Abstract - As the existing power systems is gradually moving from a traditional power transmission system to the more highly developed smart grid our objective in this research work is to make the power flow control more intelligent. In this paper an old problem of phase balancing for power flow control is considered and solved by network reconfiguration technique using the fuzzy logic. Network reconfiguration is required as a solution to the problems associated with power distribution system such as planning, power loss and power flow unbalancing. The proposed technique is implemented in IEEE 30 bus system to balance the power flow in under loaded or overloaded lines. The total load per phase of the lines is considered as input to the fuzzy system and load required to inter changing unbalanced lines is the output. The fuzzy logic system's suggested load values, both negative and positive, are to be considered as input to the load changing system. Load flow analysis, which can be used to compute the electric potential build and the difference in vector positions of the active values at each bus, as well as the consumption of energy expressed as curves in individual transmission circuit, is at the core of modern power systems. The objectives of this research can be used to define the system's most important lines, leading to better production scheduling and the reduction of the risk of voltage instability.

Keywords - Feeder load balancing; Fuzzy logic control; Network reconfiguration
there is a possibility for transmissibility of feeder connection. It can be transferred to less loaded feeders instead of connecting them to the heavily loaded. To minimize the unbalanced flowing feeder current, the connecting phases of some feeders are altered manually after thorough analysis of the situation in a simulated environment using a software. This study proposes the use of fuzzy logic based load changing system as problem solving technique to balance the feeder load. Fuzzy logic has risen in importance in this field because it is a realistic, effective, and adaptable technique. The concept of fuzzy sets provides a suitable method for converting design, operator’s knowledge into dynamic control systems that is simple to fix instantaneous applications. The fundamental contribution of this study is to identify the majority fault finding transmission line in IEEE 30 bus system, its breakdown potentially cause the system to fail completely. In this paper make comments how to get better grid's procedure by making ideas operating how to improve the process of such lines. After considering the load flow analysis results, those dangerous transmission lines will be identified. Although in some cases change the current phase imbalance, this method is more timely and fallacious. In this study Newton Raphson method is used in calculation of power flow in IEEE 30 bus system.

For feeder reconfiguration, Baean and Kelly utilized the state estimate methodology[1].Various research have been conducted on loss minimization of feeder distribution [3-4].With the advancements in the fields of artificially simulated intelligent systems and high voltage electronic equipments in power systems, it has become much easier than before to analyze the phase and load balance problem. Customers will benefit from advanced automation that is also cost-effective [4]. The estimated load current that the feeder can handle could be used as a reference. The IEEE 30 bus system has been the focus many studies on a variety of topics. We present a number of similar research in this part, all of which are appropriate to our work[5].The author [5] get a load flow analysis with the goal of determining the converge bus voltages used Newton-Raphson method, as well as comparing the two statistical methods in conditions of difficulty and meeting charge. M.Sugeno, Industrial applications of fuzzy control[8]. Performance curve of Newton-Raphson method in Load Flow Analysis using MATLAB, Nivedita Nayak and Dr. A.K. Wadhwani. Review of load-flow computation methods [10], by B. Stott.Ulas Eminoglu and M. Hakan Hocaoglu for radial distribution systems, a new power flow method with voltage dependent load models has been developed [15].

2. FEEDER DESCRIPTION

Distribution feeders usually are 3 phase 4-wire star connected system with an interconnected system. It is required to understand the conductors' current capabilities while avoiding any tapping. The connection between the distribution transformer and the distribution feeder has been rearranged properly to enable for a balanced state. There are four distribution feeder systems viz. radial, parallel feeders, ring main, and mash connected system. The mash connected system method is the simplest and most economical to work with, from the point of view of construction and security. For the difficulty in this paper, we take for granted IEEE-30 bus test system. IEEE-30 bus test systems are widely used by researchers to execute new thoughts and concept .The IEEE-30 bus test system is described in detailed technical note point. It has 30 buses, 41 transmission lines plus different transformers and synchronous condensers make the IEEE-30 bus test system. The system is demonstrated in Figure 2.1 below.
3. METHODOLOGY

The process of estimating the magnitude and phase angle of voltage at each bus in a power system under balanced 3-phase steady state conditions is known as the load flow problem. This method can be used to calculate actual and reactive power losses in the transmission system and transformers, along with equipment losses. For this research, we examined load flow analysis of the IEEE-30 bus test system utilizing the Newton Rephson Method. A load flow analysis was obtained for the proposed example, in which all of the systems transmission lines are operating. The measured load flow further disconnecting one transmission line instantaneously for a total of 41 times. The major goal of experimenting this was to calculate and identify the least performing flow values in the system in the event of a single transmission line failure. In other words, a study of the IEEE-30 bus test system susceptibility to a single transmission line failure. We may also simulate the effect of voltage collapse failure in an IEEE-30 bus test system by removing the lines that overload when a single line fails and repeating the cycle. After this, process utilizes fuzzy logic for load balancing. Load balancing (also known as phase balancing) is a useful tool for reducing
distribution feeder losses, boosting system safety. Load currents can be changed from highly loaded to less loaded feeders by changing the open/close configuration of the feeder switches. In this paper will see the use of fuzzy logic for the purpose of load balancing in this application study the link joining particular distribution transformer and the feeder must be properly organize to enhance the system phase voltage and current imbalances. As a result, phase balancing can include reconsidering the network layout in order to reduce total real power losses caused by line branches. Load flow equation is taken from [3]. The process of proposed intelligent system is shown in Fig. 3.1

![Flowchart for load balancing](image)

**Fig. 3.1 Flowchart for load balancing**

**Load flow equation by Newton Repson method**

\[
\Delta P_i = P_{op} - P_{(cal)} \quad i = 2, 3, \ldots, n
\]

(3.1)

\[
\begin{bmatrix}
H & N' \\
M & L'
\end{bmatrix}
\]

(3.2)

Obtain the value of \(\Delta \delta\) and \(\Delta \frac{V}{V}\) from equation shown below

\[
\begin{bmatrix}
\Delta P \\
\Delta Q
\end{bmatrix} = \begin{bmatrix}
H & N' \\
M & L'
\end{bmatrix} \begin{bmatrix}
\Delta \delta \\
\Delta V \\
\frac{V}{V}
\end{bmatrix}
\]

(3.3)
Using the value of $\Delta \delta$ and $\Delta V_i$ calculate in the above step, modify the voltage magnitude and phase angle at all load buses by the equation shown below

$$V_i^{(r+1)} = V_i^{(r)} + \Delta V_i^{(r)}$$

(3.4)

$$\delta_i^{(r+1)} = \delta_i^{(r)} + \Delta \delta_i^{(r)}$$

(3.5)

$$V_i^{(r+1)} = V_i^{(r)} + \Delta V_i^{(r)}$$

(3.6)

### 3.1 Input and Output OF Fuzzy Controller

In this paper, must first construct the input and output variables before designing the fuzzy logic controller. The output is Change, which indicates the positive or negative load change (kW) for each phase. Load is the input, which is the total phase load (kW) for each of the three phases. Table 3.1.1 displays the fuzzy categorization for the input variable, and Fig. 3.1.1 illustrates the fuzzy membership function for the input variable. Table 3.1.2 displays the fuzzy output classification, and Fig. 3.1.2 illustrates the corresponding triangular “fuzzy membership” functions for the output variable. Fuzzy nomenclature for the input and the output variables shown in Table 3.1.3. The non-aligned connection between the chosen output and input variables is visualized in Fig. 3.1.3.

**Table 3.1.1. Fuzzy nomenclature for the input variable**

<table>
<thead>
<tr>
<th>SL. No.</th>
<th>Input (Load) Description</th>
<th>Fuzzy Nomenclature</th>
<th>Percentage range of line MVA rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Very Less Loaded</td>
<td>VLL</td>
<td>45% - 50%</td>
</tr>
<tr>
<td>2</td>
<td>Less Loaded</td>
<td>LL</td>
<td>50% - 55%</td>
</tr>
<tr>
<td>3</td>
<td>Medium Less Loaded</td>
<td>MLL</td>
<td>55% - 60%</td>
</tr>
<tr>
<td>4</td>
<td>Perfectly Loaded</td>
<td>PL</td>
<td>60% - 70%</td>
</tr>
<tr>
<td>5</td>
<td>Slightly Overloaded</td>
<td>SOL</td>
<td>70% - 75%</td>
</tr>
<tr>
<td>6</td>
<td>Medium Overloaded</td>
<td>MOL</td>
<td>75% - 80%</td>
</tr>
<tr>
<td>7</td>
<td>Overloaded</td>
<td>OIL</td>
<td>80% - 85%</td>
</tr>
<tr>
<td>8</td>
<td>Heavily Overloaded</td>
<td>HIL</td>
<td>85% - 90%</td>
</tr>
</tbody>
</table>

**Table 3.1.2. Fuzzy nomenclature for the output variable**
Table 3.1.3: Fuzzy nomenclature for the input and the output variables

<table>
<thead>
<tr>
<th>SL. No.</th>
<th>Output (Change) Description</th>
<th>Fuzzy Nomenclature</th>
<th>Percentage range of line MVA rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>High Subtraction</td>
<td>HS</td>
<td>-25% to -20%</td>
</tr>
<tr>
<td>2</td>
<td>Subtraction</td>
<td>S</td>
<td>-20% to -15%</td>
</tr>
<tr>
<td>3</td>
<td>Medium Subtraction</td>
<td>MS</td>
<td>-15% to -10%</td>
</tr>
<tr>
<td>4</td>
<td>Slight Subtraction</td>
<td>SS</td>
<td>-10% to -5</td>
</tr>
<tr>
<td>5</td>
<td>Perfect Addition</td>
<td>PA</td>
<td>0 to 10%</td>
</tr>
<tr>
<td>6</td>
<td>Medium Addition</td>
<td>MA</td>
<td>+5% to +10%</td>
</tr>
<tr>
<td>7</td>
<td>Large Addition</td>
<td>LA</td>
<td>+10% to +15%</td>
</tr>
<tr>
<td>8</td>
<td>Very Large Addition</td>
<td>VLA</td>
<td>+15% to +20%</td>
</tr>
</tbody>
</table>
4. Application Result

In this section shows the application result outcomes using the fuzzy logic load balancing technique. For the simulation, Matlab fuzzy toolbox [6] is implemented. The Mamdani [7] fuzzy assumption technique is used. Then use of 32-MVA line as an example input load configuration for one phase. Using the fuzzy controller mentioned earlier, we attempt to balance it. The eight fuzzy rules were used to create a graphical representation of (output load change) for the 3 phases that correspond this input load are shown in Fig. 4.1. The Mamdani approach [7] is used in the defuzzification process. A change in phase line 42 whose MVA rating is 32 of the output load is determined.
According to the output of lines is mostly very low loaded, but some lines are highly overloaded and slightly overloaded, according to the fuzzy logic rule. In this research, using of fuzzy logic and a combinatorial optimization-based implementation technique, investigate the phase balancing problem in the field of power system. As a result, the approaches and application provided in this study are based on the following assumptions. In this paper line 41 whose MVA rating is 32 is perfectly loaded is resulted by fuzzy shown in table 4.2

<table>
<thead>
<tr>
<th>Line No.</th>
<th>MVA Rating</th>
<th>before fuzzy system</th>
<th>after fuzzy system</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>P flow (MW)</td>
<td>Q flow (MVAr)</td>
</tr>
<tr>
<td>1</td>
<td>130</td>
<td>147.00464</td>
<td>-14.779</td>
</tr>
<tr>
<td>2</td>
<td>130</td>
<td>64.15866</td>
<td>4.253</td>
</tr>
<tr>
<td>3</td>
<td>65</td>
<td>31.89110</td>
<td>2.606</td>
</tr>
<tr>
<td>4</td>
<td>130</td>
<td>60.08551</td>
<td>0.462</td>
</tr>
<tr>
<td>5</td>
<td>130</td>
<td>72.45313</td>
<td>2.642</td>
</tr>
<tr>
<td>6</td>
<td>65</td>
<td>46.24380</td>
<td>0.332</td>
</tr>
<tr>
<td>7</td>
<td>90</td>
<td>62.34209</td>
<td>-10.144</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>9</td>
<td>130</td>
<td>41.48121</td>
<td>-0.998</td>
</tr>
<tr>
<td>11</td>
<td>65</td>
<td>15.64737</td>
<td>-7.277</td>
</tr>
<tr>
<td>12</td>
<td>32</td>
<td>8.94964</td>
<td>0.407</td>
</tr>
<tr>
<td>14</td>
<td>65</td>
<td>15.64737</td>
<td>7.138</td>
</tr>
<tr>
<td>15</td>
<td>65</td>
<td>21.03856</td>
<td>13.629</td>
</tr>
<tr>
<td>17</td>
<td>32</td>
<td>5.54120</td>
<td>2.040</td>
</tr>
<tr>
<td>20</td>
<td>16</td>
<td>2.30320</td>
<td>0.361</td>
</tr>
<tr>
<td>21</td>
<td>16</td>
<td>5.74203</td>
<td>0.187</td>
</tr>
<tr>
<td>22</td>
<td>16</td>
<td>6.75696</td>
<td>1.381</td>
</tr>
<tr>
<td>23</td>
<td>16</td>
<td>3.51021</td>
<td>0.386</td>
</tr>
<tr>
<td>24</td>
<td>16</td>
<td>-1.99721</td>
<td>-3.029</td>
</tr>
<tr>
<td>26</td>
<td>32</td>
<td>0.29252</td>
<td>5.061</td>
</tr>
<tr>
<td>29</td>
<td>32</td>
<td>-1.87073</td>
<td>-1.622</td>
</tr>
<tr>
<td>31</td>
<td>16</td>
<td>2.8805</td>
<td>2.790</td>
</tr>
<tr>
<td>32</td>
<td>16</td>
<td>2.92005</td>
<td>0.651</td>
</tr>
<tr>
<td>33</td>
<td>16</td>
<td>0.88106</td>
<td>0.994</td>
</tr>
</tbody>
</table>
5. Conclusion

Phase balancing is a critical and realistic procedure for reducing distribution feeder losses and improving safety. In this research, we propose a load balancing system based on fuzzy logic, as well as load change implementation system based on optimization algorithms. Total (kw) load per phase of the feeders is supplied into the fuzzy stage. The load transform values are the fuzzy step's output, with a negative value designed for load leaving a 'positive value' for load, receiving. The entire load remains constant throughout phase balancing because the sum of the negative and positive numbers is zero. The input of the load-changing system will be read by the fuzzy line. The implementation system divides the alter (kw) values by the number of load points, then chooses the appropriate load locations using combinatorial optimization approaches. It also ensures that load points are properly interchanged between the releasing and receiving phase’s unbalanced 3-phase, 4-wire feeders are being used to test the load balancing system. A specific design example that uses Matlab for simulations illustrates the proposed system's application. Additional implementation results for different feeder loading configurations show that imbalance conditions have improved. The planned fuzzy logic phase balancing method and implementation systems are both practical and effective in minimizing feeder disturbance. The phase balancing technique and system described in this paper might be applied to different distribution system and feeders load configuration.

5. References


