The Large Disturbance Recognition based on the Decision Tree of Disturbance Characteristic Value

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Abstract

Because of the development and improvement of PMU synchronous phasor measurement technology, the monitoring range of WAMS system also increased. The analysis ability of WAMS dispatch center station is constantly growing, and the real-time dynamically monitoring ability of power system is also enhancing continually. The disturbance recognition method based on each sequence voltage phasor proposed in this article is just one of the researches on the application function of WAMS center station. Through the simple data processing and a certain extraction method of characteristic value, we can get the disturbance characteristic values for determining the disturbance. But compared with the fault diagnosis, disturbance recognition needs to deal with the more complex disturbance, and the required application data are more specific, this article only makes a preliminary study, still needs to improve in the following two aspects.

Keywords

Large disturbance recognition, Smart grid, Disturbance Characteristic Value.

1. Introduction

When the large disturbance occurs in power system, voltage will change greatly, and even mutation. And the substantial change of voltage is the inevitable result of amplitude and phase Angle changed[1-3].The existing literature and research methods adopted only amplitude as the characteristic value to determine the type of disturbance, but the data provided by PMU is phasor, and phase angle also can be used as the characteristic value to reference and applied to large disturbance recognition, so we use PSASP software to verify the change of phase angle when disturbance occurs[4-7].

Using PSASP software to simulate respectively for the normal operation, short-circuit (including three phase short circuit, two phase grounding short circuit, two phase short circuit and single phase grounding short circuit), the cutting machine and cutting load this several conditions of the three machines nine nodes system, and comparing the voltage data obtained, to get the change of voltage amplitude and phase Angle after disturbance[8-12].

System diagram is as shown in figure 1, STNA, STNB and STNC bus with load, load model adopts the comprehensive load model, in which constant impedance model accounts for 50%, the constant power model accounts for 50%.

2. Attribute selection method of decision tree

Assume that there are a few of incompatible events, namely $a_1, a_2 ... a_n$, and the one also the only one between them occurs, then the average amount of information can be measured as shown in formula 1:

$$I(a_1, a_2, ... a_n) = \sum_{i=1}^{n} I(a_i) = \sum_{i=1}^{n} P(a_i) \log_2 \frac{1}{P(a_i)} \tag{1}$$

Assume that A is a variable set, which takes the different value $a_1, a_2 ... a_n$, so the amount of information can be measured based on the information entropy, define the information entropy of variable set A as

$$E(A) = \sum_{i=1}^{n} P(a_i) \log_b \frac{1}{P(a_i)} \tag{2}$$

In the formula, the logarithmic base number b can be any positive number, different b determines different information entropy, in most cases b=2; and stipulate when $P(a_i) = 0$, $P(a_i) \log_b \frac{1}{P(a_i)} = 0$.

When constructing a decision tree, if the set S is a training sample set, then the number of training sample set tuples is $|S|$; the sample is divided into n different classes, that is $C_1, C_2 ..... C_n$, the size of these classes can be respectively denoted by $|C_1|, |C_2|, ... |C_n|$, the probability of any sample S belonging to the class C_i is

$$P(S_i) = |C_i| / |S| \tag{3}$$

From above formulae we can derive the average information entropy of a known sample classification is:

$$E(S|C_1, C_2, ... C_n) = \sum_{i=1}^{n} \frac{|C_i|}{|S|} \log_2 \frac{|S|}{|C_i|} \tag{4}$$

If A is a random variable containing limited values, then define the information entropy of A is $P(S_i) = |C_i| / |S|$.

If random variable X and Y are not independent, and their values are limited, when given $Y = y_i$, we can define the conditional entropy of X as follow:

$$E(X|Y = y_i) = \sum_{i} P(x_i|y_i) \log_2 \frac{1}{P(x_i|y_i)} \tag{5}$$

Summation includes all values of X.

If random variable Y is given, then the average conditional entropy of the random variable X can be defined as:

$$\begin{aligned} E(X|Y) &= \sum_{j} P(y_j) E(X|Y = y_j) \\ &= \sum_{j} P(y_j) \sum_{i} P(x_i|y_i) \log_2 \frac{1}{P(x_i|y_i)} \end{aligned} \tag{6}$$

When constructing a decision tree, assuming that A is an attribute that contains m different and independent values $a_1, a_2 ... a_m$, according to these values divide the training sample set S into m subsets $\{S_1, S_2, ... S_m\}$, then the conditional entropy of decision tree classification determined by the attribute A is:

$$E(S|A) = \sum_{j=1}^{m} P(S_j) \sum_{i=1}^{n} P(C_i|S_i) \log_2 \frac{1}{P(C_i|S_j)} \tag{7}$$

In the formula above, $P(C_i|S_j)$ is the probability of subset S_j belonging to class C_i, assuming the number of the samples of class C_i in subset S_j is $|S_{ij}|$, then we can get $P(C_i|S_j) = |S_{ij}| / S$.

3. The disturbance recognition of oil field power grid

In order to verify the feasibility and effectiveness of the large disturbance recognition method proposed in this article in actual power grid, we apply the method in a variable region of oil field power grid[13-15].

In a certain oil field the substation and voltage level are complex, the certain oil field voltage has $110\,\text{kV}$, $66\,\text{kV}$ and $35\,\text{kV}$ several voltage levels[13]. Due to the huge scale and complexity of oil field power grid, before the simulation verification we should simplify the circuit of the variable region of a certain oil field power grid for point line, as shown in Figure 1.

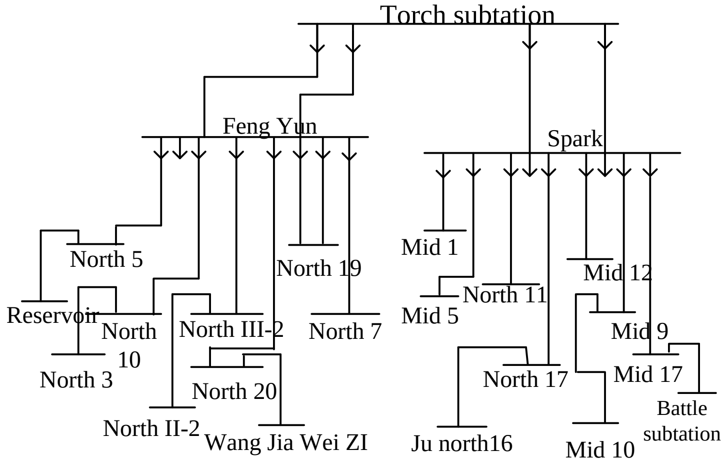

Figure.1 The circuit diagram of areas in certain oil field power grid

A torch substation via double circuit line supplies power for the Feng Yun substation and the Spark substation, under the Feng Yun substation there are following with North 5 substation, North 10 substation, North 19 substation, North III-2 substation, North 20 substation, North 7 substation, and under the Spark substation there are following with Mid 5 substation, North 11 substation, North 17 substation, Mid 13 substation, Mid 9 substation, Mid 1 substation, Mid 17 substation, North II-4 substation, in which the transmission line of supplication for North II-4 substation is standby line, each substation continues to follow with loads, generally used for other transformer substations standby power.

According to the changing trend of disturbance characteristics, in order to observe and compare more intuitionally, we change the trend of various electrical quantities into logical variable. When the electric quantity corresponding to the amplitude of positive sequence voltage increases, we set its corresponding logical variable as 1, set as -1 when the electric quantity decreases, when the change is not obvious we set logical variable as 0; Similarly, the setting of the logical variable corresponding to the phase angle of positive sequence voltage is like this. If the electrical quantities corresponding to the negative sequence voltage and zero sequence voltage exist, set the corresponding logical variable as 1, if not, set as 0.

Assume the variable quantity of the amplitude of positive sequence voltage is ΔU_1, the variable quantity of the phase angle of positive sequence voltage is $\Delta\theta_1$, the negative sequence voltage is U_2, the zero sequence voltage is U_0.

4. Conclusion

(1) Because the number of laying the PMU units in the grid is limited at present, and the PMU units are mostly laid in the 220kV bus and important lines, cannot cover the whole net, so we cannot get the status data of entire net, and part of the disturbance information cannot be uploaded to the dispatch center, then the recognition accuracy is influenced. Therefore, in the future we should study the optimal allocation of PMU in the angle of grid disturbance recognition, so as to realize the dynamic monitoring of the entire network.

(2) In this paper, we has studied several common power grid disturbances, due to the disturbance types that appeared in the actual operation of the power grid is more, and sometimes there are more than one place where large disturbance occurred, so how to identify and deal with this situation is still a problem to be studied.

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