A Fuzzy Based Under-Frequency Load Shedding Scheme for Islanded Distribution Network Connected with DG

H. Mokhlis\textsuperscript{1, 2}, J. A. Laghari\textsuperscript{1, 3}, A. H. A. Bakar\textsuperscript{2}, M. Karimi\textsuperscript{1, 2}

Abstract – The frequency of power system is very sensitive to load changing when operating in islanded mode. This may cause overloading or loss of generation cases. Under-Frequency Load Shedding (UFLS) Scheme is commonly applied to stabilize the frequency during these cases. Conventional UFLS scheme operates successfully in interconnected grid system and may not work well when applied to DG based system operating in islanded mode. This paper presents a new fuzzy logic based under-frequency load shedding scheme implemented on mini hydro type-DG operating in islanded mode. The proposed strategy is based on frequency, rate of change of frequency and load prioritization. In proposed UFLS scheme, a fuzzy logic load shedding controller (FLLSC) with Load Shed Controller Module (LSCM) is modelled. FLLSC measures amount of load to be shed and LSCM shed the respective load to stabilize frequency. The proposed scheme is validated on different event-based and response-based cases. Simulation results show that proposed scheme is effective in shedding optimal number of loads while stabilizing the frequency. Copyright © 2012 Praise Worthy Prize S.r.l. - All rights reserved.

Keywords: Distributed Generation (DG), Fuzzy Logic Load Shedding Controller (FLLSC), Load Shed Controller Module (LSCM), Islanded Distribution Network

Nomenclature
\begin{itemize}
  \item $f_c$: Frequency of the center of inertia
  \item $\Delta f$: Frequency deviation
  \item $df/dt$: Rate of change of frequency
  \item $H$: Generator inertia constant
  \item $P$: Active power at new voltage/frequency
  \item $P_0$: Active power at base voltage/frequency
  \item $Q$: Reactive power at new voltage/frequency
  \item $Q_0$: Reactive power at base voltage/frequency
  \item $\Delta P$: Imbalance power
  \item DG: Distributed Generation
  \item FLLSC: Fuzzy logic load shedding controller
  \item RCB: Remote Circuit Breaker
  \item UFLS: Under-frequency load shedding
  \item LSCM: Load shedding controller module
\end{itemize}

I. Introduction

Distributed generation (DG) refers to small type of electric power generation having capacity less than 10 MW [1]. DG units are located near load centers in order to avoid expansion of the existing network and supply the new load areas.

Due to market deregulation and environmental constraints, the use of DG resources has been widely employed in power industry[2].

The increasing trend of DG penetration in power system network has opened the new challenging issues in the field of power system.

The use of DG has provided benefits to the end user, power utilities and DG’s owner in terms of reliability, efficiency of power and economics [3]-[5]. However, penetration of DG causes various problems to the existing network and power system need to be modified.

One of the constraints is operation of DG during islanded mode, in which DG is electrically isolated from the main grid [6], [7]. This causes overloading or loss of generation cases and requires load shedding technique to stabilize the frequency within acceptable range.

The conventional load shedding scheme employs frequency relay to stabilize frequency under abnormal conditions. In this scheme, the under frequency relay operates when system frequency falls below a certain threshold value. Conventional UFLS scheme shed a fixed amount of electrical power in fixed steps.

This scheme is unreliable in shedding the optimal number of loads [6]-[9]. Efforts have been made to improve the existing conventional UFLS scheme by combining the generator tripping with UFLS scheme in order to stabilize power system during unstable conditions [10]. Another effort for improving the conventional load shedding scheme is presented by simultaneously studying the transmission and distribution network [11].

Since, conventional load shedding scheme shed the load in fixed steps without estimating the amount of load to be shed. Hence, it often shed more load than required.

This problem is solved by employing power swing equation to estimate the amount of load to be shed. The technique is known as an adaptive UFLS scheme.
The literature on adaptive UFLS scheme has reported that the most schemes employ voltage variation to identify and shed the sensitive load buses [12], a combination of frequency, \(df/dt\) and voltage changes [13] and initial slope of \(df/dt\) for setting the under-frequency relays [14]. These schemes can operate successfully, provided that grid is facilitated with high speed communication technology. This leads to intelligent UFLS schemes. The intelligent UFLS schemes employ two-way high speed communication system, power system automation. The intelligent UFLS schemes require fast and accurate measurements units to acquire knowledge and information regarding the network for optimally shedding the load [15]-[17].

These UFLS scheme may not ensure system security when applied in islanded distribution network connected with DG. This is due to the fact that system frequency severely disturbed during islanding mode. Also, DG system has smaller inertia which causes to drop frequency quickly. Hence, a DG system operating in islanded mode requires an appropriate adaptive load shedding scheme. The research on UFLS schemes based on islanded system has shown that not much work has been conducted in this area. The developed load shedding schemes by various authors are based on frequency and \(df/dt\) information, customers willingness to pay and load histories [18] and best time to shed the loads [19].

This paper proposes a new fuzzy based under-frequency load shedding scheme for islanded distribution network connected with DG. The proposed strategy uses fuzzy logic control approach to stabilize frequency by shedding some amount of load. The scheme has two parts. Fuzzy logic load shedding controller (FLLSC) and load shed controller module (LSCM). FLLSC monitors system status at every instant of time, and determines frequency of the equivalent inertial center \(f_c\) as below [22]:

\[
f_c = \frac{\sum_{i=1}^{N} H_i f_i}{\sum_{i=1}^{N} H_i}
\]

where, \(H_i\) is inertia constant of \(i^{th}\) generator in s and \(f_i\) is frequency of \(i^{th}\) generator in Hz and \(N\) shows number of generators. Fig. 1 illustrates layout of load shedding scheme. Standard frequency pick value to begin load shedding scheme is set to 49.5 Hz as practised in TNB, Malaysia [23].

When DG system encounter load disturbance, FLLSC check frequency limit of 49.5 Hz. If frequency goes below 49.5Hz, FLLSC investigate about the type of disturbance (Event-based or Response-based) occur on DG and estimates amount of load to be shed.

\[\text{In order to avoid unnecessary shedding of load due to smaller disturbances, the absolute value of } \Delta P_{\text{min}} \text{ is fixed to 50 kW as this is minimum load value in the distribution network. If estimated value is greater than } \Delta P_{\text{min}} \text{ FLLSC sends estimated } P \text{ to LSCM for shedding respective loads. FLLSC sends estimated value to LSCM via communication link.} \]

\[\text{The delay time which includes calculation time, communication time and circuit breaker operation time is assumed as 100 ms, which is according to practical considerations [6], [12].} \]

\[\text{The co-ordination of under-frequency protection of generator with under-frequency load shedding scheme is very important. If system frequency goes below certain threshold value, under frequency protection relay of} \]
generator will operate and system will collapse unnecessarily.

Hence, under-frequency load shedding technique should be applied in such a way that frequency recovers without going below threshold value.

The minimum allowed operating frequency usually specified by the manufacturer according to the type of turbine is 47.5 Hz [24].

In this paper, distribution network is assumed to have reliable monitoring devices and fast communication system for transmitting data.

Real-time measurement and Remote Circuit Breaker (RCB) are facilitated at each of the load feeder. The system state variable monitoring (i.e. active power, frequency and voltage) are monitored by FLLSC whereas breaker status of load feeders is monitored by LSCM. The flow chart of proposed scheme is shown in Fig. 2.

In FLLSC, there are two strategies: (1) Event-based and (2) Response-based scheme. FLLSC decides right strategies based on frequency, \( \frac{df}{dt} \) and breaker status at the DG units. The description of these strategies is as follows:

### II.2. FLLSC for Event-Based Case

Event-based case may occur when one of DG unit is tripped during islanded mode. This tripping incident may be initiated by the failure operation or malfunction of generator differential protection. It may also happen due to transmission line failure in power system. FLLSC will estimate the amount of load to be shed thus, preventing system from blackouts. When Event-based occurs, FLLSC will estimate total power imbalance as given in Equation (2):

\[
\Delta P = P_{DG} - P_{Load}
\]

where, \( \Delta P \) is power imbalance, \( P_{DG} \) is DG dispatching power, \( P_{Load} \) is total load demand.

FLLSC sends estimated value of \( \Delta P \) to LSCM which sheds the load according to load priority defined in load look-up table.

### II.3. FLLSC for Response-Based Case

Response-based case occurs due to sudden increment of load in an islanded system. In this case, number of load to be shed depends on the disturbance magnitude. FLLSC estimates the power imbalance by using frequency and \( \frac{df}{dt} \) as input signals. After estimating power imbalance, FLLSC sends estimated value to LSCM for shedding the required load.

### II.4. Fuzzy logic Load Shedding Controller (FLLSC) Modelling

Fuzzy logic load shedding controller is modelled in PSCAD software. Since, PSCAD does not provide fuzzy logic tool box, FLLSC is modelled by writing C-coding.

Fuzzy logic load shedding controller for UFLS scheme consists of two inputs and one output. The inputs of fuzzy logic load shedding controller are frequency (\( f \)) and rate of change of frequency (\( \frac{df}{dt} \)). The output is amount of load shed (\( L_{shed} \)). Depending upon the input values, fuzzy logic will estimates the amount of load required to be shed. The FLLSC comprises of fuzzification, rule base, inference mechanism and defuzzification steps as shown in Fig. 3.

![Fig. 3. Fuzzy logic load shedding controller block diagram](image)

The respective membership function of frequency and rate of change of frequency (\( \frac{df}{dt} \)) and \( L_{shed} \) are shown in Figs. 4-6. The linguistic variables of input frequency are Low (Low), Vlow (Very Low), Extlow (Extremely Low), Vextlow (Very Extremely Low) and input rate of change of frequency (\( \frac{df}{dt} \)) membership functions are HN (High Negative), LN (Low Negative), LP (Low Positive), HP (High Positive).
The linguistic variables of output Lshed are Vsshed (Very Small Shed), Sshed (Small Shed), Bshed (Big Shed), Vbshed (Very Big Shed).

The fuzzy logic load shedding controller input and output membership functions are formed in C-coding by using one dimensional array concept. The triangular membership functions are divided into two slope equations for fuzzification. In fuzzification, the real input values are converted into fuzzy set values which assign degree to which these inputs belong to each of the appropriate fuzzy sets.

Fuzzy rule base is used in IF-THEN rule form to assign the input and output control such as:
- IF frequency is low and df/dt is HN THEN Lshed is Sshed.
- IF frequency is Vextlow and df/dt is HN THEN Lshed is Vbshed.
- The other rules of fuzzy logic controller are summarized in Table I.

The inference mechanism evaluates active signals for taking control actions from the fuzzy rules. Finally, defuzzification is carried out through weighted average to convert the fuzzy linguistic variable into real crisp values.

| RULE TABLE FOR FUZZY LOGIC LOAD SHEDDING CONTROLLER (FLLSC) |
|-------------------|-------------------|-------------------|-------------------|
| Frequency         | Low               | Vlow              | Extlow            | Vextlow           |
|                   | Sshed             | Sshed             | Bshed             | Bshed             |
|                   | Vbshed            | Vbshed            | Sshed             | Vbshed            |

III. Test System for Under-Frequency Load Shedding Scheme (UFLS)

The test system for analyzing the proposed UFLS scheme is shown in Fig. 7. The DG test system consists of two mini-hydro power plants units. Each DG unit has 2 MVA (maximum power dispatch is 1.83MW) capacity and is modelled in PSCAD/EMTDC software. The system consists of 27 buses and 20 lumped loads.

The DG units are operated at 3.3 kV voltage level and are connected with transformer to step-up the voltage level to 11 kV. Each node is connected with remote circuit breaker (RCB) that can be remotely controlled for load shedding purposes.

The distribution network having two DG units is assumed to be disconnected from grid. The standard model for exciter and governor and hydraulic turbine provided in PSCAD/EMTDC library are used in this study. The IEEE type AC1A excitation standard model is chosen in this work and its model parameters are shown in Table II.

The governor consists of PID controller including pilot and servo dynamics models and its parameters are shown in Table III.

The hydraulic turbine for this study is considered as Non-elastic water column without surge tank and its parameters are shown in Table IV. The distribution network has load profile consisting of base load and peak load capacity.
TABLE II

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_C$</td>
<td>0</td>
<td>$K_f$</td>
<td>0.03</td>
</tr>
<tr>
<td>$T_a$</td>
<td>0</td>
<td>$T_e$</td>
<td>1</td>
</tr>
<tr>
<td>$K_a$</td>
<td>400</td>
<td>$K_x$</td>
<td>0.8</td>
</tr>
<tr>
<td>$T_e$</td>
<td>0.02</td>
<td>$V_{AMAX}$</td>
<td>-1.45</td>
</tr>
<tr>
<td>$V_{AMIN}$</td>
<td>-1.45</td>
<td>$V_{MAX}$</td>
<td>-5.43</td>
</tr>
<tr>
<td>$SE(VE1)$</td>
<td>0.1</td>
<td>$SE(VE2)$</td>
<td>0.03</td>
</tr>
<tr>
<td>$VE1$</td>
<td>4.18</td>
<td>$VE2$</td>
<td>3.14</td>
</tr>
</tbody>
</table>

where $P$ is active power at new voltage and frequency, and $P_0$ is active power at base voltage and frequency, $Q$ is reactive power at new voltage and frequency, and $Q_0$ is reactive power at base voltage and frequency. $K_{pf}$ and $K_{qf}$ are the co-efficient of active and reactive load dependency on frequency. The parameter of this model are the exponents $a$ and $b$. With these exponents equal to 0, 1 or 2, the model represents constant power, constant current, or constant impedance characteristics, respectively [25]. $\Delta f$ is frequency deviation ($f - f_0$). In this study, the exponent value for $a$ and $b$ is set to 1.0 and 2.0 respectively. Meanwhile, $K_{pf}$ and $K_{qf}$ is set to 1.0 and -1.0 respectively. Thus, by choosing these values, load is voltage and frequency dependent type. The power consumption of each load and its rank type is presented in Table V. The loads are ranked based on their load priority and look-up table is created according to prioritization. This load priority is created on active power value of each load. Both event-based and response-based strategies of UFLS scheme are considered. Depending upon the system load capacity, generating system can be operated at base load and peak load capacity, respectively [25].

IV. Case Studies

Under-frequency load shedding scheme is tested on Event-based and Response-based case studies. All case studies of load shedding scheme are tested on islanded distribution network connected with DG. The descriptions of case studies are summarized in Table VI.

V. Result and Discussions

V.1. Case I: Event-Based Case without Load Shedding Scheme

To simulate Event-based case without applying load shedding scheme, one of the DG unit is tripped-off from islanded distribution system.

<table>
<thead>
<tr>
<th>Load</th>
<th>Bus Number</th>
<th>Peak Load</th>
<th>Base Load</th>
<th>Load Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1013</td>
<td>0.0684</td>
<td>0.0423</td>
<td>0.0456</td>
</tr>
<tr>
<td>2</td>
<td>1141</td>
<td>0.0795</td>
<td>0.0495</td>
<td>0.0531</td>
</tr>
<tr>
<td>3</td>
<td>1012</td>
<td>0.0795</td>
<td>0.0495</td>
<td>0.0531</td>
</tr>
<tr>
<td>4</td>
<td>1010</td>
<td>0.1095</td>
<td>0.0576</td>
<td>0.063</td>
</tr>
<tr>
<td>5</td>
<td>1047-1079</td>
<td>0.1794</td>
<td>0.0792</td>
<td>0.11721</td>
</tr>
<tr>
<td>6</td>
<td>1057</td>
<td>0.189</td>
<td>0.1152</td>
<td>0.126</td>
</tr>
<tr>
<td>7</td>
<td>1058</td>
<td>0.198</td>
<td>0.123</td>
<td>0.132</td>
</tr>
<tr>
<td>8</td>
<td>1018-1039</td>
<td>0.234</td>
<td>0.1101</td>
<td>0.15099</td>
</tr>
<tr>
<td>9</td>
<td>1064</td>
<td>0.1488</td>
<td>0.0867</td>
<td>0.0993201</td>
</tr>
<tr>
<td>10</td>
<td>1018</td>
<td>0.1743</td>
<td>0.108</td>
<td>0.11619</td>
</tr>
<tr>
<td>11</td>
<td>1154</td>
<td>0.2097</td>
<td>0.1275</td>
<td>0.1401</td>
</tr>
<tr>
<td>12</td>
<td>1004</td>
<td>0.2121</td>
<td>0.1314</td>
<td>0.14151</td>
</tr>
<tr>
<td>13</td>
<td>1046</td>
<td>0.2535</td>
<td>0.1578</td>
<td>0.1701</td>
</tr>
<tr>
<td>14</td>
<td>1020</td>
<td>0.2745</td>
<td>0.1716</td>
<td>0.1845</td>
</tr>
<tr>
<td>15</td>
<td>1029</td>
<td>0.3468</td>
<td>0.2148</td>
<td>0.2313</td>
</tr>
<tr>
<td>16</td>
<td>1019</td>
<td>0.1902</td>
<td>0.099</td>
<td>0.10671</td>
</tr>
<tr>
<td>17</td>
<td>1151</td>
<td>0.2208</td>
<td>0.0996</td>
<td>0.107199</td>
</tr>
<tr>
<td>18</td>
<td>1056</td>
<td>0.345</td>
<td>0.3282</td>
<td>0.35259</td>
</tr>
</tbody>
</table>

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Since, loads in islanded system are supplied by two DGs, loss of one DG will give a great impact to islanded system. As a result, all load is shifted to the remaining operating DG unit. The frequency response of DG without applying load shedding scheme is shown in Fig. 8. From Fig. 8, it can be noticed that when event-based case occurred and load shedding scheme is not applied, frequency of operating DG unit goes below the safe frequency limit of 47.5 Hz, stables at 28.67 Hz and never recovered to normal value. This will cause tripping of operating DG unit due to operation of protection relay which will leads to power blackouts. Hence, load shedding scheme is necessary in order to able DG unit operating continuously, and prevent power system from power collapse.

<table>
<thead>
<tr>
<th>Case Studies</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case I</td>
<td>Event-Based case without load shedding scheme</td>
</tr>
<tr>
<td>Case II</td>
<td>Event-Based case with Load Shedding Scheme</td>
</tr>
<tr>
<td>(1)</td>
<td>Peak Load Scenario</td>
</tr>
<tr>
<td>(2)</td>
<td>Base Load Scenario</td>
</tr>
<tr>
<td>Case III</td>
<td>Response-Based case with Load Shedding Scheme</td>
</tr>
<tr>
<td>(1)</td>
<td>Peak Load Scenario</td>
</tr>
<tr>
<td>(2)</td>
<td>Base Load Scenario</td>
</tr>
</tbody>
</table>

Fig. 8. Frequency response at Event-based case without load shedding scheme.

V.2. Case II: Event-Based Case with Load Shedding Scheme

V.2.1. Peak Load Scenario

To simulate Event-based case with load shedding scheme at Peak load (3.66 MW), one of the DG unit is tripped-off from islanded distribution system at \( t=10 \) s.

The FLLSC checks first frequency limit of 49.5 Hz. After checking this, FLLSC check about type of load disturbance applied on islanded distribution system. FLLSC by monitoring RCB status of DG units determines that system encountered Event-based load disturbance.

FLLSC estimates the amount of load to be shed and sends signal to LSCM, which immediately trip significant number of load feeders to stabilize frequency.

The frequency response of DG for this case is shown in Fig. 9.

Fig. 9 shows that by applying proposed load shedding scheme, DG frequency has undershoot of 48.56 Hz and recovered to 50Hz after some time.

The proposed scheme shed load up to 11\textsuperscript{th} load ranked for this case. It is noticed that DG frequency while stabilizing has an overshoot up to 50.3 Hz. This frequency overshoot explains that amount of load shed is not optimal.

To investigate this issue, load ranked 11\textsuperscript{th} is not shed to confirm whether amount of load shed is optimal or not and response is shown in Fig. 10.

Fig. 10 shows that proposed fuzzy based UFLS scheme sheds the optimal number of loads as the frequency does not rise to normal value and stables at 46 Hz when one less load is shed.

DG unit enable to supply 1.83 MW load after one DG being tripped and its graph is shown in Fig. 11.
V.2.2. Base Load Scenario

To simulate Event-based case with load shedding scheme at Base load (2.5 MW), one of the DG unit is tripped-off from islanded distribution system at \( t = 10 \) s.

The frequency response of DG for this case is shown in Fig. 12. It can be noticed from Fig. 12 that by applying proposed load shedding scheme, DG frequency has undershoot of 47.62 Hz and recovered to 50 Hz after some time. The proposed scheme shed load up to 10\(^{th}\) load ranked. Fig. 13 shows DG frequency when one less load is shed. It is observed that when ranked 10\(^{th}\) is not shed, DG frequency goes to 46.141 Hz. Since, DG frequency goes below the safe limit of 47.5 Hz and will cause tripping of generator due to operation of protection relay. Hence, proposed fuzzy based UFLS scheme sheds the optimal number of loads.

![Fig. 12. Frequency response during Event-based case at Base load](image1)

![Fig. 13. Frequency response without shedding load ranked 10\(^{th}\)](image2)

The power supplied by operating DG unit is 1.47 MW and its graph is shown in Fig. 14. The optimal amount of load shed during peak load and based load are shown in Table VII.

![Fig. 14. Power graph for Event-based case at Base capacity](image3)

V.3. Case III: Response-Based Case with Load Shedding Scheme

V.3.1. Peak Load Scenario

To simulate Response-based condition at peak load capacity (3.66 MW); a new load feeder rated 0.54 MW is suddenly connected to bus number 1056 in islanded distribution network. Upon addition of this amount of load, total load becomes 3.66 MW + 0.54 MW = 4.2 MW.

By adapting proposed UFLS scheme, FLLSC checks for frequency limit of 49.5 Hz. After checking this, FLLSC check about type of load disturbance applied on system. FLLSC by monitoring RCB status of DG units determines that system encountered Response-based load disturbance. The FLLSC by measuring frequency and \( df/dt \), estimates the amount of load to be shed for this case. If estimated amount is greater than \( \Delta P_{\text{min}} \); FLLSC sends signal to LSCM, which immediately trip significant number of load feeders to stabilize the frequency. However, if estimated amount is less than \( \Delta P_{\text{min}} \); FLLSC does not sends signal to LSCM, DG unit’s remains operating without requiring any load to be shed.

The frequency response of DG for this case is shown in Fig. 15.

![Fig. 15. Frequency response for Response-based case at Peak Load](image4)

Fig. 15 shows that DG frequency has undershoot of 49.078 Hz and recovers to normal value after some time. The proposed methodology shed load up to 5\(^{th}\) load ranked. It can be observed that DG frequency while stabilizing has an overshoot up to 50.15 Hz. This frequency overshoot explains that amount of load shed is not optimal. To investigate this issue, load ranked 5\(^{th}\) is not shed to confirm whether amount of load shed is optimal or not and response is shown in Fig. 16. It can be noticed that the proposed fuzzy based UFLS scheme sheds optimal number of loads as frequency does not rise.

### TABLE VII

<table>
<thead>
<tr>
<th>Event-Based Case</th>
<th>Undershoot</th>
<th>Power Imbalance</th>
<th>Load Shed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Load</td>
<td>48.56 Hz</td>
<td>1.83 MW</td>
<td>1.83 MW</td>
</tr>
<tr>
<td>Base Load</td>
<td>47.62 Hz</td>
<td>1.25 MW</td>
<td>1.03 MW</td>
</tr>
</tbody>
</table>

![Fig. 15. Frequency response for Response-based case at Peak Load](image4)
to normal value and stabilizes at 47.8 Hz when one less load is shed. The power supplied by DG is 3.68237 MW and is shown in Fig. 17.

The power supplied by DG is 2.9413 MW as shown in Fig. 19. The optimal load shedding values for response-based case are shown in Table VIII.

![Fig. 16. Frequency response at peak load when load ranked 5th is not disconnected](image1)

![Fig. 17. Power graph for Response-based case at Peak load](image2)

V.3.2. Base Load Scenario

To simulate Response-based load shedding case at Base load capacity (2.5 MW); a new load feeder rated 0.54 MW is suddenly connected to bus number 1056 in islanded distribution network. Upon addition of this amount of load, total load becomes 2.5 MW + 0.54 MW = 3.04 MW. Response-based load shedding is applied at \( t = 10 \) s. The frequency response of DG for this case is shown in Fig. 18.

![Fig. 18. Frequency response for response-based case at Base load](image3)

In Fig. 18, The DG frequency has undershoot of 47.92 Hz and frequency recovers to normal value after some time. The proposed methodology shed load up to 2nd load ranked.

VI. Conclusion

This paper has presented a new fuzzy based adaptive under-frequency load shedding scheme, suitable for islanded distribution network connected with DG. The proposed scheme used frequency, rate of change of frequency, load priority to develop the load shedding strategy.

The proposed UFLS scheme is suitable for both Event-based and Response-based cases. The effectiveness and robustness of this scheme has been investigated on different cases from base load to peak load. Form the simulation results it can be concluded that proposed load shedding scheme successfully stabilizes the frequency by shedding optimal number of loads.

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References


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