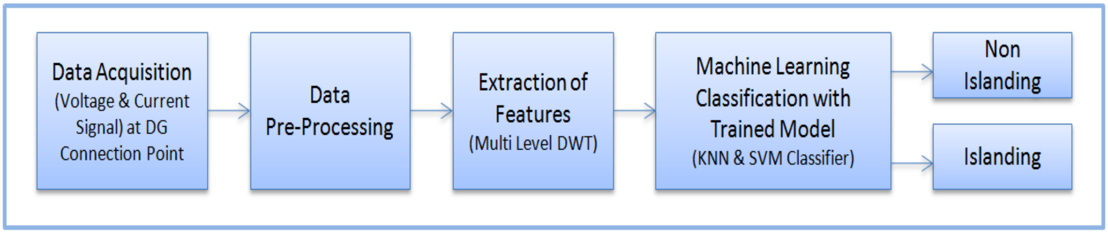


Figure 1:- Block Diagram

IV. Simulation Model

In order to investigate the performance of the different Techniques during various contingencies a simulation model was implemented. It is important that the model reflects a real system in all vital parts. The behavior of the simulated system must be similar to what happens in a real situation. How this has been achieved is described in the following.

In this thesis the emphasis has been put on wind power turbines and induction generators. The reason for this is the ongoing extension of wind power..This model is a set having two 9 MW wind farm each consisting of six 1.5 MW wind turbines connected to a 25 kV distribution system exports power to a 120 kV grid through a 30 km, 25 kV feeder[13].Wind turbines using a doubly-fed induction generator (DFIG) consist of a wound rotor induction generator and an AC/DC/AC IGBT-based PWM converter. The stator winding is connected directly to the 50 Hz grid while the rotor is fed at variable frequency through the AC/DC/AC converter. The DFIG technology allows extracting maximum energy from the wind for low wind speeds by optimizing the turbine speed, while minimizing mechanical stresses on the turbine during gusts of wind. The wind speed is maintained constant at 15 m/s. The control system uses a torque controller in order to maintain the speed at 1.2 pu. The reactive power produced by the wind turbine is regulated at 0 Mvar. As per the reference paper [13] we have designed the simulink model. Various test cases are created and using that dataset is created, that is further used for training. Also, Machine learning classifiers like KNN and SVM are tested on this simulink model only.

Specification

- Generator: rated short-circuit MVA=1000, f=50 Hz, rated kV =120, V_{base} = 120 kV.
- Grounding transformer: rated MVA=100, nominal voltage=25kV, f=50Hz, R0=0.025pu, X0=0.75pu, Rm=500pu, Xm=500pu.
- Distributed Generations (DGs): Wind farm (9 MW) consisting of six 1.5-MW wind turbines (Doubly Fed Induction Generator) of 50 Hz is connected to a 25-kV distribution system exports power to a 120-kV grid through a 30-km 25-kV feeder.
- Transformer T1: rated MVA = 10, f = 50 Hz, rated kV = 120/25, V_{base} = 25 kV, R1=0.00375pu, L1=0.1pu, R2=0.00375pu, L2=0.1pu, R_m= 500 pu, L_m= 500pu.
- Transformer T2, T3: rated MVA = 10, f = 50 Hz, rated kV = 25/575, V_{base} = 575kV, R1=0.00375pu, L1=0.1pu, R2=0.00375pu, L2=0.1pu, R_m= 500 pu, L_m= 500pu.
- Distribution lines (DL): PI-Section, 30 km each, V_{base} = 25 kV, R_1 = 0.1153 ohms/km, R_0 = 0.413 ohms/km, L_1 = 1.05e-3 H/km, L_0 = 3.32e-3 H/km, C_1 = 11.33e-009 F/km, C_0 = 5.01e-009 F/km. Normal loading data: L1=L2=12MW, C1= C2=12MW,0.9MVAR .
- **Statistical Parameter:**

1. Mean

For a random variable vector *A* made up of *N* scalar observations, the mean is defined as,

$$\mu = \frac{1}{N}\sum_{i=1}^{N} A_i.$$

2. Standard deviation

For a random variable vector *A* made up of *N* scalar observations, the standard deviation is defined as,

$$S = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N} \left|A_i - \mu\right|^2},$$

Where $\boldsymbol{\mu}$ is the mean of A:

$$\mu = \frac{1}{N}\sum_{i=1}^{N} A_i.$$

3. Entropy

E = entropy(I) returns E, a scalar value representing the entropy of grayscale image I. Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image. Entropy is defined as

-sum(p.*log2(p))

Where, p contains the histogram counts returned from imhist. By default, entropy uses two bins for logical arrays and 256 bins for uint8, uint16, or double arrays. I can be a multidimensional image. If I has more than two dimensions, the entropy function treats it as a multidimensional grayscale image and not as an RGB image.

4. Root mean square

The root mean square level of a vector X is

$$X_{\mathrm{RMS}} = \sqrt{\frac{1}{N}\sum_{n=1}^{N} |X_n|^2},$$

With the summation performed along the specified dimension.

5. Variance

For a random variable vector *A* made up of *N* scalar observations, the standard deviation is defined as,

$$V = \frac{1}{N-1}\sum_{i=1}^{N} |A_i - \mu|^2$$

Where μ is the mean of A:

$$\mu = \frac{1}{N}\sum_{i=1}^{N} A_i.$$

Some definition of variance use a normalization factor of N instead of N-1 which can be specified by setting w to 1. In either case, the mean is assumed to have the usual normalization factor N[27].

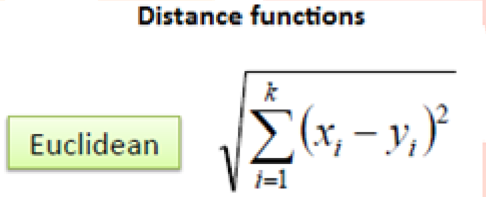
V. Machine Learning

Machine learning is a subset of artificial intelligence in the field of computer science that often uses statistical techniques to give computers the ability to "learn" (i.e., progressively improve performance on a specific task) with data, without being explicitly programmed [26].Machine learning tasks are typically classified into two broad categories, depending on whether there is a learning "signal" or "feedback" available to a learning system.

A. KNN Algorithm

B. SVM Algorithm

C. A case is classified by a majority vote of its neighbors, with the case being assigned to the class most common amongst its K nearest neighbors measured by a distance function. If K = 1, then the case is simply assigned to the class of its nearest neighbor.



D.

E. Choosing the optimal value for K is best done by first inspecting the data. In general, a large K value is more precise as it reduces the overall noise but there is no guarantee. Cross-validation is another way to retrospectively determine a good K value by using an independent dataset to validate the K value.

- **Support Vector Machine Algorithm**

Support Vector Machine or SVM is one of the most popular Supervised Learning algorithms, which is used for Classification as well as Regression problems. However, primarily, it is used for Classification problems in Machine Learning. The goal of the SVM algorithm is to create the best line or decision boundary that can segregate n-dimensional space into classes so that we can easily put the new data point in the correct category in the future. This best decision boundary is called a hyper plane.SVM chooses the extreme points/vectors that help in creating the hyper plane. These extreme cases are called as support vectors, and hence algorithm is termed as Support Vector Machine. Consider the below diagram in which there are two different categories that are classified using a decision boundary or hyper plane

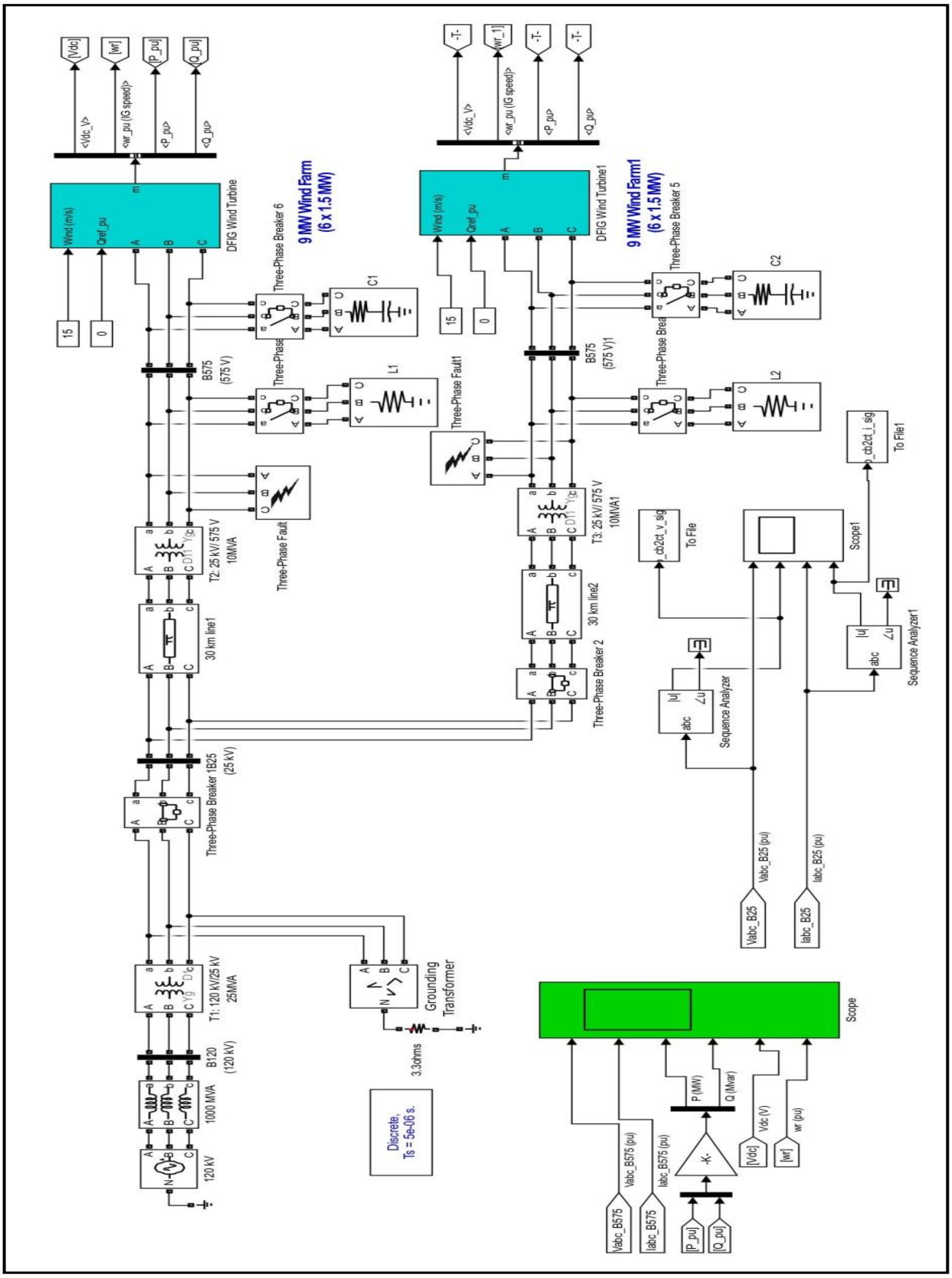


Figure 2:- Simulink Model

VI. RESULT AND DISCUSSION

In order to carry out the evaluation of the islanding detection algorithms we have used intel i3 processor with 4GB RAM on 64 bit windows 7 ultimate OS. For the implementation we have used MATLAB R2016A version

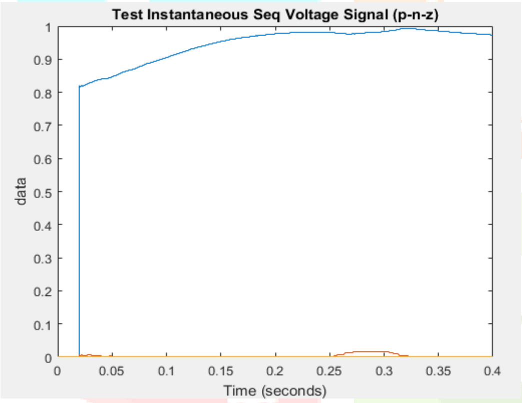
- **Case Studies for Testing**

Table 1:- Testing cases

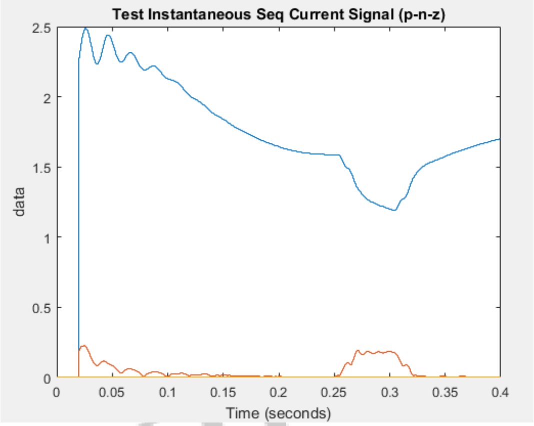
Sr. No.	Cases	Description
1	Non-islanding	A-G Fault
2	Non-islanding	A-B-C Fault
3	Islanding	Trip switching at no load
4	Islanding	Grid disconnected
5	Non-islanding	Load switching (C1,C2,L1,L2)
6	Islanding	Grid disconnected with load L1,L2
7	Non-islanding	A-G fault with load C1,C2,L1,L2
8	Islanding	Trip switching with load L1 L2
9	Islanding	Trip switching with load L1 L2 C1 C2
10	Non-islanding	A-B-C Fault with load L1 & L2
11	Non-islanding	A-B fault
12	Non-islanding	B-C fault with load L1 L2
13	Non-islanding	A-B-G fault
14	Non-islanding	A-C-G fault with load L1 L2
15	Non-islanding	A-B-C-G fault
16	Non-islanding	A-B-C-G fault with load L1 L2
17	Non-islanding	B-C fault
18	Non-islanding	A-C fault
19	Non-islanding	B-C-G fault
20	Islanding	Power cut
21	Non-Islanding	Load Switching L1 L2

Case 1: Non-islanding

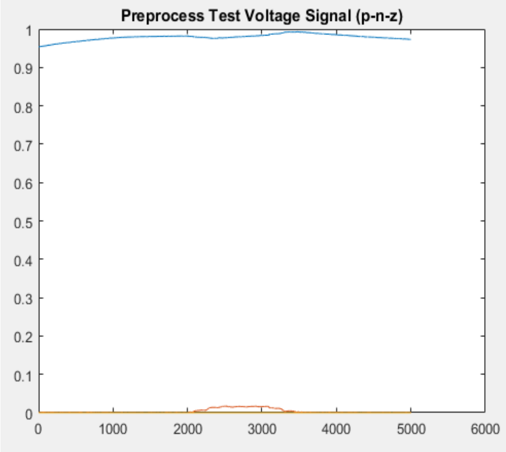
A-G fault: Fault resistance=0.01, cb1 close cb2 close apply fault from 0.25 to 0.3 with no load at line 1.



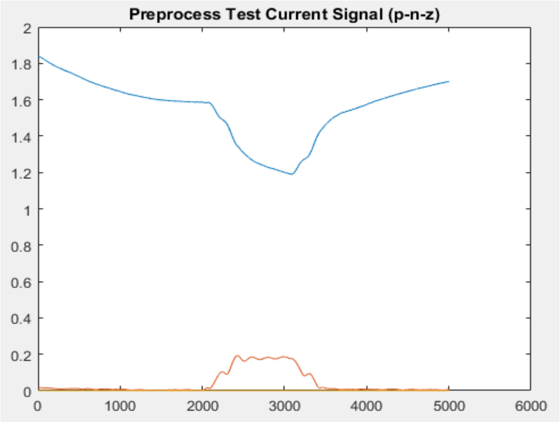
Snapshot 1:- A-G fault (TISVS)



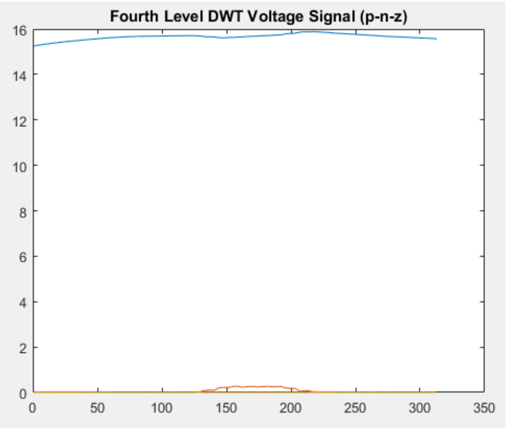
Snapshot .2:- A-G fault (TISCS)



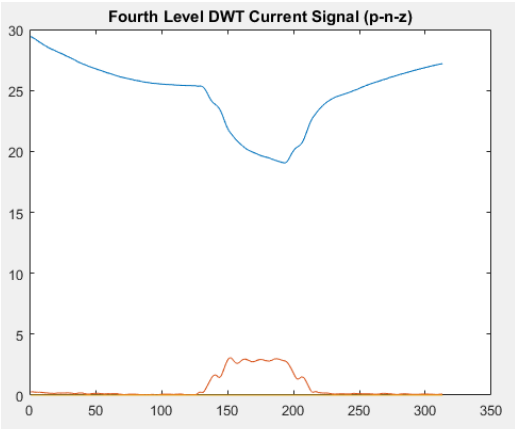
Snapshot 3:- A-G fault (PTVS



Snapshot 4:- A-G fault (PTCS)

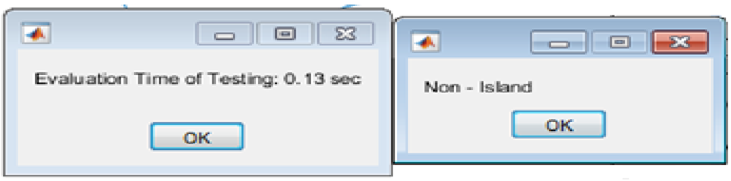


Snapshot 5:- A-G fault (FLDWTVS)



Snapshot 6:- A-G fault (FLDWTCS)

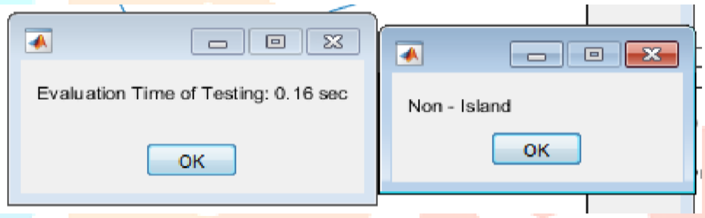
KNN


Evaluation Time of Testing: 0.13 sec

Non - Island

Snapshot 7:- A-G fault (Evaluation time for KNN)

SVM


Evaluation Time of Testing: 0.16 sec

Non - Island

Snapshot 8:- A-G fault (Evaluation time for SVM)

Table 2:- Actual and predicted output of testing cases

Sr. No.	**Scenario**	**Actual output**	**Predicted output**	
			KNN	**SVM**
1	A-G Fault	Non-islanding	Non-islanding	Non-islanding
2	A-B-C Fault	Non-islanding	Non-islanding	Non-islanding
3	Trip switching at no load	Islanding	Islanding	Islanding
4	Grid disconnected	Islanding	Islanding	Islanding
5	Load switching (C1,C2,L1,L2)	Non-islanding	Non-islanding	Non-islanding
6	Grid disconnected with load L1,L2	Islanding	Islanding	Islanding
7	A-G fault with load C1,C2,L1,L2	Non-islanding	Non-islanding	Non-islanding
8	Trip switching with load L1 L2	Islanding	Islanding	Islanding
9	Trip switching with load L1 L2 C1 C2	Islanding	Non-islanding	Islanding
10	A-B-C Fault with load L1 & L2	Non-islanding	Non-islanding	Non-islanding
11	A-B fault	Non-islanding	Non-islanding	Non-islanding
12	B-C fault with load L1 L2	Non-islanding	Non-islanding	Non-islanding
13	A-B-G fault	Non-islanding	Non-islanding	Non-islanding
14	A-C-G fault with load L1 L2	Non-islanding	Non-islanding	Non-islanding
15	A-B-C-G fault	Non-islanding	Non-islanding	Non-islanding
16	A-B-C-G fault with load L1 L2	Non-islanding	Non-islanding	Non-islanding
17	B-C fault	Non-islanding	Non-islanding	Non-islanding
18	A-C fault	Non-islanding	Non-islanding	Non-islanding
19	B-C-G fault	Non-islanding	Non-islanding	Non-islanding
20	Power cut	Islanding	Islanding	Islanding
21	Load Switching (L1 L2)	Non-islanding	Non-islanding	Non-islanding

- **Performance Evaluation for Testing**

Table 3:- Accuracy of KNN and SVM classifier

Classifier	**Events**	**Predicted Events**		**Accuracy**
		Islanding	Non-islanding	
KNN	Islanding	5	1	95.23%
	Non-islanding	0	15	
SVM	Islanding	6	0	100%
	Non-islanding	0	15	

Table 4 :- Training and testing time for KNN and SVM classifier

Sr. No.	**Method**	**Training Time**	**Testing Time**
1	KNN	0.72sec	0.12sec
2	SVM	1.16sec	0.15sec

- **Comparative Analysis**

Table 5:- Comparative analysis of different islanding detection techniques

Sr. No.	**Islanding Detection Techniques**	**Overall Accuracy (%)**
1	Proposed method (KNN and SVM)	KNN – 95.23
		SVM – 100
2	Intelligent based relay [15]	83.33
3	Data mining decision tree algorithm[29]	94.5
4	Over/under frequency[30]	90.24
5	ROCOF based technique[30]	93.81

VII. Conclusion

This dissertation has explored an approach to detect islanding using discrete wavelet transform & machine learning classification and the following conclusions have been reached.

- From the analysis, we can conclude that proposed methodology out performs existing methods.
- Out of implemented two classifiers SVM & KNN, experimental results shows that SVM Performs better than KNN Classifier.
- Training & Testing time for KNN classifier is less than SVM classifier.
- Proposed Method can be implemented in real time so as to improve the efficiency of islanding detection.
- The results indicate that proposed methodology is fast and accurate.

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