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An Efficient Load Shedding Scheme from Customer's Perspective

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ABSTRACT:The safe operation of electrical power systems is an on-going problem. Despite the existing defence lines in the different electrical systems, they are not immune to widespread incidents leading to tripping of most customers. In the defence plans against these major incidents, selective load shedding, even optimized but brutal, is the last resort before total shutdown. This paper addresses a new power system control strategy from customer's perspective. Due to power deficit we've to shed some amount of loads eventually. Now the main challenge is to determine the minimum load amount for shedding so that we can maximize the electricity supply to customers. Using control algorithm we'll find out that minimum amount of load.

Keywords: Minimum Load, Control Algorithm, Power Deficit

I. INTRODUCTION

During power deficit, one of the main operator's tasks is to keep as many customers on-line as possible. The rise in need is very steep for the reasons of rise in electrical utility appliances which is now the order of the day. So the developing countries where there is free market cannot ration the usage of electrical appliances. This has steeply increased the necessity. The efficient load shedding means to improve power system stability, by providing a real time adapted load control and load shedding, in situations where the power system otherwise would go unstable. The main aspects are evaluating the right amount and location of power response for a given disturbance and evaluating the right time response expected in order to comply with the acceptable stability recover. Blocking can be viewed as if the power exchanges were not controlled. Some lines located on particular paths may become overload and this phenomenon is called blocking. Blocking management can be defined as the quick operations taken by the technical persons to relieve the problem. One such approach is efficient load shedding. If excessive load shedding in the system is done, there will be sudden change in the system voltage profile that causes transients in the system.

II. FUNDAMENTALS OF LOAD SHEDDING

The data's from the substation are taken and with these an idea for optimum load shedding is arrived using different standard algorithm. The below are the conventional load shedding methodologies followed by the utility providers.

1. Breaker Interlock Load Shedding

This is the simplest method of carrying out load shedding. For this scheme, the circuit breaker interdependencies are arranged to operate based on hard wired trip signals from an intertie circuit breaker or a generator trip. This method is often used when the speed of the load shedding is critical. Even though its execution is fast but it has few drawbacks.

2. Under Frequency relay Load Shedding

Guidelines for setting up a frequency load shedding are common to both large and small systems. Upon reaching the frequency set point and expiration of pre-specified time delay, the frequency relay trips one or more load breakers. This cycle is repeated until the system frequency is recovered. e.g., 10% load reduction for every 0.5% frequency reduction.

3. Programming based Load Shedding

With a programmable logic controller scheme, load shedding is initiated based on the total load versus the number of generators online or detection of under-frequency conditions. Each substation PLC is programmed to initiate a trip

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signal to the appropriate feeder breakers to shed a preset sequence of loads. This static sequence is continued until the frequency returns to a normal, stable level.

III. PROPOSED METHODOLOGY

Till now there is no standard load shedding methods implemented in Bangladeshi power grid operations. Decision for load shedding will be taken using conventional power flow calculations at centralized load centres and it will be communicated to local or sub load centres where it will be implemented. The load shedding scheme mainly has included the measurements of important parameters for estimating the magnitude of disturbance. The initial estimation of the disturbance is based on the rate of change of frequency. The location of load to be shed and the amount to be shed from each bus is calculated by the empirical formula. Here we'll use Fuzzy Logic as control algorithm to find out the minimum load amount to be shed.

IV. PROCEDURES FOR LOAD SHEDDING

- The data's which are responsible for system transients are collected firstly. For our consideration, the data's from Rampura substation is collected and used for load shedding.
- The ranges of voltage, frequency, power is taken here.
- After the data's are collected it is converted to per unit basis, if it not so.
- Create a table and enter the values of voltage, frequency, power.
- The value of reactive power is considered here.
- Now change in voltage and frequency with respect to time is calculated for calculation purpose.
- The amount of load shedding is calculated by using the formula,

S= ((dv/dq) / (∑ dv/dq)) pdiff.
Where,
S= load to be shed.
dv = change in voltage w.r.t time.
dq = change in power w.r.t time.
Pdiff= power difference.

To calculate the pdiff value, Pdiff= (2H/fo) (df/dt).
Where,
H= inertia constant (5sec).
fo= nominal frequency

- After calculation the amount of load to be shed is known. Now a new column in which load to be shed and in another the pdiff values are entered.
- From the table the minimum and maximum ranges of values of each variable is calculated to create the membership function.
- Now membership function is created for voltage, frequency, pdiff, reactive power by dividing the ranges into 3 categories, for simple calculation.
- Membership function for this consideration is LOW, MEDIUM, HIGH.
- Find the corresponding values in table.
- Create rules based on membership function. (if-then rule)
- Create a fuzzy linguistic control table.
- Apply the values in fuzzy MATLAB software and create the rules from the table.
- It must be noted that the rules which we create must radios must satisfy all the values within given range
- For our given value the amount of load shed is displayed
- Now if we compare the output with the conventional methods of load shedding it will be minimum only.

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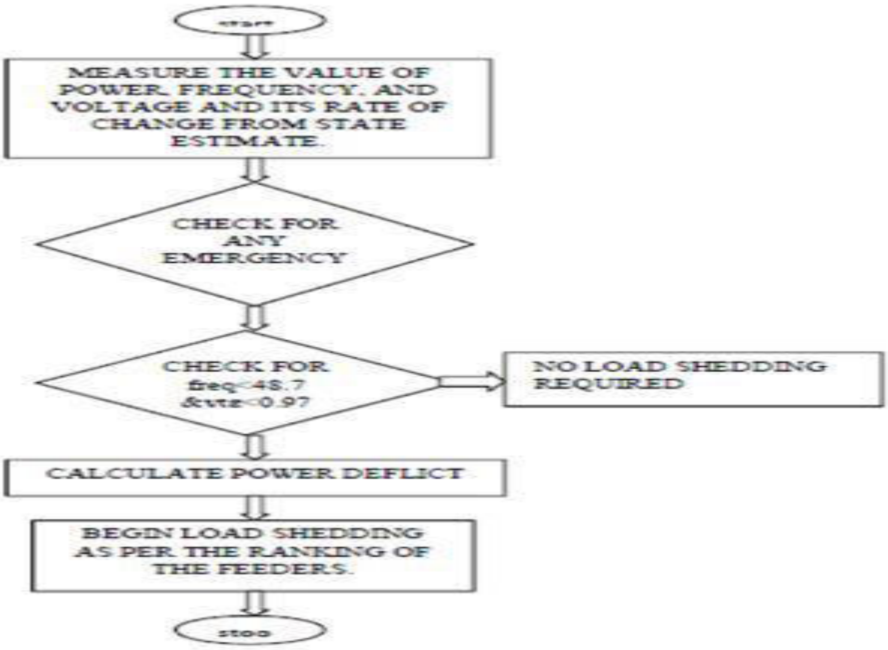
V. FLOW CHART FOR LOAD SHEDDING



VI. MEMBERSHIP FUNCTION CREATION

Let each variable and the load shedding amount, s, be distinguished by three linguistic terms: LOW (L), MEDIUM (M), HIGH (H). After analysis and from observation, the following linguistic rules describing the load-shedding amount at substation can be formed. The membership function is created by considering the min and max ranges of the variables and dividing each into 3 equal values and classifying each by the name low, medium, high as we mentioned earlier.

Table 1: Load's Data

S.No.	Voltage	Reactive power	Frequency
1	1.025	0.41	48.7
2	1.02	0.15	48.5
3	1.035	0.5	49.5
4	1.05	0.1	49.2
5	1.045	0.3	49.7
6	0.999	0.29	48.5
7	0.994	0	50
8	0.997	0	50
9	1.009	0.5	49.5
10	0.989	0	50
11	0.997	0.15	48.5
12	0.993	0.48	48.7
13	1.014	0.15	48.5
14	1	0.12	48.5

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15	0.991	0.31	48.6
16	0.983	0.27	48.5
17	0.987	0.38	48.7
18	1.007	0.67	48.7
19	1.004	0.15	48.5
20	0.98	0.27	48.7
21	0.977	0.23	48.7
22	0.978	0.22	48.7
23	0.976	0.12	49.3
24	0.968	0.27	48.7
25	0.974	0.13	49.4
26	1.015	0.2	49.8

Table 2: Rate of Change

S.No.	dv/dt	dq/dt	df/dt
1	0.025	0.59	1.3
2	0.02	0.85	1.5
3	0.035	0.5	0.5
4	0.05	0.9	0.8
5	0.045	0.7	0.3
6	0.001	0.71	1.5
7	0.006	1	0
8	0.003	1	0
9	0.009	0.5	0.5
10	0.011	1	0
11	0.003	0.85	1.5
12	0.007	0.52	1.3
13	0.014	0.85	1.5
14	0	0.88	1.5
15	0.009	0.69	1.4
16	0.017	0.73	1.5
17	0.013	0.62	1.3
18	0.007	0.33	1.3
19	0.004	0.85	1.5
20	0.02	0.73	1.3
21	0.023	0.77	1.3
22	0.022	0.78	1.3
23	0.024	0.88	0.7
24	0.032	0.73	1.3

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25	0.026	0.87	0.6
26	0.015	0.8	0.2
	∑dv/dt=0.441	∑dq/dt=19.63	

Table 3: Loads to be shed

S.No	Pdiff	Load to be shed
1	0.26	0.49
2	0.31	0.32
3	0.1	0.31
4	0.16	0.39
5	0.06	0.17
6	0.31	0.02
7	0	0
8	0	0
9	0.1	0.08
10	0	0
11	0.31	0.04
12	0.26	0.15
13	0.31	0.23
14	0.31	0
15	0.28	0.16
16	0.31	0.32
17	0.26	0.24
18	0.26	0.24
19	0.31	0.06
20	0.35	0.42
21	0.33	0.44
22	0.37	0.46

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23	0.35	0.42
24	0.35	0.68
25	0.33	0.44
26	0.04	0.03

The range of voltage value is selected and the membership function is created within that range by dividing the difference value of max and min value by 3. Now the value is added with the least (min) value to find the first membership function. With the first membership value the divided value is again added to form the second membership function and so on. Now the logic table considering range in the table for above data.

Fuzzy Logic Table				
Input1 Voltage	Input2 r.power	Input3 freq	Input4 pdiff	output load shed
medium(0.995-1.022)	medium(0.166-0.33)	high(49.56-50)	low(0-0.12)	low(0-0.68)
low(0.968-0.995)	medium(0.166-0.33)	high(49.56-50)	low(0-0.12)	low(0-0.68)
high(1.022-1.05)	high(0.33-0.5)	medium(49.13-49.56)	low(0-0.12)	medium(0.23-0.46)
high(1.022-1.05)	low(0-0.166)	medium(49.13-49.56)	medium(0.12-0.24)	medium(0.23-0.46)
low(0.968-0.995)	medium(0.166-0.33)	low(48.7-49.13)	high(0.24-0.37)	high(0.46-0.68)

Generation Data			
S.No	Voltage	r.power	frequency
1	1.025	2.24	48.7
2	1.02	1.25	48.5
3	1.035	0.63	49.3
4	1.05	0.49	49.5
5	1.045	1.24	48.5
6	1.015	0.33	49.7

Rate of Change		
S.No	dv/dt	dq/dt
1	0.025	1.24
2	0.02	0.25
3	0.035	0.37
4	0.05	0.51
5	0.045	0.24
6	0.015	0.33

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Loads to be shed		
S.No	Pdiff	Load to be shed
1	0.27	0.08
2	0.31	0.38
3	0.14	0.2
4	0.1	0.15
5	0.31	0.89
6	0.06	0.04

Logic table considering range in the table for above data.

Fuzzy Logic Table			
Input1 Voltage	Input2 freq	Input3 pdiff	output load shed
low(1.015-1.027)	low(48.5-48.9)	low(0.06-0.14)	low(0.04-0.32)
low(1.015-1.027)	low(48.5-48.9)	high(0.22-0.31)	medium(0.32-0.6)
medium(1.027-1.039)	medium(48.9-49.3)	medium(0.14-0.22)	low(0.04-0.32)
high(1.039-1.05)	high(49.3-49.7)	medium(0.14-0.22)	low(0.04-0.32)
high(1.039-1.05)	low(48.5-48.9)	high(0.22-0.31)	high(0.6-0.89)
low(1.015-1.027)	high(49.3-49.7)	low(0.06-0.14)	low(0.04-0.32)

Simulation Result

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Transformer Data	
Transformer Specification	Tap Setting Per Unit
2-3	0.96
2-13	0.96
3-13	1.017
4-8	1.05
4-12	1.05
6-19	0.95
7-9	0.95

VII. COMPARATIVE RESULT

S.No.	Voltage	Frequency	Load to be shed (Conventional)	Load to be shed(Fuzzy)
1	1.025	48.7	0.49	0.4
2	0.983	48.5	0.32	0.2
3	0.978	48.7	0.46	0.3
4	1.014	48.5	0.23	0.02
5	0.968	48.7	0.68	0.4

VIII. CONCLUSION

From the comparison it is clear that fuzzy scaling of critical parameters and writing the fuzzy linguistic rules properly, has clearly given food results. The amount of load to be shed is minimized. This method has been developed from the data's obtained from the substation and the discussions with the field engineers. It is a logical thought by some ways and means the load shedding has to be minimized. Even though load shedding is the last resort and practically followed method to relieve blocking, there is a constant urge both from field engineers and academic circle to analyze and find some ways to minimize the load shedding. In that regard this work can be respected. By building robust electronics in such a Way that the fuzzy outputs are tuned to an fuzzy controller which is again governed by another control device with feedback system and data acquisition system to monitor the bus parameters, when this forms a robust loop, this idea can be tested and if the results are satisfactory this can be implemented in distribution substations.

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