Active Distribution Grid Power Flow Analysis using Asymmetrical Hybrid Technique

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ABSTRACT

A conventional distribution power flow analysis has to be improved regards the changes in distribution network. One of the changes is a grid operation because a new grid concept, e.g. micro-grid and aggregation, is aimed to be operated based on area itself. Consequently, each area can be actively operated in either grid connected mode or islanding mode. Hence, this paper proposes an asymmetrical power flow analysis using hybrid technique to support this flexible mode change. The hybrid technique offers an opportunity to analyze power flow in a decoupling way. This means that the power flow analysis can be performed separately in each grid area. Regards the distributed generation, this paper also introduces a model based on inverter-based operation, i.e. grid forming, grid supporting and grid parallel. The proposed asymmetrical hybrid load flow method is examined in three case studies, i.e. a verification study with the DIgSILENT PowerFactory, a demonstration of decoupling analysis approach and a performance study with the Newton-Raphson method.

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1. INTRODUCTION

Since, the distributed generations are dramatically integrated into distribution network, the new concept of distribution network operation, e.g. micro-grid, aggregation and cell, are discussed and demonstrated in field test [1-3]. According to this reason, the distribution grid operation can be changed from a passive network to be an active network. This means that each network area is aimed to be operated based on area itself. Figure 1 shows an example of interconnected active distribution networks, which each area is able to balance the power by itself or request the power from neighborhood area. Thus, this kind of network can be operated in an islanding mode or a grid connected mode. Regarding this flexible operation, the distribution network has a character of an active grid. Therefore, a distribution power flow analysis has to be improved to support this change.

In order to analyze this kind of grid operation, this paper introduces a hybrid calculation technique because this technique offers a decoupling analysis opportunity. The hybrid calculation technique requires just only the interconnected voltages from neighborhood area to perform decoupling power flow analysis, while the power flow result is the same as a whole power system analysis [4]. As a result, the active distribution network can be analyzed based on each area.

To apply hybrid calculation technique for distribution power flow analysis, the unbalance condition and the multi-phase network topology have to be taken into account [5]. Looking for the distribution network power flow, it found that the studies are mainly categorized by network topology, i.e. three-phase system [6], [7] and multi-conductor system [8], [9]. The major difference between those two systems is the interest of neutral cable. As the neutral wire analysis becomes a vital topic due to a single-phase feed-in of DG unit and the unbalance condition analysis, so the three-phase four-wire system framwork is concerned in this paper.

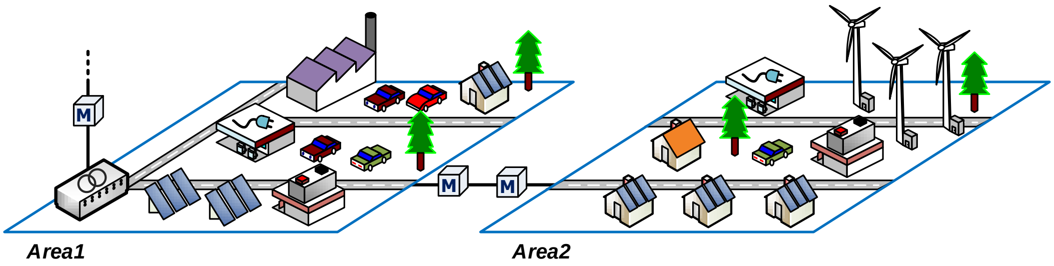


Figure 1. Interconnected active distribution networks

Regarding the modelling of DG unit for power flow analysis, it is conventionally defined in three-phase system. For example, [9] has presented the sequence components technique for the DG unit modelling, and the model is defined based on conventional PU node. However, the operation modes of inverter-based DG unit, i.e. grid forming unit, grid supporting unit and grid parallel unit, are different [10] and [11]. In order to take the inverter into account, the DG unit model in this paper is therefore represented by inverter-based operation. Clearly, the model is structured based on the three-phase four-wire network.

Considering all mentioned topics according to active distribution network, this paper proposes a decoupling asymmetrical power flow using hybrid calculation method and a model of inverter-based DG unit. To approve the proposed asymmetrical hybrid power flow method, the DIgSILENT PowerFactory program is used as a benchmark. Afterwards, the decoupling analysis approach using hybrid technique is demonstrated. Finally, the algorithm performance is discussed. Note that, the proposed power flow analysis method is not only for active distribution network but also for a general network.

2. INVERTER-BASED DISTRIBUTION GENERATION MODEL

In general power flow study for unbalanced distribution system, a bus type of DG unit is modelled as negative PQ node [12]. However, the new grid connection standard of DG unit, e.g. VDE-AR-N 4105 [13], is defined a description of DG unit based on inverter-based. Hence, the bus types of DG unit has to be modelled based on inverter-based. There are three modes inverter-based operation, which are taken into account for the bus type modelling in this paper, i.e. grid forming mode, grid supporting mode and grid parallel mode.

2.1. Grid Forming Unit Model

The grid forming unit is in charge of system voltage and frequency regulation by balancing the power of generators and loads. It can be implied that the grid forming is operated like a constant voltage source. In this case, the model of voltage source can be used as a model of the grid forming unit. Figure 2(a) depicts the three-phase system, whose reference can be selected between neutral and ground.

Remark that the grid forming unit can be only operated under grid islanding mode, and it must contain only one unit in the islanding area. If the grid islanding mode is changed to the grid connected mode, the grid forming unit must be switched to the grid supporting operation because the reference voltage are regulated by the main grid.

2.2. Grid Supporting Unit Model

The grid supporting unit is able to control the active- and reactive power output. The generated power has to follow the power dispatch strategies. Hence, the model of grid supporitng unit for power flow calculation is basically a negative PQ node as shown in Figure 2(b). The negative direction power stands for generation type. Moreover, the switch in each phase means that the injected power of DG unit can be freely switched on/off. On the same hand, it can be selected between three-phase and single-phase.

2.3. Grid Parallel Unit Model

The description of a grid parallel unit is uncontrollable generators. The power is fed as much as possible into the grid. This kind of operation refers to a small PV system. From operation point of view, the model of grid parallel can utilize the negative PQ model in Figure 2(b) as well. Another description of grid parallel unit is an impedance load [10]. Its model is shown in Figure 2(c).

In addition to those three modes, the inverter-based DG unit can also operate as a current source. The model for current source inverter is presented in Figure 2(d). In short conclusion, the models of grid forming unit, grid supporting unit, grid parallel and current source inverter are simply defined through Figure 2. They can be freely selected either three-phase system or single-phase system.

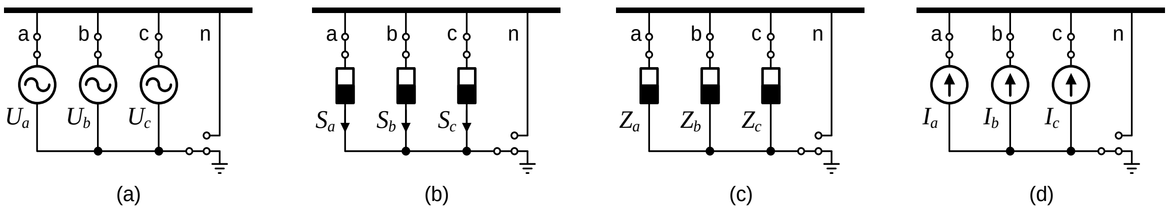


Figure 2. Bus type model of inverter-based DG unit

3. HYBRID CALCULATION TECHNIQUE

As mentioned that the decoupling approach is required for the power flow analysis of active distribution network, thus, the hybrid calculation technique is introduced. The key concept of decoupling approach based on hybrid technique is an integrated voltage of interconnected areas [4]. Before having a look on the hybrid calculation technique and its decoupling approach in detail, the conventional power flow analysis methods, i.e. a current injection method and Newton-Raphson method, are discussed.

The current injection method solves power flow solution by using a current iteration through bus admittance matrix. Regarding this process, it is obvious that the current injection method is unsuitable for the decoupling analysis strategy since there is no chance to integrate the voltage from the interconnected grids.

The Newton-Raphson method is commonly used and applied in power flow study because of very good convergent characteristic. The power flow analysis based on Newton-Raphson method is solved by finding a minimum error allowance of power mismatches through the Jacobi matrix. Considering a compatibility with the decoupling analysis strategy, the conventional Newton-Raphson method can deal with only one fixed voltage source, called slack. Due to that reason, the conventional method is not able to analyze the interconnected areas in a decoupling way. However, the Newton-Raphson method can be further developed in order to handle with more than one voltage source because the correction vector and the power mismatch equation is described by the voltage value. The disadvantage is that, the Jacobi matrix has to be updated in every iteration step, and this can consequently take a computational time.

Due to unsuitable conditions of both mentioned methods for decoupling analysis approach, the hybrid calculation technique is introduced, because the input parameter of hybrid technique can be mixed between voltage and current.

3.1. Hybrid Matrix Formulation

The key technique for hybrid calculation is the hybrid matrix. To find out the hybrid matrix, the bus admittance matrix has to be initially sorted regarding the group of input voltage source and current source in a form of Euqation 1.

$$\begin{bmatrix} [\underline{I}_K] \\ [\underline{I}_U] \end{bmatrix} = \begin{bmatrix} [\underline{Y}_{AA}] & [\underline{Y}_{AB}] \\ [\underline{Y}_{BA}] & [\underline{Y}_{BB}] \end{bmatrix} \cdot \begin{bmatrix} [\underline{U}_U] \\ [\underline{U}_K] \end{bmatrix} \quad (1)$$

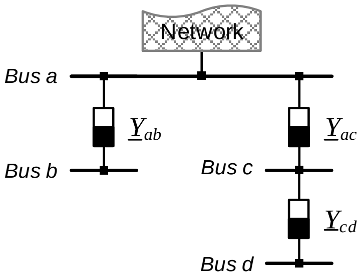
where the admittance group $[\underline{Y}_{AA}]$ is a square admittance matrix, which is related to the unknown voltage vector $[\underline{U}_U]$. Similarly, the square matrix $[\underline{Y}_{BB}]$ is linked with the known voltage vector $[\underline{U}_K]$. The rest parts of the sorted admittance matrix are defined by matrix $[\underline{Y}_{AB}]$ and $[\underline{Y}_{BA}]$, respectively. In order to complete the hybrid equation, the group of unknown vector and known vector have to be rearranged according to Equation 2. Consequently, the sorted bus admittance matrix is also reformed. Thus, the hybrid matrix formulation is directly obtain as in Equation 3.

$$\begin{bmatrix}[\underline{U}_U]\\ [\underline{I}_U]\end{bmatrix}=\begin{bmatrix}[\underline{Y}_{AA}]^{-1} & -[\underline{Y}_{AA}]^{-1}[\underline{Y}_{AB}]\\ [\underline{Y}_{BA}][\underline{Y}_{AA}]^{-1} & [\underline{Y}_{BB}]-[\underline{Y}_{BA}][\underline{Y}_{AA}]^{-1}[\underline{Y}_{AB}]\end{bmatrix}\cdot\begin{bmatrix}[\underline{I}_K]\\ [\underline{U}_K]\end{bmatrix} \quad (2)$$

$$[\underline{H}]=\begin{bmatrix}[\underline{Y}_{AA}]^{-1} & -[\underline{Y}_{AA}]^{-1}[\underline{Y}_{AB}]\\ [\underline{Y}_{BA}][\underline{Y}_{AA}]^{-1} & [\underline{Y}_{BB}]-[\underline{Y}_{BA}][\underline{Y}_{AA}]^{-1}[\underline{Y}_{AB}]\end{bmatrix} \quad (3)$$

3.2. Example of Sorted Bus Admittance Matrix

As the hybrid matrix [$\underline{H}$] is defined by sorted bus admittance matrix, thus, it is significant to figure out the process of sorted bus admittance matrix. An examined network is illustrated in Figure 3(a). The network consists of four buses, and its admittance matrix is shown in Figure 3(b).



(a) Examined System

$$\begin{bmatrix}\underline{I}_a\\ \underline{I}_b\\ \underline{I}_c\\ \underline{I}_d\end{bmatrix}=\begin{bmatrix}\underline{Y}_{ab}+\underline{Y}_{ac} & -\underline{Y}_{ab} & -\underline{Y}_{ac} & 0\\ -\underline{Y}_{ab} & \underline{Y}_{ab} & 0 & 0\\ -\underline{Y}_{ac} & 0 & \underline{Y}_{ac}+\underline{Y}_{cd} & -\underline{Y}_{cd}\\ 0 & 0 & -\underline{Y}_{cd} & \underline{Y}_{cd}\end{bmatrix}\cdot\begin{bmatrix}\underline{U}_a\\ \underline{U}_b\\ \underline{U}_c\\ \underline{U}_d\end{bmatrix}$$

(b) Bus Admittance Matrix

Figure 3. Examined system and its bus admittance for sorted bus admittance process

Assuming the unknown voltage vector [$\underline{U}_U$] is the voltage of bus *b* and *c*. The known voltage vector [$\underline{U}_K$] is the voltage of bus *a* and *d*. To acquire the four blocks of the sorted admittance matrix, the bus admittance matrix has to be rearranged regarding the unknown- and the known voltage group. So, the new bus admittance matrix is obtained as in Equation 4.

$$\begin{bmatrix}\underline{I}_b\\ \underline{I}_c\\ \underline{I}_a\\ \underline{I}_d\end{bmatrix}=\begin{bmatrix}\underline{Y}_{ab} & 0 & -\underline{Y}_{ab} & 0\\ 0 & \underline{Y}_{ac}+\underline{Y}_{cd} & -\underline{Y}_{ac} & -\underline{Y}_{cd}\\ -\underline{Y}_{ab} & -\underline{Y}_{ac} & \underline{Y}_{ac}+\underline{Y}_{cd} & 0\\ 0 & -\underline{Y}_{cd} & 0 & \underline{Y}_{cd}\end{bmatrix}\cdot\begin{bmatrix}\underline{U}_b\\ \underline{U}_c\\ \underline{U}_a\\ \underline{U}_d\end{bmatrix} \quad (4)$$

The matrix in Equation 4 is called the sorted admittance matrix. The four blocks of sorted admittance matrix, i.e. [$\underline{Y}_{AA}$], [$\underline{Y}_{AB}$], [$\underline{Y}_{BA}$], and [$\underline{Y}_{BB}$], are divided by dash line. Noticeably, [$\underline{Y}_{AA}$] and [$\underline{Y}_{BB}$] are square matrixes, which their matrices dimensions are depended on the size of voltage vector [$\underline{U}_U$] and [$\underline{U}_K$], respectively. The matrix [$\underline{Y}_{AB}$] and [$\underline{Y}_{BA}$] are the transpose matrixes of each other.

In summary, the hybrid calculation supports the requirement of decoupling approach. The known voltage vector [$\underline{U}_K$] is a key point to integrate interconnected grids voltages into a single area analysis. Therefore, this character enables the decoupling power flow analysis.

4. DECOUPLING ASYMMETRICAL HYBRID POWER FLOW ALGORITHM

Applying the hybrid technique for asymmetrical power flow algorithm, the target equation of power flow solution is formulated as in Equation 5. The equation is evolved based on and three-phase four-wire system in order to support the unbalance conditions in distribution network and the analysis of neutral cable. The subscript *abcn* stands for three-phase four-wire systems.

$$\begin{bmatrix}[\underline{U}_{Uabcn}]\\ [\underline{I}_{Uabcn}]\end{bmatrix}=[\underline{H}_{abcn}]\cdot\begin{bmatrix}[\underline{I}_{Kabcn}]\\ [\underline{U}_{Kabcn}]\end{bmatrix} \quad (5)$$

To figure out the proposed power flow method, the algorithm flow chart is depicted in Figure 4. The algorithm can be separated in two parts, power flow calculation part and voltage regulation part.

4.1. Power Flow Calculation Part

The power flow calculation part is performed in the inner loop. The target values of power flow solution are known apparent power [$\underline{S}_{Kabcn,i}$] and known voltage [$\underline{U}_{Kabc,i}$]. An index *i* describes a bus number. A superscript 0 represents an initial value. The solutions of the power flow study are clearly the voltage of unknown power buses [$\underline{U}_{Uabcn,i}$]. As mentioned that the decoupling approach can be done by integrated the interconnected grids voltages, those voltage are described by the voltage vector [$\underline{U}_{K,abcn,g}$], where *g* is a number of interconnected grids. The workflow of the algorithm process is elucidated in steps as:

a. Firstly, the apparent power set point [$\underline{S}_{Kabc,i}$] is divided by initial bus voltage vector [$\underline{U}_{Uabc,i}^{0}$], in order to obtain the initial injection current vector [$\underline{I}_{Kabc,i}^{0}$] for the first iteration.

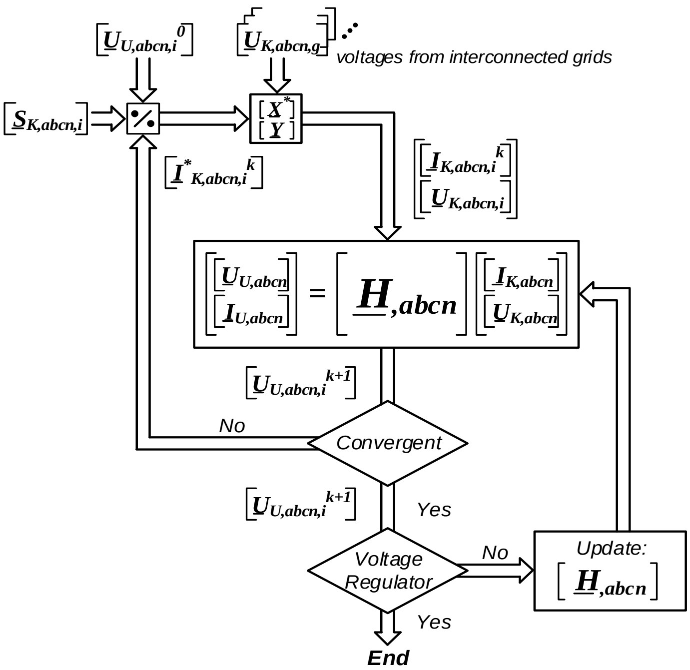


Figure 4. Decoupling power flow analysis algorithm based on asymmetrical hybrid calculation technique

b. Next, the injection current vector [$\underline{I}_{Kabc,i}$] is combined with the known voltage buses vector from interconnected grids [$\underline{U}_{Kabcn,g}$]. This combination is forwarded to the hybrid calculation process as the input vector.

c. After the calculation, the results of unknown bus voltages [$\underline{U}_{Uabcn,i}$] are fed back in order to update a new current injection vector for the next iteration loop. When the unknown voltage vector is convergent, the power flow calculation process is accomplished.

Remarks, the proposed asymmetrical power flow algorithm does not need to concern any compensation technique for unbalance condition because the network description is defined by one hybrid matrix. Moreover, the algorithm can be applied for the multi-phase and single-phase network as well.

4.2. Voltage Regulation Part

To regulate the systems voltage, the element like tap-changing transformer has to be occupied in the network. The regulation mechanism of proposed algorithm is controlled by an updating hybrid matrix process. For example, when the tap of transformer is changed, this means that the network parameter or the hybrid matrix is also changed. The selection of hybrid matrix is done by comparing a voltage difference between the result from power flow part and the initial voltage regards the transformer tap position. Then, the tap position can be figured out. Afterwards, the power flow calculation part is repeated in order to calculate new power flow solution. The hybrid matrix regards the tap position is pre-calculated, since it is a known parameter. Based on the same process, the updating hybrid matrix method can be applied for any discrete voltage control element. Note that, the feedback signal of automatic voltage regulation is the positive sequence voltage of regulated bus [14].

5. CASE STUDIES

The proposed asymmetrical hybrid power flow method is examined by three case studies. The first case is the algorithm and power flow result verification, which the DIgSILENT PowerFactory is a reference. Besides the algorithm verification, this case also proves the network model. The second case demonstrates the application for active distribution network analysis, which the decoupling analysis approach and the model of inverter-based DG units are studied. Lastly, the performance between proposed algorithm and Newton-Raphson algorithm is investigated and discussed.

5.1. Case1 – Algorithm and Power Flow Result Verification

For the verification, the DIgSILENT PowerFactory is used as a benchmark, where the Newton-Raphson is an analysis method in this program. The examined network is partially selected from the existing network from [15], as presented in Figure 5. The network is 10 kV medium voltage level, which is connected to the low voltage level through 20/0.4 kV Dyn1 distribution transformer. The low voltage network consists of three primary feeders. The cable is the three-phase with a neutral cable, NAYY 4x50SE. The applied power is considered as an asymmetrical spot load and generation. The voltage regulator target is set to 1±0.01 pu. of the positive sequence voltage.

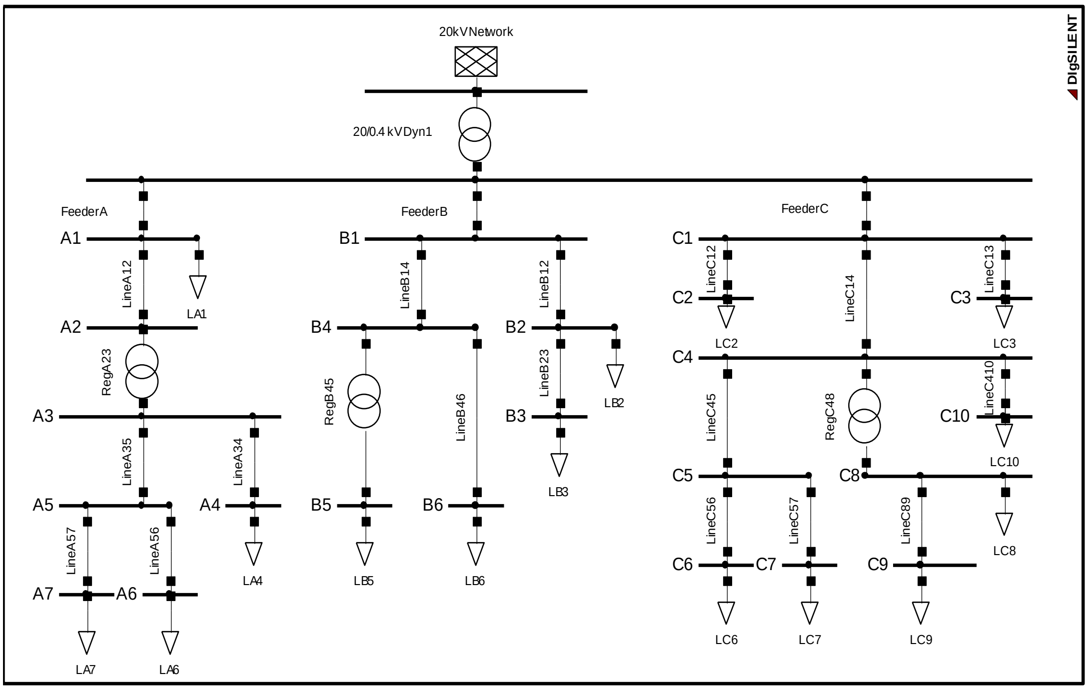


Figure 5. Bus type model of inverter-based DG unit

After performing power flow analysis, the power flow result of feeder C is selected for a discussion. Figure 6(a) show a comparative result of voltage profile in per-unit of phase *a*. From voltage profile graph the power flow result from PowerFactory program and proposed algorithm are almost identical.

To emphersize the accuracy of the proposed algorithm, the absolute voltage difference between PowerFactory and the proposed algorithm of phase *a* to neutral voltage ($\underline{U}_{an}$) are examined as displayed in Figure 6(b). The difference is in the range of 1.6 ‰ or 0.0016 pu. This also proves that the developed algorithm is reliable, and also the network models are correct.

Regarding the voltage control part, it can be noticed form Figure 6.a that the voltage at node C8 is regelated to target value, which is 1.0057 pu. from proposed algorithm and 1.0056 pu. from PowerFactory. In short summarization, this case study validates the proposed as well as the network models.

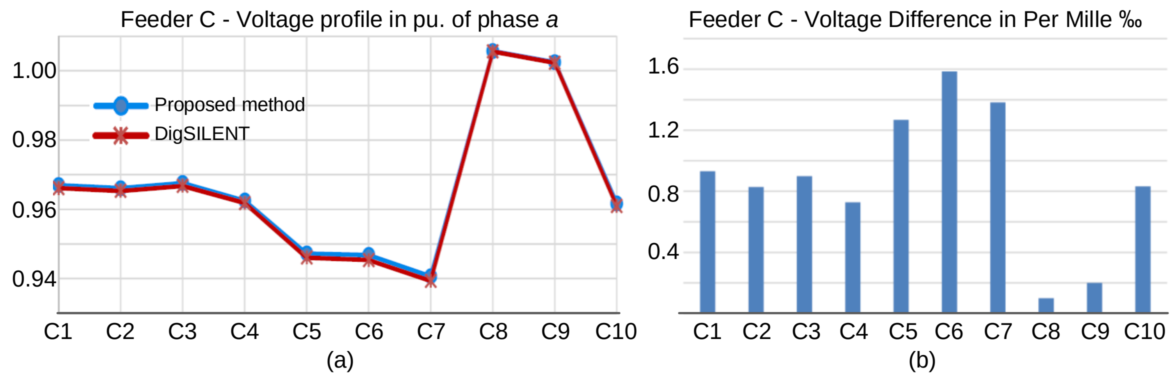


Figure 6. Comparative power flow solution of feeder C

5.2. Case2 – Demonstration of Asymmetrical Hybrid Decoupling Analysis

Presenting the decoupling approach of asymmetrical hybrid power flow analysis, the IEEE 123-bus feeder is selected. This test feeder offers full asymmetrical condition. The network topology is structured by the multi-phase systems as well as untransposed cables. Furthermore, the loads are described with strong unbalanced spot loading. Nevertheless, it has to be modified in some part in order to test the decoupling approach and the model of inverter-based DG unit. Figure 7 illustrates the modified IEEE 123-bus feeder. The modification parts are described as follows: the location of inverter-based DG units are defined with the white dot. The power configurations of inverter-based DG unit are calculated by the 0.9 power factor based on the data in [16], which the grid supporting mode is applied in this part. The substation is defined through 115/4.16kV 5MVA Dyn1 distribution transformer. Two voltage regulator are set to 1±0.05 pu. But, the cable and load configurations are kept at the provided data from IEEE test feeder. Lastly, in the examination, all switch configurations are set to close.

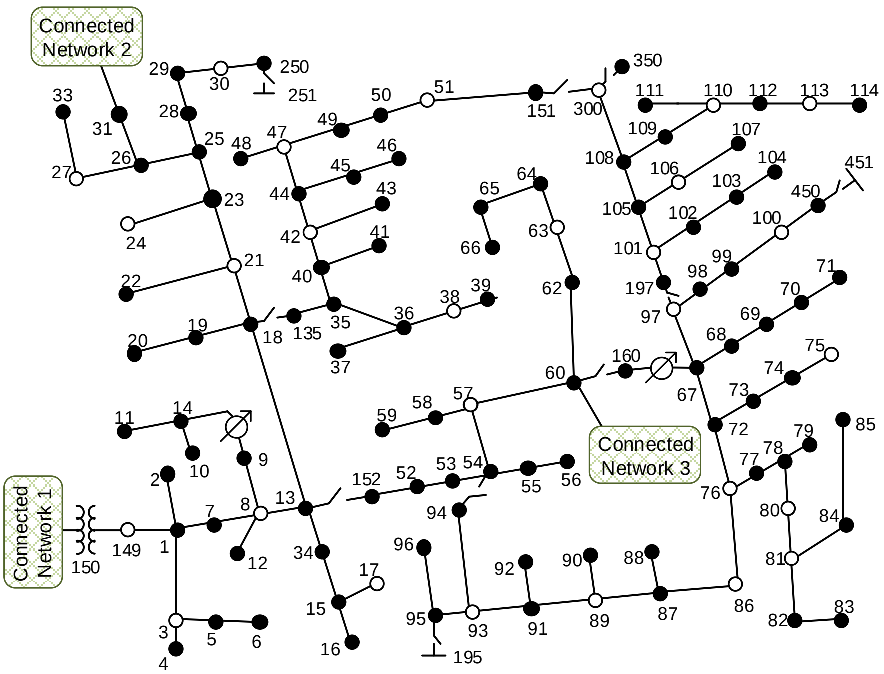


Figure 7. Modified IEEE 123 nodes test feeder

As mentioned that the asymmetrical hybrid decoupling power flow analysis requires the interconnected voltages in order to describe behaviors of those interconnected areas. In test network, there are three interconnected areas. Their interconnected voltages of network 1, network 2 and network 3 are given in Table 1. Regarding the assigned values in Table 1, it can be implied that the network1 is operated as grid forming mode. The network 2 and network 3 are constant voltage source. To present the capability of asymmetrical model analysis, the network 2 is given as a single-phase system, and the network 3 is a three-phase system.

Table 1. Applied Voltage at Interconnected Networks

Connected network	$\lvert\underline{U}_a\rvert$ [pu.]	$\angle\underline{U}_a$ [deg]	$\lvert\underline{U}_b\rvert$ [pu.]	$\angle\underline{U}_b$ [deg]	$\lvert\underline{U}_c\rvert$ [pu.]	$\angle\underline{U}_c$ [deg]
1	1.000	0.000	1.000	-120.00	1.000	120.00
2	-	-	-	-	0.962	88.16
3	0.950	-34.78	0.981	-152.20	0.950	87.40

The power flow solution result of selected nodes are shown in Table 2. From the solution, the first notice is multi-phase issue. The result proves that the proposed algorithm can handle with single-phase, two-phase and three-phase system. Next, the voltage level at bus 14 and bus 67 are observed. As the voltage in the setting range, thus, both voltage regulators are functioned appropriately.

Table 2. Power flow solution of selected nodes

Node	$\lvert\underline{U}_a\rvert$ [pu.]	$\angle\underline{U}_a$ [deg]	$\lvert\underline{U}_b\rvert$ [pu.]	$\angle\underline{U}_b$ [deg]	$\lvert\underline{U}_c\rvert$ [pu.]	$\angle\underline{U}_c$ [deg]
8	0.987	-32.66	0.997	-151.11	0.987	88.66
14	0.984	-32.74	-	-	-	-
30	0.958	-33.76	0.993	-151.60	0.962	88.21
36	0.957	-33.75	0.991	-151.77	-	-
39	-	-	0.990	-151.80	-	-
44	0.955	-33.86	0.988	-151.84	0.961	88.17
46	0.954	-33.88	-	-	-	-
67	0.956	-35.05	0.981	-152.28	0.954	87.36
81	0.945	-35.33	0.979	-152.46	0.940	87.12
102	-	-	-	-	0.942	87.29
108	0.944	-35.33	0.982	-152.39	0.944	87.40
114	0.936	-35.64	-	-	-	-

In order to observe the behavior of interconnected networks, the power transfer are calculated, shown in Table 3. The result presented that the network 2 injects the power into the examined area, whereas the network 3 consumes the power. The summarization of power flow direction is illustrated in Figure 3. Remarks, the connected network 1 operate as grid forming mode or slack node. It is in charge of balancing the power of entire examined network.

Table 3. Power transfer between interconnected networks

Connected network	P_a $[kW]$	Q_a $[k\,\text{var}]$	P_b $[kW]$	Q_b $[k\,\text{var}]$	P_c $[kW]$	Q_c $[k\,\text{var}]$
1	1368.5	181.4	1193.0	89.9	1045.7	197.7
2	-	-	-	-	-20.00	-2.20
3	20.10	10.05	22.50	10.25	18.10	9.30

To conclude, the decoupling analysis approach by using hybrid calculation technique can be done by exchanging the voltage value between interconnected networks. However, it has to state that a time synchronization is an important issue for exchanging the voltage value. Otherwise the power flow solution and the power transfer between interconnected networks could be miscalculation. Figure 8 shows the power flow diagram of interconnected systems.

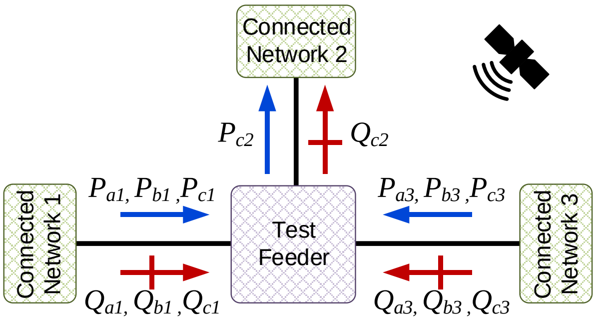


Figure 8. Power flow diagram of interconnected systems

5.3. Case3 – Performance Discussion

In order to inspect the algorithm performance, the classical Newton-Raphson analysis method is taken into account. Therefore, the interconnected systems and decoupling analysis approach do not taken into account in this study. The examined network in this case are the DISPOWER network of case study1 and the original IEEE 123 test feeder. Regarding the calculation platform, the Newton-Raphson and the proposed algorithm are run on Matlab script based on 64-bit operating system 3.3 GHz with installed memory 8 GB. The power flow result is evaluated by mean square error. The error allowance is less than 1 mV.

After perform the power flow calculation, the iteration step and computational time are compared. The comparative result is illustrated in Figure 9. According to the iteration step comparison, it can be expected that Newton-Raphson process requires less iteration steps than proposed hybrid algorithm, since the hybrid calculation is basically based on the current iteration process. The expected advantage of proposed method is computational time. The proposed hybrid can solved the solution faster than Newton-Raphson method. With this performance, the proposed hybrid technique can be one solution to support a real-time power flow calculation. Regarks, the performance power flow algorithm is a matter of accuracy or fast calculation, which is related to the maximum allowance error of calculated variable.

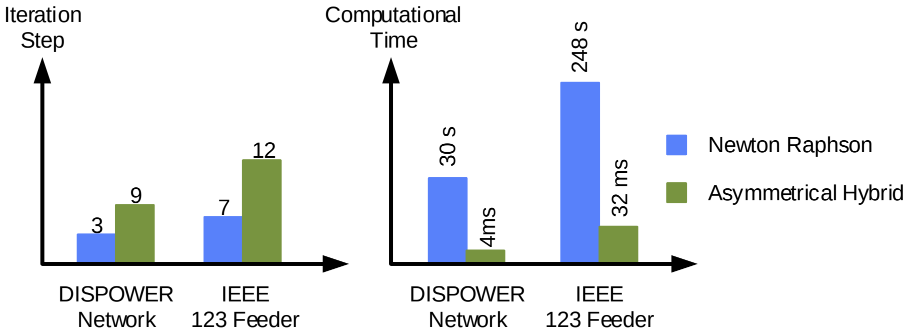


Figure 9. Algorithm performance comparison

6. CONCLUSION

This paper presents the decoupling asymmetrical power flow using hybrid technique. The decoupling approach is developed to support the active network operation, which are aimed to be operated based on each area. The asymmetrical issue is taken into account according to unbalance conditions in distribution network as well as a multi-phase feed-in of DG unit. The power network model is developed based on three-phase four-wire system. The DG unit model is modeled based on inverter-based operation, i.e. grid forming, grid supporting and grid parallel.

In order to validate the proposed power flow algorithm and the network modelling, the DIgSILENT PowerFactory program is used as a benchmark. The examined network consists of multi-phase network and multi-phase load and feed-in power. As a result, both power flow solutions are identical. This means that the algorithm and the network model are correct. Then, to present the application of decoupling analysis approach for active distribution network, the modified IEEE 123-bus feeder with three interconnected areas are demonstrated. The result proves that the hybrid technique works properly with hybrid technique.

All in all, the proposed power flow method creates a chance to realize the management process in active distribution network. Last but not least, it is worthy to mention that the proposed method can be utilized in general power flow study as well.

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